The Fukushima Daiichi Accident

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THE FUKUSHIMA DAIICHI ACCIDENT

TECHNICAL VOLUME 3
EMERGENCY PREPAREDNESS AND RESPONSE

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

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EMERGENCY PREPAREDNESS AND RESPONSE

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The IAEA thanks the large number of experts who were involved in this report. It is the result of the dedicated efforts of many people. All participants listed at the end of this technical volume made valuable contributions, but a particularly heavy load was borne by the Co-Chairs and coordinators of the working groups. The efforts of many expert reviewers, including members of the International Technical Advisory Group, are also gratefully acknowledged.

THE REPORT ON THE FUKUSHIMA DAIICHI ACCIDENT

At the IAEA General Conference in September 2012, the Director General announced that the IAEA would prepare a report on the Fukushima Daiichi accident. He later stated that this report would be "an authoritative, factual and balanced assessment, addressing the causes and consequences of the accident, as well as lessons learned".[1]

The report is the result of an extensive international collaborative effort involving five working groups with about 180 experts from 42 Member States (with and without nuclear power programmes) and several international bodies. This ensured a broad representation of experience and knowledge. An International Technical Advisory Group provided advice on technical and scientific issues. A Core Group, comprising IAEA senior level management, was established to give direction and to facilitate the coordination and review. Additional internal and external review mechanisms were also instituted. The organizational structure for the preparation of this publication is illustrated in Fig. 1.

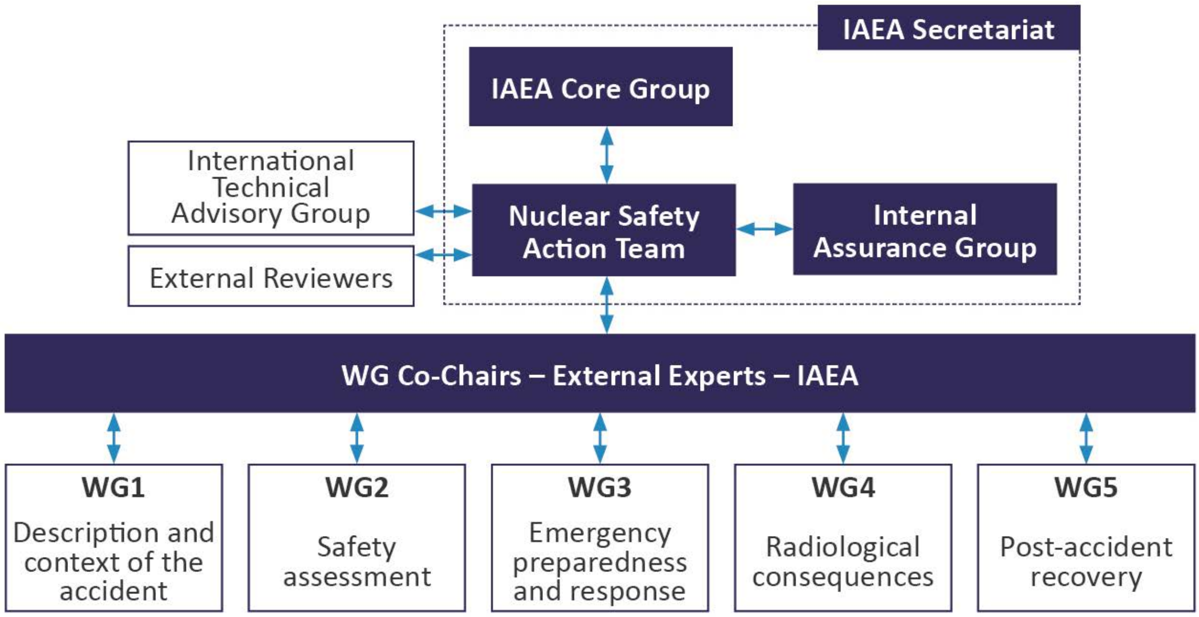

FIG. 1. IAEA organizational structure for the preparation of the report on The Fukushima Daiichi Accident.

The Report by the Director General consists of an Executive Summary and a Summary Report. It draws on five detailed technical volumes prepared by international experts and on the contributions of the many experts and international bodies involved.

The five technical volumes are for a technical audience that includes the relevant authorities in IAEA Member States, international organizations, nuclear regulatory bodies, nuclear power plant operating organizations, designers of nuclear facilities and other experts in matters relating to nuclear power.

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Introductory Statement to Board of Governors (2013), https://www.iaea.org/newscenter/statements/introductory-statement-board-governors-3.

The relationship between the content of the Report by the Director General and the content of the technical volumes is illustrated in Fig. 2.

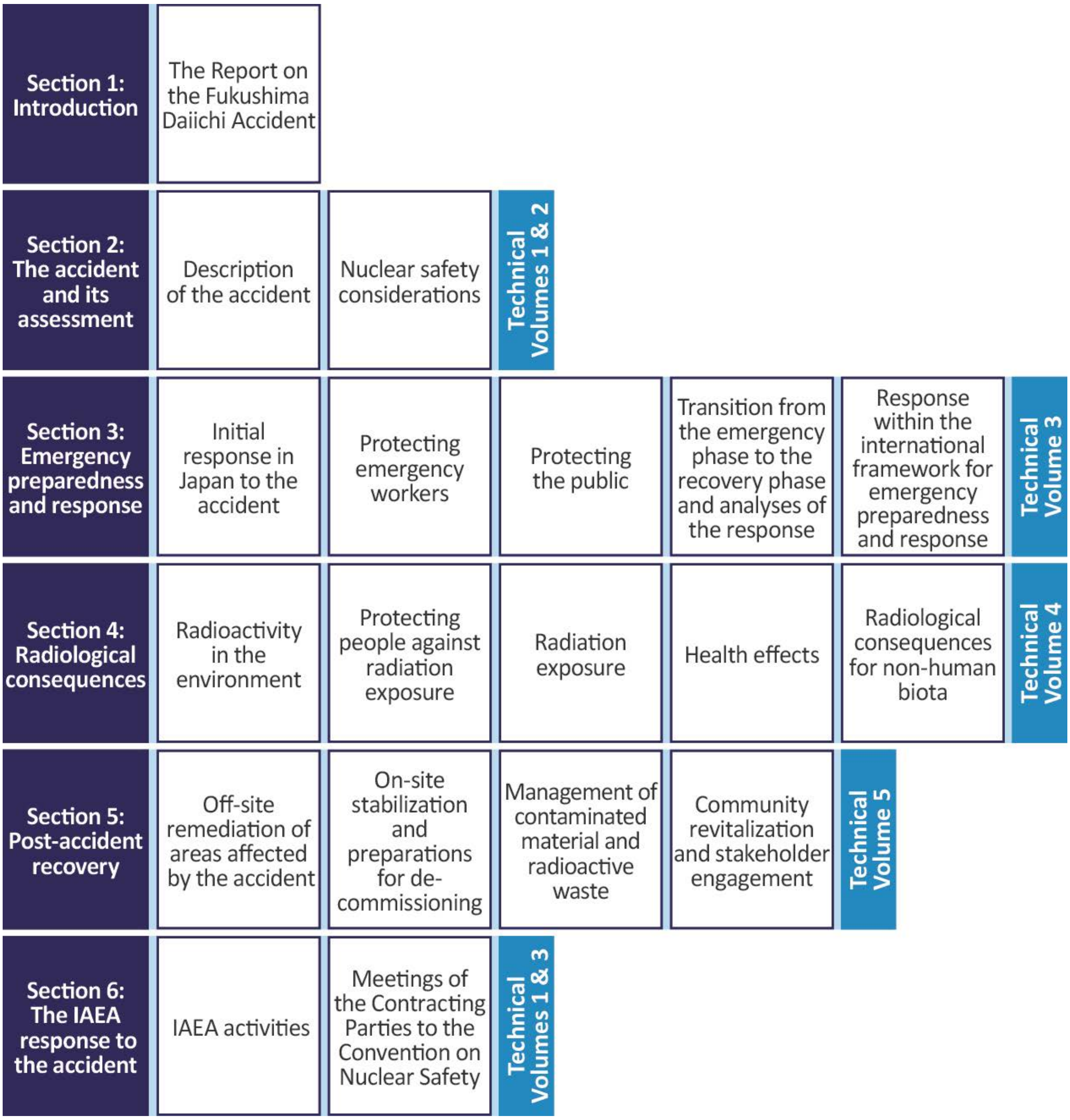

FIG. 2. Structure of the Summary Report and its relationship to the content of the technical volumes.

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EMERGENCY PREPAREDNESS AND RESPONSE

3. INTRODUCTION

This volume describes the key events and response actions from the onset of the accident at the Fukushima Daiichi nuclear power plant (NPP), operated by the Tokyo Electric Power Company (TEPCO), on 11 March 2011. It also describes the national emergency preparedness and response (EPR) system in place in Japan and the international EPR framework prior to the accident. It is divided into five sections.

Section 3.1 describes the initial actions taken by Japan in response to the accident, involving: identification of the accident, notification of off-site authorities and activation of the response; mitigatory actions taken on-site; and initial off-site response.

Section 3.2 describes the protective measures taken for personnel in response to the natural disaster, protection of emergency workers, medical management of emergency workers and the voluntary involvement of members of the public in the emergency response.

Section 3.3 describes the protective actions and other response actions taken by Japan to protect the public. It addresses urgent and early protective actions; the use of a dose projection model, the System for Prediction of Environmental Emergency Dose Information (SPEEDI), as a basis for decisions on protective actions during the accident; environmental monitoring; provision of information to the public and international community; and issues related to international trade and waste management.

Section 3.4 describes the transition from the emergency phase to the recovery phase. It also addresses the national analysis of the accident and the emergency response.

Section 3.5 describes the response by the IAEA, other international organizations within the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE), the actions of IAEA Member States with regard to protective actions recommended to their nationals in Japan and the provision of international assistance.

A summary, observations and lessons conclude each section.

There are three appendices and two annexes that provide supplementary information. Appendix I describes the key documents and elements of Japan’s EPR system that existed prior to the accident. Appendix II describes the radiation emergency medical system that was in place in Japan prior to the accident. Appendix III describes the emergency drills and exercises that took place prior to the accident. Annex I contains a provisional English translation by the IAEA of the notification faxes sent by the Fukushima Daiichi NPP Site Superintendent to off-site officials on 11 March 2011. Annex II reproduces a copy of a message issued by the International Commission on Radiological Protection (ICRP) on 21 March 2011 that includes quotes from its generally applicable recommendations. The annexes are included on the attached CD-ROM.

Key events relevant to the EPR area and response actions during the first year after the accident have been compiled in chronological order and are presented in the form of a timeline in Fig. 3–1.

11 March

- **14:46** | Great East Japan Earthquake, loss of off-site power, all operating reactors automatically shut down
- **15:36** | Second tsunami wave started flooding site (estimated inundation height: Onahama Port (OP) +14.5 m)
- **15:42** | Fukushima Daiichi NPP reported a specific event (station blackout) to national and local governments under Article 10 of the Act on Special Measures Concerning Nuclear Emergency Preparedness (Nuclear Emergency Act)
- **16:45** | Fukushima Daiichi NPP reported an event classified as a nuclear emergency (inability of water injection of the emergency core cooling system for Units 1 and 2) under Article 15 of the Nuclear Emergency Act to national and local governments
- **19:03** | Declaration of a nuclear emergency by the national Government and establishment of Nuclear Emergency Response Headquarters (NERHQ)
- **20:50** | Fukushima Prefecture issued an evacuation order for an area of 2 km radius around Fukushima Daiichi NPP
- **21:23** | National Government issued an evacuation order for an area of 3 km radius and sheltering order for a 3–10 km radius around Fukushima Daiichi NPP

12 March

- Fukushima Prefectural Government began monitoring evacuees using criterion of 13 000 counts/min
- **03:20** | Off-site Centre (OFC) became partially operational
- **05:44** | National Government issued an evacuation order for an area of 10 km radius around Fukushima Daiichi NPP
- **13:15** | Local Nuclear Emergency Response Headquarters (Local NERHQ) issued an order to local government that, if a decision is taken to implement iodine thyroid blocking (ITB), stable iodine tablets would need to be distributed to evacuation facilities
- **15:36** | Explosion in Unit 1: destruction of water and power provisions, degrading site radiological conditions
- **18:25** | National Government issued an evacuation order for an area of 20 km radius around Fukushima Daiichi NPP
- **19:04** | Seawater injection into the core of Unit 1 started

13 March

- **05:58** | Fukushima Daiichi NPP reported an event classified as a nuclear emergency (loss of reactor cooling function at Unit 3) under Article 15 of the Nuclear Emergency Act to national and local governments

14 March

- Monitoring criterion for full decontamination of the public increased from 13 000 counts/min to 100 000 counts/min
- **11:01** | Explosion in Unit 3 and destruction of alternative water injection equipment for Units 1 and 3
- **13:38** | Fukushima Daiichi NPP reported an event classified as a nuclear emergency (loss of reactor cooling function at Unit 2) under Article 15 of the Nuclear Emergency Act to national and local governments

15 March

- Dose criterion for emergency workers increased from 100–250 mSv (with retroactive effect from 14 March)
- **05:30** | Government-TEPCO Integrated Response Office established in Tokyo
- **06:14** | Sound in Unit 2 primary containment vessel, explosion in Unit 4 reactor building
- **09:00** | Maximum radiation level at main gate (c. 12 mSv/h)
- **11:00** | National Government issued an order to shelter for residents within a 20–30 km radius of Fukushima Daiichi NPP
  | Relocation began of OFC to Fukushima Prefectural Public Hall

FIG.3–1. Timeline of key events relevant to EPR and actions in response to the emergency at the Fukushima Daiichi NPP.

20:40–50 | Dose rates in the order of a few hundred μSv/h measured in some locations beyond the 20 km evacuation zone

17 March
- Provisional Regulation Values to restrict food and drinking water established

20 March
- National Government received aerial monitoring data from the United States of America

21 March
- National Government began to issue restrictions on the distribution of specific food

25 March
- National Government recommended voluntary evacuation for residents within the 20–30 km radius of the Fukushima Daiichi NPP

11 April
- National Government announced criterion of 20 mSv dose to determine areas beyond the 20 km evacuation zone from which people might need to be relocated

17 April
- TEPCO issued a Roadmap that outlined the steps toward recovery on the site

19 April
- National Government established criterion of 20mSv/y to determine reopening of schools (the criterion of 20 mSv/y was later reduced to 1 mSv/y)

22 April
- Deliberate Evacuation Area, Evacuation Prepared Area in Case of Emergency and Restricted Area established

25 April
- Joint press conferences between various organizations involved in the response held from this day onward

15 May
- Commencement of relocation from the Deliberate Evacuation Area

17 May
- National Government issued Roadmap for Immediate Actions for the Assistance of Nuclear Sufferers

30 June onwards
- National Government began to designate locations for relocation, identified as Specific Spots Recommended for Evacuation

30 September
- Evacuation Prepared Area in Case of Emergency lifted

16 December
- Conditions for a cold shutdown state achieved in Units 1–3

1 April 2012
- Standard limits established with activity concentrations for radionuclides in food and drinking water on the basis of 1 mSv/y criterion

FIG.3–1. Timeline of key events relevant to EPR and actions in response to the emergency at the Fukushima Daiichi NPP. (cont.). [1]

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[1] Throughout this volume, Japan Standard Time (JST) is used, except for Section 3.5, which uses Universal Time Coordinated (UTC) when describing activities at the international level. JST is nine hours ahead of UTC.

3.1. INITIAL RESPONSE IN JAPAN TO THE ACCIDENT

3.1.1. Relevant EPR arrangements in Japan prior to the accident

Before the accident at the Fukushima Daiichi NPP, separate arrangements were in place for responding to nuclear emergencies and natural disasters at the national and local levels. These arrangements did not envisage the need to respond to a nuclear emergency and a natural disaster occurring simultaneously [1, 2] (see Appendix I for more details). Lessons identified from the response to the Japan Nuclear Fuel Conversion Co. (JCO) Tokaimura criticality accident in 1999 [3, 4] resulted in an increased role of the national Government in managing the response to a nuclear emergency [5].

It was planned that the core entities in managing a nuclear emergency would be the Nuclear Emergency Response Headquarters (NERHQ)[2] and its Secretariat[3], as well as the Local Nuclear Emergency Response Headquarters (Local NERHQ)[4] (see Appendix I). The NERHQ would direct and coordinate the national response, which was to include preparing and issuing orders[5] and/or recommendations on evacuation to the local government [5].

The overall management of the national response to a nuclear emergency was to be coordinated at the local level, as soon as possible, by the Local NERHQ at the Off-site Centre (OFC). The OFC was to be established within a 20 km radius of an NPP [7]. For the Fukushima Daiichi and Fukushima Daini NPPs, the OFC was to be established within 5 km of the Fukushima Daiichi NPP. Each OFC had the necessary facilities and equipment to communicate with the Prime Minister's Office, the Cabinet Office and other relevant national and local authorities. It also allowed easy communication with the Emergency Response Centre established by the Ministry of Economy, Trade and Industry (METI) and the Nuclear and Industrial Safety Agency (NISA), which was part of the ministry (METI/NISA-ERC). The Local Prefectural Nuclear Emergency Response Headquarters and the Joint Council for Nuclear Emergency Response (JCNER) were also planned to be located in the Off-site Centre [1, 2, 8].

For the prefectural response to a nuclear emergency, it was planned that the Local Prefectural Nuclear Emergency Response Headquarters and the Prefecture Headquarters for Disaster Control would coordinate activities at the prefectural level. The JCNER would coordinate between the national response at the local level and the prefectural response [1, 5, 8].

Notification from the NPP to local and national governments was required under Article 10 of the Act on Special Measures Concerning Nuclear Emergency Preparedness (hereafter referred to as Nuclear Emergency Act) [5] when certain 'specific events' occurred, such as failure of all AC power supplies for more than five minutes [9]. Under Article 15 of the Nuclear Emergency Act [5], a report of a nuclear emergency would be sent when certain predefined criteria were met or exceeded, such as the loss of all capabilities to cool the reactor [5, 7, 10].

---

[2] The NERHQ, which was planned to be located in the Prime Minister's Office, was to be composed of those appointed by the Prime Minister from among the officials of the Cabinet Secretariat and designated administrative organs [5]. The Prime Minister was to serve as the Director General of the NERHQ.

[3] The NERHQ Secretariat was to be staffed by representatives of key organizations and headed by the Director General of the Nuclear and Industrial Safety Agency (NISA), which was part of the Ministry of Economy, Trade and Industry (METI). It would be located in the METI/NISA Emergency Response Centre (METI/NISA-ERC) in the METI building.

[4] The Local NERHQ was to be staffed by individuals from all relevant organizations, with the METI Senior Vice Minister as Director General. It was planned to be located at the Off-site Centre.

[5] The Nuclear Emergency Act [5] and the Disaster Countermeasures Basic Act [6] use the terms 'instructions' and 'recommendations' for issuing protective actions. An 'instruction' is mandatory and the public is therefore required to adhere to it. A 'recommendation' is only a suggestion and therefore not mandatory. However, for the purposes of clarity, the term 'orders' is used in this report as an equivalent of 'instructions'.

Table 3.1–1 lists the criteria to be used by the operators of the Fukushima Daiichi NPP for notification and reporting, as they were listed on the reporting forms (see Annex I).

TABLE 3.1–1. CRITERIA TO BE USED BY THE OPERATORS OF THE FUKUSHIMA DAIICHI NPP FOR REPORTING AN EMERGENCY

Type of events	Criteria	Type of events	Criteria
Article 10[a] (Specific Event)	(i) Rise in site boundary radiation dose rate	Article 15[a] (Nuclear Emergency)	(i) Abnormal rise in the site boundary radiation dose rate
	(ii) Release of radioactive material (higher than preset levels) through the normal release path		(ii) Abnormal release of radioactive material through the normal release path
	(iii) Release of radioactive materials due to a fire, explosion or other hazard		(iii) Abnormal release of radioactive material due to a fire, explosion or other hazard
	(iv) Scram failure		(iv) Out-of-reactor criticality
	(v) Leakage of reactor coolant		(v) Loss of the reactor shutdown function
	(vi) Loss of reactor feedwater		(vi) Inability of water injection of the emergency core cooling system
	(vii) Loss of reactor heat removal function		(vii) Abnormal rise in containment pressure
	(viii) Station blackout		(viii) Loss of pressure suppression function
	(ix) Loss of DC power supply (partial loss)		(ix) Loss of reactor cooling function
	(x) Drop in the reactor water level at shutdown		(x) Loss of DC power supply (complete loss)
	(xi) Drop in the fuel pool water level		(xi) Core meltdown
	(xii) Unavailability of the control room		(xii) Abnormal drop in reactor water level at shutdown
	(xiii) Possible out-of-reactor criticality		(xiii) Unavailability of the control room

[a] Nuclear Emergency Act [5]

Table 3.1–2 provides additional details from the relevant Cabinet Order and Ministerial Ordinance [7, 9, 10].

These criteria were not used as emergency action levels (EALs)[6] which would trigger implementation of predetermined public protective actions without additional assessment and judgement off-site. There was no emergency classification system in place that would address the need for prompt and informed management of the response to severe emergencies, as per the IAEA safety standards [13, 14].

It was assumed that a report of an event under Article 15 of the Nuclear Emergency Act [5] would follow a notification of a ‘specific event’ under Article 10 [8]. Notifications under Articles 10 and 15 could also be sent simultaneously as an initial report. However, it was not envisaged that notification under Article 15 only would be submitted as an initial report [15].

The NPP Site Superintendent would establish the on-site Emergency Response Centre (ERC) to direct the on-site Emergency Response Organization (ERO), which would implement different emergency

[6] Emergency action level (EAL) is a specific, predetermined, observable criterion used to detect, recognize and determine the emergency class of an event, which, if met or exceeded, would trigger declaration of the appropriate emergency class and initiation of the predefined response actions for that emergency class [11-13].

response functions to prevent progression of the accident and to mitigate its consequences, to protect plant personnel and to address any other site related issues in accordance with established plans and procedures (see Appendix I for background information).

TABLE 3.1–2. CRITERIA FOR A SPECIFIC EVENT AND FOR A NUCLEAR EMERGENCY AS SPECIFIED IN THE RELEVANT NATIONAL LAW [9]

Events	Criteria for a Specific Event	Criteria for a Nuclear Emergency
a) Radiation dose near the site boundary	5 µSv/h or more at one point for more than consecutive 10 minutes	500 µSv/h or more at one point for more than consecutive 10 minutes
	5 µSv/h or more at two or more points simultaneously	500 µSv/h or more at two or more points simultaneously
b) Detection of radioactive materials in usual release points such as exhaust pipes	When the concentration of radioactive materials equivalent to 5 µSv/h or more continues for 10 minutes or more, or radioactive materials equivalent to 50 µSv/h or more are released	When the concentration of radioactive materials equivalent to 500 µSv/h or more continues for 10 minutes or more, or radioactive materials equivalent to 5 mSv/h or more are released
c) Detection of radiation or radioactive materials by fire, explosion, etc. (outside the control zone)	Radiation dose of 50 µSv/h or more	Radiation dose of 5 mSv/h or more
	Release of radioactive materials equivalent to 5 µSv/h or more	Release of radioactive materials equivalent to 500 µSv/h or more
d) Individual events of each nuclear installation:		
Failure of reactor scram	When the nuclear reactor shutdown cannot be performed by usual neutron absorbers	When all reactor shutdown functions are lost in a case where emergency reactor shutdown is necessary
Loss of reactor coolant	When leakage of nuclear reactor coolant occurs, which needs operation of the emergency core cooling system	When water cannot be injected into the nuclear reactor by any emergency core cooling system
Loss of all AC power supplies	When power supply from all AC power supplies fails for 5 minutes or more	When all functions for cooling a reactor are lost with loss of all AC power supplies
Decrease in water level of the spent fuel pool at reprocessing facilities	When water level is decreased to the point where a fuel assembly is exposed	—

In the case of the Fukushima Daiichi NPP, for example, the on-site ERC, if necessary, would send a request for support to TEPCO Headquarters, using TEPCO's capabilities or resources gathered from other nuclear operating organizations, through the Agreement on Cooperation between Japanese Nuclear Operators [16, 17]. A clearly established procedure for requesting such assistance was included in the Fukushima Daiichi NPP Nuclear Operator Emergency Action Plan [16].

The provision of resources to the NPP by the national Government was not clearly described in the other emergency plans existing at the different levels [1, 2, 8].

Off-site response would start from a notification on a reportable event under Article 10 of the Nuclear Emegency Act [5] sent by an NPP to national and local governments. Key actions to be taken if an event fell under Article 10 and/or Article 15 of the Nuclear Emergency Act are summarized in Fig. 3.1–1 [1, 5, 6, 8, 16].

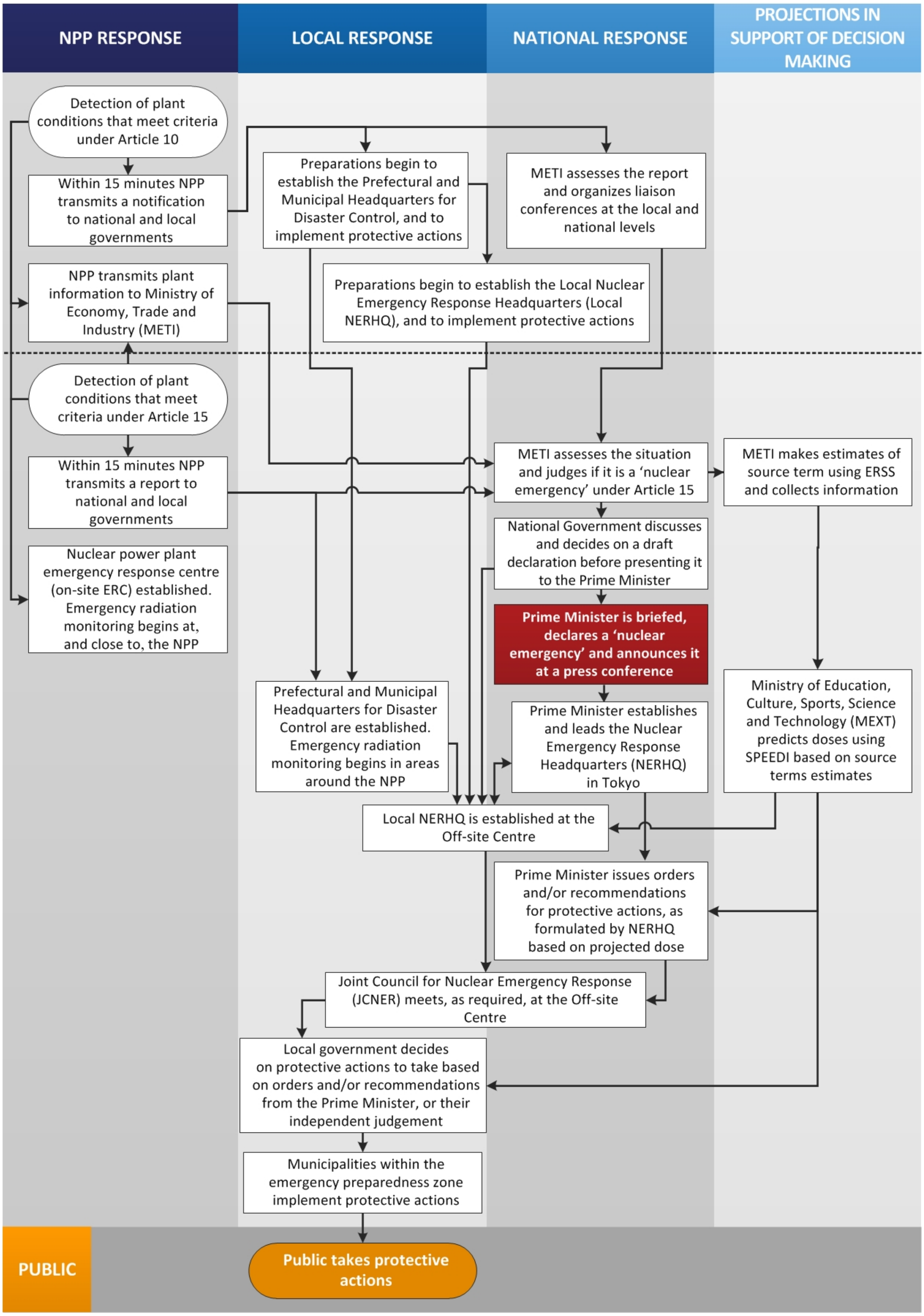

FIG. 3.1–1. Key actions to be taken if an event falls under Article 10 and/or Article 15 of the Nuclear Emergency Act [5], as planned prior to the Fukushima Daiichi accident (based on Refs [1, 5, 6, 8, 16]).

After receiving a notification, national officials in Tokyo (METI/NISA) would assess the event report [8] and a liaison conference of relevant ministries and agencies on accident management would be convened in Tokyo, along with a local liaison conference on accident management at the respective OFC to assess the situation and coordinate the initial response. If it was judged that the event fell under the classification of a nuclear emergency as set forth in Article 15 of the Nuclear Emegency Act [5], the response would proceed as described below without establishing these conferences, or closing them if they had already began.

If NISA assessed a declaration of a Nuclear Emergency to be warranted (as per Article 15), it would prepare a draft public notice of a declaration of a Nuclear Emergency and a draft of orders and/or recommendations for the heads of local governments, which would be sent to the Cabinet Secretariat located in the Prime Minister's Office and the Cabinet Office [2].

The Deputy Chief Cabinet Secretary for Crisis Management, the Director General of the government office responsible for safety regulation (NISA) and the Director General of the Cabinet Office for Disaster Preparedness would then promptly discuss and decide on these drafts, while incorporating inputs from local governments, as necessary, to be presented to the Prime Minister. If there was no time to complete this procedure, then verbal consent would be obtained [8].

The Prime Minister would be briefed on the event, and if he/she concurred with the draft, the declaration of a Nuclear Emergency would be issued.

The Prime Minister would establish and direct (as Director General) the NERHQ and NERHQ Secretariat located in the METI/NISA-ERC to coordinate the emergency response. The NERHQ would monitor conditions at the nuclear facilities and coordinate with local governments.

The Prime Minister would also direct the establishment of the Local NERHQ at the OFC. Nuclear safety inspectors at the site would immediately go to the OFC[7], and a Senior Specialist for Nuclear Emergency Preparedness would start the process of activating the Local NERHQ. The Vice Minister of METI (who would act as the Director General of the Local NERHQ), along with representatives of relevant national organizations (e.g. the Nuclear Safety Commission of Japan (NSC)) from Tokyo and representatives from the local government, would also go to the OFC.

The NPP Site Superintendent would provide the relevant off-site organizations (e.g. METI) with timely information of the accident progression. In parallel with the assessment of the event and activation of the national response described above, METI, as soon as the notification was received (as shown on the right hand side of Fig. 3.1–1), would monitor conditions at the NPP. It would attempt to make predictions of the accident evolution, including predictions of timing, rate and composition of possible releases (i.e. the source term) of radioactive material from the NPP based on plant conditions provided by the operator and using the Emergency Response Support System (ERSS)[8].

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) would use the source term predictions by METI to predict off-site consequences (e.g. projected doses to the public) from the possible release of radioactive material using the System for Prediction of Environmental Emergency Dose Information (SPEEDI). Doses that were predicted by using SPEEDI would be compared with predetermined criteria for taking protective actions [19] to determine where and what

[7] Some nuclear safety inspectors would remain at the site to monitor the plant situation for reporting to METI/NISA.

[8] The ERSS is a computer-aided tool to assess the status at the nuclear power plant and predict the progression of an accident [18].

protective action(s) should be taken (see Section 3.3 for details). MEXT would transmit the predictions to terminals in the NERHQ, Local NERHQ, NSC, Prefecture Headquarters for Disaster Control and elsewhere. Within the NERHQ, protective action recommendations would be drafted for issuance by the Prime Minister, who would be responsible for issuing orders and/or recommendations for protective actions to the public [8].

Thus, determination of the protective actions was to be based on the projections performed in real time. There was no system in place to recommend urgent protective actions for the public based on pre-defined plant conditions which, if met, would correspond to a specific emergency class and would trigger a decision on urgent protective actions for the public without additional assessment and judgement [11, 13].

The Prime Minster would provide orders and/or recommendations to the local government on the implementation of protective actions. The local governments (prefecture/town/city/village) would decide on the protective actions to be taken based on: (a) the orders and/or recommendations given by the Prime Minister (or NERHQ Director General); (b) decisions taken within the JCNER (if there was enough time); or (c) their own independent judgement [2, 6].

Local authorities would make preparations to establish the Prefecture Headquarters for Disaster Control[9], in order to coordinate the response to a nuclear emergency at the prefectural level, and the Local Prefectural NERHQ at the OFC [1].

The prefecture and municipalities would send representatives to the OFC to staff the Local NERHQ and JCNER. The Local NERHQ would organize the JCNER, consisting of representatives of national and local governments and the NPP. The representatives of the JCNER would share information and coordinate protective actions and information to be provided to the media. The policies concerning key issues associated with protective action recommendations would be discussed and decided through the Emergency Response Policy Meeting of the JCNER. The Local NERHQ at the OFC would have the capability to make predictions on the impact of releases using SPEEDI (operated by MEXT), based on data obtained from ERSS (operated by METI), and to monitor environmental radiation levels in real time using monitoring posts located in the vicinity.

Once the Local NERHQ at the OFC was operational, the Prime Minister would delegate to the Director General of the Local NERHQ part of his/her authority. This would include responsibilities that are best assumed locally (concerning orders and/or recommendations to evacuate residents, restrict the intake of beverages and food, and implement iodine thyroid blocking (ITB)).

Close coordination between the NERHQ, Local NERHQ and others would be accomplished by using the on-line Integrated Nuclear Emergency Preparedness Network and a videoconference system.

The prefecture and the local municipalities would start preparations for sheltering or evacuation, such as setting up shelters, making vehicles available to transport local residents and arranging sound trucks (see Section 3.3.2.1) [1]. The logistics of sheltering and evacuations would be carried out according to predetermined plans.

A disaster wireless system and sound trucks would be used to warn and inform the residents. For example, evacuees gathered at assembly points would be evacuated using vehicles provided by the Government or, if necessary, by vehicles provided by their owners. Special consideration would be

[9] Within the arrangements for Fukushima Prefecture, the Prefecture Headquarters for Disaster Control would be located in the Fukushima Prefectural Office.

given to vulnerable people such as elderly persons, infants, pregnant women and injured or sick persons. If stable iodine tablets for ITB were to be prescribed for the public, the tablets would be distributed by the prefecture at the time of the accident. No pre-distribution of stable iodine tablets to the population living close to an NPP at the preparedness stage was foreseen.

The local governments would implement the protective actions for the public within the 10 km emergency planning zone (EPZ) of an NPP in accordance with their emergency response plans.

Local residents would be monitored (screened) for external contamination and decontaminated if the criteria established were exceeded. If required, exposed and contaminated individuals would be treated at designated radiation emergency medical hospitals as well as at the National Institute of Radiological Sciences (NIRS) located in Chiba (approximately 40 km from Tokyo).

In parallel, the on-site ERO would keep off-site officials informed about the developments on-site. Radiation monitoring in the wider area would be conducted by the national Government and the prefecture[10], while the operator would conduct monitoring at and near the NPP site.

3.1.2. Identification, notification and activation in response to the accident

As a result of the Great East Japan Earthquake that occurred at 14:46 on 11 March 2011 off the north-eastern coast of Japan, the Fukushima Daiichi NPP lost off-site electrical power, the emergency diesel generators (EDGs) were automatically activated and the reactor protection systems were initiated in accordance with the design of the NPP [17].[11] In addition to causing strong ground motion and infrastructure damage, the earthquake generated a series of large tsunami waves. When the second of these waves arrived at the Fukushima Daiichi NPP at 15:36, it overwhelmed the tsunami barrier seawalls, flooded the main buildings and caused extensive damage to the structures and equipment necessary for keeping the plant in safe shutdown [20]. As a consequence, the Fukushima Daiichi NPP entered into a condition in which the Nuclear Operator Emergency Action Plan [16] was to be fully activated. This triggered actions to set up the on-site ERC and on-site ERO.

The flooding caused a loss of all AC power in Units 1–5, creating a situation referred to as ‘station blackout’. Within the next 10–15 minutes, DC power, too, was lost in Units 1, 2 and 4. This resulted in the loss of monitoring and operating functions in the main control rooms, the loss of tools for communication with workers in the field, the loss of lights and the loss of all motor operated systems (i.e. safety systems and cooling facilities).

The loss of AC/DC power shortly after the tsunami also resulted in the loss of core cooling in Units 1–3, leading to severe damage to the fuel in the core [12].

Notification of a ‘specific event’ for Units 1[13] to 5 under Article 10 of the Nuclear Emergency Act [5] due to a station blackout was communicated by the plant by telephone to NISA and by fax to TEPCO

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[10] For Fukushima Prefecture, radiation levels would be monitored in real-time at 23 locations in the vicinity of the local Environmental Radioactivity Monitoring Centre located next to the OFC. In addition, the Centre would deploy monitoring teams.

[11] For a detailed description of the onset and progression of the accident, see Technical Volume 1, Sections 1.1 and 1.3.

[12] According to IAEA safety standards [11, 13, 14], the loss of core cooling warranted the classification of the event as a General Emergency and the implementation of urgent protective actions for the public off the site, since it would result in severe damage to the fuel in the core and could potentially result in a large release of radioactive material.

[13] In the following account, the evolution of the situation at Unit 1 is described in detail, because progression of the situation at this unit was most important for decisions on public protective actions, as it was the first unit to experience severe damage to the fuel in the core.

Headquarters, METI, the Governor of Fukushima Prefecture and the mayors of Okuma Town and Futaba Town (Fig. 3.1–2) (Fax 1, Annex I).[14]

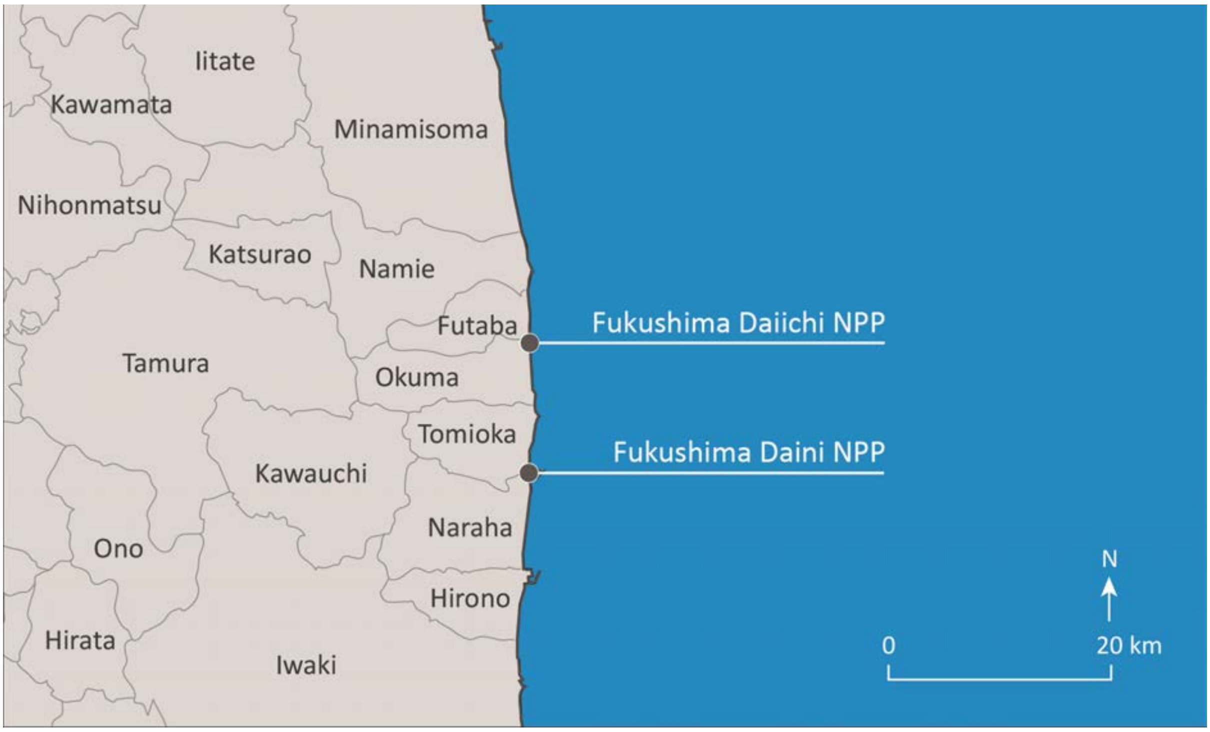

FIG. 3.1–2. Municipalities near the Fukushima Daiichi and Fukushima Daini NPPs [21].

After trying to send a fax message to Namie Town (receipt of which could not be acknowledged), repeated attempts were made to communicate by telephone, disaster priority mobile phone, satellite mobile phone and hotline. However, since all the means of communication were out of order, no phone contact could be established [17].

On 11 March, TEPCO staff, in order to explain the conditions at the relevant NPPs, personally went to the four municipalities in which the NPPs are located (Okuma Town and Futaba Town for Fukushima Daiichi, and Naraha Town and Tomioka Town for Fukushima Daini). In addition, TEPCO staff visited Namie Town on 13 March to explain the situation [9].

At 16:25, the shift supervisor reported to the on-site ERC on the occurrence of a situation falling under Article 15 of the Nuclear Emergency Act [5]. At 16:36, the Site Superintendent confirmed that, due to the loss of the water injection function of the emergency core cooling system (ECCS), Article 15 of the Nuclear Emergency Act was applicable [5, 17].

At 16:45, the Fukushima Daiichi NPP reported to off-site officials (Fax 2, Annex I) an event at Units 1 and 2 classified as a nuclear emergency (under Article 15 of the Nuclear Emergency Act [5]) [17, 22-24], based on the inability of the ECCS to inject water into the reactors of Units 1 and 2 [24].

[14] TEPCO notified NISA of a ''specific event' for Units 1–5 under Article 10 of the Nuclear Emergency Act [5] by telephone at 15:42. According to the fax sheet received by the NISA from TEPCO, the received time was recorded as 16:00. The delay in the receipt of the fax might have been caused by technical difficulties [21].

This notification indicated that the NPP staff could no longer maintain core cooling in the reactors of Units 1 and 2 and thus could no longer prevent the fuel in the cores from being damaged.

At 22:10 (Fax 8, Annex I), based on displays in the control room, it was reported to off-site officials that the reactor water level in Unit 1 was above top of active fuel (TAF). However, as shown in Fig. 3.1–3 [17, 25], the water level was, in fact, below TAF at this time.

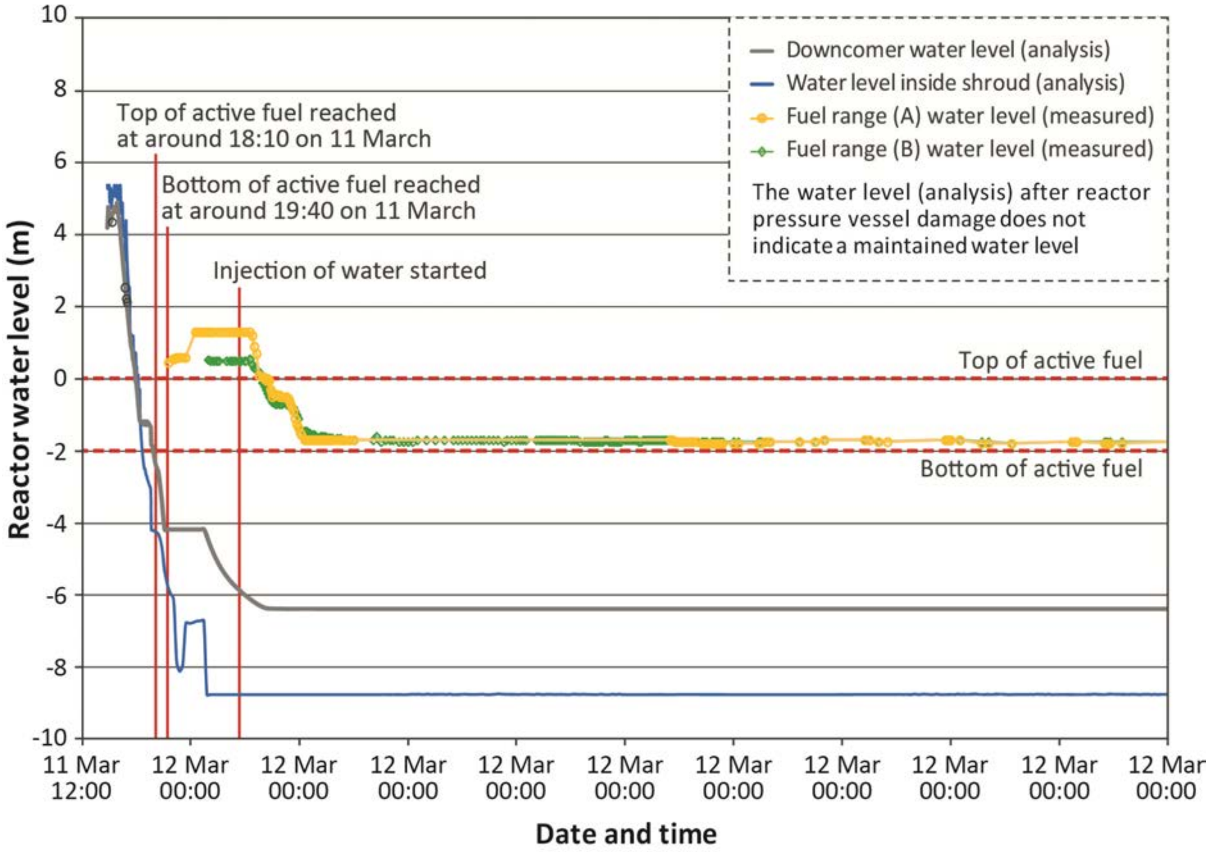

FIG. 3.1–3. Water level in Unit 1 as a function of time [17].

This error occurred because the water level instrumentation was not designed to function under emergency conditions [17, 21].[15]

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[15] According to IAEA safety standards [11], the response of control room instrumentation under accident conditions needs to be considered in the development of the EPR arrangements.

3.1.3. Mitigatory actions

Figure 3.1–4 presents a timeline of key events relevant to the mitigatory actions[16] taken after the onset of the accident[17].

3.1.3.1. Management and implementation

The initial mitigatory actions after the earthquake took place in accordance with TEPCO's abnormal operating procedures[18]. An ERC, headed by the Site Superintendent, was established at the Fukushima Daiichi NPP around 15 minutes after the earthquake [17, 27]. It was located in the seismically isolated building, which was fitted with special features, including an autonomous electrical power supply and ventilation systems with filtration devices. This building had been constructed[19] as a result of lessons learned from the experience of the Kashiwazaki-Kariwa NPP following the Niigata-Chuetsu-Oki earthquake in 2007, and its use enabled mitigatory actions to continue at the site during the response to the accident [17]. All safety systems behaved as expected.

The situation changed dramatically when the tsunami wave hit the NPP. As most of the cooling systems of all the three operating reactors (Units 1, 2 and 3) became inoperative, the overriding priority was to take mitigatory actions to restore core and containment cooling in these reactors in order to prevent radioactive releases, or reduce the size of such releases. At Units 4, 5 and 6 (which were undergoing planned refuelling and/or maintenance outages), the critical parts that needed to be cooled were the spent fuel pools [17]. Accordingly, the NPP staff started to implement the Fukushima Daiichi NPP Nuclear Operator Emergency Action Plan[20].

The mitigatory actions were conducted in a complicated and stressful environment marked by: damage to the plant's infrastructure caused by the tsunami (e.g. presence of a huge amount of debris); occurrence of aftershocks, which triggered the tsunami alerts; lack of electricity supply, which disabled most of the plant's equipment and lighting inside the buildings; difficulties in communication, both on-site and off-site; failure of the safety systems needed for core cooling; and other challenging conditions (hydrogen explosions, increased radiation levels, etc.). Workers at the site carried out mitigatory actions under very difficult conditions; they worked longer hours under far more tiring circumstances than would normally be expected [17].

The simultaneous occurrence of these circumstances had not been considered in the emergency plans. Consequently, the ERO became overwhelmed, and many mitigatory actions could not be carried out in a timely manner [17].

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[16] Mitigatory actions are immediate actions to reduce the potential for conditions to develop that would result in exposure or a release of radioactive material requiring emergency actions on or off the site, or to mitigate source conditions that could result in exposure or a release of radioactive material requiring emergency actions on or off the site [12, 26].

[17] Mitigatory actions are also discussed as part of the overall description of the onset and progression of the accident in Technical Volume 1, Sections 1.1 and 1.3. They are addressed in Technical Volume 2, Section 2.4, from the nuclear safety perspective, e.g. assessing the accident management actions and procedures and the implementation of severe accident management criteria and guidelines during the accident. This section describes mitigatory actions from the perspective of emergency preparedness and response on the site, e.g. actions undertaken by the on-site ERO, as described in the Nuclear Operator Emergency Action Plan [16].

[18] The abnormal operating procedures were implemented for a 'natural event' and a 'turbine and electrical incident' as described in more detail in Technical Volume 1, Section 1.1.[19] Construction of the seismically isolated building started in March 2009 and the building was put into operation in July 2010.

[19] Construction of the seismically isolated building started in March 2009 and the building was put into operation in July 2010.

[20] This plan provided the basis for organizational and material resources and emergency actions to be carried out on-site and for liaison with off-site entities (e.g. TEPCO, NERHQ and Local NERHQ) [16].

11 March

- 14:46 | Great East Japan Earthquake, loss of off-site power, all operating reactors automatically shut down
- 15:36 | Second tsunami wave started flooding site (estimated inundation height: OP+14.5 m)

12 March

- 00:06 | Site Superintendent ordered preparations for venting of Unit 1
- 01:30 | Prime Minister and METI approved implementation of venting of Units 1 and 2
- 03:30 | Attempts to vent Unit 1 failed
- 06:50 | Minister of METI ordered venting to be carried out
- 07:11 | Prime Minister and NSC Chairman met NPP Site Superintendent to discuss conditions at the plant and status of venting
- approx. 12:00 | Site Superintendent ordered preparation for seawater injection
- 14:00 | Operators opened venting line of Unit 1 and received confirmation of venting at 14:30
- 15:20 | TEPCO notified NERHQ that, following preparations, seawater injection would begin for Unit 1
- 15:36 | Explosion in Unit 1: destruction of water and power provisions, degrading site radiological conditions
- 17:55 | METI issued an order to TEPCO to inject sea water into Unit 1
- 18:05 | Prime Minister received report from METI about the order to inject sea water into Unit 1
- 19:04 | Seawater injection into the core of Unit 1 started
- 19:25 | Site Superintendent instructed to delay seawater injection; seawater injection continued
- 19:55 | Explanation about seawater injection provided to Prime Minister; Prime Minister authorized seawater injection

13 March

- 06:20 | Direct telephone line installed connecting Prime Minister's Office to the plant

14 March

- 11:01 | Explosion in Unit 3 and destruction of alternative water injection equipment for Units 1 and 3
- 19:45 | TEPCO began to prepare evacuation guidelines for non-essential staff located on-site

15 March

- J-Village started to be used as a general logistical support base
- 03:00 | Prime Minister informed by METI of full withdrawal of on-site staff
- 04:17 | Prime Minister asked TEPCO President about full withdrawal of staff and was subsequently informed it was not planned
- 05:30 | Government-TEPCO Integrated Response Office established in Tokyo
- 06:14 | Sound in Unit 2 primary containment vessel, explosion in Unit 4 reactor building
- 09:00 | Maximum radiation level at main gate (ca. 12 mSv/h)

FIG. 3.1–4. Timeline of key events relevant to mitigatory actions on-site.

The national Government became involved in decisions concerning mitigatory actions, such as the injection of seawater for fuel cooling [25, 27]. Roles, responsibilities and authorities in this regard had not been clearly assigned at the preparedness stage.

Insights of this situation can be illustrated by the following examples concerning: venting of the Unit 1 reactor; seawater injection; and evacuation of personnel from the NPP site.

Venting of the reactor

Once clear symptoms of core damage in Unit 1 were detected on the evening of 11 March, primary containment venting became the overriding priority[21], together with the resumption of water injection into the reactor core [17]. At approximately 00:55 on 12 March, TEPCO reported to the relevant authorities an abnormal increase in the containment pressure as defined in Article 15 of Nuclear Emergency Act [5, 27]. The containment pressure built up before venting took place, leading to an increase in the leakage of hydrogen into the reactor building, which subsequently led to a hydrogen explosion on 12 March. On 11 March, the Chairman of the Nuclear Safety Commission of Japan (NSC), upon hearing that the DC power supply at the Fukushima Daiichi NPP had been lost, believed that "[t]he only thing to do is to depressurize, inject water, and vent the unit" [25]. He therefore urged TEPCO to "quickly start venting".

The Prime Minister's Office[22] became aware of the necessity of containment venting at 01:30 on 12 March and obtained the Prime Minister's approval to conduct the venting. At 03:06, the Minister of METI and TEPCO's Managing Director held a joint press conference, in which they announced the venting. As the scheduled time passed, and the venting had yet to be carried out, the Office on the fifth floor of the Prime Minister's Office requested an explanation for the delay. In response, it was explained that venting required manual action to be carried out in the plant under very difficult conditions, including working in an environment of increased radiation levels (e.g. an estimated dose rate of 300 mSv/h in the valve area) [28].

TEPCO reported the details about the ongoing preparations for the implementation of the containment venting to METI/NISA-ERC through a TEPCO liaison in NISA. At approximately 06:50 on March 12, the Minister of METI issued an order under paragraph 3, Article 64 of the Reactor Regulation Act, to implement containment venting [29]. Although the Fukushima Daiichi NPP was informed of the implementation order, NPP staff did not proceed with the preparation, as scheduled, due to the difficult on-site conditions (e.g. the absence of lighting, increased radiation levels and frequent aftershocks) [27]. Since the Prime Minister could not obtain consistent information from TEPCO regarding containment venting and other actions, he decided to visit the Fukushima Daiichi NPP site to directly review the situation [25].

Seawater injection

Seawater injection was considered to be very important to prevent further deterioration of the conditions inside primary containment [17, 25]. At around 15:20 on 12 March, TEPCO notified the NERHQ that, as soon as preparations were complete, sea water would be injected into Unit 1 by the use of firefighting equipment [25]. However, NISA officials who were stationed in the METI/NISA-

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[21] For a detailed discussion, see also Technical Volume 1, Section 1.3.

[22] The Prime Minister and his support staff were located on the fifth floor of the Prime Minister's Office (in the Prime Minister's working office and reception rooms), while the Crisis Management Centre was located in the basement of the building. This decision making group was separate from the NERHQ. This set-up was not in accordance with the decision making process that was specified in the Nuclear Emergency Response Manual [8] and had been exercised prior to the accident.

ERC and the Prime Minister's Office could obtain only fragmentary information[23], and they could not fully appreciate the difficulty of the seawater injection operation [27]. At 17:55, an order was issued by METI to TEPCO to inject sea water into the reactor of Unit 1. At about 18:00, the Prime Minister was briefed by staff in the fifth floor Office of the Prime Minister's Office on the plan for the injection of sea water. He raised concerns regarding criticality, which were considered as not having been sufficiently answered, and, consequently, he did not approve the seawater injection.

There was no indication of efforts being made at the time to tell the Prime Minister that the Fukushima Daiichi NPP was already working toward seawater injection or that METI had already issued an order to carry it out. Seawater injection at the Fukushima Daiichi NPP Unit 1 started at 19:04, but this fact was not conveyed to the Office on the fifth floor of the Prime Minister's Office. At around 19:25, the fifth floor Office instructed the Fukushima Daiichi NPP Site Superintendent to delay the seawater injection, as it was still being deliberated at the Prime Minister's Office. At around 19:55, after further explanation, the Prime Minister approved the injection [25, 27].

TEPCO was notified by personnel dispatched to the Prime Minister's Office that "the Prime Minister has not approved seawater injection," leading to deliberation between the on-site ERC and the ERC at TEPCO Headquarters [17]. A decision was taken to temporarily suspend the injection. However, the Site Superintendent continued seawater injection, as he believed that this was vital in order to prevent accident progression [17].

Evacuation of plant personnel

On the night of 14 March, the President of TEPCO was informed that evacuation of all non-essential on-site personnel from the Fukushima Daiichi NPP was being considered if the circumstances were to deteriorate [21]. Before dawn of 15 March, the President contacted NISA and reported that the situation at Unit 2 was grave, that he would not rule out an evacuation of non-essential personnel, and that he was seeking NISA's approval. He did not clearly state that essential personnel would remain at the NPP site. Discussions were carried by the Prime Minister's Office until around 03:00 on 15 March. At about 03:00, the Prime Minister [21] was informed of the request, and he immediately responded that evacuation of all personnel was unacceptable. The TEPCO President was called to the Prime Minister's Office to confirm TEPCO's intentions on the matter. The TEPCO President confirmed that the company was not planning to evacuate all personnel from the plant [17]. The Prime Minister proposed that the rapid sharing of information and good communication between the parties be ensured in the future, and that the national Government and TEPCO establish an integrated response headquarters at TEPCO's Headquarters.

3.1.3.2. Off-site support

Shortly after the beginning of the accident, the on-site ERC requested, through the ERC at TEPCO Headquarters[24], additional human resources and equipment to be sent to the Fukushima Daiichi NPP. With the establishment of the integrated response headquarters between the national Government and TEPCO, a clear process for addressing needs to support on-site mitigation and recovery actions had been put in place [17, 25].

[23] At this time, the nuclear safety inspectors at the Fukushima Daiichi NPP had already evacuated to the OFC.

[24] One of the tasks of this ERC was to provide support to the on-site ERC at the Fukushima Daiichi NPP with regard to human resources and equipment.

Human resources

Personnel from TEPCO, from contractors and from other Japanese NPPs (not operated by TEPCO) were dispatched to the Fukushima Daiichi site to assist with various tasks, including restoring power and monitoring instruments, injecting cooling water into the reactors, removing rubble and monitoring radiation levels [17]. Personnel from national government agencies and organizations — such as the Japan Self-Defense Force (SDF), police and firefighters — were also dispatched to the site. They helped with activities including operating the large equipment needed to pour or spray water onto the spent fuel pools in Units 1, 3 and 4 and providing helicopter surveillance of the spent fuel pools [17, 22, 27].

During the first days of the emergency, about 400 people on average were dispatched to the Fukushima Daiichi NPP site every day [17]. In many cases, operations were performed by specialized personnel from TEPCO owing to the extremely demanding conditions prevailing on the site [17].

As the accident progressed, more human resources became available on the site, which made it possible to cope more effectively with serious unforeseen problems (e.g. uncontrolled releases of highly contaminated water to the sea, which occurred in the first days of April 2011) [17].

Equipment

Following the tsunami, there were multiple equipment failures on-site, and a range of portable equipment and heavy machinery was necessary to cope with the situation. The first equipment provided to assist in on-site mitigation activities was collected in the evening of 11 March and reached the site in the morning of 12 March. Some of this equipment was supplied by TEPCO and some by the Japanese official authorities (e.g. the SDF). Many types of portable equipment were delivered, such as: mobile AC power generators; equipment for power restoration (mainly cables and transformers); mobile pumps (engine driven), such as fire engines with all of the associated fittings and equipment; mobile air compressors; radiation monitoring vehicles; batteries of different types, voltages and sizes; and portable lighting equipment. In some cases (especially for batteries and equipment to restore electric power supply), a logistical procurement team was established near the Fukushima Daiichi site to manage the request and/or procurement of the equipment needed [17].

Extensive damage of the transport infrastructure due to the earthquake and tsunami, in addition to insufficient pre-planning, impaired the effectiveness of this support. For example, when the request for equipment did not contain an adequate specification of what was required, it led to the procurement of equipment that was incompatible with existing plant equipment (due to mismatched fittings, connectors, etc.) [17].

The delivery of equipment was hampered by multiple problems. Fear of contamination from radioactive material deposited on vehicles impeded the transport of supplies necessary for the response [17]. On-site emergency workers encountered difficulties in obtaining authorization from the police to travel on roads leading to and from the site [17]. Truck drivers abandoned deliveries or retreated, requiring on-site emergency workers with driving licences to replace them [17]. Receiving, managing and organizing the arrival of deliveries was logistically very challenging [17].

In addition to portable equipment, some heavy equipment was provided to the Fukushima Daiichi NPP by different national organizations (e.g. the SDF) and also by local and prefectural organizations (e.g. firefighting brigades) [17, 30].

To manage and streamline the support, some logistical points were established, mainly for administrative and radiation control of personnel coming to the site. These points were established at the J-Village[25] and the TEPCO Onahama Coal Center [17].

3.1.4. Management of the off-site response

Figure 3.1–5 presents a timeline of key events relevant to management of the off-site response to the accident.

11 March

Time	Event
14:46	Great East Japan Earthquake, loss of off-site power, all operating reactors automatically shut down
	METI/NISA-ERC established immediately after the earthquake
14:50	Emergency Response Office for dealing with the earthquake established at the Prime Minister's Office
15:06	On-site ERC established
	TEPCO Headquarters in Tokyo activated its ERC for general disasters
15:14	National Government established the Emergency Disaster Response Headquarters at the Prime Minister's Office
15:36	Second tsunami wave started flooding site (estimated inundation height: OP+14.5 m)
15:40	Personnel from TEPCO Fukushima office walked to the local government hall and informed staff that Fukushima Daiichi NPP had lost all AC power
15:42	Fukushima Daiichi NPP reported a specific event (station blackout) to national and local governments under Article 10 of the Act on Special Measures Concerning Nuclear Emergency Preparedness (Nuclear Emergency Act)
16:00	TEPCO Headquarters in Tokyo started to establish an ERC for nuclear emergencies
	Loss of all power reported from Off-site Centre (OFC)
	Director General of Local NERHQ and METI and NISA officials departed from Tokyo to OFC
	NSC held an extraordinary meeting and formed an Emergency Technical Advisory Body
16:25	Inability to inject water into the reactor of Unit 1 using any of the ECCSs identified at the NPP
16:36	Emergency Response Office in the Prime Minister's Office established for the nuclear accident
	Presumed severe accident conditions in Units 1 and 2, classification of a nuclear emergency
16:45	Fukushima Daiichi NPP reported an event classified as a nuclear emergency (inability of water injection of the emergency core cooling system for Units 1 and 2) under Article 15 of the Nuclear Emergency Act to national and local governments
16:55	Fukushima Daiichi NPP reported that the water level of Unit 1 was being monitored again and an event classified as a nuclear emergency (inability of water injection of the ECCS for Unit 2) under Article 15 of the Nuclear Emergency Act to national and local governments

FIG. 3.1–5. Timeline of key events relevant to the management of the off-site response.

[25] J-Village is located about 20 km south of the Fukushima Daiichi NPP. Prior to the accident, it was a football training facility. After the accident, it was utilized as a general logistical support base, e.g. for preparing workers for assigned tasks, for monitoring and decontamination, as necessary, after completion of the assigned tasks, for triage, etc. [22].

- **17:12** | Fukushima Daiichi NPP reported an event classified as a nuclear emergency (inability of water injection of the ECCS for Unit 1) under Article 15 of the Nuclear Emergency Act to national and local governments
- **17:37** | Fukushima Daiichi NPP reported to national and local governments that radiation levels were within normal range in the area surrounding the plant
- **17:42** | Minister of METI informed Prime Minister and requested approval for declaration of a nuclear emergency
- **18:30** | Prime Minister approved declaration of a nuclear emergency under Article 15 of the Nuclear Emergency Act
- **19:03** | Declaration of a nuclear emergency by the national Government and establishment of Nuclear Emergency Response Headquarters (NERHQ)
- **20:30** | Prime Minister took charge of the Crisis Management Centre and subsequently relocated to the fifth floor of the Prime Minister's Office
- **21:01** | Fukushima Daiichi NPP reported the inability of the reactor core isolation cooling system to inject water into Unit 2; reactor water level may reach the top of active fuel (Unit 2); preparing to request local governments to evacuate residents; radiation exposure of workers unknown to national and local governments

12 March

- **03:20** | Off-site Centre (OFC) became partially operational
- **10:30** | First meeting of JCNER

15 March

- **05:30** | Government-TEPCO Integrated Response Office established in Tokyo
- **11:00** | Relocation began of OFC to Fukushima Prefectural Public Hall

FIG. 3.1–5. Timeline of key events relevant to management of the off-site response (cont.).

The locations of the core entities involved in the management of the off-site responses to the Fukushima Daiichi accident are presented in Fig. 3.1–6.

At 14:50 on 11 March 2011, an Emergency Response Office for dealing with the earthquake was established in the Prime Minister's Office by the Deputy Chief Cabinet Secretary for Crisis Management, and members of the Emergency Operations Team were convened there [31].

After the earthquake, METI/NISA immediately established its ERC and began gathering information about the state of the NPPs in the affected areas.

At 15:06, an ERC for general disasters was established at the TEPCO Headquarters office in Tokyo. Efforts then began to identify and evaluate possible earthquake damage to all NPPs operated by TEPCO and to restore power to those places experiencing a blackout [17, 27].

At 15:14, the national Government established the Emergency Disaster Response Headquarters in the Prime Minister's Office, with the Prime Minister as the Headquarters' Director General; the Headquarters' Secretariat was set up in the Prime Minister's Cabinet Office. At 15:37, the first meeting of the headquarters was held [27].

At 15:42, the Fukushima Daiichi NPP Site Superintendent made an Article 10 notification ('specific event') to the national Government (METI/NISA) and local governments (see Fax 1, Annex I).

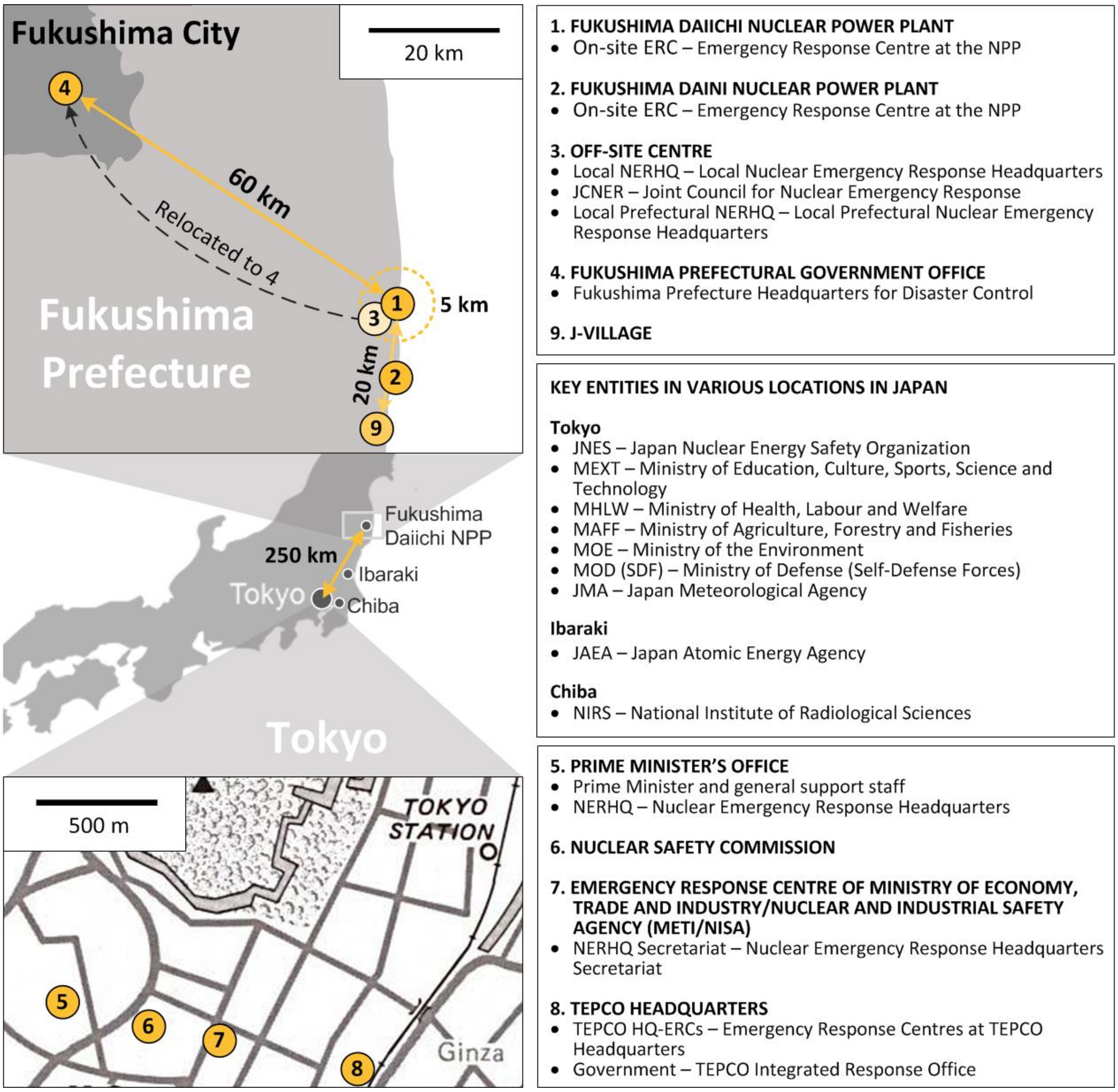

FIG. 3.1–6. Location of core entities involved in the management of off-site responses during the Fukushima Daiichi accident [1, 8, 17, 25, 32-44].

