The Accident at TEPCO's Fukushima Nuclear Power Stations

Nuclear Emergency Response Headquarters
Government of Japan

June 20-24, 2011
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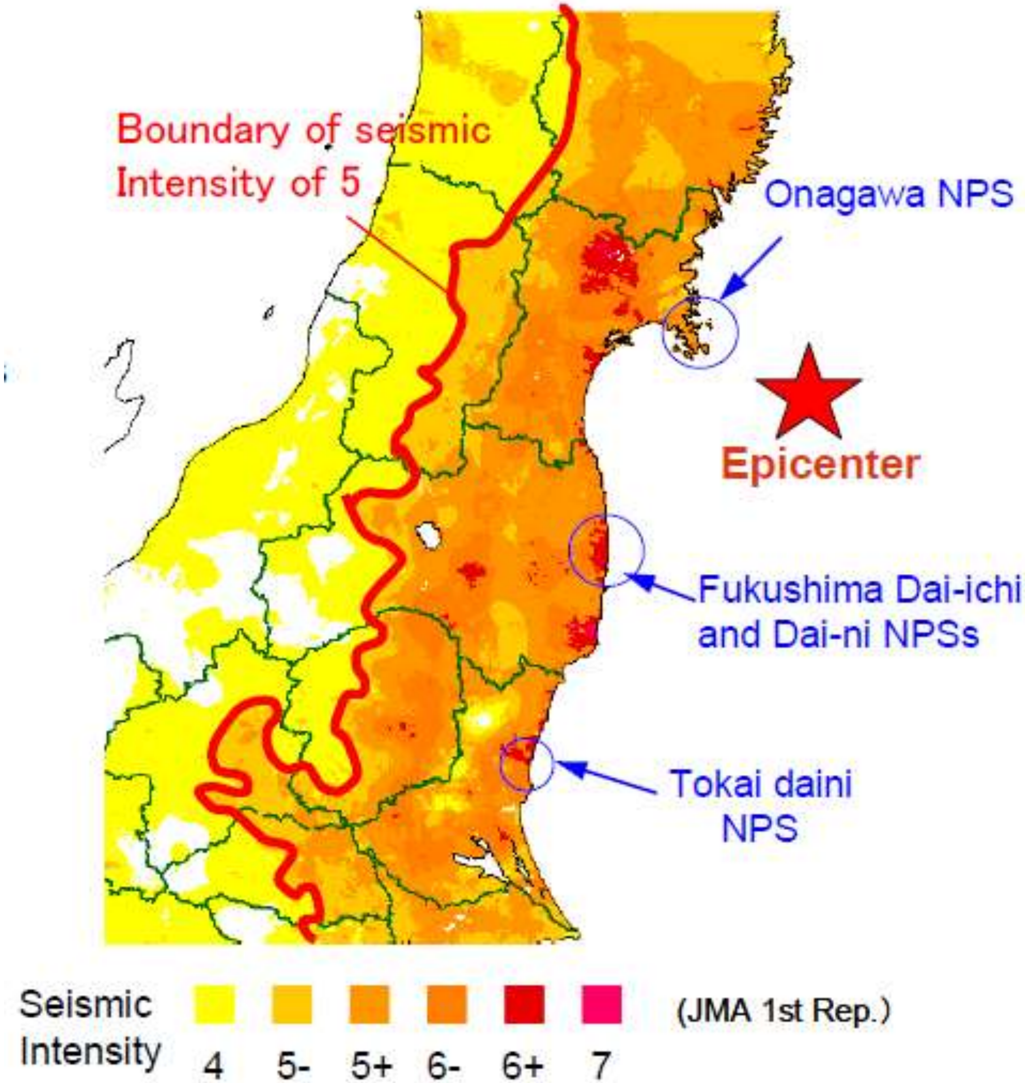
Vienna

Contents

1. Occurrence and Development of the Accident

Tohoku District - off the Pacific Ocean Earthquake

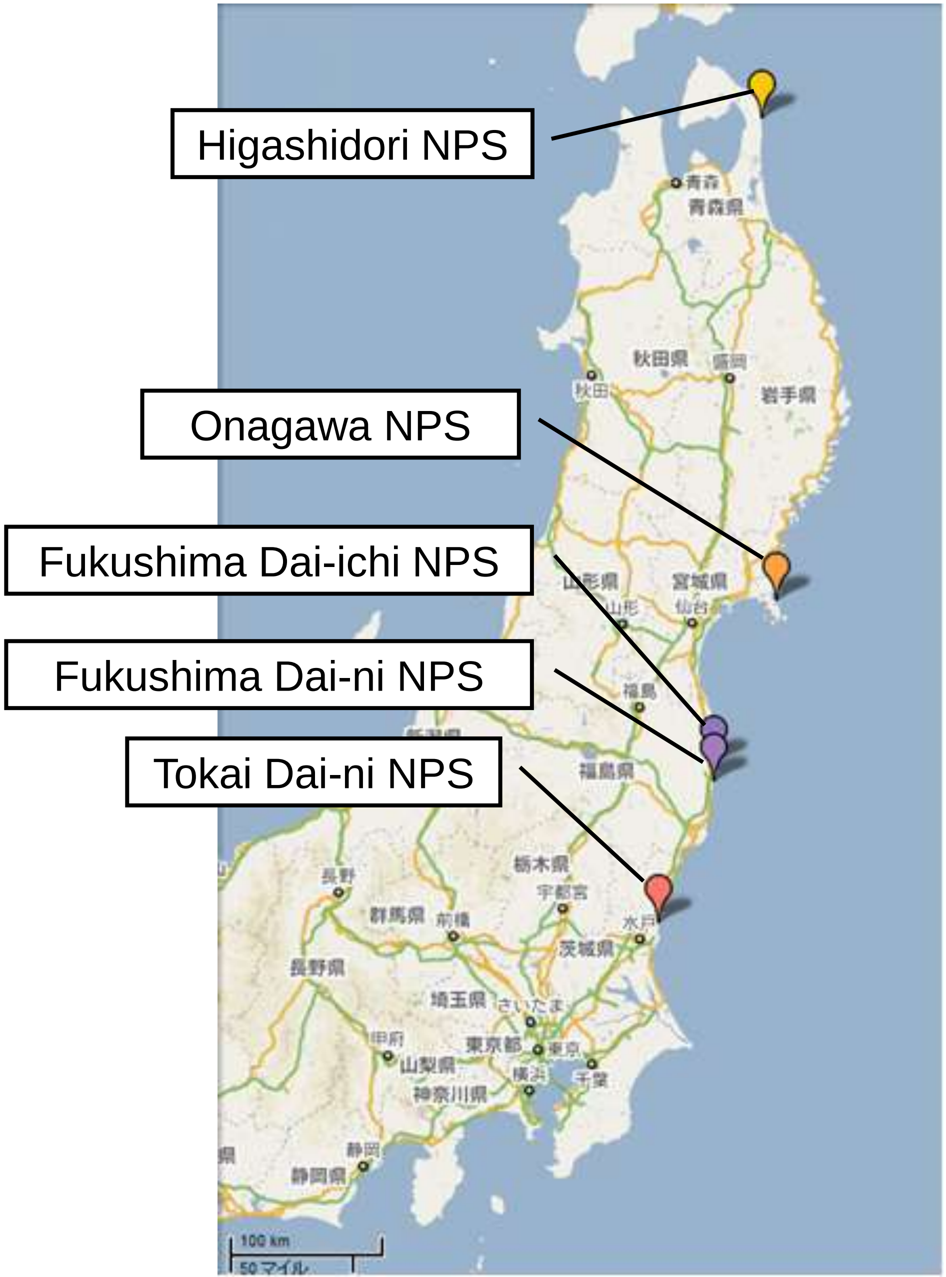


Reference: JMA Release [Online]. http://www.jma.go.jp/jma/index.html
Partially modified by JNES.

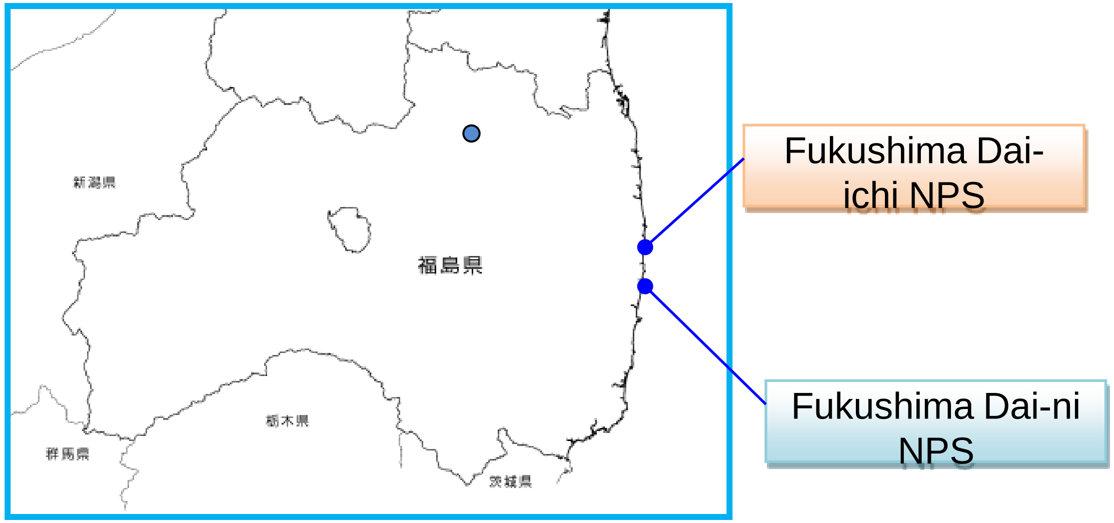
Map of JMA seismic intensities observed during the main shock.

- Occurrence: 14:46 March11, 2011
- Mw(moment magnitude): 9.0
- Epicenter: approximately 130km off the coast of Sanriku (at 38.10 degrees north latitude, 142.86 degrees east longitude and 23.7km deep)

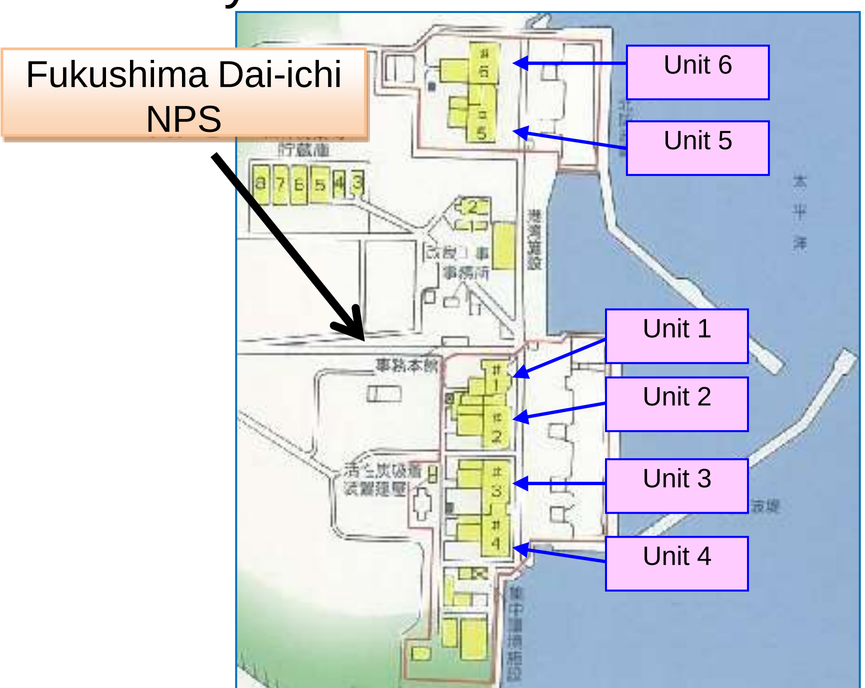
Location of NPSs in the Tohoku District

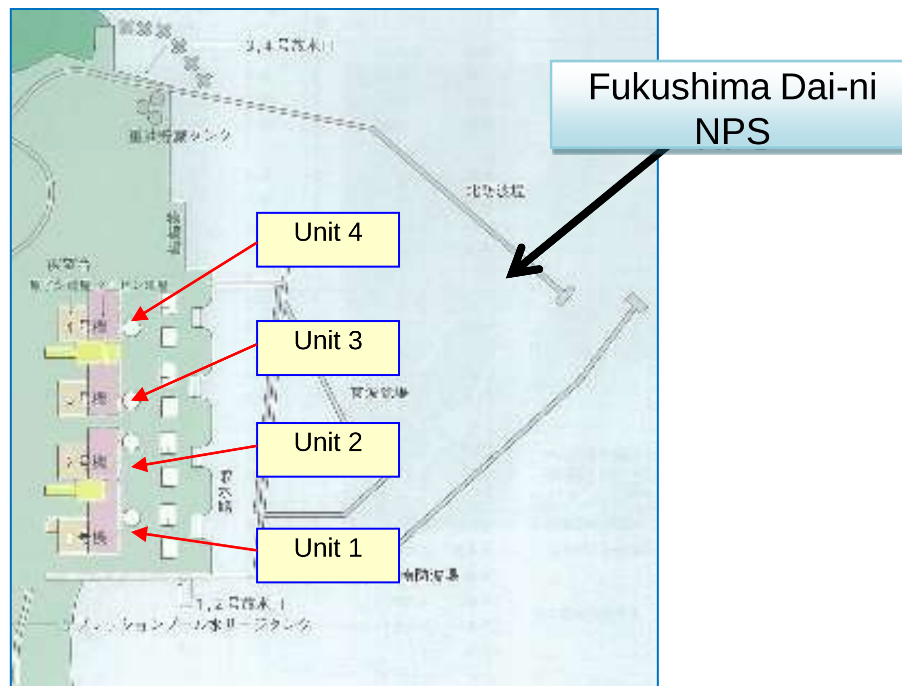


Location of NPSs within Fukushima



Layouts of Fukushima Dai-ichi NPS and Fukushima Dai-ni NPS





Generation Facilities at the Fukushima Dai-ichi NPS

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Electric output(MWe)	460	784	784	784	784	1100
Commercial operation	1971/3	1974/7	1976/3	1978/10	1978/4	1979/10
Reactor model	BWR3	BWR4			BWR5	
PCV model	Mark-1					Mark-2
Number of fuel assemblies in the core	400	548	548	548	548	764

Generation Facilities at the Fukushima Dai-ni NPS

	Unit 1	Unit 2	Unit 3	Unit 4
Electric output(MWe)	1100	1100	1100	1100
Commercial operation	1982/4	1984/2	1985/6	1987/8
Reactor model	BWR5			
PCV model	Mark-2	Mark-2 Advance		
Number of fuel assemblies in the core	764	764	764	764

Generation Facilities at the Higashidori NPS
Tohoku Electric Power Company

	Unit 1
Electric output(MWe)	1100
Commercial operation	2005/12
Reactor model	BWR-5
PCV model	Mark-I Advance
Number of fuel assemblies in the core	764

Generation Facilities at the Tokai Dai-ni NPS
Japan Atomic Power Company

	Unit 1
Electric output(MWe)	1100
Commercial operation	1978/11
Reactor model	BWR-5
PCV model	Mark-II
Number of fuel assemblies in the core	764

Generation Facilities at the Onagawa NPS
Tohoku Electric Power Company

	Unit 1	Unit 2	Unit 3
Electric output(MWe)	524	825	825
Commercial operation	1984/6	1995/7	2002/1
Reactor model	BWR-4	BWR-5	BWR-5
PCV model	Mark-I	Mark-I Advance	
Number of fuel assemblies in the core	368	560	560

Status of Fukushima Dai-ni NPSs

Units	Status after the earthquake and the tsunami
Unit 1, 2 and 4 TEPCO	**Shutdown of 3 units due to the earthquake** → External power maintained (1 out of 3) → Sea water pumps could not operate due to tsunami and resulted in loss of pressure suppression functions. → Later, cooling functions recovered due to the restoration work. → Unit 1: cold shutdown at 17:00 on March 14 → Unit 2: cold shutdown at 18:00 on March 14 → Unit 4: cold shutdown at 07:15 on March 15
Unit 3 TEPCO	**Shutdown due to the earthquake** → External power maintained (1 out of 3) → All functions worked → Cold shutdown at 12:15 on March 12

Status of the other NPSs

Stations	Status after the earthquake and the tsunami
Higashidori NPS Tohoku Electric Power Co.	**Undergoing a periodic operation (1 unit)** → Loss of external power supply due to the earthquake → Start-up of emergency diesel generators
Onagawa NPSs Tohoku Electric Power Co.	**Shutdown of 3 units due to the earthquake** → A part of external power supply lines and seawater pumps survived after the earthquake and the tsunami. → Cold shutdown at 1:17 on March 12
Tokai Dai-ni NPS Japan Atomic Power Co.	**Shutdown of 1 unit due to the earthquake** → Loss of external power supply due to the earthquake → A emergency diesel generator survived after the tsunami. → Cold shutdown at 0:40 on March 15

Collapsed Tower

- Damage of external power supply systems of the Fukushima Dai-ichi and Dai-ni NPSs

(Source: TEPCO)

Tsunami getting over seawall at the Fukushima Dai-ichi NPS

(Source: TEPCO) (Source: Google)

Fukushima Dai-ichi NPS

(AC Power supply)

[External power supply] → [Emergency diesel generators]

X	Yonomori -line No.1
X	Yonomori- line No.2
X	Okuma- line No.1
X	Okuma-line No.2
X	Okuma-line No.4
X	TEPCO nuclear line

↑ **earthquake**

X	(Unit 1)
X	(Unit 1)
X	(Unit 2)
X	(Unit 2)
X	(Unit 3)
X	(Unit 3)
X	(Unit 4)
X	(Unit 5)
X	(Unit 5)
X	(Unit 6)
X	(Unit 6)
O	(Unit 6)

↑ **Tsunami**

Main Sequence of the accident of Unit1, Unit2 and Unint3 of Fukushima Dai-ichi NPS

Loss of external power supply due to earthquake

Start-up of emergency power generation

All emergency diesel power generators stopped except for one generator in Unit6 due to tsunami

(11 emergency diesel power generator stopped, and one generator(with air cooling)survived.)

Loss of all AC power supply except for Unit6

(Unit 5 took power supply from Unit6 on 13 March).

Core cooling system not using AC power

(Unit1:IC(isolation condenser), Unit2 (RCIC(reactor core isolation cooling system), Unit3: RCIC and HPCI (high pressure core injection system)

Stop of core cooling system not using AC power

Water injection from a fire extinguishing line

(Unit1:pure water->sea water, Unit2: sea water Unit3: pure water-> sea water)

During this time without cooling, the fuel was exposed and core melt started, generating hydrogen

Fukushima Dai-ichi NPS

(Core cooling)

Loss of all AC power supply

Core cooling system not using AC power → Water injection from a fire extinguishing line

	Core cooling system not using AC power		Water injection from a fire extinguishing line
Unit 1	IC	Unit 1	**fresh water → sea water**
Unit 2	RCIC	Unit 2	**sea water**
Unit 3	RCIC and HPCI	Unit 3	**fresh water → sea water**

IC: isolation condenser
RCIC: reactor core isolation cooling system
HPCI: high pressure core injection system

Accident Management Measures at Fukushima Dai-ichi related to this Accident

Items	Contents
Alternative coolant injection	• Lines via condensate water makeup systems from the condensate storage tanks as the water sources • Lines via fire extinguishing systems and condensate water makeup systems from the filtrate tanks as the water sources
PCV vent facilities	• PCV vent facilities were installed to bypass the standby gas treatment system so that they can vent the PCV when the pressure is high.
Power interchange facilities	• Power interchange facilities have been installed such that the power supply of the alternating current source for power machinery (6.9kV) and the low voltage alternating current source (480V) can be interchanged between adjacent reactor facilities (between Units 1 and 2, between units 3 and 4, and between Unit 5 and 6).

Unit 1 RPV pressure and water level

Code
Methods for Estimation of Leakages and Consequences of Releases (**MELCOR**)

Analysis conditions
- IC worked intermittently until tsunami attacked. Further operation of IC was not considered.
- Based on the records, HPCI operation was not considered.
- PCV leakage areas (assumption) at 18 hours and at 50 hours are ca. 7 cm^2 and ca. 35 cm^2, respectively.
- Amount of water injected through the fire extinguishing line is based on the records, but varies with RPV pressure.

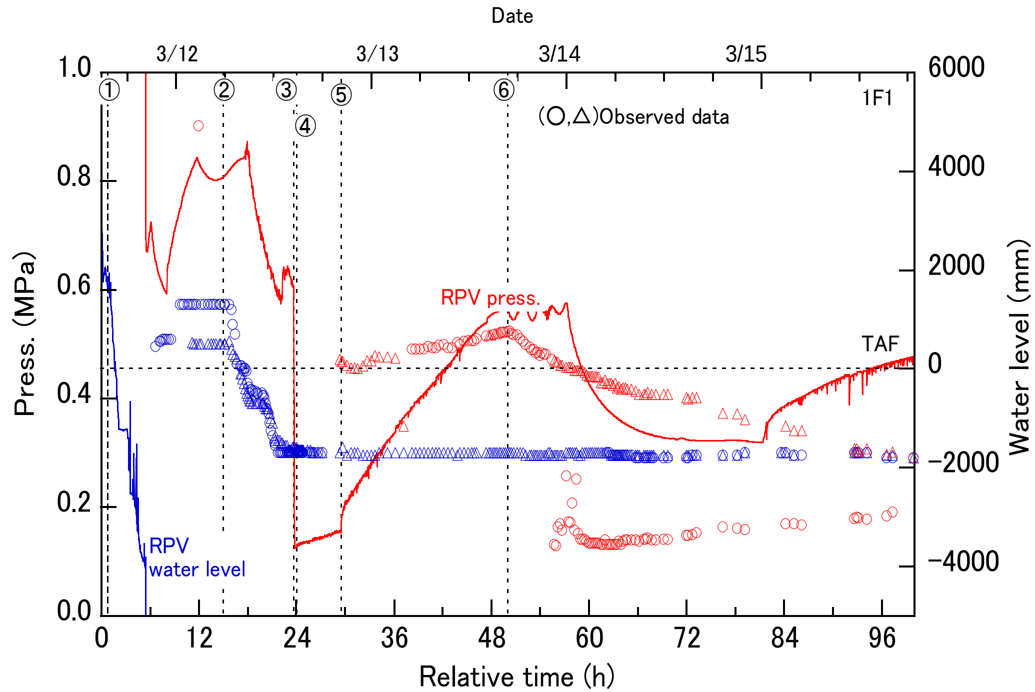


Fig. RPV pressure and water level (unit 1) [case 2]
①IC stop, ②PCV failure (assumption), ③W/W ventilation (open), ④W/W ventilation (close), ⑤sea water inject., ⑥expansion of PCV failure (assumption)

Fukushima Dai-ichi NPS Unit 1

(Status of the reactor core)

- 14:46 March 11: Loss of external power supply, Start-up of emergency diesel generators
- 14:52 March 11: Start-up of isolation condenser
- 15:37 March 11: Loss of all AC power
- 05:46 March 12: Start of fresh water injection from a fire extinguishing line

→ Water injection seemed to have stopped for 14 hours and 9 minutes.

- **around 17:00 March 11**: **The fuel was exposed, and the core melt started afterwards**.

Unit 2 RPV pressure and water level

Code

Methods for Estimation of Leakages and Consequences of Releases (**MELCOR**)

Analysis conditions

- RCIC had worked until 13:25 on Mar 14.
- Water source of RCIC is changed from CST to S/P at 4:20 on Mar 12.
- Leakage (ca. 50 cm^2) from gas phase of D/W at 21 hours is assumed.
- Leakage (ca. 300 cm^2) from gas phase of S/C is assumed.
- Amount of water injected through the fire extinguishing line is based on the records, but varies with RPV pressure.

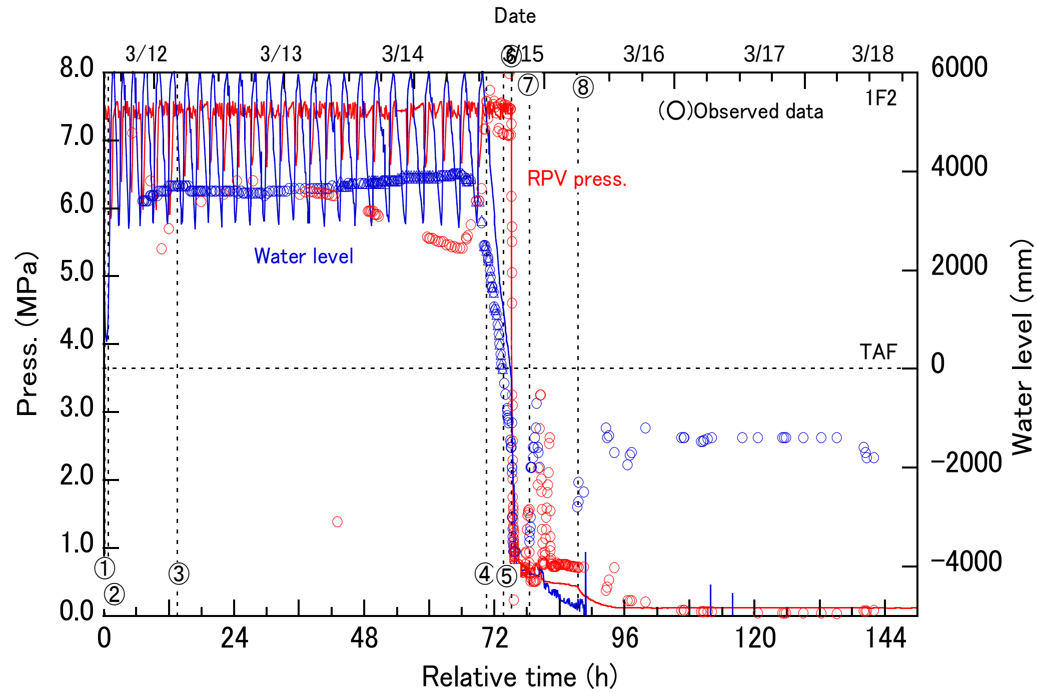


Fig. RPV pressure and water level (unit 2) [TEPCO-2] ①RCIC start manually, ②SBO, ③Water source change from CST to S/P, ④RCIC stop, ⑤Sea water inject., ⑥ RPV depressurized, ⑦S/R valve-2 open, ⑧Impact sound

Fukushima Dai-ichi NPS Unit 2

(Status of the reactor core)

- 14:47 March 11: Lose of external power supply, Start-up of emergency diesel generators
- 14:50 March 11: Start-up of RCIC (reactor core isolation cooling system)
- 15:41 March 11:Lose of all AC power
- 13:25 March 14: Stop of RCIC
- 19:54 March 14: Start of seawater injection from a fire extinguishing line

→ Water injection seemed to have stopped for 6 hours and 29 minutes.