Upon receiving the fax notification from the Fukushima Daiichi NPP regarding the occurrence of a 'specific event' under Article 10 of the Nuclear Emegency Act [5], TEPCO also established an ERC for nuclear emergencies at its headquarters in Tokyo. Since then, both of TEPCO's ERCs (for general disasters and for nuclear emergencies) operated as a joint ERC (hereafter referred as TEPCO HQ-ERC) [17]. In the early stages of the accident, the person meant to assume the role of Head of the TEPCO HQ-ERC was unavailable[26]. Staff from the TEPCO Headquarters office were dispatched

[26] It was planned that in a nuclear emergency the President of TEPCO would be the head of the TEPCO HQ-ERC. However, when the accident at the Fukushima Daiichi NPP occurred, he was away on a business trip. The President returned to Tokyo around 09:00 on 12 March. When the earthquake occurred, the TEPCO Chairman was on a business trip to China, but returned to Tokyo at around 16:00 on 12 March [17]. Until the arrival of the TEPCO President, the company's Managing Executive Officer acted as the head of the TEPCO HQ-ERC, although this authority should have been delegated to the TEPCO Vice-President in the absence of the President. This decision was based on the specific conditions of the event [17].

almost immediately after the earthquake to the ERC at METI/NISA to function as a liaison with the TEPCO HQ-ERC [17].

The TEPCO HQ-ERC dealt simultaneously with the Fukushima Daiichi accident, the situation at the Fukushima Daini NPP and the impact of the earthquake on the large distribution and generation grid network operated by the company. This challenged the ability of the TEPCO HQ-ERC and the ERC at the Fukushima Daiichi NPP to understand the progression of the nuclear accident and define response strategies at the very beginning of the accident. Nevertheless, after these initial challenges, the TEPCO HQ-ERC assumed a key role by providing both human and material resources (e.g. portable equipment) for the on-site response [17].

The NSC, after receiving a message from NISA about the Article 10 notification, held an extraordinary meeting and formed an Emergency Technical Advisory Body [27].

At 16:36, the Deputy Chief Cabinet Secretary for Crisis Management established an Emergency Response Office for the nuclear accident in the Prime Minister's Office and expanded the Emergency Operations Team to handle both the natural disaster and the emergency at the Fukushima Daiichi NPP [21, 22].

At 16:45, the Fukushima Daiichi NPP Site Superintendent sent a report of an event classified as a nuclear emergency under Article 15 of the Nuclear Emergency Act [5] to the national Government (METI (NISA)) and to local governments (see Fax 2, Annex I).

At around 17:00, the Prime Minister asked the NISA Director General for an explanation of the Article 10 notification, but the latter could not provide any details; neither could the TEPCO staff members who were sent to the Prime Minister's Office. However, they gave some general information on the consequences that would ensue if the AC power at the Fukushima Daiichi NPP was not re-established [21].

After receiving the report from the Fukushima Daiichi NPP of an event classified as a nuclear emergency, NISA conducted technical verifications and judged the situation to be indeed a nuclear emergency under Article 15. At around 17:42, after giving his consent to the results of this assessment, the Minister of METI went to the Prime Minister to obtain his approval for a declaration of a nuclear emergency [25]. Their discussions were interrupted for about five minutes [21] when the Prime Minister met with the heads of the ruling and opposition parties. The Prime Minister gave his approval for the declaration of a Nuclear Emergency at about 18:30 [21].

The Prime Minister issued a declaration of a nuclear emergency at 19:03 on 11 March 2011 and established the NERHQ and Local NERHQ [22]. This was more than two hours after having been notified by the Fukushima Daiichi NPP of an event at Units 1 and 2 classified as a nuclear emergency under Article 15 of the Nuclear Emergency Act [5, 22].

The first meeting of the NERHQ took place at 19:03 on 11 March. Eight meetings were held by the NERHQ between 11 and 15 March 2011.

At 19:45, a press conference was held announcing the declaration of a nuclear emergency and the establishment of the NERHQ. No orders or recommendations for protective actions were issued at that time [25].

At about 20:30, the Prime Minister went to the Crisis Management Centre to take charge of the Government's response to the natural disaster and nuclear emergency [21]. Soon afterwards, he moved to his working office at the fifth floor of the Prime Minister's Office.

Deliberations concerning the off-site protective actions were conducted at the fifth floor of the Prime Minister's Office, including evacuation [27] and mitigatory actions[27] to be taken at the Fukushima Daiichi NPP. The discussions were based on information collected by the Emergency Response Office and the opinions of the Minister of METI, other relevant ministers, the Chief Cabinet Secretary, TEPCO staff members who were present or on the telephone, NISA officials, the Chairman of the NSC and other parties concerned (advisors, secretaries, Prime Minister's Office officials and personnel). This information was not always exchanged with the NERHQ [25]. As a result, multiple unplanned and uncoordinated communications routes were used, which had an impact on the coordination between individual organizations.

In accordance with the arrangements prior to the accident, the NERHQ was supposed to direct and provide comprehensive coordination of the national response to a nuclear emergency. The NERHQ Secretariat collected information through faxes sent from TEPCO and enquiries made to the TEPCO HQ-ERC. However, this was found to be an ineffective and slow method of obtaining information.

As the accident evolved so quickly, there was no time for detailed discussions during meetings of the NERHQ. The core group for the emergency response became the Prime Minister and senior officials, located at the Prime Minister's Office. The Prime Minister issued evacuation orders to local governments without the involvement of the secretariat of the NERHQ [25].The Government–TEPCO Integrated Response Office, an integrated headquarters of the operating organization and the government response organization, was established on 15 March 2011 at TEPCO Headquarters in Tokyo [27] to ensure the timely sharing of information at the national level. This was a new entity, the creation of which was not anticipated in the emergency plans.

METI (NISA) dispatched staff to the Local NERHQ at the OFC at about 16:00 on 11 March. However, the OFC staff reported to NISA at about the same time that they had lost all power, phones, fax and other systems, which led to difficulties in initiating operations in the OFC [25, 45].

The METI Senior Vice Minister (who was to serve as the Director General of the Local NERHQ) departed from Tokyo to the OFC (a distance of about 250 km), along with seven others (e.g. NSC and MEXT representatives) at around 16:00 on 11 March, but did not arrive until about midnight due to the damaged transport infrastructure. They found that the OFC had no AC power [45]. It began partial operation at 03:20 on 12 March 2011, once power had been re-established [45].

The Vice Governor of Fukushima Prefecture arrived at the OFC at around 23:00 on 11 March. Only one of the six nearby towns sent representatives to the OFC, because they were involved in the implementation of evacuation orders [27]. Numerous national level organizations were expected to send representatives to the OFC, but only NISA, MEXT, the NSC, and the Ministry of Defense (SDF) did so immediately [27]. The Ministry of Health, Labour and Welfare (MHLW) did not send a staff member to serve as the chief of the medical squad of the Local NERHQ until 21 March.

The first meeting of the JCNER was held on 12 March at 10:30 [45], at which point the implementation of protective actions, including evacuation, shelter and ITB, was discussed.

The Local NERHQ and other entities, which were supposed to operate from the Off-site Centre (JCNER and Local Prefectural NERHQ), could not fulfil their roles fully, especially during the first days of the emergency. This was due to the damage caused by the earthquake and tsunami, which included: damage to communication systems, the inability to obtain and analyse plant and environmental data, and the limited participation of relevant organizations. In addition, although the

[27] Mitigatory actions that were discussed at the time included whether or not to inject sea water into the reactors.

Local NERHQ was expected to regularly report on its consolidated information at press conferences at the OFC, these did not take place because, from the morning of 12 March[28], the OFC was located in the evacuation area to which access was restricted.

As the OFC was located within 5 km of the Fukushima Daiichi NPP, this resulted in a number of additional difficulties [27]. For example, after 13 March, shortages of food, water and fuel occurred, because normal deliveries within the evacuation zone were suspended.

On 15 March 2011, it became necessary to evacuate the Off-site Centre, due to the worsening radiological conditions[29] (>1 mSv/h), and to relocate it to the Fukushima Prefectural Public Hall, located approximately 60 km from the Fukushima Daiichi NPP (see Fig. 3.1–6) [27, 45]. This was where the Prefecture Headquarters for Disaster Control conducted its operations after moving from their originally planned location, the Fukushima Prefectural Government Office, which had been damaged by the earthquake [25][30]. This facility did not have capabilities equivalent to those of the Off-site Centre, which led to difficulties, for example, in sharing information in real time among the relevant authorities.

The OFC was planned to be the location where monitoring was to be coordinated, as it had direct connections with local monitoring stations. Relocation to the Fukushima Prefectural Public Hall complicated the fulfilment of this task [22, 27].

The OFC was also planned to be the location where announcements to the media would be made at the local level. However, once operations began, its location within the evacuation zone rendered it inaccessible to journalists. Following the relocation of operations from the OFC, press conferences were held from 15 March onwards at the Fukushima Prefectural Public Hall [21] by spokespersons of the Local NERHQ. A further difficulty was that enquiries from residents could not be addressed at the OFC, as had been planned [1], owing to power cuts that caused failures in communication lines [45].

After the start of the nuclear emergency, a large number of staff was already working on the various functional squads of the Fukushima Prefecture Headquarters for Disaster Control, responding to the earthquake and tsunami. Hence, the personnel available to respond to the nuclear emergency was significantly limited, making it impossible to implement the structure laid out in the nuclear response section of the Fukushima Prefecture Disaster Management Plan [1, 25].

To address this need, a new 'nuclear squad'[31] was formed in the Fukushima Prefecture Headquarters for Disaster Control, as part of the organizational structure set-up to respond to the earthquake and tsunami, in order to coordinate emergency response activities at the prefectural level (see Fig. 3.1–7) [25].

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[28] At 05:44 on 12 March evacuation was ordered for the 3–10 km zone around the Fukushima Daiichi NPP.

[29] The Off-site Centre had not been designed to withstand the increasing radiation levels.

[30] Fukushima Prefecture established its Prefecture Headquarters for Disaster Control at 14:46 on 11 March. Around 15:00, it was decided to move the location from the Fukushima Prefectural Government Office, which was unusable due to damage, to the Fukushima Prefectural Public Hall, which was located only a few minutes walk from the Fukushima Prefectural Government Office. The movement was completed by around 15:30 [46].

[31] A new nuclear squad was formed because the existing nine functional squads, as specified in the Fukushima Prefecture Disaster Management Plan [1] were engaged in response to the earthquake and tsunami [25].

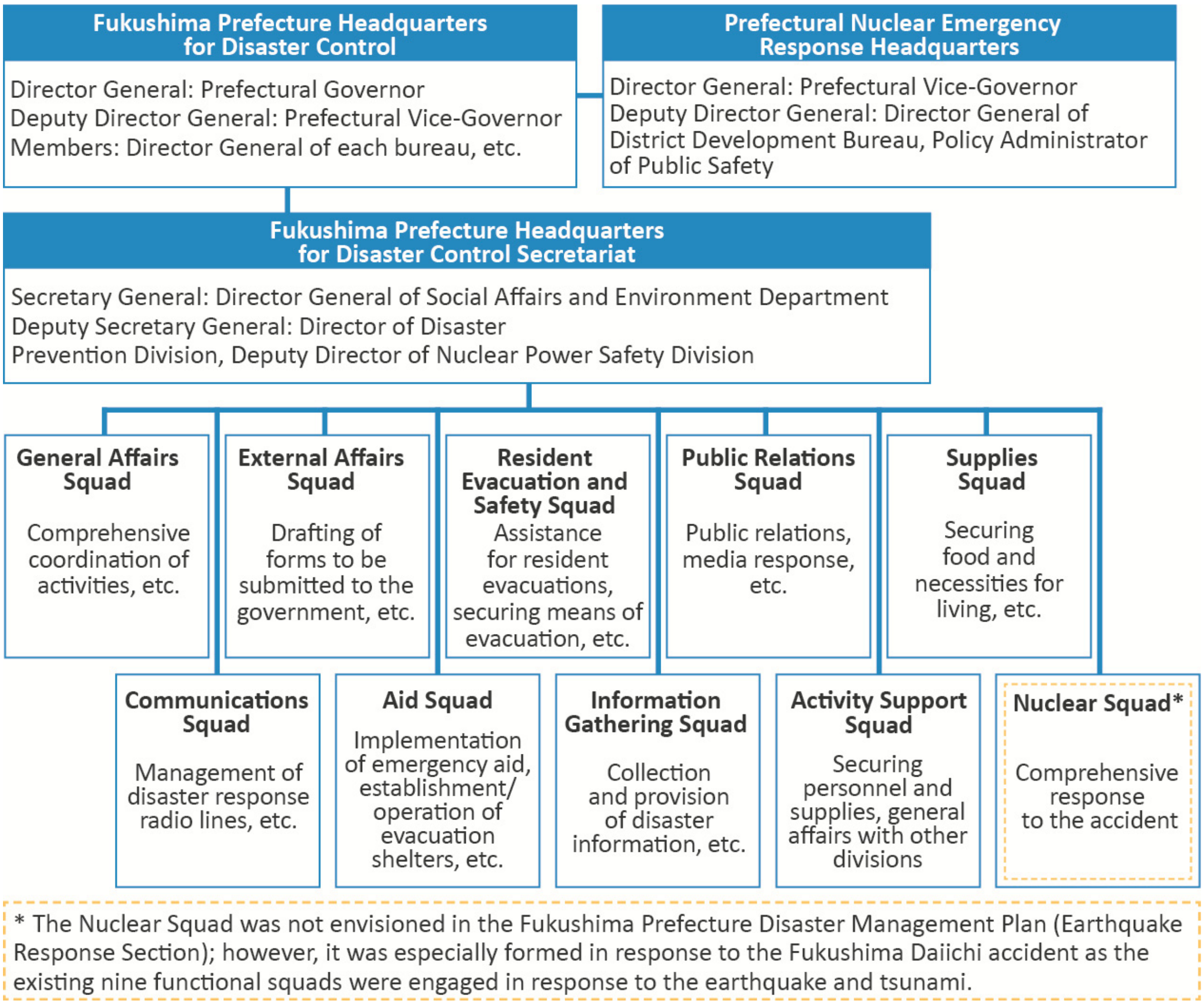

FIG. 3.1–7. Organizational structure of the Fukushima Prefecture Headquarters for Disaster Control [25].

However, the squad's staffing was limited, and there was no clearly defined scope of operations to address the issues of a nuclear emergency. Officials in the nuclear squad were under the impression that the response to the nuclear emergency was to be carried out mainly at the OFC [25].

In addition to the problems described above, there were also logistical difficulties. As a result of the move to the Fukushima Prefectural Public Hall, the Prefecture Headquarters for Disaster Control had only two municipal disaster management radio communication lines in operation, whereas the main conference room of its original location, in the Fukushima Prefectural Government Office, was equipped with 47 lines [25].

3.1.5. Summary

At the time of the accident, separate arrangements were in place to respond to nuclear emergencies and natural disasters at the national and local levels. There were no coordinated arrangements for responding to a nuclear emergency and a natural disaster occurring simultaneously. Consequently, this was also not addressed in relevant training and exercise programmes.

The arrangements to respond to nuclear emergencies envisaged that, following the detection of relevant adverse conditions at an NPP (e.g. loss of all AC power supplies for more than five minutes or loss of all capabilities to cool the reactor), a notification would be sent from the plant to local and national governments. The national Government would then assess and determine whether the situation was to be categorized as a nuclear emergency. If the situation was categorized as a nuclear emergency, a declaration to that effect would be issued at the national level, and decisions about necessary protective actions would be taken on the basis of dose projections. Arrangements did not foresee the recommendation of public protective actions based on plant conditions without additional assessment and judgement by the off-site authorities.

After the onset of the accident, NPP personnel promptly activated the on-site ERC and notified off-site officials of conditions under Article 10 of the Nuclear Emergency Act [5] and subsequently of the conditions under Article 15 of the Act. The seismically isolated building provided an adequate environment for the work of the on-site ERO early in the response.

Based on a report from the Fukushima Daiichi NPP, the national Government declared a nuclear emergency in the evening of 11 March, more than two hours after having been notified by the Fukushima Daiichi NPP of an event at Units 1 and 2 classified as a nuclear emergency under Article 15 of the Nuclear Emergency Act [5, 22].

The on-site response was marked by the extreme difficulties resulting from the effects of the earthquake and tsunami, such as the lack of electric power supply (causing failure of multiple pieces of equipment and impeding access to, and habitability of, plant buildings) and the presence of rubble that obstructed on-site activities. In addition, the evolution of the accident (several large hydrogen explosions, harsh radiological conditions, etc.) challenged the capabilities of the on-site responders.

This meant that many mitigatory actions could not be carried out in a timely manner. In addition, the national Government was directly involved in decisions concerning mitigatory action on the site.

At the request of the operator, TEPCO, off-site resources (staff and equipment) were mobilized to support the on-site ERO. Extensive damage of the transport infrastructure due to the earthquake and tsunami, in addition to insufficient pre-planning, impaired the effectiveness of off-site support. For example, some equipment that was delivered was not compatible with equipment that was already in operation.

The response at the national level was led by the Prime Minister and senior officials at the Prime Minister's Office in Tokyo. At TEPCO Headquarters in Tokyo, a joint response organization between the operator and the Government was also established.

The activation of the emergency Off-site Centre, located 5 km from the Fukushima Daiichi NPP, was difficult because of extensive infrastructure damage caused by the earthquake and tsunami. Within a few days, it became necessary to evacuate the Off-site Centre due to adverse radiological conditions. Thus, the Local NERHQ that was planned to run operations from the OFC could not fulfil its role fully, especially during the first days of the emergency.

3.1.6. Observations and lessons

— **In preparing for the response to a possible nuclear emergency, it is necessary to consider emergencies that could involve severe damage to nuclear fuel in the reactor core or to spent fuel on the site, including those involving several units at a multi-unit plant possibly occurring at the same time as a natural disaster.**
Consideration needs to be given to the possibility of a severe nuclear accident, irrespective of the cause, possibly involving more than one unit at a site and occurring simultaneously with a natural disaster, which could result in disruption at the site and of the local infrastructure. Systems, communications and monitoring equipment for providing essential information for both on-site and off-site responses need to be able to function under such circumstances.

Facilities where the response will be managed (e.g. on-site and off-site emergency response centres) need to be selected or designed to be operational under a full range of emergency conditions (radiological, working and environmental conditions), and need to be suitably located and/or protected so as to ensure their operability and habitability under such conditions.

— **The emergency management system for response to a nuclear emergency needs to include clearly defined roles and responsibilities for the operating organization and for local and national authorities. The system, including the interactions between the operating organization and the authorities, needs to be regularly tested in exercises.**
  Arrangements are needed that integrate the response to a nuclear emergency with the response to natural disasters and human-made disasters (e.g. earthquakes, floods and fires).
  The on-site response needs to be managed by personnel located at the site who have knowledge of the plant and of the situation. The on-site and off-site responses need to be coordinated based on pre-planned arrangements.

— **There is a need for arrangements to conduct mitigatory actions for the full range of postulated emergencies, including emergencies not considered in the design basis (e.g. severe fuel damage) and those involving several units at a multi-unit plant.**
  In developing these arrangements, there is a need to consider the response of the personnel, instrumentation and systems of the facility under different emergency conditions. This includes the development, maintenance and testing of plans and procedures for responding to severe reactor accidents, including immediate response actions and those for staffing emergency response positions, particularly in the case of long lasting emergencies involving multiple units. The mitigatory actions need to be agreed on at the preparedness stage and then implemented on-site in an emergency response without consultation with, and/or request for approval by, off-site officials.

— **Arrangements are needed to enable the on-site emergency response organization (ERO) to provide and receive assistance (including heavy equipment) for performing mitigatory actions in an emergency, particularly in the case of long lasting emergencies and emergencies involving several units at a multi-unit plant.**
  These arrangements need to ensure that the assistance received (e.g. equipment) is compatible with existing on-site capabilities under different emergency conditions.

3.2. PROTECTING EMERGENCY WORKERS

This section describes the protection of personnel involved in the emergency response at the site, referred to as on-site emergency workers, and the protection of emergency workers and 'helpers' from the public involved in the emergency response off the site, referred to as off-site emergency workers and helpers, respectively.[32] The term helpers refers to members of the public who willingly and voluntarily were involved in the off-site emergency response and, therefore, did not have the status of worker for an employer at the time of this involvement. On-site emergency workers include NPP personnel, either directly employed by TEPCO or subcontracted, as well as personnel from the SDF, firefighting services and police engaged in emergency work on-site. Off-site emergency workers include personnel from different organizations and services (governmental and non-governmental) involved in the emergency response off-site due to their engagement in evacuating the public and special facilities, providing support to evacuees, providing medical care and carrying out monitoring and sampling, etc.

The timeline of events that are important for the protection of emergency workers during the response to the Fukushima Daiichi accident are shown in Fig. 3.2–1.

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[32] The focus of this section is on the initial phase of the emergency, when the major challenges of ensuring adequate protection for emergency workers were faced.

11 March

- Four on-site workers injured as a result of the tsunami and two workers died
- Plant personnel not considered essential for the emergency response evacuated from the NPP site
- 320 electronic personal dosimeters (EPDs) located in the seismically isolated building and several other controlled areas of the plant were functioning
- Radiation monitoring activities started, including radiation surveys around the site
- Relief teams from the Japanese Red Cross Society engaged in the response off-site
- Evening | High dose rates detected in the reactor building of Unit 1; protection measures were implemented

12 March

- Monitoring performed off-site until 14 March within the 20 km zone that had been ordered to evacuate
- 04:20 | High radiation levels near the turbine building of Unit 1
  Contract workers temporarily returned to seismically isolated building without injecting water from the fire engine into the reactor core of Unit 1
- 05:00 | Contracting company authorized staff to assist with water injection
- 15:36 | Five on-site emergency workers sustained conventional injuries as a result of the explosion in Unit 1

13 March

- ITB implemented as a protective measure for emergency workers on-site

14 March

- Evacuation of non-essential plant personnel on-site completed
- Relief teams dispatched from Japanese Red Cross Society departed from Fukushima Prefecture. Fukushima Red Cross Hospital remained to provide relief activities off-site
- 11:01 | Four SDF personnel and seven TEPCO workers sustained conventional injuries on-site after explosion in Unit 3

15 March

- Dose criterion for emergency workers increased from 100–250 mSv (retroactive effect to 14 March)
- New radiation protection contingency provisions adopted on-site (e.g. group-assigned EPDs)
- J-Village starts to be used as a general logistical support base
- Off-site rescue team suspended mission (dose criterion of 5 mSv reached) before completing rescue of patients at a hospital located within 5 km of Fukushima Daiichi NPP

17 March

- Revised dose criterion of 250 mSv also implemented for national Government employees engaged in emergency work on and off-site, excluding those from firefighting services

19 March

- First occupational physicians present at seismically isolated building for medical management of on-site emergency workers

23 March

- Remaining female on-site emergency workers evacuated

24 March

- Two on-site workers exposed to high levels of contaminated water at their feet

FIG. 3.2–1. Timeline of key events important for the protection of emergency workers.

26 March

- Measures implemented for on-site areas to improve the situation at the seismically isolated building due to buildup of radioactive contamination (between 26 March and 8 April)

30 March

- One doctor and two nurses from TEPCO hospital in Tokyo stationed at J-Village to provide first aid treatment for workers

31 March

- Every emergency worker on-site provided with an EPD

Early April

- Medical clinic at J-Village renovated and designated as a primary radiation emergency medicine facility
- Medical headquarters established at Local NERHQ in Fukushima City. First comprehensive medical response plan for medical management of on-site emergency workers developed

15 April

- Initial triage and first aid started to be provided during the day by occupational health physicians at the Fukushima Daiichi NPP

Late April

- Increased number of hospitals in Fukushima and nearby prefectures agreed to accept injured on-site emergency workers

May

- On-site worker died due to a heart attack. Arrangements made for doctors to be available at seismically isolated building on a 24 hour a day, 7 days a week basis

1 July

- Twenty-four hour medical emergency care facility established at Fukushima Daiichi NPP

2 August

- ITB was implemented only for emergency workers on-site carrying out emergency work in designated buildings

26 August

- Ministry of Health, Labour and Welfare (MHLW) issued a notification and guidelines for ensuring radiation protection of emergency workers involved in decontamination work off-site

1 November

- 100 mSv effective dose criterion re-established for new emergency workers engaged in emergency work

21 November

- Administration of ITB stopped for emergency workers on-site

16 December

- 100 mSv effective dose criterion re-established for the majority of emergency workers (on-site and off-site) engaged in emergency work, except approximately 50 TEPCO employees working on-site

30 April 2012

- 100 mSv effective dose criterion re-established for the remaining 50 TEPCO employees

FIG. 3.2–1. Timeline of key events important for the protection of emergency workers (cont.).

3.2.1. Relevant arrangements in Japan prior to the accident

The national legislation and guidance in Japan prior to the accident addressed measures to be taken for the protection of emergency workers[33]. However, the arrangements that were in place addressed these measures only in a general way and not in sufficient detail.

The NSC's Nuclear Emergency Preparedness Guide specified the following protective measures to be applied for emergency workers involved in the emergency response and recovery activities: distribution of direct reading personal dosimeters (e.g. pocket dosimeters, alarm dosimeters), distribution of protective masks for reducing inhalation of contaminated air (depending on the emergency tasks) and administration of stable iodine (i.e. ITB). In addition, this guide addressed the importance and need for a continuous programme of education and training of emergency workers to provide for smooth and effective implementation of various emergency response activities [19].

The Basic Disaster Management Plan [2] required that the operator and the different prefectural and local authorities involved in the emergency response would provide the relevant staff. The plan also assigned the national Government the role of providing specialized personnel from various governmental bodies (e.g. the SDF, National Police Agency, Fire and Disaster Management Agency, Japanese Coast Guard).

The Fukushima Daiichi NPP Nuclear Operator Emergency Action Plan [16] defined protective measures for emergency workers in a generic way, covering the following areas: defining responsibilities; assigning generic duties in emergency preparedness and response; and listing an inventory of available instrumentation (e.g. survey meters and electronic dosimeters) as prescribed in the Ordinance on Prevention of Ionizing Radiation Hazards [47] and elaborated in the Regulatory Guide on Emergency Preparedness for Nuclear Facilities (hereafter referred to as the Nuclear Emergency Preparedness Guide) [19].

The dose limits for all emergency workers were set in the national legal framework and were derived from the report of the Radiation Council, issued in 1998 [48], which considered the IAEA safety standards [49]. These dose limits were incorporated into relevant legal instruments, such as the Ordinance on Prevention of Ionizing Radiation Hazards [47], the Nuclear Emergency Act [5], the National Personnel Authority Rules [50] and the Nuclear Emergency Preparedness Guide [19], addressing emergency workers from different organizations and services. Dose limits for emergency workers were specified according to the intended tasks. The upper dose limit was set at 100 mSv for life saving actions and activities to prevent the development of catastrophic conditions. Efforts to minimize the exposure to emergency workers continued to be required under these circumstances [19, 47] (see Table 3.2–1).

[33] The IAEA uses the term 'emergency workers' to cover those with specified duties as a worker (any person who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relation to occupational radiation protection) in response to an emergency, including workers employed, both directly and indirectly, by registrants and licensees as well as personnel of responding organizations, such as police officers, firefighters, medical personnel, and drivers and crews of evacuation vehicles [14, 26]. In Japan the term 'emergency preparedness personnel' is used to cover all those who perform emergency response activities in a nuclear emergency, such as "… communication of public information and instructions to residents in the vicinity, guidance of residents in the vicinity for evacuation, traffic control, radiation monitoring, medical treatment provision, and actions to prevent a situation from developing into a disaster in a nuclear facility, and those who perform disaster recovery activities such as removal of radioactive contaminants" [19].

TABLE 3.2–1. DOSE CRITERIA FOR EMERGENCY WORKERS [19]

Effective dose	Equivalent dose to the eye	Equivalent dose to the skin	Tasks
100 mSv	300 mSv	1 Sv	Performing inevitable emergency activities, such as saving lives and preventing the development of catastrophic conditions
50 mSv	—	—	Performing disaster emergency response activities and disaster recovery activities

These dose limits were the maximum doses that were permissible to be received, but only by male emergency workers and female emergency workers who could not become pregnant [47]. Female workers who could become pregnant were not to be engaged in emergency work which might lead to doses exceeding these dose criteria. However, in cases where they were designated as radiation workers (and not as emergency workers), they may have been given some tasks in response to an emergency and the dose limits for occupation exposure of 5 mSv quarterly were to be applied.

Although the above mentioned report of the Radiation Council considered the IAEA safety standards, the dose criteria to be applied for emergency workers included in the report and subsequently transposed in the legal framework in Japan were lower than those provided in the IAEA safety standards (i.e. para. I-1 of IAEA Safety Standards Series No. GS-R-2, and para. V.27 of the Basic Safety Standards) [11, 49].

3.2.2. Protection of personnel at the NPP following the earthquake and tsunami

Following the tsunami alert, efforts were made to protect plant personnel (about 6000 people) from the expected impact of the tsunami. Tsunami alerts were broadcast using the on-site public address system, advising personnel to evacuate and to relocate to designated locations at higher levels. While in most cases, these efforts were successful, not all personnel received the tsunami alert and evacuation orders [17, 25]. Two workers who were checking equipment after the earthquake on the underground floor of the Unit 4 turbine building were drowned in the flooding caused by the tsunami [17].

The protection of plant personnel from the effects of the tsunami was successful largely due to lessons learned from the experience at the Kashiwazaki-Kariwa NPP following the Niigata-Chuetsu-Oki earthquake in 2007, and efforts made afterwards in developing procedures for exiting in an emergency [17].

From 11 to 14 March 2011, plant personnel not considered essential for emergency activities — including female workers and most of the employees of subcontractors — were evacuated from the site. In the morning of 15 March, an evacuation of additional plant personnel took place because of worsening conditions at the site. An estimated 50–70 staff remained on the site, while approximately 650 people were temporarily evacuated to the Fukushima Daini NPP using buses or private vehicles. They began to return to the Fukushima Daiichi NPP from noon on the same day [17].

3.2.3. Protective measures for emergency workers

During the accident, a range of impromptu measures were adopted to maintain an acceptable level of protection for on-site emergency workers under the extreme conditions.

3.2.3.1. Management of doses

In the initial phase of the accident, the system for providing radiation protection at the Fukushima Daiichi NPP was severely affected. Almost all of the 5000 electronic personal dosimeters (EPDs) and associated readers and chargers became inoperable, because the controlled area access points where EPDs were kept, were flooded. Only about 320 EPDs remained operable, some of them located in the seismically isolated building, others located in different controlled areas of the plant [17].

As of the evening of 11 March, dose rates exceeding 1 mSv/h were detected in the reactor building of Unit 1 [17]. As a consequence, the following protection measures were put in place by the ERO [17, 51]:

- Strict control of access to buildings where high radiation levels were detected or suspected;
- Use of protective clothing and respiratory protection for emergency workers working outdoors or performing continuous work in the vicinity of the reactors, for example in the plant control rooms. Emergency workers needed to wear protective equipment before they left the seismically isolated building to carry out their assigned tasks. Where possible, the protective equipment consisted of a full mask fitted with a mixed charcoal and particulate filter or a particulate filter. When no filters were available, dust masks were provided instead.

New radiation protection contingency provisions were adopted from 15 March 2011, in view of the progression of the accident and the worsening radiological conditions on-site resulting from the radioactive releases [17, 30]. Since there were insufficient EPDs available for all the emergency workers on-site, an instruction was issued to share a single EPD for groups of emergency workers devoted to work that could be expected to have homogeneous radiological conditions (group assigned EPD). The doses received by emergency workers in the seismically isolated building were controlled by area dose rate monitoring and time spent in the area. This situation continued until the end of March 2011, by which time a sufficient number of dosimeters had been received from other NPPs [17, 27] to equip every emergency worker on-site with an EPD [17, 30, 53, 54].

Owing to the extreme circumstances associated with the accident, the radiological conditions in the seismically isolated building began to degrade. The release of fission products led to a buildup of radioactive contamination at the entrance and check points within the building and an increase in radiation dose rates at windows that had the lowest shielding properties. Several measures were taken between 26 March and 8 April 2011 to improve the situation, including: use of portable fans and filters to supply filtered air from outside and extraction of air from the affected building; installation of floor pads made with materials that were easy to decontaminate; modifications to the building entrance points to separate personnel checking activities from the outside and the inhabited spaces; and installation of lead shielding on windows [17, 30].

There was also a buildup of radioactive contamination in the three main reactor control rooms (MCRs). Although these areas had been fitted with dedicated habitability systems, they had become inoperable due to the loss of electrical power. Portable fans were used to increase the exhaust of the contaminated atmosphere in the MCR enclosures a few weeks after the onset of the accident [17].

Radiation monitoring, including radiation surveys around the site, notably at the boundaries of the site and in the area around Units 1–4, were performed from the first days of the accident. These activities were important for providing a broad overview of the accident’s evolution and the radiological conditions at the site. They also contributed to improving the protection of emergency workers. Maps of the radiological conditions at different areas of the plant were drawn up, paying particular attention to areas where emergency activities were taking place and to the access routes between different working points where significant doses could be received [17, 53, 55]. During the weeks when there was a shortage of EPDs, the tracking of individual doses to emergency workers was difficult. Some workers left the site without returning their EPD or without providing information required to track the work group to which the emergency worker had been assigned. Consequently, entrance check points were established at the seismically isolated building, at J-Village (where entrance and exit check points were installed) and at the Onohama Coal Centre, which served as the base for exit check points. Those emergency workers gaining access to the controlled area were recorded and EPDs were assigned at the entry points, and were then retrieved at the exit points. Personal records of the emergency workers entering and leaving the area were maintained. Whole body counters (WBCs) were also installed in J-Village and at the Okahama Coal Centre (mobile WBCs). These WBCs were used for internal contamination checks, which were performed mainly for workers suspected of being internally contaminated and for female workers [17, 53, 55].

Recognizing the problems encountered in tracking individual doses, a campaign to recover individual dose data for all the emergency workers was undertaken. This included thorough cross-checking of records, personal surveys to gather information on all relevant aspects of the emergency workers' activities to retrieve sufficient data to estimate doses (including the dose rates to which they were exposed and the duration of exposure). After this campaign, there were ten cases for which the doses were unknown or for which insufficient data existed for assessing the doses [17, 51, 53, 55]. This required an additional investigation, primarily to determine the identity of the workers and, thereafter, to reconstruct their doses. While the investigation was successful in the recovery of contact information for three of these ten workers, seven remained unidentified, with no entry in any of TEPCO's contractors' records. However, the three workers for whom the contact information was found could, for various reasons, not be contacted (for example, they had left their job or had moved) [17].

Emergency workers from off-site services, primarily from the firefighting services and the SDF, were engaged in activities associated with the cooling of spent fuel pools at the Fukushima Daiichi NPP. Their employers were made responsible for ensuring their protection while working on the site. These emergency workers wore protective clothing and respiratory protection. In an effort to manage their doses received during these activities, they were also provided with personal dosimeters and survey meters [56]. However, some issues emerged with TEPCO's subcontractors, particularly the firefighting services, when they were called upon to respond on the site. The lack of proper knowledge of the contract conditions and questions as to whether they covered the response to an emergency of this type, initially resulted in a refusal to respond by the firefighting service subcontracted by TEPCO. As none of the TEPCO employees were capable of using the fire engines, the ERO, in cooperation with the Local NERHQ, arranged for a local firefighting team, which was to be supported by a limited number of personnel from the subcontracted firefighting service. Eventually, the subcontracted firefighting service agreed to take on the assignment [27, 57]. For the off-site emergency workers, particularly those intervening in the emergency for the first time, TEPCO provided brief training in the form of 30 minute explanation sessions[34] before they entered the NPP. This training did not include all emergency workers, and it was not considered by national authorities as being sufficient. Training was conducted in J-Village and covered topics such as the use of protective clothing and masks, dose management aspects and effects from radiation exposure [25, 51, 53, 54]. Insufficient training in the use of respiratory protection was considered to be one of the contributing factors of the internal contamination among emergency workers on the site even as late as June 2011 [53, 54, 57, 58].

The accident also presented TEPCO with challenges in ensuring the well-being of on-site emergency workers, for example in providing adequate facilities and conditions for resting, sleeping, eating,

[34] The brief explanatory training sessions were conducted until about May 2011.

sanitation, etc. In the absence of arrangements in this regard prior to the accident, it took several months for TEPCO to address these challenges [57, 59-63].

Before any emergency work was performed within the 30 km zone around the Fukushima Daiichi NPP, the SDF made a preliminary dose assessment based on the duration estimated for the intended emergency work and the latest monitoring results from the working area or from its neighbourhood. The emergency tasks were always carried out wearing simple protective clothing. Individual dosimeters were used by SDF members to monitor their exposure and to confirm their cumulative dose during the work. Initially, the SDF set and successfully implemented the upper limit of the cumulative exposure dose for an individual member from its teams to be 50 mSv for male and 5 mSv for female emergency workers. In order to ensure compliance with these criteria during the actual implementation of emergency work, lower levels (30 mSv for male or 3 mSv for female emergency workers) were used as turn-back doses. Thereafter, SDF emergency workers were subject to the increased dose criterion of 250 mSv effective dose for specific tasks (see Section 3.2.3.2); however, no SDF member received exposure exceeding this criterion [22].

While performing emergency tasks within 20 km of the Fukushima Daiichi NPP, the firefighting teams also used simple protective clothing and were measuring the dose rate and cumulative dose during their tasks for compliance with the criteria applicable for emergency workers. The upper dose criterion for emergency work was decided by the individual firefighters' headquarters, with account taken of the values set in the manual for firefighting activities at nuclear power facilities prepared by the Fire and Disaster Management Agency in March 2001. After each operation, firefighters had their doses measured and recorded; these measurements showed that none of the firefighters exceeded the set criterion of 100 mSv effective dose during the performance of their tasks [22].

Emergency workers also included police who were engaged off-site within the 20 km area. They were provided with protective clothing and respiratory protection. Their doses were managed by individual dosimeters and survey meters. Although stable iodine tablets were distributed to a total of 552 police officers, none of them took the tablets [64].

In order to provide for adequate rescue and transport of patients in hospitals and nursing homes within the 20 km zone around the Fukushima Daiichi NPP, medical staff teams were engaged as emergency workers and were provided with individual dosimeters to monitor their doses throughout the intervention. For female nurses, the dose criterion of 5 mSv was applied. In some cases, such as the one at Futaba Hospital on 15 March, the dosimeters of five female nurses sounded an alarm, as the dose criterion of 5 mSv was approached, resulting in the team suspending its mission before completing the rescue of all the patients at the hospital. The rescue and transportation operation had to be finished later by other teams [27].

Although an evacuation order was issued within the 20 km zone on 12 March, monitoring continued to be performed within this area until 14 March [27].

Early on in the response, by 13 March, relief teams of the Japanese Red Cross Society (JRCS) contributed to the emergency response following the earthquake and tsunami, as well as the subsequent nuclear emergency, by providing medical care and support to members of the public. However, due to the lack of preparedness for responding to a nuclear emergency, a lack of relevant knowledge about radiation emergency medical response and the lack of protective and monitoring equipment, all the relief teams dispatched from JRCS chapters left Fukushima on 14 March. The Fukushima Red Cross Hospital remained to provide relief activities [65].

3.2.3.2. Dose limits

Despite the various measures to improve the radiological conditions in which emergency workers were performing their tasks, it became clear that, within a few days, the cumulative doses of many emergency workers who had been working on-site since the onset of the accident were approaching the prescribed dose criterion for inevitable emergency work (100 mSv effective dose) in the Ordinance on Prevention of Ionizing Radiation Hazards [47].

On 14 March 2011, the dose limit for emergency workers undertaking specific emergency work was temporarily increased to 250 mSv[35] to allow the necessary activities to continue on-site and within a 30 km radius of the Fukushima Daiichi NPP [67, 68]. This change was implemented by means of an exemption to the Ordinance on Prevention of Ionizing Radiation Hazards, published on 15 March 2011, with retroactive effect from 14 March 2011 [67, 68].

The dose criterion of 250 mSv was not to be applied to female emergency workers who could become pregnant, because the exemption [67] was specifically issued in relation to Article 7, paragraph 2, of the Ordinance [47], which applied only to male emergency workers and to female emergency workers who could not become pregnant. For those females who could become pregnant and who were designated as radiation workers prior to the accident, the dose limit of an effective dose of 5 mSv per quarter was applied (see also Section 3.2.1). The dose limits for a member of the public (1 mSv effective dose in a year) were applied to female personnel who were not designated or registered as either radiation workers or emergency workers prior to the accident but remained at the site after its onset performing auxiliary tasks in the seismically isolated building. Due to the worsening situation at the site, all female emergency workers were evacuated from the site between 14 and 23 March [17, 30]. Eventually, all female workers who stayed in the building were designated as radiation workers and a relevant dose limit of an effective dose of 5 mSv per quarter was applied to them. Two female workers exceeded this dose limit [53].

The temporary increase in the dose limit to 250 mSv was withdrawn on 1 November 2011 for on-site emergency workers who began working from this date onwards. On 16 December 2011 this dose limit was withdrawn for the majority of the remaining emergency workers, and on 30 April 2012 it was withdrawn for a group of approximately 50 TEPCO employees with accumulated doses exceeding 100 mSv who had specialized knowledge and experience in operating the reactor cooling systems and in maintaining the facilities and equipment for suppressing the emission of radioactive materials [57, 68, 69].

Three days after the decision to increase the dose criterion for emergency workers (on 17 March), discussions were held within the Government regarding further increasing this dose criterion to 500 mSv. Some preparatory arrangements were undertaken, but no final decision was made for doing so [27].

Article 4, paragraph 3, of the National Personnel Authority Rule 10-5 on Radiation Injury Prevention for Employees specifies the application of the dose criteria for governmental employees engaged in emergency response, such as nuclear safety inspectors [27, 50]. Because this requirement for national government employees engaged in emergency response was specified in a document other than the Ordinance on Prevention of Ionizing Radiation Hazards [47] to which the exemption was issued, the revision of the criteria stipulated on 15 March did not apply immediately to this group of emergency

[35] It was reported in Ref. [66] that the increase to 250 mSv resulted in confusion as to why this was being done and whether it resulted in a substantial increase in health risks.

workers, while it did apply to local government employees[36] engaged in emergency work. However, the National Personnel Authority of Japan followed the publicly announced increase in the dose criteria for emergency workers and, on 17 March, issued a revision to the National Personnel Authority Rule 10-5 on Radiation Injury Prevention for Employees for the increased dose criterion to also be applied to national government employees under the same circumstances [27, 58].

Although the staff of the Ministry of Defense, including the SDF personnel, were in governmental service, they were not considered national government employees. Nevertheless, the revised criteria for emergency work came into force on 14 March for the SDF personnel because the rules of the National Personnel Authority were applicable.

Dose criteria to be applied for emergency workers from the firefighting services as local government employees engaged in emergency response on-site were additionally specified in the manual for firefighting activities at nuclear power facilities, which was prepared by the Fire and Disaster Management Agency in March 2001. The manual stipulates an effective dose limitation of 100 mSv for emergency work to save lives. There was no change in this dose criterion, which applied to emergency workers from the firefighting services [27].

Using the legal basis explained above that existed prior to the accident, the Fukushima Prefecture Disaster Management Plan [1] provided the dose criteria to be applied for personnel of Fukushima Prefecture engaged in performing general emergency tasks. These criteria were 50 mSv effective dose and 100 mSv effective dose for emergency tasks such as mitigatory actions and rescue activities.

Despite the difficulties, the protective measures taken for on-site emergency workers were generally successful in controlling radiation exposures and limiting them to levels far below those at which acute radiation syndrome might be expected to occur. This applies to all on-site emergency workers, including TEPCO employees and subcontractors, SDF personnel and firefighters. Of the latter category, none of those who were engaged in taking on-site mitigatory actions, such as injecting water into a spent fuel pool, were exposed to radiation doses exceeding 100 mSv [27].

However, there were six cases in which emergency workers incurred doses in excess of the dose limit of 250 mSv. These ranged from the highest dose of 678 mSv (of which 590 mSv was from internal contamination) to the lowest dose of 308 mSv (of which 260 mSv was from internal contamination). Successive follow-up checks revealed several causes for this: unavailability of adequate respiratory protection against volatile iodine for the emergency workers in the control room early after the onset of the accident (11–12 March); ITB not being implemented until the evening of 13 March; respiratory protection not worn for different reasons (e.g. too tight, fogging of the mask's glass while breathing); taking individual actions leading to inadvertent ingestion (e.g. smoking, eating and drinking in the contaminated environment); and repeated exposure to the severe working conditions in which the assigned tasks were performed. In addition, unexpected high external doses of about 180 mSv were received by two workers due to the unanticipated presence of highly contaminated water in the working area [17, 27, 30].

In an effort to comply with the 250 mSv dose limit, TEPCO subsequently issued a rule that applied from 11 March to 15 December 2011 to exempt emergency workers who had received doses exceeding 200 mSv from further emergency work at the Fukushima Daiichi NPP [30, 70]. On 28 April 2011, a notice was issued by the Ministry of Health, Labour and Welfare [70]. In this rule, a compliance with the dose limit of 100 mSv for five consecutive years was requested to be applied by all employers of radiation workers involved in emergency work at the Fukushima Daiichi NPP with

[36] Who were subject to the Industrial Safety and Health Act [52], under which the above mentioned Ordinance is set.

regard to further work involving occupational exposure that was not associated with the Fukushima Daiichi NPP[37] [71].

The difficulties in providing radiation protection at the plant also resulted in delays in the communication to emergency workers of the doses received and the unavailability of cumulative doses for emergency workers in time for consideration of restrictions to prevent further exposures. It took several months for TEPCO to adequately manage the notification system for this purpose [25, 53, 55, 57].

3.2.3.3. Iodine thyroid blocking

Iodine thyroid blocking (ITB)[38] was implemented as a protective measure for emergency workers from 13 March 2011. The initial advice to take stable iodine tablets was sent (as a fax message) from the Tokyo headquarters of TEPCO to the Fukushima Daiichi NPP at around noon on 12 March. However, this message did not reach the medical team of the on-site ERO.

On 13 March, the general manager of the on-site ERO advised the on-site medical team leader to make an internal announcement. The on-site medical team leader gave instructions for the administration of stable iodine tablets and dosage. Notices about the distribution of stable iodine tablets were put up around the site. This measure applied to emergency workers under 40 years of age and, to those over 40 years who wished it, who were engaged in emergency work that could result in a projected thyroid equivalent dose of 100 mSv. For the first few days, the on-site medical team gave instructions about the administration of stable iodine during the morning and evening on-site ERO meetings. Thereafter, information about administration was disseminated within the seismically isolated building, as changes were made to the advice. From 2 August 2011, ITB was implemented only for emergency workers carrying out emergency work in designated buildings on the site, and, on 21 November 2011, this measure was terminated [17].

There were a total of approximately 30 000 stable iodine tablets in stock in the main office building at the Fukushima Daiichi NPP. At the time of the accident, stable iodine tablets were distributed to the seismically isolated building; however, the stable iodine tablets were not available and ready for use in the MCRs and they could not be distributed in a timely manner to the MCRs due to the devastation caused by the earthquake and the tsunami.

The on-site medical team initially distributed the stable iodine tablets to the managers of the workers for further distribution. Subsequently, tablets were distributed at a designated place at the plant. In each case, a list of workers was made available to be signed by emergency workers (and sometimes by the manager) on receipt of the tablets. However, in some cases, these lists were incomplete or lost. For example, one of three emergency workers who stayed in the MCR of Units 3 and 4 between 11 March and the evening of 13 March remembered taking stable iodine tablets, but no record of the intake could be found [27].

During the entire period of on-site implementation of ITB, approximately 17 500 tablets were administered to 2000 emergency workers. About 75% of the emergency workers received fewer than ten tablets per individual, although one individual received as many as 87. Emergency workers who took more than 20 tablets or who were continually taking the tablets for more than 14 days were given

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[37] According to the IAEA safety standards, "[w]orkers shall not normally be precluded from incurring further occupational exposure because of doses received in an emergency exposure situation." [11].

[38] 'Iodine thyroid blocking' is an urgent protective action to be taken in an emergency involving radioactive iodine. Iodine thyroid blocking involves the administration of a compound of stable iodine (usually potassium iodide) to prevent or reduce the uptake of radioactive isotopes of iodine by the thyroid gland [12].

a medical examination. In total, 178 emergency workers were estimated to have incurred thyroid equivalent doses of over 100 mSv, and 25 emergency workers under the age of 40 were found not to have taken stable iodine tablets [17].

3.2.3.4. Planning the emergency work for decontamination activities

The planning of decontamination work started after the urgency associated with the implementation of protective actions for the public abated and when sufficient information from field monitoring was obtained. It was based on the Basic Policy for Emergency Response on Decontamination Work [72] and the Guidelines for Municipal Decontamination Work [73] issued on 26 August 2011. Following this policy and guidelines, the Ministry of Health, Labour and Welfare issued a notification in accordance with this policy, and guidelines for ensuring the radiation protection of emergency workers involved in the decontamination activities [74]. Every employer had the responsibility to ensure the protection for each worker engaged in decontamination work by taking measures that included:

- Using personal dosimeters to control the dose due to external exposure while performing decontamination work, recording the data and informing the worker on the dose incurred on a daily basis and on cumulative dose once a month;
- Keeping the dose below 20 mSv per year for male workers and female workers who were not pregnant or were not expected to be pregnant, or under 5 mSv per three months for female workers who were or were expected to be pregnant;
- Wearing of respiratory protection, when required, and adequate personal protective equipment when the work was carried out;
- Instructing workers not to smoke, eat or drink at the workplace;
- Providing workers with instruction and training adequate for their expected duties before starting the decontamination work;
- Provision of periodical health examinations, at least once every six months for full time workers engaged in the decontamination work.

Following this notification, policy and guidelines, a Ministerial Ordinance on Prevention of Ionizing Radiation Hazards at Work to Decontaminate Soil and Wastes Contamined by Radioactive Materials Resulting from the Great East Japan Earthquake and Related Works and its guidelines were published on 22 December 2011, with 1 January 2012 as the date of entry into force [75-77].

Activities to be undertaken in the weeks and months following the onset of the accident had been carefully planned so that adequate attention was given to the protection of those engaged in the decontamination work within the framework for occupational exposure for normal operations consistent with the IAEA safety standards [11, 49].

3.2.3.5. Designation of emergency workers

Many different types of emergency workers were needed to support the on-site and off-site emergency response. On-site emergency workers included NPP personnel, either directly employed by TEPCO or subcontracted, as well as personnel from the SDF, the firefighting services and police engaged in emergency work on the site [17]. Off-site emergency workers included personnel from different organizations and services (governmental and non-governmental). Their tasks included evacuation of the public and of special facilities, offering support to evacuees, providing medical care, and carrying out monitoring and sampling [27, 57, 65, 78].

Not all of the emergency workers had been designated as such prior to the emergency (e.g. some TEPCO employees and employees of subcontractors who served as emergency workers), and arrangements were not in place to integrate them into the response after their designation as emergency workers. Additionally, many of those who had not been designated prior to the emergency had not been trained to work under nuclear emergency conditions. For example, they had not been trained in radiation protection aspects, informed of the potential health risks from radiation exposure, or trained in the use of respiratory protection or in dealing with patients potentially contaminated with radioactive material [79]. This resulted in some delay in the implementation of mitigatory actions early in the response [27].

3.2.4. Medical management of emergency workers

Obtaining the necessary medical treatment for emergency workers with conventional injuries was difficult, because several hospitals were closed as a result of the evacuation or sheltering, and some were not prepared to treat patients possibly contaminated with radioactive material [79, 80]. Until primary medical care was provided on the site, emergency workers with conventional injuries were transported to one of two local hospitals for treatment[39] [63, 80]. As a consequence of the earthquake and tsunami, two workers were slightly injured, two required treatment in the hospital and two workers died on 11 March. One worker was treated at the designated radiation emergency hospital in Okuma Town. Another worker who required surgical treatment was transported to a hospital in Koriyama City due to the disruption of the water supply at the hospital in Okuma Town. Overall, 30 emergency workers from Fukushima Daiichi NPP visited hospitals for treatment of trauma and/or other illnesses not related to radiation exposure in March 2011 [81].

About 17 hours after the earthquake, the NIRS dispatched the Radiation Emergency Medical Assistance Team (REMAT), consisting initially of a physician, a nurse, and a health physicist, to the Local NERHQ (in the Off-site Centre) to perform assessments of the contamination and decontamination of emergency workers[40] [79].

On 12 March, five workers sustained conventional injuries without suffering contamination as a result of the first hydrogen explosion at the Unit 1 reactor building. No triage was performed for them at the site [80]. Four of the injured workers were transported using facility vehicles to a non-designated medical clinic, while one worker, with injuries requiring surgical treatment, was referred to a hospital in Koriyama City.

No medical doctors were available at the Fukushima Daiichi NPP for the first week after the accident [80]. From 19 March, occupational health doctors began to provide primary care for on-site emergency workers at the ERC in the seismically isolated building, if this was required [17, 63, 80].

At the Fukushima Daini NPP, an occupational physician and two nurses were present 24 hours a day, seven days a week, to provide first aid and general medical management for on-site emergency workers, if required. This service was provided from 11 March onward at the health management office. In addition, on 16 March, three medical doctors, two nurses and a general assistant were dispatched from Toden Hospital and other hospitals to assist them.

On 14 March, four SDF personnel and seven TEPCO workers sustained conventional injuries after the second hydrogen explosion, which took place at Unit 3. Four SDF personnel were brought to the Local NERHQ, where the initial triage was performed. All of them showed contamination on their protective gear (above 1 mSv/h at 10 cm from the surface). After removal of their protective gear and decontamination (e.g. taking a shower), the remaining contamination on the face was measured. One

[39] Radiation and disaster emergency medical systems in Japan prior to the accident are described in Appendix II.

[40] Later on, many experts, including physicians, nurses, radiation protection experts, health physicists and logisticians, were sent to Fukushima Prefecture from the NIRS.

SDF member was transferred by ambulance to the Fukushima Medical University (FMU) Hospital in Fukushima City. He was diagnosed with a conventional injury to the shoulder and arm. One of the other patients had a contaminated wound on a thigh and was transferred to the NIRS by a SDF helicopter [82].

Three of the seven TEPCO workers were transferred by ambulance to the FMU Hospital, accompanied by a nurse and a radiation protection expert from the NIRS, since the primary hospitals for a radiation emergency were either located within the evacuation zone or did not function. However, even hospitals located outside of the evacuation area could not receive contaminated patients due to the lack of knowledge about medical response to a radiation emergency. The doses of experts who took care of patients with contamination were a few tens of μSv [79, 83].

For the medical management of multiple casualties during the Fukushima Daiichi accident, a triage process that incorporated elements of medical and radiological triage was developed [84]. Following initial triage on the site, all injured workers were transported for medical and radiological triage at J-Village [17, 22, 63, 80].

Screening facilities and decontamination tents provided by the SDF and fire departments from other prefectures were set up at J-Village, which was established on 15 March as the only access point to the NPP. On 18 March, an emergency physician arrived at J-Village, accompanying the fire brigades which were engaged in emergency cooling operations for the spent fuel pool of Unit 3. In addition, one SDF doctor and two to three SDF nurses were deployed at J-Village from 17 March onward [21] [17].

On 24 March, two workers received high doses to their feet from the contaminated water in the basement of the Unit 3 reactor building. They were initially evaluated and decontaminated by a part-time occupational health doctor at the seismically isolated building of the Fukushima Daiichi NPP and transported by a facility vehicle to J-Village where an emergency physician carried out a second evaluation before final transportation to the FMU Hospital. A medical doctor from the NIRS was dispatched to the FMU Hospital to support treatment and decontamination. The two workers were transported to the NIRS for dose assessment, the results of which were as follows: equivalent dose to the skin of 466 mSv for each worker and committed effective dose of 39 mSv and 35 mSv, respectively. As of 30 March, one doctor and two nurses from the TEPCO hospital in Tokyo were located at J-Village to provide first aid treatment for workers.

In early April 2011, a medical clinic at J-Village (which had served as a sport clinic prior to the accident) was renovated and designated for the medical management of affected on-site emergency workers as a primary radiation emergency medical facility. Emergency physicians, nurses and radiation specialists were located at this facility with the support of the Japanese Association for Acute Medicine, Hiroshima University and the NIRS [63, 80]. In early April 2011, the medical headquarters were established at the Local NERHQ in Fukushima City and the first comprehensive medical response plan for the medical management of on-site emergency workers was developed by the Local NERHQ (see Fig. 3.2–2) [84].

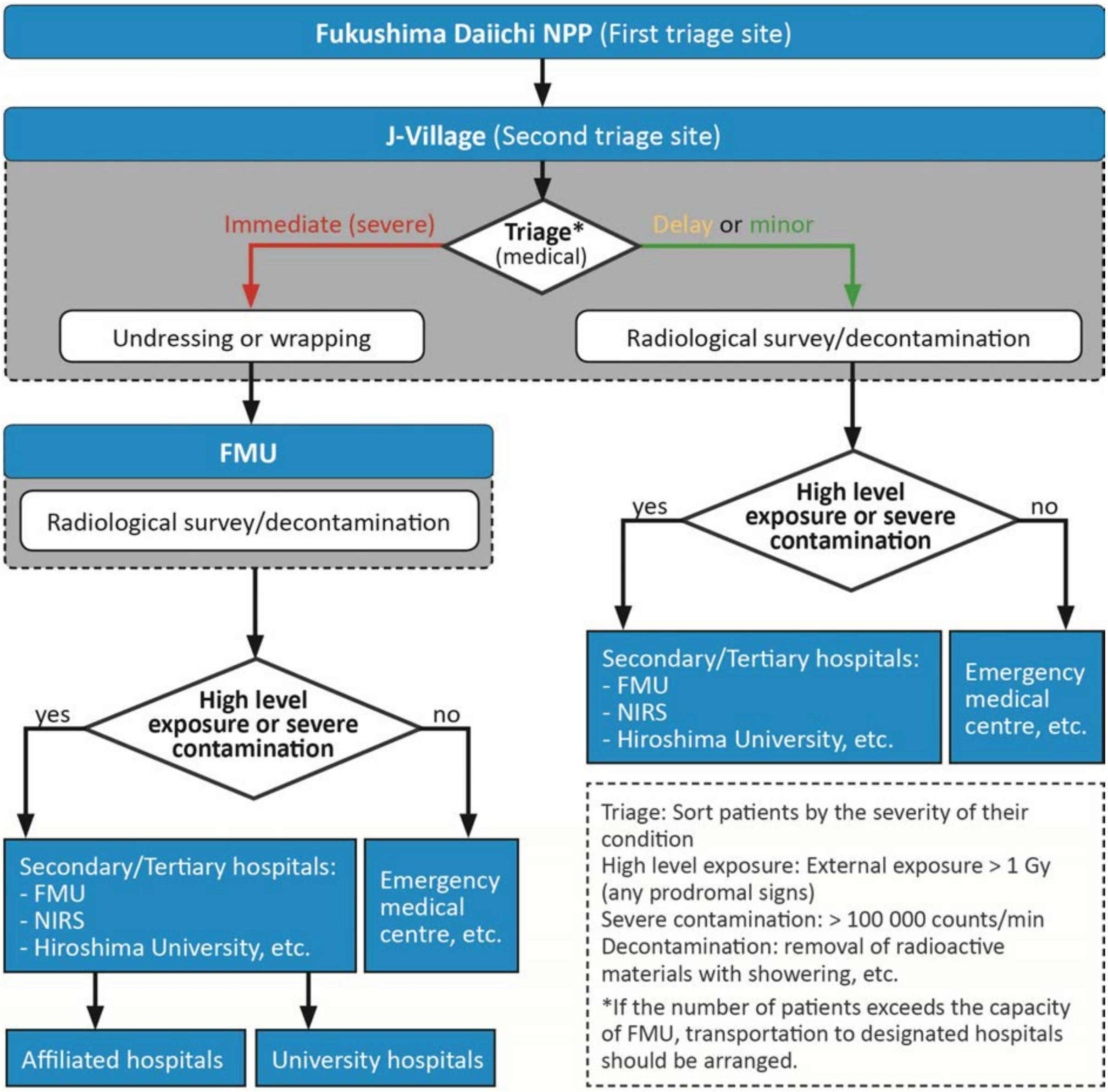

FIG. 3.2–2. Triage arrangements and roles of hospitals as of 22 April 2011 [84].

In the case of a mass casualty event, the first triage was to be performed on-site; the second triage and life-saving actions were to be provided by the emergency physicians at J-Village. Since vehicles were not allowed to enter the 20 km restricted zone, the injured workers were transported by TEPCO or SDF vehicles from the site to J-Village before transportation to referral hospitals by fire department ambulances or SDF helicopters. Severely injured personnel with contamination were to be transported by SDF aircraft to the designated radiation emergency hospitals outside Fukushima Prefecture, such as the NIRS, affiliated hospitals in the Kanto region and Hiroshima University [85].

In late April 2011, more hospitals, including disaster medical centres in Fukushima and nearby prefectures, were requested to accept on-site emergency workers in the case of injury [84].

As was mentioned earlier, initial triage and first aid was provided at the Fukushima Daiichi NPP by occupational health physicians during the day from 15 April [86]. Following an event in May 2011, when a worker died from a heart attack, arrangements were made for doctors to be available around the clock at the seismically isolated building of the Fukushima Daiichi NPP. This was arranged with the involvement of the University of Occupational and Environmental Health and the Japan Labour Health and Welfare Organization [17, 87, 88]. During this time, the medical doctors treated emergency workers for the consequences of the excessive heat that was caused by the use of personal protective equipment. Actions were implemented to reduce the health effects induced by the heat, such as compulsory rest, use of cooling jackets and rehydration measures [89].

A 24 hour medical emergency care facility at the Fukushima Daiichi NPP was established on 1 July 2011 on the first floor of the Unit 5–6 reactor management building (located 650 m north of the Unit 1 reactor building), which became known as the '5/6 ER'. Emergency physicians, nurses and radiological technicians experienced in the medical management of nuclear emergencies were recruited from emergency medical services all over Japan. This was done through the efforts of the Ministry of Health, Labour and Welfare (MHLW) in cooperation with the Japan Association of Acute Medicine, following guidance given by the Prime Minister's Office. The facility was located in the middle of the Restricted Area, where only authorized personnel and vehicles were allowed to enter [80, 88].

However, despite the establishment of temporary medical facilities (5/6 ER and the J-Village clinic), significant delays continued in the provision of medical care by emergency hospitals because of the distance of J-Village and hospitals from the Fukushima Daiichi NPP. This situation was exacerbated by the fact that the roads surrounding the Fukushima Daiichi NPP remained disrupted and by the establishment of a no fly zone in the 20 km Restricted Area.

Figure 3.2–3 presents an overview of the medical conditions managed at the Fukushima Daiichi NPP from March 2011 until June 2012 [80, 90].

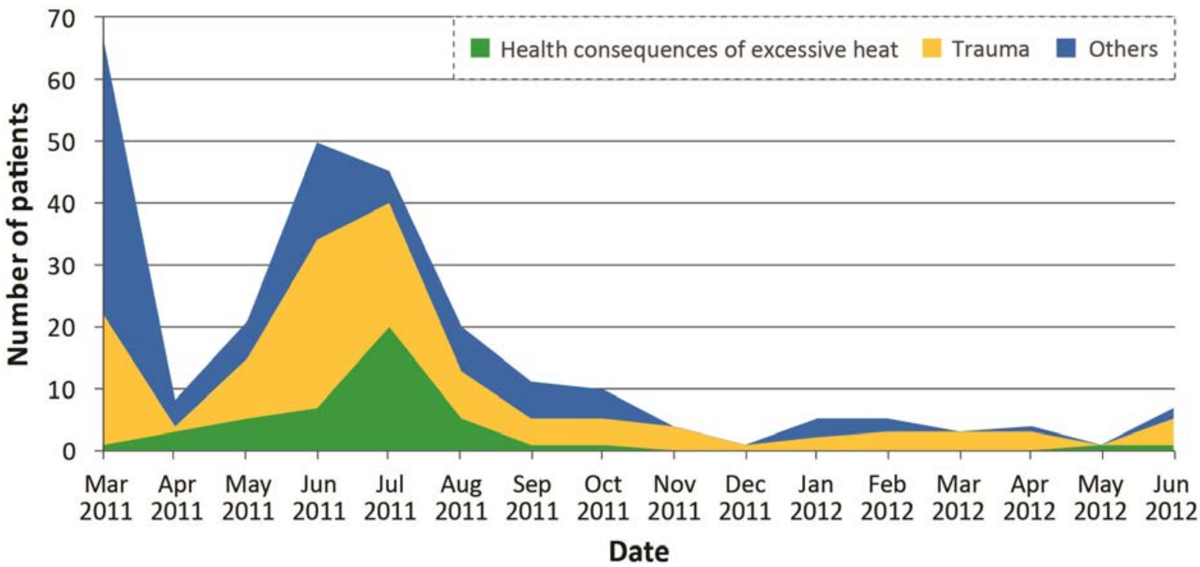

FIG. 3.2–3. Injuries and illnesses treated at the Fukushima Daiichi NPP (from March 2011 to June 2012)[41] [80, 90].

During this period, three deaths occurred, primarily due to cardiac arrest and none of them related to radiation.

[41] Among the reasons specified as 'others' are medical problems such as headache, sickness, etc.

3.2.5. Voluntary involvement of members of the public in the emergency response

In the aftermath of the accident, people from the affected areas, as well as from all over Japan, and from a number of non-governmental organizations (helpers) volunteered to assist in such activities as the provision of food, water and necessities, and later in decontamination and monitoring activities.

This demonstrates the need to identify, at the preparedness stage, when and how such helpers may be involved in the aftermath of an accident, and how they will be integrated in the emergency response organization and afforded an adequate level of protection. National authorities issued guidance on the type of activities helpers could carry out and on measures to be taken for their protection [78, 91, 92].

Self-employed workers, residents and volunteers who performed decontamination works in their local area were asked to follow the applicable sections of the MHLW's Guidelines on Prevention of Radiation Hazards for Workers Engaged in Decontamination Works [78, 93].

There were a number of NGOs that recruited volunteers from all over Japan who participated in decontamination works, environmental radiation monitoring, etc., in Fukushima Prefecture. The Ministry of the Environment and the Fukushima Prefectural Government supported such initiatives of NGOs by distributing information through governmental web sites [78, 91].

With regard to the assignment of specific tasks undertaken in decontamination areas and the responsibility of coordination and supervision, the MHLW's Guidelines on Prevention of Radiation Hazards for Workers Engaged in Decontamination Works [93] stipulated the following:

- Residents and self-employed workers were expected to conduct decontamination activities, etc., as a communal group when they needed to decontaminate the soil of their residences, offices, farmland and so forth in areas where the average ambient dose rate might exceed 2.5 μSv/h. In such cases, the frequency of the work should be less than dozens of times (days) per year, to prevent individuals from receiving effective doses higher than 1 mSv/y through the work.
- In the case of recruiting volunteers from outside the special decontamination areas, the volunteer organizers should note that the exposure dose limit to the public from the radiation source was specified as 1 mSv/y under the planned exposure situation defined by the International Commission on Radiological Protection (ICRP).

This information was also provided on the web site of the Ministry of the Environment and in its leaflet for volunteers [78, 92-94].

3.2.6. Summary

At the time of the accident, the national legislation and guidance in Japan addressed the requirements and the measures to be taken for the protection of emergency workers, but only in general terms and not in sufficient detail. Practical arrangements, such as the Nuclear Operator Emergency Action Plan at the Fukushima Daiichi NPP [16] or the Fukushima Prefecture Disaster Management Plan [1], were generic and did not contain sufficient guidance on how measures were to be implemented in the event of a nuclear accident.

Implementation of the arrangements for ensuring the protection of workers against radiation exposure was severely affected by the extreme conditions at the site. In order to maintain an acceptable level of protection for on-site emergency workers, a range of impromptu measures was implemented. These measures resulted in doses far below those that could have resulted in acute radiation syndrome and, in most cases, below the legally set national dose limit for emergency workers. Nevertheless, a few emergency workers received doses in excess of these levels, mainly due to a lack of training and incorrect implementation of protective measures (e.g. improper use of respiratory protection, late implementation of ITB measures or taking actions that resulted in inadvertent ingestion of radionuclides).

Many emergency workers from different professions were needed to support the emergency response. Emergency workers came from various organizations and public services. Not all had been designated prior to the emergency as emergency workers (e.g. some TEPCO employees and subcontractors). There were no arrangements in place to integrate into the response those emergency workers who had not been designated prior to the accident.

Contact details and doses for some of emergency workers were not adequately tracked and/or recorded at the time. In addition, many of those who had not been identified as emergency workers prior to the emergency (e.g. some medical staff and members of the Japanese Red Cross Society) lacked adequate training and guidance to work under emergency conditions. Some of the rescue teams that supported the evacuation process were not provided with adequate training in radiation protection and were not given information on the potential health risks from radiation exposure, or information dealing with possibly contaminated patients.

During the response, the dose limit for emergency workers undertaking specific emergency work was temporarily increased to 250 mSv, to allow the necessary activities to continue. These dose criteria were not always applied consistently to all emergency workers, considering their expected duties. For example, the dose limit of 250 mSv was not applicable to emergency workers from the firefighting service.

Medical management of emergency workers was also severely affected and major efforts were required to meet the needs of on-site emergency workers. Difficulties were encountered in seeking required medical treatment for on-site emergency workers because several hospitals were closed as a result of the evacuation or sheltering orders, while others were not prepared to treat patients with possible contamination. Detailed arrangements for the medical management of emergency workers had not been developed at the preparedness stage. Occupational health doctors started to provide primary care for on-site emergency workers at the on-site ERC in the seismically isolated building eight days after the beginning of the accident. Two triage centres were established, one on-site and the other in J-Village, which also served as a base facility for emergency workers and for their decontamination, if required.

As of 1 July 2011, an emergency care facility was established at the Fukushima Daiichi NPP. For this facility, medical staff trained to deal with radiation emergencies had been recruited from all over Japan. However, significant delays continued in the provision of medical care to emergency workers for various reasons, including the distance of hospitals from the Fukushima Daiichi NPP, roads being disrupted and a no fly zone being established within the 20 km zone.

Members of the public, referred to as helpers, volunteered to assist in the off-site emergency response. National authorities issued guidance on the type of activities that helpers could carry out and on measures to be taken for their protection.

3.2.7. Observations and lessons

— **Emergency workers need to be designated, assigned clearly specified duties, regardless of which organization they work for, given adequate training, and be properly protected during an emergency. Arrangements need to be in place to integrate into the response those emergency workers who had not been designated prior to the emergency.**
  Account needs to be taken of those who may not have been designated as emergency workers at the preparedness stage. Dose criteria for emergency workers need to be set in advance and applied in a consistent manner for the assigned emergency duties.

- **Arrangements need to be pre-planned for members of the public (referred to as helpers) who volunteer to assist in response actions to be integrated into the emergency response organization and to be afforded an adequate level of radiation protection.**
  The arrangements need to include measures for their safety, including dose criteria to be applied, registration and integration within the emergency response organization and training ('just-in-time' instructions before undertaking the assigned duties) prior to the start of their work.
- **There is a need to involve non-governmental organizations in establishing adequate emergency arrangements at the preparedness stage to facilitate their effective support to the overall emergency response.**
  This needs to cover the identification of their roles, the development of procedures and the provision of training.
- **Arrangements for the protection of emergency workers need to be elaborated in detail in the relevant emergency plans and procedures.**
  These plans and procedures need to be routinely tested to ensure their effective implementation. The arrangements need to include: those for ensuring the operability and habitability of emergency response facilities under a range of hazardous conditions; those for ensuring the well-being of emergency workers; and those for timely communication of doses incurred and associated health risks to emergency workers.
- **There is a need for the training of emergency workers in the implementation of measures and actions for their protection in an emergency, with specific emphasis on severe environmental and radiological conditions.**
  Training programmes, including drills and exercises, need to cover the use of personal protective equipment, self-protective measures and actions to prevent inadvertent ingestion.
- **Arrangements for medical preparedness and response in relation to emergency workers need to be detailed and integrated in the overall emergency planning.**
  These arrangements need to take into account the necessity to promptly provide medical care to emergency workers and to function under severe environmental and radiological conditions.

3.3. PROTECTING THE PUBLIC

3.3.1. Arrangements for protecting the public in Japan prior to the accident

Prior to the accident, 10 km EPZs, in which emergency preparedness was to be significantly enhanced, had been established around the Fukushima Daiichi and Fukushima Daini plant sites (Fig. 3.3–1). There were plans to implement protective actions within these zones [1].

The emergency response plans envisaged that decisions on protective actions would be based on dose projections performed at the time when a decision was necessary (see Appendix I for more details). Doses were to be projected by using a dose projection model, the System for Prediction of Environmental Emergency Dose Information (SPEEDI) after the onset of the accident and to be compared with predetermined dose criteria to determine what protective actions were needed and where they were to be applied [8, 19]. This approach was not in line with IAEA safety standards, which stipulate that the initial decisions on urgent protective actions[42] for the public need to be based on plant conditions [11, 13].

[42] Urgent protective actions are actions that must be taken promptly (normally within hours) in order to be effective. The most common urgent protective actions in a nuclear emergency are evacuation, sheltering, ITB, restriction of the consumption of potentially contaminated food and decontamination of individuals.

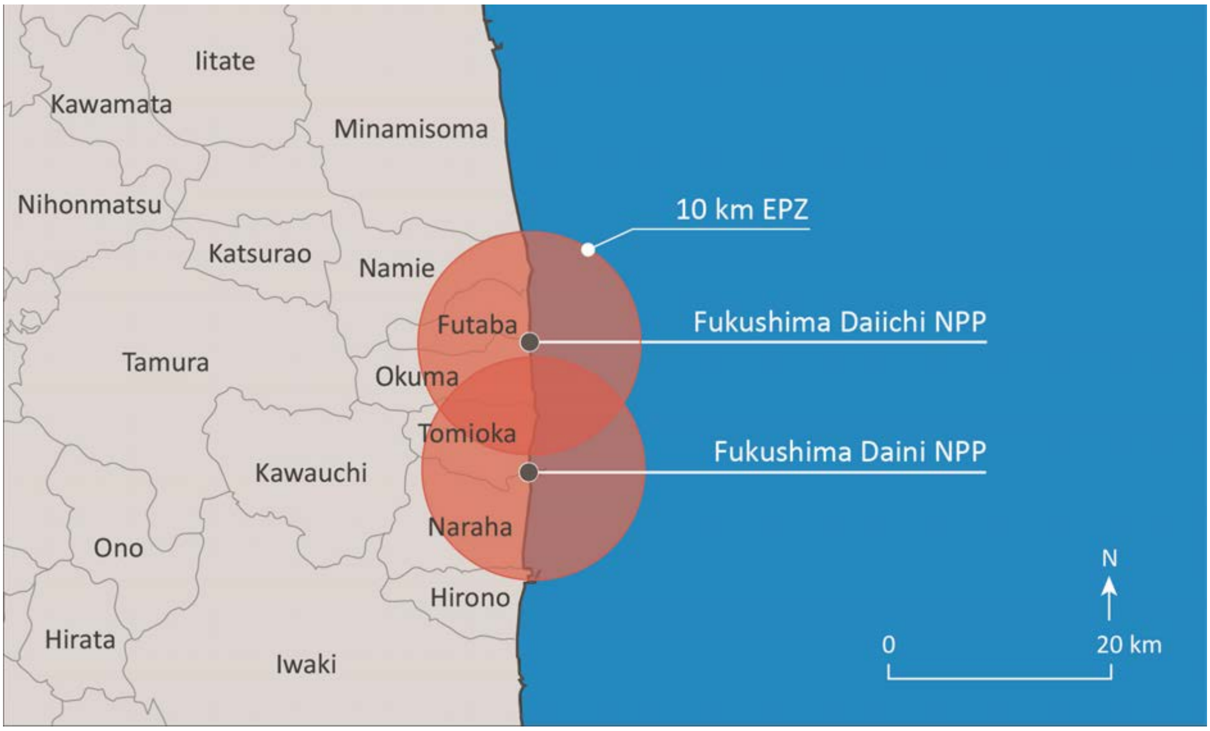

FIG. 3.3–1. Emergency planning zones (EPZs) for the Fukushima Daiichi and Fukushima Daini NPPs established prior to the accident [1].

Predetermined criteria were available for sheltering[43], evacuation[44] and ITB in terms of projected dose (see Table 3.3–1). There were no predetermined criteria in terms of measurable quantities, such as operational intervention levels (OIL[45]). The dose criteria for sheltering, evacuation and ITB were consistent with the guidelines for generic intervention levels for these protective actions that have been established in the IAEA safety standards [11].

There were no predetermined criteria (i.e. generic, in terms of dose, or operational, in terms of measurable quantities) for relocation[46] [19].

It was envisaged that METI, as soon as notification was received from the operator of the NPP, would monitor conditions at the plant and attempt to predict the timing, rate and composition of possible releases of radioactive material from the NPP, based on plant conditions provided by the operator and using the Emergency Response Support System (ERSS). MEXT would then use the outcome of these predictions from METI to perform a projection of doses to the public from the possible releases of radioactive material using SPEEDI.

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[43] Sheltering is the short term use of a structure for protection from an airborne plume and/or deposited radioactive material [12].

[44] Evacuation is the rapid, temporary removal of people from an area to avoid or reduce short term radiation exposure in an emergency. Evacuation may be performed as a precautionary action based on plant conditions [12].

[45] An OIL is a type of action level that is used immediately and directly (without further assessment) to determine the appropriate protective actions or other response actions on the basis of an environmental measurement or laboratory analysis [11]. It is a calculated level, measured by instruments or determined by laboratory analysis, that corresponds to generic criteria, expressed in terms of dose. OIL is typically expressed in terms of dose rate, ground or surface concentration, or activity concentration of radionuclides in the environment, food, or drinking water samples [11].

[46] Relocation is the non-urgent removal of people to avoid longer term exposure (e.g. within one year) from deposited radioactive material [12].

MEXT would transmit the predictions to terminals in the NERHQ, Local NERHQ, NSC, Prefecture Headquarters for Disaster Control, and elsewhere, in order to support decisions on, and implementation of, protective actions. Within the NERHQ, protective action orders/recommendations would be drafted for issuance by the Prime Minister based on the dose projection of SPEEDI and the criteria for taking actions in the NSC's Nuclear Emergency Preparedness Guide [19]. The Local NERHQ would have the capability to make predictions of the impact of releases using SPEEDI, based on data obtained from the ERSS, and to monitor environmental radiation levels in real time, using monitoring posts located in the vicinity.

The importance of initiating protective actions upon detection of conditions in the power plant that can result in core damage has been recognized for many years [95] and supported by numerous studies. The most recent study by the United States Nuclear Regulatory Commission [96] shows that initiating protective actions upon detection of conditions that will result in core damage can be very effective in reducing the risk of detectable radiation induced health effects.

The NSC's Nuclear Emergency Preparedness Guide [19] provided guidance for the establishment of EPZs. According to the Guide, the analysis used to establish the size of the EPZ showed that protective actions such as sheltering and evacuation should be unnecessary outside of the EPZ. Within the EPZ, arrangements needed to be made for: communicating information to the residents; establishing an environmental monitoring system; and implementing urgent protective actions, etc.

As indicated in the Guide [19], the amount of release was inversely estimated from the levels of dose, as criteria for protective actions (see Table 3.3–1), namely 10 mSv effective dose due to external exposure and 100 mSv equivalent dose to childhood thyroid at distances of 8 km and 10 km from an NPP [15]. Thus, release characteristics consistent with those postulated for severe reactor accidents were not considered.

TABLE 3.3–1. CRITERIA FOR THE IMPLEMENTATION OF SHELTERING, EVACUATION AND IODINE THYROID BLOCKING[47]

Projected dose (mSv)[a]		
Effective dose due to external exposure	Equivalent dose due to internal exposure: Of childhood thyroid due to radioactive iodine; Of the bone surface or lung due to uranium of the bone surface or lung due to plutonium	Protective measure
10–50	100–500	Residents must seek shelter indoors, such as their houses. Windows, etc., should be closed to ensure airtightness. However, seek shelter in a concrete building or evacuate as instructed, if there is a release of neutron beams or gamma rays directly from the facility.
50 or more	500 or more	Residents must seek shelter in a concrete building or evacuate as instructed.
Equivalent dose of childhood thyroid due to radioactive iodine (mSv)[a]		Protective measure
100		Iodine thyroid blocking for individuals of less than 40 years of age, if needed, and considering the implementation of other protective measures.

[a] The projected dose is a dose that an individual would receive if he/she stayed outdoors and no actions were taken during the release of radioactive material or radiation.

[47] The contents of the table are taken from the Regulatory Guide on Emergency Preparedness for Nuclear Facilities, developed by the NSC of Japan, as translated into English [19].

There were no provisions for a precautionary action zone (PAZ) to plan for prompt protection of those at greatest risk (i.e. in the immediate vicinity of the site).

The dose criteria in the NSC's Nuclear Emergency Preparedness Guide [19] for sheltering, evacuation and ITB were consistent with the guidelines for generic intervention levels and generic action levels for protective actions in an emergency established in the IAEA safety standards [11].

The criteria of activity concentrations of specific radionuclides to be used in the case of a nuclear emergency for restrictions on food and drink produced in Japan had been developed before the accident[48] (Table 3.3–2) [19]. However, these values had not been adopted for use in an emergency as specific regulatory limits[49] [21, 25].

TABLE 3.3–2. CRITERIA FOR RESTRICTIONS ON THE INTAKE OF FOOD AND DRINK[50] (NUCLEAR EMERGENCY PREPAREDNESS GUIDE)

Food and drink	Radionuclide
	Radioactive iodine (representative nuclide of mixed nuclides: I-131)
Drinking water Milk/dairy products	3×10^2 Bq/kg or more
Vegetables (excluding root vegetables and potatoes)	2×10^3 Bq/kg or more
	Radioactive caesium
Drinking water Milk/dairy products	2×10^2 Bq/kg or more
Vegetables Grain Meat, eggs, fish, other	5×10^2 Bq/kg or more
	Uranium[a]
Drinking water Milk/dairy products	20 Bq/kg or more
Vegetables Grain Meat, eggs, fish, other	1×10^2 Bq/kg or more
	Alpha nuclides of plutonium and transuranic elements[a] (total of radiation concentrations of Pu-238, Pu-239, Pu-240, Pu-242, Am-241, Cm-242, Cm-243 and Cm-244)
Drinking water Milk/dairy products	1 Bq/kg or more
Vegetables Grain Meat, eggs, fish, other	10 Bq/kg or more

[a] As the indices of restrictions on intake of food products marketed for infants, 20 Bq/kg was to be applied for uranium, and 1 Bq/kg for alpha nuclides of plutonium and transuranic elements. However, this criterion was to be applied to those products cooked and served for meals.

[48] The MHLW is responsible for food and water safety in Japan.

[49] Criteria for food imported into Japan (370 Bq/kg of radioactive caesium — ^{137}Cs and ^{134}Cs) were established as a regulatory limit following the accident at the Chernobyl NPP in the former Soviet Union in 1986 [25].

[50] The contents of the table are taken from the Regulatory Guide on Emergency Preparedness for Nuclear Facilities, developed by the NSC of Japan, as translated into English [19].

3.3.2. Urgent protective actions

The timeline of events that were important for urgent protective actions during the response to the Fukushima Daiichi accident are shown in Fig. 3.3–2. Owing to the overlap in the EPZs of the Fukushima Daiichi and Daini NPPs (see Fig. 3.3–1), decisions on the urgent protective actions for the Fukushima Daini NPP are also described.

11 March

- 15:42 | Fukushima Daiichi NPP reported a specific event (station blackout) to national and local governments under Article 10 of the Act on Special Measures Concerning Nuclear Emergency Preparedness (Nuclear Emergency Act)
- 16:45 | Fukushima Daiichi NPP reported an event classified as a nuclear emergency (inability of water injection of the emergency core cooling system for Units 1 and 2) under Article 15 of the Nuclear Emergency Act to national and local governments
- 18:33 | Fukushima Daini NPP reported a specific event (loss of reactor heat removal function for Units 1, 2 and 4) under Article 10 of the Nuclear Emergency Act to national and local governments
- 20:50 | Fukushima Prefecture issued an evacuation order for an area of 2 km radius around Fukushima Daiichi NPP
- 21:23 | National Government issued an evacuation order for an area of 3 km radius and sheltering order for a 3–10 km radius around Fukushima Daiichi NPP

12 March

- Fukushima Prefectural Government began monitoring evacuees using criterion of 13 000 counts/min
- 00:30 | Evacuation of 3 km area completed
- 05:22 | Fukushima Daini NPP reported an event classified as a nuclear emergency (loss of pressure suppression function for Unit 1) under Article 15 of the Nuclear Emergency Act to national and local governments
- 05:44 | National Government issued an evacuation order for an area of 10 km radius around Fukushima Daiichi NPP
- 07:45 | National Government issued an evacuation order for an area of 3 km radius and sheltering order for a 3–10 km radius around Fukushima Daini NPP
- 13:15 | Local Nuclear Emergency Response Headquarters (Local NERHQ) issued an order to local government that, if a decision is taken to implement ITB, stable iodine tablets would need to be distributed to evacuation facilities
- 14:00 | Evacuation of staff, patients and elderly began at Futaba hospital; seriously ill and bedridden patients remained
- 15:36 | Explosion in Unit 1: destruction of water and power provisions, degrading site radiological conditions
- 17:39 | National Government issued an evacuation order for an area of 10 km radius around Fukushima Daini NPP
- 18:25 | National Government issued an evacuation order for an area of 20 km radius around Fukushima Daiichi NPP

14 March

- Monitoring criterion for full decontamination of the public increased from 13 000 counts/min to 100 000 counts/min
- 10:30 | Evacuation by bus of seriously ill and bedridden patients from Futaba hospital began

FIG. 3.3–2. Timeline of key events important for urgent protective actions.

15 March

- 11:00 | National Government issued an order to shelter for residents within a 20–30 km radius of Fukushima Daiichi NPP

16 March (approximately)

- Evacuation of 20 km zone around Fukushima Daiichi NPP completed

25 March

- National Government recommended voluntary evacuation for residents within the 20–30 km radius of the Fukushima Daiichi NPP

FIG. 3.3–2. Timeline of key events important for urgent protective actions (cont.).

3.3.2.1. Evacuation and sheltering

During the response to the accident, 'source term' estimates[51] from the ERSS could not be provided as an input to SPEEDI owing to the loss of on-site power. Decisions on evacuation and sheltering were taken on the basis of plant conditions (i.e. loss of core cooling), rather than on dose projections as had been planned [22, 25].

Decisions based on events at the Fukushima Daiichi NPP

At 20:50 on 11 March 2011, Fukushima Prefecture issued an evacuation order for residents within a radius of 2 km of the Fukushima Daiichi NPP on the basis of information received directly from TEPCO personnel who visited the Fukushima Prefectural Government Office (this was done in addition to receiving the Article 15 notification from the Fukushima Daiichi NPP) [6, 22, 25, 27].

The 2 km evacuation zone was determined based on experience gained in past emergency preparedness exercises [25].The Fukushima Prefectural Government was not aware that, at that time, the national Government was also considering the need to evacuate the population from the vicinity of the Fukushima Daiichi NPP [25].

The decisions of the national and local governments on protective actions were not always coordinated, mainly as a result of the severe communication problems and partly due to the difficulties in activating the Off-site Centre [45]. At 21:23 on 11 March, the national Government issued an evacuation order for an area within a radius of 3 km of the plant, and sheltering for an area within a radius of 3–10 km.[52] The national Government decided on the 3 km radius based on the recommendation in the IAEA safety standards [13] for the PAZ and because it was thought to be sufficient even if venting was required [21][53]. When the national Government issued its order for a 3 km radius evacuation, it was not aware that local government had already issued an order for a 2 km radius evacuation [27].

At 05:44 on 12 March 2011, the national Government issued an order for the evacuation of an area with a radius of 3–10 km, and at 18:25 it extended it to an area within a radius of 20 km of the plant [22, 25]. As a result of the plant conditions, difficulties in coordination and insufficient pre-planning, orders for evacuation and sheltering were modified several times within 24 hours.

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[51] That is, estimates of the timing, rate and composition of the releases.

[52] The national Government issued an order for evacuation about 4½ hours after the Fukushima Daiichi NPP notified off-site officials at 16:45 of an event under Article 15 of the Nuclear Emergency Act [5] (Fax 2, Annex I).

[53] However, it should be noted that IAEA guidance for the radius of the PAZ is not based on venting.

This new order was explained by the Prime Minister at 20:32 on 12 March to the media [27]. No descriptions were found in the report of the Investigation Committee on the Accident at the Fukushima Nuclear Power Stations[54] that the Chief of the Nuclear Emergency Response Headquarters instructed the population within a 10–20 km radius to shelter while waiting to evacuate [21, 27, 97].

Decisions based on events at the Fukushima Daini NPP

Cooling of reactor Units 1, 2 and 4 of the Fukushima Daini NPP was lost at 18:33 on 11 March. A notification based on Article 10 of the Nuclear Emergency Act [5] was sent to the national Government and local governments. On 12 March, between 05:22 and 06:07, pressure suppression functions were also lost, resulting in a submission by the NPP of a report pursuant of the provisions of Article 15 of the Nuclear Emergency Act [5].

At 07:45, METI declared a nuclear emergency, after having received approval from the Prime Minister. An evacuation order to citizens within a radius of 3 km and an order for sheltering within a 3–10 km radius of the Fukushima Daini NPP was issued at 07:45 on 12 March 2011 [27].

Following the hydrogen explosion in Unit 1 of the Fukushima Daiichi NPP (at 15:36 on 12 March), a decision was taken at 17:39 on 12 March to evacuate residents within a 10 km radius around the Fukushima Daini NPP as a precaution in case of a similar hydrogen explosion at this plant [27]. As this 10 km evacuation zone was within the 20 km evacuation zone around the Fukushima Daiichi NPP, no further protective actions were needed in relation to the Fukushima Daini NPP.

Implementation of evacuation of the public

At the time of the accident at the Fukushima Daiichi NPP, about 1900 residents lived in the 2 km zone; about 6000 residents in the 3 km zone, about 51 000 residents in the 10 km zone and about 78 000 residents in the 20 km zone. Evacuations[55] also affected those working in these areas [25].

There were major problems in communicating evacuation orders from the national Government to the local government: only three municipalities within the evacuation zone (Futaba Town, Okuma Town and Tamura City) received these orders; the other seven municipalities in the evacuation areas were unable to receive the orders due to problems in telephone communication caused by the earthquake [25]. However, before the national evacuation order was received, municipalities had already issued evacuation orders to residents based either on their independent judgement of the situation or on information obtained via the media [27].

The communication of evacuation orders to the public in municipalities was arranged by using the local disaster management radio communication network, sound trucks, police cars and door-to-door visits [27]. Also, some citizens learned from the media about the need for evacuation and started to leave the area voluntarily [25, 27]. For instance, when evacuation orders were issued for residents in the 3 km zone around the Fukushima Daiichi NPP, nearly all of the residents had already moved to locations outside of this zone. Evacuation of the 3 km zone was completed by about 00:30 on 12 March [27].

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[54] The Investigation Committee on the Accident at the Fukushima Nuclear Power Station was established by the Cabinet decision of 24 May 2011 with the aim of making policy proposals on measures to prevent further spread of the damage caused by the accident and a recurrence of similar accidents in the future. The members of the Committee, with academic and various other backgrounds, were appointed by the Prime Minister [21].

[55] The evacuation of hospitals and nursing care facilities is dealt with in Section 3.3.2.3.

There were difficulties in evacuation due to infrastructure damage and communication and transportation problems resulting from the earthquake and tsunami. In spite of damaged roads and traffic jams, most residents not requiring medical support began to leave the evacuation area within a few hours after the orders for evacuation had been issued [25].

Figure 3.3–3 shows the percentage of evacuated residents in various locations as a function of time and with respect to the timing of the evacuation orders.

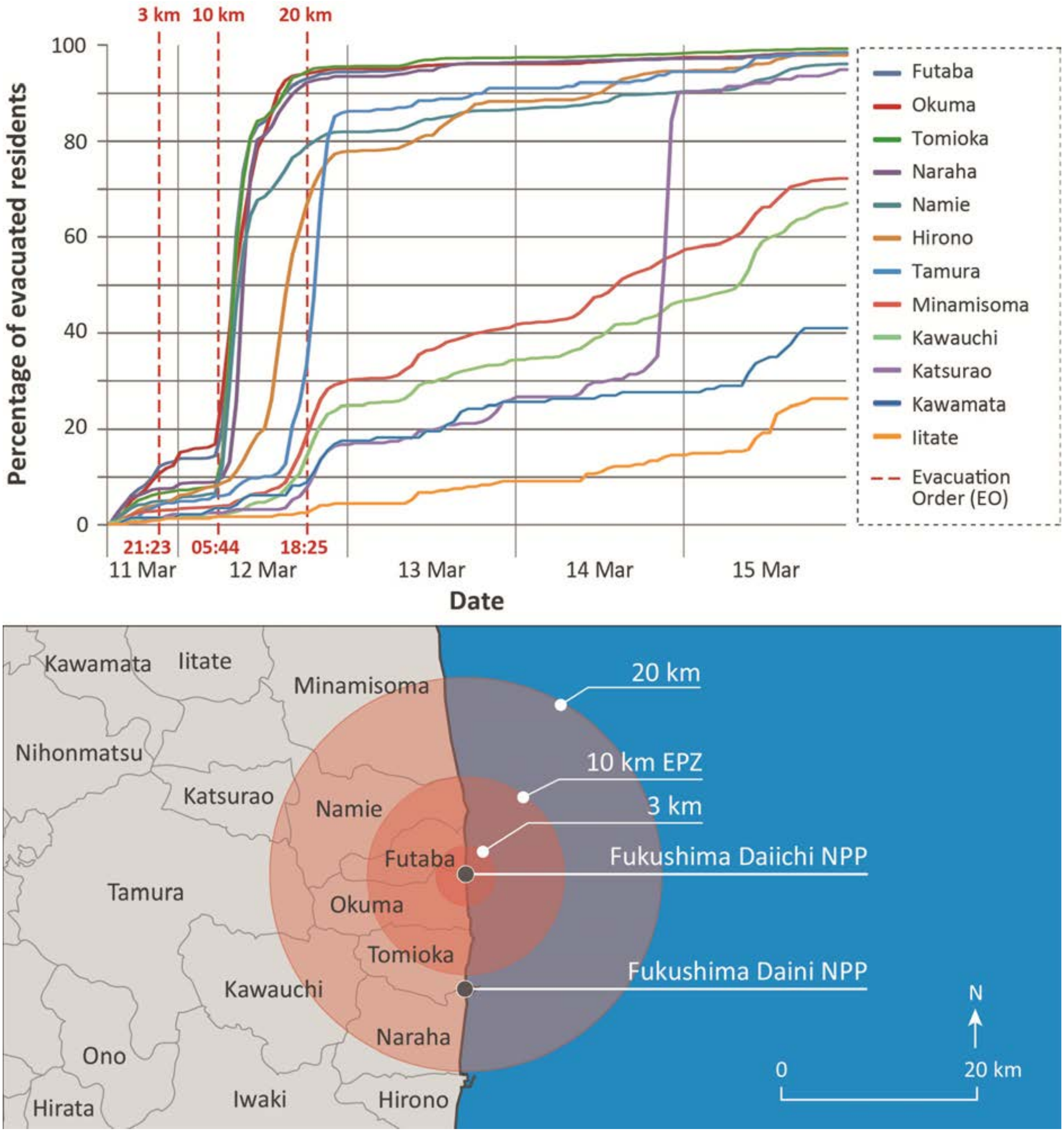

FIG. 3.3–3. Percentage of evacuated residents in various locations [25].

This figure demonstrates that, once evacuation orders had been issued, implementation was rapid. In Futaba Town, Okuma Town and Tomioka Town, which had many areas within the 10 km zone from the Fukushima Daiichi NPP, 80–90% of the residents had left the area within a few hours after the evacuation order [25]. In areas where no orders for protective actions were issued, e.g. in Iitate Village, residents started to voluntarily leave the area, and by 15 March more than 20% of the population had moved.

According to the Fukushima Prefecture Disaster Management Plan [1], each city/town/village was primarily responsible for implementing protective actions, but in the event of an emergency across the borders of cities, towns and villages, Fukushima Prefecture had the responsibility of formulating an evacuation plan. Shelters to receive evacuees from Fukushima Prefecture were also designated outside the EPZ for the Fukushima Daiichi and Fukushima Daini NPPs (in Iwaki City and Minamisoma City). Fukushima Prefecture also had the possibility to request other municipalities to receive the evacuees [1].

The prefecture coordinated the evacuation of Futaba Town and Okuma Town when evacuation of the 10 km zone was ordered [25]. In other cases, the towns in the evacuation zones made their own arrangements bilaterally with the recipient towns for the destination of their evacuated citizens. In some municipalities, residents were initially advised to go to shelters which were located in the same town or village [25]. Many evacuees were evacuated to locations within 20 km of the nuclear power plant and, each time the evacuation zone was expanded, some of those who had already been evacuated were required to move again. For example, Tomioka Town evacuated its residents to Kawauchi Village, which itself was subject to evacuation according to a decision made by the Government four days later [27]. Some residents were evacuated to areas which were later designated to be within the 'Deliberate Evacuation Area'[56], and thus had to be evacuated more than once: approximately 50% of the residents from Namie Town, 30% from Futaba Town and 25% from Tomioka Town. For other municipalities, it was about 10% of residents who had to be evacuated more than once [25].

More than 20% of the evacuees from towns in the vicinity of the Fukushima Daiichi NPP (Futaba Town, Okuma Town, Tomioka Town, Naraha Town, Hirono Town and Namie Town) were required to move more than six times [25].

The majority of the municipalities located in the 20 km zone learned of the national Government's decision to expand evacuation out to this distance via the media. The pattern of evacuation within municipalities varied. For example, part of Kawauchi Village fell within the 20 km zone and was ordered to evacuate by the national Government at 18:25 on 12 March. Approximately 20–30% of the residents were evacuated on that day. The local government then issued an order for evacuation of those residents of Kawauchi Village located within the 20 km radius on 13 March. Two days later, on 15 March, the local government issued a recommendation for voluntary evacuation of the entire population of Kawauchi Village, which was revised to a full evacuation on 16 March [25].

The completion of the evacuation of the 20 km zone took about three days. There was a need for information[57] to be provided to evacuees, such as how to prepare for an evacuation, how long the evacuation could last [25] and what actions to take while awaiting evacuation.

When the evacuation zone was expanded to 20 km, there were also difficulties in defining which areas were included in this zone. Due to the earthquake, only a limited number of communication channels were available locally. In addition, the OFC had maps only for areas within the 10 km radius, i.e. the

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[56] An area established on 22 April 2011 from which residents were encouraged to relocate within roughly one month (see Section 3.3.3.1).

[57] Prior to the accident, leaflets had been distributed to residents located in the EPZ that provided instructions on how to evacuate, including the need to close ventilation systems in houses prior to leaving.

EPZ areas of the Fukushima Daiichi and Fukushima Daini NPPs. Thus, municipalities did not receive detailed instructions from the Local NERHQ at the OFC [27].

Implementation of sheltering of the public

Sheltering is a short term protective action and is used typically for a few days. It is usually used as a temporary measure whenever immediate and safe evacuation is not possible (e.g. for special facilities[58] for which immediate evacuation would create additional risk), and whenever conditions make immediate evacuation impossible or hazardous (e.g. in severe weather). Sheltering, by itself, is not considered to be adequate protection against a release from a damaged reactor core and, if possible, needs to be undertaken in conjunction with ITB.

The order for the sheltering of residents living within a radius of 20–30 km area from the Fukushima Daiichi NPP was given at 11:00 on 15 March and remained in force until 25 March [22, 25]. The residents were not told how long they could expect to have to shelter [25], nor were instructions given on how to minimize indoor contamination while sheltering [98].

This extended time of sheltering and the breakdown of the local infrastructure resulted in serious disruptions to people's lives [7]. For example, in Iwaki City, there was a misunderstanding of the extent of the order to shelter: stores and supermarkets were closed throughout the city, while the order applied only for one area in the northern part of the city [27]. While, by 21 March, the Government supplied the sheltered residents with gas, food and medicine, the level of support proved to be insufficient [25].

Sheltering was not extended to five towns and villages due to their own initiatives:

- Naraha Town received an evacuation order for residents residing within a 3 km zone but decided to evacuate all residents on 12 March;
- Hirono Town, which received an evacuation order for residents residing within a 10 km zone, recommended voluntary evacuation of all residents on 12 March, although a majority of the town's area was located beyond the 10 km zone;
- Katsurao Village decided to evacuate its residents on 14 March;
- Namie Town decided to evacuate its residents on 15 March;
- Kawauchi Village decided to evacuate its residents on 16 March [25].

On 25 March 2011, a recommendation for voluntary evacuation was issued by the national Government to residents within the 20–30 km zone [22, 25], in part because of the difficulties caused by prolonged sheltering [25, 27]. Many residents, however, had already voluntarily left the area. Voluntary evacuation started during the early days of the accident. NERHQ also informed Fukushima Prefecture about lodging facilities and transportation, but the decision whether or not to choose voluntary evacuation after the Government's recommendation was left to the citizens themselves [25]. In Minamisoma City, residents started to evacuate voluntarily as early as 12 March, and about 70% had left the city by 15 March with the help of officials (see Fig. 3.3–3). In addition, charter buses were made available for residents in Minamisoma City between 18 and 20 March, and again on 25 March.

On 22 April, the advisory to shelter for areas located within a radius of 20–30 km from the NPP was lifted [27]. Yet, the recommendation for voluntary evacuation was still valid.

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[58] Special facilities include telecommunications centres that need to be staffed, chemical plants that cannot be evacuated until certain actions have been taken to prevent fire or explosions, hospitals with patients who cannot be immediately evacuated and prisons whose inmates have to continue to be managed [11].

Access control to the 20 km zone around the Fukushima Daiichi NPP

On 28 March, a decision was taken to prohibit access to the evacuated areas, and evacuees were informed about this decision on 30 March [27]. Before full access controls were established, some evacuees had returned to their homes in the evacuated areas to collect belongings [27], and no monitoring of the public had been conducted when they exited the area.

On 22 April[59], the existing 20 km evacuation zone around the Fukushima Daiichi NPP was established as a Restricted Area[60], with controlled re-entry and conditions for temporary access. This decision was made in consideration of the rights of residents and was based on consultation with local governments [99]. On 9 May, the NSC provided advice on the implementation of temporary access.

The following conditions were specified for temporary access to the 3–20 km radius: an external dose rate of less than 200 μSv/h; and the time spent in the Restricted Area limited to a maximum of five hours [27].

Safety instructions were given to residents entering the Restricted Area, requiring them to wear protective clothing, carry a dosimeter and a walkie-talkie to ensure a means of communication in case of an emergency, and to bring only small items back from the Restricted Area. In addition, residents were required to be monitored for possible contamination when returning from the Restricted Area, and to undergo decontamination, if necessary [22].

In May 2011, short term temporary access was granted sequentially after coordination with the relevant local governments, with arrangements in place, including specific instructions and monitoring for contamination [27, 99, 100]: access to Kawauchi Village (on 10 and 12 May), Katsurao Village (12 May), Tamura City (22 May), Minamisoma City (25 and 27 May), Tomioka Town (25 May), Futaba Town (26 and 27 May) and Namie Town (26 and 27 May) [22, 100].

Between 13 May and 30 June, almost 20 000 residents, accompanied by staff of the respective municipalities, went to the Restricted Area (see Fig. 3.3–4).

From the end of May, private vehicles were allowed to be transferred from the Restricted Area and, when necessary, contamination monitoring was arranged for these vehicles. Private companies were given temporary access to the Restricted Area if their business would be considerably affected without such access [22].

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[59] At 11:00 on 21 April, the NERHQ issued a directive to the heads of all concerned municipalities that restricted areas should be established within the specified radius. The official establishment date was 00:00 on 22 April.

[60] Restricted Areas, established pursuant to the provisions of Article 63, Paragraph (1), of the Disaster Countermeasures Basic Act, applied by replacing the terms and phrases pursuant to Article 28, Paragraph (2), of the Nuclear Emergency Act [5].

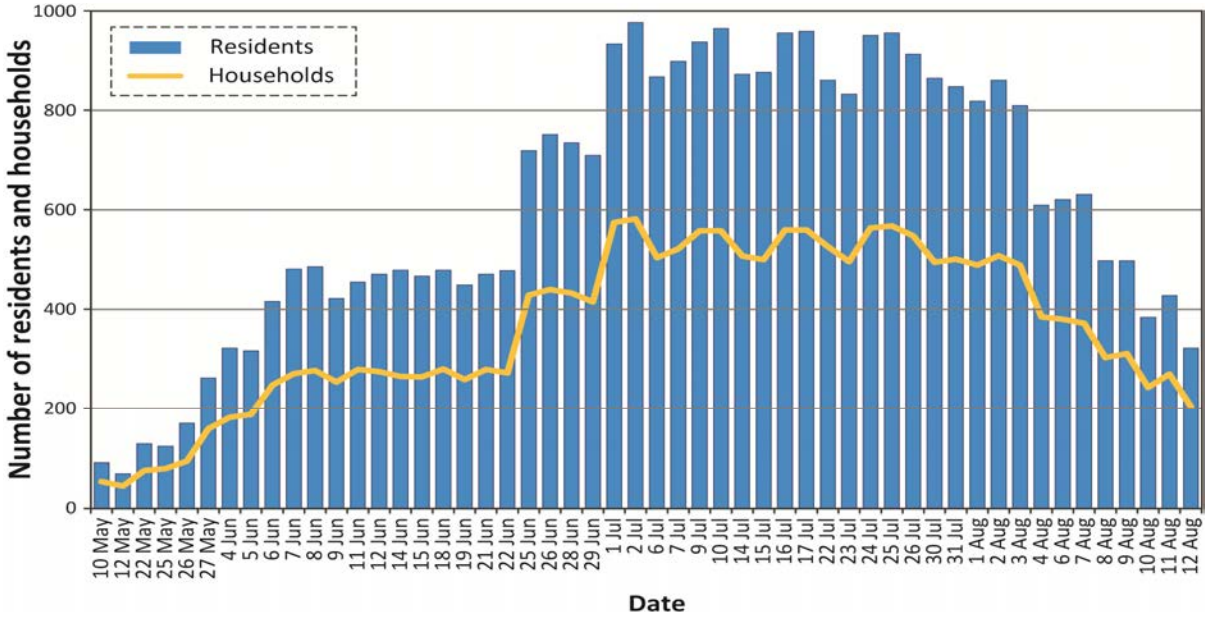

FIG. 3.3–4. Trends in the number of evacuated residents and households temporarily accessing the Restricted Area between May and August 2011 [30].[61] *Evacuation of hospitals and nursing care facilities.*

From 12 March, all hospitals within 20 km (including the designated radiation emergency hospitals) began to close to the public as a consequence of the evacuation order. Three hospitals were completely closed on 13 March and, from 15 March, only one — Fukushima Rosai hospital, located in Iwaki City, approximately 44 km south of the Fukushima Daiichi NPP — of the five primary radiation emergency hospitals in Fukushima Prefecture was functioning (see Appendix II for more details of the emergency medical systems prior to the accident). However, it suffered from severe shortage of medical personnel, who left because of a fear of radiation, among other factors. The only designated radiation emergency hospital in Fukushima Prefecture with sufficient functional capacity was the Fukushima Medical University (FMU) Hospital, which was located 60 km north-west of the plant [80].

In accordance with the Basic Disaster Management Plan [2], the local government needed to give adequate consideration to vulnerable people, such as the elderly and people with disabilities, and to try to evaluate their health conditions in the evacuation area. Prior to the accident, it was planned that evacuation of hospitals within the 10 km EPZ was to be undertaken following the emergency plans, which had been prepared by the hospitals for response to conventional hazards (e.g. fire) [1]. Only one hospital had prepared an evacuation manual for a nuclear emergency [25]. The assumption was that a nuclear emergency would be on the same scale as the JCO Tokaimura criticality accident of 1999 [25], which had only limited impact off-site. Thus, the evacuation of all patients from hospitals and nursing homes located within or beyond the EPZ was not anticipated [25]. During the investigation performed by the National Diet of Japan after the accident [25], medical staff explained that: "[i]t was impossible for us to find, by ourselves, transportation for all the hospitalized patients and hospitals to which all of them could be transferred, unless the number of hospitalized patients was around ten". They further pointed out that "[n]either the earthquake evacuation drills nor the nuclear accident drills were implemented based upon a prior anticipation of having to evacuate all hospitalized patients" [25].

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[61] The dates in this figure are not in a linear sequence; the slope and area defined by the histogram and line should therefore be interpreted with caution.

According to Tanigawa et al. [101], approximately 2220 patients and elderly people stayed in seven hospitals and 17 nursing homes within the 20 km evacuation zone. Significant challenges were encountered when evacuating patients from these hospitals and nursing homes (e.g. providing appropriate transport and evacuation shelters with medical supplies). There were seriously ill patients (e.g. terminally ill patients, patients requiring dialysis) whose conditions made it difficult to transport them without potentially causing harm or injury. During the evacuation of hospitals and nursing homes, some fatalities did occur [25]. Official sources have attributed 51 deaths (as of April 2011) to the evacuation of patients and residents from hospitals and nursing homes located within 20 km of the Fukushima Daiichi NPP [102].

Evacuation of the public within a 3 km radius was completed at 00:30 on 12 March [27]. On the morning of 13 March, lists were compiled by the Prefectural Headquarters for Disaster Control of hospitals located within the evacuation zone that had been evacuated only partially [21]. It was estimated initially that the number of patients and elderly people remaining amounted to approximately 700. However, no accurate data were available at that time [103]. The condition of the patients was also unknown. For example, the need to provide continual medical care for mentally ill patients from a psychiatric hospital was not anticipated [21].

In the morning of 13 March, the Prefecture Headquarters for Disaster Control received a request from the Local NERHQ to take care of patients at Futaba Hospital and other places. Upon receiving this request, lists of hospitals and people remaining within 20 km of the NPP were prepared and completed by around 21:40 on 13 March. Based on these lists, the rescue team of the Local Prefectural NERHQ began managing the locations of screening sites and evacuation shelters and assigning people to specific locations. The staff at these shelters informed the Local Prefectural NERHQ that, as a condition for accepting the evacuees, they would have to be monitored and decontaminated [21]. None of the hospitals in Fukushima Prefecture were able to accept the hospitalized patients that were evacuated. Arrangements were made for the evacuated patients to be monitored at a location 30 km away, at the Soso Public Health Centre in Minamisoma City.

The largest number of patients and elderly people (339) evacuated was from Futaba Hospital, located within 5 km from the Fukushima Daiichi NPP. The Prefectural Headquarters for Disaster Control was unaware that many of the patients at the hospital were bedridden (e.g. requiring dialysis, suffering from dementia or in a terminal condition) [21]. It was assumed that, since Futaba Hospital treated patients with mental health problems, only a few of them would have physical problems [21].

Patients from this hospital were transported on 14 March “over a long distance (approximately 230 km) and over a long period of time (over ten hours), with the result that some patients lost their physical strength and others died” [25] (see Fig. 3.3–5). Three patients died in the vehicle during the evacuation, and an additional 11 patients died by early morning of the following day at the evacuation shelter (a high school), at which no medical facilities were available to the patients [25]. Some of the patients and elderly people were not accompanied by the appropriate medical staff when they were evacuated. It was also reported that, during transportation, some bedridden patients were laid on bus seats and suffered traumas when they fell off the seats; in other cases, patients were placed in an unheated room at an evacuation shelter [101].

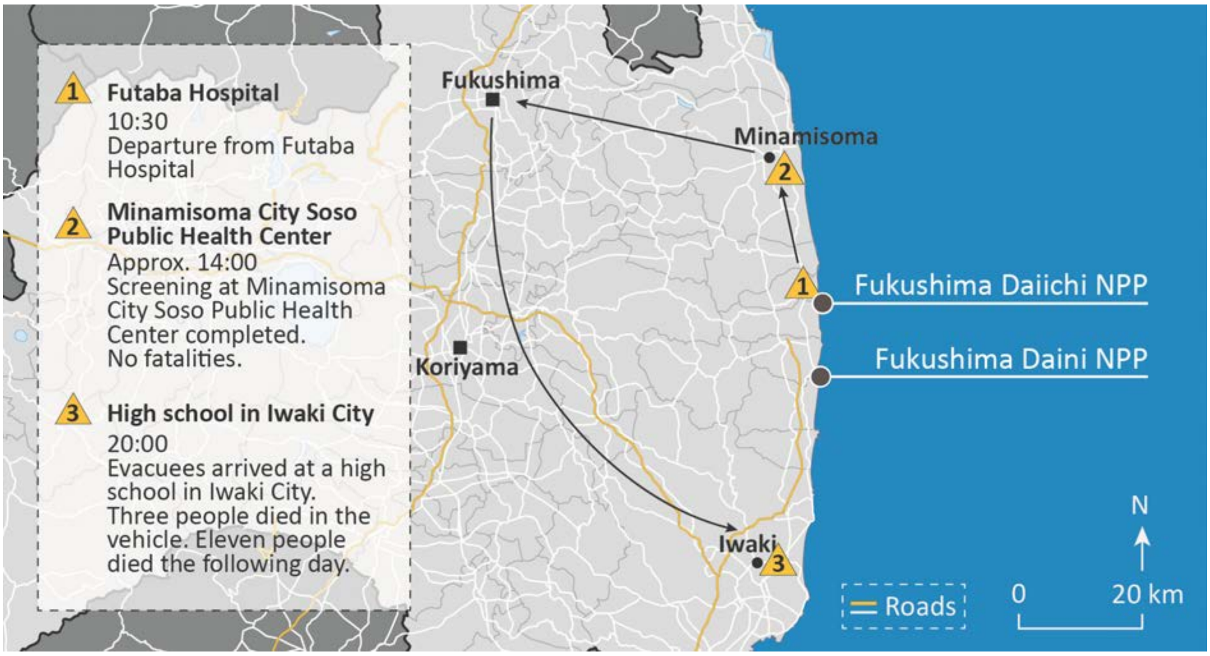

FIG. 3.3–5. The 230 km route of the journey taken by patients evacuated from Futaba Hospital to the high school in Iwaki City [25].

Several rescue teams were dispatched to Futaba Hospital. However, the failure of communication systems meant that the rescue teams were unable to coordinate their missions. One team suspended its mission due to its adherence to the occupational dose limit for females (5 mSv) [21]. The second rescue team did not confirm, prior to leaving, that all patients had been evacuated from all buildings of the hospital. Consequently, some patients were left behind. Four of the remaining 130 patients died at the hospital — two on 13 March and two on 14 March — and another patient left the hospital and went missing [21].

On 15 March 2011, the national Government ordered sheltering in a radius of 20–30 km from the Fukushima Daiichi NPP. On 17 March, the evacuation of all hospitalized patients and elderly people in care facilities within the sheltering zone was initiated because of a shortage of medical supplies and commodities in the area. At this time, the Disaster Medical Assistance Team (DMAT)[62] headquarters, located at the MHLW, planned and arranged the evacuation of more than 400 patients with the support of DMATs [105]. It took two days to obtain permission from the Government to dispatch DMATs to Fukushima Prefecture, largely due to the need for inter-ministerial coordination[63]. Many ambulances and SDF vehicles were mobilized at this time, and DMATs were engaged in performing triage of the patients at collection sites and in providing medical care before and during evacuation. Although it took four days to complete, the evacuation was performed safely without any casualties.

3.3.2.2. Iodine thyroid blocking

Radioactive iodine can be released when the fuel in the reactor core or fuel recently removed from the core overheats. People near the NPP (within about 10–30 km), even those being sheltered, may then

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[62] A DMAT is a specially trained medical team for dealing with disasters, consisting of one doctor, two nurses and a logistics specialist [104].

[63] The radiation emergency medical system had been developed under the direction of MEXT, whereas DMATs were under the MHLW.

inhale radioactive iodine, which would concentrate in the thyroid gland causing exposure. Inhalation of radioactive iodine by pregnant women may also lead to exposure of the foetus. The uptake of radioactive iodine by the thyroid gland can be reduced by increasing the intake of stable iodine, which diminishes the impact of radioactive iodine on the thyroid gland (and the foetus). This process is known as iodine thyroid blocking (ITB). To be effective, stable iodine must be administered before or shortly after inhalation or ingestion of the radioactive iodine (i.e. within about two to six hours) [106].

At 13:15 on 12 March, the Local NERHQ issued an order to the Prefectural Government and the respective towns (Okuma Town, Futaba Town, Tomioka Town and Namie Town) that, if a decision was taken to implement ITB, then stable iodine tablets would need to be distributed to evacuation centres, and pharmacists and doctors would need to be stationed at these centres [27]. However, implementation of the ITB was not ordered.

From 03:10 on 15 March to 16 March, discussions were held between the NSC and Local NERHQ through the METI-ERC concerning the distribution of stable iodine tablets to the public. Finally, the Local NERHQ issued an order at 10:35 on 16 March to the Fukushima Prefectural Government and municipalities indicating that stable iodine should be administered to those who were being evacuated from within a radius of 20 km of the Fukushima Daiichi NPP. However, the Fukushima Prefectural Government did not follow this order, because it had already confirmed that evacuation of people from within the 20 km zone was complete [27].

On 14 March, the Fukushima Prefectural Government decided to distribute two stable iodine tablets to each resident younger than 40 years old outside the 20 km radius and within an approximate radius of 50 km of the Fukushima Daiichi NPP. By 20 March, the Fukushima Prefectural Government had distributed approximately 1 000 000 stable iodine tablets [27].

Administration of stable iodine for ITB was not implemented uniformly, owing primarily to inadequate pre-planned arrangements. Some local governments distributed stable iodine tablets but did not advise taking them, while others distributed the tablets and advised the public to take them, and still others awaited instructions from the national Government [27].

With regard to the use of ITB based on skin monitoring results, a meeting of the national Government took place at midnight on 12 March to decide whether and when to issue orders on administration of stable iodine. It was decided that stable iodine should be taken when the results of skin monitoring (screening)[64] exceeded 10 000 counts/min, but this was not implemented[65].

3.3.2.3. Monitoring of the public

In general terms, it is very unlikely that, in the event of a severe reactor emergency, radioactive material deposited on the skin or clothing would represent an important health hazard to anyone off-site. Following the accident at the Fukushima Daiichi NPP, radioactive material deposited on the skin and clothing of the public was monitored to determine if protective or other response actions were warranted.

The monitoring teams in Fukushima Prefecture were managed in a structured manner with teams, equipment and activities scheduled and registered. A system was established for sharing information, with meetings held twice a day. At each briefing, radiation protection and safety issues, including an

[64] In some documents describing the response to the Fukushima Daiichi accident, monitoring of the public is called screening.

[65] While the effectiveness of taking stable iodine when the skin is already contaminated above certain criteria would be limited, it is considered a good practice, as it helps reduce some of the dose to the thyroid [107].

explanation of the steps for preventing internal contamination, were emphasized. The members of the monitoring teams wore protective coveralls and face masks. The monitoring teams were composed of personnel with experience conducting monitoring under normal conditions. Since the members of the monitoring teams routinely worked with radiological detection equipment, it was assumed that no special training for conducting monitoring under emergency conditions was required. The monitoring teams used Geiger–Mueller (GM) survey meters held 1 cm from the body of a monitored individual. For each individual, a few minutes were needed to perform the monitoring.

In accordance with its emergency plan, the Fukushima Prefectural Government began monitoring evacuees as of 12 March, using an operational intervention level (OIL) of 13 000 counts/min that was established for personal decontamination prior to the accident (which corresponded to a response to a surface concentration of 40 Bq/cm^2 for the monitoring instruments they were using) [21].

From 14 March [21], the Fukushima Prefectural Government raised the OIL for public monitoring to 100 000 counts/min[66] for personal decontamination and 13 000 counts/min for partial wipe-off decontamination[67] [21]. The OIL for personal decontamination was increased on the recommendation of the radiation emergency medical team in view of the fact that whole body decontamination was unsuitable under the low temperatures prevailing at the time; most evacuees did not have a change of clothes, and no heated shower facilities were available [21].

On 20 March, the Local NERHQ issued an order to raise the OIL level to 100 000 counts/min based on the provisions of Article 20, Paragraph 3, of the Nuclear Emergency Act [5]. This meant that no decontamination would be required for those with count rates of less than 100 000 counts/min. However, the Fukushima Prefectural Government did not change its practice of conducting partial wipe-off decontamination for those with count rates of 13 000 counts/min, in order to avoid confusing those performing the monitoring and to ensure the safety of those with count rates of 13 000 counts/min [21].

Shelters, hospitals, apartments and other facilities, not only in Fukushima Prefecture but also in other prefectures, began to refuse accepting evacuees who did not have evidence that monitoring had been performed. Because of this, a certification process was created, and a certificate was issued if the monitoring did not detect levels above the criteria (100 000 counts/min) during the initial survey or after decontamination. The issuance of certificates caused problems, because shelters refused to accept evacuees without a certificate. In its document issued on 21 March 2011, the Community Health Office of MHLW stated that it was not appropriate for public health centres to issue certifications, because this could lead to an increased workload that may interfere with essential tasks.[68] However, Fukushima Prefecture did not stop issuing the certificates, since they were still in demand [108].

It was also reported that some medical staff at medical facilities refused to treat patients who were possibly contaminated [109].

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[66] 100 000 counts/min is consistent with the OIL for skin contamination in IAEA safety standards [14] calling for skin decontamination and medical examination.

[67] Partial wipe-off decontamination involves using wet towels or tissues for removing localized contamination.

[68] Article 6 of the Community Health Act (Act No. 101 of 1947) stipulates essential tasks by public health centres. On 18 March 2011, the Community Health Office, General Affairs Division, Health Service Bureau and MHLW, requested community health departments in the prefectural government (a city as prescribed by the Cabinet Order as set forth in Article 5(1) of the Community Health Act) and in a special ward of Tokyo to conduct health consultations related to the health effects of radiation on residents in public health centres and equivalents. The document issued by the Community Health Office on 21 March 2011 additionally requested that public health centres do not issue certifications because of the higher workload this would entail, which would have an impact on essential tasks, including health consultations.

More than 200 000 people, representing over 10% of the population of Fukushima Prefecture, were monitored in total. The measurement results of 901 individuals were between 13 000 and 100 000 counts/min, and these individuals therefore needed partial wipe-off decontamination. The measurement results of 102 individuals were higher than 100 000 counts/min, thus requiring whole body decontamination. The results of measurements for the latter group were below 100 000 counts/min once they had removed their clothing [27].

3.3.2.4. Prevention of inadvertent ingestion

The inadvertent ingestion of radioactive material deposited on the skin or on the ground (e.g. from inadvertent ingestion of dirt on hands) can be a significant source of dose for those living near the NPP (e.g. 10–30 km) in the first few days following a release [110]. Inadvertent ingestion can be reduced by following some simple precautions, such as keeping hands away from the mouth and refraining from eating with possibly contaminated hands or smoking in the potentially contaminated areas. However, no evidence was found that such orders were provided to the public around the Fukushima Daiichi NPP.

3.3.2.5. Restriction on ingestion of local produce, milk from grazing animals, rainwater and wild grown products

The accident at the Chernobyl NPP clearly demonstrated that ingestion of food and water directly contaminated by the release (e.g. leafy vegetables and rainwater) or contaminated through the food chain (e.g. milk from animals grazing on open grass and wild products[69]) can be a major source of dose within the first weeks following a release [111].

Following a radioactive release, the patterns of the deposition are very complex and are constantly changing if there is an ongoing release. These complex and changing deposition patterns may make it impossible to promptly identify areas that warrant restrictions on consumption, solely on the basis of monitoring and sampling, particularly for those items that could be consumed shortly after the radioactive material has been deposited (e.g. within the first week). Therefore, as an urgent protective action, restriction of the consumption of food and water directly contaminated by the release of radionuclides (e.g. leafy vegetables, milk from animals grazing on open grass, rainwater and wild products) needs to be taken immediately after a release and before monitoring is performed. Afterwards, restrictions on food and water consumption need to be based on monitoring results of food and water samples [107, 112].

Within 24 hours of the onset of the accident at the Fukushima Daiichi NPP, the Ministry of Agriculture, Forestry and Fisheries (MAFF) requested the Fukushima Prefectural Government to stop collection of wild mushrooms and wild edible plants and to stop harvesting crops in the event of any releases of radionuclides into the environment [113]. On 15 March, MAFF started providing instructions and guidance on sampling and analysis to the local governments of affected prefectures and cities.

3.3.3. Early protective actions

Early protective actions are those actions that must be taken within days or weeks to be effective. They can be long lasting, even after the termination of the emergency. Unlike urgent protective actions, it is generally possible to base these actions on the results of monitoring that takes account of the specific nature of the release of radioactive material and its dispersion in the environment.

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[69] For example, wild mushrooms and game.

Examples of early protective actions include relocation, restrictions on food and drinking water and controls on agriculture [11, 12]. A timeline of events related to the implementation of early protective actions relevant to the Fukuskima Daiichi accident is presented in Fig. 3.3–6.

12 March

- Early morning | Monitoring began within a 20 km radius of the Fukushima Daiichi NPP (suspended at 21:00)

15 March

- 09:00 | Maximum radiation level at main gate (ca. 12 mSv/h)
- Evening | Sampling results measured above 277 000 Bq/kg (^{131}I) and 31 100 Bq/kg (^{137}Cs) in vegetation (more than 30 km from the Fukushima Daiichi NPP)
- 20:40–50 | Dose rates in the order of a few hundred µSv/h measured in some locations beyond the 20 km evacuation zone

16 March

- Responsibility of environmental monitoring re-assigned from local government to MEXT

17 March

- Provisional Regulation Values to restrict food and drinking water established
- Dose rates above 100 µSv/h measured beyond the area already evacuated

18 March

- NSC requested NISA to check the existence of houses where the dose rate was above 100 µSv/h

19–20 March

- Concentrations exceeding Provisional Regulation Values detected in raw milk, spinach and leafy vegetables (more than 100 km from Fukushima Daiichi NPP)

19 March

- MAFF provided information to cattle farmers aimed at ensuring radionuclide levels in livestock were not significantly affected by radionuclides in animal feed

20 March

- National Government received aerial monitoring data from the United States of America

21 March

- National Government began to issue restrictions on the distribution of specific foods

22–23 March

- Residents informed to refrain from allowing infants to drink tap water at locations more than 100 km from Fukushima Daiichi NPP

25 March

- National Government recommended voluntary evacuation for residents within the 20–30 km radius of the Fukushima Daiichi NPP

11 April

- National Government announced criterion of 20 mSv dose to determine areas beyond the 20 km evacuation zone from which people might need to be relocated

19 April

- National Government established criterion of 20mSv/y to determine reopening of schools (The criterion of 20 mSv/y was later reduced to 1 mSv/y)

FIG. 3.3–6. Timeline of key events relevant to early protective actions.

22 April

- Deliberate Evacuation Area, Evacuation Prepared Area in Case of Emergency and Restricted Area established

15 May

- Commencement of relocation from the Deliberate Evacuation Area

30 June onwards

- National Government began to designate locations for relocation, identified as Specific Spots Recommended for Evacuation

30 September

- Evacuation Prepared Area in Case of Emergency lifted

FIG. 3.3–6. Timeline of key events relevant to early protective actions (cont.).

3.3.3.1. Relocation

As discussed in Section 3.3.2.1, on 25 March a recommendation for voluntary evacuation within the 20–30 km zone was announced [25, 27]. A large proportion of residents had already left before the recommendation was issued [25].

On 11 April 2011, the national Government announced that the criterion of 20 mSv dose projected to be received within one year from the date of the accident would be used to determine areas beyond the 20 km evacuation zone from which people might need to be relocated[70] [22]. This criterion was recommended by the NSC on 10 April [25, 27, 114], applying the lowest level in the 20–100 mSv band of reference levels for emergency exposure situations from the ICRP [115][71], at which consideration should be given to reducing doses. According to the ICRP [115], the selection of the criteria also needs to be justified and do more good than harm, considering the overall impact of the actions taken to reduce the dose.

Monitoring results from 15 March and afterwards indicated that there were areas beyond the evacuated areas where the dose to residents would exceed 20 mSv/y [25].

On 22 April 2011, a Deliberate Evacuation Area was established beyond the 20 km evacuation zone to include areas where the projected dose criterion of 20 mSv in one year might be exceeded[72]. This was pursuant to the provision of Article 20, Paragraph 3, of the Nuclear Emergency Act [5]. The boundary of the area was determined in part by using estimated values of the integrated (cumulative) effective dose over one year after the onset of the accident based on measurements [21].

The area covered Katsurao Village, Namie Town and Iitate Village, part of Kawamata Town, and part of Minamisoma City. The national Government issued an order to the effect that relocation of people from this area should be implemented in approximately one month [22, 117].

The delay in establishing a Deliberate Evacuation Area was due to the need to coordinate and consider the opinions of different stakeholders, as there were no existing criteria for relocation prior to

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[70] Most of the official Japanese documents describing the response to the Fukushima Daiichi accident do not use the term relocation but refer to the movement of people as 'evacuation'.

[71] Prior to this decision, on 21 March, a message was issued by the ICRP which contained quotes from generally applicable recommendations of the ICRP (see Annex II).

[72] The recommendation of the ICRP was considered as a reference by the NSC when determining the criteria for establishing the Deliberate Evacuation Area. The criteria for establishing the Deliberate Evacuation Area was authorized by the Japanese Government after reporting its basis to Nuclear Emergency Response Headquarters [116].

the accident. There were also concerns that an expansion of the zone would cause confusion and anxiety among the public [25].

In addition to the Deliberate Evacuation Area, an Evacuation Prepared Area in Case of Emergency (hereafter referred to as Evacuation Prepared Area) was established on 22 April 2011 (see Fig. 3.3–7). Residents of the Evacuation Prepared Area were advised to shelter or evacuate by their own means in the event of possible renewed concerns regarding the Fukushima Daiichi NPP. The designation of the Evacuation Prepared Area was lifted on 30 September 2011 [27].

As a result of the environmental monitoring conducted beyond the Restricted Area (i.e. the 20 km evacuation zone) and the Deliberate Evacuation Area, specific locations were identified with projected doses to residents above 20 mSv within one year after the occurrence of the accident. On 16 June, the national Government announced a guideline which specified that these locations should be designated as Specific Spots Recommended for Evacuation. As of 30 June, the national Government began to designate these locations to be relocated [25, 27].

In order to implement this action, the Local NERHQ was given the task to consult and coordinate with the Fukushima Prefectural Government and the municipalities where the spots recommended for evacuation were located. On 30 June and 25 November, it was recommended that residents living in specific hot spots in Date City should be relocated; on 21 July and 3 August, the same recommendation was made for residents living in Specific Spots of Minamisoma City [27]. As of May 2012, 282 houses were declared to be located in Specific Spots [25]. Residents of these households were offered the choice to relocate; if they decided to do so, they would receive compensation[73]. The implementation of this relocation varied. In some cases, local governments established their own criteria for identifying households to be relocated and also set different criteria to be applied for children and pregnant women [25].

Reopening of schools

Schools in Japan had been closed for spring vacation from the end of March. Local government officials had to decide at an early stage whether to reopen schools and under what conditions. There was a need to set a criterion for reopening schools located in the areas where residents were advised to shelter. At the start of April, Fukushima Prefecture requested the national Government for advice concerning the reopening of schools. Preparation of advice involved consultations between MEXT, which provided air monitoring results, and the NSC. A letter from the ICRP, sent on 21 March 2011, was taken into account.

Initially, on 19 April 2011, a dose criterion of 20 mSv/y was established for this purpose. Based on this dose criterion, an operational criteria of a dose rate of 3.8 μSv/h was calcuated and used in the decision about reopening schools. On 19 April 2011, a decision was also made to restrict outdoor activities at schools and kindergarten grounds with dose rates of more than 3.8 μSv/h [25].

Based on this operational criteria of 3.8 μSv/h, decontamination activities were perfomed for the schools in Fukushima Prefecture. According to the information provided by the Report of National Diet of Japan [25], decontamination activities were also performed for most of the schools in Fukushima Prefecture, including those where the operational criteria were not exceeded. This was done to address public concerns.

The reopening of schools was categorized as action in an existing exposure situation, while the establishment of the Deliberate Evacuation Area was handled as an emergency exposure situation. However, in both cases, the criterion of 20 mSv projected annual dose was used [25].

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[73] However, some residents who remained also requested compensation.

The criterion of 20 mSv/y was later reduced to 1 mSv/y. According to the Report by the National Diet, this was done in response to concerns on the part of the public [25]. On 27 May, a notification was issued by MEXT for reducing the dose to children, students and others at schools and other facilities in Fukushima Prefecture. The notification specified a target dose of 1 mSv per year, stipulated that dosimeters should be distributed to schools and stated that financial support for decontamination was to be offered to schools with dose rate measurements higher than 1 μSv/h.

On 26 August, MEXT announced that, after the summer vacation, the criterion of 1 mSv/y would be applied to schools, and the operational criterion of 1 μSv/h would be used [27].

Overview of implemented urgent and early protective actions

The areas and locations for which protective actions were ordered or recommended until 30 September 2011 are shown in Fig. 3.3–7.

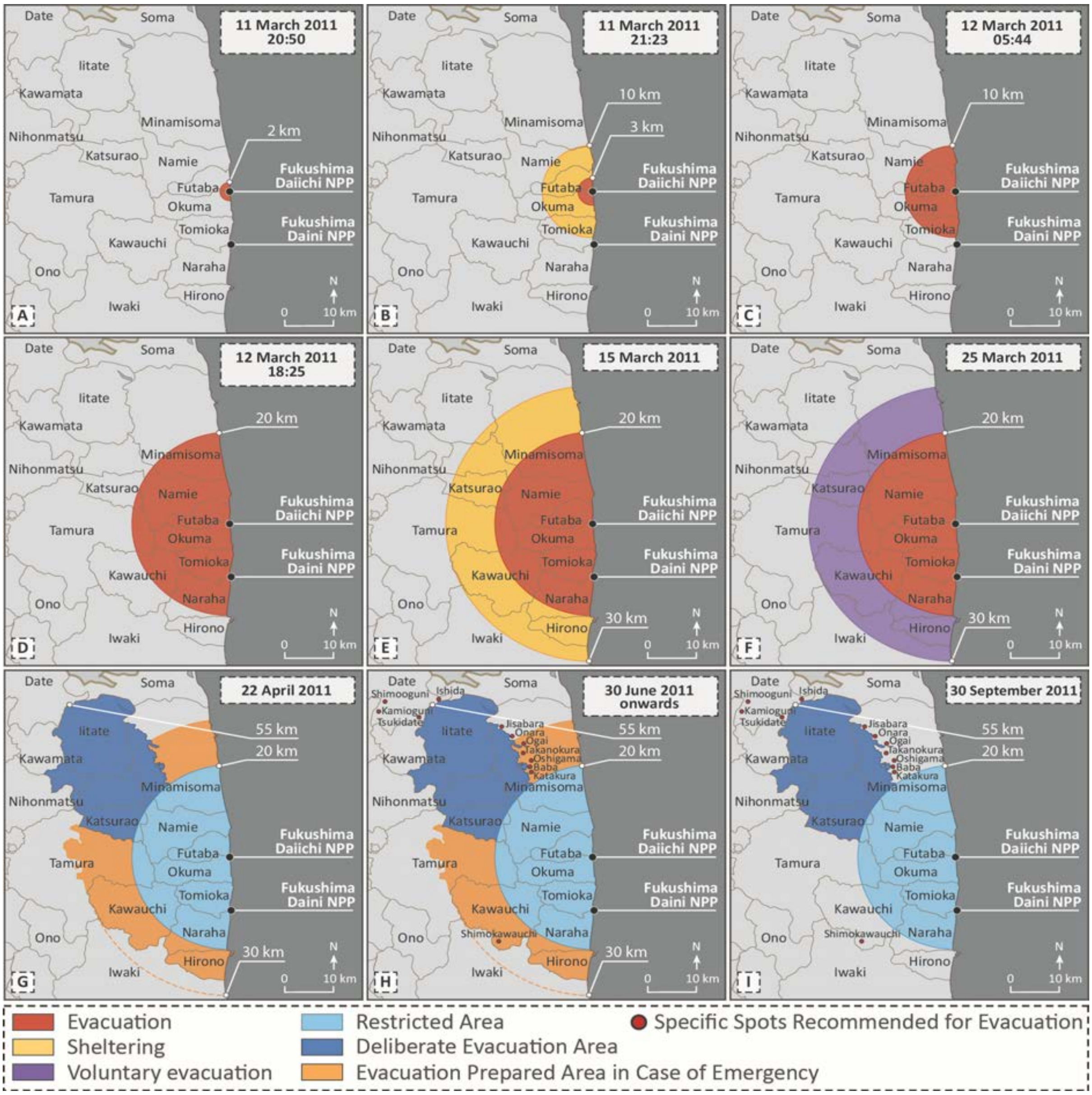

FIG. 3.3–7. Areas and locations where protective actions were ordered or recommended until 30 September 2011 (based on Refs [22, 25, 27, 99]).