- **around 18:00 March 14 : The fuel was exposed, and the core melt started afterwards**.

Unit 3 RPV pressure and water level

Code

Methods for Estimation of Leakages and Consequences of Releases (**MELCOR**)

Analysis conditions

- RCIC had worked until 11:36 on Mar 12.
- HPCI worked from 12:35 on Mar 12 to 2:42 on Mar 13.
- Water source of RCIC and HPCI is CST.
- Depressurization of RPV was confirmed at 9:20 on Mar 13.
- PCV ventilation line was opened and closed repeatedly.
- It is presumed that water injection rate can maintain slightly below the level of the fuel range, and not the flow rate of the discharge side of the fire pump.

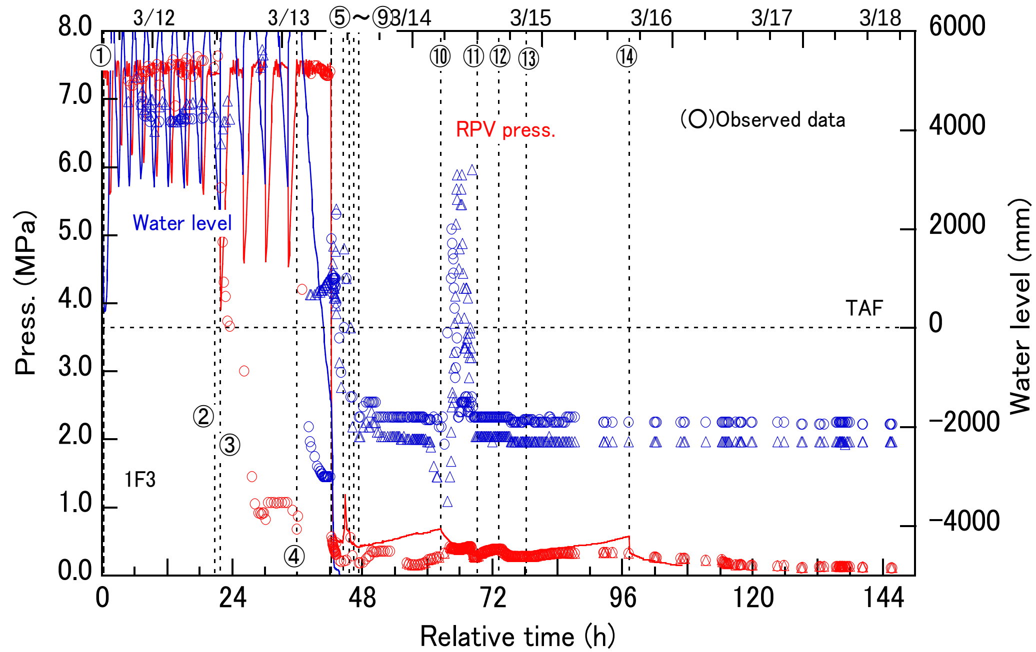


Fig. RPV pressure and water level (unit 3) [TEPCO-2]
①RCIC start manually, ②RCIC stop, ③HPCI start, ④HPCI stop, ⑤S/RV(open), ⑥PCV vent (open), ⑦Water inject., ⑧ PCV vent (close), ⑨Sea water inject., ⑩~⑭PCV vent (open⇔close)

Fukushima Dai-ichi NPS Unit 3

(Status of the reactor core)

- 14:47 March 11: Loss of external power supply, Start-up of emergency diesel generators
- 15:05 March 11: Start-up of RCIC
- 15:41 March 11: Lose of all AC power
- 11:36 March 12: Stop of RCIC
- 12:35 March 12: Start-up of HPCI (high pressure core injection system)
- 02:42 March 13: Stop of HPCI
- 09:25 March 13: Start of fresh water injection from a fire extinguishing line

→ Water injection seemed to have stopped for 6 hours and 43 minutes.

- **around 08:00 march 13**: **The fuel was exposed, and the core melt started afterwards.**

Hydrogen explosion and the sound of an impact

- Unit 1 15:36 March 12: Hydrogen explosion in the reactor building
- Unit 3 11:01 March 14: Hydrogen explosion in the reactor building
- Unit 2 around 06:00 March 15: Noise of explosion around the suppression chamber of the PCV (There is a possibility that hydrogen explosion occurred in the torus room of the PCV.)
- Unit 4 around 06:00 March 15: Explosion in the reactor building (**An inflow of hydrogen from Unit 3 may be possible**, as the exhaust pipe for venting the PCV joins the exhaust pipe from unit 4 before the exhaust.)

Standby Gas Treatment System exhaust pipe

(Source: TEPCO)

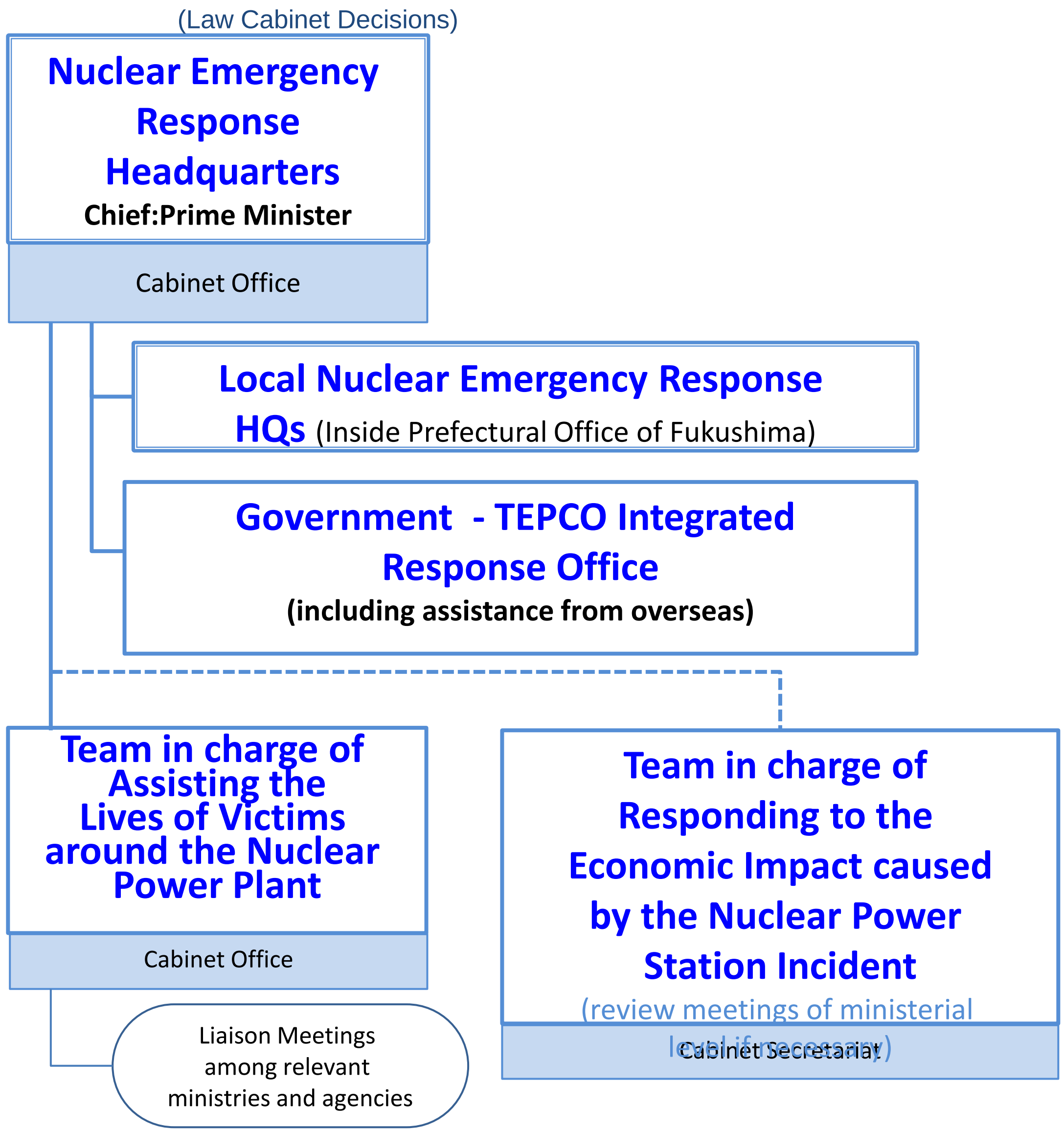
Condition of the spent fuel pool (Unit 4)

Due to the analysis result of nuclides in the water extracted from the spent fuel pool using a concrete pump truck, it is assumed that no extensive damage in the fuel rods occurred.

(Source: TEPCO)