3.3.3.2. Protective actions relating to food and drink

Following a release of radioactive material resulting from damage to the fuel in a reactor core, consumption of vegetables grown in the open air, milk from animals grazing on contaminated grass and rainwater can be one of the largest contributors of dose [13].

Authorities in Japan took actions to control the distribution of food, milk and drink from affected areas.

Food and milk

Environmental monitoring was being carried out by the Fukushima Prefectural Government as early as 15 March 2011 and was based on their Prefecture Disaster Management Plan. The results of initial environmental monitoring programmes began to indicate the levels of radionuclides present in vegetation, surface waters and soils in different locations.

On the evening of 15 March, initial results were available indicating ^{131}I at levels ranging from 277 to 1230 kBq/kg and ^{137}Cs in the range of 31.1 to 169 kBq/kg in vegetation (weeds) at four locations, at a distance of 36 km and 46 km from the Fukushima Daiichi NPP [25]. These levels were higher than the provisional regulation values[74] established by MHLW two days later, on 17 March, under the Food Sanitation Act, by adopting into law the criteria in the NSC Nuclear Emergency Preparedness Guide (Table 3.3–3) [118].

As mentioned in Section 3.3.1, criteria for activity concentrations of specific radionuclides for use as the basis for placing restrictions on food and drinking water, in the case of a nuclear emergency, had been developed in Japan before the accident [19]. However, these values had not been adopted for use in an emergency as specific regulatory limits [25, 27]. Therefore, within days of the accident the authorities were deciding on limits related to radionuclides in food and drink. Overnight, from 14 to 15 March, MHLW and MAFF were in discussions about control and regulatory actions relating to radioactivity in food.

Results for activity concentrations of ^{131}I, ^{134}Cs and ^{137}Cs in leafy vegetables, pond water and soil samples, taken on 16 and 17 March 2011, indicated high levels of these radionuclides at various locations [119].

Fukushima Prefecture, the Tokyo Metropolitan Government and Tochigi, Ibaraki and Gunma prefectures commenced monitoring of food items as of March 16 [25]. Results specifically relating to food were published on the MHLW web site from 19 March. For example, food samples reported on 19 March included three raw milk samples taken in Fukushima Prefecture and 12 vegetable samples (spinach and spring onions) taken from Ibaraki Prefecture; these were representative of the food in production at this time of year in Japan.

Subsequently, the NERHQ developed measures aimed at defining the food production and collection areas affected, and restricting the consumption and movement of products exceeding the criteria. Arrangements were made for controlling food and drinking water through directions issued from NERHQ. These arrangements included: (1) radionuclide concentration levels of radioactive caesium and radioactive iodine in food and drinking water established as Provisional Regulation Values under the Food Sanitation Act, above which food and drinking water were restricted; and (2) measurements

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[74] These levels also included radionuclides that were not directly relevant to this emergency, for example uranium and alpha emitting radionuclides of plutonium and transuranic elements, that were developed for accident scenarios other than those postulated for an NPP.

of radionuclide concentrations in samples of food and drinking water. Within a few weeks, the levels of ^{131}I had decreased significantly owing to its short half-life (about 8 days), and the food restrictions in the medium to long term were based on concentrations of radioactive caesium only [118].

TABLE 3.3–3. PROVISIONAL REGULATION VALUES FOR RADIONUCLIDE LEVELS IN FOOD AND WATER UNDER THE FOOD SANITATION ACT

Nuclide	Product	Provisional Regulation Value (Bq/kg)
Radioactive iodine (representative radionuclides among mixed radionuclides: I-131)	Drinking water Milk, dairy products*	300
	Vegetables (except root vegetables and tubers) [Fishery products, included from 5 April 2011] **	2000
Radioactive caesium	Drinking water Milk dairy products	200
	Vegetables Grains Meat, eggs, fish, etc.	500
Uranium	Infant food Drinking water Milk, dairy products	20
	Vegetables Grains Meat, eggs, fish, etc.	100
Alpha-emitting nuclides of plutonium and transuranic elements (total radioactive concentration of Pu-238, Pu-239, Pu-240, Pu-242, Am-241, Cm-242, Cm-243, Cm-244)	Infant food Drinking water Milk, dairy products	1
	Vegetables Grains Meat, eggs, fish, etc.	10

* The order was not to use products in excess of 100 Bq/kg for infant formula or for drinking directly (hence the drinking water limit for infants was also effectively 100 Bq/kg).
** On 5 April 2011, based on measured concentrations of ^{131}I in fish samples (sand lance), the Provisional Regulation Values were added for activity concentrations of radioactive iodine (2000 Bq/kg) in fishery products [120].

On 21 March 2011, the national Government began to issue restrictions on the distribution of specific food [121] that evolved with the changing situation. The Director General of the NERHQ directed the governors of Fukushima, Ibaraki, Tochigi and Gunma prefectures to impose restrictions on the distribution of spinach and kakina harvested in these prefectures, and fresh milk produced in Fukushima Prefecture [121]. Food restrictions were formulated on the basis of the results of monitoring of food samples that determined which foods were exceeding the criteria and were used to defined the geographical location(s) affected [122, 123].

On 22 March 2011, food sampling results indicated levels of radionuclides above the Provisional Regulation Values in other types of vegetables and also in fresh milk in other areas. Therefore, in addition to the earlier food restrictions, on 23 March, the Director General of NERHQ directed the

Governor of Fukushima Prefecture to impose restrictions on the consumption and/or distribution of leafy vegetables, any flower head brassicas and turnips produced in Fukushima Prefecture. The Director General of NERHQ also directed the Governor of Ibaraki Prefecture to impose restrictions on the distribution of fresh milk and parsley produced in Ibaraki Prefecture [122]. Separate orders issued by the MHLW on 23 March 2011 instructed governors in the neighbouring prefectures of Miyagi, Yamagata, Saitama, Chiba, Niigata and Nagano to extend the monitoring programme of agricultural and livestock products [123].

Over the following months and years, it was this mechanism of using surveillance monitoring and analytical results to determine which foods exceeded the criteria, and to define the affected geographical location(s) where products were contaminated, that was used to formulate food restrictions.

Food monitoring activities increased to include many different prefectures, with Fukushima Prefecture and neighbouring prefectures taking significantly more samples than those located farther from the site of the accident. From 19 March 2011, and over the first four months following the accident, the average number of food samples per day reported by the MHLW was reasonably constant at around 60. This number increased rapidly from July to a maximum of over 700 sample results reported per day in December 2011 (Fig. 3.3–8) [124].

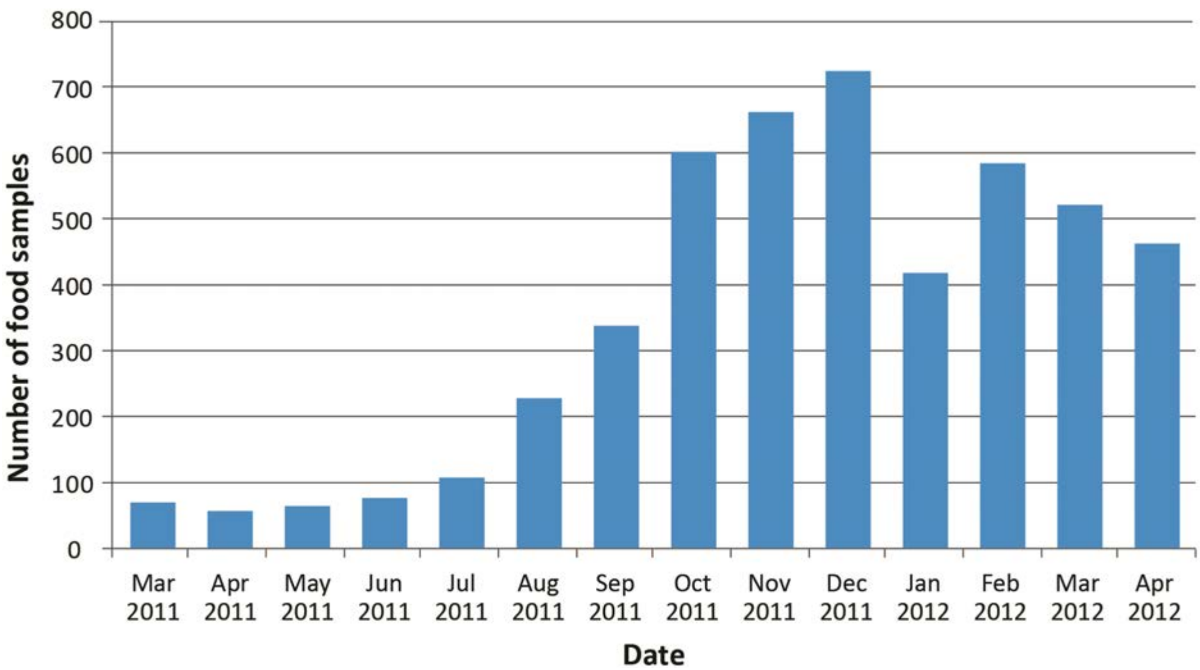

FIG. 3.3–8. Average daily number of food samples reported by MHLW from March 2011 to April 2012 [124].

On 22 March, TEPCO informed MHLW of data indicating radionuclide levels in seawater samples collected at and around a water drain located in the south of the Fukushima Daiichi NPP. MHLW immediately asked Ibaraki and Chiba prefectures to extend their monitoring plans to include seafood available at the coast (due to earthquake and tsunami damage there was no offshore sea fishing) [125].

On 4 April 2011, a policy was established that enabled placement of food restrictions not only in areas defined by prefectural boundaries but also in smaller geographical areas (such as cities, towns and villages), as appropriate. The policy set out a process to establish or lift restrictions on different food products. Prefectures could apply for modifications to restrictions on the condition that the food monitoring results were below Provisional Regulation Values three consecutive times in weekly monitoring tests [25].

This policy and the legal mechanism of issuing directions under the Nuclear Emergency Act [5] were subsequently used to establish, modify or remove restrictions on different food products. This 'sample and restrict' policy was revised several times to adapt to the situation [27].

The policy revision in June 2011 was necessary because levels of ^{131}I had declined significantly, and levels of caesium radionuclides in food became the main focus of concern. Additional prefectures were also directed to sample food on a regular basis, and additional types of foods were incorporated into the monitoring plans. Samples at that time included foods which were consumed in large quantities in Japan even if the food had not previously been identified as having elevated levels of radionuclides. The revision of 4 August 2011 directed more prefectures to sample foods regularly and emphasized that beef had previously been identified as containing radioactive caesium above the provisional regulatory values [126].

On 1 April 2012, standard limits came into force, which replaced the Provisional Regulation Values (Table 3.3–4).

TABLE 3.3–4. STANDARD LIMITS FOR RADIONUCLIDE LEVELS IN FOOD AND DRINK INTRODUCED ON 1 APRIL 2012

Category	Standard limit for radioactive caesium (Bq/kg)
Drinking water (including beverages)	10
Infant food	50
Cattle milk, including milk based drinks and milk based milk substitutes, but excluding yogurt or yogurt drinks	50
General food	100

These limits specified activity concentrations for radionuclides in food and drinking water on the basis of an effective dose of 1 mSv/y (while the criterion of 5 mSv/y had been used as a basis for the Provisional Regulation Values). The limits took into account the contributions to dose of a range of radionuclides released during the accident by assuming that these additional radionuclides were present in fixed proportions to the concentration of caesium radionuclides. As a consequence, these values were much lower than the Provisional Regulation Values they replaced [127].

Tap water

From 17 March onwards, the concentrations of radionuclides in tap water were measured for each prefecture [22].The MHLW provided regular updates on tap water monitoring data. On 19 March, the MHLW notified local government departments and agencies that the public should avoid consuming tap water if the radionuclide concentration exceeded the Provisional Regulation Values. The MHLW also provided results of water monitoring [22]. On 21 March, the MHLW notified local government departments and agencies that infants should avoid consuming tap water if the radionuclide concentration exceeded the Provisional Regulation Values of 100 Bq/kg of radioiodine [128]. On the same day, the MHLW also announced that radioiodine concentrations (965 Bq/kg of ^{131}I) at a small scale water utility in Iitate Village exceeded the Provisional Regulation Values. Residents were advised of the low health risk and were allowed to continue consuming the water if no alternatives were available. They were also advised that the water could be used for other domestic uses [129, 130].

On 22 March 2011, the MHLW announced the results of drinking water monitoring on the previous day and requested that Date City, Koriyama City, Tamura City, Minamisoma City and Kawamata Town in Fukushima Prefecture inform their residents to refrain from having infants intake tap water (including giving infants formula milk dissolved by tap water, etc.), because radionuclide levels exceeded the Provisional Regulation Value (100 Bq/kg of ^{131}I) that was applicable to infants' drinking water [128]. Similar advice was issued on the following day (23 March) for Iwaki City in Fukushima Prefecture, by the Tokyo Metropolitan Government [131], Tokai Village and Hitachiota City in Ibaraki Prefecture [132]. Thereafter, the MHLW continued the practice of announcing the previous day's drinking water monitoring results and advised the population to refrain from drinking water, as necessary. Advice not to drink tap water was subsequently extended to cover additional prefectures.

On 4 April 2011, the MHLW announced the water monitoring policy, the imposition of restrictions and the cancellation of previous restrictions on drinking water [133]. With regard to the water supply monitoring policy, the MHLW directed regional water suppliers to monitor water by undertaking surveys to measure ^{131}I and caesium radionuclide levels, especially in Fukushima, Miyagi, Yamagata, Niigata, Ibaraki, Tochigi, Gunma, Saitama, Kanagawa, Chiba and Tokyo prefectures. Tap water suppliers were directed to sample water from taps or water filtration plants.

3.3.3.3. Actions to protect agriculture

This part focuses on early actions taken to protect agriculture, specifically in relation to animal feed (primarily to prevent the uptake of caesium radionuclides into dairy and meat products) and actions to minimize the risk of producing rice with caesium radionuclide levels in excess of the Provisional Regulation Values.

Animal feed and contamination of beef

On 19 March 2011, MAFF provided information for cattle farmers as a Notice on Farming Management [27]. This was issued through the prefectural governments in the Tohoku and Kanto districts. This notice was aimed at ensuring that radionuclide levels in livestock were not significantly affected by radionuclides in animal feed. It stated that: cattle raised in regions where dose rates were higher than background must be fed with hay from grass that had been cut, gathered and stored prior to the accident; drinking water for cattle had to be kept in a sealed water tank to prevent contamination; and cattle must not be sent to graze (outdoors on pasture) until further notice.

On 14 April 2011, MAFF provided cattle farmers with a notice via the prefectural governments in the Tohoku and Kanto districts to establish Provisional Permissible Values of concentration levels of radioactive caesium and radioactive iodine in forage for cattle (including hay, pasture grass and straw), in order to prevent or reduce the contamination of beef and milk. This notice stated that the concentrations of radionuclides should be below 70 Bq/kg for radioactive iodine and 300 Bq/kg for radioactive caesium in forage for milking cattle, below 300 Bq/kg for radioactive caesium in forage for beef cattle and below 5000 Bq/kg for radioactive caesium in forage for cattle other than milking and beef cattle [27].

On 8 July 2011, levels of caesium in beef samples exceeding the Provisional Regulation Value (500 Bq/kg) in food were measured in samples collected from Fukushima Prefecture and subsequently in beef from other prefectures. The MAFF Notice on Farming Management was addressed to cattle farmers, but it was not communicated to grain farmers who produced rice straw. It is likely that cattle farmers had fed their cattle with rice straw that had been stored outdoors and had probably been contaminated. A control regime was put in place to prevent such meat from being distributed to consumers [27].

On 1 August 2011, before the rice and wheat harvest, MAFF notified all prefectural governments of maximum Provisional Permissible Values for animal feed (300 Bq/kg of radioactive caesium in feed for cattle, horses, pigs, domestic fowl and other domestic animals, and 100 Bq/kg in feed for farmed fish). Restrictions on the use, production and distribution of feed that exceeded the Provisional Permissible Values were thus established in order to prevent the contamination of animal products with radionuclides via rice bran and wheat bran feed that exceeded the Provisional Permissible Values.

However, on 18 December 2011 and 21 March 2012, beef samples from Fukushima and Iwate prefectures were again identified to have exceeded the Provisional Regulation Values for radioactive caesium [134], possibly due to contaminated feed. Nevertheless, the contaminated meat was detected through routine sampling, and a control regime was put in place to prevent it from being distributed to consumers.

In order to reflect the revision to radionuclide concentration values presented in the standard limits for radionuclide levels in food and drink, the Provisional Permissible Values of radioactive caesium in animal feed were revised prior to the new standard limits for food and drink coming into force on 1 April 2012. New activity concentration levels applicable to caesium radionuclides in feed were established on 3 February 2012 and 23 March 2012 as follows: 100 Bq/kg for horse and cattle feed; 80 Bq/kg for pig feed; 160 Bq/kg for domestic fowl feed; and 40 Bq/kg for farmed fish feed.

Rice production and levels of radionuclides in soil

Protective measures were also put in place to protect the rice harvest in 2011 (see Ref. [27] and Ref. [134]).

On 8 April 2011, the NERHQ issued a policy on restrictions on planting and cultivating rice in agricultural soil that had radioactive caesium levels in excess of 5000 Bq/kg [27]. This level was based on information on the transfer of caesium from soil to rice. Before the accident, the National Institute for Agro-Environmental Sciences had reviewed data relating to radioactive caesium levels in paddy field soil and the rice it produced. These data indicated a transfer coefficient[75] of 0.1 for radioactive caesium from soil to unpolished brown rice. The data also suggested that this transfer coefficient did not depend on the soil type. Polished rice had a lower transfer coefficient, but the more conservative value of 0.1 was used because some Japanese consumers eat brown rice on a daily basis. The upper limit of radioactive caesium in soil in rice production areas (of 5000 Bq/kg) was thus intended to avoid harvesting rice that would exceed the Provisional Regulatory Value of 500 Bq/kg at the end of the growing season [134].

As a precaution, and in view of the fact that rice is a staple food in Japan, the NERHQ, on 22 April 2011, directed the head of the Fukushima Prefectural Government to restrict the cultivation of rice (planting restriction) in 2011 within a 20 km radius of the Fukushima Daiichi NPP as well as in the Deliberate Evacuation Area and the Evacuation Prepared Area, where levels of radioactive caesium in soil exceeding the upper limit were found.

On 30 May 2011, MAFF commenced work in cooperation with MEXT to investigate radionuclide concentrations in agricultural soil. On 30 August 2011, MAFF published a map of radioactive caesium concentration levels in agricultural soils which was based on the results of a survey where soil was sampled from either paddy fields (sampled at 15 cm depth) or other farmland (≤ 30 cm

[75] A transfer coefficient is derived by dividing the concentration of radioactive caesium in the edible portion of the plant (e.g. rice grains) by the radioactive caesium concentration in the soil in which it was grown.

depth) mostly in Fukushima Prefecture but also including samples taken from Miyagi, Tochigi, Gunma, Ibaraki and Chiba Prefectures [30]. In areas where rice cultivation was at that time restricted, the maximum level of radioactive caesium detected in the soil of paddy fields was greater than 30 000 Bq/kg, but in other areas of Fukushima Prefecture it was less than 5000 Bq/kg (upper limit for rice production). MAFF released an updated map of radioactive caesium concentrations in agricultural soils on 23 March 2012 that covered a larger area and included more data points [135].

In August 2011, MAFF also announced that monitoring surveys were to be undertaken to measure radioactive caesium levels in cultivated rice in areas where agricultural products were subject to monitoring surveys, in neighbouring cities, towns and villages, and where radioactive caesium levels in farmland soil exceeded 1000 Bq/kg. Pre-harvest monitoring was to be performed one week prior to harvesting. In rice production areas where the levels of radioactive caesium in rice exceeded 200 Bq/kg as a result of preliminary monitoring, MAFF required one rice sample to be collected per 15 hectares. Where the radioactive caesium in rice was below 200 Bq/kg, MAFF required less intensive sampling (an average of seven rice samples per city, town and village). This rice sampling was undertaken before the rice harvest, and all rice samples collected were found to be below the Provisional Regulation Value [27].

Further monitoring of radionuclide levels in rice was undertaken after the rice harvest as part of the routine monitoring programme. On 29 November 2011, the MHLW announced a restriction on the distribution of rice produced in a specific area of Fukushima Prefecture, because unpolished (brown) rice samples were found to have levels of radioactive caesium above the Provisional Regulation Value [136]. This rice was produced in an area that had not been sampled in the pre-harvest monitoring survey.

3.3.4. Use of the dose projection model SPEEDI as a basis for decisions on protective actions during the accident

As mentioned in Section 3.3.2.1, owing to the loss of power on-site at the Fukushima Daiichi NPP, source term estimates could not be provided by ERSS's subfunction as input data to the SPEEDI system. Thus, it was not possible to project the off-site doses as a basis for decision making on protective actions, using these systems [25]. The alternate projections of doses were performed using other assumptions (predetermined source term of typical severe accidents); however, these projections were not used as a basis for deciding on urgent protective actions [25]. It is extremely difficult to predict the release timing, changes of wind direction and rainfall [25]. During the emergency, it was determined by senior officials and officials in charge that "the accident is not a situation where SPEEDI can be used" [25].

It is also likely that the timing, magnitude, composition and duration of releases would be similarly difficult to predict under many severe reactor accident conditions[76]. For example, severe releases may occur by routes that cannot be monitored by the control room and therefore magnitude, composition or duration of the release may not be known. In addition, severe releases could occur over several days, resulting in very complex deposition patterns off-site, as occurred during the accident at the Chernobyl NPP. The Fukushima Daiichi accident also demonstrated this. The releases during the accident were not predicted, and even a year after the emergency, it was not clear how the releases occurred [17]. In addition, none of the releases from the plant were from release routes that were being monitored. The difficulty in modelling releases for the Fukushima Daiichi accident is illustrated in Figs 3.3–9 and 3.3–10. Figure 3.3–9 shows the ^{137}Cs deposition projected by Japan using a

[76] Examples of causes of containment leakage/failure that are not predicable and that can result in a severe release are: (a) hydrogen explosions; (b) overpressure; (c) by-pass; and (d) failure to isolate. The only release pathway that is predictable is managed venting, and, in most cases, releases by this route would be small [137].

computer model, and Fig. 3.3–10 shows the actual ^{137}Cs deposition concentrations resulting from the accident. The modelling did not reflect the actual situation because of uncertainties in predicting the timing and magnitude of the release, despite having been made on the basis of data available several months after the accident.

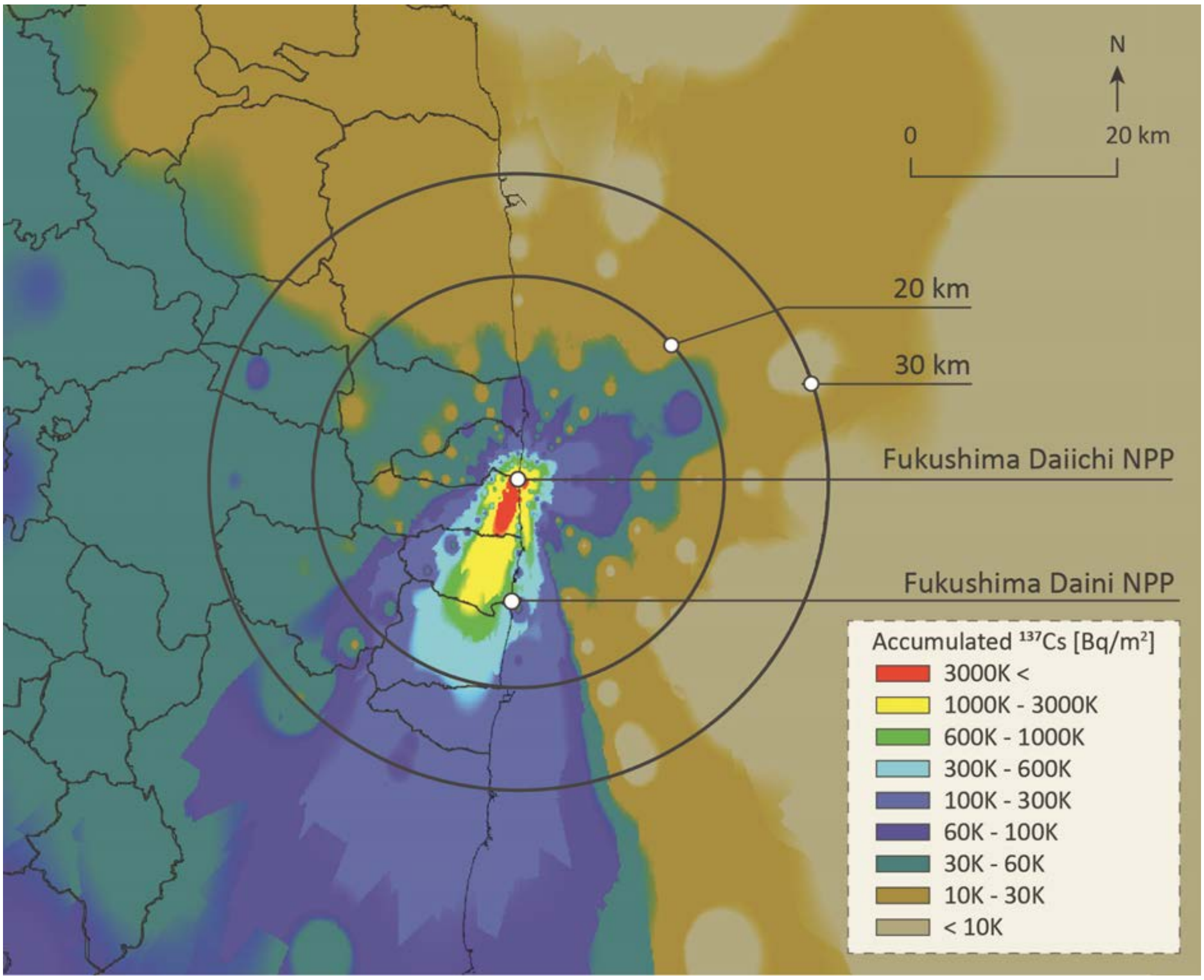

FIG. 3.3–9. ^{137}Cs deposition concentrations based on a model projection [138].

While core damage is sometimes predictable, predictions of containment vessel failure, etc., are extremely difficult to make and, furthermore, it is virtually impossible to make accurate predictions about the amount of released radioactive material and the dose in the early phase when urgent protective actions need to be determined promptly. Hence, it is difficult to make decisions for effective implementation of urgent protective actions based on predictions made in real time [13].

Using the dose projection models for deciding on and communicating the evacuation routes at the time of an accident is likely to cause delays and unnecessary complications. Therefore, deciding and communicating the evacuation route at the time of an accident is not practical [25]. Characteristics of the release, atmospheric dispersion and deposition all may vary significantly, both temporally and spatially, during the evacuation, which may result in the need to change the evacuation routes. Indeed, during the period of the largest overland release from the Fukushima Daiichi NPP (15 March), the wind directions changed by 180 degrees [17]. In addition, failures of communication systems and other problems could make it impossible to effectively implement such changes to evacuation routes. The fundamental concept is to pre-plan and exercise those parts of the response that need to be taken promptly in order to be effective. Detailed arrangements need to be established in advance and exercised to ensure effective evacuations [139, 140].

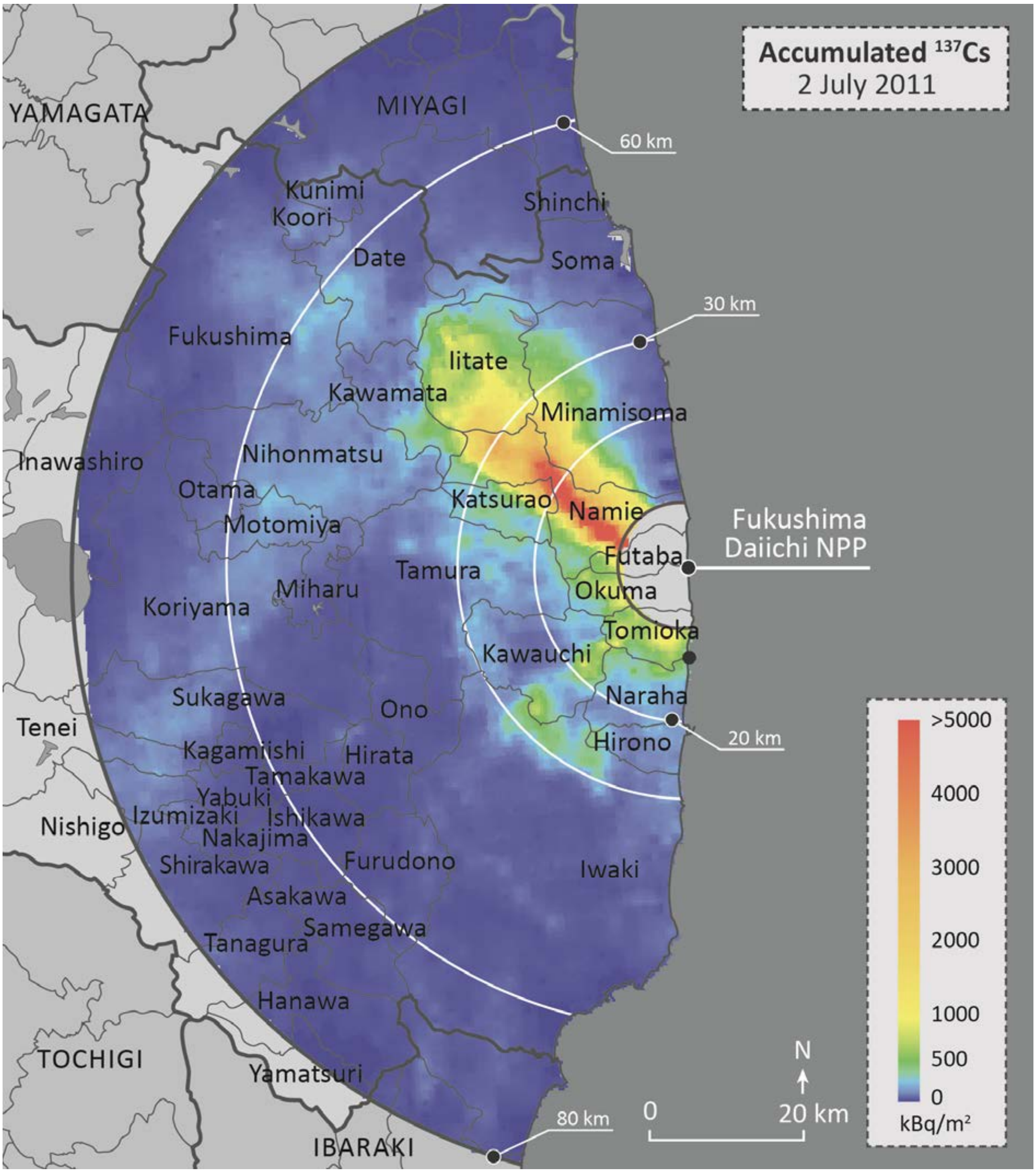

FIG. 3.3–10. Actual ^{137}Cs deposition concentrations [25].

Before the accident [25], EPR experts in Japan began questioning the method of determining protective actions based on projections such as those produced by SPEEDI. Specifically, questions were raised as to the reliability of accident simulation analyses using ERSS, or SPEEDI's radioactivity impact projections that utilized ERSS data. The question whether evacuation orders could really be made by relying on SPEEDI's calculation results, given these uncertainties, was discussed during a meeting conducted by the NSC one month prior to the accident [25].

3.3.5. Environmental monitoring

3.3.5.1. Relevant arrangements in Japan prior to the accident

Under the national EPR arrangements in place prior to the accident [2] in an emergency, the local government would perform environmental monitoring[77] and provide the results to the Local NERHQ [22]. The local government would be supported by teams and equipment provided by MEXT, the NPP operator and designated agencies (e.g. the NIRS and the Japan Atomic Energy Agency (JAEA)) [27].

The three objectives for environmental monitoring were described in the NSC's Regulatory Guide on Emergency Preparedness for Nuclear Facilities (Nuclear Emergency Preparedness Guide) [19] as: (1) Determining the dose rate around the nuclear facility and concentrations of radionuclides in the atmosphere; (2) Determining the concentrations of radionuclides in environmental samples; and (3) Promptly estimating the projected dose in the environment to determine the appropriate protective actions.

Environmental monitoring was to be performed in accordance with the Guideline for Environmental Radiation Monitoring developed by the NSC [141].

The Fukushima Prefecture Disaster Management Plan [1] described the organization and functions of the monitoring and sampling team, including the number of personnel needed to perform functions and the planned flow of information. It also specified that the planning for implementation of monitoring and sampling should be determined at the time of the emergency, with measuring and sampling points to be selected from the locations specified in the Emergency Monitoring Procedure contained in the plan. Detailed lists of available equipment and personnel had been compiled and pre-prepared forms for recording results had been developed (e.g. recording locations and measurements) [1]. The Fukushima Prefecture Disaster Management Plan [1] stipulated that the strategy for monitoring should focus on: (1) locations where iodine concentrations and dose rates are expected to be high; (2) ground deposition in all directions in the vicinity of the NPP; (3) a 60° sector (fan shaped area) around the point at which the highest atmospheric releases of radioiodine concentrations are expected; and (4) densely populated areas downwind from the NPP.

3.3.5.2. Environmental monitoring as a basis for protective actions

Prior to the accident, 23 monitoring posts, under the responsibility of Fukushima Prefecture, were located within about 5 km of the Fukushima Daiichi NPP (Fig. 3.3–11). However, as a result of earthquake and tsunami, only one of these was functioning at the time of the accident [21]. The local government had 12 monitoring vehicles [1] and four germanium semiconductor detectors as well as a number of NaI scintillation detectors[78] [22]. However, two of the four germanium semiconductor detectors were not functioning due to the damage caused by the earthquake [27].

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[77] Environmental monitoring is the measurement of external dose rates due to sources in the environment or of radionuclide concentrations in environmental media.

[78] Used for identifying released radionuclides (gamma emitters) and determining radionuclide concentrations.

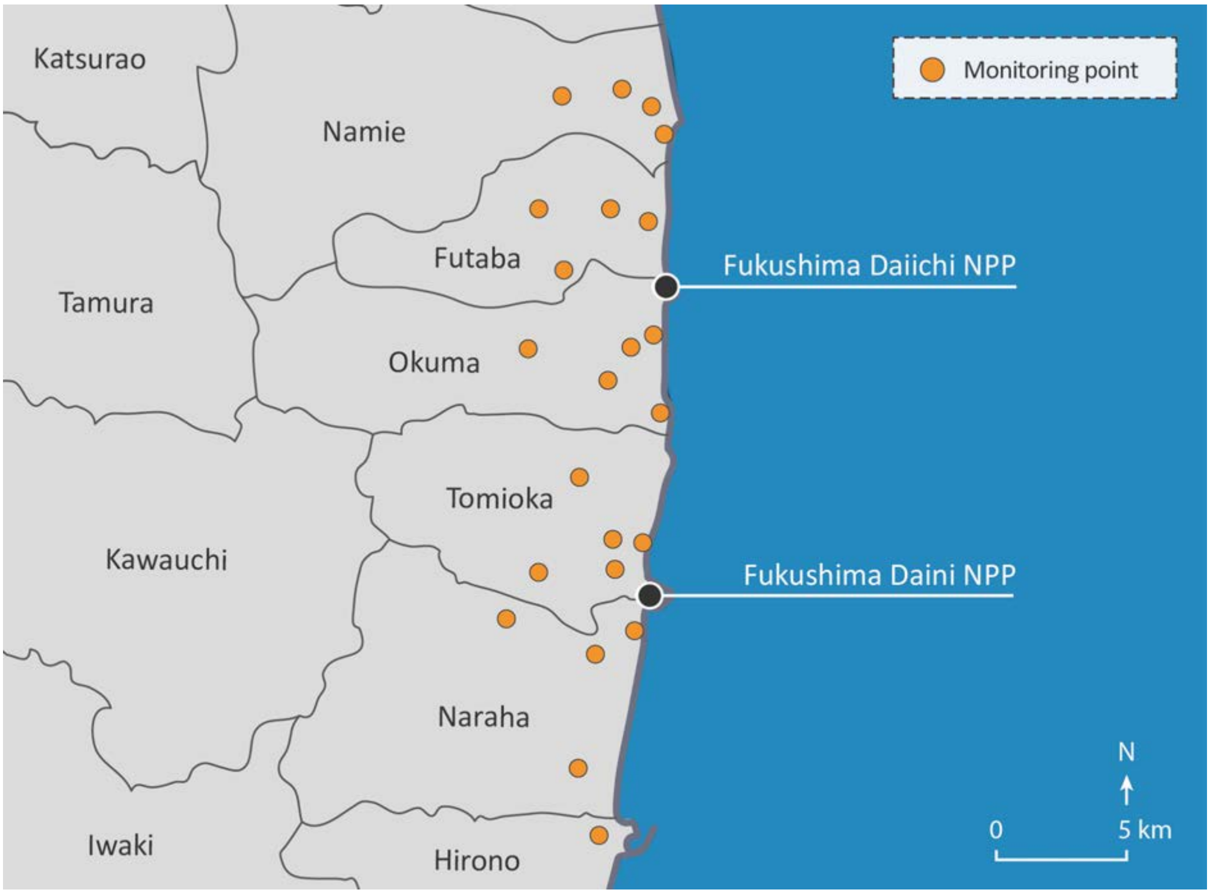

FIG. 3.3–11. Location of 23 monitoring posts located within about 5 km of the NPPs [142]

Initial environmental monitoring activities were associated with numerous difficulties, including: continuing tsunami warnings; dangerous conditions on the roads; vehicles falling into cracks; flat tyres; and shortages of fuel. In addition, the immediate priority was searching for missing people in the affected area rather than environmental monitoring. The relocation of the OFC, where monitoring was to be coordinated, on 15 March to Fukushima City, further complicated the situation [22, 27].

The 12 monitoring vehicles of the local government ran out of fuel and were abandoned [27], along with most of the monitoring equipment [27], and thereafter the national Government led the environmental monitoring efforts [27].

Vehicles and monitoring personnel were obtained from various response organizations (e.g. the National Police Agency and the Ministry of Defense), with 15 monitoring vehicles being used for monitoring from 15 March onwards [22, 27]. Locations for environmental monitoring were determined based on consideration of the results of previous measurements, the wind direction and topographical features [22], in accordance with the Fukushima Prefecture Disaster Management Plan [1].

Early in the morning of 12 March, monitoring began within a radius of 20 km of the Fukushima Daiichi NPP, which was suspended at 21:00 due to damaged roads, fuel shortages and an increase in dose rates. A reduced team of ten members continued monitoring activities on the next day [27]. Monitoring was terminated within the 20 km zone on 14 March, once evacuation within this area had been completed [27]. The first monitoring results measured on 12 March between 08:09 and 09:19 included handwritten results recorded on a photocopied map [143]. The first monitoring results were made public on 13 March.

On 15 March, there was a major release, with the airborne plume traversing over land. Rain on that evening resulted in significant deposition [17]. Dose rates between 255 and 330 μSv/h[79] were measured in the evening of 15 March in three locations beyond the 20 km evacuation zone, as shown in Fig. 3.3–12 [22, 25, 27].

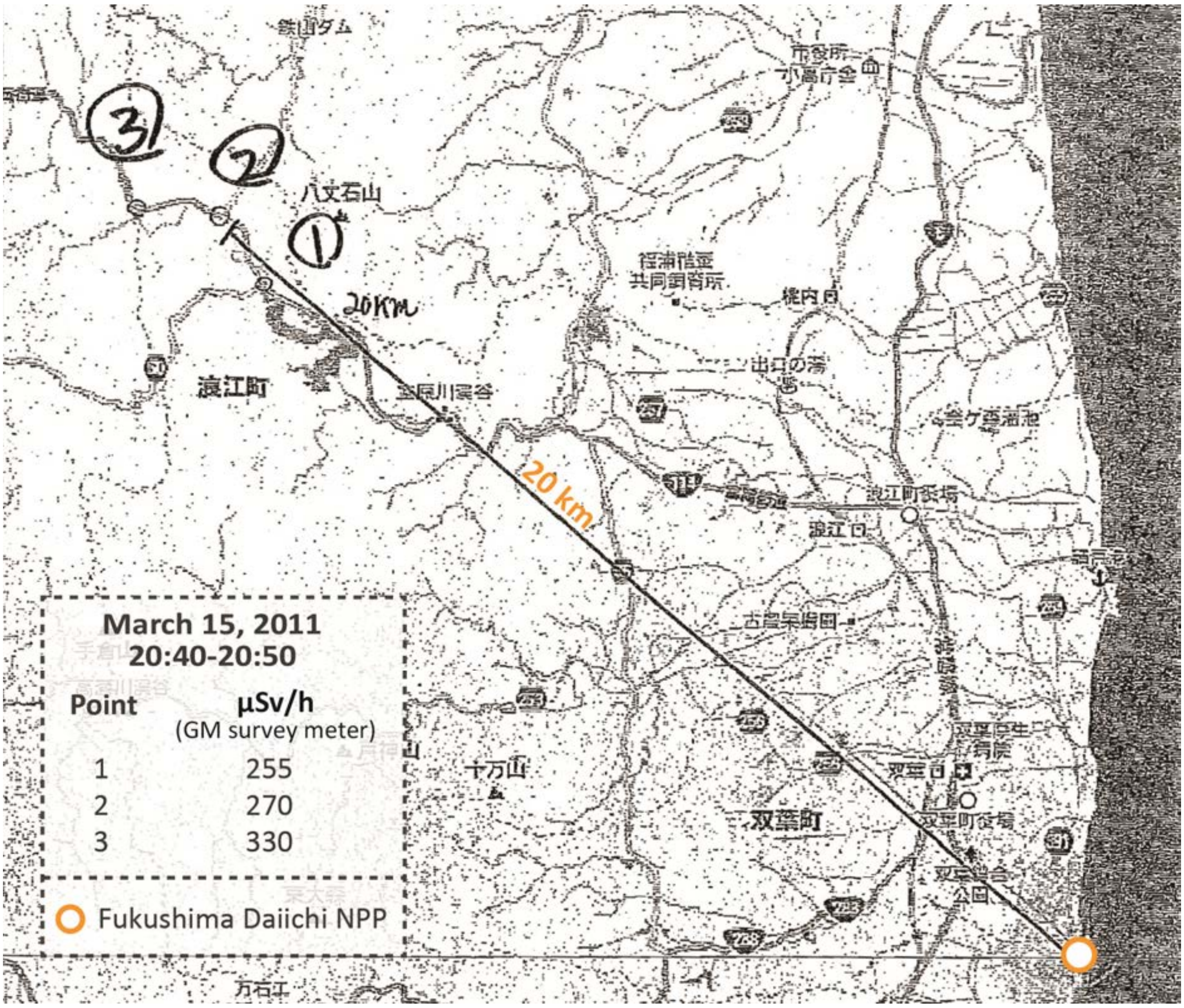

FIG. 3.3–12. Dose rates between 255 and 330 μSv/h measured on 15 March at three locations [22]

Figure 3.3–13 presents the dose rate (μSv/h) measurements from 16 March to 27 May at the locations indicated in Fig. 3.3–14. Figure 3.3–13 shows that on 17 March a value of 170 μSv/h was measured at Monitoring Point 32, which was at a location 30 km north-west of the Fukushima Daiichi NPP, in Namie Town. On 18 March, the NSC requested NISA to check if houses were located in the vicinity of that monitoring point [27]. On 24 March, integrated dosimeters were installed at 15 locations [22], which included Monitoring Point 32 [27]. On 29 March 2011, residents in Namie Town and Iitate Village were advised to shelter for as long as possible, even if they lived outside the 30 km radius

[79] This dose rate from deposition exceeded the dose rate OIL for relocation given in IAEA Safety Standards [14] (this comparison is performed due to the absence of national criteria). The IAEA was in contact with the official contact points in Japan providing explanatory information about the generic and operational criteria and the basis for their recalculation in the prevailing circumstances, as explained in IAEA Safety Standards and technical guidance.

zone. Residents of Namie Town and Iitate Village were relocated after 22 April, since they were located in the Deliberate Evacuation Area [27].

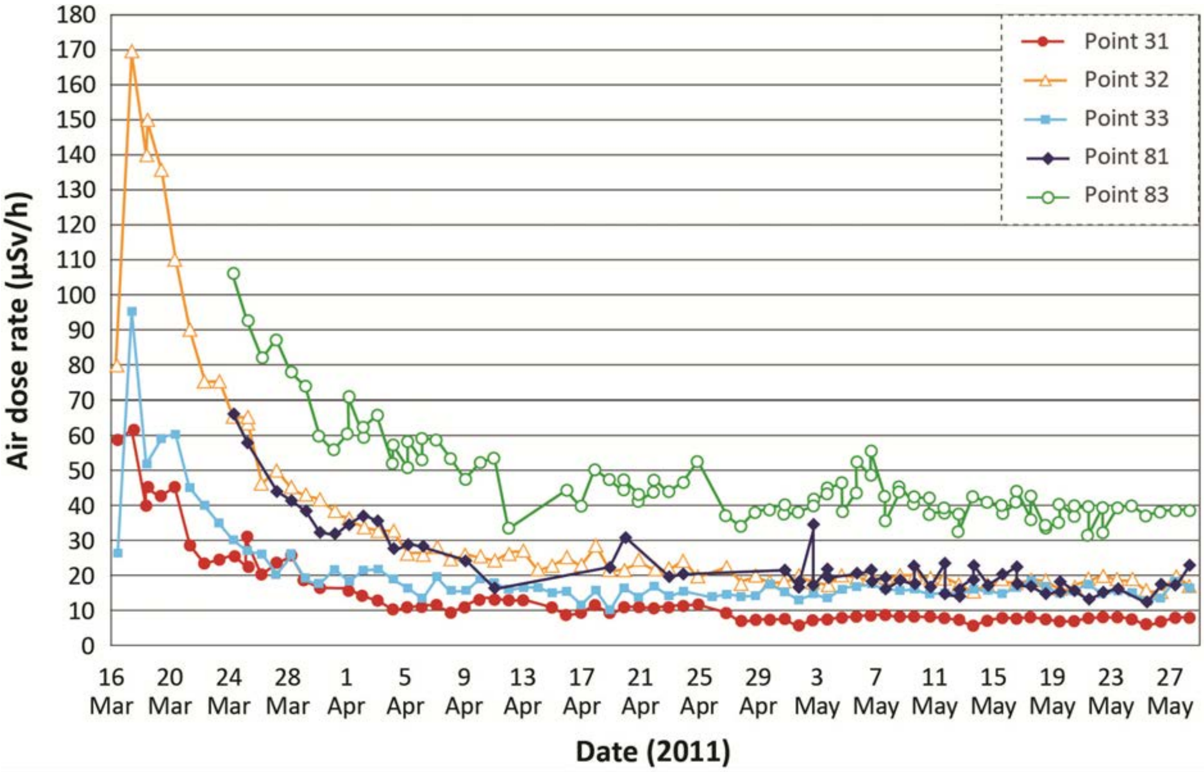

FIG. 3.3–13. Dose rate results (µSv/h) measured from 16 March 2011 onwards at the monitoring locations indicated in Fig. 3.3–14 [22].

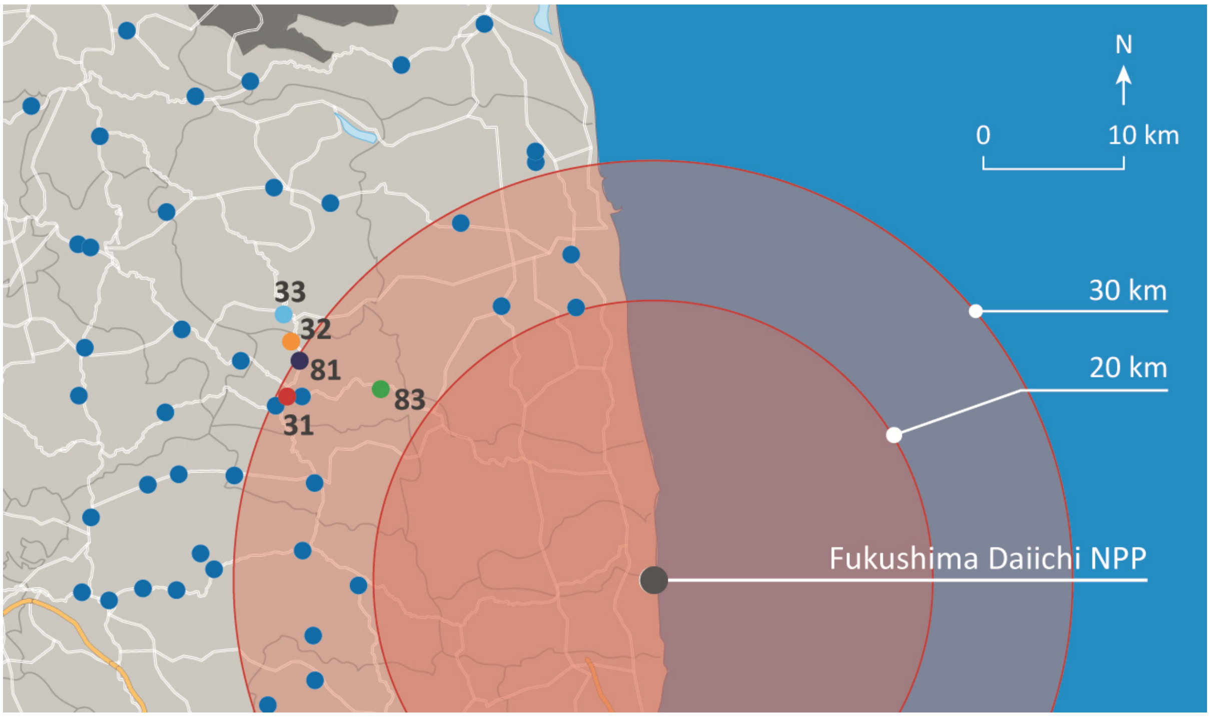

FIG. 3.3–14. Locations of dose rate measurements shown in Fig. 3.3–13 [22].

On 20 March 2011, MEXT received aerial monitoring data, via the Japanese Ministry of Foreign Affairs, from the United States Department of Energy (USDOE) [21]. Figure 3.3–15[80] shows the aerial monitoring results for measurements performed by the USDOE between 17 and 19 March. MEXT requested the Ministry of Foreign Affairs, on 21 March, to send the results also to the NSC. On the same day, the results were then sent to the NSC, the Cabinet Secretariat and MHLW [21].

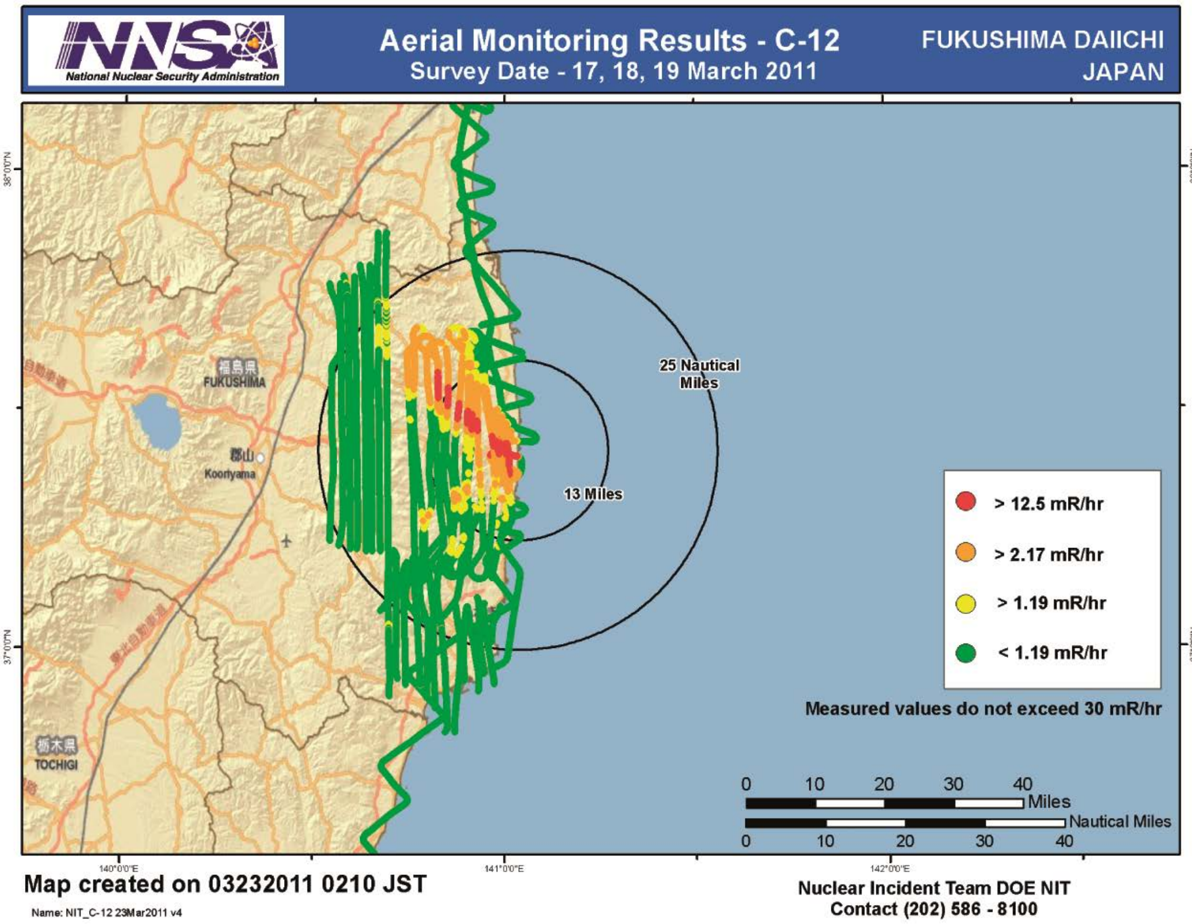

FIG. 3.3–15. Airborne measurements of the dose rate at 1 m above ground level (mR/h) taken between 17 and 19 March 2011 [144].

On 21 March, MEXT issued a monitoring plan for areas outside the 20 km zone from the Fukushima Daiichi NPP, called the Plan to Conduct Detailed Monitoring in Restricted Area and Planned Evacuation Zone[81], which was revised three times before a plan to conduct detailed monitoring was issued on 13 June [145]. This plan did not describe the overall purpose of the monitoring and did not specify the criteria that would be used to determine the extent of areas for implementation of protective actions [146].

On 25 March, an Airborne Monitoring Action Plan was issued describing the strategy for airborne monitoring outside the 30 km zone from the Fukushima Daiichi NPP [147]. The plan was revised

[80] Note that the results in this figure are given in mR/hour, not in μSv/h.

[81] The Planned Evacuation Zone is identical to the Deliberate Evacuation Area discussed in Section 3.3.3.1.

three times during April–May 2011. Monitoring was to be conducted overland, out to a distance of approximately 50 km from the NPP.

On 22 April, the Enforced Plan on Environmental Monitoring was announced, which stated that the results of environmental monitoring were to be presented on maps showing dose rate, estimation of accumulated dose and soil contamination with the objective of verifying the boundaries of the areas to be relocated [148]. This plan was revised on 11 May [149].

On 6 May, based on joint airborne monitoring with the USDOE, MEXT created a map (Fig. 3.3–16) showing the dose rate at 1 m above the ground surface normalized to 29 April 2011 [22]. The data were obtained by 42 fixed wing and helicopter survey flights over a period of 23 days. Dose rates were averaged over areas of 300–1500 m in diameter. No aerial survey data were collected either directly over the NPP itself, or over the eastern part of the town of Inawashiro, because of the mountainous terrain, which was not easily accessible by low flying aircraft. The dose rate was confirmed to be below 1 μSv/h in the eastern part of Inawashiro by vehicle borne measurements [150]. The survey boundary was chosen based on preliminary measurements that showed the extent of the deposition [150, 151].

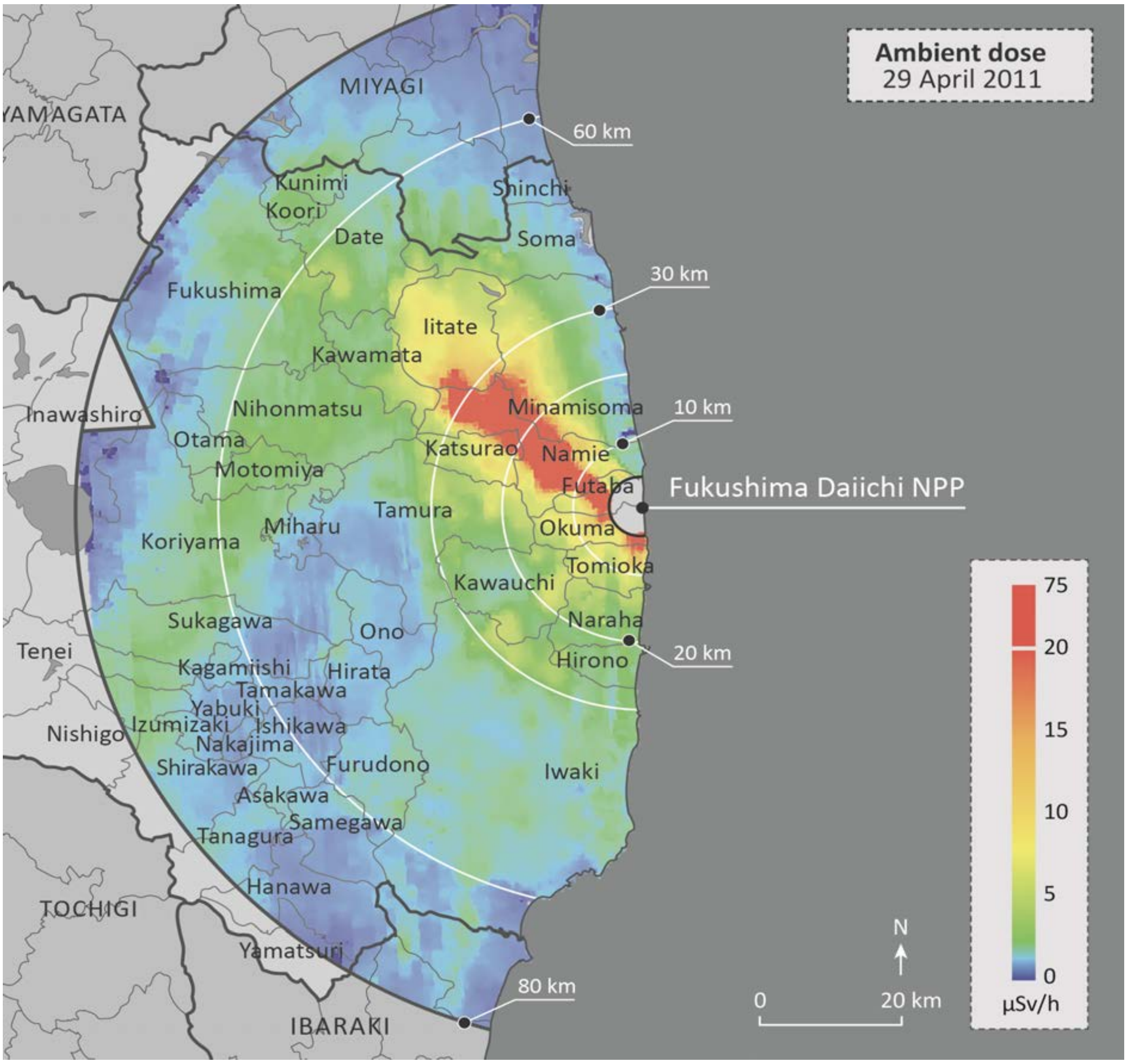

FIG. 3.3–16. Dose rate at 1 m above ground level (μSv/h) normalized to 29 April 2011 [22].

On 8 June, MEXT announced the Strenghtening of Monitoring of Environmental Radioactivity Levels by Prefecture [152], which specified that air dose rate monitoring should be performed by all 47 prefectures in Japan [152].

On 13 June, the Plan to Conduct Detailed Monitoring in Restricted Area and Planned Evacuation Zone was announced, describing the detailed monitoring programmes in these areas [145]. As of 15 March, vehicle borne dose rate monitoring was performed[82] on national and prefectural roads within 100 km (and slightly beyond) of the Fukushima Daiichi NPP, and on city, town and village roads within 80 km of the NPP [30]. Dose rates were measured over the road and inside the vehicles [153]. During this campaign, up to 15 monitoring cars[83], each with three people, were used to record measurements every 10 s (approximately every 100 m). A total of about 17 000 km out of the targeted 20 000 km of roads were monitored. The following data were recorded for each measurement performed during the period of 6–13 June (see Fig. 3.3–17 [30]): location, time, date, dose rate (in μSv/h), meteorological conditions and the organization performing the measurement (e.g. JAEA, MEXT) [153].

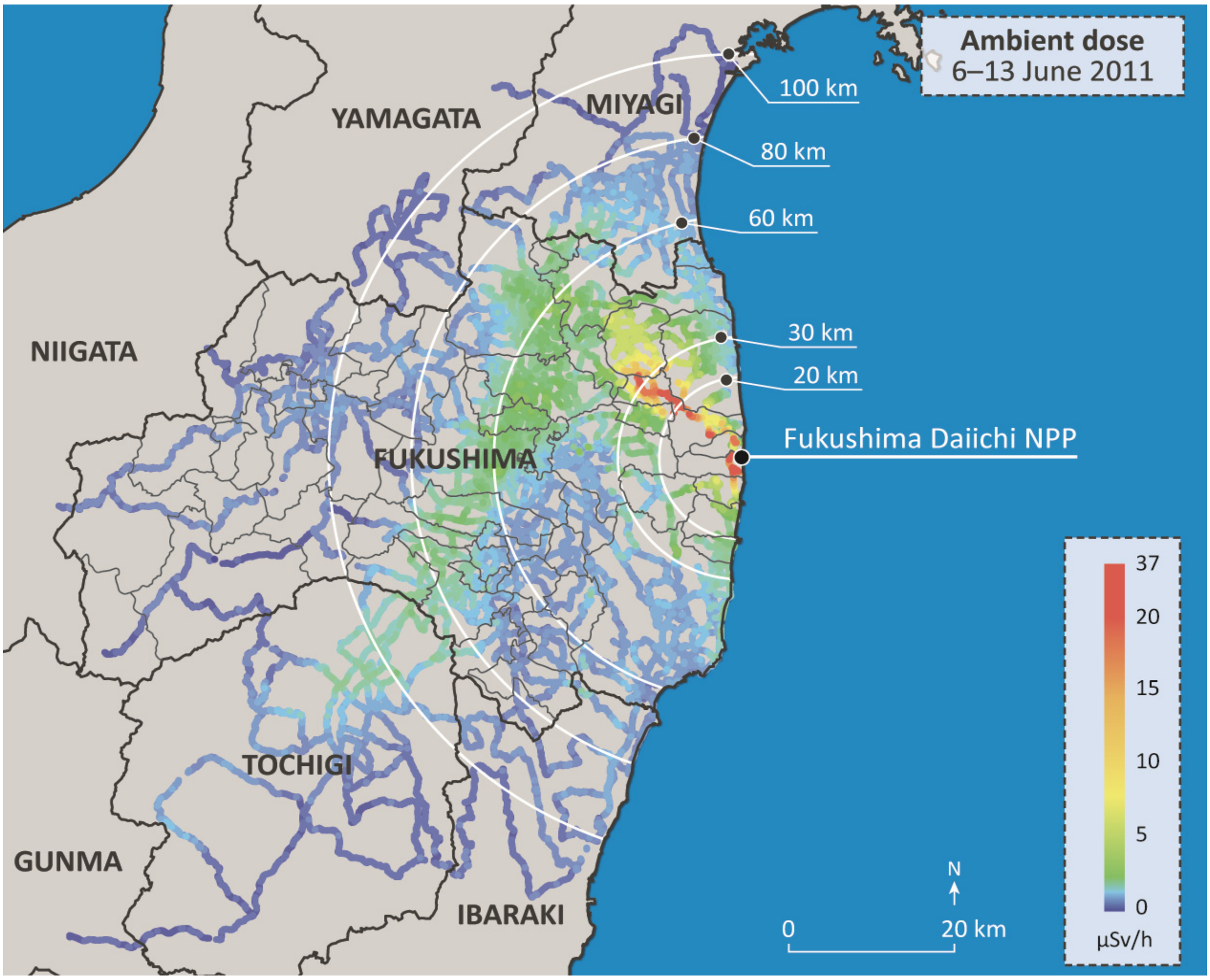

FIG. 3.3–17. Vehicle borne measurements of the dose rate at 1 m above ground level (μSv/h) taken between 6 and 13 June 2011 (released by MEXT on 2 August 2011) [30].

[82] Excluding the evacuated areas (within 20 km of the Fukushima Daiichi NPP).

[83] From MEXT, JAEA, Fukushima Prefecture, the National Police Agency, the Ministry of Defense and electrical power companies [22].

Figures 3.3–18 and 3.3–19 show the estimated integrated (cumulative) effective dose from external exposure while living normally[84] in the affected area for two months and for one year following the accident, respectively. These maps were created by MEXT and issued on 16 May [22]. Figure 3.3–18 presents the estimated dose received during the first two months from the start of the accident (until 11 May 2011). Figure 3.3–19 presents the estimated dose received during the first year (until 11 March 2012). The line in red shows the boundary of the area where the integrated dose over the first year was estimated to exceed 20 mSv, which was the dose criterion for establishing the Deliberate Evacuation Area. The population living in the Deliberate Evacuation Area was relocated, in some cases after 11 May 2011. By this time, projected doses, based on the assessment by MEXT, were greater than 20 mSv for those living in some locations, as shown in Fig. 3.3–18.

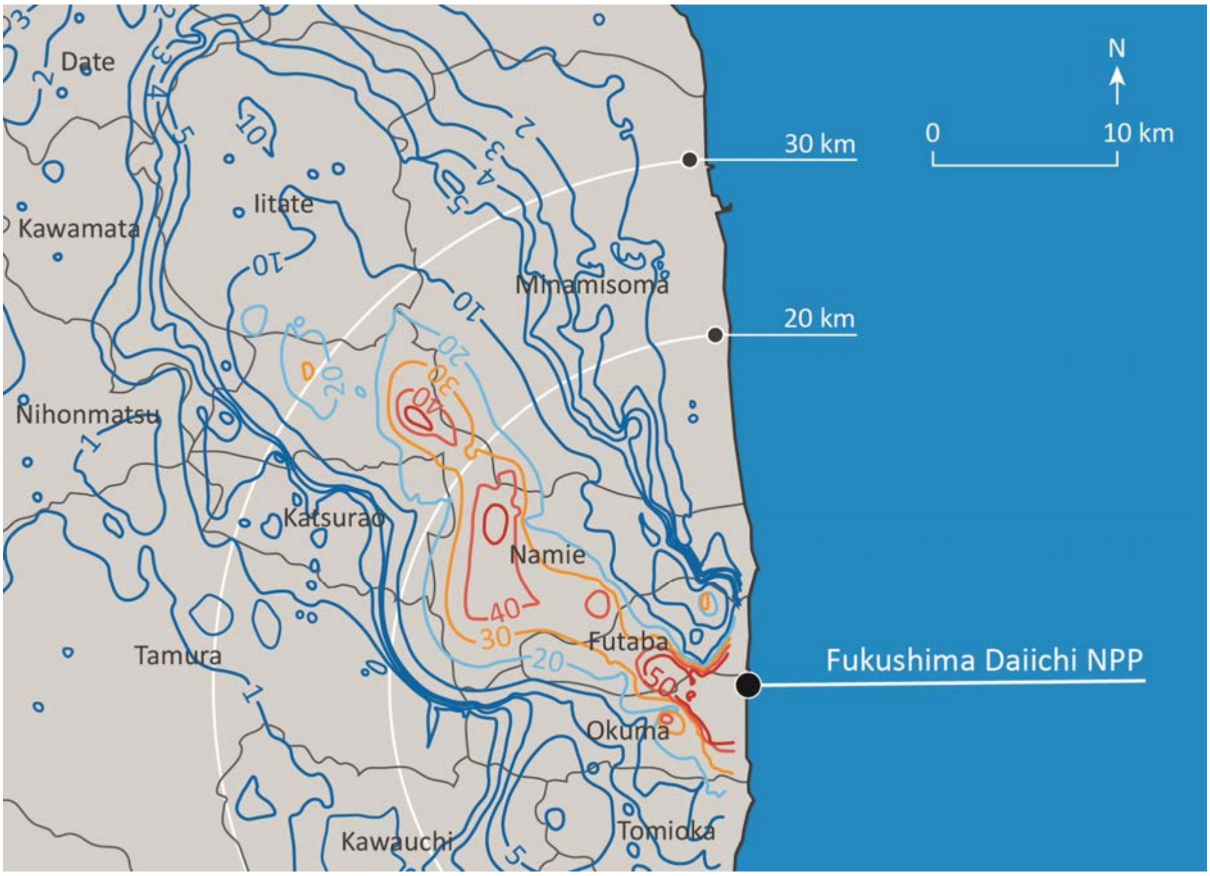

FIG. 3.3–18. First two months dose estimation (integrated dose, mSv, up until 11 May, 2011) [22].