2. Response to the Nuclear Emergency

Organization for response to the nuclear emergency

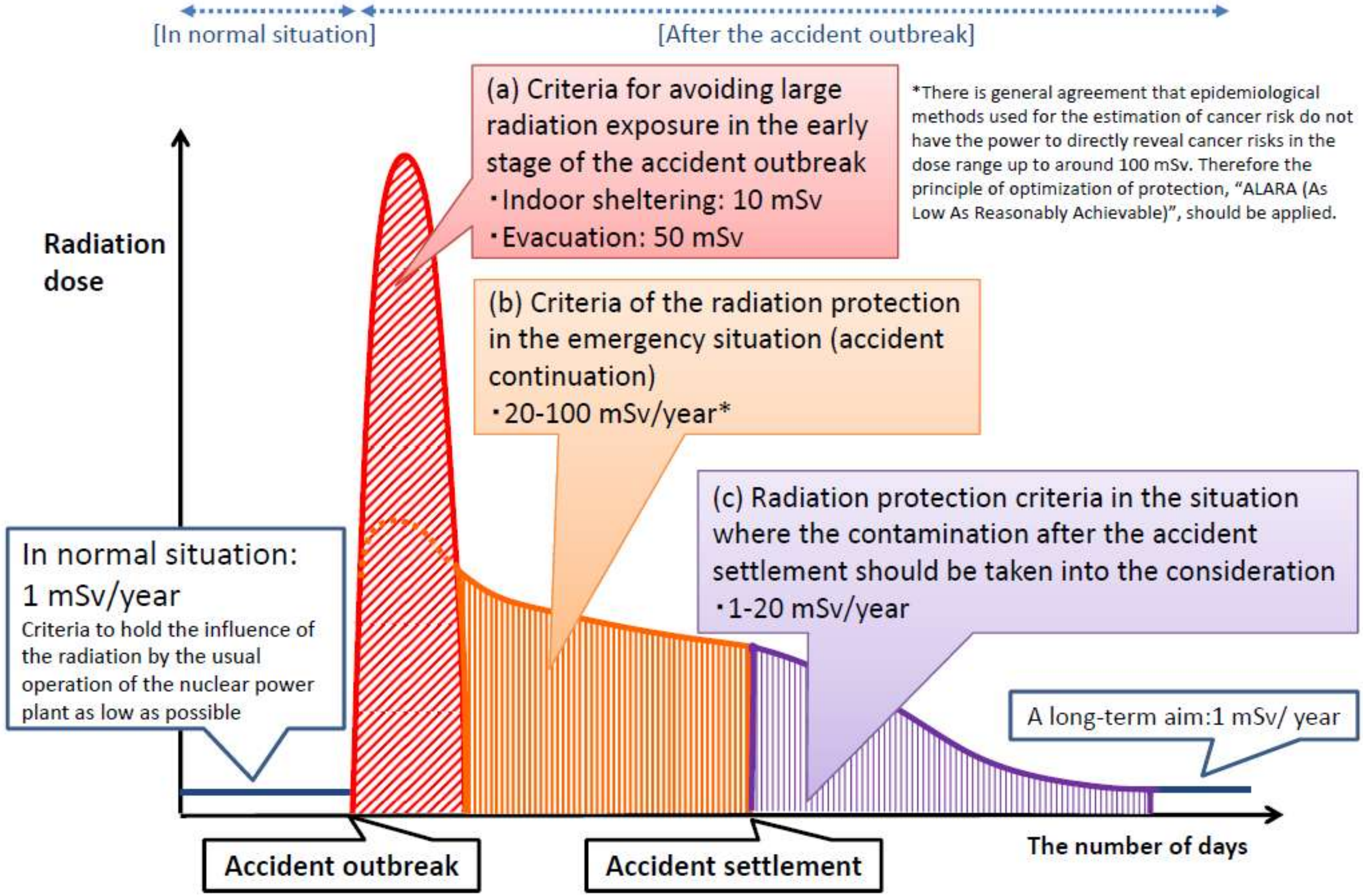


Authority of the radiation dose standard

Standard for the radiation dose	Authority
(1)Integrated radiation dose in the normal situation. • Public radiation exposure dose limit. 1 mSv/year	• Notice of Ministry of Economy, Trade and Industry • "Public notices which provides the dose limit based on the provisions of the rules about establishment operation etc. • Of the practical use nuclear reactors for electricity generation" Article 3:radiation dose out of the peripheral surveillance area. • ICRP recommendation Publication 60 (1990):Dose limit of the public radiation exposure.
(2)Integrated dose at the time of the accident	
(a) Standard for avoiding large radiation exposure in the early stage of the accident outbreak 10mSv (indoor sheltering) 50m Sv (evacuation)	• The guidance of the Nuclear Safety Commission • "About the disaster prevention measures such as nuclear energy facilities" • IAEA safety requirements GS-R-2 "Preparedness and Response for a Nuclear or Radiological Emergency" (2002)
(b)Standard of the radiation Protection in the emergency situation(accident continuation) 20-100 mSv	• ICRP recommendation Publication 103 (2007) • IAEA safety requirements GSG2 "Preparedness and Response for a Nuclear or Radiological Emergency" (2011)
(C)The radiation protection Standard in the situation where the pollution after the accident has come to a settlement should be taken into the consideration 1-20 mSv/year	• ICRP recommendation Publication 103 (2007) • Reference level for protecting the public in the situation where the pollution after the accident has come to a settlement should be taken into the consideration (existing situation)

ICRP: International Commission on Radiological Protection

The idea of the criteria of the radiation dose for the radiation protection



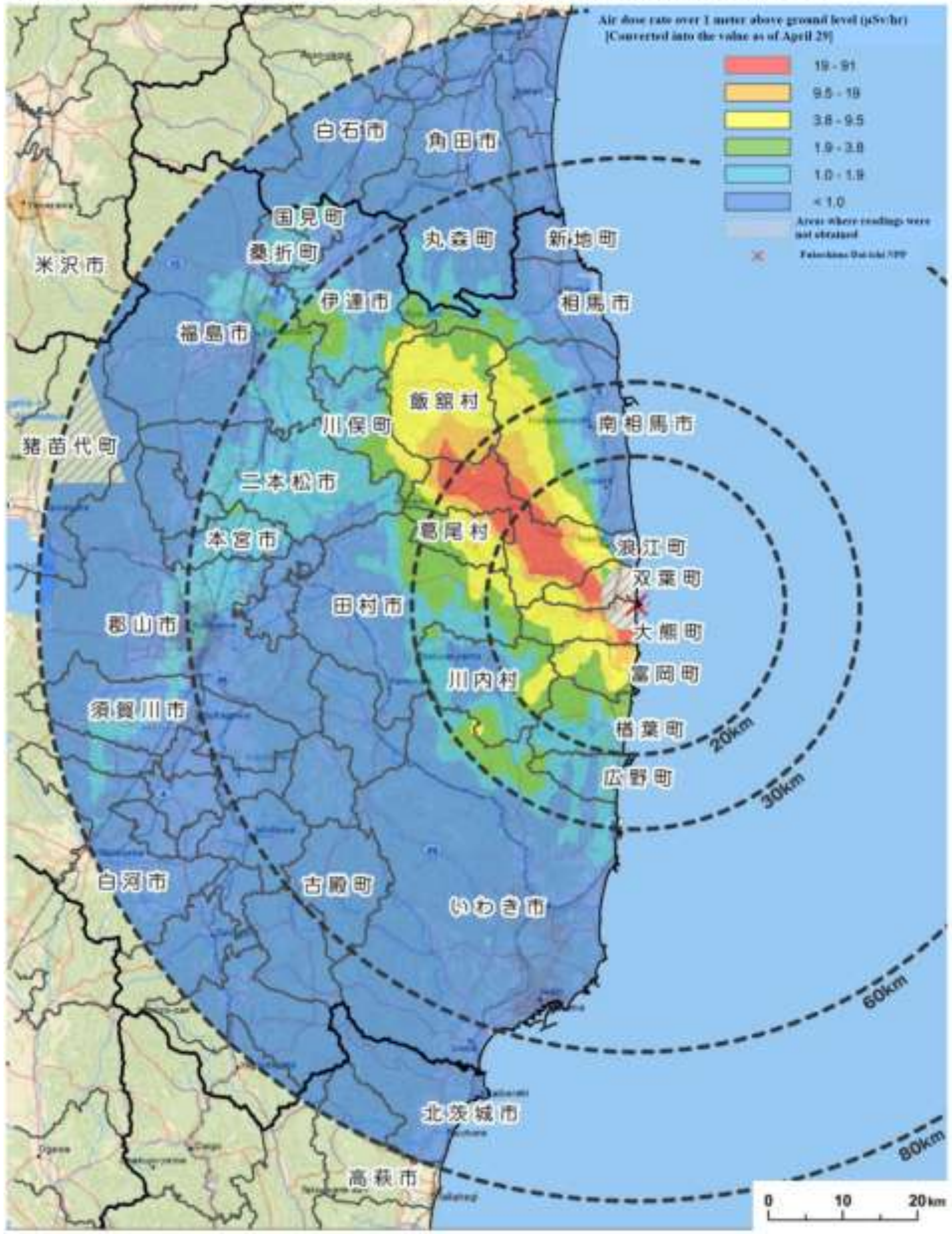
The policies for dose criteria for radiation protection

Integrated dose in accident

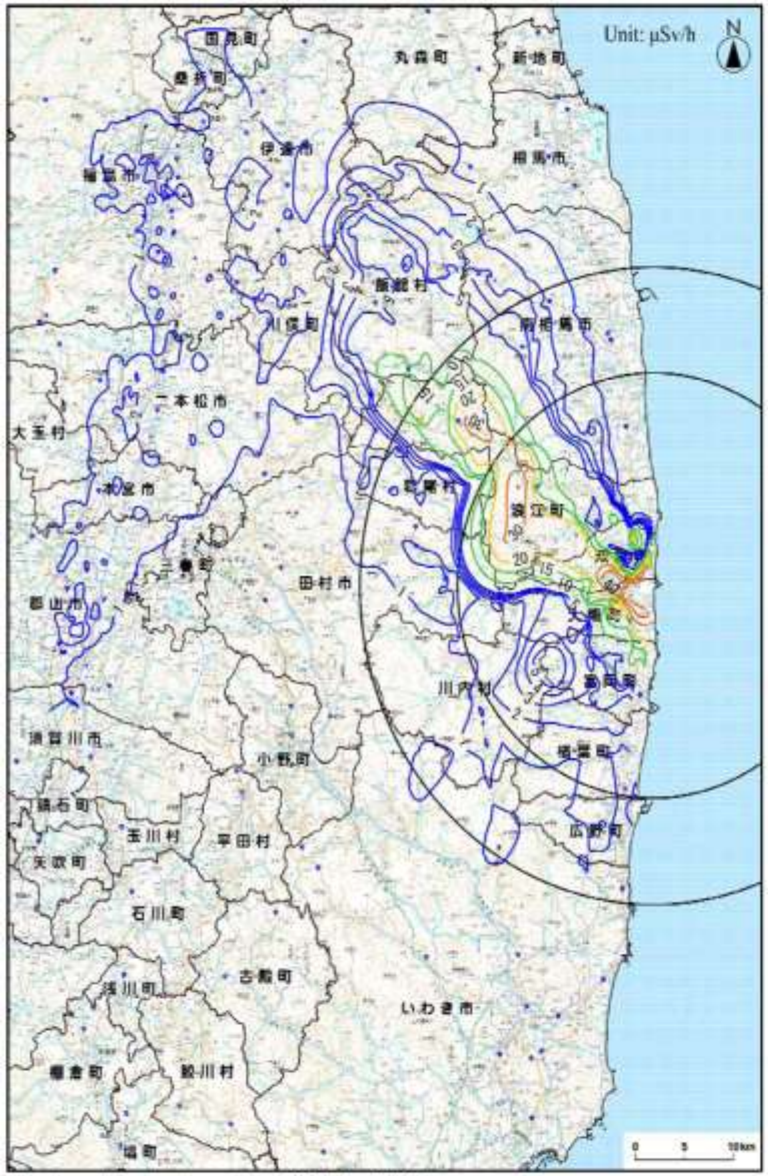
Radiation protection criteria for public in accident	Contents
(a) Criteria to prevent large exposure in the early stage of the accident	As for the criteria to be used for protection measures in the early stage of accidents(indoor sheltering/evacuation), the regulatory guide by the Nuclear Safety Commission, "Emergency Preparedness for Nuclear Facilities", provide criteria for projected dose as **effective dose from external exposure "10-50 mSv (indoor sheltering)" and "over 50mSv(evacuation)".** These criteria were determined by reference to the IAEA safety requirementGS-R-2 "Preparedness and Response for a Nuclear or Radiological Emergency"(2002)
(b) Criteria in the emergency situation(accident continuation)	In this accident, if people would continue to live the area with high level dose by local accumulation of radioactive materials released from the plant, integrated dose to the people might become high level. Therefore, the Prime Minister, who is the Chief of the Nuclear Emergency Response Headquarters, considering the opinion of the Nuclear Safety Commission into account, established "deliberate evacuation area". The deliberate evacuation area was set by reference to **the recommendation 2007 of ICRP in which 20-100mSv is suggested as a reference level to protect public in the emergency exposure situation and IAEA safety guidance GSG2 "Preparedness and Response for a Nuclear or Radiological Emergency"(2011) in which the countermeasures for protection in the emergency situation are described to be optimized under 100 mSv/year,** and in consideration of basic principle "Radiation exposure should be kept as low as reasonably achievable". Predicted integrated dose of 20 mSv in one year from the accident outbreak is adopted as the criteria for the deliberate evacuation area.
(c) Radiation protection criteria in the situation where contamination from past accidents should be taken into the consideration	**In the 2007 recommendation of ICRP, a standard of "1-20 mSv/year" is provided as a reference level for protecting the public from contamination after accidents(existing exposure situation).** And also, the principle of optimization of protection, "ALARA(As Low As Reasonably Achievable)" is to be applicable to the existing exposure situation.

Result of airborne monitoring by MEXT and DOE

Readings of air dose monitoring inside 80km zone of Fukushima Dai-ichi NPS



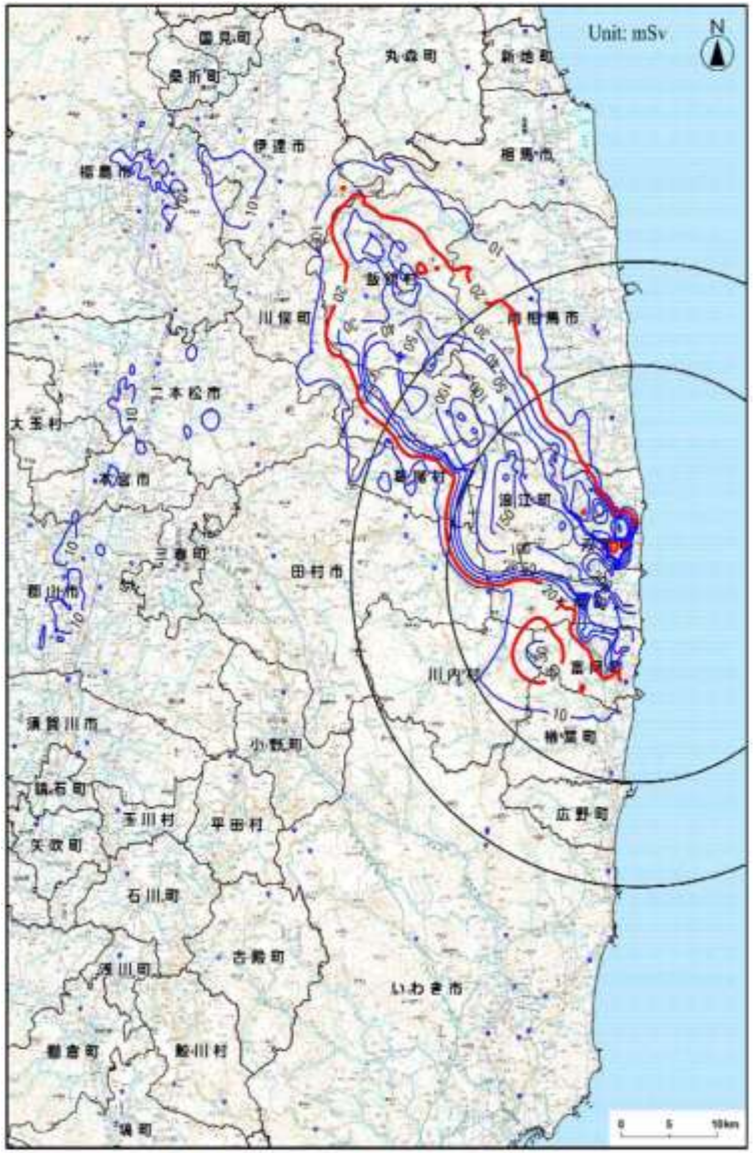
Dose Readings Map



Based on actual values observed up to 24:00, May 11, 2011.