[84] The dose rate value was multiplied by 0.6 in consideration of the reduction in the dose rate achieved by being in a wooden building for 16 hours a day [22]. This is essentially the same model used to calculate the relocation OILs in IAEA Safety Standards [14].

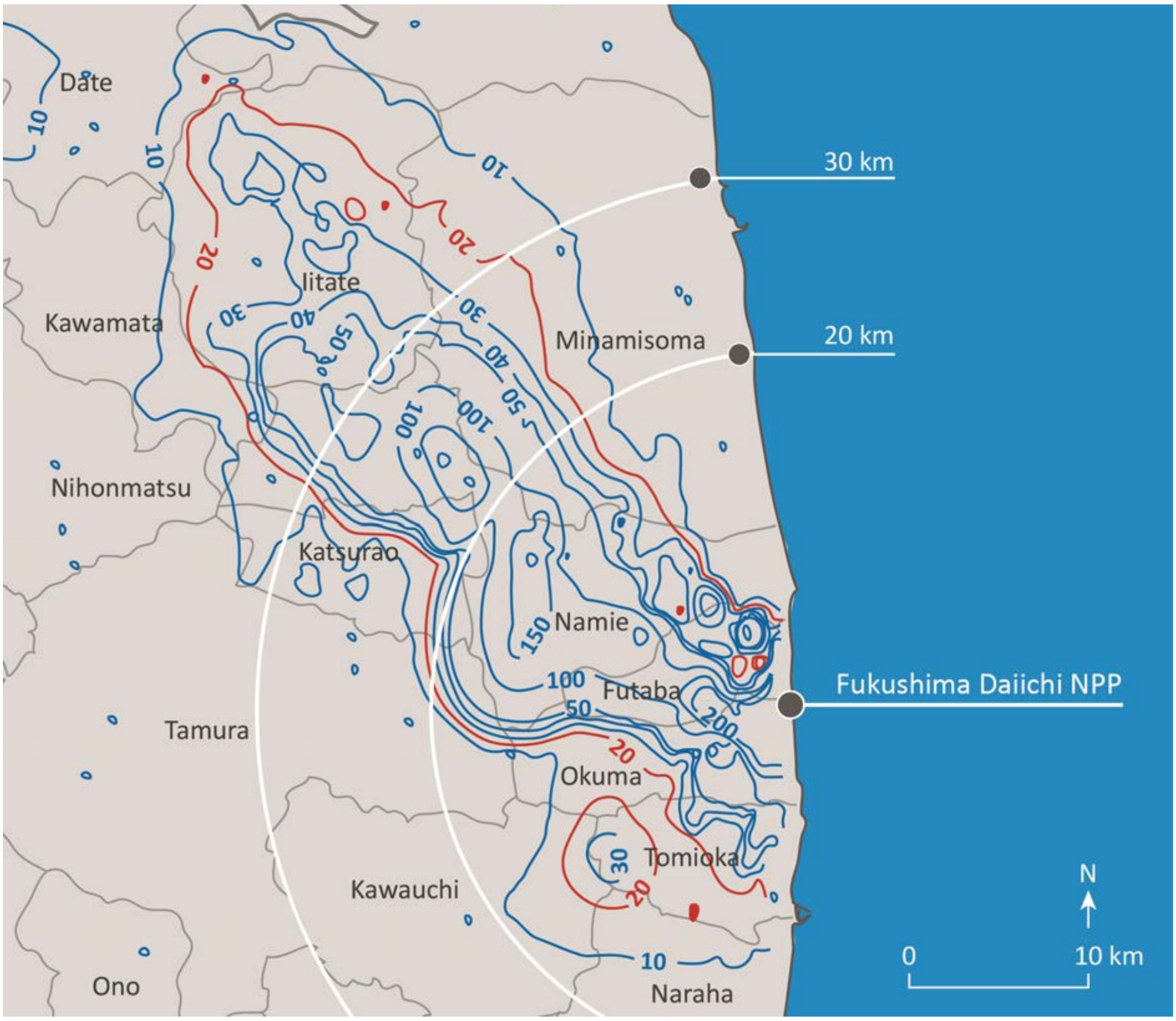

FIG. 3.3–19. First year dose estimate (integrated dose, mSv, up until 11 March 2012) [22].

3.3.5.3. Soil and seawater sampling and analyses

Development of the soil contamination map took almost three months and, as described below, was extremely resource intensive [22]. The soil contamination map was useful in the later phase of the emergency to inform decisions on lifting and adjusting protective actions, as it enabled the characterization of the deposition of radioactive material. Soil and seawater measurements were not used as a basis for decisions on relocation and designation or adjustment of the evacuation and relocation areas, as this was done based on dose rate measurements.

From mid-March 2011, MAFF took responsibility for transporting samples and performing the analysis at various national laboratories and institutes [27]. Initially, two institutes were able to analyse a total of about 40 samples a day [27]. Figure 3.3–20 shows a map of the surface activity concentration of ^{134}Cs made public on 30 August 2011. It shows the concentrations at about 2200 locations within roughly 100 km of the Fukushima Daiichi NPP [30].[85] More than 400 cooperators from 94 organizations, including universities, medical institutions and private companies, collaborated

[85] A ^{137}Cs map was also available from MEXT. The ratio between ^{137}Cs and ^{134}Cs is uniform across the survey region.

over 85 days to perform the radionuclide analysis of soil samples collected from the top 5 cm of soil [153, 154].

The dose rate was also measured at the sample locations [30]. Within 80 km of the Fukushima Daiichi NPP, samples were taken at one location within each 2 km × 2 km area. Beyond 80 km of the plant, samples were taken at one location within each 10 km × 10 km area [154, 155].

Samples were taken in accordance with the standardized method described by MEXT in a detailed manual issued on 26 May 2011 (a similar manual was issued in 1983) [156].

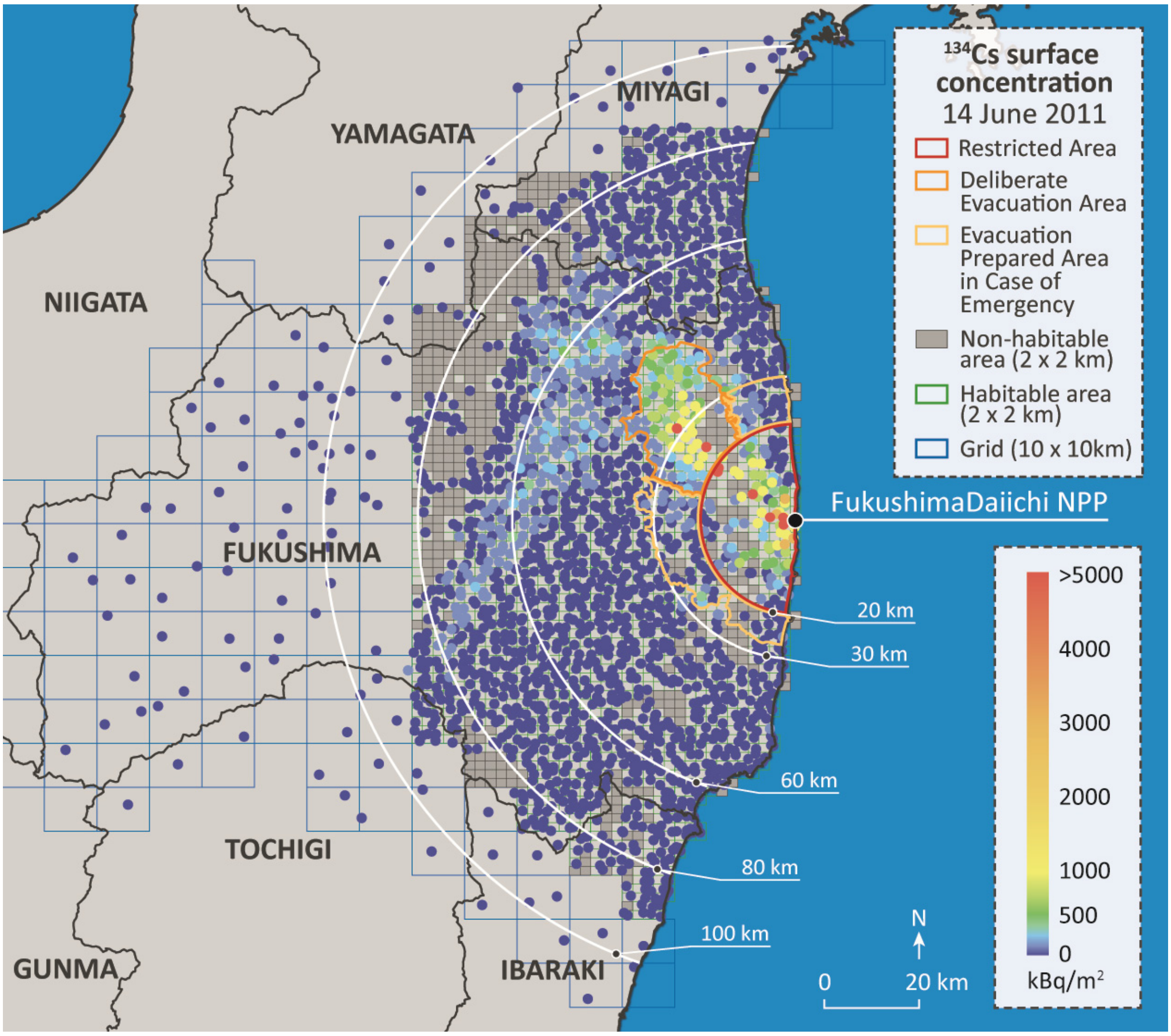

FIG. 3.3–20. Surface concentration of ^{134}Cs on soil (Bq/m^2) normalized to 14 June 2011. Samples were taken between 6 June and 8 July 2011 (released by MEXT on 30 August 2011) [30].

On 22 March, the Sea Area Monitoring Action Plan was announced [157]. According to this plan, activity concentrations in the sea water and airborne dust, and dose rates over the sea, were measured at locations approximately 30 km off the coast of the Fukushima Daiichi NPP. Samples of sea water were collected at eight locations parallel to the coastline at intervals of approximately 10 km [157].

On 5 April, it was announced that five sea monitoring buoys were to be placed at sampling locations [158]. On 25 April, it was announced that six additional water sampling points were to be established, increasing the number of locations where sampling of sea water was performed from 28 to 34 points [159].

On 6 May, cooperation between the relevant ministries, agencies and institutions for sea monitoring in a wider area off the coasts of Miyagi, Fukushima and Ibaraki prefectures was announced [160]. The method of sea monitoring was to measure 0.5 L samples of sea water that were taken once every four days at 16 points (at 12 points prior to 21 April). Between 28 March and 7 May, samples were taken using a water sampler instrument at differing depths: top (nearly 1–2 m below the surface); middle (between the surface and seabed); and bottom (approximately 10 m above the seabed).[86] Samples of particulates in air above the sea were measured [22].

3.3.6. Public information

A timeline of key events relevant to providing information to the public is presented in Fig. 3.3–21.

11 March

- Hotline established by NISA
- 15:16 | Mobile NISA issued first message on the impact of the earthquake on nuclear facilities
- 16:30 | First press release by TEPCO issued; press room established at TEPCO Headquarters
- 19:45 | Press conference by the national Government on the declaration of a nuclear emergency and establishment of NERHQ
- 21:52 | Press conference by the national Government on evacuation orders

12 March

- 03:06 | Joint press conference (between METI/NISA and TEPCO) on venting implementation for Unit 1
- Early morning | Press conference by TEPCO on venting
- 09:35 | Press conference by the national Government on expansion of the evacuation zone to 10 km
- 20:32 | Press conference by the national Government on expansion of the evacuation zone to 20 km

13 March

- Hotline established by NIRS
- Fukushima Prefecture Government opened a counselling service on radiation issues

15 March

- 11:00 | Press conference by the national Government on the order to shelter within a 20–30 km radius of the Fukushima Daiichi NPP

23 March

- SPEEDI data calculated based on data obtained after the evacuation order was issued on 12 March was released to the public

25 April

- Joint press conferences between various organizations involved in the response held from this day onward

FIG. 3.3–21. Timeline of key events relevant to providing information to the public.

[86] From 23–27 March, seawater samples were taken at eight locations at the top every two days. Sampling from the middle and bottom levels began from 25 April and 28 March, respectively.

3.3.6.1. Relevant arrangements in Japan prior to the accident

Arrangements for keeping the public informed during a nuclear emergency were in place prior to the accident.

The Fukushima Prefecture Disaster Management Plan [1] included arrangements for the appointment of a press manager to be responsible for releasing information to the public and to manage announcements from the local emergency response centre. It was envisaged that the Director General of the Prefecture Headquarters for Disaster Control would provide public information on an emergency and related protective actions to the affected municipalities and organizations and would hold press conferences at the request of the news media [1].

At the local level, communication would be provided by a staff member from NISA, who was designated as the spokesperson. The designated individual had to travel from Tokyo to the OFC [8], which would take some time in an emergency. The arrangements also specified the need to establish a telephone hotline in order to respond to enquiries from the public. Consideration was given to the provision of information to vulnerable people in an emergency, such as the elderly, infants, pregnant women, the injured, physically or mentally handicapped people and foreign nationals. In addition, the plan specified the need to reduce the adverse effects of misinformation [1].

At the national level, arrangements were in place that recognized the need of relevant response organizations to coordinate the provision of information to the public, including the content, timing and method of any announcements [8]. In addition, the arrangements required that a spokesperson be designated in advance from both the regulatory body and the national Government, given that individual press conferences would be held by both the regulatory body and the Chief Cabinet Secretary[87] following the declaration of a nuclear emergency [8]. In addition, the Basic Disaster Management Plan [2] described the need for promotional measures (e.g. public information activities) during the recovery phase for small and medium enterprises, farmers and fishermen affected by a nuclear emergency. It also specified the need to prevent or mitigate negative effects of the emergency, such as those caused by misinformation.

The Basic Disaster Management Plan [2] of the national Government and the prefectural and city/town/village disaster management plans were publicly available. In addition, the prefecture and municipalities held explanatory meetings on nuclear emergency preparedness for the residents [161].

Although the arrangements identified the need to address public concerns and mitigate other non-radiological consequences[88] of the emergency, there was no specific technical guidance as to how this would be implemented. While arrangements recognized the need to ensure consistency in the release of information to the public, procedures for achieving this had not been formalized.

3.3.6.2. Keeping the public informed

Information was provided to the public throughout the emergency via several channels, including television, radio, internet and telephone hotlines.

The OFC was intended as the location for media announcements at the local level. Once the OFC began to operate, its location within the evacuation zone rendered it inaccessible to journalists.

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[87] Or an alternate.

[88] These include economic, social and psychological effects, which are typically the most severe consequences of a nuclear or radiological emergency [11].

Following relocation of operations from the OFC, press conferences were held, beginning on 15 March, by spokespeople of the Local NERHQ at the Fukushima Prefecture Public Hall [21].

Some of the material released to the public was independently developed by the Local NERHQ [22]. The Local NERHQ took the initiative to publish newsletters and distribute them to each evacuation centre as of April 2011. Relevant information was also broadcast periodically via local radio stations, since television reception and internet connections were unavailable in some areas owing to the disruptions in power supplies. Five newsletters and 62 radio broadcasts had been issued by May 2011 [22].

The regulatory body, NISA, released its initial message on the impact of the earthquake on nuclear facilities via 'Mobile NISA' at 15:16 on 11 March 2011, 30 minutes after the earthquake. The spokesperson provided a press briefing on the status of the fuel of Unit 1 and subsequently resigned. NISA's spokesperson changed several times. At one point, four different people served as spokesperson within a two day period [27]. As NISA itself recognized, [162], the spokespeople were found to have insufficient training and experience in dealing with the media, and no arrangements were in place to facilitate the provision of technical advice to the individual acting as spokesperson. As a result, it happened that staff from the regulatory body presented conflicting opinions at a press conference [21].

On 12 March 2011, NISA held three press conferences on the expansion of the evacuation zone to 10 km. More than 150 press releases were issued and 182 press conferences were held by NISA between 11 March 2011 and 31 May 2011 [22]. On one occasion, fourteen press briefings were given in a single day by the NISA spokesperson. As the situation stabilized, the frequency of press conferences was reduced to twice or three times a day. The briefings focused on events relating to the accident, and very little information was provided on the preparation for evacuation [22]. Moreover, it became clear that there were not enough staff members available at NISA to ensure a 24 hour provision of information to the public and the media [162].

In the first few weeks after the accident, the national Government, NISA, local emergency response organizations, local governments and TEPCO held independent press conferences and in some cases, the information provided to the public was inconsistent [21]. The Chief Cabinet Secretary held regular press conferences twice a day, and also on an ad hoc basis, to provide information to the public on the accident and the views of the Government [22]. The results of environmental monitoring were presented at press conferences and press briefings by MEXT [22].

The NSC held daily press conferences from 25 March to 24 April 2011, and eight press conferences were held by the NSC from 25 April to 19 May 2011 [22]. The information presented by the NSC spokesperson focused on the rationale and justification for advice and recommendations made by the NSC [22].

TEPCO issued its first press release at 16:30 on 11 March 2011 and established a press room at its Headquarters in Tokyo. Technical personnel were required for explanations at these press conferences, making these staff members unavailable for emergency response activities. This problem was later solved by the recruitment of other experts, such as retirees, to provide technical explanations [17].

In early April, a proposal to hold joint press conferences between the Government and TEPCO was rejected out of concern within the Government that this cooperation between the regulator and the nuclear operator being regulated would be inappropriate [21]. However, as of 25 April 2011, joint press conferences were held[89]. These press conferences were hosted by the Special Advisor to the Prime Minister, NISA, TEPCO, the NSC, MEXT and other organizations. Graphs, diagrams and pictures were used during the joint press conferences to help non-specialists understand the technical and specialized information on reactors and radiological conditions [22]. This approach contributed to the consistency of the information that was provided [27].

Arrangements established prior to the accident did not specify if SPEEDI dose projection results were to be made publicly available [2, 8]. On 23 March, SPEEDI projected dose estimates based on environmental data were made available to the public (Fig. 3.3–22) [25]. These estimates represented the projected integrated dose for the period 12–24 March. When this diagram was released to the public, it was not explained that these results had not yet been available on 12 March, when the decisions for evacuation had been taken, since the assessment was made based on environmental measurements taken after the evacuation [25]. The lack of this explanation before announcing the data resulted in misunderstanding and confusion among the public. For example, some people living within a 20 km radius of the NPP who had been instructed to evacuate on 12 March were moved to a shelter that was located in an area north-west of the NPP that was later found to be heavily contaminated. After release of the SPEEDI results, it was erroneously claimed that non-disclosure of these dose estimates resulted in exposures that could have been prevented [25].

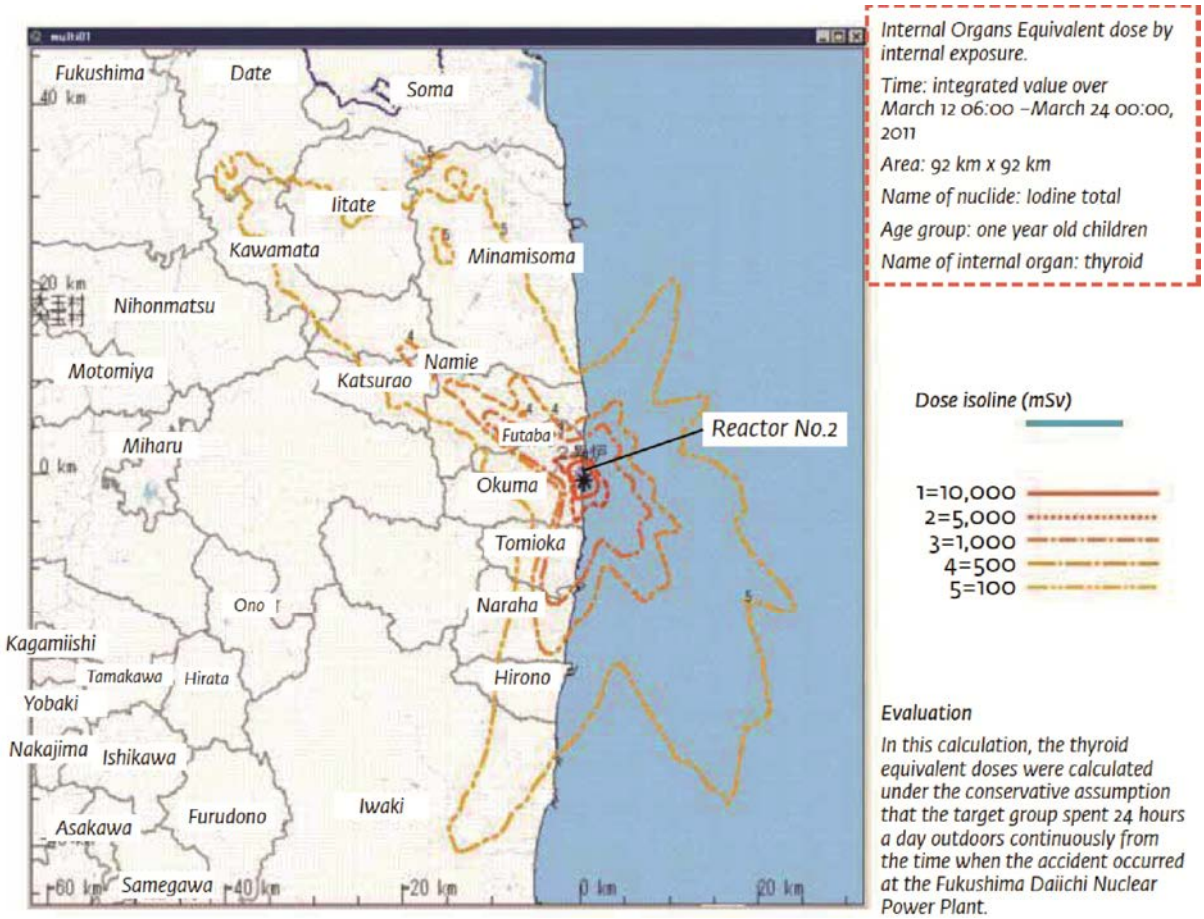

FIG. 3.3–22. SPEEDI dose estimates based on environmental data and released to the public on 23 March 2011 [25].

[89] The joint press conferences were held at the Joint Headquarters of Fukushima Nuclear Power Plant Emergency Response, which was renamed the Government-TEPCO Integrated Response Office on 9 May 2011.

Another set of SPEEDI data was released on 26 April 2011. It was the result of SPEEDI projections of dose rates for 12 March, 18:00–19:00, which had been calculated just before the evacuation orders for a radius of 20 km were issued at 18:25 (Fig 3.3–23). These projections were made using a unit release rate and, as noted on the results, they did "… not represent the actual distribution of radiation doses" [25]. Hence, they could not have been used as a basis for taking protective actions. However, this was not properly explained to the public, resulting in some misunderstanding.

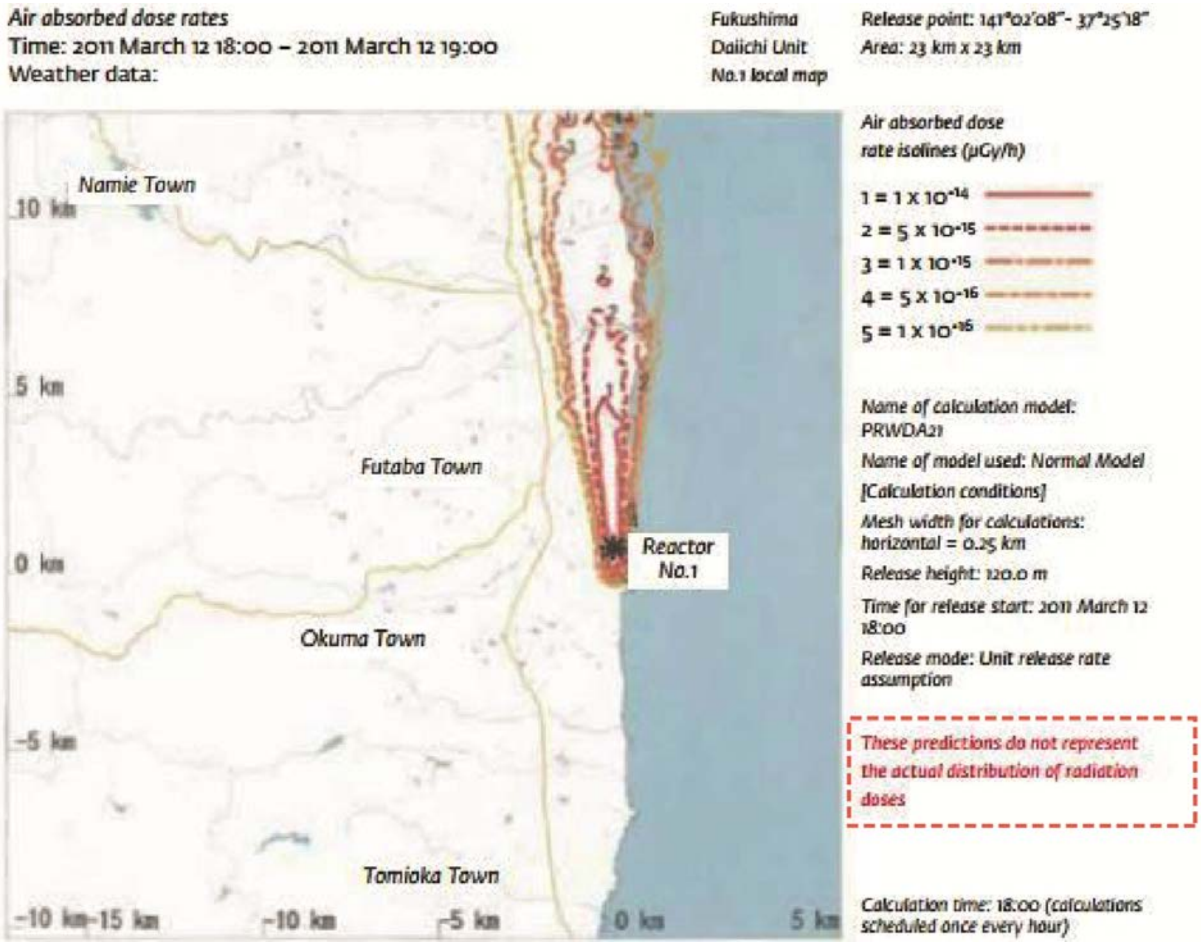

FIG. 3.3–23. SPEEDI dose rate projections based on unit release rate obtained just before evacuation orders were issued for a radius of 20 km at 18:25 on 12 March [25].

3.3.6.3. Addressing public concerns and communicating the health risks

While it was not possible to conduct activities related to answering enquiries from residents at the OFC as planned [1], owing to the power cuts causing failures in communication lines [45], enquiries from the public were addressed via several hotlines.

For example, on 11 March 2011, NISA established a hotline to respond to queries relating to the evolution of the emergency and radiation safety. It received approximately 15 000 calls between 17 March and 31 May 2011 [22]. The number of telephone lines was increased from five to 13 on 17 March, and additional assistance was provided by staff from the Japan Nuclear Energy Safety Organization (JNES). The largest number of enquiries was received on 30 March, with almost 500 calls [22]. On 17 March 2011, MEXT and the JAEA opened a hotline to provide health counselling and facilitate the dissemination of correct information; it received a total of 17 500 calls by 18 May 2011 [22].

NIRS also opened a hotline on 13 March [163] to provide medical information on radiation exposure and health counselling, which received a total of 6500 calls by 11 April 2011 [163]. In addition, the Atomic Energy Society of Japan offered explanations and information to the public.

The Fukushima Prefectural Government was supported by the national Government in the opening of counselling services on radiation that were located at the Fukushima Prefectural Government office. More than 14 000 enquiries have been received since it opened on 18 March[90] [22, 165]. Questions ranged from concerns about the possible effects of radiation on pregnancy to the meaning of the numerical values reported by the media [166].

Feedback from the public received via hotlines and counselling services identified the need for easily understandable information and supporting material [22]. It proved difficult to explain to the public radiation protection concepts and the basis for decisions on protective actions (e.g. references levels, exposure situations, stochastic effects) [21, 25].

Despite efforts to address public concerns, in some cases people took actions that were not helpful and were considered to do more harm than good in the belief that they were protecting themselves. Examples of such concerns, actions and responses included:

- Pregnant women worrying about their foetus based on the hazards to health from radiation [109, 167];
- Using inappropriate substitutes for ITB agents [109];
- Stigmatizing those from the affected area [167];
- Worrying about the possibility of radiation induced cancers [109];
- Rejecting products from the affected area [167];
- Cancelling necessary nuclear medical treatments due to fear of radiation [168].

An example of the tools used to address public concerns is shown in Fig. 3.3–24. This figure represents a good example of helpful material to enhance communication to the public by explaining the basics of radiation in everyday life. However, additional materials to complement this figure, when used in an emergency, are necessary. When applied to address public concerns in an emergency, it would need to be accompanied by appropriate explanations to remedy its shortcomings. For example, this figure explains/presents cases of external penetrating radiation only and does not address the intake, for instance, from radioactive iodine. It does not address the exposure scenarios at the time of the accident, such as people living on contaminated ground for extended periods of time or the equivalent dose to the foetal thyroid from ingestion or inhalation of radioactive iodine. It also fails to indicate the doses at which one could expect to see radiation induced effects. In addition, the figure does not address the numerous reported quantities, such as dose rate from deposition and concentrations in food, water and milk.

[90] The counselling services were still operating in December 2014 [164].

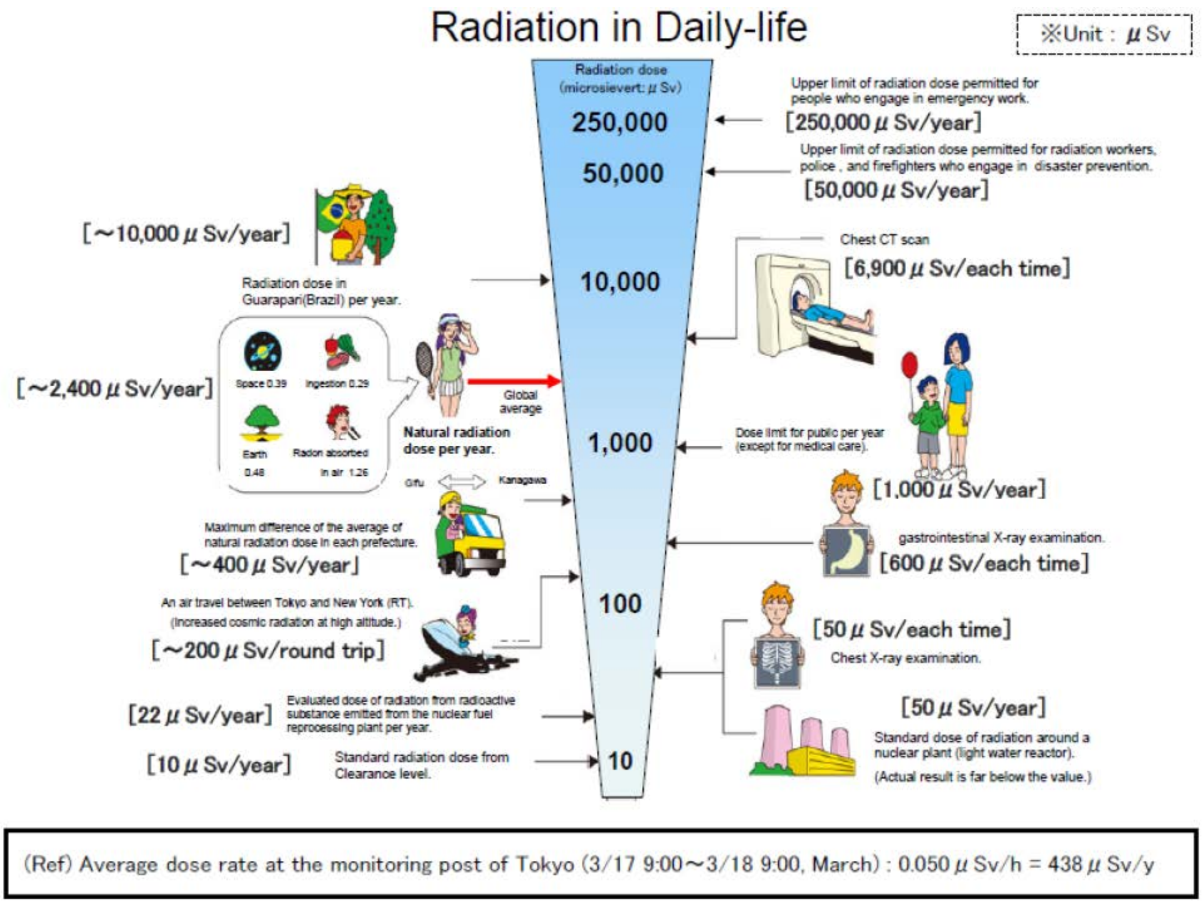

FIG. 3.3–24. Diagram used by Japanese authorities to explain radiation in daily life [169].

The International Commission on Radiological Protection (ICRP) has pointed out:

> "There are great difficulties to communicate radiological information to non-experts and the public at large using the ICRP system and its quantities. This is a consequence of the rather intricate concept behind the system of quantities which uses more than one quantity (organ (equivalent) doses and whole body (effective) dose) and combines physical exposure data with scientific data on radiation risk for organs and tissues. In other words, the system and the quantities have shown to be well suited for operational radiation protection but they are much less suited for communication with non-experts, particularly in emergency situations." [170]

In addition, the report by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) on the levels and effects of radiation exposure due to the Fukushima Daiichi accident [171] states:

> "The doses to the general public, both those incurred during the first year and estimated for their lifetimes, are generally low or very low. No discernible increased incidence of radiation-related health effects are expected among exposed members of the public or their descendants. The most important health effect is on mental and social well-being, related to the enormous impact of the earthquake, tsunami and nuclear accident, and the fear and stigma related to the perceived risk of exposure to ionizing radiation. Effects such as depression and post-traumatic stress symptoms have already been reported."

3.3.6.4. Providing information to foreign countries and foreign media

Information was provided to the diplomatic corps in Tokyo through regular briefings, held by the national Government on a daily basis from 13 March to 18 May 2011, and three times a week from 19 May onward [27]. During the briefings, an explanation was provided on the status of the accident and the protective actions and other response actions being taken by the staff responsible for their respective areas. The staff giving the briefings came mainly from the Foreign Ministry, but also from the NSC, MEXT, MHLW, MAFF, the Fishery Agency and NISA. In total, 46 such briefings were held by 11 May [22].

Beginning on 13 March 2011, joint press conferences on the status of the accident and actions taken by the Japanese Government were held, mostly on a daily basis, for the foreign news media by relevant national ministries and government agencies [27]. Videos of press conferences were posted on web sites of the Japanese Government Internet TV and the Foreign Press Center in Japan. When factual errors and unfounded rumours were identified in the coverage of the foreign media, the Japanese Government addressed them and encouraged the media in question to present the correct facts.

A notification channel via fax and email to the diplomatic corps was also established. The diplomatic missions of Japan provided information to their host States, which were posted on web sites in a total of 29 different languages [22]. Briefings were also given to businesses overseas and in Japan [22].

From 12 March 2011 onward, the national Government posted information in English, Chinese and Korean on the web sites of the relevant ministries and agencies [162]. In addition, Twitter and Facebook accounts were created under the name of 'Kantei'[91] to send summaries of the press conferences by the Prime Minister and Chief Cabinet Secretary to a wide range of audiences.

Challenges encountered in providing information to the international community related principally to the demands on human resources for translating materials and responding to information requests by telephone [162].

3.3.6.5. Using the International Nuclear and Radiological Event Scale

The International Nuclear and Radiological Event Scale (INES) is a tool for promptly and consistently communicating to the public the safety significance of events associated with sources of ionizing radiation with the aim of keeping the public as well as nuclear authorities accurately informed on the occurrence and consequences of reported events. The primary purpose of INES is to facilitate communication and understanding among the technical community, the media and the public on the safety significance of events. The INES scale applies to any event associated with the use, storage and transport of radioactive material and radiation sources, whether or not the event occurs at a facility.

INES uses a numerical rating to explain the significance of events associated with sources of ionizing radiation (see Fig. 3.3–25). Events are rated at seven levels: Levels 1–3 are 'incidents' and Levels 4–7 are 'accidents'. The scale is designed such that the severity of an event is approximately ten times greater for each increase in level of the scale. These levels consider three areas of impact: (1) people and the environment; (2) radiological barriers and control; and (3) defence in depth.

Events without safety significance are rated as Below Scale/Level 0. Events that have no safety relevance with respect to radiation or nuclear safety are not rated on the scale.

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[91] The Prime Minister's Office in Japanese.

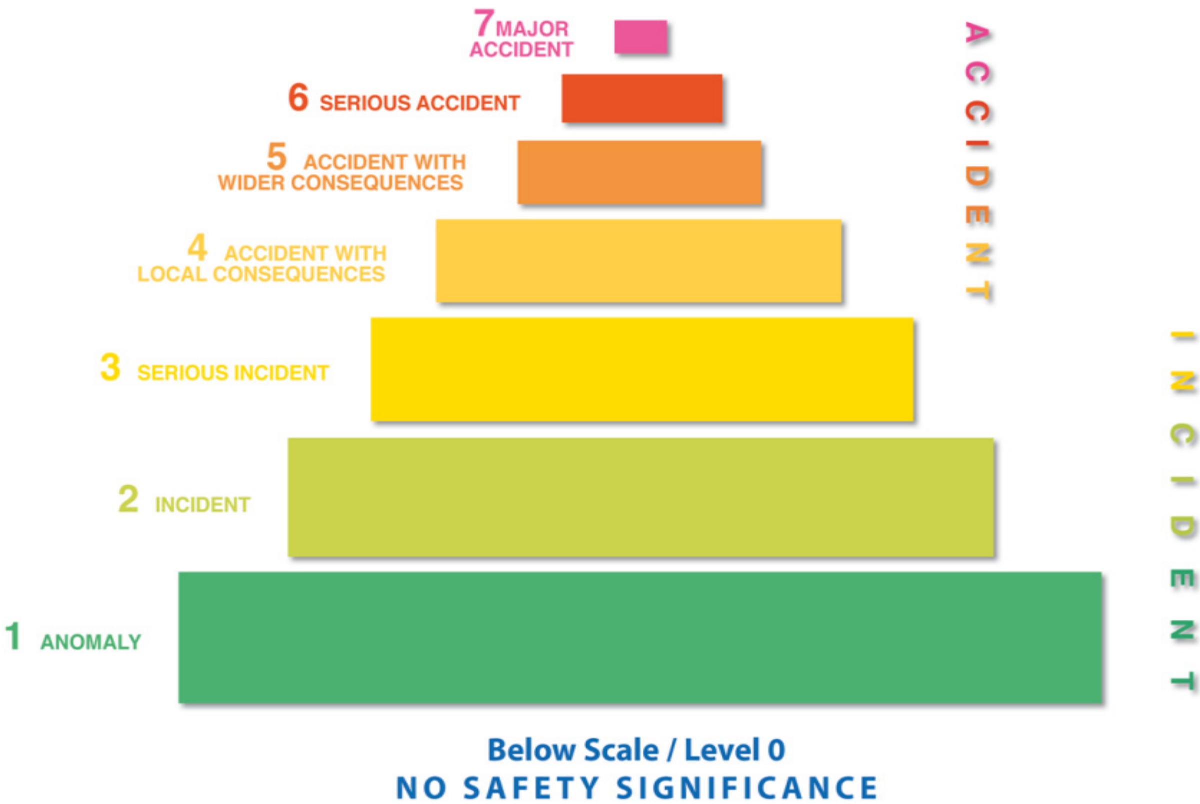

FIG. 3.3–25. The International Nuclear and Radiological Event Scale.

Various INES ratings were reported by Japan following the Fukushima Daiichi accident.

The first INES rating was posted on the Nuclear Events Web-based System (NEWS) at 00:41(UTC) on 12 March 2011. A provisional INES rating at Level 3 was assigned to the event at Unit 1 and 2, based on the elevated pressure in the confinement vessels of Units 1 and 2 and considering its impact on defense in depth. In this Event Rating Form (ERF), NISA also outlined the status of the Onagawa, Fukushima Daiichi and Fukushima Daini NPPs.

The second ERF was issued by NISA and published on NEWS at 15:05(UTC) on 12 March 2011. A provisional INES rating at Level 4 was assigned to the event at Unit 1, based on the dose rate at the site boundary, impact on the radiological barriers and controls at the facility.

The ERF with INES rating Level 4 for Unit 1 that had been issued on 12 March 2011 was up-rated to provisional Level 5 on 18 March 2011, based on the high dose rate at the site boundary and at the suppression chamber[92], i.e. considering the impact on the radiological barriers and controls at the facilities. It was also reported that at least one worker received a dose of about 106 mSv, which was in excess of the annual limit (100 mSv).

On the same day, separate ERFs were issued for the events at Units 2, 3 and 4. The event at Unit 2 was up-rated to provisional Level 5. The provisional Level 5 rating was also assigned to the event at Unit 3. The Unit 4 event was assigned provisional Level 3, based on the inoperability of the cooling

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[92] The high values were thought to be the result of the release of more than a few percent of core inventory.

function and the water supply function at the spent fuel pool, taking into account their impact on the defence in depth.

On 12 April 2011, the fourth report was issued rating the accident at provisional Level 7. The rating was based on the estimation of the amount of radioactive material released.

The event at the Fukushima Daini NPP was rated on 18 March 2011. Provisional Level 3 was assigned to Units 1, 2 and 4, considering the impact on the defence in depth resulting from the loss of the residual heat removal system.

3.3.7. International trade

Protection and control of international trade in a nuclear emergency is both an urgent protective action and a long term measure. This measure is necessary to minimize the adverse non-radiological consequences of an emergency [13].

Many activities and measures were initiated that were aimed at: (1) reassuring the public, industries and States of the safety of Japanese products; (2) facilitating international trade of Japanese products and preventing delays in distribution; and (3) providing advice and guidance to businesses and industries, in particular in Fukushima Prefecture [59, 60, 172-176].

These activities also included explanations at different international conferences and ministerial meetings about the relaxation of restrictions on Japanese exported products and about the need for any measures restricting trade in Japanese goods to be based on scientific grounds and in line with World Trade Organization (WTO) agreements.

Most importing States introduced control measures on Japanese goods; many increased existing import controls or requested a certificate from the Government of Japan; and some banned the import of Japanese goods or those from certain regions of Japan (mostly agricultural products) for a period of time.

In June 2011, Japan established a certification system[93] for food products intended for export, which helped to reassure the public and other interested parties that controls were in place. This system was extended in September 2011 to cover shipping containers and some industrial products intended for export [177], including fee subsidization as a governmental measure to reduce the burden on Japanese companies. The list of government designated inspection organizations that issued certificates were made available on the Japan External Trade Organization (JETRO) web site [177] to facilitate access to information for the companies concerned.

In addition to the certification system, the regulatory developments of the destination countries (i.e. country specific restrictions and requirements) were followed, and easily accessible information was provided on web sites to those Japanese organizations and companies engaged in export activities of different products, such as food, crafts and textiles [178, 179].

A survey of radioactivity levels in textile products produced in various parts of Japan and the world was performed in order to ascertain the impact of radioactivity on Japanese textile products [180]. The survey was conducted from April to May 2011, and the results were published in June 2011. The results showed no significant differences in radioactivity levels among the various products analysed,

[93] The certification system was based on the Japan Chamber of Commerce and Industry Act issued in 1953 (Act No. 143, Aug.1, 1953).

regardless of their place of production, whether produced in different places within Japan or manufactured outside Japan [180].

On 23 June 2011, Australia reported that no radioactive contamination of automobiles imported from Japan could be detected [181]. Between 12 March and 15 July 2011, 522 transportation vehicles and 5846 cargo shipments were monitored at Russian border checkpoints [182]. Only six vehicles that exceeded the Russian Federation's operational criteria[94] were returned to Japan. The US Food and Drug Administration (FDA) did not detect any radioactivity or impose any ban on non-food products that were imported from Japan and were subjected to radiation control[95] [183].

3.3.8. Waste management in the emergency

Safe and effective management of radioactive waste requires preplanned arrangements, including criteria and plans for characterizing and categorizing waste; operational criteria to assess the effectiveness of decontamination efforts; a method of testing decontamination methods before their general use; a method of minimizing the amount of waste and avoiding the unnecessary mixing of different waste categories; a method of determining appropriate predisposal management; appropriate storage options and sites; and a plan for the long term management of waste [11].

3.3.8.1. Relevant arrangements in Japan prior to the accident

Arrangements for the management of radioactive waste established in Japan prior to the accident covered waste generated in facilities such as NPPs, but it did not include radioactive waste that had been generated in public areas [184]. Detailed strategies, guidelines and instructions for radioactive waste management were developed after the accident.

The Fukushima Prefecture Disaster Management Plan [1] specified activities to be carried out by the Fukushima Prefectural NERHQ. A team responsible for decontamination and radioactive waste disposal was established [1], but no technical guidance had been developed prior to the accident on how decontamination and waste management operations would be implemented.

3.3.8.2. Activities during the emergency phase

Off-site waste that was generated following the accident may be classified either as debris from the earthquake/tsunami (often referred to as disaster waste) or as a consequence of remediation activities. Around 2.3 million tonnes of contaminated debris from the earthquake and tsunami were collected during 2011, and the estimate[96] of the volume of soil generated from decontamination was between 16 and 22 million m^3 after volume reduction (incineration) [185]. The debris consisted of materials such as wood, concrete and metal, while remediation wastes included sludge from water and sewage treatment, incinerated ash, trees, plants and soil resulting from decontamination activities [30, 186].[97]

Various instructions and guidelines were developed to address issues related to waste.

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[94] The dose rate measured up to 1.1 μSv/h above background. The Russian Federation's operational criterion was 0.3 μSv/h (above background).

[95] FDA regulated products such as medicines, porcelain plates and bowls, ceramic mortar and pestle, medical devices and cosmetic colour powder. For other shipments and products imported from Japan, the US Customs and Border Protection had the authority to carry out radiation control.

[96] At the time of writing this volume.

[97] For a detailed description of the management of contaminated material and radioactive waste, see Technical Volume 5, Section 5.4.

On 25 March, 12 April, 26 April and 6 May 2011, based on technical advice from the NSC [22], instructions were issued by MAFF on how to dispose of vegetables and raw milk in areas subject to food restriction(s). Instructions on what to do with foods that were not to be consumed were issued in the form of 'Question and Answers' on the MAFF web site on 26 April 2011 [187]. For example, it was recommended that harvested vegetables should not be ploughed under farmland or burned. Other vegetables could be harvested without ploughing, and, after the harvest, they should all be gathered and stored in one place. Farm works such as tillage could then be carried out. With regard to raw milk, taking into account the relatively low level of detected radionuclides it contained, farmers were advised to pour it into a specific point of their land or spread it on a specific and narrow area of their farm. In the case of large quantities (e.g. dairy companies), the milk was to be disposed of at waste disposal facilities [187].

Following the detection of radionuclides in waterworks and sewage sludge in prefectures located mainly in the east of Japan, an inquiry was initiated on 12 May 2011 on the approach to immediate handling of secondary by-products of sewage treatment in Fukushima Prefecture [30]. The results of the inquiry were issued on 16 June and specified the methods for the management of 'dewatered' sludge, such as the utilization of a particulate trap for concentrations exceeding 500 000 Bq/kg and a system for sealing the resulting ash in containers. The minimum distance of landfill storage locations from residential areas and the appropriate use of secondary by-products (e.g. concrete) that contained dehydrated sludge were also specified. In addition, the document described the condition of the disposal sites, including the criteria that indicated the appropriate long term management of the site and whether monitoring was warranted [188].

The storage, interim storage and transport of 'dewatered' sludge were outlined in the guidance [30, 186]. This included the thickness of shielding and recommendations on the frequency of monitoring of the shielding or containers (dose equivalent rate), exhaust gases from incineration (concentrations) and water (concentrations) at the facilities used for interim storage. The guidance also specified the need for maintaining records of the waste being kept at the interim storage.

For the decontamination works of the schools in Fukushima Prefecture, MEXT announced on 19 April its provisional concept on the utilization of school buildings and school yards, etc., of schools in Fukushima Prefecture [30, 72].

The Near-Term Policy to Ensure the Safety for Treating and Disposing Contaminated Waste around the Site of the Fukushima Daiichi NPP was issued by the NSC on 3 June 2011 [186]. This document provided dosimetric criteria for: recycled materials; protection of workers treating the materials; protection of members of the public in the vicinity of treatment facilities; and protection of members of the public in the vicinity of a disposal site. The NSC proposed that materials affected by the accident — i.e. debris, sludge from the water and sewage treatments, incinerated ash, trees, plants and soil resulting from decontamination activities — would be disposed of under proper management and that some materials may be considered for reuse. Products manufactured from these reused materials would be checked for contamination and managed appropriately before being released onto the market. Appropriate protective measures would ensure that radiation exposure of workers and the public was kept as low as reasonably achievable [186]. A final disposal strategy would be derived based on the quantities of waste, types of radioactive material, radioactivity concentration and evaluations of the long term safety of disposal facilities.

The radiation dose to workers engaged in processing contaminated materials was limited to 1 mSv/y. The same criterion of 1 mSv/y was specified for residents in the vicinity of contaminated waste treatment facilities, with a requirement that all necessary actions had to be undertaken to achieve this stipulated level. Furthermore, criteria of 10 μSv/y and 300 μSv/y were specified for residents in the vicinity of treatment facilities for the post-operational period, and for the basic and less likely exposure scenarios, respectively [30].

Guidelines on processing of disaster waste supposedly contaminated by radioactive materials were established on 19 June 2011, and the Guideline on Disaster Waste Processing in Fukushima Prefecture was issued on 23 June 2011. The basic approach, outlined in these documents, was for the volume of disaster waste to be minimized by recycling or by incineration, as appropriate [30].

The policy provided detailed instructions for recycling; in particular how disaster waste could be recycled if radionuclide concentrations were below those established using the clearance level of 10 μSv/y. In addition, provisions were made for the reuse of materials under controlled conditions at activity concentrations exceeding clearance levels. Guidance on the use of metals contaminated by radioactive materials and broken concrete waste was also provided [30].

The policy stipulated that flammable waste would be incinerated at facilities equipped with bag filter and exhaust fume absorption functions. Monitoring of the ground, water, exhaust gas and drains was to be performed on a continual basis. Detailed guidelines on the methods of incineration of combustible waste were provided, including the operational criteria for temporary storage (greater than 8000 Bq/kg) or disposal (8000 Bq/kg or less) of the ash. Operational criteria (dose rate in μSv/h), were specified for use in approximating the concentrations of the waste [30]. Incombustible disaster waste was subject to landfill processing.

The Basic Policy for Emergency Response on Decontamination Work [72] was established by the NERHQ on 26 August 2011 as an interim policy until the Act on Special Measures Concerning the Handling of Environment Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with Tohoku District: Off the Pacific Ocean Earthquake that Occurred on March 11, 2011 [189] was fully in force. The Act was enacted on 26 August 2011, promulgated on 30 August 2011 — with portions of the Act entering into force the same day — and entered fully into force in January 2012 [189]. It outlined the management of the contaminated areas and included the assignment of responsibilities to the national and local governments, the operator and the public. It facilitated the transition from an emergency exposure situation to an existing exposure situation. It also formalized the long term management of environmental monitoring, decontamination measures and the designation, treatment, storage and disposal of soil and waste contaminated by radioactive material. For a detailed discussion on the above, see Technical Volume 5, Section 5.4.

3.3.9. Summary

National emergency arrangements at the time of the accident envisaged that decisions on protective actions would be based on estimates of the projected dose to the public that would be calculated when a decision was necessary using the dose projection model SPEEDI. The arrangements did not envisage that decisions on urgent protective actions for the public would be based on predefined specific plant conditions. However, in response to the accident, the initial decisions on protective actions were made on the basis of plant conditions. Estimates of the source term could not be provided as an input to SPEEDI owing to the loss of on-site power.

The arrangements prior to the accident included criteria for sheltering, evacuation and iodine thyroid blocking in terms of projected dose, but not in terms of measurable quantities. There were no predetermined criteria (i.e. generic, in terms of dose, or operational, in terms of measurable quantities) for relocation.

Prior to the accident, 10 km emergency planning zones were in place around the Fukushima Daiichi and Fukushima Daini NPPs. However, the extent of these zones did not take into account the potential for a severe accident. In addition, provisions were not in place to extend relevant protective actions beyond the emergency planning zone.

Protective actions and other response actions for the public implemented during the accident included: evacuation; sheltering; iodine thyroid blocking (through the administration of stable iodine); restrictions on the consumption of food and drinking water; relocation; and the provision of information.

The evacuation of people from the vicinity of the Fukushima Daiichi NPP began in the evening of 11 March 2011, with the evacuation zone gradually extended from a radius of 2 km from the plant to 3 km, and then to 10 km. By the evening of 12 March, it had been extended to 20 km. Owing to a lack of detailed preplanned arrangements for evacuation to locations outside the 10 km emergency planning zone, and because of difficulties in coordination, many evacuees were relocated several times during the first 24 hours.

The area in which people were ordered to shelter extended from within 3–10 km of the plant shortly after the accident to within 20–30 km by 15 March. In the area within a 20-30 km radius of the NPP, the public was ordered to shelter until 25 March, when the national Government recommended voluntary evacuation. Prolonged sheltering resulted in disruption in people's daily lives owing to the breakdown of the local infrastructure.

Administration of stable iodine for iodine thyroid blocking was not implemented uniformly, primarily due to the lack of detailed arrangements.

There were difficulties in evacuation due to the damage caused by the earthquake and tsunami and the resulting communication and transportation problems. In spite of damaged roads and traffic jams, most residents not requiring medical support left the evacuation areas within a few hours of the evacuation orders.

There were also significant difficulties encountered when evacuating patients from hospitals and nursing homes within the 20 km evacuation zone.

After the urgent protective actions had been taken on the basis of plant conditions, there was a need to obtain environmental monitoring data beyond the evacuated areas to verify the levels of radionuclides in the environment and to adjust the initial protective actions, if necessary. Environmental monitoring following the accident was performed in difficult and hazardous conditions and with limited equipment and staff.

On 22 April, the existing 20 km evacuation zone was established as a Restricted Area, with controlled re-entry. A Deliberate Evacuation Area was also established beyond the Restricted Area in locations where the specific dose criteria for relocation might be exceeded.

Once radionuclides were detected in the environment, arrangements were made on 17 March 2011 regarding restrictions on the consumption and distribution of food and consumption of drinking water and protective actions in the agricultural area. These arrangements included the development of levels of radioactive caesium and iodine in food and drinking water, called Provisional Regulation Values, above which foods and drinking water were restricted.

Later on, criteria were also established for fishery products, animal feed and agricultural soil for rice cultivation. The mechanism for placing restrictions on food and water evolved with the changing situation. A system was established to prevent foods with radionuclide levels exceeding the Provisional Regulation Values from entering the supply chain. Legal restrictions or voluntary measures were then communicated in order to: (a) prevent food with radionuclide levels in excess of the Provisional Regulation Values from entering the supply chain, and (b) provide advice on how to minimize (avert) the dose (e.g. residents were advised to refrain from having infants drink tap water).

A number of challenges were encountered in the process of controlling the distribution of food, milk and drink from affected areas, including: (i) defining the criteria (activity concentrations of radionuclides) that could be used as the basis for food control; (ii) determining which foods, in different geographical locations, were or could be affected above these criteria; (iii) dealing with insufficient infrastructure and resources for sampling and analyses; and (iv) addressing the concerns of some local governments about performing the sampling and analyses [25].

Several channels were used to keep the public informed and to respond to people's concerns during the emergency, including television, radio, the Internet and telephone hotlines. Feedback from the public received via hotlines and counselling services identified the need for easily understandable information and supporting material. There was a lack of formalized procedures to ensure consistency in the release of information to the public from different response organizations. In some cases, this led to inconsistent information being provided. There were also instances when spokespersons were found to have had insufficient training and experience in dealing with the media, and several changes in spokespersons occurred over a short time period.

While various protective actions were implemented to ensure the safety of the public, people's concerns with regard to their safety were not always addressed to their satisfaction. During the emergency, calculated doses or various measured quantities (e.g. dose rates or radionuclide concentrations) were used to explain the situation, without placing them into context and trying to explain the situation to the public.

The International Nuclear and Radiological Event Scale (INES) was used separately for rating different units at the same site. This led to public and media concerns each time the INES rating was revised to a higher level.

Most importing countries introduced radiation control measures on Japanese goods, and many intensified import controls or requested a certificate from the Japanese Government, and some banned the import of Japanese goods for a period of time. In this regard, the establishment of a testing and certification system in Japan for food and other products intended for export helped to reassure the public and interested parties, such as importing States.

The radioactive waste arising from the accident was managed in a manner that did not compromise the protection strategy. Detailed strategies, guidelines and instructions for radioactive waste management were developed during the response to the emergency.

Decisions of the national and local governments were not always properly coordinated, mainly owing to severe communication problems caused by the inoperability of the Off-site Centre. For example, Fukushima Prefecture decided on the evacuation of a 2 km zone around the Fukushima Daiichi NPP (based on information received directly from TEPCO personnel) at 20:50 on 11 March, without being aware that the national Government would take a decision to evacuate a 3 km zone only 33 minutes later, at 21:23.

Furthermore, there were insufficient instructions on how to prepare for the evacuation. Consequently, some residents returned home to collect belongings before full access controls were in place by the end of March 2011. In May 2011, short term temporary access was allowed to the Restricted Area in a controlled manner and with the necessary instructions and monitoring.

Dose rate measurements from 15 March onward indicated that relocation for some areas beyond the 20 km evacuation zone was warranted. The order for relocation of people from these areas (establishment of the Deliberate Evacuation Area) was given on 22 April, and relocation began around 15 May. In addition, areas warranting relocation were identified outside the Deliberate Evacuation Area until November 2011.

3.3.10. Observations and lessons

- **Arrangements need to be in place to allow decisions to be made on the implementation of predetermined urgent protective actions for the public based on predefined plant conditions.**
  These arrangements are necessary because decision support systems, including those using computer models, may not be able to predict the size and timing of a radioactive release (the source term), the movement of plumes, deposition levels or resulting doses quickly or accurately enough in an emergency to be able to provide the sole basis for decisions on initial urgent protective actions.
  At the preparedness stage, there is a need to develop an emergency classification system based on observable conditions and measurable criteria (emergency action levels). This system enables the declaration of an emergency shortly after the detection of conditions at a plant that indicate actual or projected damage to the fuel and initiation of predetermined urgent protective actions for the public (in the predefined zones) promptly following classification of the emergency by the operator. This emergency classification system needs to cover a full range of abnormal plant conditions.
- **Arrangements need to be in place to enable urgent protective actions to be extended or modified in response to developing plant conditions or monitoring results. Arrangements are also needed to enable early protective actions to be initiated on the basis of monitoring results.**
  At the preparedness stage, there is a need to establish arrangements to, among others: (1) define emergency planning zones and areas; (2) establish dose and operational criteria (levels of measurable quantities) for taking urgent protective actions and other response actions, including dealing with special population groups within emergency zones (e.g. patients in hospitals); (3) enable urgent protective actions to be taken before or shortly after a release of radioactive material; (4) enable prompt establishment of access controls in areas where urgent protective actions are in place; (5) extend protective actions beyond the established emergency planning zones and areas if necessary; (6) establish dose and operational criteria for taking early protective actions and other response actions, e.g. relocation and food restrictions, that are justified and optimized, taking into account a range of factors such as radiological and non-radiological consequences, including economic, social and psychological consequences; and (7) establish arrangements for revision of operational criteria for taking early protective actions on the basis of the prevailing conditions.
  Emergency planning zones and areas, within which arrangements for the implementation of urgent and other protective actions are made, need to be established with severe nuclear emergencies taken into account. Such zones are to be established at the preparedness stage as part of a comprehensive protection strategy. There is also a need to establish arrangements to extend actions beyond the established planning zones and areas, if needed under conditions prevailing in an emergency.
  As part of preparedness for urgent protective actions, sheltering needs to be considered as a short term protective action, accompanied by iodine thyroid blocking.
  Arrangements need to take into account the possibility of restricting consumption and distribution of possibly contaminated local produce, milk from grazing animals and drinking water before the monitoring and analysis of samples are carried out.
- **Arrangements need to be in place to ensure that protective actions and other response actions in a nuclear emergency do more good than harm. A comprehensive approach to decision making needs to be in place to ensure that this balance is achieved.**
  These arrangements need to be developed with a clear understanding of the full range of possible health hazards presented in a nuclear emergency and of the potential radiological and non-radiological consequences of any protective actions.
  Protective actions need to be taken in a timely and safe manner, taking into account possible unfavourable conditions (e.g. severe weather or damage to infrastructure).

Preparations in advance are necessary to ensure the safe evacuation of special facilities, such as hospitals and nursing homes. Continued care or supervision must be provided for those who need it.

The need for the provision of instructions to all categories of farmers and for assisting those individuals who have been relocated also needs to be addressed.

— **Arrangements need to be in place to assist decision makers, the public and others (e.g. medical staff) to gain an understanding of radiological health hazards in a nuclear emergency in order to make informed decisions on protective actions. Arrangements also need to be in place to address public concerns locally, nationally and internationally.**

Public concerns need to be effectively addressed in a nuclear emergency. This includes the means to relate measurable quantities (e.g. dose rates) and projected radiation doses to radiological health hazards in a manner that allows decision makers (and the public) to make informed decisions concerning protective actions. Addressing public concerns contributes to mitigating both the radiological and the non-radiological consequences of the emergency.

These arrangements need to ensure prompt explanation of any health risks and possible appropriate individual actions for reducing these risks. Arrangements need to be in place to provide the public with useful, consistent and understandable information throughout a nuclear emergency, including an answer to the public's principal concern about potential health consequences; and to provide the public with an explanation of the basis for protective action recommendations.

International concerns could be addressed, in part, by means of certification systems to demonstrate that tradable goods meet international standards and to reassure importing States and the public.

— **Medical staff (health care professionals) need to be trained in basic medical response to a nuclear emergency and in adequate management of (possibly) contaminated patients to avoid delays in the treatment of injured people.**

Facilities that could be used as potential reception centres for triage, screening, decontamination and primary care of patients (either emergency workers or the public) need to be identified at the preparedness stage to facilitate the mobilization of resources during an emergency. Those treating or transporting contaminated patients would need to take the same kinds of precautions that would normally be applied when dealing with potentially infectious patients.

— **Emergency arrangements need to include provisions at the preparedness stage for implementing restrictions on the use and distribution of non-food commodities which have been, or could be, contaminated as a result of the emergency.**

Generic and operational criteria are needed to assess, where necessary, the adequacy of goods for use and distribution, and to establish a system for ensuring that controls are placed on those goods intended for international trade. These arrangements need to minimize major disruptions in international trade, while ensuring protection of the public.

— **Radioactive waste arising from the emergency needs to be managed in a manner that does not compromise the protection strategy.**

Detailed technical guidance for the management of radioactive waste, including food waste and waste generated from decontamination and remediation activities, needs to be developed at the preparedness stage. The guidance needs to include consideration that possible locations for facilities to store the radioactive waste on an interim basis and for long term disposal may need to be identified in advance. These arrangements need to be determined and agreed with the involvement of all relevant stakeholders, such as the local communities, at the preparedness stage.

3.4. TRANSITION FROM THE EMERGENCY PHASE TO THE RECOVERY PHASE AND ANALYSES OF THE RESPONSE

3.4.1. Transition from the emergency phase to the recovery phase

Figure 3.4–1 represents a timeline of key events relevant to the transition from the emergency phase to the recovery phase.

March – April
- Characterization of the exposure situation and exposure pathways

17 April
- TEPCO issued a roadmap that outlined the steps toward recovery on the site

17 May
- National Government issued Roadmap for Immediate Actions for the Assistance of Nuclear Sufferers

May
- Initiation of the Fukushima Health Management Survey

13 June
- Announcement of a detailed monitoring plan

July and August
- Guidance on termination of protective actions issued by the NSC

26 August
- Enactment of Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the NPS Accident Associated with the Tohkou District–Off the Pacific Ocean Earthquake that Occurred March 11, 2011
- Basic Concept for Pushing Ahead with Decontamination Works and Basic Policy for Emergency Response on Decontamination Work issued by NERHQ

30 September
- Evacuation Prepared Area in Case of Emergency lifted

1 November
- 100 mSv effective dose criterion re-established for new emergency workers engaged in emergency work

16 December
- Conditions for a cold shutdown state achieved in Units 1–3
- 100 mSv effective dose criterion re-established for the majority of emergency workers (on-site and off-site) engaged in emergency work, except approximately 50 TEPCO employees working on-site

1 April 2012
- Standard limits established with activity concentrations for radionuclides in food and drinking water on the basis of 1 mSv/y criterion

30 April 2012
- 100 mSv effective dose criterion re-established for the remaining 50 TEPCO employees

FIG. 3.4–1. Timeline of key events relevant to the process of transitioning from the emergency phase.

3.4.1.1. Relevant arrangements in Japan prior to the accident

The specific policies, guidelines and criteria, as well as overall arrangements for the transition from the emergency phase[98] to the recovery phase, were developed after the accident [190]. Prior to the accident, the national framework in Japan had not taken into account situations requiring long term recovery operations over wide areas [57].

3.4.1.2. International standards and recommendations on transitioning prior to the accident

IAEA Safety Standards Series No. GS-R-2, Preparedness and Response for a Nuclear or Radiological Emergency [11], specifies requirements for the establishment of arrangements for the transition from emergency phase operations to routine long term recovery operations and for the resumption of normal social and economic activity, including generic optimized intervention levels for initiating and terminating temporary relocation. It emphasizes the need for planning for such a transition at the preparedness stage.

The approach with regard to radiation protection in ICRP recommendations, issued in Publication 103 in 2007, is based on the characteristics of radiation exposure for the following three situations: planned, emergency[99] and existing[100] exposure situations [115]. The management of long term exposures following a nuclear or radiological emergency is to be treated as an existing exposure situation. These recommendations also recognize that the process of transitioning to the existing exposure situation following an emergency requires planning in advance; this planning is to be done as part of the overall emergency preparedness process. In addition, it is recommended that the process of transitioning be carefully balanced to include the views of all relevant stakeholders, including the public, with the fundamental goal that this approach is justified, i.e. it does more good than harm [115].

The ICRP recommendations in Publication 103 introduced the concept of reference level that is to be applied to an emergency and an existing exposure situation as "…the level of dose or risk, above which it is judged to be inappropriate to plan to allow exposures to occur, and below which optimisation of protection should be implemented" [115].

In addition, the recommendations specified the bands for reference levels in terms of residual dose to be applied for both exposure situation as follows: 20–100 mSv acute or annual effective dose for emergency exposure situations and 1–20 mSv acute or annual effective dose for existing exposure situations, stating that the "chosen value for a reference level will depend upon the prevailing circumstances of the exposure under consideration" [115].

In developing arrangements for the transition from the emergency phase to the recovery phase after the accident, the Japanese authorities decided to apply the latest recommendations of the ICRP [115, 191, 192].

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[98] The period of time from the detection of conditions warranting an emergency response until the completion of all the actions taken in anticipation of or in response to the radiological conditions expected in the first few months of the emergency. This phase typically ends when the situation is under control, the off-site radiological conditions have been characterized sufficiently well to identify where food restrictions and temporary relocation are required, and all required food restrictions and temporary relocations have been implemented [12].