Dose Readings Map (Estimated values) as of May 11,2011)

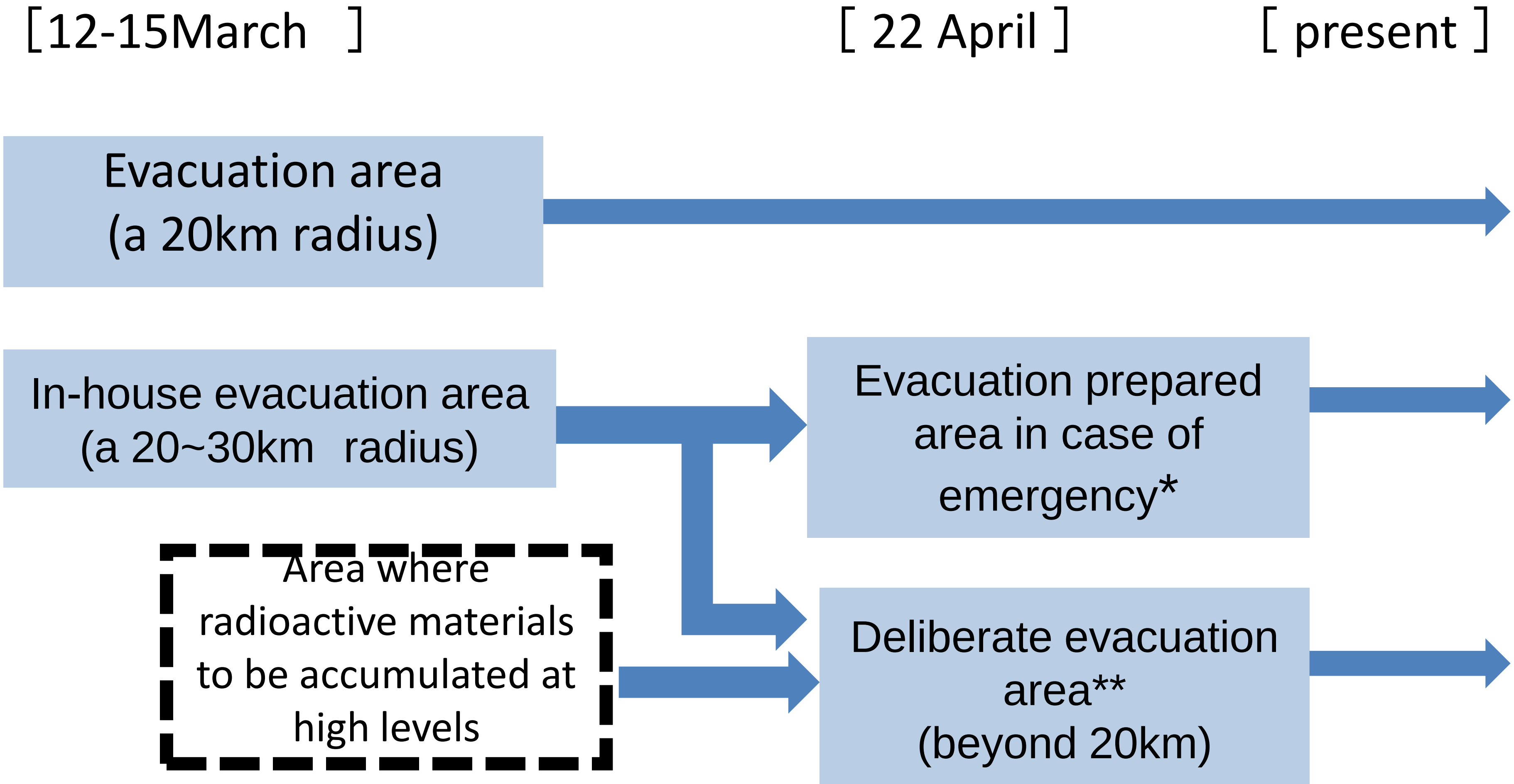
Integrated Dose Readings Map



Based on actual values observed up to 24:00, May 11, 2011

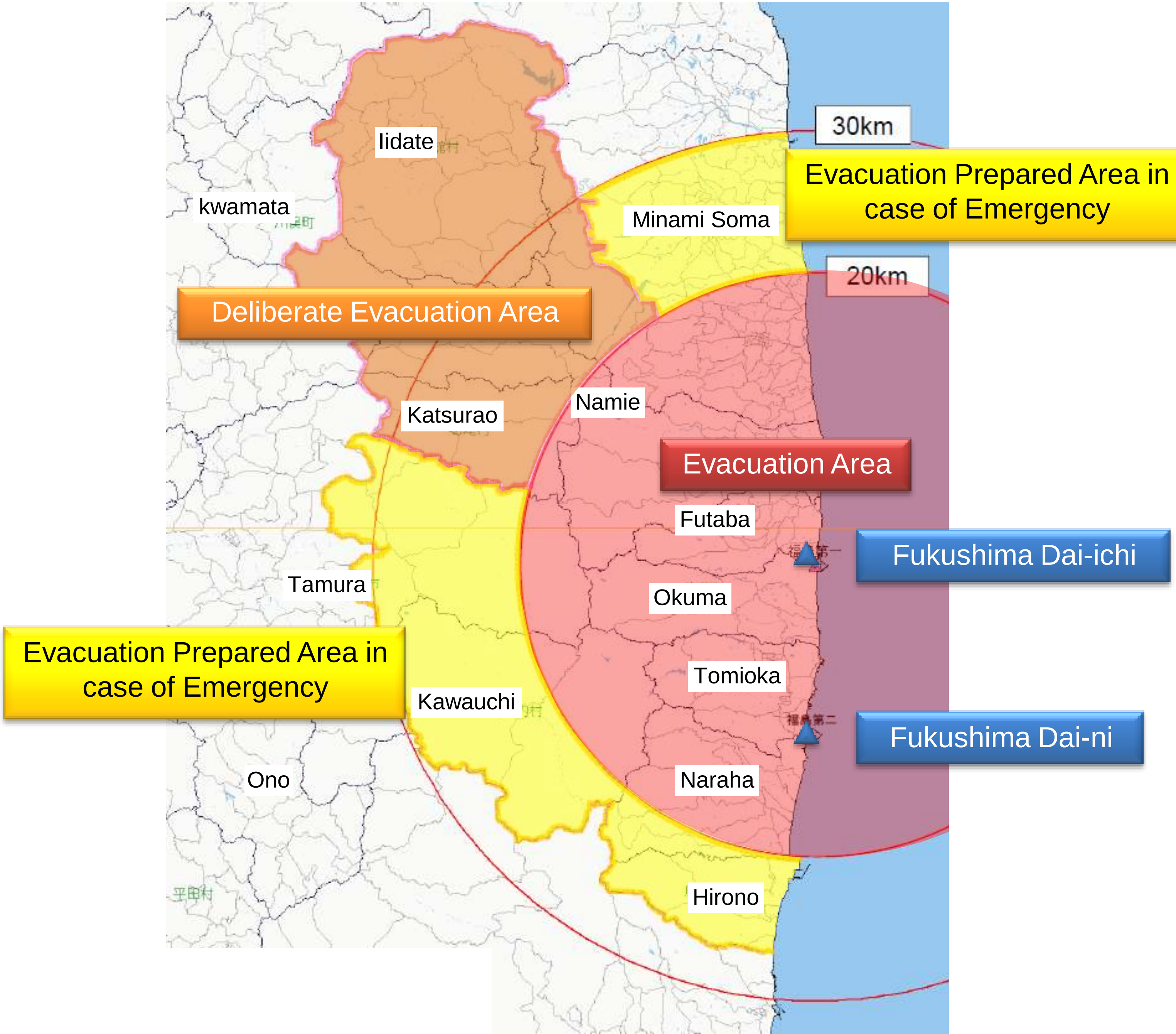
Integrated Dose Estimation Map
(Integrated dose up until March 11,2012)

Protected Areas



*In-house evacuation area excluding deliberate evacuation area was renamed as evacuation prepared area in case of emergency.
**Deliberate evacuation area needed to establish for specific areas beyond 20km radius where radioactive materials are to be accumulated at high levels.

Protected Areas



Number of sufferers

Area	Number of people
Evacuation area	About 78,000 (population in this area)
Deliberate evacuation area	About 10,000 (population in this area)

3. Discharge of Radioactive Materials to the Environment

Unit 1 Distribution of CsI

Code
Methods for Estimation of Leakages and Consequences of Releases (**MELCOR**)

Analysis conditions
- IC worked intermittently until Tsunami attacked. Further operation of IC was not considered.
- Based on the records, HPCI operation was not considered.
- PCV leakage areas (assumption) at 18 hours and at 50 hours are ca. 7 cm^2 and ca. 35 cm^2, respectively.
- Amount of water injected through the fire extinguishing line is based on the records, but varies with RPV pressure.

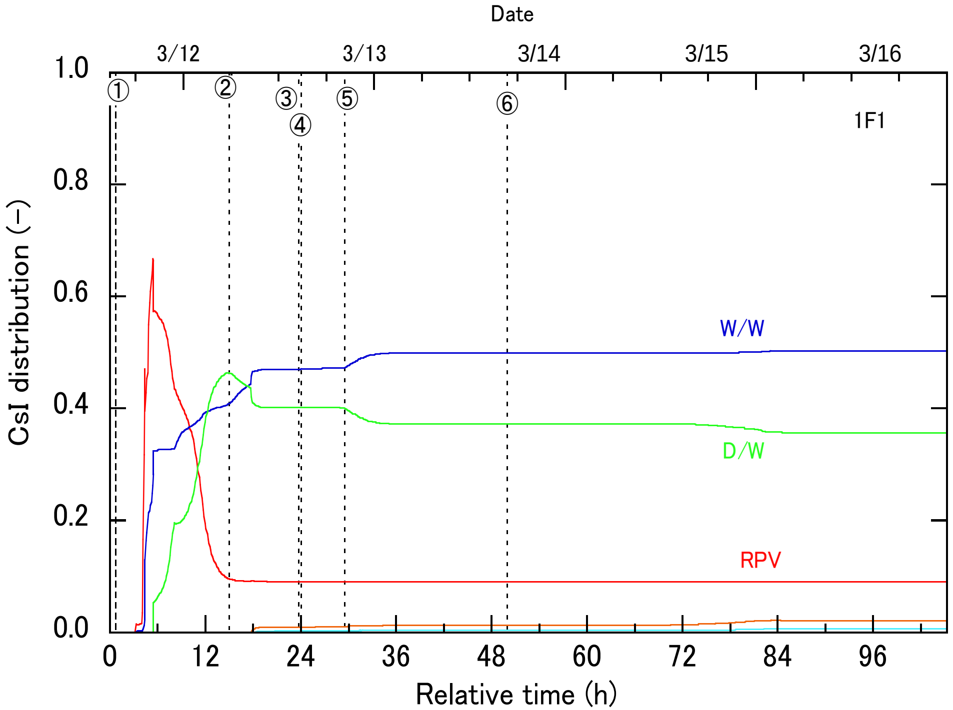


Fig. Distribution of CsI (unit 1) [case 2]
①IC stop, ②PCV failure (assumption), ③W/W ventilation (open), ④W/W ventilation (close), ⑤sea water inject., ⑥ expansion of PCV failure (assumption)

Unit 2 Distribution of CsI

Code

Methods for Estimation of Leakages and Consequences of Releases (**MELCOR**)

Analysis conditions

- RCIC had worked until 13:25 on Mar 14.
- Water source of RCIC is changed from CST to S/P at 4:20 on Mar 12.
- Leakage (ca. 50 cm^2) from gas phase of D/W at 21 hours is assumed.
- Leakage (ca. 300 cm^2) from gas phase of S/C is assumed.
- Amount of water injected through the fire extinguishing line is based on the records, but varies with RPV pressure.

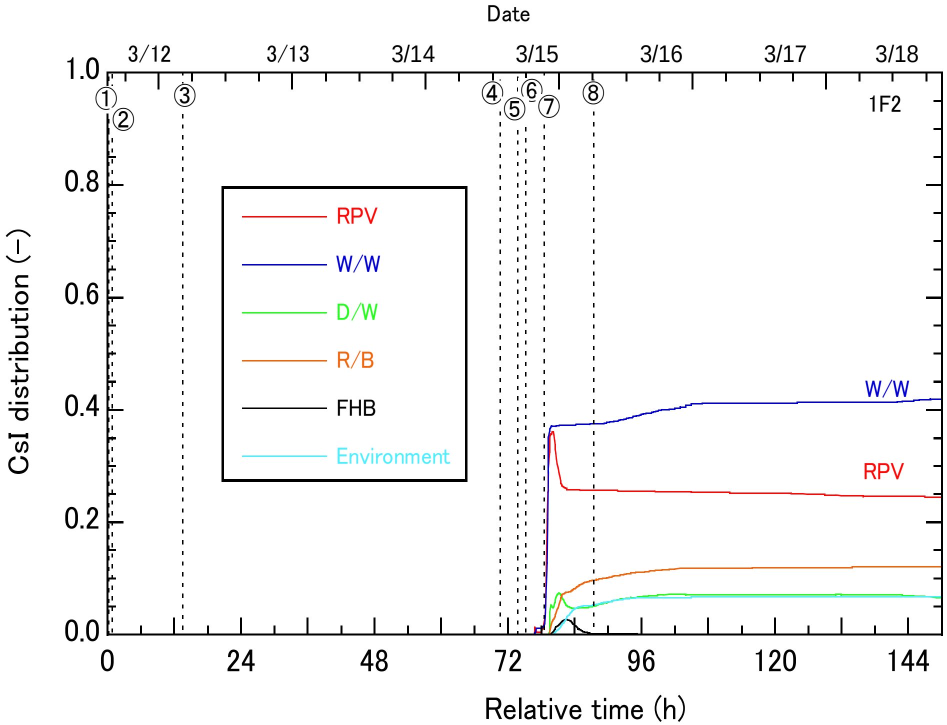


Fig. Distribution of CsI(unit 2) [TEPCO-2]
①RCIC start manually, ②SBO, ③Water source change from CST to S/P, ④RCIC stop, ⑤Sea water inject., ⑥RPV depressurized, ⑦S/R valve-2 open, ⑧Impact sound

Unit 3 Distribution of CsI

<u>Code</u>

Methods for Estimation of Leakages and Consequences of Releases (**MELCOR**)

<u>Analysis conditions</u>

- RCIC had worked until 11:36 on Mar 12.
- HPCI worked from 12:35 on Mar 12 to 2:42 on Mar 13.
- Water source of RCIC and HPCI is CST.
- Depressurization of RPV was confirmed at 9:20 on Mar 13.
- PCV ventilation line was opened and closed repeatedly.
- It is presumed that water injection rate can maintain slightly below the level of the fuel range, and not the flow rate of the discharge side of the fire pump.

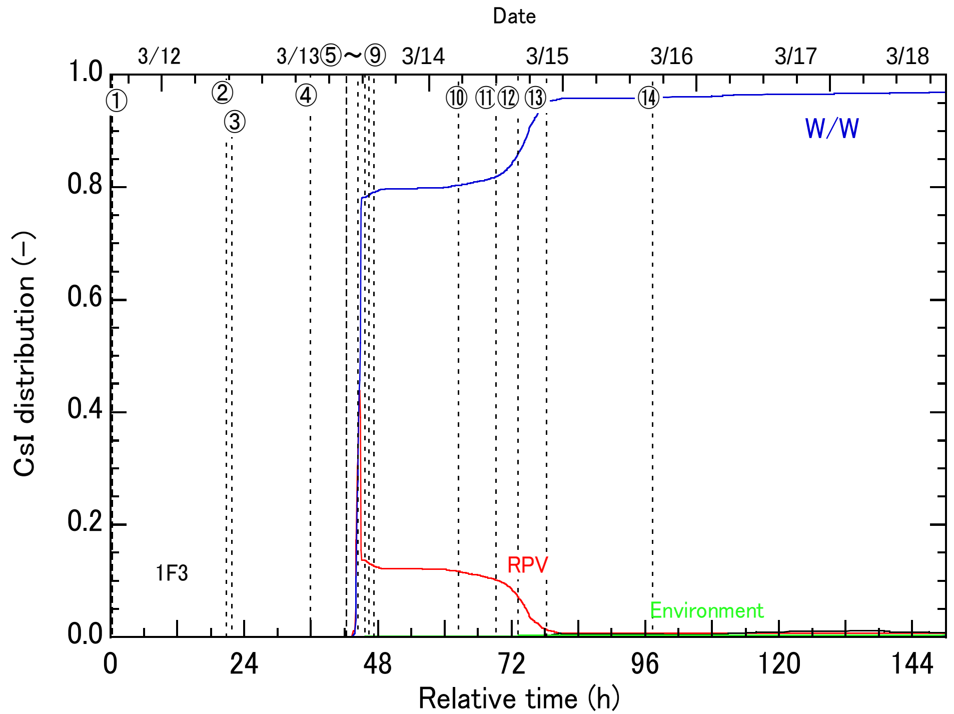


Fig. Distribution of CsI (unit 3) [TEPCO-2]
①RCIC start manually, ②RCIC stop, ③HPCI start, ④HPCI stop, ⑤S/RV(open), ⑥PCV vent (open), ⑦Water inject., ⑧ PCV vent (close), ⑨Sea water inject., ⑩~⑭PCV vent (open⇔close)

Release rate of radioactive materials

Fukushima Dai-ichi	Noble gases	Iodine	Other nuclides
Unit 1	Almost all	1%	Other nuclides: Less than 1%
Unit 2	Almost all	0.4%~7%	Tellurium: 0.4%~3% Cesium : 0.3%~6%
Unit 3	Almost all	0.4%~0.8%	Other nuclides: 0.3%~0.6%

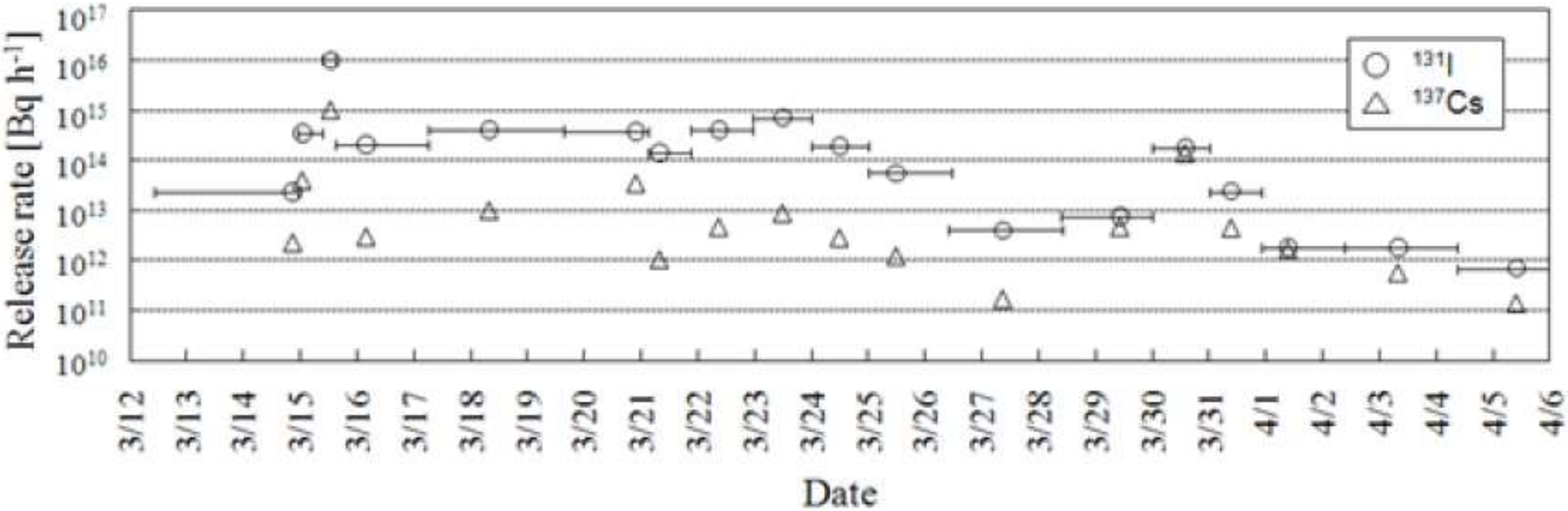
Amounts of radioactive materials discharged to the atmosphere

Organization	I-131	Cs-137
NISA (JNES) (April)*	$1.3X10^{17}$	$6.1X10^{15}$
NISA (JNES) (May)*	$1.6X10^{17}$	$1.5X10^{16}$
NSC (JAEA)**	$1.5X10^{17}$	$1.2X10^{16}$

(Unit: Bq)

*NISA with assistance from JNES made this estimation based on the analysis of reactor status.
**NSC with assistance from JAEA made this estimation based on the data of environmental monitoring and air diffusion calculation.

Provisional discharge rates of I-131 and Cs-137



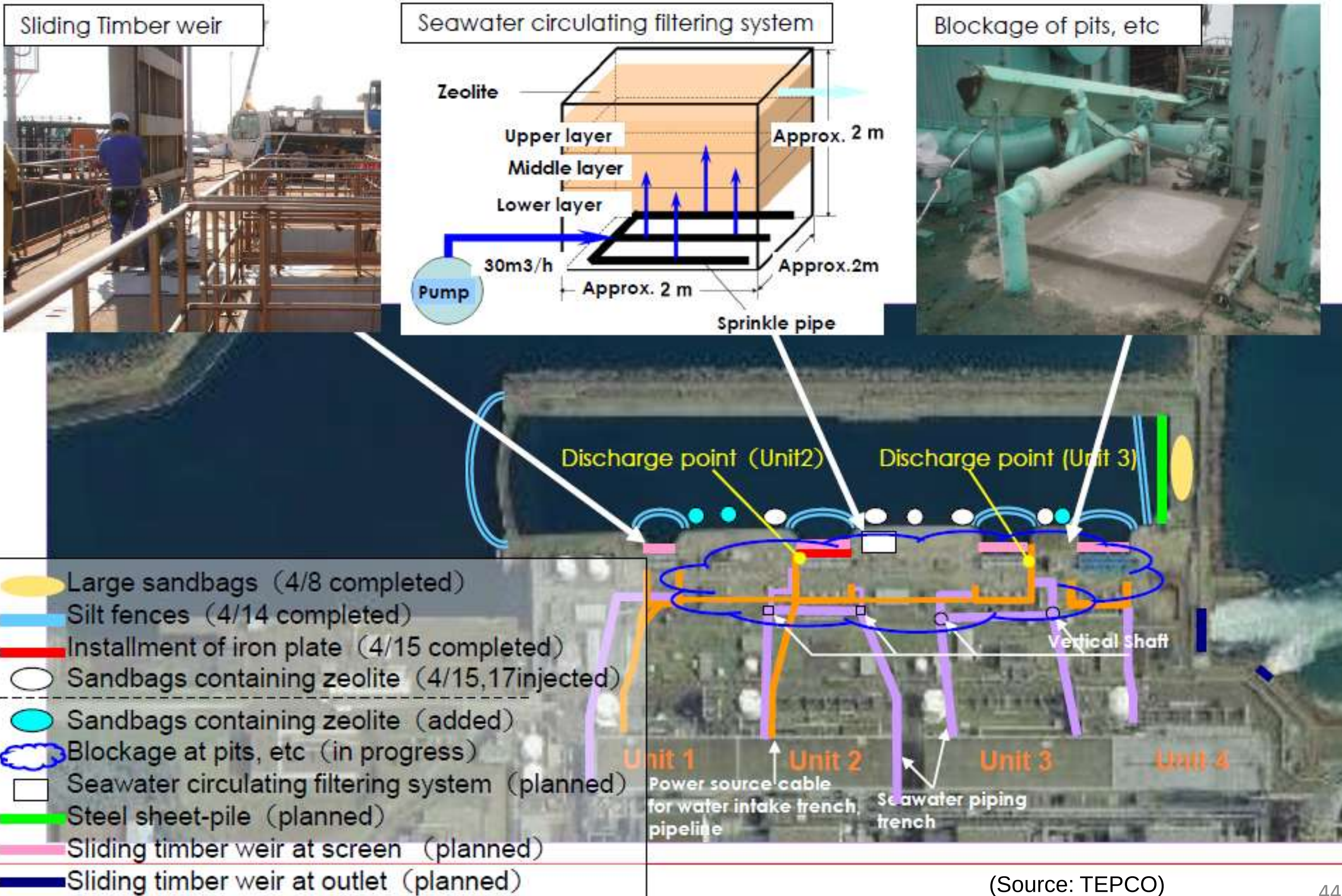
The horizontal bar represents estimated continuing discharge time