[99] An unexpected situation that occurs during the operation of a practice, requiring urgent action. Emergency exposure situations may arise from practices [115].

[100] A situation that already exists when a decision on control has to be taken, including natural background radiation and residues from past practices that were operated outside the ICRP's recommendations [115].

3.4.1.3. Plans for returning to normality

The process for transition from the emergency phase to the recovery phase included adjusting the protective actions and arrangements made early in the emergency response and taking account of the information available on the conditions in the affected areas (obtained primarily through comprehensive monitoring) [145, 193]. It also included consideration of the necessary longer term recovery operations.

Gathering relevant information through comprehensive environmental monitoring, which was aimed at supporting the implementation of early protective actions (relocation, food restrictions, etc.), also made it possible to plan and implement longer term remedial actions in an informed manner, including additional thorough monitoring and decontamination activities as well as the identification of any need for medical follow-up. The announcement that control of the situation had been regained at the Fukushima Daiichi NPP (attainment of 'cold shutdown state'[101]) in December 2011 and the enactment of Act No. 110 of 2011 [189] facilitated the process of transitioning from the emergency phase to long term recovery operations.

The overall responsibility of managing the process for returning to normality rested with NERHQ. The Nuclear Emergency Act [5] specified that termination of NERHQ would take place when the "..declaration of the cancellation of a nuclear emergency situation is issued…", with the NSC to provide advice on the termination of the emergency [5].[102]

On 17 April 2011, TEPCO issued a roadmap that outlined the steps towards recovery on the site (basic policy, targets and immediate actions in the areas of: cooling, mitigation of consequences, and monitoring and decontamination) [194].

The objectives and conditions to be met for the termination of the emergency phase were defined in the plan to return to normality announced by the Japanese Government on 17 May 2011 [190]. On 17 May 2011, METI issued the Roadmap for Immediate Actions for the Assistance of Nuclear Sufferers [190]. This listed nine groups of actions divided into steps scheduled to be implemented over different time periods connected to TEPCO's roadmap. Step 1 had a target of mid-July, step 2 a target of around three to six months after achieving step 1, and step 3 for the mid-term period.

The nine groups of actions were:

(1) Actions for the recovery from the accident at TEPCO's Fukushima Daiichi NPP;
(2) Actions related to the area evacuated up to 20 km based on plant conditions (Evacuation Area);
(3) Actions related to the area whose population was to be relocated (Deliberate Evacuation Area);
(4) Actions related to the area whose population was advised to shelter (Evacuation Prepared Area in Case of Emergency);
(5) Actions to ensure the safety and reassurance of those affected;
(6) Actions to secure employment and provide support to farms and industries;
(7) Actions to support the local municipalities in the affected areas;
(8) Actions related to compensation of sufferers, affected businesses, etc.;
(9) Actions to assist those returning to areas that were evacuated.

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[101] The term cold shutdown state was defined by the Government of Japan at the time specifically for the Fukushima Daiichi nuclear power plant. Its definition differs from the terminology used by the IAEA and others.

[102] As of June 2015, the formal cancellation of a nuclear emergency situation has not been issued.

This roadmap was intended to facilitate communication and preparations for the transition to long term recovery operations and the resumption of normal social and economic activity. It allocated responsibilities and specified other organizational aspects of the transition process and the objectives and conditions for termination of the emergency phase.

The roadmap was revised in July 2011 [195]. Status updates on the progress in implementing the roadmap were issued each month until December 2011 [196].

The attainment of Step 1 of Action 1 (radiation dose in steady decline) was confirmed in July 2011 by monitoring results indicating that the release of radioactive material had steadily declined since the start of the accident [194, 197].

Actions 2–4 outlined the steps to be taken in the areas where the population had been evacuated, relocated or advised to shelter.[103] These actions were to be carried out following completion of Step 2 of Action 1 (stability assessment of the reactors).

On 19 July 2011, the requirements for lifting protective actions were set forth in the NSC's Basic Policy of the Nuclear Safety Commission of Japan on Radiation Protection for Termination of Evacuation and Reconstruction (referred to hereafter as 'the Policy') [192] The Policy summarized the NSC's recommendations for the termination of protective actions and the restoration of normal life.

The Policy recommended that the areas categorized as being in an emergency exposure situation could be re-categorized as being in an existing exposure situation when the release of radioactive material from the Fukushima Daiichi NPP would be under control, and the exposures due to residual radioactive materials in the areas could be limited to 20 mSv/y[104] or less. The Policy stated that the public should participate in the planning and formulation of the protective actions, and that appropriate consideration should be given to all relevant aspects such as health, environment, society, economy, ethics, psychology and politics [30, 192].

The Policy also recommended that operational criteria should be used to determine where long term protective actions needed to be implemented. It stipulated that the reference level for the optimization of the protective actions be selected from the lower part of the 1–20 mSv/y band, in accordance with the ICRP's recommendation for the management of an existing exposure situation [192]. However, no recommendations were made related to the principle of justification.

On 13 June 2011, the Plan to Conduct Detailed Monitoring in Restricted Area and Planned Evacuation Zone was announced, which explained that monitoring of air, soil, forests, human-made materials (e.g. homes, roads) and water would be performed within the Restricted Area and Deliberate Evacuation Area; with the results of monitoring used to develop model projects for decontamination [145]. In addition, a monitoring coordination meeting with representatives from the relevant ministries, Fukushima Prefecture and TEPCO was held in July to promote coordination. A Comprehensive Monitoring Plan that specified the roles of the organizations was issued in August 2011. This plan was revised in March 2012 to improve cooperation between the

[103] The steps included obtaining emergency housing, providing temporary access and making preparations for relocation of the population of these areas (Deliberate Evacuation Area).

[104] It should be noted that this benchmark (20 mSv/y) is the same as the one used to judge the need for evacuation of the public in the Deliberate Evacuation Area, as well as the one initially applied in determining the acceptability of reopening the schools (see also Section 3.3.4.2), which resulted in major public concerns and confusion over the level of protection being afforded [25].

organizations[105] and to increase the monitoring activities in order to enable a review of the areas where evacuation orders had been issued, and address increasing concern of the release of radioactive materials into the sea from the rivers over the medium to long term. An on-line portal was also launched to facilitate the joint provision of monitoring results by the various organizations [145].

The provisions for the protection of workers were gradually modified, depending on the work being undertaken [27, 69]. As more information about hazardous conditions in which specific work needed to be undertaken was gathered, and there was more time for detailed planning of the work in the affected areas, the requirements and arrangements for the protection of emergency workers and other workers started to become more stringent. As explained in Section 3.2.3.2, the increased dose criterion for emergency workers of 250 mSv was withdrawn gradually starting on 1 November 2011 for newly engaged emergency workers and on 16 December 2011 (attainment of cold shutdown state at the plant was announced) for most emergency workers. However, even when this was being announced, it was obvious that there was a continued need for about 50 TEPCO employees to be subject to less stringent dose criteria, owing to the specifics of the duties they carried out. It was about a year after the onset of the accident and several months after the attainment of a cold shutdown state was announced (30 April 2012) that the increased dose criterion of 250 mSv was fully withdrawn for emergency workers with specific duties to maintain the control over the reactors and spent fuel pools under hazardous emergency conditions [68, 198].

In parallel with these efforts to manage the doses of emergency workers on the site within the 100 mSv criterion (see Section 3.2.3.2), the preparation for the planned decontamination and restoration work necessitated the establishment of a new legal framework for ensuring adequate protection of workers engaged in these works. This was mainly because regulations in Japan, at the time of the accident, did not sufficiently cover activities during the existing exposure situation following an emergency. As of 26 August 2011, for all workers engaged in decontamination work, restoration and waste management, the requirements for occupational exposure in normal operation were applied for the existing exposure situation (i.e. planned exposure situation) [199, 200]. Later on, relevant ordinances were either developed, or revised, in 2012 and 2013 [57, 76, 77, 201, 202]. Although not explicitly referred to, the new requirements and respective guidelines for the protection of workers engaged in decontamination works or works under designated dose rates were considered by the MHLW as useful also for local residents and volunteers who were in the special decontamination areas [57, 76, 77]

Simultaneously with the ongoing efforts to characterize fully the exposure situation and to plan for decontamination activities, long term health surveillance was initiated at the end of June 2011 (the Fukushima Health Management Survey) [59]. The purpose of the survey was to perform thyroid examinations of those aged 18 or younger at the time of the accident who were located in Fukushima Prefecture at the time of the accident. In addition to this activity, a survey and other supporting activities were initiated to evaluate the doses received by the population of the prefecture [173].

On 4 August 2011, the NERHQ requested the advice of the NSC on the areas where protective actions were being implemented (evacuation, relocation and sheltering), in order to determine whether any changes were required. On the same day, the NSC provided a document entitled Standpoint of the Nuclear Safety Commission for the Termination of Urgent Protective Actions Implemented for the Accident at the Fukushima Daiichi Nuclear Power Plant [203], which included guidance on the termination of the protective actions specific to the areas that had been recommended to shelter, relocate and evacuate. The recommendations for the approach to the termination were: (1) the

[105] These organizations included, among others: MEXT; NSC; MHLW; MAFF; Fisheries Agency; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment; Fukushima Prefectural Government; and TEPCO.

projected annual dose to the public is lower than the criterion of 20 mSv; (2) preparation for the implementation of long term protective actions had been made; and (3) a framework for the participation of the relevant local governments and residents in the process of deciding on the long term protective actions is developed.

On 9 August 2011, the Japanese Government prepared a review of the areas where protective actions were being implemented. The following three requirements for termination of the protective actions were outlined in the review: (1) the safety status of the NPP; (2) a decrease in the dose rate; and (3) restoration of the public service functions and infrastructure.

On the same day, a statement was issued by NISA and MEXT on the status of the NPP and environmental monitoring results that verified that requirements 1 and 2 of the Roadmap for Immediate Actions to Assist Residents Affected by the Nuclear Accident had been met [30].

On 19 August, all cities, towns and villages that had been advised to shelter (in the Evacuation Prepared Area) began preparing disaster recovery programmes, which were submitted to the Japanese Government. This was undertaken in order to fulfil requirement 3 of the Roadmap for Immediate Actions [190]. Over the next six weeks, consultations were held between the local governments and national Government on the areas where advice to shelter (in the Evacuation Prepared Area) had been given to the residents. On 30 September, the advice to shelter was withdrawn by the Japanese Government as a result of an assessment of the safety status of the Fukushima Daiichi NPP and measurements of the dose rate in the relevant areas. The announcement stated that monitoring would continue to be conducted and that local governments would implement their restoration plans. It was also noted that the date by which the public could return to the area would vary among local governments and would be undertaken with support provided by the national Government [193].

On 26 August, the goals and policies to be pursued over the next two years were issued by the NERHQ in the Basic Concept for Pushing Ahead with Decontamination Works and Basic Policy for Emergency Response on Decontamination Work [30, 72]. Act No. 110 of 2011 [189] outlined the management of the contaminated areas and included the assignment of responsibilities to the national and local governments, the operator and the public. It was enacted on 30 August 2011 and enforced in January 2012. The act facilitated the transition from an emergency exposure situation to an existing exposure situation; it formalized the long term management of environmental monitoring, decontamination measures, and the designation, treatment, storage and disposal of radioactive waste.

On 16 December 2011, a cold shutdown state was achieved at the NPP, which was used to indicate that the control of the situation had been regained [21]. This meant that Step 2 of Action 1 of the roadmap issued in May had been completed.

A review of the areas where protective actions were being implemented was required for completion of Step 2 of Action 1. The review of areas (Restricted Area and Deliberate Evacuation Area) was issued on 26 December 2011 by the Japanese Government in a document called Basic Concept and Issues to be Challenged for Rearranging the Restricted Areas and Areas to which Evacuation Orders have been Issued where Step 2 has been Completed [21]. The review of the areas was undertaken in consideration of the dose criterion of 20 mSv/y in terms of projected dose. Its criteria and area designations are presented in Table 3.4–1.

TABLE 3.4–1. CRITERIA, DESIGNATION AND COLOUR OF AREA SHOWN IN FIG. 3.4–2 [21]

Criteria	Designation	Colour shown in Fig. 3.4–2
Annual cumulative dose would be less than or equal to 20 mSv	Areas in which evacuation orders are ready to be lifted	Green (Area 1)
Annual cumulative dose may exceed 20 mSv but is less than 50 mSv	Areas in which residents are not permitted to live	Orange (Area 2)
Annual cumulative dose exceeds 50 mSv	Areas in which residents will not be able to return for a long time	Red (Area 3)

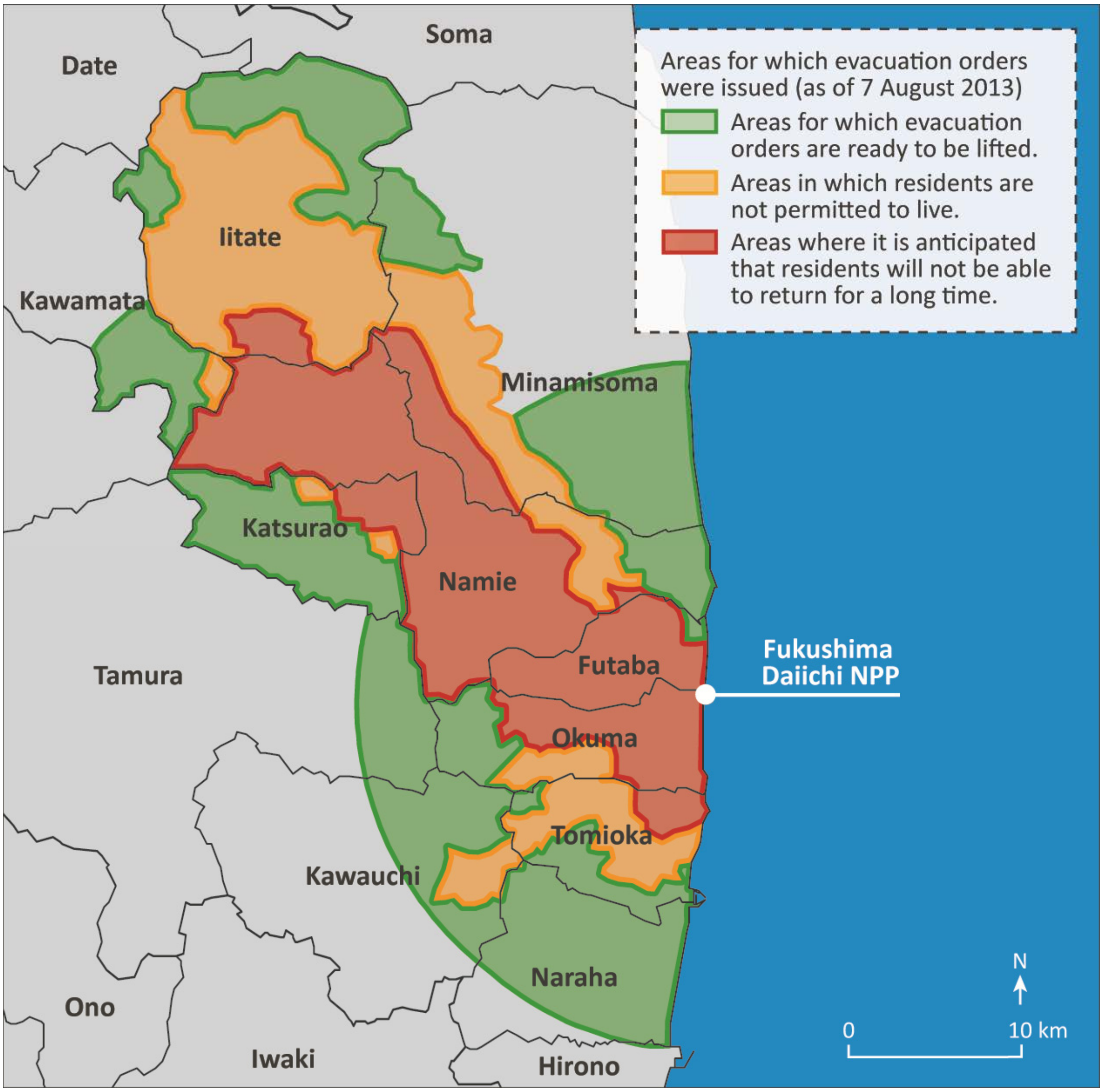

FIG. 3.4–2. Completion of the arrangement for areas where evacuation orders have been issued (7 August 2013) [204].

3.4.2. Analyses of the response

Analyses of the accident and the emergency response were undertaken by various bodies in order to identify lessons and to enhance, among other areas, emergency preparedness and response arrangements in Japan.

The timeline of events that are important for the analyses of the response are shown in Fig. 3.4–3.

24 May 2011
- Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company established

June 2011
- Report to the IAEA Ministerial Conference on Nuclear Safety submitted by NERHQ

July 2011
- NSC Working Group established to review the Regulatory Guide for Emergency Preparedness of Nuclear Facilities

September 2011
- Additional report by NERHQ submitted to the IAEA on the occasion of the Board of Governors meeting and General Conference 2011

26 December 2011
- Investigation Committee on the Accident at the Fukushima Nuclear Power Stations issued interim report

December 2011
- National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission established
- TEPCO Fukushima Nuclear Accident Analysis Report (interim version) issued

22 March 2012
- NSC Working Group submitted to NSC an interim report on revision of Regulatory Guide for Emergency Preparedness of Nuclear Facilities

June 2012
- Revision of Act on Special Measures Concerning Nuclear Emergency Preparedness

20 June 2012
- TEPCO Fukushima Nuclear Accident Analysis Report (final version) issued

5 July 2012
- National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission issued final report

23 July 2012
- Investigation Committee on the Accident at the Fukushima Nuclear Power Stations issued final report

19 September 2012
- Establishment of Nuclear Regulation Authority (NRA)

October 2012
- NRA released results to help determine the area of the Urgent Protective Action Planning Zone

FIG. 3.4–3. Timeline of key events important for analyses of the response

19 October 2012

- Revised version of national Government Nuclear Emergency Response Manual issued

31 October 2012

- Nuclear Emergency Response Guidelines issued by NRA

December 2012

- Cabinet Office held briefing sessions for local governments and prepared an amended manual on local emergency response plans

March 2013

- Approximate deadline for local governments to amend local emergency response plans

FIG. 3.4–3. Timeline of key events important for analyses of the response (cont.).

3.4.2.1. Analysis of the emergency performed in Japan

An analysis of the accident and of the emergency response was performed and presented in the form of reports[106], issued by the Government of Japan [22, 30], by two investigation committees created by the Government and the Parliament, respectively [21, 25, 27] and by the operating organization (TEPCO) [17] to identify actions to be taken that would prevent the occurrence of other emergencies and to improve the emergency arrangements in Japan. Following an agreement with the Government of Japan, the IAEA conducted a preliminary fact finding mission from 24 May to 2 June 2011 to identify initial lessons to be learned from the accident and share this information with the international community [51]. In addition, actions were taken by the NSC to review and update the organization's guidance, which was used as a basis for developing the relevant nuclear EPR documents of Japan. The regulatory body, NISA, also conducted a review to identify those measures that should be implemented immediately to update and improve the national EPR system.

The Government of Japan submitted the report to the IAEA Ministerial Conference on Nuclear Safety in June 2011 [22] presenting lessons in the following areas important for emergency preparedness and response: (1) combined natural disaster and nuclear emergency; (2) environmental monitoring; (3) allocation of roles between central and local organizations; (4) communication in an emergency; (5) response to assistance from other States and communication with the international community; (6) modelling of the release of radioactive materials; and (7) criteria for evacuation and radiation protection guidelines in nuclear emergencies. An additional report was submitted to the IAEA in September 2011 [30]. It provided information on further developments and progress in addressing the lessons that had been identified in the first report issued in June 2011.

The NERHQ and relevant government organizations were tasked with addressing these lessons.

On 2 December 2011, TEPCO released an Interim Report, which summarized the results of the investigations it had completed at the time and proposed various countermeasures, mainly in the equipment area, that were to address the causes of the accident and prevent a recurrence [31]. TEPCO's Final Report was issued in June 2012 [17] and highlighted issues that were identified during the response to the emergency, including: emergency response organization; communication of information; transportation of materials and equipment; and radiation protection.

[106] Reports from academia and from the private sector were also issued (e.g. from the Atomic Energy Society of Japan and the Rebuild Japan Initiative Foundation) [205, 206].

A detailed reconstruction of the accident scenario was performed to analyse the initiating event and determine the damage caused by the earthquake and tsunami. Consideration was given to the root causes of the emergency. Regulatory controls, general safety implications and necessary improvements concerning emergency arrangements were identified.

The report of the Fukushima Nuclear Accident Independent Investigation Commission established by the National Diet of Japan contained a recommendation for, among other things, reform of the national emergency preparedness and response system, including clarification of the roles and responsibilities of the Government, local government and operators in an emergency [25].

The Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company, created by the government, found that there was a need for Japan to take into account lessons from the international community and to include international standards, such as those developed by the IAEA, in its national guidelines [21].

The NSC had been considering, since 2006, to apply the guidance provided in IAEA Safety Standards Series No. GS-G-2.1 [13, 25].

In 2010, the NSC initiated a review of its Regulatory Guide for Emergency Preparedness for Nuclear Facilities (Nuclear Emergency Preparedness Guide) [19]. As stated in The Basic Policies for the Near-Term Initiatives of the Nuclear Safety Commission of December 2010 [207] it was planned to consider adoption of international standards into the Emergency Preparedness Guide and was still under consideration when the accident occurred on 11 March 2011.

The NSC established a working group under the Special Committee on Disaster Countermeasures on Nuclear Facilities to review the Emergency Preparedness Guide in July 2011. While reviewing the guide, the following aspects were taken into consideration: (1) the circumstances of the accident; (2) the investigation and examination by the National Diet of Japan, Fukushima Nuclear Accident Independent Investigation Commission [25], as well as by the Government Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company [21, 27]; (3) ICRP recommendations and IAEA safety standards; (4) deliberations among the working group members; (5) nuclear emergency countermeasures taken in other countries; and (6) the actual state of affairs and the effectiveness of measures in Japan.

The Special Committee submitted its interim report on the revision of the Regulatory Guide for Emergency Preparedness of Nuclear Facilities to the NSC in March 2012 [208] This document was then used as a basis for the development of the new regulatory guidelines issued by the newly established Nuclear Regulatory Authority (NRA) [100]. The new regulatory guidelines were subsequently implemented by the local governments when the local arrangements were revised.

In June 2011, NISA specified the measures for all NPPs that were to be immediately implemented, which included securing the means of communication on-site to ensure a quick response in the event of a severe emergency. Operators were directed to implement these measures, and NISA then verified their implementation. Furthermore, in March 2012, in a report on the technical knowledge of the accident at the Fukushima Daiichi NPP [209], NISA consolidated these measures as items to be reflected in future safety regulations. There were 30 safety measures recommended by NISA that included securing and improving a command post at the time of an emergency, securing communication functions, securing reliability of instrumentation facilities, reinforcement of plant status monitoring functions, reinforcement of environmental monitoring functions in an emergency, building an emergency response system and implementation of training.

3.4.2.2. Strengthening the national EPR system

In order to strengthen the national EPR system based on the experience and lessons learned from the accident and the establishment of the NRA on 19 September 2012, the Atomic Energy Basic Act, the Nuclear Emergency Act [5], and other related laws and regulations were amended, and the Government developed a new framework for nuclear emergency preparedness and response. This included changes to the Government's Nuclear Emergency Response Manual [210] and preparation of the regulatory body's Nuclear Response Guidelines [211] in order to reflect the amendments [212].

As a result of the revision of the Atomic Energy Basic Act, a Nuclear Emergency Preparedness Commission was established within the Cabinet, with the Prime Minister serving as the Chairperson and the Chief Cabinet Secretary, the Minister of the Environment, and the NRA Chairman serving as Vice Chairpersons [212]. The purpose of the Commission is to implement and promote nuclear emergency response policies in a unified manner by the Government [212, 213].

The revision of the Nuclear Emergency Act enhanced measures to strengthen the functions of the NERHQ in an emergency [5]. The NERHQ would be established, with the Prime Minister serving as Chairperson and the NRA Chairman serving as one of the Vice Chairpersons [212].

Changes to the Nuclear Emergency Act also included clearer assignment of on-site and off-site roles [5, 212]. The NRA now oversees the technical and professional safety requirements of on-site nuclear facilities. Other relevant ministries and agencies will handle the procurement of equipment at nuclear facilities and other off-site activities under the supervision of the Chief of NERHQ [212]. The Secretary-General of the NRA Secretariat will serve as the Director General of the NERHQ.

The chapter on nuclear emergency response in the Basic Disaster Management Plan was also revised [216]. Jurisdictions were changed following the establishment of the NRA and the crisis management system at the Prime Minister's Office, and the allocation of roles in taking on-site and off-site actions were specified. As described in Section 3.1.1., the Basic Disaster Management Plan specified that a Nuclear Emergency Response Manual of the national Government was to be prepared; this was also revised to reflect the changes made in the Plan [210].

At the first meeting of the Nuclear Emergency Preparedness Commission, the Nuclear Emergency Response Manual was approved [210]. It addressed such issues as the deployment of staff and response procedures of the NRA and other ministries and agencies during an emergency.

In conjunction with the Nuclear Emergency Act [5], which was revised on 19 September 2012, the Cabinet Office revised the related ministerial ordinances that covered the off-site centres and the associated technical standards guidelines. Prefectures hosting off-site centres will be responsible for assessing their preparedness based on the revised ministerial ordinances and guidelines.

3.4.2.3. Strengthening national guidance on EPR

In accordance with the Nuclear Emergency Act [5], the NRA is required to establish the Nuclear Emergency Response Guidelines to ensure that operators, the national Government and local governments coordinate the implementation of nuclear emergency response measures [212]. The NRA initiated relevant discussions with interested parties immediately after its inauguration and established the guidelines on 31 October 2012. The guidelines were subsequently revised on 27 February, 5 June and 5 September 2013 [211].

The emergency preparedness arrangements specified in the Nuclear Emergency Response Guidelines [212] are based on the IAEA safety standards in the area of EPR [11, 13, 14]. Arrangements include the following:

— Predetermined criteria, to be established for decision making in an emergency; these include emergency action levels (EALs)[107] and operational intervention levels (OILs);
— New zones (see Fig. 3.4–4), to be established with PAZs and urgent protective action planning zones (UPZs), within which arrangements are to be made for urgent protective actions;
— Protective actions (e.g. sheltering, evacuation, administration of stable iodine tablets, etc.), to be taken within the zones based on the predetermined criteria;
— A new system, for providing information, emergency monitoring and medical management, as well as education and training (e.g. for emergency workers);
— Requirements for prompt emergency monitoring;
— Requirements for prompt public information;
— Requirements for long term monitoring of human health and the environment;
— Requirements for the implementation of decontamination.

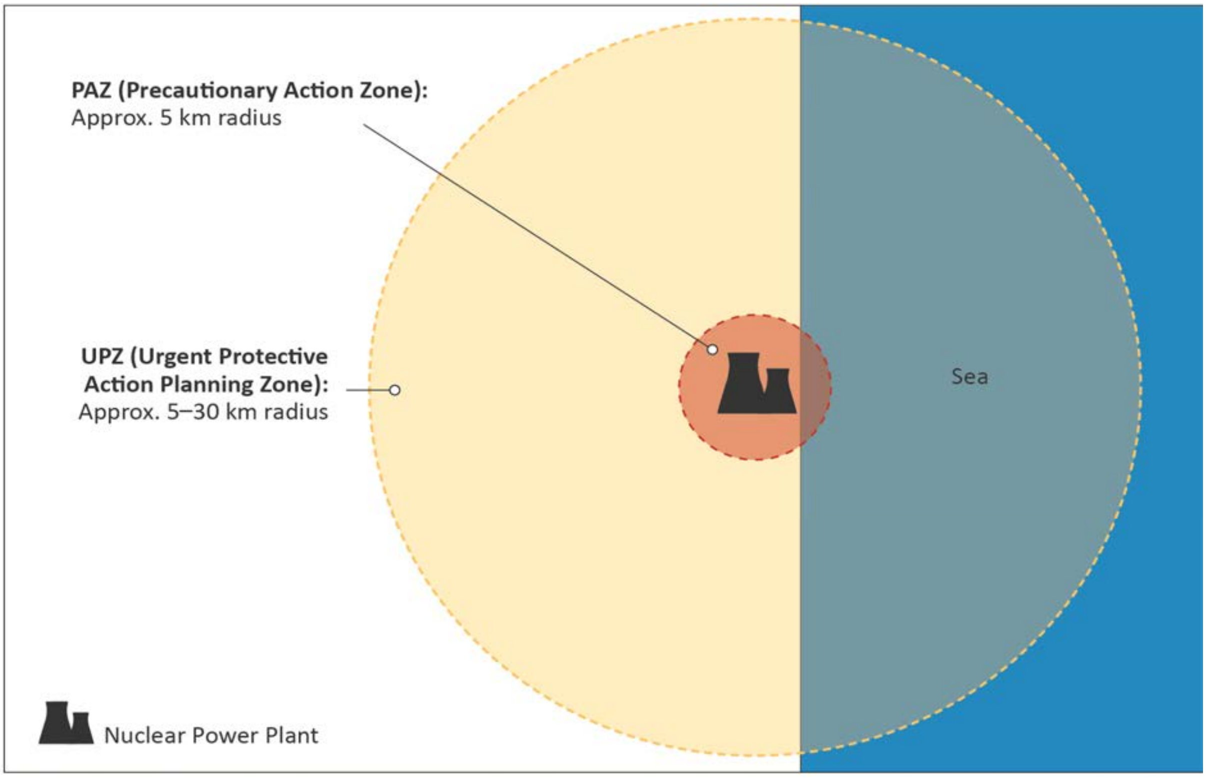

FIG. 3.4–4. Visual depiction of a PAZ and a UPZ [208].

Arrangements ensure that urgent protective actions are implemented within the predetermined zones upon the declaration of a General Emergency. Within the PAZ, evacuation of all local residents must

[107] The operator of a nuclear facility is required to immediately determine the applicable emergency class (based on the EALs), notify national and local governments and propose appropriate protective actions, if applicable. To enable appropriate protective actions to be implemented promptly, nuclear operators are required to consider establishing more detailed EALs that will reflect conditions at each power reactor and submit them to the NRA. The NRA will then examine the EALs and provide recommendations, if warranted [212].

generally be implemented immediately when the situation is classified as a General Emergency, and sheltering is recommended prior to evacuation. Within the UPZ, sheltering must be implemented as a general rule until phased evacuation or protective actions based on OILs are implemented. Beyond the UPZ, sheltering is generally implemented in the same way as within the UPZ. Accordingly, local residents must be warned that there is a possibility that temporary relocation might be necessary under the prevailing circumstances [212].

The NERHQ or local governments are required to issue orders and/or recommendations on the intake of stable iodine, in principle based on the decision by the NRA. Within the PAZ, the NERHQ or local governments are required to immediately issue orders and/or recommendations concerning evacuation and the administration of pre-distributed stable iodine tablets when the situation is classified as a General Emergency. Beyond the PAZ, the NRA determines the necessity of taking stable iodine, in addition to possible evacuation and sheltering, after which the NERHQ or local governments issue the necessary orders and/or recommendations [212].

The national and local governments are required to make arrangements for the provision of appropriate medical screening of evacuees and those temporarily relocated. Simple decontamination measures will be implemented, taking into account the effectiveness of such measures, if the specific OIL is exceeded [212].

For restrictions on the ingestion of food and drink, areas where dose rates exceeded a specific OIL are to be identified and the measurement of radionuclide concentrations in food and drink should be initiated. If these measurements confirm radionuclide concentrations in excess of the specific OIL, consumption of food or drink will be restricted. In implementing these restrictions, the NRA is required to disseminate all relevant information to local governments via the NERHQ; the local governments, in turn, are required to inform all local residents [212].

The guidelines emphasize the importance of stakeholder involvement in implementing intermediate and long term protective actions. The national and local governments are required to conduct continuous environmental monitoring to ascertain changes to a exposure situation to enable decisions, such as revisions to the evacuation zone size and determination of measures to manage and reduce exposures [212].

The national and local governments are required to take appropriate protective actions based on the results of estimating individual doses to the population living in long term contaminated areas. The national and local governments are also obligated to conduct long term health surveillance, including the mental health of residents, and to monitor for possible radiation induced health effects [212].

Government officials are obliged to implement decontamination to enable residents to return to their normal lives as quickly as possible. Government organizations will encourage public participation by providing all decontamination information, guidance, materials, equipment and training, and by deploying specialized advisors. The exposure of workers engaged in decontamination is to be managed in accordance with the relevant laws and regulations [199, 202, 212].

The authorities are required to carefully consider decisions on the transition from an emergency exposure situation to an existing exposure situation, such as lifting evacuation directives and other protective actions [212].

The most important changes in the national EPR system are summarized in Table 3.4–2. The table lists the guidance that was in place prior to the accident, which has been developed since the accident and the relevant IAEA safety standards [11, 13, 14]. Figure 3.4–5 shows an example of the implementation scheme of urgent and early protective actions in the guidance.

TABLE 3.4–2. NATIONAL GUIDANCE IN JAPAN BEFORE AND AFTER THE ACCIDENT AND THE ASSOCIATED IAEA SAFETY STANDARDS

National guidance in Japan		IAEA safety standards [11, 13, 14]
Before the accident [19]	After the accident [211]	
Emergency reporting system	Emergency classification system (General Emergency Alert) with predetermined associated protective actions and other response actions	Emergency classification system (General Emergency Alert) with predetermined associated protective actions and other response actions
EPZ of 10 km	PAZ of around 5 km and UPZ of around 30 km with arrangements to take urgent protective actions	PAZ and UPZ with arrangements to take urgent protective actions
No operational criteria in place	OIL1: dose rate criteria for evacuation within a day OIL2: dose rate criteria for relocation within a week OIL3: dose rate criteria for food restrictions OIL4: β counts/min for decontamination and medical screening OIL6: radionuclide concentrations for food and drink restrictions The OILs follow the system documented in the IAEA safety standards and technical guidance [14, 107]	OILs for evacuation, relocation, food restrictions, public monitoring, etc.

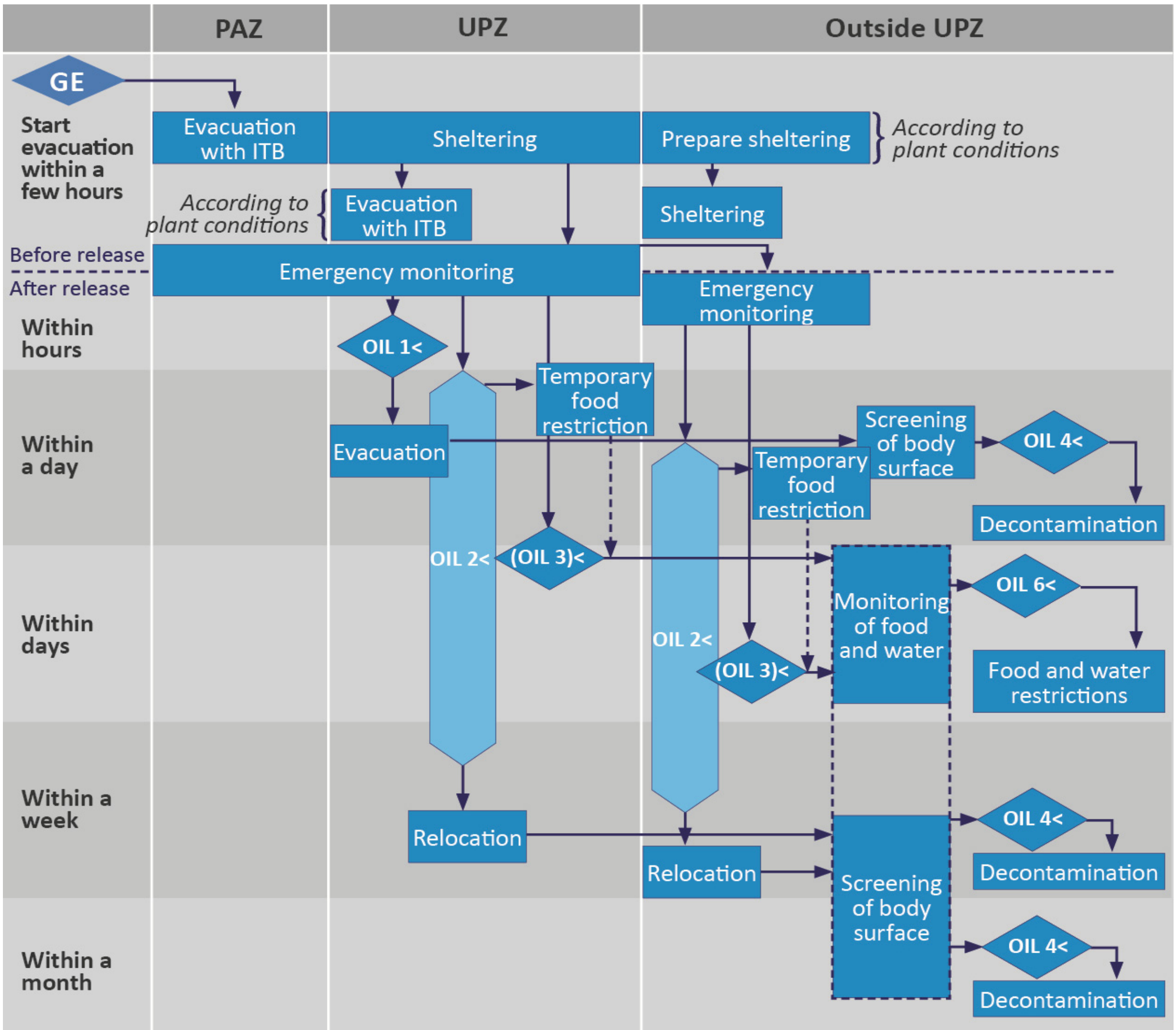

FIG. 3.4–5. Example of implementing protective actions [211].

3.4.2.4. Implementation of strengthened national guidance on EPR

Pursuant to the provisions of the revised Disaster Countermeasures Basic Act[108] [6] and the revised Nuclear Emergency Act [5], local governments were required to amend their local emergency response plans by 18 March 2013. These revisions were required to reflect the national guidance on EPR developed after the accident (i.e. the Nuclear Emergency Response Guidelines of the NRA) [211].

Owing to issues related to coordination and securing of evacuation sites, support was provided from the national Government and the regulatory body to the local government for the implementation of the national guidance on EPR developed after the accident.

In order to support local governments in revising arrangements, the Cabinet Office held briefing sessions and prepared amended guidance for local governments. As areas included in the UPZ may extend across multiple prefectures, the Cabinet Office held a conference to address this issue, and adjustments were then made to the protective actions to ensure coordination and consistency in their implementation [212].

To help determine the size of the UPZ, the NRA performed a simulation on the spread of radioactive materials resulting from an emergency corresponding to the Fukushima Daiichi accident, the results of which were released by the end of 2012 [212]. These results showed that the area requiring planning for protective actions had to be expanded beyond the 10 km zone established prior to the accident [214, 215]. It is anticipated that the NRA and the Cabinet Office will provide support to local governments to enhance the local emergency response systems [212].

Examples of activities to address lessons in the area of combined natural disaster and nuclear emergency included reinforcement of off-site centres and arrangements for the prompt deployment of materials and equipment [211]. Regarding environmental monitoring, it was stated that the national Government should prepare a system for emergency radiation monitoring centres located in relevant areas and make plans for deploying staff and equipment [211]. The chain of command structure across ministries and agencies was reviewed and revised [210] to address the need to clearly allocate roles between central and local organizations. Responsibilities were also designated and clearly assigned in the Basic Disaster Management Plan [216]. In the area of communication, arrangements to facilitate joint press conferences were established [210]. In response to the lessons learned in the area of assistance, contact points for each neighbouring country have been specified [210], and lists of equipment for responding to nuclear emergencies and methods for international information sharing, including through international notifications, are being developed.[109] In addition, to enhance the provision of information internationally, since December 2013, Japan has regularly provided information on the response to the accident to the international community in a comprehensive manner, which is reflected on the IAEA homepage [217].

In the area of modelling of the release of radioactive material, the utilization of analytical tools is expected to support effective environmental monitoring. After examining the major release of radioactive material after the Fukushima Daiichi accident, it was realized that it is not possible to obtain accurate information on emission sources in nuclear or radiological emergencies. In addition, in the report of The National Diet of Japan Fukushima Nuclear Accident Independent Investigation

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[108] See Appendix I for more information.

[109] For example, the revised IAEA publication EPR-RANET 2013 reflected Japan's proposals, such as the addition of 'stabilization of situations at accident sites' into the functional areas of RANET, listing of equipment which can be utilized to stabilize situations on the site with detailed specifications, and the registration of equipment possessed by private entities, to enhance the IAEA's RANET capabilities [217].

Commission (NAIIC) [25], it was pointed out that “[t]he weather forecast information used for calculating predictions has limitations, particularly with regard to localized rainfall, snowfall, etc.”

As a consequence, it is not considered possible to calculate predictions or estimations accurately using SPEEDI in nuclear or radiological emergencies [217].[110]

The national guidance on EPR developed after the accident was therefore changed mainly in order to reflect the IAEA safety standards and the latest technical guidance in the area of EPR [11, 13, 107].

3.4.3. Summary

Specific policies, guidelines, criteria and arrangements for the transition from the emergency phase to the recovery phase, were not developed until after the Fukushima Daiichi accident. In developing these arrangements, the Japanese authorities applied the latest recommendations of the International Commission on Radiological Protection (ICRP). The Japanese authorities decided to apply the latest ICRP recommendations to defined exposure situations (i.e. emergency exposure situations and existing exposure situations), although these recommendations had not been included in the national framework prior to the accident. This caused certain difficulties, for example, it proved difficult to define the termination of the emergency exposure situation and the subsequent transition to the existing exposure situation.

Developed arrangements included adjusting the protective actions and the arrangements made early in the emergency response and undertaking longer term recovery operations. These processes addressed the immediate needs arising during the transition process.

The Japanese authorities made substantial efforts in the development of specific policies, criteria and detailed guidelines and arrangements in this regard and in their subsequent implementation.

The transition process included the adjustment of implemented protective actions and arrangements to take account of the longer term exposure situation. The transitioning process required comprehensive monitoring to describe the exposure situation in detail.

The provisions for the protection of workers were gradually modified, depending on the work being undertaken.

The involvement of the public in policy making with regard to the transition from an emergency situation, and the relaxation or removal of previously imposed protective actions, gradually increased.

Analyses of the accident and of the emergency response were performed and presented in the form of reports, including those issued by the Government of Japan, the operating organization (TEPCO) and two investigation committees created by the Government and the Parliament, respectively. This work was undertaken in order to identify lessons and to enhance EPR arrangements in Japan. The review and analysis included a reconstruction of the accident scenario, consideration of the root causes of the accident, regulatory controls and general implications for safety. A number of improvements in emergency preparedness and response arrangements were identified as a result.

On the basis of these analyses and lessons identified, corrective actions were taken to strengthen emergency preparedness and response arrangements [210, 212]. Reviews were conducted of the

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[110] As described in the revised Nuclear Emergency Response Guidelines, EALs and radiation monitoring will be used for decisions about protective actions. It was decided that SPEEDI can be used as reference information for other purposes, except for the judgement of protective actions in emergencies.

relevant legislation and emergency plans and procedures by the various organizations. The necessary revisions to relevant national legislation and some relevant policies, plans and procedures have since been made in a timely manner. A Nuclear Emergency Preparedness Commission was established within the Cabinet to ensure that nuclear emergency response policies would be implemented and promoted by the Government [212]. The NRA developed Nuclear Emergency Response Guidelines [211], also taking into account the IAEA safety standards in the area of emergency preparedness and response.

Implementing corrective actions identified as a result of national analysis of the emergency and emergency response included prioritizing improvements to be made to the EPR system, assigning implementation of the improvements to a specific organization, establishing a coordinating body to oversee the improvements and providing support at the national level for improvements made at the local level.

3.4.4. Observations and lessons

- **Arrangements need to be developed at the preparedness stage for termination of protective actions and other response actions, and transition to the recovery phase.**
  At the preparedness stage there is a need to plan for the transition from the emergency phase to the long term recovery phase, and for resumption of normal social and economic activities. The arrangements need to: (1) establish formal processes to decide on the termination of protective actions and other response actions; (2) clearly allocate responsibilities; (3) establish criteria for the termination of protective actions and other response actions; and (4) provide a strategy and process for consulting the public.
  Transitioning may differ from one location to another in the affected areas. This may result in complex and simultaneous applications of different requirements specific to the exposure situation in each area. This needs to be clarified and clearly communicated to all organizations and the public at the preparedness stage to avoid raising concerns that some members of the public or some workers are less protected than others in the transition phase.
- **Timely analysis of an emergency and the response to it, drawing out lessons and identifying possible improvements, enhances emergency arrangements.**
  Such an analysis needs to include a review of all relevant arrangements, including national laws and regulations, allocation of authorities and responsibilities, emergency response plans and procedures, facilities, equipment, training and exercises. Analysis provides a basis for revision of the arrangements, as necessary. The adequacy of revised emergency arrangements needs to be demonstrated through exercises.

3.5. RESPONSE WITHIN THE INTERNATIONAL FRAMEWORK FOR EMERGENCY PREPAREDNESS AND RESPONSE

An extensive international framework for emergency preparedness and response was in place at the time of the accident, comprising international legal instruments, IAEA safety standards and operational arrangements.

3.5.1. International EPR framework for a nuclear or radiological emergency prior to the accident

The responsibility for emergency preparedness and response for nuclear or radiological emergencies rests with the State, as does the protection of human life, health, property and the environment.[111] The State is responsible for ensuring that EPR arrangements are in place at the national, regional, local and operating organization/facility levels. Where appropriate, the State is also responsible for ensuring coordination of national EPR arrangements with the relevant international arrangements to which the State accessed or is otherwise a party (e.g. through bilateral and/or multinational agreements).

The impact of any nuclear or radiological emergency can rapidly become of regional and global interest and concern. Effective management of nuclear or radiological emergencies therefore requires efficient national and international arrangements for sharing reliable information related to the emergency to ensure protection of human life and health, property and the environment.

The international EPR framework at the time of the accident at the Fukushima Daiichi NPP consisted of: (a) international legal instruments; (b) IAEA safety standards; and (c) operational arrangements (see Fig. 3.5–1).

FIG. 3.5–1. International EPR framework at the time of the accident at the Fukushima Daiichi NPP.

The main international legal instruments on EPR are the Convention on Early Notification of a Nuclear Accident (Early Notification Convention) [219] and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention) [220]. These conventions are supplemented by bilateral or multilateral agreements between and amongst States and relevant international organizations. In addition, the Convention on Nuclear Safety [227] and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) [228] address some aspects of EPR in relation to nuclear installations and to management of spent fuel and radioactive waste, respectively.

[111] According to IAEA safety standards [218], the government shall make provision for emergency preparedness to enable a timely and effective response in a nuclear or radiological emergency.

The key IAEA safety standards in the EPR area at the time of the accident consisted of the General Safety Requirements publication Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-R-2 [11], published in 2002[112], supplemented by the Safety Guide on Arrangements for Preparedness for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-G-2.1 [13][113], published in 2007. In addition, in March 2011, a Safety Guide on the Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-2 [14], was published under the joint sponsorship of FAO, IAEA, ILO, PAHO and WHO. This Safety Guide provides guidance on the criteria for use in determining protective actions and other response actions to be taken in a nuclear or radiological emergency. The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115 [49], which was published in 1996 and has since been superseded by IAEA Safety Standards Series No. GSR Part 3 (see Ref. [26]), also included parts that were related to EPR. These safety standards were supported by a series of technical guidance and tools in EPR covering specific aspects (examples include generic assessment procedures for determining protective actions during a reactor accident and generic procedures for medical response during a nuclear or radiological emergency [221, 222]).

The international operational arrangements comprised the Emergency Notification and Assistance Technical Operations Manual (ENATOM), IAEA Response and Assistance Network (RANET), Joint Radiation Emergency Management Plan of the International Organizations (JPLAN) and bilateral arrangements among relevant international organizations and/or States [223–225].

In addition, the international system for dealing with nuclear or radiological events relies on the central coordinating role and functions of the IAEA Secretariat and on IACRNE[114] as the prime interagency coordination mechanism in EPR.

3.5.1.1. The Early Notification Convention

Article 1, paragraph 1 of the Early Notification Convention states that:

> "This Convention shall apply in the event of any accident involving facilities or activities[115] of a State Party or of persons or legal entities under its jurisdiction or control…from which a release of radioactive material occurs or is likely to occur and which has resulted or may result in an international transboundary release that could be of radiological safety significance for another State" [219].

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[112] This publication is jointly sponsored by the Food and Agriculture Organization of the United Nations (FAO), IAEA, International Labour Organization (ILO), OECD Nuclear Energy Agency (OECD/NEA), Pan American Health Organization (PAHO), United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and World Health Organization (WHO).

[113] This publication is jointly sponsored by FAO, IAEA, ILO, PAHO, OCHA and WHO.

[114] Formerly, the Inter-Agency Committee for the Co-ordinated Planning and Implementation of Response to Accidental Releases of Radioactive Substances, which was established following a meeting of representatives of FAO, United Nations Environment Programme (UNEP), ILO, UNSCEAR, World Meteorological Organization (WMO), WHO and IAEA at the Special Session of the IAEA General Conference in September 1986 [226].

[115] Facilities and activities here refers to any nuclear reactor wherever located; any nuclear fuel cycle facility; any radioactive waste management facility; the transport and storage of nuclear fuels or radioactive wastes; the manufacture, use, storage, disposal and transport of radioisotopes for agricultural, industrial, medical and related scientific and research purposes; and the use of radioisotopes for power generation in space objects.

Article 2 of this Convention states that in the event of a nuclear accident or radiological emergency the State Party has to:

> “(a) forthwith notify, directly or through the International Atomic Energy Agency (hereinafter referred to as the "Agency"), those States which are or may be physically affected as specified in article 1 and the Agency of the nuclear accident, its nature, the time of its occurrence and its exact location where appropriate; and
> (b) promptly provide the States referred to in sub-paragraph (a), directly or through the Agency, and the Agency with such available information relevant to minimizing the radiological consequences in those States…” [219].

The notifying State Party is required to provide the following information and data, as then available:

“(a) the time, exact location where appropriate, and the nature of the nuclear accident;
(b) the facility or activity involved;
(c) the assumed or established cause and the foreseeable development of the nuclear accident relevant to the transboundary release of the radioactive materials;
(d) the general characteristics of the radioactive release, including, as far as is practicable and appropriate, the nature, probable physical and chemical form and the quantity, composition and effective height of the radioactive release;
(e) information on current and forecast meteorological and hydrological conditions, necessary for forecasting the transboundary release of the radioactive materials;
(f) the results of environmental monitoring relevant to the transboundary release of the radioactive materials;
(g) the off-site protective measures taken or planned;
(h) the predicted behaviour over time of the radioactive release.” [219]

This information is required to be supplemented at appropriate intervals by further relevant information on the development of the emergency situation, including its foreseeable or actual termination (para. 2, Article 5 of Ref. [219]).

Further, with a view to minimizing the radiological consequences, States Parties may notify in the event of nuclear accidents other than those specified in Article 1 of the Early Notification Convention (Article 3) [219].

Although the IAEA is not a party to this convention, the following specific roles are accorded to the IAEA: (1) inform States Parties, Member States, other States which are or may be physically affected, and relevant international intergovernmental organizations, of a notification received from a State Party of the occurrence and location of a nuclear or radiological accident; and (2) promptly provide any State Party, Member State or relevant international intergovernmental organizations, upon request, with the information received relevant to minimizing the radiological consequences (Article 4 of Ref. [219]).

As part of emergency preparedness, each State Party should make known to the IAEA and to other States Parties, directly or through the IAEA, its competent authorities and point of contact responsible for issuing and receiving the notification and information. Such points of contact and a focal point within the IAEA should be available continuously. Each State Party should also promptly inform the IAEA of any changes that may occur. The IAEA is required to maintain an up to date list of States authorities and points of contact as well as points of contact of relevant international organizations and should provide it to States Parties and Member States and to relevant international organizations (paras 1–3, Article 7 of Ref. [219]).

3.5.1.2. The Assistance Convention

In accordance with the provisions of the Assistance Convention, the States Parties should cooperate between themselves and with the IAEA to facilitate prompt assistance in the event of a nuclear or radiological emergency to minimize its consequences and to protect life, property and the environment from the effects of radioactive releases. The Assistance Convention recognizes that States Parties may agree on bilateral or multilateral arrangements or, where appropriate, a combination of these, for preventing or minimizing injury and damage which may result in the event of a nuclear accident or radiological emergency (see para. 1 and 2, Article 1 of Ref. [220]).

If a State Party needs assistance in order to respond to a nuclear or radiological emergency, whether or not the emergency originates within its territory, jurisdiction or control, it may call for assistance from any other State Party, directly or through the IAEA, and from the IAEA, or, where appropriate, from other international intergovernmental organizations.

> "A State Party requesting assistance shall specify the scope and type of assistance required and, where practicable, provide the assisting party with such information as may be necessary for that party to determine the extent to which it is able to meet the request. In the event that it is not practicable for the requesting State Party to specify the scope and type of assistance required, the requesting State Party and the assisting party shall, in consultation, decide upon the scope and type of assistance required." (para. 2, Article 2 of Ref. [220]).

Each State Party to which a request for such assistance is directed shall promptly decide and notify the requesting State Party, directly or through the IAEA, whether it is in a position to render the assistance requested, and the scope and terms of the assistance that might be rendered.

The IAEA has the specific response role to respond to a State Party's or a Member State's request for assistance in accordance with the Statute and the terms of the Convention by: (a) making available appropriate resources allocated for this purpose; (b) promptly transmitting the request to other States and international intergovernmental organizations which according to the IAEA's information, may possess the necessary resources; (c) coordinating assistance at the international level which may thus become available, if so requested by the requesting State; (d) making available, to a State Party or a Member State requesting assistance, appropriate resources allocated for the purpose of conducting an initial assessment of the emergency; (e) offering its good offices to the States Parties and Member States; and (f) establishing and maintaining liaison with relevant international intergovernmental organizations for the purposes of obtaining and exchanging relevant information and data, and making a list of such organizations available to States Parties, Member States and the aforementioned organizations (para. 6 of Article 2 and Article 5 of Ref. [220]).

As part of emergency preparedness, States Parties shall, within the limits of their capabilities, identify and notify the IAEA of experts, equipment and materials which could be made available for the provision of assistance to other States Parties as well as the terms, especially financial, under which such assistance could be provided. The State Parties request the IAEA as a general matter, to: (a) collect and disseminate to State Parties and Member States information concerning: experts, equipment and materials which could be made available in the event of nuclear accidents or radiological emergencies; and methodologies, techniques and available results of research relating to response to nuclear accidents or radiological emergencies; and (b) assist a State Party or a Member State when requested in: (i) preparing both emergency plans in the case of nuclear accidents or radiological emergencies and the appropriate legislation; (ii) developing appropriate training programmes for personnel to deal with nuclear accidents or radiological emergencies; (iii) developing appropriate radiation monitoring programmes, procedures and standards; and (iv) conducting investigations into the feasibility of establishing appropriate radiation monitoring systems (Article 5 of Ref. [220]).

3.5.1.3. Other applicable legal instruments

The Convention on Nuclear Safety [227] and the Joint Convention [228] also address emergency preparedness aspects in relation to nuclear installations and to the management of spent fuel and radioactive waste, respectively.

The Convention on Nuclear Safety [227] has the objective of achieving and maintaining a high level of nuclear safety worldwide in relation to nuclear installations[116]. This includes establishing and maintaining effective defences in these installations against potential radiological hazards in order to protect individuals, society and the environment. This convention also includes the objective "to prevent accidents with radiological consequences and to mitigate such consequences should they occur" [227] In relation to the latter, Article 16 requires that each Contracting Party takes appropriate steps to ensure that on-site and off-site emergency plans are in place for nuclear installations and that these plans are routinely tested. In addition, each Contracting Party is required to ensure that its own population and the competent authorities of the States in the vicinity of the nuclear installation that are likely to be affected by an emergency at a nuclear installation are provided with information that is appropriate for emergency planning and response. For Contracting Parties that do not have nuclear installations on their territory but that are likely to be affected by an emergency at a nuclear installation in the vicinity, the Convention on Nuclear Safety requires adequate preparation and testing of emergency plans for their territories (paras 1–3, Article 16 of Ref. [227]).

Similarly, the Joint Convention [228] has the objective of ensuring a high level of safety worldwide in relation to spent fuel and radioactive waste management, including ensuring effective defences against potential hazards during all stages of spent fuel and radioactive waste management. The Joint Convention also seeks "to prevent accidents with radiological consequences and to mitigate their consequences should they occur during any stage of spent fuel or radioactive waste management" [228]. In light of this objective, Article 25 requires that each Contracting Party ensure that there are on-site and, if necessary, off-site emergency plans before and during operation of a spent fuel or radioactive waste management facility, and that these plans are tested at appropriate intervals. In addition, each Contracting Party that is likely to be affected by an emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory is required to take appropriate steps to prepare and to test emergency plans for its territory (paras 1 and 2, Article 25 of Ref. [228]).

Both the Convention on Nuclear Safety and the Joint Convention establish mechanisms for reviewing measures taken by Contracting Parties to implement each of the obligations of the conventions. These mechanisms include preparation and submission of reports elaborating measures taken to meet the obligations under these conventions and their review and discussion at review meetings held at regular intervals[117]. Measures taken by each Contracting Party to fulfil obligations on emergency preparedness set forth in Article 16 of the Convention on Nuclear Safety and in Article 25 of the Joint Convention are thus subject to reporting, review and discussion (Article 25 of Ref. [228] and Article 16 of Ref. [227]).

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[116] In this context, nuclear installation means for each Contracting Party to the Convention on Nuclear Safety any land based civil nuclear power plant under its jurisdiction, including such storage, handling and treatment facilities for radioactive materials as are on the same site and are directly related to the operation of the nuclear power plant. Such a plant ceases to be a nuclear installation when all nuclear fuel elements have been removed permanently from the reactor core and have been stored safely in accordance with approved procedures, and a decommissioning programme has been agreed to by the regulatory body.

[117] The interval between such review meetings should not exceed three years.

3.5.1.4. IAEA safety standards and technical guidance on EPR

IAEA Safety Standards Series No. GS-R-2 [11] establishes requirements for an adequate level of preparedness and response for a nuclear or radiological emergency with the aim of minimizing the consequences of an emergency should it occur. This publication addresses preparedness and response for all types of nuclear or radiological emergencies irrespective of their cause, including those of very low probability (e.g. events that are beyond the design basis of a facility) and those involving a combination of a nuclear or radiological emergency and a conventional emergency (e.g. earthquake).

Building on experience from responses to actual emergencies, IAEA Safety Standards Series No. GS-R-2 sets common goals to be achieved and the common concepts and approaches to be taken for adequate preparedness to effectively respond to a nuclear or radiological emergency. In addition, this publication sets comprehensive requirements for practical arrangements to be made to support the functions performed in an emergency response for achieving the goals set for the emergency response.

The general requirements that need to be fulfilled before planning include: (1) clear allocation of roles and responsibilities for emergency preparedness and response, including identification of a coordinating authority for that purpose and establishing a management system for ensuring timely, coordinated and effective response and decision making; and (2) assessing threats (hazards)[118] as a basis for a graded approach in establishing EPR arrangements [11]. Following these general requirements, functions to be performed in an emergency response are elaborated, and requirements for arrangements to support these functions are set. These functional requirements include:

— Managing and coordinating emergency response to a nuclear or radiological emergency at all levels (national, regional, local and operator levels and, where appropriate, at the international level) under an all-hazard approach and setting up a clear command and control system for that purpose.
— Identifying an emergency situation on the basis of observable conditions and measurable criteria (EALs) and declaring the emergency class; activating pre-planned on-site response actions and, where relevant, notifying an off-site notification point to activate pre-planned off-site response actions. This includes setting up notification point(s) for receiving such notifications as well as designating organization(s) for sending/receiving information to/from other States and the IAEA (in accordance with the Early Notification Convention).
— Taking actions to mitigate the development of hazardous conditions resulting in exposure or a release of radioactive material warranting response actions to be taken on-site and off-site. This includes the provision of off-site emergency services in support of the on-site emergency response.
— Taking urgent protective actions to avoid severe deterministic effects and to avert doses and to adjust these actions on the basis of information that becomes available. This includes: (1) setting national intervention levels/criteria in terms of doses and measurable quantities/observables for taking such actions, taking account of a range of national factors (such as financial and social aspects); (2) establishing off-site emergency zones[119]; (3) ensuring that off-site officials decide and promptly implement urgent protective actions off-site; and (4) ensuring that diverse means for communicating on-site and with off-site locations are available at all times.
— Providing information regarding emergency preparedness and response to the potentially affected population within emergency zones at the preparedness stage and warning and instructing them in an emergency on actions to take. This includes identification at the preparedness stage of special

[118] The term 'threat' is no longer used in IAEA safety standards in the area of EPR due to its specific meaning in the area of nuclear security; instead, the term 'hazard' is used.

[119] For facilities in threat (hazard) categories I and II only.

population groups within emergency zones (e.g. disabled persons, hospital patients or prisoners), for whom specific arrangements need to be made for the safe implementation of protective actions.

- Designating emergency workers and ensuring their protection. This includes establishing guidance for managing, controlling and recording their doses, identifying hazardous conditions in which they may need to perform their duties and providing specialized protective equipment, procedures and training.
- Assessing the magnitude and likely development of hazardous conditions (including ensuring monitoring and assessment capabilities), in order to identify new hazards promptly and to refine the strategy for response as necessary. This includes development of operational intervention levels (OILs) at the preparedness stage and their use and revision in light of conditions prevailing during the emergency.
- Communicating with the general public in a nuclear or radiological emergency, which would include responding to incorrect information and rumours and responding to enquiries from the public and news media.
- Taking agricultural countermeasures, countermeasures against ingestion and longer term protective actions in order to avert doses. This includes ensuring monitoring and assessment for the areas potentially or actually affected by the emergency, establishing national intervention levels and action levels in accordance with international standards, development and use of operational intervention levels, safe and effective management of radioactive waste, and assessment of exposure incurred by members of the public as a consequence of the accident.
- Mitigating the adverse psychological, social and economic consequences (i.e. non-radiological consequences) of the emergency and the response. This includes consideration of economic impacts and impacts on employment, as well as the need for social welfare in the longer term, when deciding on response actions to be taken within emergency zones. It also includes responding to public concerns in an emergency, promptly explaining the associated health risks and preventing inappropriate actions on the part of workers and the public.
- Transitioning from the emergency phase to routine long term recovery operations and resumption of normal social and economic activity. This includes clear allocation of responsibilities, sharing and transferring information, assessing consequences, establishing formal processes to decide on withdrawal of restrictions and other arrangements imposed during the emergency, setting principles and criteria to do so, and consulting the public.

These functional requirements are supplemented by the following requirements for elements of infrastructure that are essential for providing an adequate response capability:

- *Authority:* Assignment of authorities for emergency preparedness and response in national legislation and documentation of the assigned authorities, roles and responsibilities at all levels as part of emergency plans.
- *Organization:* Establishment of organizational relationships and interfaces among operating and response organizations, including documentation of the positions and specific functions assigned as part of emergency plans and identifying personnel to adequately fulfil these positions.
- *Coordination of emergency response:* Preparation of operational protocols to coordinate the emergency response at operator and local, regional, national levels and, where appropriate, at the international level and their documentation as part of emergency plans. This also includes coordination among different organizations to develop and use tools, procedures and criteria in emergency response in order to avoid inconsistencies and confusion on the part of the public and decision makers.
- *Plans and procedures:* The development and coordination of emergency plans and procedures at operator, local, regional and national levels on the basis of assessed hazards.
- *Logistical support and facilities:* Provision of tools, instruments, supplies, equipment, communication systems, specific functional facilities and documentation needed to ensure an effective emergency response. This also relates to the operability and usability of these items and

facilities under postulated radiological, working and environmental conditions that may be encountered in the emergency response.
- *Training, drills and exercises:* Selection of knowledge, skills and abilities necessary to perform specific functions in emergency response and selection of adequately qualified personnel for these positions. This includes the need to ensure continual training of personnel (to include the personnel responsible for making decisions on protective actions in the emergency zones) and to conduct drills and exercises on a regular basis.
- *Quality assurance programme:* Establishment of a programme to ensure that all the supplies, equipment, communication systems, facilities and documentation (plans, procedures, checklists, manuals, etc.) are, as appropriate, continuously up to date, available and functional for use in an emergency. This includes review and evaluation of responses in emergencies and in drills and exercises in order to identify and record areas requiring improvement and to ensure that these improvements are made.

In addition, IAEA Safety Standards Series No. GS-R-2 [11] contains three annexes that provide:

- Additional information on the protection of emergency workers performing specific tasks that may result in exceeding the dose limits for occupational exposure.
- Action levels of dose from acute exposure at which intervention is expected to be undertaken under any circumstances.
- Guidelines for intervention levels for taking specific protective actions (sheltering, evacuation, 'iodine prophylaxis'[120], temporary relocation and permanent resettlement) and action levels for imposing restrictions on foodstuffs.

IAEA General Safety Guide No. GS-G-2.1 [13] provides recommendations and guidance on the implementation of selected requirements established in IAEA Safety Standards Series No. GS-R-2 [11]. This guide describes appropriate responses (so called concepts of operations) to a range of nuclear or radiological emergencies and includes:

- A description of emergency zones and areas and their suggested radius;
- A description of abnormal facility conditions associated with a specific emergency class and immediate actions to be taken on-site and off-site upon declaration of the emergency class;
- A description and overview of urgent protective actions and other response actions;
- A description of adequate emergency related facilities and locations necessary to support emergency response.

The IAEA has also developed technical guidance and tools covering, in detail, particular aspects of EPR in order to support Member States and relevant international organizations in implementation of the IAEA safety standards in the area of EPR. At the time of the Fukushima Daiichi accident, extensive technical guidance and tools were already in place[121], of which the following are the most relevant:

- *IAEA-TECDOC-955 [221]:* Generic Assessment Procedures for Determining Protective Actions during a Reactor Accident (published in 1997) provides the technical procedures for determining protective actions for the public and for controlling dose to emergency workers in case of an accident at a nuclear reactor. These include: procedures for classifying an accident based on plant conditions and recommending protective actions, projecting consequences, coordinating

[120] The term 'iodine thyroid blocking' is used instead of iodine prophylaxis in the latest IAEA publications.

[121] Available on the IAEA web site at the following URL:
http://www-ns.iaea.org/tech-areas/emergency/technicalproducts.asp?s=1.

environmental monitoring, interpreting environmental data, determining public protective actions and controlling emergency worker doses. The publication also describes an emergency assessment organizational structure recommended for the optimum implementation of the accident assessment procedures.

- *EPR-METHOD [112]:* Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency (published in 2003) provides tools and information needed to develop a response capability which complies with the safety requirements. The publication also provides information concerning methodologies, techniques and available results of research relating to a response to radiation emergencies. It includes a practical, step by step method for developing integrated operator, local and national capabilities for emergency response.
- *EPR-MEDICAL [222]:* Generic Procedures for Medical Response during a Radiation Emergency (published in 2005) provides the medical community with practical guidance for medical emergency preparedness and response. It describes the tasks and actions required of different members of the national, regional and local medical infrastructure that would be in accordance with the provisions of the IAEA safety standards. This publication provides the tools, generic procedures, and data needed for dose assessment and initial medical response to radiation emergencies. It explains the roles and responsibilities of the members of the emergency medical response organization within the general response organization.
- *IAEA-TECDOC-1092 [229]:* Generic Procedures for Monitoring in a Nuclear or Radiological Emergency (published in 1999) provides practical guidance for environmental, source, personal and equipment monitoring during a nuclear or radiological emergency. The publication provides procedures for radiation monitoring, environmental sampling and laboratory analyses in an emergency response. It includes information on measurement and sampling techniques, equipment and personnel specification and on recording results for further interpretation and analyses.

Although a range of IAEA safety standards, technical guidance and tools in EPR existed at the time of the Fukushima Daiichi accident, Japan did not fully utilize them in its national practice [21, 51]. Efforts that were initiated, particularly in 2006, to update and strengthen the national standards in Japan (such as the regulatory guide covering emergency preparedness in relation to nuclear facilities) and to make them conform to the relevant IAEA safety standards failed due to disagreements among different national authorities [21]. One of the reasons for not strengthening the national standards was the concern that significant changes in the existing EPR system would be a source of confusion among the public and that it would be extremely difficult to explain that there was a need for emergency preparedness that assumes the occurrence of a severe accident, when residents living in the vicinity of nuclear power plants had been persuaded that a major accident would not occur [21].