(source: Material 4-2 for NSC the 31th held on May 12, 2011)

Release of radioactive materials to the seawater

Events	Results	Remarks
Leakage from Unit2 (2 April -6April)	On April 2, it was discovered that highly contaminated water was flowing into the seawater from the crack on the lateral surface of the pit. Total discharged amount of the radioactive was assumed to be approximately $4.7 X10^{15}$ Bq.	**[Countermeasures]** Drilled a hole into the pit and injected water glass (sodium silicate) into the pit.
Discharge to the sea (4 April-10 April)	In order to secure capacity for highly contaminated water, TEPCO discharged low-level radioactive water into the sea water. Total discharged amount was presumed to be approximately $1.5X10^{11}$ Bq.	The radioactive density monitored at the measurement points including near the power station did not indicate significant fluctuation in comparison with the trend one week before the discharge.
Leakage from Unit3 (11 May)	On May 11, TEPCO confirmed the outflow from a pit near the Intake Channel of Unit3 into the sea. Total amount can be estimated at $2.0X10^{13}$Bq.	**[Countermeasures]** • Inserting fabrics and filling concrete inside pit • Reconfirmation of other leakage possibilities • Strengthening the monitoring

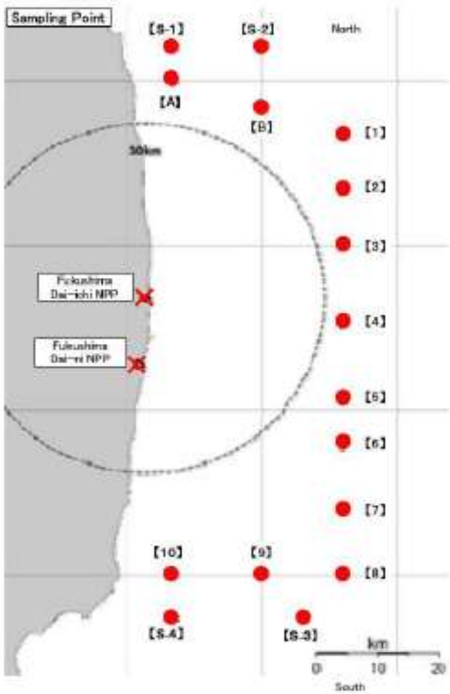
Countermeasures for preventing diffusion of liquid containing radioactive materials

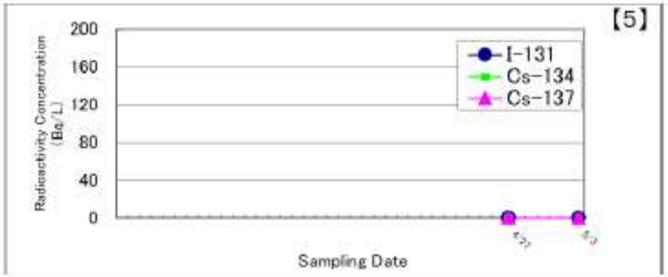


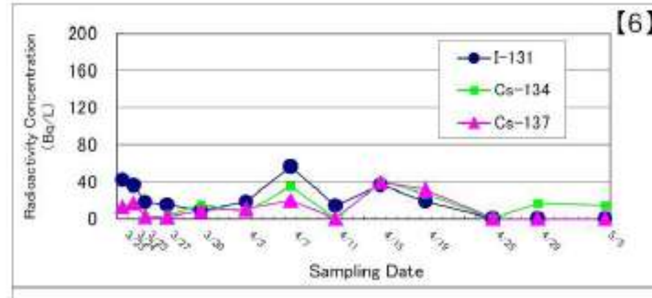
(Source: TEPCO)

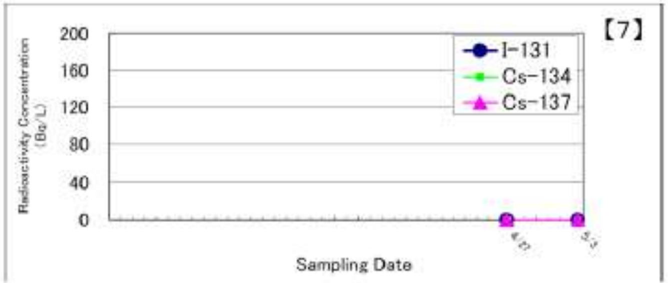
Results of radionuclide quantitative analyses

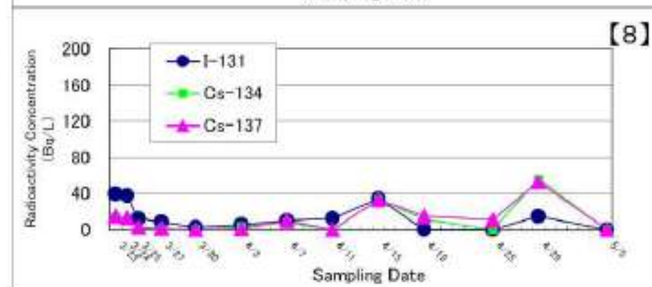
(Sea water: out of 30km zone of Fukushima Dai-ichi NPS)