3.5.1.5. International operational arrangements in EPR

Emergency Notification and Assistance Technical Operations Manual

At the time of the accident at the Fukushima Daiichi NPP, the ENATOM Manual[122] [223] facilitated the implementation of those articles of the Early Notification Convention [219] and the Assistance Convention [220] that are operational in nature, such as the provisions for notification and information exchange and the communication protocols for Contact Points identified under the Early Notification Convention and the Assistance Convention.

[122] As of 1 June 2012, ENATOM was superseded by the Operations Manual for Incident and Emergency Communication (EPR-IEComm, 2012) [230].

As described in the manual, at the time of the accident at the Fukushima Daiichi NPP, the IAEA operated a secure and protected web site for the exchange of official information with contact points in Member States and at relevant international organizations called Emergency Notification and Assistance Conventions (ENAC) web site[123].

The IAEA has developed a set of exercises of various levels of complexity — called convention exercises (ConvEx) — to practise with Member States and relevant international organizations different arrangements within the international emergency preparedness and response framework. ConvEx exercises are divided into three levels of complexity: ConvEx-1, ConvEx-2 and ConvEx-3. The goal of the ConvEx-1 and ConvEx-2 exercises is to test whether National Warning Points and National Competent Authorities are available within the expected time frames, whether contact channels are accurate and whether National Competent Authorities can appropriately complete various reporting forms. The exercises are also intended to test the procedures for information exchange and for requesting/providing assistance using moderately complex scenarios. ConvEx-3 exercises are large scale international exercises focusing mostly on response in the early phase of a severe nuclear or radiological emergency, irrespective of its cause. The purpose of these exercises is to assess and evaluate national and international emergency response arrangements, including arrangements for information exchange, provision of assistance and coordination of public information [223].

IAEA Response and Assistance Network

The IAEA Response and Assistance Network (RANET) was established to facilitate the provision of international assistance upon request and in compliance with the Assistance Convention. This system forms an operational mechanism to provide assistance in different technical areas, with the help of national capabilities registered in the network. The capabilities for assistance cover specific areas, such as: radiation survey, environmental sampling and analysis, assessment and advice, decontamination, medical support, dose assessment, source search and recovery and advice on emergency response actions [224].

The role of the IAEA upon receipt of a request for assistance is to: (i) evaluate the situation and, if needed, deploy a fact finding assistance mission to the requesting State to further assess the situation; (ii) recommend activation of specific RANET capabilities, if appropriate; (iii) ensure development of an assistance action plan, in coordination with all parties; (iv) liaise with the requesting State to reach agreement on the assistance action plan; and (v) provide financial, organizational and logistic support, as appropriate [224].

Joint Radiation Emergency Management Plan of the International Organizations

The Joint Radiation Emergency Management Plan of the International Organizations [225] is a comprehensive interagency mechanism for nuclear and radiological emergency preparedness and response. It provides a practical mechanism for coordination and clarifies the roles and capabilities of the participating international organizations in preparing for and responding to nuclear and radiological emergencies [225].

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[123] As of June 2011, this protected web site was replaced by the Unified System for Information Exchange in Incidents and Emergencies (USIE).

3.5.1.6. The EPR system of the IAEA

At the time of the accident, the IAEA's central role within the international EPR framework included: prompt notification of the emergency to States and relevant international organizations; exchange and/or provision of official (authenticated and verified)[124] information to States and international organizations; coordination of international assistance, upon request of the State concerned; provision and/or coordination of public information that is timely, accurate and appropriate; and coordination of the inter-agency response. The IAEA[125] discharged its role through its Incident and Emergency System (IES), consisting of a 24 hour contact point and an operational focal point, the Incident and Emergency Centre (IEC). The internal arrangements for the implementation of the IES were defined in the IAEA's Response Plan for Incidents and Emergencies [231].

The IES consists of a warning point, an on-call system, an on-duty system and the IES Steering Group, with the following functions:

— The warning point is a 24 hour communication centre through which incoming messages are received and acted on. Since the IEC is not normally continuously staffed, the Security Control Centre of the United Nations Security and Safety Service serves as a warning point.
— The on-call system ensures that the initial response to any incoming message is timely and adequate. The following on-call officers are available to facilitate and coordinate the initial response: an emergency response manager (ERM); a nuclear installation specialist; a radiation safety specialist; a nuclear security specialist; an external event specialist; and a logistics support officer. In addition, a public information officer is also available at all times. The on-duty system ensures that the IAEA response is effective and commensurate with the nature and magnitude of the event/situation. It consists of three modes of operation[126], a set of response functions and a roster of trained staff members.
— The IES Steering Group oversees the response of the IAEA and guides the response on matters of policy.

Each event is classified according to the extent of its actual or potential radiological consequences. The urgency and response actions vary depending on the actual or potential magnitude and seriousness of the event [231].

3.5.1.7. Inter-Agency Committee on Radiological and Nuclear Emergencies

Although the Early Notification Convention and the Assistance Convention assign specific response functions and responsibilities to the IAEA and the Parties, various international intergovernmental organizations have — by virtue of their statutory functions or related legal instruments — functions and responsibilities that encompass aspects of emergency preparedness and response.

The prime interagency coordination mechanism ensuring that coordinated and consistent arrangements and capabilities for preparedness and response to nuclear and radiological emergencies are developed and maintained is the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE), for which the IAEA provides the secretariat [225].

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[124] In this context, authentication is the process of confirming that the message received originates from an official contact point. Verification is the process of confirming that a message received is clear, consistent and understood.

[125] This applies to the IAEA Secretariat.

[126] Normal/ready mode, basic response mode and full response mode.

It is recognized by the participating international organizations that good planning in advance of an emergency can substantially improve the response. With this in mind, IACRNE members develop, maintain and co-sponsor the Joint Radiation Emergency Management Plan of the International Organizations [225].

At the time of the accident, the IACRNE included 15 international intergovernmental organizations[127].

3.5.2. IAEA response

In its response[128] to the accident, the IAEA followed its mandate and operational arrangements [223, 224, 226, 231]; in accordance with the IAEA Statute, the Early Notification Convention and the Assistance Convention.

At the time of the accident, the official Japanese designated contact points and competent authorities, as required under the Early Notification Convention and the Assistance Convention, for communications with the IAEA's IEC during a nuclear or radiological emergency were the following organizations:

— Ministry of Foreign Affairs, International Nuclear Energy Cooperation Division, as the 24-hour National Warning Point (NWP)[129] and as both National Competent Authority (Abroad)[130] (NCA (A)) and National Competent Authority (Domestic)[131] (NCA (D)).
— Ministry of Economy, Trade and Industry (METI)/Nuclear and Industrial Safety Agency (NISA), as an NCA(D).
— Ministry of Education, Culture, Sports, Science and Technology (MEXT) as an NCA(D).
— Ministry of Land, Infrastructure and Transport (MLIT), Technology and Safety Division, as an NCA(D).

Additionally, as required by the IAEA Statute, the IAEA maintained information exchange with the Permanent Mission of Japan to the International Organizations in Vienna. In accordance with mandates under the IAEA Statute, the Early Notification Convention and the Assistance Convention,

[127] The European Commission (EC), European Police Office (EUROPOL), FAO, IAEA, International Civil Aviation Organization (ICAO), INTERPOL, International Maritime Organization (IMO), OECD/Nuclear Energy Agency (OECD/NEA), PAHO, United Nations Environment Programme (UNEP), United Nations Office for the Coordination of Humanitarian Affairs (OCHA), United Nations Office for Outer Space Affairs (UN OOSA), UNSCEAR, World Health Organization (WHO) and World Meteorological Organization (WMO). In addition, the Joint Plan was developed in cooperation with the UNSCEAR secretariat. The Preparatory Commission of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) and the Euro-Atlantic Disaster Response Coordination Centre (EADRCC) became IACRNE members in 2012 and 2013, respectively.

[128] The activities of the IAEA Secretariat in response to the Fukushima Daiichi accident were reported to the Board of Governors on 3 June 2011 by the Director General (GOV/INF/2011/8) [232].

[129] In accordance with the ENATOM arrangements, a single institution in a State has been designated by its Government to receive at any time an initial notification/advisory/follow-up message and/or request for assistance or verification and immediately to act upon it. The NWP needs to be available 24/7 and must be staffed with persons who can understand and speak English [223].

[130] In accordance with the ENATOM arrangements, it is a single institution within a State that is expected to verify or arrange for the verification of any relevant information provided during a nuclear or radiological emergency originating in another State, as well as being in a position to receive notifications, advisory messages, follow-up information and requests for assistance [223].

[131] In accordance with the ENATOM arrangements, it is an institution within a State authorized by its Government to issue an initial notification/advisory/follow-up message, as appropriate, or reply to a request for verification/information regarding a nuclear or radiological emergency. A State can designated more than one NCA(D), but it is expected that each NCA(D) is in an appropriate position within the State's national emergency response system to send or provide relevant information during a domestic event [223].

and as documented in the ENATOM arrangements[132], these contact points and competent authorities were the only official sources of information regarding the accident. All communication between the IEC, as the IAEA focal point for response, and the designated organizations were through established ENATOM procedures to hasten the overall exchange and verification of information.

The IAEA, through its emergency arrangements, liaised directly with METI/NISA, which was the official contact point in Japan [232]. Japan provided information in accordance with Article 3 of the Early Notification Convention.

However, the Government of Japan, during the course of its response to the earthquake and tsunami and its response to the nuclear accident, assigned responsibilities for different aspects of these responses to other governmental organizations, including the MHLW and the Prime Minister's Office, where the NERHQ was located. These organizations were not official contact points for the IEC but served as key organizations for different aspects of the response in Japan [232]. During the early phase of the response, the Permanent Mission of Japan to the International Organizations in Vienna was used as the contact point to communicate with these organizations; however, as the emergency progressed, direct contact between these organizations and the IEC was established.

During the response to the accident, the IAEA's four key operational roles — notification and official information exchange through officially designated contact points; provision of timely, clear and easily understandable public information; provisions and facilitation of international assistance on request; and coordination of inter-agency response — were met by taking the following actions:

- Activation of the IEC response;
- Development of Status Summary Reports;
- Provision of briefings for Member States;
- Creation of the Fukushima Accident Coordination Team;
- Visit of the IAEA Director General to Japan;
- Meeting of the IAEA Board of Governors in March 2011;
- Maintaining coordination of the inter-agency response;
- Provision of information to the public;
- Provision of briefings for the press;
- Planning and implementation of IAEA technical missions to Japan;
- Planning and implementation of activities of IAEA laboratories;
- Organization and arrangements for the Ministerial Conference on Nuclear Safety in June 2011.

An overview of the IAEA's response through May 2011 is shown in Table 3.5–1. The initial actions taken in response to the accident on the first day are described in detail in Section 3.5.2.1.

[132] Under ENATOM arrangements, communication with the IAEA was expected to be in English.

TABLE 3.5–1 OVERVIEW OF EVENTS AND SUMMARY OF THE IAEA'S RESPONSE UNTIL THE END OF MAY 2011 [232]

Date	Time [UTC[133]]	Event/activity
IAEA's IEC operations		
03-11	05:46	An earthquake of magnitude 9.0 occurred off the east coast of Japan.
03-11	06:42	The on-call external events specialist contacted the on-call emergency response manager (ERM) to inform the IEC of the occurrence of the earthquake and the potential effect on the NPPs.
03-11	07:21	The Emergency Response Manager (ERM) made first contact with NISA.
03-11	07:48	The first of two offers of IAEA assistance sent to NISA and the Permanent Mission of Japan to the International Organizations in Vienna.
03-11	08:06	First information for Member States and international organizations — EMERCON[134] message No. 1 from NISA — published on the ENAC web site.
03-11	08:20	The IEC activated and declared Full Response Mode operations (staffed continuously).
03-11	08:25	The IEC distributed its first in-house email message.
03-11	08:30	First press statement published on the IAEA web site.
03-11	08:45	First of 170 EMERCON messages from NISA (ENAC web site) received — only the Onagawa plant mentioned.
03-11	09:39	First IEC request to the WMO Regional Specialized Meteorological Centres (RSMCs) (lead: Tokyo, Beijing and Obninsk) for standard meteorological products for a potential radioactive release from the Fukushima Daiichi NPP sent out.
03-11	09:45	Second EMERCON message from NISA received; Fukushima Daiichi and Onagawa plants mentioned.
03-11	10:20	NISA press release published on the ENAC web site.
03-11	11:00	The IEC decision to operate in eight hour shifts.
03-11	15:00	First answers to Member States and international organizations which had sent requests for information.
03-11	20:02	First of 203 IEC Status Summary Reports published on the ENAC web site and distributed to Member States.
03-11	22:00	Updated status of Fukushima Daiichi NPP published and distributed.
03-12	09:43	Updated information on explosion in Unit 1 sent to all contact points.
03-12	12:00	First satellite picture from IAEA safeguards satellite imagery unit received.
03-12	12:39	Second of the two offers of assistance sent to METI.
03-12	14:17	RANET members contacted on availability of registered services.
03-12	17:05	First atmospheric dispersion products published on the ENAC web site (subsequently at least daily).
03-12	19:40	Updated status report sent to all contact points (subsequently twice a day).
03-13	10:33	Reminder to all contact points that information is available on the ENAC web site.
03-13	20:00	Updated information on Onagawa plant sent to all contact points.
03-14	02:45	Confirmation of explosion at Unit 3 sent to all contact points.
03-14	07:00	The IEC changes to two 12 hour shifts.
03-15	05:10	Information on high radiation levels outside the Fukushima Daiichi NPP sent to all contact points.

[133] UTC – Universal Time Coordinated. UTC = JST –9 hours.

[134] EMERCON is, according to ENATOM arrangements [223], an emergency conventions code word to be used in communicating a nuclear or radiological emergency to the Agency [232].

TABLE 3.5–1 OVERVIEW OF EVENTS AND SUMMARY OF THE IAEA'S RESPONSE UNTIL THE END OF MAY 2011 [232] (cont.)

Date	Time [UTC[135]]	Event/activity
IAEA's IEC operations		
03-15	11:00	First of 14 video conferences of the IACRNE.
03-15	08:00	Expert from the Austrian National Weather Service (provided through WMO) joined the IEC.
03-15	08:00	FAO representative joined the IEC.
03-15	12:00	Request received from Japan for IAEA assistance (Note Verbale from the Permanent Mission of Japan to the International Organizations in Vienna).
03-16	11:00	The on-site and off-site radiological situation included in the Status Summary Report.
03-17	17:00	First special request for fine resolution atmospheric dispersion products sent to WMO RSMC Montreal. Status Summary Report expanded to cover situation at spent fuel pools.
03-18	09:00	Liaison with the IAEA Secretariat's field team 1 started.
03-20	05:00	Status Summary Report expanded to include radionuclide concentrations in food and water.
03-21	00:51	Status Summary Report expanded to include deposition data.
03-22	22:49	OECD/NEA compilation of governmental decisions published for the first time (and updated regularly thereafter).
03-23	09:15	Status Summary Report expanded to include isotopic concentrations in air, food and sea water.
03-24	13:36	Results of fine resolution atmospheric dispersion modelling around Fukushima Daiichi site published on the ENAC web site and summary included in Status Summary Report.
03-26	11:34	Questionnaire sent to Member States requesting information regarding governmental decisions and recommendations made in relation to the Fukushima Daiichi accident with regard to citizens in or going to Japan, food or goods exported from Japan and screening of passengers and goods; the information provided by Member States was compiled by the OECD/NEA.
03-30	08:00	WHO representative joined the IEC for two weeks.
04-05		The IEC reduced the number of staff on night shifts.
04-14	16:00	The IEC agreed with the WMO RSMCs to request the meteorological products three times a week.
04-22	21:32	The IEC reduced number of Status Summary Reports to one per day.
05-03	13:00	The IEC operations changed to Basic Response Mode (the IEC staffed during the day 12/7, the on-call officers ready to respond during the night 12/7).
05-09	18:20	The IEC reduced the number of Status Summary Reports to three times per week (Monday, Wednesday, Friday).
Assistance to Japan		
03-11	07:48	The first of the two offers of IAEA assistance sent to NISA and the Permanent Mission of Japan to the International Organizations in Vienna.
03-12	12:39	The second of the two offers of IAEA assistance sent to NISA and the Permanent Mission of Japan to the International Organizations in Vienna.
03-12	17:18	The IEC sent a communication to all Member States registered as a member of RANET asking registered Member States to advise the IEC of the current status of their capabilities regarding the provision of specialized assistance to Japan.
03-15	21:45	The Government of Japan requested IAEA assistance "through the dispatch to Japan of experts in the fields of environmental monitoring and effects of radiation on human health" [232].

[135] UTC – Universal Time Coordinated. UTC = JST –9 hours.

TABLE 3.5–1 OVERVIEW OF EVENTS AND SUMMARY OF THE IAEA'S RESPONSE UNTIL THE END OF MAY 2011 [232] (cont.)

Time [UTC[136]]		Event/activity
Assistance to Japan		
03-16	21:45	The IEC forwarded a request for assistance from the Government of Japan to contact points in the United States of America and France for remotely controlled aerial vehicles, robots and remotely controlled ground vehicles for carrying equipment in the high dose rate areas.
Missions to Japan		
03-17		IAEA Director General's visit to Japan.
03-18		First of four IAEA monitoring team missions.
04-03		Boiling water reactor expert team mission.
04-18		Last of four IAEA monitoring team missions.
03-26		Joint IAEA/FAO food safety assessment team mission.
03-31		Marine monitoring team mission.
05-24		IAEA international fact finding expert mission.
Other IAEA activities		
03-15		Fukushima Accident Coordination Team (FACT) established.
03-15		Fukushima Nuclear Safety Team (FNST) established.
03-15		Fukushima Radiological Consequences Team (FRCT) established.
Coordination with international organizations		
03-15	11:00	First IACRNE coordination meeting: EC, FAO, IAEA, OECD/NEA, UNEP/OCHA, UNSCEAR, WHO, WMO
03-17	12:00	Second IACRNE coordination meeting: EC, FAO, IAEA, ICAO, IMO, OECD/NEA, PAHO, UNEP/OCHA, UNSCEAR, World Tourism Organization (UNWTO), WHO, WMO.
03-21	12:00	Third IACRNE coordination meeting: EC, FAO, IAEA, ICAO, IMO, OECD/NEA, PAHO, UNEP/OCHA, UNSCEAR, WHO, WMO.
03-23	12:00	Fourth IACRNE coordination meeting: EC, FAO, IAEA, ICAO, IMO, OECD/NEA, PAHO, UNEP/OCHA, UNSCEAR, WHO, WMO.
03-25	12:00	Fifth IACRNE coordination meeting: FAO, IAEA, ICAO, IMO, OECD/NEA, PAHO, UNEP/OCHA, UNSCEAR, WHO, WMO.
03-29	12:00	Sixth IACRNE coordination meeting: EC, FAO, IAEA, ICAO, IMO, OECD/NEA, PAHO, UNSCEAR, WHO, WMO.
04-01	12:00	Seventh IACRNE coordination meeting: FAO, IAEA. ICAO, IMO, OECD/NEA, PAHO, UNSCEAR, WHO, WMO; Permanent Mission (PM) of Japan.
04-07	12:00	Eighth IACRNE coordination meeting: EC, FAO, IAEA, ICAO IMO, OECD/NEA, PAHO, UNSCEAR, WHO, WMO; PM of Japan.
04-11	12:00	Ninth IACRNE coordination meeting: EC, FAO, IAEA, ICAO, IMO, OECD/NEA, UNSCEAR, WHO; CTBTO, PM of Japan.
04-21	12:00	Tenth IACRNE coordination meeting: FAO, IAEA, ICAO, IMO, OECD/NEA, PAHO, UNSCEAR, WHO, WMO; CTBTO, PM of Japan.
05-05	12:00	Eleventh IACRNE coordination meeting: FAO, IAEA, ICAO, IMO, PAHO, UNSCEAR, WHO, WMO; CTBTO, PM of Japan.

[136] UTC – Universal Time Coordinated. UTC = JST –9 hours.

TABLE 3.5–1 OVERVIEW OF EVENTS AND SUMMARY OF THE IAEA'S RESPONSE UNTIL THE END OF MAY 2011 [232] (cont.)

Time [UTC[137]]		Event/activity
Coordination with international organizations		
26-05	12:00	Twelfth IACRNE coordination meeting: FAO, IAEA, ICAO, IMO, PAHO, UNSCEAR, WHO, WMO; CTBTO, PM of Japan.
16-06	12:00	Thirteenth IACRNE coordination meeting: EC, FAO Rome, IAEA, ICAO, IMO, PAHO, UNEP/OCHA, UNSCEAR, WHO, WMO, CTBTO, PM of Japan.
07-07	12:00	Fourteenth IACRNE coordination meeting: FAO/IAEA, FAO Rome, IAEA, ICAO, IMO, PAHO, UNSCEAR, WHO, WMO, CTBTO.

3.5.2.1. IAEA initial response

The response of the IAEA Secretariat to the accident is described in detail in Ref. [232].

At 06:42 UTC on 11 March 2011, fifty-six minutes after the magnitude 9.0 earthquake had occurred off the east coast of Japan, the IAEA's International Seismic Safety Centre (ISSC) notified the IAEA's on-call Emergency Response Manager of the earthquake and the potential for damage at four nuclear power plants on the north-east coast of Japan, and of the potential for a tsunami. This was a trigger for the IAEA's initial response.

Thirty-nine minutes later (at 07:21 UTC), the IAEA established communication with the official contact point in Japan designated under the Early Notification Convention and the Assistance Convention, METI/NISA, and verified information on the occurrence of the earthquake and the tsunami and commenced enquiries as to the safety of nuclear installations and radioactive sources in the affected areas of Japan. At 07:48 UTC, the IAEA sent an offer of assistance, formally offering its good offices, to METI/NISA and the Permanent Mission of Japan to the International Organizations in Vienna.

At 08:06 UTC, the IAEA published initial information for States and international organizations on the ENAC web site as EMERCON message No. 1. The message was posted as an Alert — this required acknowledgement by States and relevant international organizations confirming that they have read the message. Many did not acknowledge receipt of the message, which required the IAEA to follow-up non-responses (by telephone) ensuring that all Member States and relevant international organizations were aware of the situation.

Fourteen minutes later (at 08:20), the IAEA's IEC declared 'Full Response Mode' operations. An appropriate number of IAEA trained staff members were called into the response centre according to their allocated responsibilities defined in the IAEA emergency response plan (REPLIE) [231].[138]

[137] UTC – Universal Time Coordinated. UTC = JST –9 hours.

[138] The IEC continued to operate in Full Response Mode, working in shifts, until 3 May 2011. On 3 May 2011, the IEC made the transition from Full Response Mode to Basic Response Mode. In contrast to the initial phase of the event, when nuclear safety issues were addressed with priority, the emphasis shifted to aspects of radiation protection and radioactivity measurements, which were reflected in the material provided in the Status Summary Reports. Preparations remained in place to move rapidly back to Full Response Mode if necessary [200] [232]. Until 15 May 2011, 230 staff members from throughout the IAEA worked in the IEC in shifts. There were more than 20 staff members in each shift in the first few weeks following the accident.

At 08:30 UTC, an initial press statement of the Prime Minister was published on the IAEA web site. The information provided initially to the IAEA consisted primarily of press releases of the Prime Minister (in Japanese). The IAEA arranged for unofficial translations to speed up the operational understanding of the situation while waiting for the official translation from Japan (press releases also contained information that was not directly relevant to the accident and waiting for official translation in their entirety would have resulted in further delays of sharing relevant information).[139]

At 08:45 UTC, three hours after the earthquake and close to two hours after the tsunami hit the Fukushima Daiichi NPP the IAEA received the initial EMERCON message from NISA in which only the Onagawa NPP were mentioned. The second message, one hour later (at 09:45 UTC), mentioned also the Fukushima Daiichi NPP.

About the same time (at 08:56 UTC), the IAEA received the first request from its Member State's official contact point under the Early Notification Convention and Assistance Convention for information about the state of the safety of the power reactors in Japan. At 15:00 UTC, after gathering and compiling enough information, the IAEA's IEC initiated answers to its official contact points in Member States and international organizations requesting information. Requests for information received from organizations in Member States that were not official contact points and from members of the public (through the IAEA public web site) were followed up by the relevant IAEA technical divisions.

At 20:02 UTC, the IAEA published its initial Status Summary Report on the ENAC[140] web site and distributed it to all contact points by fax. Two hours later (at 22:00 UTC), the IAEA published and distributed an updated summary. That concluded official information sharing with Member States and international organizations on the first day of the accident.

3.5.2.2. Status Summary Reports

As mentioned above, at 20:02 UTC on 11 March, the IEC published on the ENAC web site the initial Status Summary Report, which, based on the official information received, described the understanding of the event and status of the facility at that time. Throughout the response, regular Status Summary Reports were developed and issued. The frequency of the Status Summary Reports was based on the rate at which new information was being received. For example, in the first weeks following the accident, the Status Summary Reports were issued at least twice a day; on 6 May 2011, the frequency of the distribution of Status Summary Reports was reduced to three times a week, and, on 1 July 2011, to once a week. From 21 December 2011 to 27 December 2012, the IEC provided Status Summary Reports to Member States on a monthly basis. However, special updates were issued whenever important information was received and verified.

In total, more than 200 Status Summary Reports, with almost 3500 pages of content, were prepared. These Status Summary Reports and subsequent technical analyses constituted the main basis of the Member State briefings and the media briefings provided by the IAEA, which subsequently formed the basis for some national briefings organized and provided by Member State organizations.

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[139] Later it was revealed that the NERHQ was also providing information to the public that was relevant to the international community; however, since the NERHQ was not an official contact point, this information was not provided to the IAEA at the onset.

[140] On 29 June 2011, the ENAC web site, which contained all of the information being shared by Japan with the IAEA, was transitioned into the new USIE web site. All information available on the ENAC web site, which includes documents and EMERCON messages, was automatically transferred to the USIE system.

Individual documents and reports that were received from Japan, other Member States and international organizations were promptly published on ENAC (and later on USIE) and faxed/emailed to official contact points. In addition, web site links received from contact points in Japan, other States and international organizations were also published on ENAC (and later on USIE). On 13 September 2011, Japan submitted its last EMERCON message on USIE. The final document relating to the status of the Fukushima Daiichi NPP and environmental condition was published on USIE on 27 December 2012.[141] In total, 186 EMERCON messages were published, in addition to 1673 other documents. More than 950 messages were received from Japan, 31 from other States and 71 from the WMO.

3.5.2.3. Briefings of Member States

The IAEA prepared a total of 19 oral briefings and presentations on the Fukushima Daiichi accident for the Permanent Missions to the International Organizations in Vienna and official Member State representatives. The briefings were conducted every day from 14 to 23 March, and subsequently on 25, 28 and 30 March, 1, 4, 12 and 19 April, and 5 May 2011. These briefings were followed by the briefings to the press (see details in Section 3.5.2.8).

The briefings included the status of Units 1–6 of Fukushima Daiichi and Units 1–4 of Fukushima Daini; the status of the spent fuel cooling pools and the common spent fuel storage pool at Fukushima Daiichi; results of environmental monitoring, including information on trends, findings and conclusions and their significance; information on restrictions on the distribution and consumption of foodstuffs and drinking water; and related information on the marine environment.

In addition, background information was provided to help put technical data (such as doses, dose rates and action limits) into context for non-technical audiences. A presentation was also provided to explain the International Nuclear and Radiological Event Scale (INES).

The Government of Japan and the IAEA coorganized a side event during the Fifth Review Meeting of the Convention on Nuclear Safety from 4 to 14 April 2011 on The Fukushima Daiichi Accident and Initial Safety Measures Worldwide [232].

A total of 27 detailed written Update Briefs were prepared and posted on the IAEA's public web site between March and June 2011. Overall, 129 individual posts were prepared and uploaded to the IAEA's public web site in the Fukushima Nuclear Accident Update Log[142] to share information with States and the public during the first months after the accident. In addition, information was shared through social media channels, such as Facebook and Twitter.

After TEPCO's roadmap announcement on 17 May 2011, update briefs provided the status of Units 1–4 in terms of the fundamental functions of IAEA safety standards for achieving a safe state, namely: control of reactivity; residual heat removal; containment integrity; confinement of radioactive material; and limiting the effects of releases. This information was presented in the form of tables in terms of the roadmap's goals and proposed measures for transition from the emergency phase to a recovery phase [232].

During these briefings and within the material made available to the public, the IAEA provided statements to clarify and explain technical issues surrounding the event. These statements did not contain prognoses of the potential evolution of the event or an assessment of the potential consequences, since such prognoses or assessments were outside of the scope of the IAEA's response

[141] The IAEA continues to regularly receive information updates from Japan, which are shared with States and the public.

[142] The original entries remain available online: http://www.iaea.org/newscenter/news/tsunamiupdate01.html.

role at the time of the accident. The role[143] in responding to an emergency at an NPP was expanded through the adoption of the IAEA Action Plan on Nuclear Safety [234]. This requested the IAEA's Secretariat to provide Member States, international organizations and the general public with timely, clear, factually correct, objective and easily understandable information during a nuclear emergency on its potential consequences, including analysis of the available information, and prognoses of possible scenarios based on evidence, scientific knowledge and the capabilities of Member States.

3.5.2.4. Fukushima Accident Coordination Team

To ensure effective interdepartmental coordination, the IAEA Director General established the Fukushima Accident Coordination Team (FACT) on 15 March 2011[144]. FACT was headed by the Director General, with the assistance of the Deputy Director General, Head of the Department of Nuclear Safety and Security. The purpose of FACT was to ensure senior level coordination of response to the accident. FACT also ensured the provision of accurate and timely information, validated by the Japanese authorities, to Member States, the news media and the general public, via oral briefings and Update Briefs posted on the IAEA's web site. Two teams were formed to support FACT: the Fukushima Nuclear Safety Team (FNST) and the Fukushima Radiological Consequences Team (FRCT).

FNST and FRCT were composed of IAEA staff from the Departments of Nuclear Safety and Security, Nuclear Energy and Nuclear Sciences and Applications, with the assistance of external experts from Member States, including Argentina, Canada, France, Germany, Italy and the Republic of Korea. In close coordination with the IEC, these teams were tasked with: coordinating and assembling the results of technical work performed throughout the IAEA; providing accurate information to inform the Director General's decisions; providing information for detailed briefings to Member States, international organizations, the media and the public; and informing the dialogue with Japan and other State authorities.

The tasks of FNST included focusing on the condition of the Fukushima Daiichi NPP and its systems, as well as on the status of the fuel within the reactors and the spent fuel pools. Through analysis of the IEC Status Summary Reports and other information, FNST evaluated the status of plant safety functions and barriers, plant parameters and the progression of actions toward stable shutdown of the units. It provided information on radioactive releases to CTBTO and to WMO's RSMCs for use in atmospheric dispersion modelling. CTBTO communicated results of the atmospheric dispersion modelling to its Member States. FNST also evaluated the results of the boiling water reactor (BWR) experts' mission to Japan.

The tasks of FRCT included: analysis of radiological monitoring data provided by Japan; analysis of pathways relevant for public exposure; analysis of trends in environmental monitoring data; evaluation of issues relating to transportation and trade; and elaboration of possible further protective measures. FRCT consolidated the data provided by Japan with the results of the IAEA's radiation monitoring teams.

Other senior staff with relevant experience and experts from Member States worked in cooperation with FNST, FRCT and the IEC on subjects that included reactor engineering, fuel integrity, other safety assessment issues, radioactive waste management and radiation monitoring [232].

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[143] In September 2013, the IAEA General Conference, in Resolution GC(57)/RES/9, further clarified that the IAEA Secretariat's response role in this context would cover all nuclear and radiological emergencies [233].

[144] FACT carried out the role and functions of the IES Steering Group within the IAEA's Secretariat response structure.

3.5.2.5. Director General's visit to Japan

The IAEA Director General visited Tokyo from 17 to 19 March for high level consultations: to express the solidarity of the international community and its full support to Japan in dealing with the consequences of the earthquake and the tsunami and to convey offers of assistance from more than a dozen countries; to ascertain whether there was any particular assistance the IAEA could provide or coordinate (such as expert missions); to obtain, first hand, information about the accident; and to stress the importance of the highest level of transparency and the timely provision by Japan to the IAEA of official information, and the confirmation (upon request) of its correct understanding by the IAEA.

The IAEA Director General met the Japanese Prime Minister, the Foreign Minister and the Minister of METI. He also had meetings with senior officials from TEPCO and from NISA, and pledged the IAEA's full support. The Prime Minister of Japan expressed his strong commitment to ensuring the highest level of transparency in sharing information and said that every effort would be made to improve the collection and provision to the international community of accurate and objective information [232].

During the Director General's visit, the IAEA's 'on the ground' support to Japan became operational. It consisted of the following three main actions [232]:

(1) A senior IAEA official was deployed in Japan to coordinate IAEA assistance activities and transmit offers of assistance from Member States to the Japanese authorities.
(2) IAEA liaison officers were deployed to Tokyo to facilitate and improve communication between the IAEA and NISA.
(3) The IAEA's radiation monitoring team began transmitting measurements to Vienna, from various locations, including locations close to the Fukushima site.

Communication with the official contact point in Japan in the early phase of the emergency response was difficult. The visit to Japan from 17 to 19 March 2011 by the IAEA Director General, and the subsequent deployment of liaison officers in Tokyo, improved communication between the IAEA and the contact point [232].

3.5.2.6. Meeting of the Board of Governors

The IAEA Director General called a meeting of the Board of Governors on 21 March 2011. At this meeting, he reported to the Member States on the results of his visit to Japan. He emphasized that the IAEA was doing everything possible to provide accurate and factual information on the accident, and that the IAEA was "working at full stretch, together with other countries and international organizations, to help Japan bring the crisis to an end and ensure the effects are mitigated as much as possible." It was noted that the IAEA would continue to do everything in its power to help Japan to overcome the Fukushima crisis and deal effectively with the aftermath [232].

The Chairman of the Board of Governors noted in his summary of the Director General's report on his visit to Japan, inter alia, that, in addition to expressing solidarity with the people of Japan, several Board members had pledged their continued support to the Government and people of Japan. The Board also emphasized that the international community had a shared responsibility to ensure that the general public were provided with accurate and reliable information on such emergencies to alleviate their concerns and that they must be kept aware of how the respective national authorities were responding to those emergencies. The Board emphasized the importance of the universalization of the relevant international instruments in the field of nuclear safety, and reaffirmed the need for Member States' continuous commitment to the application of the highest standards of nuclear safety, to avoiding complacency, and to drawing and acting upon the lessons learned from the Fukushima

Daiichi accident. Following the meeting of the Board, the Chairman issued a press statement summarizing the Board's discussions [232].

3.5.2.7. Coordination of the interagency response

As has been mentioned, the primary interagency coordination mechanism with regard to nuclear and radiological emergencies is the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE). The IAEA (specifically, its IEC) provides the secretariat for the IACRNE, pursuant to the IAEA's own roles and responsibilities. The IACRNE, under IEC coordination, maintains the Joint Radiation Emergency Management Plan of the International Organizations (JPLAN) [225].

In accordance with its responsibilities under the JPLAN, the IAEA, on 11 March 2011, promptly notified all relevant international organizations and activated JPLAN. The IEC initiated coordination of the interagency response to the Fukushima Daiichi accident, with particular regard to reaching a common understanding of the accident situation, and to coordinating public information. According to the bilateral agreements between the secretariats of the IAEA, FAO, WHO and WMO, those international organizations sent liaison officers to the IEC to ensure effective response coordination.

On 15 March 2011, the first IACRNE coordination meeting was conducted through a video teleconference. The IEC held regular video teleconferences of the IACRNE[145] to brief participants on the situation, exchange information among international organizations, consider and coordinate response activities, reach a common understanding of the situation and inform the public through joint press releases and other forms of information distribution. Participants of the video conferences were the EC, FAO, IAEA, ICAO, IMO, OECD/NEA, PAHO, UNEP, OCHA, UNSCEAR, WHO and WMO. WTO and CTBTO participated as observers. In addition, the Permanent Mission of Japan to the International Organizations in Vienna attended the meetings at the invitation of the IACRNE Secretary.

At these meetings commonly agreed tasks were assigned to specific organizations. For some issues ad hoc task groups were established, for example on transport and on dose assessment. IACRNE facilitated the formation of a task group to address issues relating to transport and tourism comprising representatives of the Airport Council International (ACI), IAEA, the International Air Transport Association, ICAO, IMO, WTO, WHO, WMO and UN. From 17 March 2011, the task group held regular telephone conference calls, which continued throughout the event. ICAO chaired the group, and WHO provided web-based document sharing to facilitate collaboration.

One of the IACRNE agreed tasks was to conduct a survey[146] on the advice that countries provided to their citizens, and on their import/export and industrial activities with Japan. The IACRNE tasked the OECD/NEA with collecting and evaluating the information received. On 26 March 2011, a questionnaire was distributed to States requesting information regarding governmental decisions and recommendations related to the Fukushima Daiichi accident with regard to citizens in or going to Japan, food or goods exported from Japan and the screening of passengers and goods. In total, 34 countries participated in the survey. The information collected was then compiled by the OECD/NEA and published on the ENAC web site.[147] The findings of this survey are elaborated in Ref. [235].

The information gathered showed that countries responded in different ways in their efforts to ensure the protection of non-food goods exported from Japan with regard to controls introduced, products

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[145] Fourteen video teleconferences in total.

[146] This survey was discussed and agreed upon in the meeting of IACRNE on 17 March 2011.

[147] The last update of the survey was published on ENAC on 21 April 2011.

covered, dates on which measures were initiated or relaxed and screening levels used [181, 235]. Some countries considered radiation controls on non-food goods unnecessary, while others initiated regular controls for possible contamination of non-food goods or intensified their regular controls in relation to specific Japanese products intended for import. At least one country performed a single radiation control of cars imported from Japan. The import of particular non-food items was banned by at least one country.

The information from the survey also showed that controls for possible contamination of non-food products intended for import were initiated by some countries as early as five days after the accident (16 March 2011). On the other hand, other countries did not impose controls of non-food products until 25 August 2011. Some countries introduced and relaxed their controls.

Non-food goods intended for import were subjected to varying types of controls by various countries. Overall, the following items were reported to be controlled differently by countries: machinery, electronic information and communications equipment, residential/commercial electrical and gas equipment, cars (both new and used), different car components, scrap, chemicals, construction materials, toys, shoes, clothes and other textile products, medicines, medical devices, cosmetics, and plates and dishes. Controls were mainly based on a screening level value of 0.2 μSv/h (as implemented by the EC), but values of 0.3 μSv/h (in the Russian Federation) and 1 μSv/h (in Singapore) were also used for screening purposes. Only if the screening level was exceeded were detailed assessments to be performed.[148]

About 40 Member States performed radiological screening of passengers, food and goods coming from Japan.

On 22 March 2011, the IEC received, through official channels, the first monitoring data from a Member State other than Japan. Subsequently, monitoring data was received from a total of 37 Member States[149]. In addition, the CTBTO provided data from its global network of radionuclide monitoring stations.

In cooperation with the International Air Transport Association and ICAO, an industry guideline for aircraft decontamination was reviewed by the IAEA for accuracy. In cooperation with ICAO, an exemption and associated guidelines were prepared for the transportation of people who may have been contaminated (internally or externally) with radioactive material. On 12 April 2011, the new guidelines were adopted and incorporated, as an addendum, in the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air, thus bringing them into force internationally for air transport [236].

Maritime safety issues were reviewed together with the IMO, and guidance was jointly prepared. A delegation of major shipping lines met with the IAEA and IMO on 4 May 2011 to discuss the means of addressing the monitoring of containers at ports. Support has been provided to shipping companies through the IAEA's Denial of Shipment Network.

International organizations such as WHO, ICAO and IMO evaluated radiological impacts on human health and transportation infrastructure. They provided timely technical information to the global

[148] Variations in the criteria used for further assessments and the assessment itself were not evaluated due to the lack of available information.

[149] Algeria, Austria, Belgium, Bulgaria, Canada, China, Czech Republic, Denmark, Finland, France, Georgia, Germany, Greece, Iceland, India, Islamic Republic of Iran, Ireland, Italy, Republic of Korea, Latvia, Lithuania, Luxembourg, Malaysia, Mexico, Philippines, Poland, Portugal, Romania, Russian Federation, Singapore, Slovakia, Spain, Sri Lanka, Sweden, Switzerland, Ukraine and the United States of America.

community. For example, information showed that radiation levels at and around airports and seaports in Japan did not pose health or transportation risks. The three organizations also provided advice to travellers to Japan.

Under JPLAN, the IAEA has practical arrangements with WMO. Specifically, WMO's RSMCs, upon IAEA request, provide standard meteorological products[150] for actual or potential releases of radioactive material to the atmosphere.

At 09:39 UTC, on 11 March 2011, the IEC made its first request to the RSMCs to run models for a potential radioactive release from the Fukushima Daiichi NPP. Thereafter, the IEC worked with the RSMCs on a regular basis, requesting them to run models and provide standard meteorological products. The results of the modelling of the lead RSMCs in the regions (Tokyo, Beijing and Obninsk) were compiled and published on the ENAC web site on a regular basis. On 17 March 2011, the IEC estimated a source term and requested RSMC Montreal to provide results from a series of more detailed (finer resolution) atmospheric transport modelling runs for the local level and regional level around the Fukushima Daiichi site [232].

On a strategic level, and from the early days after the accident, the IAEA Director General was in close contact with the United Nations Secretary-General to ensure effective coordination among different international organizations. He also consulted with the Director General of WHO, the Executive Secretary of CTBTO, the Director General of FAO and the Secretary-General of WMO to maintain effective coordination of activities.

At its 22nd regular meeting on 8 and 9 December 2011 [237], IACRNE initiated an assessment of the interagency response to identify lessons to be learned for further enhancement of the response and coordination mechanism. At this meeting, international organizations discussed the following items extensively: (a) reports of international organizations on the response to the Fukushima Daiichi accident, as well as continual activities undertaken by each organization in strengthening its emergency arrangements; (b) the need to strengthen the procedures for cooperation and coordination in providing public information at the international level; (c) the need to strengthen the existing exercise regimes, including the ConvEx regime; (d) the need to maintain awareness of the inter-agency coordination mechanism on the part of senior management of IACRNE member organizations; (e) the need to establish an ad hoc working group on air and maritime transportation[151] considering the experience gained in the interagency response to the Fukushima Daiichi accident; and (f) the need to review and revise JPLAN (2010 Edition)[152].

3.5.2.8. Provision of information to the public and media by the IAEA

This section summarizes the public information activities by the IAEA, including the coordination that took place at the international inter-agency level (IACRNE).

In general terms, journalists and members of the public turned to the IAEA during the accident, expecting some answers that the IAEA could not always provide as doing so would have exceeded its mandate.

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[150] Standard meteorological products include: the trajectory of particles, deposition and integrated concentration of radioactive material for up to 72 hours after the initial release.

[151] The ad hoc IACRNE Working Group on Air and Maritime Transportation was established in March 2013.

[152] JPLAN has since been revised, and the 2013 edition came into effect on 1 July 2013.

The IAEA's intense round-the-clock public information activities in response to the Fukushima Daiichi accident ensured that the information it could provide reached its audience, despite technical challenges and intense pressure. At the IAEA, the Division of Public Information maintained continuous emergency communications with the press and public from 11 March to 22 April 2011[153]. Public information officers supported the delivery of information to the media and the public, organizing press conferences, handling thousands of telephone calls, providing detailed technical responses to hundreds of email queries and drafting over 120 updates for the public web site. To handle the influx of these telephone calls and emails, extended shifts were established and temporary support staff deployed.

The IAEA called its first press conference on 14 March. Some journalists expressed frustration about this taking place several days after the tsunami, as they had hoped for an opportunity to pose questions to the IAEA sooner than that. Following the 14 March conference, the IAEA called frequent press conferences, with 16 held between that date and 2 June 2011. These press conferences were initially attended by over 150 journalists from major international news agencies and broadcasters. National media from 37 States attended the briefings, including staff of nine Japanese newspapers and television broadcasters. Information provided during the briefings was featured prominently in over 4000 articles published in Arabic, English, French, Italian, German, Japanese, Portuguese, Russian and Spanish. Following each of the briefings, audio and video packages were distributed to the media; they were downloaded over 2500 times by registered journalists. A news conference and five media briefings were held during the Director General's visit to Tokyo from 17 to 19 March 2011. In addition, major interviews were held by the Director General with the BBC, CNN, Le Monde, Nippon Hoso Kyokai (NHK) (Japan) and the New York Times and about a dozen further interviews were arranged for the international media with senior IAEA staff.

A purpose built emergency update web site (a 'dark web site'[154] called IAEA Alert Log) was activated by the IAEA shortly after the earthquake occurred. Over 260 updates, read by 3.6 million visitors, were delivered onto the IAEA Alert Log within six weeks. Posts initially were posted only to this site and not on the IAEA's front page, meaning that visitors to that page had to continue navigating to find information about the accident. Later, all of the communications issued via the traditional channels (press briefing, email) were also packaged for dissemination via the front page of the IAEA public web site, and Facebook, Twitter, Flickr, SlideShare, YouTube and Scribd. With the exception of the dark web site, these communication channels had been used routinely by the IAEA prior to the accident.

Because of the enormous volume of visits to iaea.org and to the IAEA Alert Log, both web sites crashed during the first post-accident weekend and intermittently for the first two weeks. The IAEA took immediate steps to fix the problem by adding internet bandwidth and intensifying its use of social media to disseminate information. Subsequently, the IAEA began using cloud computing to upload and disseminate information, reducing pressure on the IAEA's servers. The IAEA's Fukushima Nuclear Accident Update Log was a site used later in the emergency to host all information (press releases, status summaries, photos, videos, etc.). It included a resources box, which contained relevant resources such as external web sites and IAEA publications. In addition, a

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[153] Emergency communications refer to those activities in public communications occurring during an emergency situation, including periodic press releases, press conferences, responses to enquiries from the media and public, and increased social media presence that are all related to a particular event. Routine communications are public communications activities that occur outside of an emergency. These include general stakeholder involvement activities such as public meetings and news stories.

[154] 'Dark web site' is an emergency blog web site [238]. The dark site was no longer used after it became clear that the web site was not accessible due to heavy demand. Instead, the regular IAEA public web site, with an emergency banner, was utilized. The updates that were posted on the dark site can now be found at:
http://www.iaea.org/newscenter/news/tsunamiupdate01.html.

frequently asked questions (FAQs) section for this particular event was developed over several days during the emergency. This process required the cooperation and clearance of internal experts, as well as coordination with a number of international organizations within IACRNE (see below for further information on the work with IACRNE).

Every communication channel that the IAEA utilized during the emergency experienced a significant and sustained increase in traffic, downloads, active users and comments. The immediate surge dissipated within the first six weeks, yet the ongoing traffic and activity levels outpaced pre-accident average levels of usage until approximately November 2011. During this period, the IAEA's public web site received more visitors (3.6 million) than during the entire previous year, 2010 (2.1 million). The number of visitors to the public web site from Japan, the second largest national audience in this period, rose from a six week average of 7000 to over 540 000. Visitors to the IAEA's social media web sites rose, with the updates on the IAEA Facebook page viewed 7.7 million times as compared to 270 000 views from January to December 2010. The PowerPoint presentations from the IAEA's briefings given in the press conferences were posted on the IAEA's social media web sites; they were viewed over 500 000 times and downloaded 20 000 times.

Facebook and Twitter were key referral sources for the public web site, with the result that the web site's audience reach moved from its pre-accident position among the top 40 000 most-viewed web sites to among the top 10 000 [239]. Notably, Twitter usage nearly quadrupled. In fact, Twitter referrals contributed to a server overload of the public web site's capacity in the first two weeks of the emergency, necessitating Twitter links to be redirected to the IAEA's Facebook page. Rules of conduct for the public using the IAEA's Facebook forum were highlighted through a note to users during the first week of the emergency, and any editorial interventions by the IAEA Facebook team, such as comment deletions, were based solely on those rules. Only a handful of the thousands of commentators disregarded these rules, prompting comment deletions, and only one user was banned for obscene and inappropriate statements. As per the best practice advised in Ref. [240] users of social media that expressed criticism of the IAEA were not censored, in order to make it possible for users to freely exercise their right of expression in a transparently administered venue.

An analysis of the email traffic revealed that the main subjects of concern included (in order of the frequency of queries): status and condition of the reactors; radiation exposure; IAEA response; Japanese Government's response; the rating on the International Nuclear and Radiological Event Scale (INES); travel restrictions; environmental impact; evacuation; and food and/or water restrictions.

The use of the INES rating was a particular concern for the public due to various reasons: Japan used the INES rating as a public information tool early in the event, with different units rated separately. This led to significant public and media confusion and concerns each time the INES rating was revised to a higher level. In addition, some foreign authorities challenged Japan's rating; therefore, while the gravity of the accident was established, the use of INES did not help clarify the situation.

At the inter-agency level, joint public statements were prepared and joint press releases were issued.

As mentioned earlier, IACRNE facilitated the formation of an ad hoc task group to address issues related to transport and tourism (Transport Task Force). The group chaired by ICAO prepared joint public statements and, on several occasions, issued joint press releases. The first press release, issued on 18 March 2011, stated that there were no restrictions on travel to Japan, while the press release issued on 1 April 2011 responded to misleading press reports and provided the travelling public with authoritative information.

Within the IACRNE, the OECD/NEA was tasked with reviewing the FAQs mentioned above and answer pages on the web sites of all responding international organizations for possible inconsistences. This review ensured consistent and accurate information and assisted in enhancing the credibility of the information being provided.

3.5.2.9. The IAEA's technical missions to Japan

The IAEA Secretariat's monitoring team missions

Between 18 March and 18 April 2011, the IAEA sent four radiological monitoring teams[155] to Japan to help validate the results of more extensive measurements by the Japanese authorities. The four teams took measurements in the Fukushima region at a number of locations inside and outside the 20 km evacuation zone. One team was also deployed in the general vicinity of Tokyo. The scope of the monitoring included dose rates and surface activity concentrations, as well as the collection of different samples and gamma spectra for selected locations from 20 km to around 80 km from the Fukushima Daiichi NPP, and in Tokyo and the surrounding area. Based upon their measurement activities, the mission demonstrated to the Japanese authorities the importance of creating a contamination map to consolidate all the measurements taken by Japan for future mitigation and decontamination activities.

A BWR expert team was sent to Japan on 3 April 2011 and concluded its mission on 12 April 2011. The mission included meetings with several government offices, with the majority of the time dedicated to detailed, technical discussions with TEPCO and METI/NISA. As the first international expert team to visit the Fukushima Daiichi site, the IAEA experts visited the Government–TEPCO Integrated Response Office in Tokyo, the Fukushima Daiichi Emergency Response Centre at the NPP (NPP-ERC) and site facilities, and the Fukushima Daini Technical Support Centre and site facilities. Detailed insights into the accident and the status of the plants were provided, and the team was given the full cooperation of the Japanese authorities and the plant operator, TEPCO. The mission proved valuable in helping to understand other information that had been provided to the IAEA. The data and findings obtained by the team were used in preparing for the IAEA International Fact-Finding Expert Mission to Japan (see p. 13 [232]).

Upon request from Japan, the IAEA sent an expert on marine monitoring programmes from the IAEA Environmental Laboratories to Japan, from 31 March to 7 April 2011, to participate for two days in the monitoring being performed from the research vessel 'Mirai', and to observe and give advice on the collection of seawater at locations about 30 km from the coast in the offshore monitoring campaign. The mission included participation in marine monitoring and laboratory visits as well as a briefing on the findings to all parties involved in the process and to the Ministry of Foreign Affairs, MEXT, the Ministry of the Environment (MOE) and the Office of the Chief Cabinet Secretary.

Joint IAEA/FAO Food Safety Assessment Team Mission

A Joint IAEA/FAO Food Safety Assessment Team (FSAT) visited Japan from 26 to 31 March 2011. The team provided advice and assistance to the Japanese authorities, including local government authorities, on technical issues related to food safety and agricultural countermeasures, including sampling and analytical strategies and interpretation of monitoring data to ensure that reliable, continual updates could be provided on the extent of food contamination in the affected areas. These data were used for the development of possible mitigation and remediation strategies to be shared with authorities at the local and national levels in Japan.

[155] None of these missions were triggered or carried out under the framework of the Assistance Convention.

IAEA International Fact Finding Expert Mission to Japan

Based upon an agreement between the Government of Japan and the IAEA, which set out the terms of reference, an IAEA International Fact Finding Expert Mission, comprising 18 experts from the IAEA and Member States, visited Japan from 24 May to 2 June 2011 [51]. The mission conducted fact finding activities for a preliminary assessment of the accident (in particular at the Fukushima Daiichi NPP). The mission also collected information on the Fukushima Daini and Tokai Daini NPP sites located in Fukushima Prefecture and in Ibaraki Prefecture, in order to make a preliminary assessment of the accident and the generic safety issues associated with the natural events, and identify issues that needed further exploration or assessment according to the IAEA safety standards.

The mission received information on the progress of the Japanese assessment of the accident and discussed specific technical issues to develop an informed assessment for sharing with the international nuclear community.

The scope of the mission focused on: external events of natural origin; plant safety assessment and defence in depth; plant response after an earthquake and tsunami; severe accident management; spent fuel management under severe facility degradation; emergency preparedness and response; and radiological consequences.

Participants in the meetings with members of the IAEA mission team included officials of the Government of Japan, governmental Advisory Committee members, representatives of licensees, and academic experts nominated by the Government of Japan, including participants from: the Prime Minister's Office, the Ministry of Foreign Affairs, NISA, MEXT, Nuclear Safety Commission (NSC), Japan Nuclear Energy Safety Organization (JNES), Japan Atomic Energy Agency (JAEA), TEPCO; and Japan Atomic Power Company Limited (JAPC).

The report of the mission was presented at the IAEA Ministerial Conference on Nuclear Safety in June 2011 [241].

3.5.2.10. Activities of the IAEA's Laboratories

The IAEA Laboratories in Seibersdorf and Monaco specialize in evaluating terrestrial and marine environmental samples, respectively. They provided an expert review of the environmental data received from the Japanese authorities. Contamination of the marine environment was monitored by TEPCO, near field, at the discharge areas of the reactors and by MEXT at offshore stations about 30 km east of the shore line. In addition, the IAEA Terrestrial Environment Laboratory in Seibersdorf received more than two hundred samples from Japan for independent analysis.

Contaminated water from the Fukushima Daiichi NPP was leaked into the sea. This gave rise to concerns about the marine life and seafood for the population. The IAEA Marine Environment Laboratory in Monaco reviewed all information concerning the marine environment. Information and advice with regard to the potential for contamination and the consumption of seafood was provided to WHO.

The laboratory also liaised with a number of centres to set up models to simulate the dispersion of radioactivity released into the Pacific Ocean. This included requesting the French group SIROCCO from the University of Toulouse to carry out a simulation of the contamination dispersed in the Pacific.

The IAEA Terrestrial Environment Laboratory provided information and methodological advice to laboratories from the ALMERA[156] network. From 29 March to 6 May 2011, the laboratory received seven sets of samples taken in Japan during IAEA missions. By 16 May 2011, more than one hundred of the samples had been analysed by high resolution gamma ray spectroscopy.

The IAEA's Radiation Monitoring and Protection Services laboratories provided radiation protection services and advice to IAEA staff travelling to Japan, as well as to staff of WHO and FAO. The services included: individual and workplace monitoring; basic protective clothing and personal protective equipment; and briefings on the radiological conditions at the plant sites and in Fukushima [232].

3.5.2.11. IAEA Ministerial Conference on Nuclear Safety

On 28 March 2011, the IAEA Director General called for a Ministerial Conference on Nuclear Safety, with broad support from Member States [242]. The conference was held in Vienna from 20 to 24 June 2011 with the overall objective of drawing lessons from the accident at the Fukushima Daiichi NPP in order to strengthen nuclear safety throughout the world. The specific objectives of the conference were to: provide a preliminary assessment of the Fukushima Daiichi NPP accident; assess national and international emergency preparedness and response levels in the light of the Fukushima Daiichi NPP accident, with a view to strengthening them; discuss safety implications and identify those areas of the global nuclear safety framework which may be reviewed with a view to strengthening them through launching a process to that effect; and to identify lessons learned and possible future action.

These main objectives were discussed both in a plenary session and in greater depth during the three working sessions. The conference provided an opportunity to undertake, at the ministerial and senior technical levels, a thorough preliminary assessment of the accident at the Fukushima Daiichi NPP and discuss actions for nuclear safety improvements, issues regarding emergency preparedness and response and the implication of the global nuclear safety framework. These three main topics were addressed in three working sessions.

An important achievement of the conference was the unanimous adoption of the Ministerial Declaration. It provided the political commitment and associated support and guidance, gave a mandate to the Director General for future work with concrete actions, and formally launched the process of strengthening post-Fukushima nuclear safety worldwide [243].

The Ministerial Declaration outlined a number of measures to improve nuclear safety and expressed the firm commitment of IAEA Member States to ensure that these measures would be actually implemented.

Ministers asked the Director General to prepare a report on the conference and a draft Action Plan building on the declaration and the conclusions and recommendations of the working sessions. They requested that the report and the draft Action Plan be presented to the IAEA Board of Governors and General Conference in their forthcoming meetings in September 2011. Ministers also called for the effective, prompt and adequately funded implementation of the Action Plan.

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[156] ALMERA is the abbreviation for Analytical Laboratories for the Measurement of Environmental Radioactivity, which is a network representing, at present, 122 laboratories from 77 States.

The Director General requested the International Nuclear Safety Group (INSAG) to prepare a report of the Ministerial Conference, including associated recommendations for future action to be submitted to the Board of Governors at its meeting in September 2011 [244].

In preparation for the IAEA Ministerial Conference, the Japanese Government drew up an extensive report [22], providing a summary of the events, addressing safety and engineering issues related to the accident and discussing the major lessons learned to date. The main elements of the report were presented during the Ministerial Conference in the working sessions.

3.5.2.12. Fukushima Monitoring Database

On 7 September 2012, the IAEA (through the IEC) launched a database of radiation measurement results collected following the Fukushima Daiichi accident called the Fukushima Monitoring Database (FMD) (https://iec.iaea.org/fmd/). The FMD is available to all Member States and the public and provides the results of near and far field radiation measurements performed in 2011 (starting on 11 March and ending with the attainment of a cold shutdown state as announced by the Government of Japan on 16 December 2011).[157] The database also contains radiological monitoring results from other Member States that were provided to the IAEA. The FMD enables researchers to search and download results of measurements such as dose rate measurements and measurements of environmental samples, including leaves, water and soil.

3.5.3. Protective actions recommended to foreign nationals within Japan

The OECD/NEA, within the framework of IACRNE, collected information on governmental decisions and recommendations made in States other than Japan during the accident, as well as on the technical basis for these decisions and recommendations. One of the topics covered related to recommendations[158] made with regard to citizens of other States living in or visiting Japan.[159]

Each State participating in the surveys issued advice or a specific instruction for the protection of its nationals in Japan. Although some States recommended that their nationals in Japan follow the recommendations and instructions of the Japanese authorities, many States issued advice or recommendations that differed from each other and also from those provided by the Japanese authorities. Thus, some States recommended that their nationals in Japan leave either the area within a radius of 80–100 km of the Fukushima Daiichi NPP or, more generally, the affected areas, including Kanto region (Tokyo, Yokohama and north of Tokyo) and Chubu areas. One State also made a recommendation to its nationals staying within 250 km of the Fukushima Daiichi NPP, including the Tokyo region, to remain indoors, with closed windows and ventilation. Several States distributed stable iodine tablets to their nationals and immediate family members in Japan. However, only one State made a recommendation to its nationals staying within 250 km of the Fukushima Daiichi NPP, including the Tokyo region, to take stable iodine tablets as a precaution. At least one State advised its

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[157] Monitoring information was collected as part of the IAEA's role in implementing the Early Notification Convention, under which Japan provided the IEC the requested information.

[158] Recognizing that inconsistencies in actions taken by different States may be difficult to explain and may possibly result in a loss of trust in officials on the part of the public, IAEA safety standards [13] recommend that arrangements be put in place to ensure that the recommended countermeasures or actions are consistent among States, or that any differences can readily be explained to the public, to allow the public (and decision makers) to make informed decisions. It also recommends that all States make arrangements to protect their interests in the event of an emergency, taking into account its citizens in the affected State(s), embassies in the affected State(s) and travellers to and from the affected State(s).

[159] The following countries responded to this question in the survey: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Islamic Republic of Iran, Ireland, Italy, Republic of Korea, Latvia, Lithuania, Luxembourg, New Zealand, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States of America.

nationals in Japan not to consume the food from the affected areas and to avoid buying food at local market places. At least seven States made sure that aircraft were available for their nationals wishing to leave Japan. In addition, many States issued recommendations for their nationals to avoid either travelling to Japan or, more specifically, travelling to the affected areas. Some States restricted their recommendations only to non-essential travel to Japan or to specific areas, including the Kanto region (Tokyo–Yokohama) [235].

Although each State was requested to provide the technical basis for its recommendations, this information was not given. Instead, responses referred to national policy and considerations that were driven by the feasibility of implementing the recommendations (and, possibly, by recommendations made by other States), rather than by radiation protection [235].

The Heads of the European Radiological Protection Competent Authorities (HERCA) reviewed the issues raised from the different approaches of the European States to protect their citizens living in or travelling to Japan, with the aim of proposing a more harmonized approach in responding to a distant emergency. The findings of this review are elaborated in Ref. [245].

3.5.4. Response of international organizations

A summary of responses[160] of relevant international organizations, based on the reports provided at the 22nd regular IACRNE meeting in December 2011 [237], follows.

3.5.4.1. Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization

The CTBTO detected the earthquake, the subsequent tsunami and the nuclear accident using all the networks of the International Monitoring System (IMS): seismic detections of the magnitude 9.0 earthquake and the subsequent ten thousand aftershocks; hydroacoustic detections showing the rupture forming under the sea; infrasound detections showing the explosions in the Fukushima Daiichi NPP; and subsequent radioactivity measurements in all the particulate and noble gas stations in the northern hemisphere and at several stations in the southern hemisphere. Atmospheric transport modelling (ATM) played an important role in predicting which stations were going to detect released radionuclides from the plant.

The CTBTO held six briefings for States Signatories, and the secure web site was used to provide data/products. Data from the CTBTO radionuclide stations (concentrations and isotopic ratios) supplied to the relevant organizations confirmed that the consequences of the event were significantly lower outside Japan and helped in the assessment of the health impact on both local and global scales.

Cooperation with the IAEA, WMO and WHO was initiated relatively early in the emergency, and the CTBTO began participation in the IACRNE videoconference meetings at the beginning of April. The CTBTO’s prompt cooperation with relevant international organizations in severe nuclear or radiological emergencies is important, in particular during the initial phase of an emergency, for an early robust assessment of the situation.

3.5.4.2. European Commission

In response to the accident [246], the European Commission (EC), DG ENER, in Luxembourg immediately activated the European Community Urgent Radiological Information Exchange (ECURIE) emergency team, which operated on a 24/7 basis for three weeks.

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[160] The summary of responses covers activities up to 1 April 2012.

Their main tasks included: ECURIE message handling, situation assessment, communication of new EC regulations, media monitoring, situation updates to Member States and other EC services, maintaining an overview of the protective actions/recommendations of ECURIE Member States, press release support to the EC spokespersons' service, support and advice to the EU Delegation in Tokyo, and general Q&A service for EC services and the European Parliament.

In Europe, very low levels of airborne radioactivity concentrations were measured. Only a few countries exchanged their measurement results through the European Radiological Data Exchange Platform (EURDEP), others opted for distribution via ECURIE channels in the form of spreadsheets, etc. The accident demonstrated the urgent need for a global environmental radiation data exchange system.

As a result of demand from European Union Member States, the EC issued non-binding guidance for criteria to be used for the measurement of ships and containers entering European harbours from the region. However, the accident demonstrated the need for harmonized measures for the radiation safety of goods and the protection of citizens.

When it appeared possible that certain foods originating from the region with radionuclide levels exceeding the relevant action levels applicable in Japan may enter the European market, the EC adopted regulations imposing special conditions governing the import of feed and food originating in or consigned from Japan.

In response to requests from Japan, the EC (DG ECHO) activated the EU Civil Protection Mechanism. Nineteen participating States offered financial assistance or in-kind support to Japan, such as protective equipment and radiation dose rate meters. Under these arrangements, a 15 person Civil Protection Assessment and Coordination Team was deployed to the site of the disaster to coordinate the distribution of assistance on the ground. The team, which included experts in logistics and radiation protection, worked with the Japanese authorities and set up the arrangements for the storage, transport and distribution of the assistance.

A key issue which arose concerning communication was how to facilitate rapid discussions among competent authorities of EU Member States in order to efficiently prepare and adopt a common European approach to challenges arising from the accident. In response, a High-Level EC Task Force was set up to follow-up the EU response to the nuclear accident.

Based upon a mandate from the European Council in March 2011, the EC, together with the European Nuclear Safety Regulators Group (ENSREG), launched EU wide comprehensive risk and safety assessments of nuclear power plants (stress tests), which included their capabilities for on-site emergency management. The mandate included a request to the EC to review the existing legal and regulatory framework for the safety of nuclear installations and to propose any improvements that may be necessary. Some of the lessons learned from the accident were expected to be taken into account during the revision of the EU Basic Safety Standards and Nuclear Safety Directives.

As part of the EU response, an inter-service group comprising EU External Action Service and EC services was formed to follow-up initiatives raised at the EU–Japan Summit of May 2011, to monitor the impact of the accident and the lessons learned, and to formulate proposals for cooperation with Japan. Proposals covered Member State activities, the supply of equipment and services, technical and scientific expertise, safety and regulatory issues, and participation in research and development programmes.

3.5.4.3. European Police Office

European Police Office (Europol), as an EU law enforcement agency which handles criminal intelligence and provides analyses in the area of serious international crime and terrorism, did not activate any general or specific response mechanism due to the accidental nature of the emergency. Also, the event fell outside the scope of Europol's competence. However, Europol officials monitored the development of the emergency through the IAEA's ENAC on a daily basis. The information received through ENAC allowed Europol to assess specific secondary but related events, such as the detection of contaminated goods at border crossings. It also made it possible for Europol to minimize the impact of speculative information by crosschecking media reports with official data.

3.5.4.4. Food and Agriculture Organization of the United Nations

FAO works in partnership with the IAEA through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (based in Vienna) in preparing for and responding to nuclear or radiological emergencies affecting food and agriculture. This includes the application of FAO capabilities as a critical counterpart in defining and implementing agricultural countermeasures and remediation strategies in response to nuclear or radiological emergencies.

FAO activities related to the Japanese nuclear emergency helped to ensure the dissemination of information on food monitoring and food restrictions, the consideration of agricultural countermeasures and remediation strategies to mitigate immediate and longer term effects arising from radionuclide contamination, and the interpretation of standards related to radiation protection of the public.

Through the Joint FAO/IAEA Division, the FAO continually staffed the FAO Desk in the IAEA's Incident and Emergency Centre.[161] It also prepared information on food contamination, monitored data and restrictions on food distribution, established a multifunctional database for the management of data submitted by the Japanese authorities, prepared and disseminated questions and answers related to food safety and the application of international standards, including the Joint FAO/WHO Codex Alimentarius Guideline Levels for Radionuclides in Foods. FAO promoted knowledge and information sharing on radioactive contamination affecting food and agriculture, including the mechanisms and persistence of such contamination, radionuclide transfer rates and international standards.

In addition, FAO was involved directly in several international missions to Japan, including participation in and follow-up to the Joint FAO/IAEA Food Safety Assessment Mission to Japan (26–31 March 2011) and the IAEA Mission on the Remediation of Large Contaminated Areas Off-Site the Fukushima Daiichi Nuclear Power Plant (7–15 October 2011) [247].

An FAO Technical Meeting on Preparedness and Response to Nuclear and Radiological Emergencies Affecting Food and Agriculture, including the Application of Agricultural Countermeasures and Remediation Strategies, was held from 14 to 18 November 2011 at FAO Headquarters in Rome. The meeting provided a detailed road map on the development of appropriate contingency planning and capacity building in response to nuclear and radiological emergencies affecting food, agriculture, fisheries and forestry, with emphasis on the development of national and international laboratory networks and infrastructures, including coordination within existing networks, and designing and conducting emergency exercises with appropriate stakeholders, including the simulation of complex events.

[161] According to the arrangements between FAO and the IAEA.

3.5.4.5. International Civil Aviation Organization

ICAO's principal role within the context of the interagency response[162] was to ensure the dissemination of information to aircraft in flight about atmospheric releases of radioactive material. ICAO convened an ad hoc Transport Task Force on 15 March 2011 to better assist transportation modal agencies respond to the accident. The Transport Task Force, led by ICAO, prepared and coordinated a number of public statements regarding travel and transport to and from Japan. ICAO and its partners had benefited greatly from the collaborative effort of the ad hoc Transport Task Force. A collaborative response and 'one voice' public information message with concerned United Nations agencies proven successful in reassuring the travelling public.

Based on the lessons learned, ICAO was urgently pursuing the fine tuning of an in-house emergency response plan (and associated emergency response centre) to coordinate its response to events like the Fukushima Daiichi accident that would impact aviation.

In addition, ICAO proposed to the IACRNE several improvements to overcome the occasional disparity and/or lack of authoritative information concerning the screening of potentially contaminated passengers and cargo.

3.5.4.6. INTERPOL

The INTERPOL CBRNE (Chemical, Biological, Radiological, Nuclear and Explosives) Sub-Directorate's strategic priorities consist of three main pillars: (1) operational data services; (2) urgent investigative support; and (3) capacity building. Despite the accidental nature of the emergency, following the accident, INTERPOL sent a message to its National Central Bureau (NCB) in Tokyo offering INTERPOL General Secretariat assistance such as disaster victim identification (DVI). However, INTERPOL's assistance was not required, and no INTERPOL staff were deployed to Japan. INTERPOL monitored the situation in Japan as well as Fukushima for any potential implications for INTERPOL.

3.5.4.7. International Labour Organization

Immediately after the Fukushima Daiichi accident, ILO prepared and put on its web site a briefing note on Radiation Safety and Protection of Workers in Nuclear and Emergency Operations. It also updated its web page on radiation protection by uploading all the publications relevant to nuclear and radiological emergencies developed either by the ILO alone or in collaboration with other international organizations. Web sites of authentic accident related information from the IAEA, WHO, the Japan Nuclear and Industrial Safety Agency, the Japan Atomic Industrial Forum, TEPCO and information on levels of radioactivity from MEXT, were also added on the ILO web site.

ILO collaborated with the WHO, IAEA, WMO, IMO, UNWTO and ICAO in the preparation of the joint public statements (news releases) on travel and transport to and from Japan in the early days of the accident.

3.5.4.8. International Maritime Organization

IMO is the specialized agency responsible for the safety and security of international shipping and the protection of the marine environment. The organization also has several arrangements in place for all manner of crises impacting the maritime domain, including radiological/nuclear incidents, both at

[162] Set out in the Joint Emergency Management Plan of the International Organizations [225].

institutional (e.g. JPLAN) and divisional (e.g. divisional emergency response) levels. The Fukushima Daiichi accident led to the activation of JPLAN and the IMO Secretariat was able to participate effectively.

Guidance to ships during emergencies such as the Fukushima Daiichi accident is issued by Navigational Area (NAVAREA) Coordinators based on the system established through the IMO. The IMO Secretariat received the guidance issued by NAVAREA Coordinators and took it into account when formulating IMO's response to the various aspects of the incident as they emerged.

The IMO Secretariat also participated in the Transport Task Force and contributed to the joint press releases providing basic guidance to air and sea passengers and crews. The opinion of the IMO is that the joint press releases clearly demonstrated their value, although this joint approach came with its own challenges of accommodating the requirements of numerous organizations and obtaining timely approval of the final versions of the releases.

3.5.4.9. OECD Nuclear Energy Agency

Within the IACRNE framework, the OECD/NEA, not being a response organization, carried out a survey to compile governmental decisions and recommendations that were made by various countries regarding their protective and other response actions (decisions regarding advice to their own citizens, their imports and exports, their industries, etc.). The survey results were consolidated into a single document, indicating the corresponding country, decision taken or recommendation made, applicable date and applicable population with three updates (the last update was posted on 21 April 2011). It was posted on the ENAC web site for official use by competent authorities.

In addition, the Committee on Radiation Protection and Public Health (CRPPH), at its meeting in May 2011, agreed on a series of actions that should be taken both to assist Japan with recovery efforts and to assist other CRPPH members to adapt their own emergency response policies and plans, as needed, to address the lessons learned. The CRPPH created the Expert Group on the Radiological Protection Aspects of the Fukushima Accident (EGRPF), which was responsible for managing the work of the CRPPH and its subgroups as it related to the Fukushima Daiichi accident. These groups agreed, among other things, to address questions from Japan, assist with the organization of the Conference on Decommissioning and Environmental Recovery, offer experience with the implication of stakeholders in consequence management and assess the implementation of the advice provided in ICRP Publication 109 [191, 248] concerning the use of reference levels and the optimization of protection strategy and emergency management lessons.

3.5.4.10. Pan American Health Organization

The PAHO Emergency Operation Centre (EOC) was activated[163] on 11 March 2011 to level 2 and stayed at that level during the first 48 hours due to the threat of tsunamis to the coastal countries in the Americas. As a result, 12 countries activated their contingency plans and four of them evacuated communities and hospitals from areas deemed to be at risk. After this early period, the EOC continued to operate at level 1, monitoring the situation mostly via ENAC, the IAEA’s emergency web site.

[163] Activation at Level 1 may be declared whenever an emergency situation can be managed primarily by the Member State and corresponding PAHO/WHO Representative Office, and requires only minimal support from PAHO Headquarters or other entities. Activation at Level 2 may be declared whenever an emergency situation occurs that requires strong regional support, especially when it involves more than one country; deployment of PAHO’s Regional Health Emergency Response Team may be required. Activation at Level 3 may be declared whenever a major emergency occurs that requires the full involvement of PAHO.

PAHO's main activities included: participating in the IACRNE teleconferences as a member organization; responding to concerns and questions from the PAHO/WHO Country Representatives and from Member States; updating and maintaining the PAHO EOC web site, including links to relevant standards and technical documents as well as to frequently asked questions in both English and Spanish; presenting the situation to PAHO's Subcommittee on Program, Budget and Administration representatives; providing information to the press and addressing press conferences; responding to questions originating from the International Health Regulations (IHR) system; disseminating information to the IHR National Focal Point of update provided by the Ministry of Health, Labour and Welfare in Japan regarding the situation of radioactive materials in tap water and food; providing comments to WHO/HQ daily talking points; and requesting Member States to take the opportunity to revise their national capacities to respond to this type of emergency.

3.5.4.11. United Nations Environment Programme

In the immediate aftermath of the Fukushima Daiichi accident, a regular line of communication along with periodic conference calls was established and maintained among the following offices of UNEP: UNEP headquarters in Nairobi; UNEP Post Conflict and Disaster Management Branch (PCDMB) in Geneva; UNEP-OCHA Joint Environment Unit (JEU) in Geneva; the secretariat of UNSCEAR; and the UNEP offices in Tokyo and Osaka.

As a member of IACRNE, UNEP was involved in interagency coordination by following the arrangements elaborated in the JPLAN. Since the Fukushima Daiichi accident, UNEP has been interested in, and has been following up, two important aspects: the non-radiological impact of the earthquake and tsunami, including waste management in particular; and the non-radiological impact of the movement of populations resulting from the earthquake and tsunami as well as from the response to the earthquake and tsunami.

3.5.4.12. United Nations Office for the Coordination of Humanitarian Affairs

OCHA was immediately alerted to the earthquake through the Global Disaster Alert and Coordination System and a Virtual On-Site Coordination Centre was activated. A United Nations Disaster Assessment and Coordination (UNDAC) team was deployed on 13 March 2011 at the request of the Government of Japan to support information management and reporting for international audiences, as well as to coordinate the deployment of international Urban Search and Rescue (USAR) teams[164]. During the emergency phase of the disaster, OCHA issued a total of 16 Humanitarian Situation Reports as well as a number of related information products, such as maps. The UNDAC team handed over to a small residual OCHA team, which left Japan on 2 April 2011, after having undertaken three humanitarian assessment missions to the affected areas. OCHA was closely involved in the follow-up and lessons learned process in Japan. The Joint Environment Unit (JEU) further supported the Secretary-General's High Level Summit on Nuclear Safety and Security in September 2012, providing inputs for the United Nations' system wide study on the implications of the accident.

3.5.4.13. United Nations Scientific Committee on the Effects of Atomic Radiation

In the event of widespread contamination of water, surface, people or commodities or of significant concern to the United Nations General Assembly or the public, the UNSCEAR Secretariat, as appropriate: establishes liaison with the IAEA, WHO and/or UNEP to coordinate a review of the levels and effects of the exposures for the General Assembly, the scientific community and/or the

[164] The issue of radiation leakage and insecurity regarding appropriate operational and safety measures to be taken had a considerable impact on humanitarian relief operations. USAR teams were requested to include radiological and nuclear experts and to have equipment for radiation detection with them.

public; liaises with the Scientific Committee and its officers; and prepares general material for public release on the levels and risks of radiation exposure.

On the 11 March 2011, first news of the event was received informally by the secretariat over the news service regarding the earthquake and tsunami, prompting them to confirm that the IEC was activated, to review material on ENAC and to stay aware of developments. Within the next 24 hours, on request from the Executive Director of UNEP, the UNSCEAR Secretariat prepared briefing material on the status and possible scenarios which were shared with relevant UNEP staff. The briefing material was updated over the weekend of 12–13 March as the situation developed, and was continued by teleconference when the UNEP coordination mechanisms were activated.

The UNSCEAR Secretariat maintained close liaison with the WHO, IAEA and UNEP on developments over the coming weeks, through video conference, teleconference and direct meetings. The UNSCEAR Secretariat coordinated with other organizations to prepare appropriate public information material to be posted on the UNSCEAR web site. The Japanese delegation to UNSCEAR proposed that the Scientific Committee conduct a two year scientific assessment of the levels and effects of the radiation exposure from the accident (similar to the one conducted after the Chernobyl accident) [249]. This proposal was accepted by the Scientific Committee in May 2011, and endorsed formally by the United Nations General Assembly in December 2011 [250]. The study involved contributions from CTBTO, FAO, IAEA, WHO and WMO [171, 251]. In addition, when the WHO launched its initiative to conduct a preliminary assessment of doses and risks [252], the UNSCEAR Secretariat acted as an observer to the relevant meetings of experts.

3.5.4.14. World Health Organization

In the Fukushima Daiichi accident, the risk of direct human exposure to radiation received priority at the WHO Headquarters, its Western-Pacific Regional Office (WPRO), and the Urban Health Emergency Management Unit at the WHO centre in Kobe, Japan. The Ministry of Health, Labour and Welfare (MHLW) notified WPRO through the IHR National Focal Point (NFP) within a few hours after the event. WHO immediately communicated the event to all the Member States in the region through the NFPs.

During the early response to the Fukushima Daiichi accident, the information needs of the WHO Member States, media, and the general public were continuously monitored and addressed. Provision of timely, consistent and accurate information to the public was one of the key components of the WHO response to the accident. Numerous information products were developed and made available, including fact-sheets, Q&As and technical briefings.

The requests from WHO Member States for advice focused mainly on the travel advisory (safety of travel to Japan and nearby areas, border control measures, screening of passengers, aircrafts, cargo and ships) and technical advice on protective actions and other response actions (evacuation, sheltering, use of potassium iodide, relocation, interpretation of monitoring data and radiation protection limits/values, safety of food and drinking water, protection of pregnant women and breastfed infants and the mental health impact of the accident and public information).

In addition, technical briefing notes related to food safety aspects and regular updates on food monitoring results were provided to WHO Member States through the International Food Safety Authorities Network (INFOSAN).

The public health risk for populations in and outside of Japan was closely monitored. The WHO Department of Mental Health provided technical assistance and advice on matters relevant to psychological impact management and developed a number of key messages and Q&As.

Jointly with relevant agencies and institutions, WHO conducted a health risk assessment (HRA) of the accident. In this context, WHO established an international expert panel to make a preliminary estimation of population radiation doses inside and outside Japan and set up an expert group to assess the radiation related health implications of the accident to support the identification of needs and priorities for public health actions.

3.5.4.15. World Meteorological Organization

WMO activated its emergency response mechanism on 11 March 2011 at the first IAEA request to provide atmospheric transport, dispersion and deposition modelling (ATM) outputs and meteorological information to designated authorities on the likely evolution of the radioactive cloud that was accidentally released from the Fukushima Daiichi NPP. The WMO's three Regional Specialized Meteorological Centres (RSMCs) in Asia (Beijing, Tokyo and Obninsk) responded immediately and issued forecast ATM charts, based on the request of a default unit release, of the dispersion of the radioactive material from the power plant according to established procedures, until they were no longer required. These RSMCs responded to nearly 50 requests for standard ATM chart production. WMO's remaining five RSMCs in other parts of the world also prepared ATM charts for inter-comparison and validation purposes, and responded to requests from countries in their respective regions. The WMO Secretariat closely coordinated the overall real time response carried out by the RSMCs with the IAEA, ICAO and WHO.

Numerous specialized (non-standard) requests were also made by the IAEA to refine and apply a best estimate source sequence for ATM calculations. Simulations were performed on high resolution (5 km grid mesh) and medium resolution (50 km grid mesh) to estimate the atmospheric spreading in the immediate region, and for greater distances (trans-North Pacific), respectively.

WMO made immediate arrangements with the National Meteorological Service of Austria (ZAMG) to provide 24/7 expert meteorological and ATM support to the IAEA on-site at the IEC. Similar arrangements were made with MeteoSwiss (Switzerland) to provide an expert to the WHO in Geneva.

WMO RSMCs also responded to CTBTO ATM-backtracking requests starting on 18 March 2011, under operational arrangements established as of 1 September 2008. In total, there were 44 requests (for 422 samples).

A WMO task team on meteorological analyses for the Fukushima Daiichi NPP accident was formed in late 2011 to develop a series of meteorological analyses in numerical form, using as much observational data and related information as available, which would be suitable for estimating the atmospheric transport, dispersion and deposition of radioactivity released from the Fukushima Daiichi NPP in 2011. National Meteorological and Hydrological Services/RSMCs of Austria, Canada, Japan, the United Kingdom and the United States of America participated in this task team. Representatives from the European Commission Joint Research Centre (Ispra, Italy) were later invited to participate in the data analysis phase of the effort. The work of this task team has been completed, and the report has been published [253]. This work contributed to the post-accident study undertaken by UNSCEAR on the levels and effects of radiation released from the accident.

3.5.5. Provision of international assistance

Provision of international assistance can be based on the Assistance Convention, bilateral or multilateral agreements among States or ad hoc arrangements between the Accident State and assisting State(s) prepared and agreed upon during an emergency. In case of the accident in Japan the latter two possibilities were used.

An offer of assistance by the IAEA[165] was sent to NISA and the Permanent Mission of Japan to the International Organizations in Vienna at 07:48 UTC on 11 March 2011. A second offer of assistance was sent on 12 March at 12:39 UTC.

On 12 March 2011, the IEC sent a communication to all Member States registered under the Response and Assistance Network (RANET) asking about the current status of their capabilities regarding the provision of specialized assistance to Japan, should Japan request it.

Throughout the emergency, the IEC received offers of assistance to Japan from Member States (Argentina, Australia, Belgium, Canada, China, Czech Republic, Finland, France, Germany, Hungary, India, Indonesia, Islamic Republic of Iran, Israel, Kazakhstan, Republic of Korea, Mexico, Pakistan, Russian Federation, Spain, Sweden and the United States of America), the European Commission, international organizations and individuals. Copies of the official offers from Member States were published on the ENAC web site and provided to the Government of Japan [232].

As of 15 September 2011, 163 countries and 43 international organizations offered to provide equipment and materials necessary for stabilizing the units (e.g. pumps, fire engines) and for evacuating the local population [254]. While some countries and organizations provided equipment (e.g. survey meters and personal dosimeters) and expertise, others responded with humanitarian aid for residents affected by the earthquake and tsunami.

The United States of America was a major contributor to international assistance, both of a humanitarian nature and in relation to the nuclear accident, owing to the presence in Japan of about 25 000 US troops, bilateral agreements between the United States of America and Japan and a formal request for assistance from the Japanese Government on 11 March 2011. Initial activities included atmospheric plume modelling, conducted by the National Atmospheric Release Advisory Center (NARAC), and deployment of a DOE radiological response team to carry out aerial and ground based monitoring in Japan. On 17 March 2011, initial aerial radiological survey measurements were taken over the Fukushima Daiichi NPP, and the first compilation of results was publicly released on the DOE web site on 22 March 2011[166]. The ground measurements conducted included basic dose rate measurements, air and soil sample analyses and in situ gamma spectroscopy.[167] The data and map products were shared with the Government of Japan on an ongoing basis. The products went directly to the Ministry of Foreign Affairs; the Ministry of Agriculture, Forestry, and Fisheries; and the Ministry of Education, Culture, Sports, Science and Technology.[168] The DOE team remained in Japan through 28 May 2011 [255].

Much of the assistance from countries in the EU was, at the request of the Japanese Government, coordinated through the EC's Monitoring and Information Centre [256, 257].[169]

The Japanese Government received offers of assistance directly from countries via the Ministry of Foreign Affairs, with NISA coordinating the delivery of equipment and materials [27]. Initially, there was some confusion over the procedures for receiving assistance, as they had not been defined in the arrangements established prior to the accident. It proved difficult to identify actual needs or to obtain relevant information, including the specification, number and delivery times of equipment and

[165] Referred to formally as 'the offer of the IAEA's good offices'.

[166] Aerial surveys were conducted for the next two and a half months.

[167] Using high purity germanium (HPGe) detectors.

[168] This collaboration was described in a joint press release issued 6 May 2011.

[169] Renamed the EC's Emergency Response Coordination Centre (ERCC) on 15 May 2013 [258].

materials. Storage places were also not secured promptly, and there were insufficient numbers of officials available to handle the process. However, the situation improved in April 2011 [27].

The Japanese Government declined offers of equipment that required training before it could be used or equipment and supplies of which Japan had sufficient stock (e.g. stable iodine). In some cases, delays incurred because it took time to identify individuals who could operate specific equipment.

Many experts visited Japan from China, France, the Republic of Korea, the Russian Federation, the United Kingdom and the United States of America to discuss relevant issues and potential assistance with Japanese Government agencies and TEPCO [22]. Japan received advice on the stabilization of the reactors and spent fuel pools, prevention of dispersion of radioactive materials and measures to cope with the accumulation of radioactive water. US organizations and agencies with expertise and capabilities in radiation survey mobilized quickly and offered critical assistance. In addition to governmental assistance, the United States nuclear industry immediately offered private sector assistance by sending supplies, technology and an industry support team comprised of nuclear engineers and other experts to lend technical expertise. Radiation specialists from the Department of Energy took hundreds of radiation readings and collected soil samples in the region [255]. The Korea Atomic Energy Research Institute (KAERI) and the Korea Institute of Nuclear Safety (KINS) also provided technical support [254, 259]. In addition, assistance in equipment and transport was provided by the United States Army and the Royal Australian Air Force [254].

Furthermore, teams put together by the multinational nuclear industry organizations composed of representatives from vendors and electricity utilities also provided technical assistance. These included the World Association of Nuclear Operators (WANO), Institute of Nuclear Power Operations (INPO) and Electric Power Research Institute (EPRI). Private companies such as Exelon Corp., AREVA, Bechtel Corp., GE Hitachi Nuclear Energy, The Shaw Group, Westinghouse Electric provided support for assessment and issue resolution at the accident site [260].

The Assistance Convention was not invoked and RANET was not utilized. In spite of this, some lessons to be taken into account for the further enhancement of RANET were identified. This was extensively discussed at the meeting on the extension of RANET capabilities held from 31 January to 2 February 2012 in Vienna. In addition to RANET registered Member States, a number of States Parties to the Assistance Convention having nuclear power programmes, selected on the basis of regional distribution and the development of their programmes, were invited. On the basis of lessons learned from the accident, Japan made a proposal to extend RANET capabilities with the functional area of 'stabilization of situations at accident sites' and to enable the registration of equipment with detailed specifications, even from private entities [261].[170]

3.5.6. Summary

An extensive international emergency preparedness and response (EPR) framework existed at the time of the accident, consisting of international legal instruments, IAEA safety standards and operational arrangements. While international legal instruments are binding for the parties, IAEA safety standards can be adopted in national practice at the State's discretion.

At the time of the accident, the IAEA had four roles in the response to a nuclear or radiological emergency: (1) notification and exchange of official information through officially designated contact points; (2) provision of timely, clear and understandable information; (3) provision and facilitation of international assistance on request; and (4) coordination of the interagency response.

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[170] The proposal was partially implemented in the revised RANET manual [262].

The IAEA's role at the time did not include providing a prognosis of the potential evolution of an accident or an assessment of the possible consequences. This role in responding to an emergency at an NPP was expanded through the adoption of the IAEA Action Plan on Nuclear Safety.

The international response to the accident involved many States and a number of international organizations.

The IAEA liaised with the official contact point in Japan, shared information on the emergency as it developed, and kept States, relevant international organizations and the public informed. Communication with the official contact point in Japan in the early phase of the emergency response was difficult. The IAEA Director General's visit to Japan, and the subsequent deployment of liaison officers in Tokyo, improved communication between the IAEA and the contact point.

In addition, according to the Emergency Notification and Assistance Technical Operations Manual (ENATOM), States were expected to notify and share information with the Incident and Emergency Centre (IEC) using appropriate reporting forms, which were intended to assist the IEC contact point in the rapid sharing of relevant information. However, in its communications with the IEC at an early stage of the accident, Nuclear and Industrial Safety Agency (NISA) did not seem to have been as familiar with the ENATOM arrangements as would have been practical.

The Nuclear Emergency Response Headquarters (NERHQ) and the Ministry of Health, Labour and Welfare (MHLW) were among the key organizations/entities in the response for Japan. They were not official contact points for the IEC.

Some States issued advice or a specific instruction for the protection of their nationals in Japan. Some advised their nationals in Japan to follow the orders and recommendations issued by the Japanese authorities in response to the emergency, while some States issued advice that differed from that provided by the Japanese authorities and other States [235]. Differences in the recommendations among States were due to various factors, including a lack of information on the evolving situation. These differences were generally not well explained to the public and occasionally caused confusion and concern.

The IAEA sent expert missions to Japan and coordinated the provision of Member State offers of assistance to Japan. The Assistance Convention was not invoked and RANET was not utilized. States provided assistance to Japan directly. This support helped the Government of Japan to manage the nuclear emergency which, together with the effects of the earthquake and tsunami, challenged national response capabilities. One of the difficulties in accepting international assistance in the early stages of the national response was the absence of national arrangements for receiving such assistance [21, 232].

In accordance with its responsibilities, the IAEA Secretariat promptly activated JPLAN and initiated coordination of the interagency response. Members of IACRNE exchanged information, focusing in particular on reaching a common understanding of the aftermath of the accident, and coordinating efforts to keep the public informed. Regular video teleconferences were held until July 2011. Joint press releases were also issued.

As part of the bilateral agreements between the respective secretariats, FAO, WHO and the WMO sent liaison officers to the IAEA to ensure effective coordination of the international response.

The existence of the IACRNE, and its Joint Plan, demonstrated that there was already a well established interagency mechanism in place to provide coordination and facilitate clarity with regard to the roles and capabilities of the participating international organizations in preparing for and responding to nuclear or radiological emergencies. These interagency response coordination mechanisms proved to be efficient; however, areas for further improvement in arrangements were also identified.

3.5.7. Observations and lessons

- **The implementation of international arrangements for notification and assistance needs to be strengthened.**
  Awareness of international arrangements for notification and assistance in a nuclear or radiological emergency, as well as existing operational mechanisms, needs to be increased, including mechanisms and procedures for notification and information exchange, for requesting and providing international assistance, etc. There is a need for enhanced training and exercises on the operational aspects of the Early Notification Convention and the Assistance Convention.
  Participation in existing mechanisms for the provision of international assistance under the Assistance Convention needs to be an integral part of national emergency preparedness efforts.
  Arrangements need to be in place at the preparedness stage for requesting and receiving assistance (on the basis of bilateral agreements or under the Assistance Convention) in a nuclear or radiological emergency.
  Lists of officially designated contact points, as required under the Early Notification Convention and the Assistance Convention, need to be continuously updated and prepared for immediate requests for information from the IAEA.
  Application of the IAEA safety standards on emergency preparedness and response at the national level would improve preparedness and response, facilitate communication in an emergency and contribute to the harmonization of national criteria for protective actions and other response actions.
- **There is a need to improve consultation and sharing of information among States on protective actions and other response actions.**
  Consultation and sharing of information on protective actions and other response actions among States in an emergency helps to ensure that actions are taken consistently. In addition, a clear and understandable explanation of the technical basis for decisions on protective actions and other response action is crucial in order to increase public understanding and acceptance at both the national and international levels.
- **There is a need for the IAEA Secretariat to provide States, international organizations and the public with timely, clear, factually correct, objective and easily understandable information during the nuclear emergency on its potential radiological consequences and the prognosis of possible emergency progression.**
- **There is a need for continuous enhancements and exercising of the inter-agency coordination mechanism in the EPR area, and for further strengthening the role of the IACRNE.**

APPENDIX I.
KEY DOCUMENTS AND ELEMENTS THAT DEFINED THE NATIONAL EPR SYSTEM FOR RESPONSE TO A NUCLEAR EMERGENCY IN JAPAN PRIOR TO THE ACCIDENT

This appendix describes[171] the basic documents and elements of the emergency preparedness and response (EPR) system in Japan as they were prior to the accident at the Fukushima Daiichi NPP, including: (a) key documents that defined the national EPR system for response to a nuclear emergency in Japan; and (b) key entities.

Information provided in this appendix is focused on elements relevant to response to an emergency at an NPP. Particular emphasis is placed on EPR aspects related to the Fukushima Daiichi NPP and nearby areas off-site.

I.1. RELEVANT DOCUMENTS

The primary legal basis for the national emergency preparedness and response system in Japan was set out in the Disaster Countermeasures Basic Act [6] and the Act on Special Measures Concerning Nuclear Emergency Preparedness [5] (see Fig. I.1). These and other documents are further described in Table I.1.

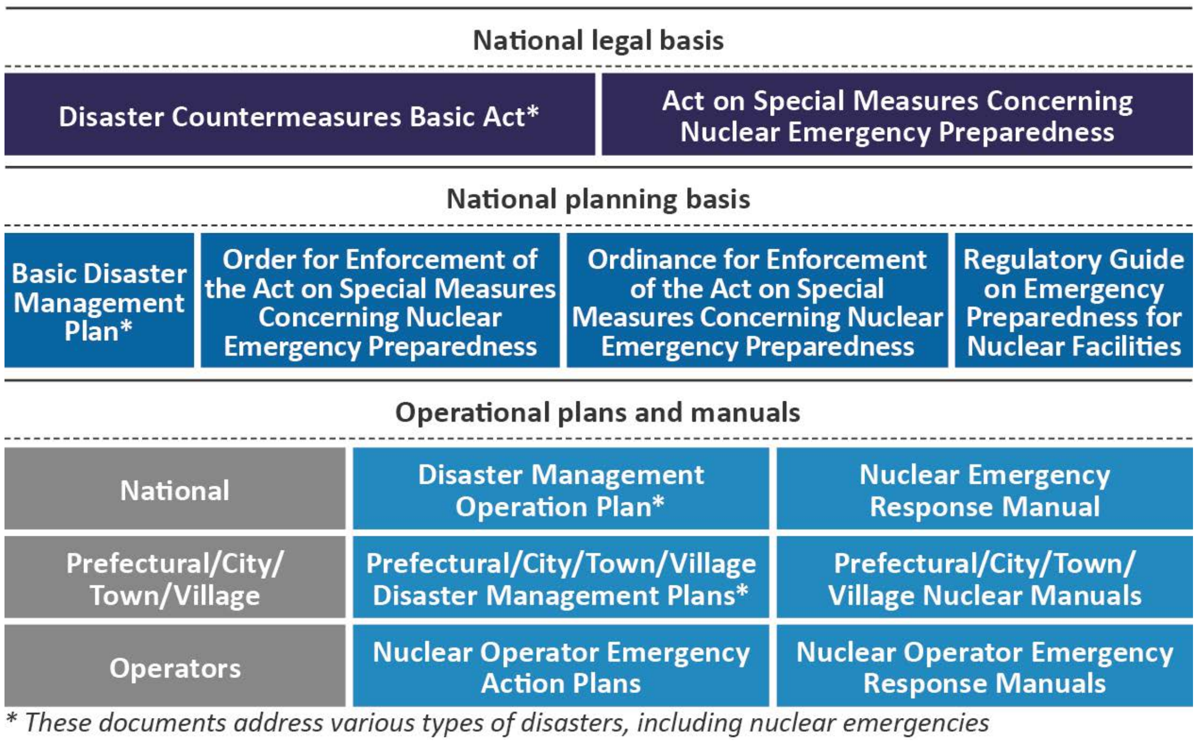

FIG. I.1. Key documents defining the national emergency preparedness and response system for a nuclear emergency in Japan at the time of the accident.

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[171] This appendix uses consistent terms in presenting the titles of the various documents and, in most cases, does not use quotes from the various translations of documents, which in some cases used different terms for the same elements of the EPR system in Japan.

The first tier of documents shown in Fig. I.1 [9] and Table I.1 provided the primary legal basis for the national EPR system, which is set out in the Disaster Countermeasures Basic Act (Basic Act) [6] and the Act on Special Measures Concerning Nuclear Emergency Preparedness (Nuclear Emergency Act) [5]. The second tier shown in Fig. I.1 and Table I.1 lists the key planning basis documents. The Basic Disaster Management Plan (Basic Plan) [2] described the roles and responsibilities and other crucial elements of the EPR system. The Cabinet Order and Ministerial Ordinance on Special Measures Concerning Nuclear Emergency Preparedness [7, 10] provided the plant criteria for determining when off-site notifications for events at an NPP are warranted. The Regulatory Guide on Emergency Preparedness for Nuclear Facilities (Nuclear Emergency Preparedness Guide) provided general technical guidelines on matters such as the distances (radius) for emergency planning zones (EPZ), projected doses at which various protective actions were warranted, activity concentrations at which food and drink restrictions were to be implemented and the dose limits for emergency workers. The third tier lists the operational documents that were intended for use in responding to an emergency at the national, local and operator levels. The Nuclear Emergency Response Manual [8] described the procedures to be implemented by the relevant national Government ministries and agencies in the event of an emergency at an NPP to include notification and decision making.

TABLE I.1. DESCRIPTIONS OF THE KEY EPR DOCUMENTS THAT DEFINED THE NATIONAL EPR SYSTEM FOR RESPONSE TO A NUCLEAR EMERGENCY IN JAPAN PRIOR TO THE ACCIDENT

Document title (Short title in parentheses)	Description
Disaster Counter-measures Basic Act (Basic Act) [a] [6]	Represented the legal basis for the prevention of and response to disasters. It was general in scope and covered all types of disasters. It defined the roles and responsibilities of national Government ministries, local governments and designated public corporations (e.g. Nippon Hoso Kyokai (NHK), Japanese Red Cross Society, Nippon Telegraph and Telephone (NTT), etc.). It provided for the formulation of disaster prevention plans and basic policies related to preventive and emergency response measures. It defined a hierarchy of the emergency plans for all types of disasters in the following way: Basic Disaster Management Plan, Operational Disaster Management Plan, and Prefectural/City/Town/Village Disaster Management Plans.
Act on Special Measures Concerning Nuclear Emergency Preparedness (Nuclear Emergency Act) [a,b] [5]	Provided description of the responsibilities of the NPP operator, national and local governments in response to a nuclear emergency. For national and local governments it outlined their responsibilities upon notification to include those of the Prime Minister. It also outlined the response actions to be taken by national and local governments upon declaration of a nuclear emergency under Article 15 to include: (a) implementation of response actions; establishment of Nuclear Emergency Response Headquarters (NERHQ) and Local Nuclear Emergency Response Headquarters (Local NERHQ); and (b) establishment of a Joint Council for Nuclear Emergency Response (JCNER). For the operators, it outlined their responsibilities for response actions during an emergency to include: (a) notification under Articles 10 and 15[b] of this Act; (b) development of a Nuclear Operator Emergency Action Plan; (c) establishment of the on-site organization for emergency response; (d) appointment and responsibilities of a Nuclear Emergency Preparedness Manager; (e) designation of an Off-Site Centre (OFC[172]); and (f) other actions to be taken by the operator. It also described coordination and cooperation among relevant organizations, plans for emergency drills, restoration from an emergency, etc.

[172] The OFC was to be established within a 20 km radius of an NPP [8]. For the Fukushima Daiichi NPP and Fukushima Daini NPP, it was to be established within 5 km of the Fukushima Daiichi NPP. Every OFC had to have the necessary facilities and equipment to communicate with the Prime Minister's Office, the METI/NISA-ERC and relevant national and local governments. It was also to be equipped with the means to monitor environmental radiation levels and the status of nuclear installations, as well as with connection to SPEEDI.

TABLE I.1. DESCRIPTIONS OF THE KEY EPR DOCUMENTS THAT DEFINED THE NATIONAL EPR SYSTEM FOR RESPONSE TO A NUCLEAR EMERGENCY IN JAPAN PRIOR TO THE ACCIDENT (cont.)

Document title (Short title in parentheses)	Description
Basic Disaster Management Plan (Basic Plan)[a] [2]	Developed as required by the Basic Act. It covered all types of disasters. One chapter was on the response to nuclear emergencies, which described the responsibilities of the facility operator and national and local governments concerning the major aspects of a response to a nuclear emergency, including: (a) notification, (b) declaration of a nuclear emergency under Article 15, (c) determination of appropriate protective actions and their implementation, (d) the role of the Prime Minister and local officials in issuing recommendations for protective actions, (e) implementation of public protective actions, (f) protection of emergency workers, (g) public communication, including provision of information to the specific groups of population and foreign embassies in Tokyo, (h) coordination of response activities and (i) communications between response Headquarters and Centres. It formed the basis for nuclear emergency management arrangements according to the emergency phases as well as recovery and rehabilitation. It requested response manuals to be developed. The Basic Plan was prepared by the Central Disaster Prevention Council (reporting to the Prime Minister); the Prefectural Disaster Management Plans were prepared by the Disaster Prevention Council at Prefectural level and reported to the Prime Minister; the Local (Prefectural/City/Town/Village) Disaster Management Plans were prepared by the Disaster Prevention Council at local level and reported to the Governor of the Prefecture [26].
Order for Enforcement of the Act on Special Measures Concerning Nuclear Emergency Preparedness and Ordinance for Enforcement of the Act on Special Measures Concerning Nuclear Emergency Preparedness (Cabinet Order and Ministerial Ordinance)[b,c] [7, 10].	Provided details for implementation of the Nuclear Emergency Act, including criteria for identification of events warranting off-site notification by an NPP in accordance with Article 10 and Article 15 of the Nuclear Emergency Act [5].
Regulatory Guide on Emergency Preparedness for Nuclear Facilities (Nuclear Emergency Preparedness Guide)[a] [19]	Provided guidelines for specialized and technical matters related to protective actions that the national Government, local governments and operators should follow when formulating operational plans, implementing protective actions in case of emergency, etc. These topics included the nature of radioactive releases, effectiveness of various protective actions, information of residents, training of emergency workers, response facilities including the OFC, and documentation. It also provided detailed guidance on: (a) concept and sizes of the emergency planning zone (EPZ), (b) projected dose criteria for the implementation of sheltering, evacuation and iodine thyroid blocking (ITB), (c) dose limits for emergency workers, (d) radionuclide activity concentrations criteria for restrictions of food and drink, (e) emergency environmental radiation monitoring and (f) emergency exposure medical treatment. It also provided technical guidance on training and drills.
Disaster Management Operation Plan[a] [6]	Required by the Basic Act. It covered all types of disasters. Each relevant national governmental ministry, agency and designated public corporation had such a plan, which contained a chapter describing their response in a nuclear emergency.
Nuclear Emergency Response Manual [8] (NER Manual)[a]	Required by the Basic Plan [2]. It described the coordination of the national response actions for the relevant national ministries and agencies once a notification has been made by an NPP under Article 10 of the Nuclear Emergency Act [5]. It also described the actions taken if an event is considered a nuclear emergency under the Article 15 of the Nuclear Emergency Act. Specified arrangements for nuclear emergency drills.

TABLE I.1. DESCRIPTIONS OF THE KEY EPR DOCUMENTS THAT DEFINED THE NATIONAL EPR SYSTEM FOR RESPONSE TO A NUCLEAR EMERGENCY IN JAPAN PRIOR TO THE ACCIDENT (cont.)

Document title (Short title in parentheses)	Description
Prefectural/ City/Town/ Village Disaster Management Plans[a] [6]	Required by the Basic Act. The plans covered all types of disasters. One chapter dealt with the response to nuclear emergencies, which provided guidance for the local governments during the response to the emergency and included: (a) notifications; (b) description of protective actions to include the role of the Prime Minister and local officials; (c) implementation of public protective actions; (d) protection of emergency workers; (e) public communications; (f) environmental radiation monitoring; and (g) the system to coordinate response activities and communications among response organizations.
Prefectural/City/Town/ Village Nuclear Manuals [1][d]	Required by the Prefectural/City/Town/Village Disaster Management Plans. They contained details concerning the response actions of Prefectures and cities/towns/villages in case of a nuclear emergency (the tasks of each emergency staff member, criteria and procedures were specified).
Nuclear Operator Emergency Action Plan (EAP)[a] [16]	Required by the Nuclear Emergency Act [5]. The table of contents along with criteria for its approval were defined in the Ordinance for Enforcement of the Nuclear Emergency Act. Developed by the operator of the NPP and contained a description of the operator measures to prevent and respond to a nuclear emergency; and activities at the preparedness stage (e.g. preparations for liaison and coordination and details of implementation of drills and exercises). Needed to be reviewed every year and revised if revisions were found to be necessary. The plan needed to be submitted to Minister of the Ministry of Economy, Trade and Industry (METI/NISA) which could require modifications if deemed necessary. A senior Specialist for Nuclear Emergency Preparedness could provide guidance and advice concerning its preparation. The operator was also required to confer in advance with the local and neighbouring city/town/village governments and inform them of the content of the plan. The operator, when it had prepared or revised an EAP, promptly notified the competent minister and made an overview of the plan publicly available.
Nuclear Operator Emergency Response Manual [263]	Required by the Nuclear Operator Emergency Action Plan. It contained details of the response by the operator to a nuclear emergency in accordance with the Nuclear Operator Emergency Action Plan.

[a] Other titles of the documents used in various Japanese documents translated into English include:

- For Disaster Countermeasures Basic Act — Basic Act, Disaster Countermeasures Basic Law [21], the Basic Act on Disaster Control Measures [9, 22].
- For Act on Special Measures Concerning Nuclear Emergency Preparedness — Nuclear Emergency Act, Nuclear Emergency Preparedness Act.
- For Basic Disaster Management Plan — Basic Plan, Basic Disaster Management Plan [2] Basic Plan for Emergency Preparedness [21, 22, 25].
- For Regulatory Guide on Emergency Preparedness for Nuclear Facilities - Nuclear Emergency Preparedness Guide.
- For Nuclear Emergency Response Manual — NER Manual [21, 25].
- For Disaster Management Operation Plan — Operational disaster prevention plan of a designated administrative organ [6], Operational disaster prevention plans of designated public corporations [6], Operation Disaster Management Plan.
- For Prefectural/City/Town/Village Disaster Management Plans — Prefectural Disaster Prevention Plan; Prefectural/City/Town/Village area disaster prevention plan [6]; City, Prefectural/City/Town/Village disaster prevention plan for a designated area [6].
- For Nuclear Operator Emergency Action Plan (EAP) — Nuclear Licensee Emergency Action Plan, NPP Operator Nuclear Emergency Action Plan.

[b] The criteria for notification under Articles 10 and 15 for an event at an NPP are contained in the Nuclear Emergency Act, the Cabinet Order and Ministerial Ordinance.

[c] The Nuclear Emergency Act requires a Cabinet Order to formulate the details, while a Cabinet Order requires a Ministerial Ordinance to formulate further details on the subject.

[d] This reference is provided as an example of a Prefectural Disaster Management Plan that would require the development of a Nuclear Manual.

I.2. MAIN ENTITITES IN THE EPR SYSTEM IN JAPAN

Table I.2 lists the main entities[173] within the EPR system in Japan that had to play key roles during the response to a nuclear emergency. It also summarizes their main roles as defined before the Fukushima Daiichi NPP accident and their planned locations, as appropriate. Figure I.2 shows the planned locations of the entities.

TABLE I.2. MAIN ENTITIES INVOLVED IN EPR SYSTEM

Entity	Summary of key EPR roles during a nuclear emergency and location of the entity
In Tokyo	
Prime Minister and Prime Minister's general support	Directs the response to any emergency as the Director General of the: Emergency Disaster Response Headquarters (for the response to non-nuclear emergencies). Nuclear Emergency Response Headquarters (NERHQ) (for the response to nuclear emergencies). In the case of an accident to the PM, a Minister of State designated by the Prime Minister in advance shall serve in this capacity. The Prime Minister is supported by an Emergency Operations Team composed of Director General level members from relevant government ministries and agencies that may meet in the event of any emergency to gather information and coordinate between related government ministries and agencies in support of the Prime Minister [25]. They are located in the Crisis Management Centre in the basement of the Prime Minister's Office in Tokyo.
Nuclear Emergency Response Headquarters (NERHQ)	Directs and provides comprehensive coordination of the national response to a nuclear emergency. Composed of those appointed by the Prime Minister from among the officials of the Cabinet Secretariat and designated administrative organs [5]. The Prime Minister serves as the Director General of the NERHQ. Located in the Prime Minister's Office.
Nuclear Emergency Response Headquarters (NERHQ) Secretariat	Plans and coordinates responses to the accident as directed by the NERHQ including collection of information on NPP status and monitoring results. Performs the key role in the national Government's response to include preparing and sending evacuation orders to the local government. Staffed by representatives from key organizations and headed by the Director General of NISA. Located in the METI/NISA-ERC in the METI building.
Nuclear Safety Commission (NSC)	Acts as an expert body on nuclear power and nuclear emergency preparedness activities and provides technical advice at the national and local level during an emergency (e.g. provides advice to the Director General of the NERHQ or the Prime Minister regarding Article 10 and 15 events) [5, 25]. Convenes an Emergency Technical Advisory Body within its secretariat upon receipt of a report on the notification of an occurrence of a specific event from METI, and provides advice to the Director General of the NERHQ or the Prime Minister to include on Articles 10 and 15 events and protective measures. Establishes an Emergency Technical Advisory Body at the OFC.
Ministry of Economy, Trade and Industry (METI)/Nuclear and Industrial Safety Agency (NISA)	Assesses the reports sent by an NPP under Article 10 or Article 15 of the Nuclear Emegency Act [5] and advises whether or not a declaration of a nuclear emergency is warranted, and relays relevant information to the PM's Cabinet Secretariat, NSC, MEXT, the Cabinet Office, concerned local governments, and the police headquarters of the concerned prefectures. If a declaration of nuclear emergency is warranted, prepares a draft public notice, which would be sent to the Cabinet Secretariat located in the Prime Minister's Office and Cabinet Office for consideration by the Prime Minister [2]. Provides the secretariat for the NERHQ with the Director General of METI/NISA as the Head of the secretariat. METI/NISA receives technical support from different bodies, such as the Japan Nuclear Energy Safety Organization (JNES).

[173] An individual or an organization.

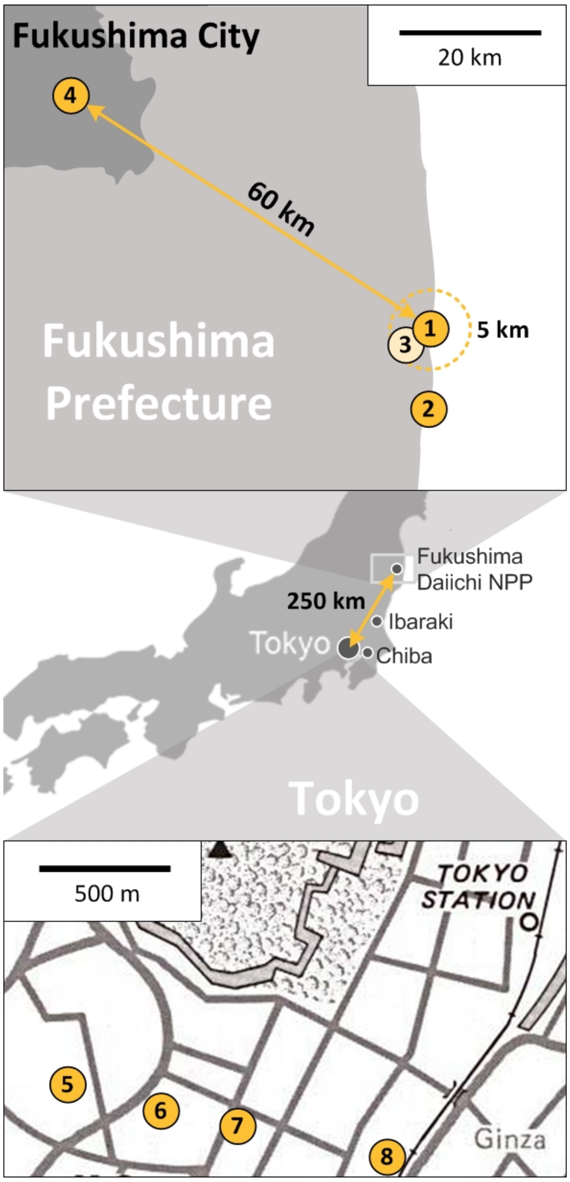
TABLE I.2. MAIN ENTITIES INVOLVED IN EPR SYSTEM (cont.)

Entity	Summary of key EPR roles during a nuclear emergency and location of the entity
In Tokyo	
Ministry of Education, Culture, Sports, Science and Technology (MEXT)	Provides support in environmental monitoring and prediction of off-site consequences (e.g. doses to the public) from the possible releases of radioactivity and environmental monitoring, using the System for Prediction of Environmental Emergency Dose Information (SPEEDI) [2]. Mobilizes emergency monitoring personnel and equipment to the site to provide support for the emergency monitoring activities.
Ministry of Health, Labour and Welfare (MHLW)	Conducts medical treatment for those suffering from emergency exposure, carries out dose evaluations of workers, ensures safety of food and water supplies, including setting intervention levels, setting of screening levels for public monitoring and setting of dose limits for personnel working for private companies [2]. Within OFC, reports implementation state of restriction of food and drink, reports state of shipment restriction of food and state of safety checks of agricultural, forestry, livestock and fishery products [2, 8].
Ministry of Agriculture, Forestry and Fisheries (MAFF)	Within OFC, reports implementation state of restriction of food and drink, reports state of shipment restriction of food and state of safety checks of agricultural, forestry, livestock and fishery products [2, 8]. Implements economic measures (e.g. monitor commodity prices of the bare necessities).
Ministry of the Environment (MOE)	Supports environmental monitoring [2, 8].
Japan Nuclear Energy Safety Organization (JNES)	Monitors conditions at the NPP and attempts to predict the timing, rate and composition of possible releases of radioactive material from the NPP (i.e. source term), based on plant conditions provided by the operator and using the Emergency Response Support System (ERSS).
Japan Meteorological Agency (JMA)	Provides the JCNER and other relevant bodies with meteorological information necessary for analysing radiological consequences and support of response actions.
Ministry of Defense (Self-Defense Force (SDF))	Provides general support of response operations to include transporting equipment, evacuation support, rescue and first aid and support of environmental monitoring [2].
TEPCO	Licensee of the Fukushima Daiichi NPP. TEPCO has a Licensee Headquarters Emergency Operations Centre, located at Headquarters, which was fitted with a dedicated communications link to the NPP-ERC. The Centre, led by TEPCO's President, conducts support activities for the NPP-ERC, such as by providing of staff or materials and equipment, and communicates information to the national Government and other organizations. Headquarters is located in Tokyo.
In Fukushima Prefecture	
Joint Council for Nuclear Emergency Response (JCNER)	Shares information and coordinates national and local activities to include implementing of protective actions. Consists of representatives from the national and local governments and operator [2, 5]. It was planned to be located at the OFC.
Local Nuclear Emergency Response Headquarters (Local NERHQ)	Once fully established, the Prime Minister may formally delegate, all or part of his/her authority to direct parts of the national response to the Local NERHQ, including the issuance of evacuation orders (see p.20 [8]). Local NERHQ was also responsible for organizing the JCNER. It was to be staffed with individuals from all relevant organizations, with the METI Senior Vice Minister as Director General. It was planned to be located at the OFC.

TABLE I.2. MAIN ENTITIES INVOLVED IN EPR SYSTEM (cont.)

Entity	Summary of key EPR roles during a nuclear emergency and location of the entity
In Fukushima Prefecture	
Local Prefectural Nuclear Emergency Response Headquarters (Local Prefectural NERHQ)	Had a liaison role by representing and providing information to the Prefectural Government. Various activities were to be carried out by this entity, including those related to: attendance at the local accident response liaison conference and the JCNER, assistance for dispatching personnel to functional teams and their activities, communication and coordination with the emergency response headquarters, the national Government, affected city/town/village and local emergency related organizations, among others [1]. It was planned to be located at the OFC.
Prefecture Headquarters for Disaster Control (for natural disaster or nuclear emergency)	Manages prefectural response to a natural disaster or nuclear emergency. The Prefectural Governor was planned to be its Director General. The Prefectural Disaster Management Plan included chapters on the response to natural disasters (e.g. earthquakes) or a nuclear emergency. The plan was formulated on the presumption that a natural disaster or nuclear emergency would not take place at the same time. Has nine squads within its structure: general affairs, information gathering, communications, public relations, external affairs, activity support, aid, supplies, and resident evacuation and safety (same nine functional squads described in the chapter on the response to a natural disaster or nuclear emergency) [25]. It was planned to be located at the Fukushima Prefectural Government Office. Municipalities Headquarters are located in the various cities, towns and villages in Fukushima Prefecture (not shown in Fig. I.2 for simplicity). Various activities were to be carried out by this entity, which included those related to: integration of emergency response measures, organizational structure and staffing of the Local Prefectural NERHQ, collection of disaster related information, determination and implementation of emergency response measures, among others [1].
Operator/Nuclear Emergency Preparedness Manager	Notifies off-site officials, protects those located on-site, takes actions to prevent the expansion of, and to mitigate, the accident. Provides data on the status of NPP to METI [5].
In other locations in Japan	
Japan Atomic Energy Agency (JAEA)	Nuclear research organization. It has a Nuclear Emergency Assistance and Training Centre (NEAT), which provides technical support to the OFC and provides JCNER with technical advice and information; it also performs dispatch of specialists, supply of emergency equipment and support for monitoring [2]. At the preparedness stage, NEAT conducts training on emergency response for various categories of emergency workers involved in off-site response [2, 27]. Located in Ibaraki Prefecture.
National Institute of Radiological Sciences (NIRS)	Provides technical support on activities such as emergency monitoring, medical support, etc. Designated as the tertiary level of radiation emergency hospital by the national Government to provide specialized medical treatment for those overexposed and/or contaminated, as well as physical and biological dose assessments. Also, designated as the national centre of radiation emergency medicine in Japan. Located in Chiba (approximately 40 km from Tokyo).

The locations of the core entities are shown in Fig. I.2.



1. FUKUSHIMA DAIICHI NUCLEAR POWER PLANT
- On-site – Emergency Response Centre at the NPP

2. FUKUSHIMA DAINI NUCLEAR POWER PLANT
- On-site – Emergency Response Centre at the NPP

3. OFF-SITE CENTRE
- Local NERHQ – Local Nuclear Emergency Response Headquarters
- JCNER – Joint Council for Nuclear Emergency Response
- Local Prefectural NERHQ – Local Prefectural Nuclear Emergency Response Headquarters

4. FUKUSHIMA PREFECTURAL GOVERNMENT OFFICE
- Fukushima Prefecture Headquarters for Disaster Control

KEY ENTITIES IN VARIOUS LOCATIONS IN JAPAN

Tokyo
- JNES – Japan Nuclear Energy Safety Organization
- MEXT – Ministry of Education, Culture, Sports, Science and Technology
- MHLW – Ministry of Health, Labour and Welfare
- MAFF – Ministry of Agriculture, Forestry and Fisheries
- MOE – Ministry of the Environment
- MOD (SDF) – Ministry of Defense (Self-Defense Forces)
- JMA – Japan Meteorological Agency

Ibaraki
- JAEA – Japan Atomic Energy Agency

Chiba
- NIRS – National Institute of Radiological Sciences

5. PRIME MINISTER'S OFFICE
- Prime Minister and general support staff
- NERHQ – Nuclear Emergency Response Headquarters

6. NUCLEAR SAFETY COMMISSION

7. EMERGENCY RESPONSE CENTRE OF MINISTRY OF ECONOMY, TRADE AND INDUSTRY/NUCLEAR AND INDUSTRIAL SAFETY AGENCY (METI/NISA)
- NERHQ Secretariat – Nuclear Emergency Response Headquarters Secretariat

8. TEPCO HEADQUARTERS
- TEPCO HQ-ERCs – Emergency Response Centres at TEPCO Headquarters

FIG. I.2. Locations of the core entities involved in the management of the response to a nuclear emergency.

APPENDIX II.
RADIATION AND DISASTER EMERGENCY MEDICAL SYSTEMS IN JAPAN PRIOR TO THE ACCIDENT

The radiation emergency medical system was comprised of three hospital levels (primary, secondary and tertiary), with the characteristics and functions of each level provided in Table II.1 [264, 265]. At the time of the Fukushima Daiichi accident, Japan had 54 operational nuclear reactors in 13 prefectures and other nuclear facilities, such as research facilities and reprocessing plants located in three prefectures. In prefectures with nuclear installations, 59 hospitals were designated as primary level hospitals, 34 as secondary level hospitals, and two as tertiary level hospitals in accordance with the radiation emergency medical system [266].

TABLE II.1. RADIATION EMERGENCY MEDICAL SYSTEM IN JAPAN PRIOR TO THE FUKUSHIMA DAIICHI ACCIDENT

	Designated level for the hospital		
	Primary	Secondary	Tertiary
Basic roles	Provide first aid and emergency treatment regardless of presence of contamination Treatment of contaminated wounds (including decontamination) Simple decontamination procedures of the head and body surface by removing clothes and/or wiping off Refer exposed patients to an appropriate hospital	Perform appropriate initial treatment for those exposed (local and whole body exposure) Perform medical treatment of concurrent health problems Perform decontamination to those contaminated, including using special wet-decontamination facilities, if available Manage internal contamination Perform triage and send to tertiary radiation emergency hospitals as appropriate	Provide highly advanced and specialized treatment, decontamination and dose assessment, as required Treatment of severe external exposure Management of patients with internal contamination which requires long term and specialized treatment Treatment of concurrent severe health problems Advanced intensive care requiring multidisciplinary medical approaches
Locations	Near the nuclear facilities	In areas where patients can be transported from the nuclear facilities and the primary hospitals by appropriate methods within relatively short time	One facility in the eastern and western parts of Japan

The local plan provided for ambulance transportation of exposed and/or contaminated patients from a nuclear facility to a primary or secondary hospital. The long distance transportation of patients from secondary to tertiary hospitals was to be provided by local government helicopters or fixed wing aircraft of the Japan Self-Defense Force (SDF) [267, 268].

In parallel, there was an established national disaster response medical system, comprising more than 600 hospitals throughout Japan. These hospitals were designated as disaster medical centres and were equipped with medical stockpiles for disasters and staffed with trained Disaster Medical Assistance Teams (DMATs) [269]. The hospitals in Fukushima Prefecture were designated as follows: four were primary radiation emergency hospitals, two were designated as both a primary radiation emergency hospital and a disaster medical centre, one as both a secondary radiation emergency hospital and a disaster medical centre, and a further five were designated only as disaster medical centres (Fig. II.1) [80].

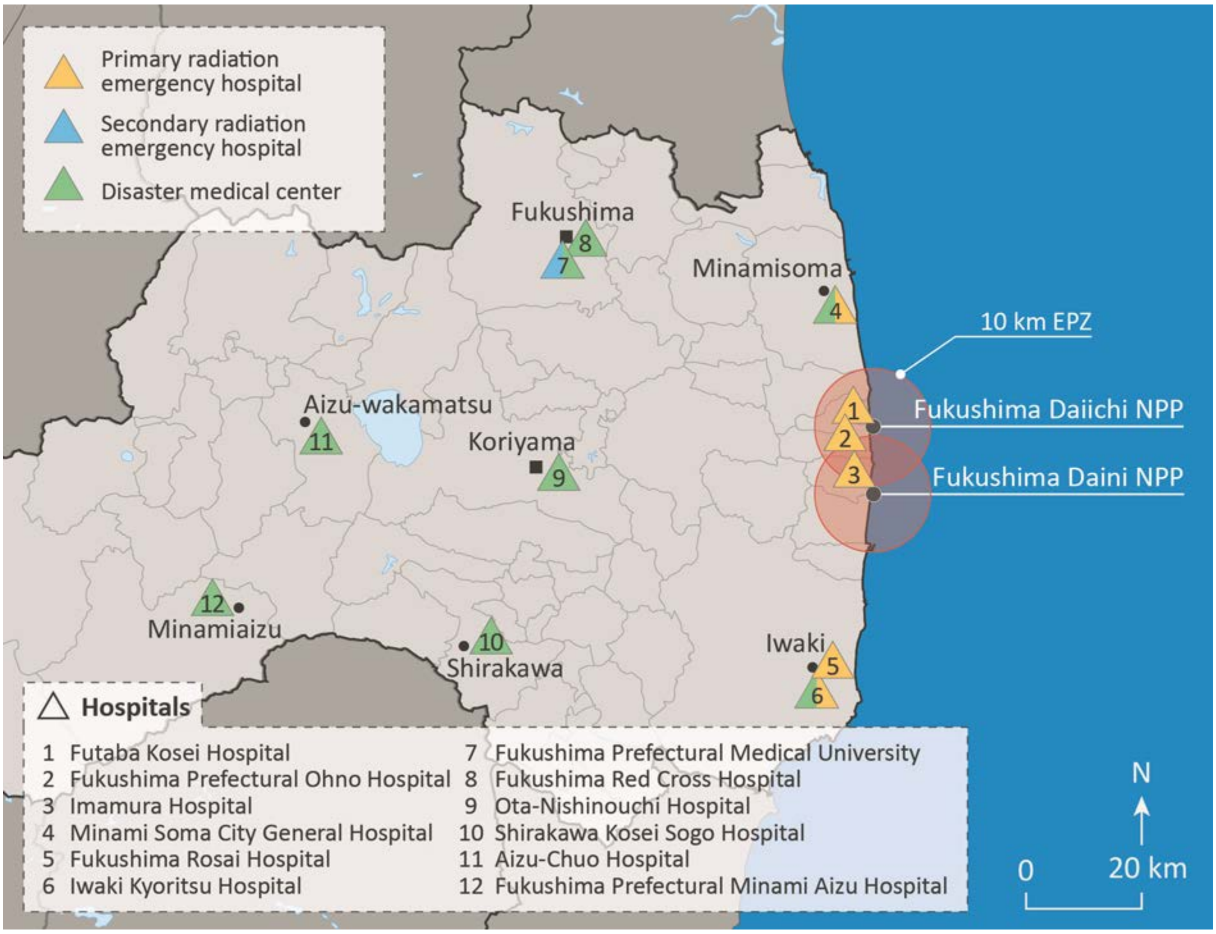


FIG. II.1. The radiation emergency medical system and disaster medical system in Fukushima Prefecture prior to the accident [270].

Overall, not all designated radiation emergency hospitals were also designated as disaster medical centres [271], meaning that they are unlikely to have been appropriately prepared for the medical management of the combined consequences of the Fukushima Daiichi accident and the Great East Japan Earthquake.

APPENDIX III.
PLANS FOR EMERGENCY DRILLS AND EXERCISES PRIOR TO THE ACCIDENT

The Nuclear Emergency Response Manual specified that nuclear emergency drills would be planned by the national Government each year and that the manual would be reviewed afterwards, as required [2, 5, 8]. NISA was designated as the main coordinator of the nuclear emergency drills. In particular, the METI Emergency Plan stipulated that the drills would include the participation of local communities, in cooperation with designated administrative agencies as well as the Government, local governments, nuclear operators and other parties involved. The drills would include the use of the OFC [272].

In addition, the Nuclear Emergency Preparedness Guide [19] provided technical guidance on training and drills, including the need for evaluating/reviewing the results of the drills in cooperation with a third party[174]. It described, inter alia, the need to periodically train emergency preparedness personnel, particularly on notification, emergency monitoring and emergency exposure medical treatment. It also recommended that the following drills and exercises to be conducted:

- An emergency notification drill;
- An emergency monitoring drill;
- An exercise combining notification and monitoring drills as well as communication to residents, etc., in the vicinity;
- A comprehensive exercise for each region including a governmental support system;
- A comprehensive joint exercise including the launch of a Nuclear Emergency Response Headquarters (NERHQ) by the national Government [19].

In October 2008, an Integrated Nuclear Emergency Response Drill was conducted at the Fukushima Daiichi NPP, involving national and local (prefectural and city/town/village) authorities, the operator (TEPCO) and about 600 local residents [275].

Public relations and information activities concerning accidents at nuclear power plants were practised mainly in association with the drills [9].

[174] Third parties are, for example, the NSC and the Sub-Committee on Nuclear Emergency and Preparedness under the Sub-Committee on Nuclear and Industrial Safety of the Advisory Committee for Natural Resources and Energy (an advisory committee to the METI Minister) [273, 274].

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CONTENTS OF CD-ROM

The following annexes to Technical Volume 3 are included on the attached CD-ROM:

Annex I: Provisional English translation by the IAEA of notification faxes sent by the Fukushima Daiichi NPP Site Superintendent to off-site officials on 11 March 2011

Annex II: ICRP message issued 21 March 2011

ABBREVIATIONS

ACI	Airport Council International
ALMERA	Analytical Laboratories for Measurement of Environmental Radioactivity
ATM	atmospheric transport modelling
BWR	boiling water reactor
ConvEx	Convention Exercises
CRPPH	Committee on Radiation Protection and Public Health
CTBTO	Comprehensive Nuclear Test-Ban Treaty Organization
DMAT	Disaster Medical Assistance Team
DOE	United States Department of Energy
DVI	disaster victim identification
EADRCC	Euro-Atlantic Disaster Response Coordination Centre
EO	evacuation order
EAL	emergency action level
EAP	Emergency Action Plan
EC	European Commission
ECCS	emergency core cooling system
ECURIE	European Community Urgent Radiological Information Exchange
EDG	emergency diesel generator
EGRPF	Expert Group on the Radiological Protection Aspects of the Fukushima Accident
ENAC	Emergency Notification and Assistance Conventions
ENATOM	Emergency Notification and Assistance Technical Operations Manual
ENSREG	European Nuclear Safety Regulators Group
EOC	emergency operation centre
EPD	electronic personal dosimeter
EPR	emergency preparedness and response
EPRI	Electric Power Research Institute
EPR-IEComm	Operations Manual for Incident and Emergency Communication
EPZ	emergency planning zone
ERC	Emergency Response Centre
ERF	event rating form
ERM	Emergency Response Manager
ERO	Emergency Response Organization
ERSS	emergency response support system
EURDEP	European Radiological Data Exchange Platform
EUROPOL	European Police Office
FACT	Fukushima Accident Coordination Team
FAO	Food and Agriculture Organization of the United Nations
FDA	US Food and Drug Administration
FMD	Fukushima Monitoring Database
FMU	Fukushima Medical University Hospital
FNST	Fukushima Nuclear Safety Team
FRCT	Fukushima Radiological Consequences Team
FSAT	Food Safety Assessment Team
GM	Geiger-Mueller
HERCA	Heads of the European Radiological Protection Competent Authorities
HPGe	High Purity Germanium
HRA	Health Risk Assessment
IACRNE	Inter-Agency Committee on Radiological and Nuclear Emergencies
ICAO	International Civil Aviation Organization
ICRP	International Commission on Radiological Protection
IEC	Incident and Emergency Centre
IES	Incident and Emergency System

IHR	International Health Regulations
ILO	International Labour Organization
IMO	International Maritime Organization
IMS	International Monitoring System
INES	International Nuclear and Radiological Event Scale
INFOSAN	International Food Safety Authorities Network
INPO	Institute of Nuclear Power Operations
INSAG	International Nuclear Safety Group
Interpol CBRNE	Interpol Chemical, Biological, Radiological, Nuclear and Explosives
ISSC	International Seismic Safety Centre
ITB	iodine thyroid blocking
JAEA	Japan Atomic Energy Agency
JAPC	Japan Atomic Power Company
JCNER	Joint Council for Nuclear Emergency Response
JCO	Japan Nuclear Fuel Conversion Co.
JEU	UNEP-OCHA Joint Environment Unit
JMA	Japan Meteorological Agency
JNES	Japan Nuclear Energy Safety Organization
JPLAN	Joint Radiation Emergency Plan of the International Organizations
JRCS	Japanese Red Cross Society
JST	Japan Standard Time
KAERI	Korea Atomic Energy Research Institute
KINS	Korea Institute of Nuclear Safety
MAFF	Ministry of Agriculture, Forestry and Fisheries
METI	Ministry of Economy, Trade and Industry
METI/NISA	Ministry of Economy, Trade and Industry/Nuclear and Industrial Safety Agency
METI/NISA-ERC	METI/NISA Emergency Response Centre
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MHLW	Ministry of Health, Labour and Welfare
MLIT	Ministry of Land, Infrastructure and Transport
MOD (SDF)	Ministry of Defense (Self-Defense Force)
MOE	Minister of the Environment
mSv	millisievert
NAIIC	National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission
NARAC	National Atmospheric Release Advisory Centre
NAVAREA	navigational area
NCA (A)	National Competent Authority (Abroad)
NCA (D)	National Competent Authority (Domestic)
NCB	National Central Bureau
NEAT	Nuclear Emergency Assistance and Training Centre
NERHQ	Nuclear Emergency Response Headquarters
NEWS	Nuclear Events Web-Based System
NFP	national focal point
NHK	Nippon Hoso Kyokai
NIRS	National Institute of Radiological Sciences
NISA	Nuclear and Industrial Safety Agency
NPP	nuclear power plant
NPP-ERC	Fukushima Daiichi Emergency Response Centre at the NPP
NRA	Nuclear Regulation Authority
NSC	Nuclear Safety Commission
NTT	Nippon Telegraph and Telephone
NWP	National Warning Point
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
OECD/NEA	OECD Nuclear Energy Agency

OFC	Off-site Centre
OIL	operational intervention level
OP	Onahama Port
PAHO	Pan American Health Organization
PAZ	precautionary action zone
PCDMB	UNEP Post Conflict and Disaster Management Branch
RANET	Response and Assistance Network
REMAT	Radiation Emergency Medical Assistance Team
RSMC	Regional Specialized Meteorological Centres
SDF	Self-Defense Force
SPEEDI	System for Prediction of Environmental Emergency Dose Information
TAF	top of active fuel
TEPCO	Tokyo Electric Power Company
TEPCO HQ-ERC	Emergency Response Centre at TEPCO Headquarters
UNOOSA	United Nations Office for Outer Space Affairs
UNDAC	United Nations Disaster Assessment and Coordination
UNEP	United Nations Environment Programme
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UNWTO	United Nations World Tourism Organization
UPZ	urgent protective action planning zone
USAR	urban search and rescue
USIE	United System for Information Exchange in Incidents and Emergencies
UTC	Universal Time Coordinated
WANO	World Association of Nuclear Operators
WBC	whole-body counters
WHO	World Health Organization
WMO	World Meteorological Organization
WPRO	Western-Pacific Regional Office
WTO	World Trade Organization
ZAMG	National Meteorological Service of Austria

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Working Group (WG) meetings

18 March 2013
Initial meeting of the WG Co-Chairs, Vienna

21–22 March 2013
1st meeting of all WGs, Vienna

12–14 June 2013
2nd meeting of all WGs, Vienna

7–9 October 2013
3rd meeting of WGs 3, 4 and 5, Vienna

9–13 December 2013
4th meeting of all WGs, Vienna

10–14 February 2014
5th meeting of all WGs, Vienna

14–17 April 2014
6th meeting of WGs 1, 2 and 3, Vienna

International Technical Advisory Group (ITAG) meetings

21–22 March 2013
1st ITAG meeting, Vienna

10 June 2013
1st Joint ITAG/Co-Chairs meeting, Vienna

11 June 2013
2nd ITAG meeting, Vienna

6 December 2013
2nd Joint ITAG/Co-Chairs meeting, Vienna

7 May 2014
3rd Joint ITAG/Co-Chairs meeting, Vienna

23–24 October 2014
4th Joint ITAG/Co-Chairs meeting, Vienna

23–24 February 2015
5th Joint ITAG/Co-Chairs meeting, Vienna

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