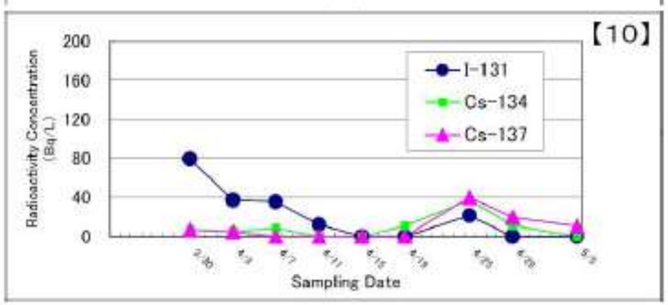


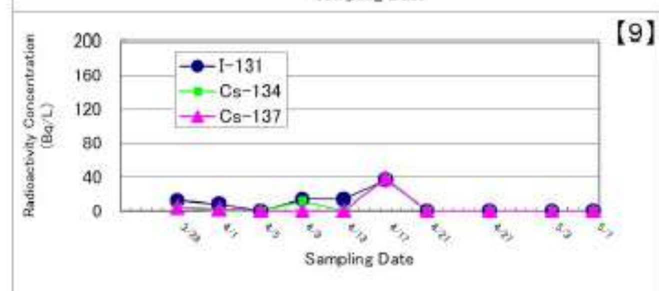


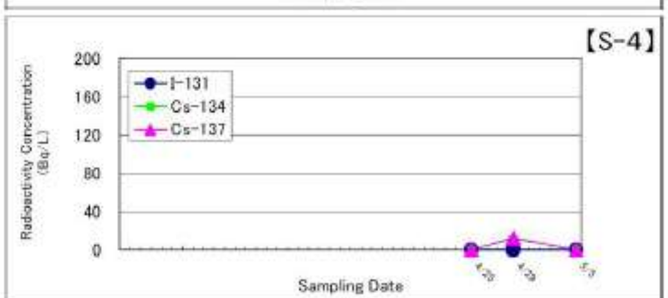


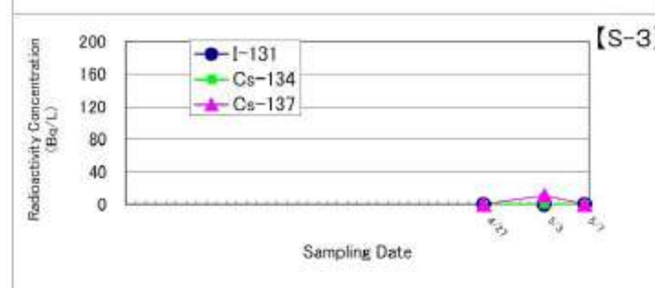




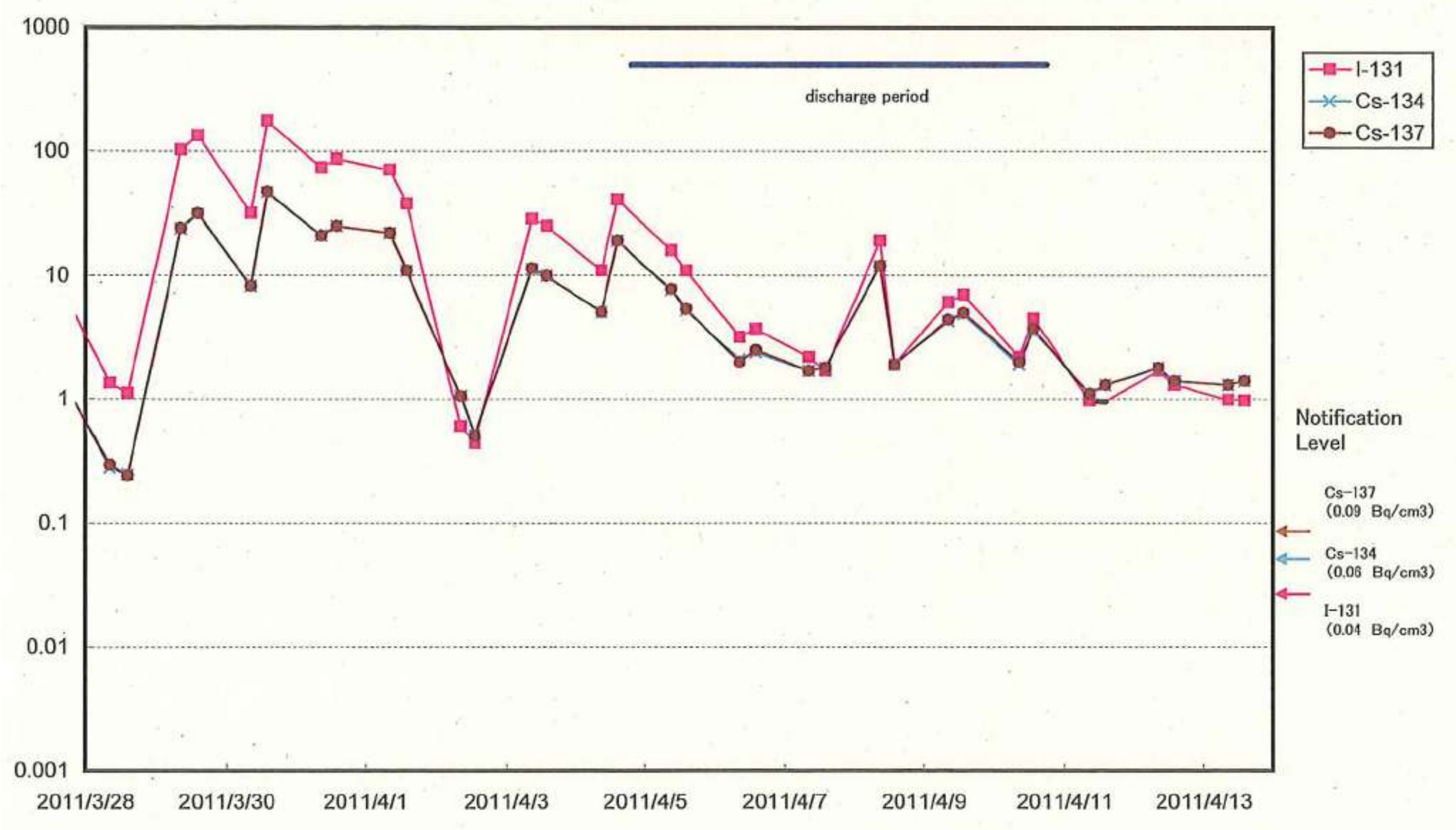




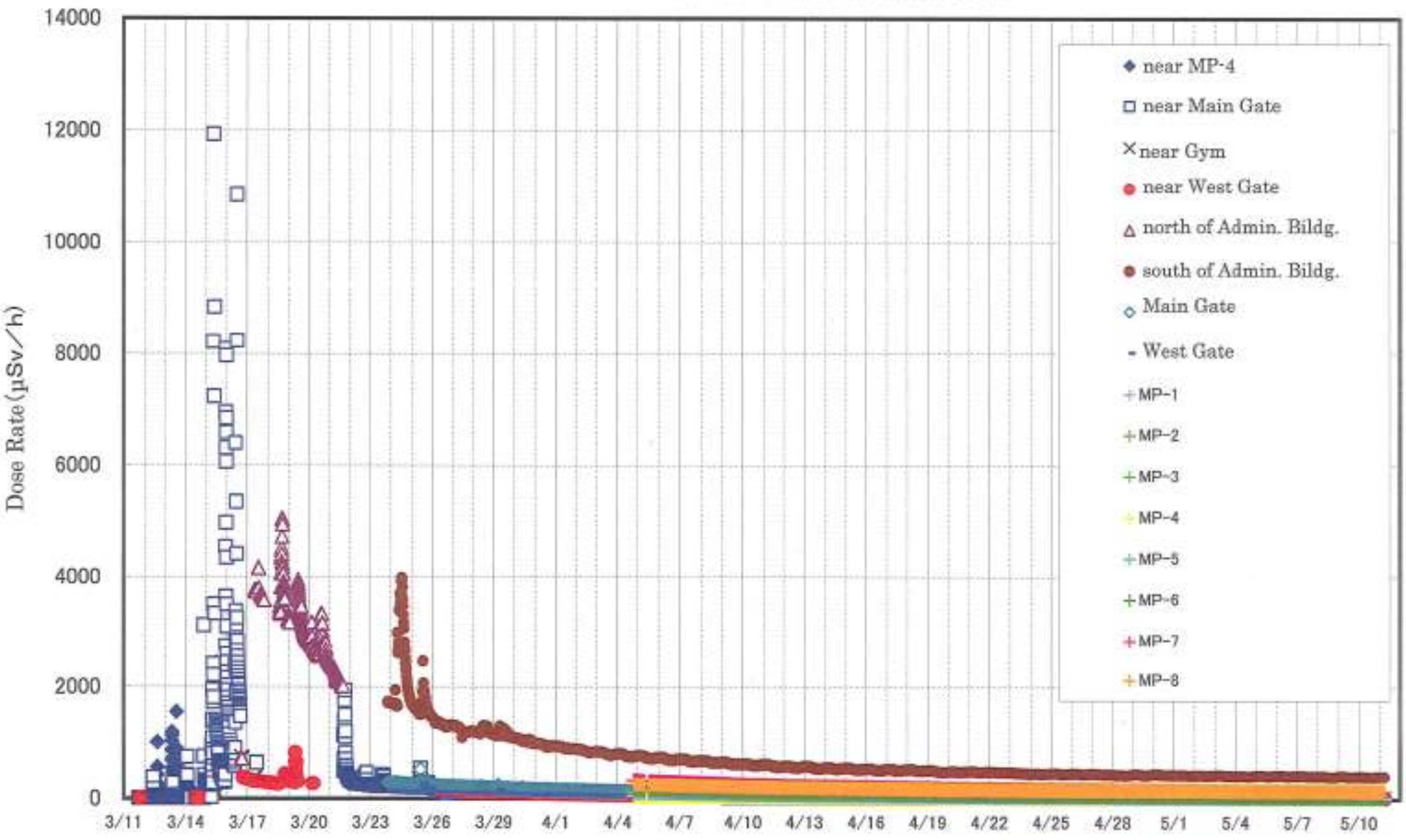




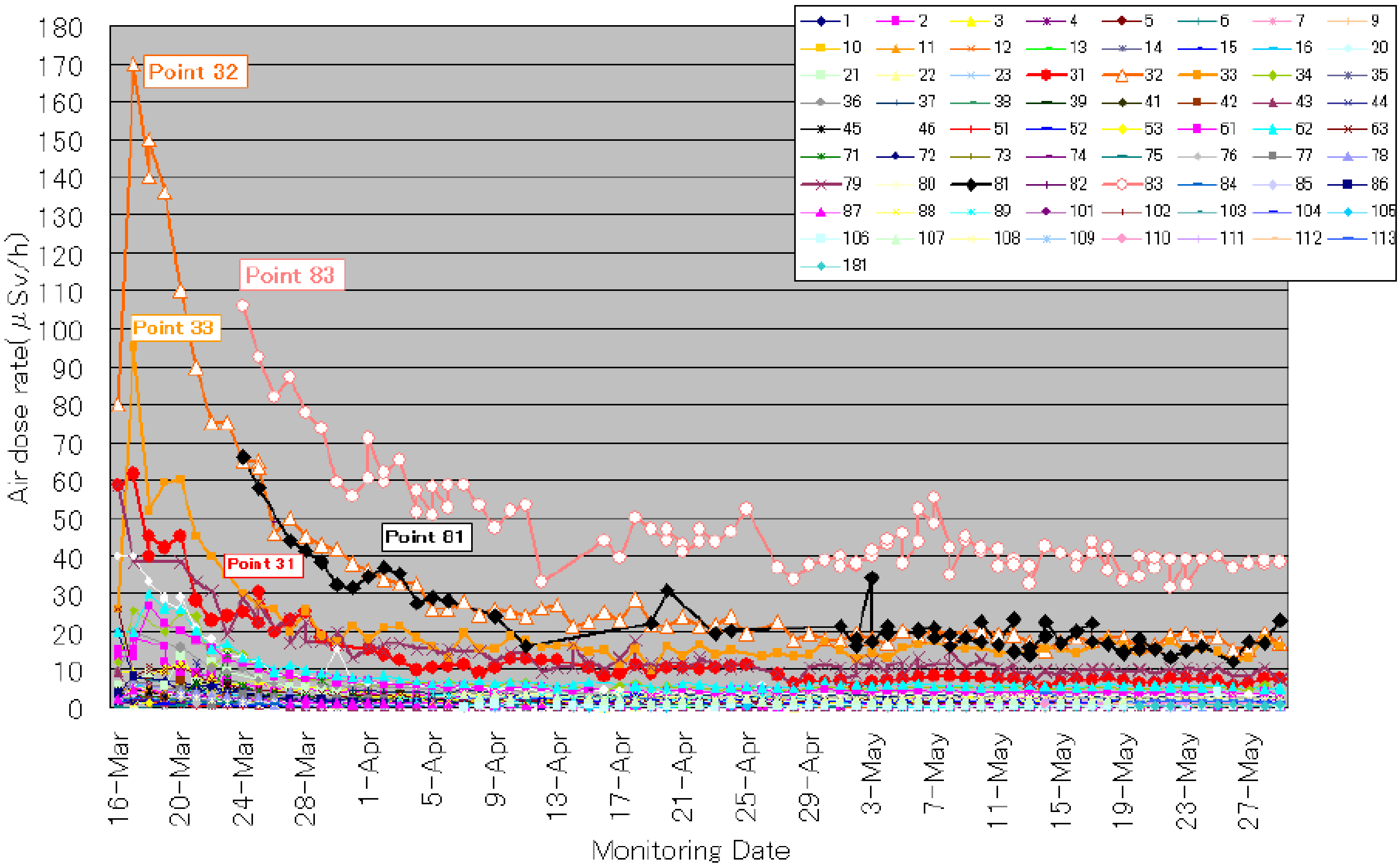
Radioactivity Concentration of Seawater at South Discharge Channel of Fukushima Dai-ichi (Bq/cm³)



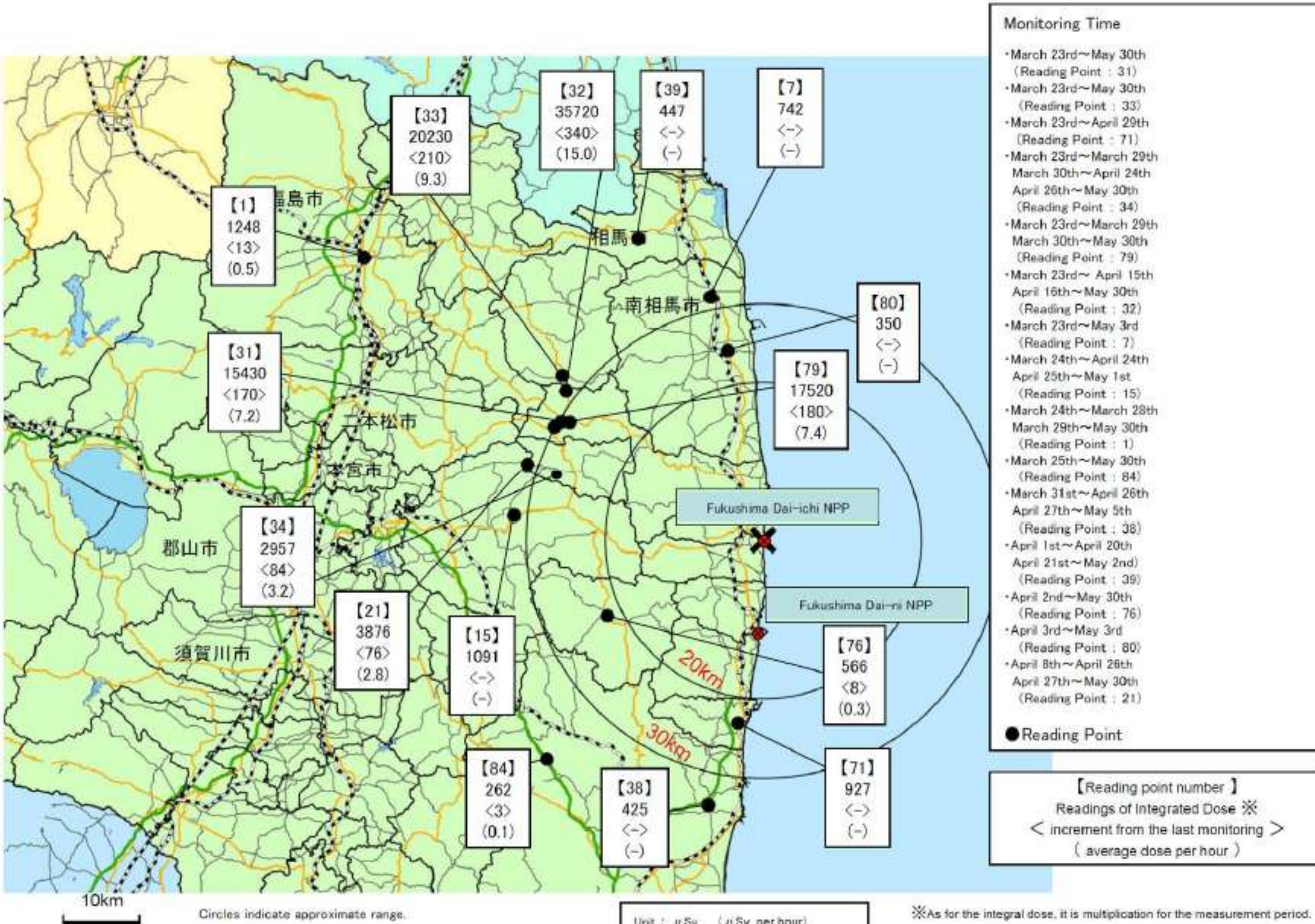
Trend of on-site Radiation Level



Time dependence of air dose rate at reading point out of 20km zone of Fukushima Dai-ichi NPS



Readings of Integrated Dose at Reading point out of Fukushima Dai-ichi NPS



4. Radiation Exposure

Workers

- Revision of dose limit in emergencies based on the accident (March 14)
  - 100mSv → 250mSv
    - ICRP 1990 Recommendations were taken into consideration.

- Radiation control measures by the operators after the accident
  - Many APDs* became unusable due to tsunami.
    - TEPCO made leaders of operational group wear APDs on behalf of the entire group.
    - On April 14, TEPCO resumed the previous system.

- System of radiation control measures in J Village
  - From March 17, J Village was utilized as a place for preparing workers for entry into Fukushima Dai-ichi NPS.

* ADP: Alarm Pocket Dosimeter

Workers

Situation

Number of People	Radiation Exposure
Total 7800 (as of May 23)	Average 7.7mSv
30	> 100mSv
A certain number of people	> 250mSv
2	< 2~3Sv (equivalent doses of the skin)

Future

- The government decided to create a database capable of tracking exposure dose over the long-term for all the workers engaged in emergency work on 17 May.

Residents

Situation

Actions	Results
Screening Survey	Most of the 195,354 people checked as of May31 were under the 100,000cpm limit.
Survey for thyroid exposure	Among the 1,080 children from 0 to 15 years old surveyed, there were no children who exceeded the screening criteria of 0.2 μSv/h

Future

- Fukushima Prefecture will estimate and evaluate the radiation dose for <u>2 million residents</u> in cooperation with related government offices and the National Institute of Radiological Sciences (NIRS).

Situation of distributing stable iodine

- Fukushima Prefecture distributed iodine to cities, towns and villages with administrative districts within 50km of the Fukushima Dai-ichi NPS

Form	Quantities
Pill	About 1.51 million pills for 0.75 million people
Powder	About 6,100 g for 0.12 to 0.18 million people

- No residents took stable iodine based on the instruction because the evacuation had already been completed at the time the instruction of taking iodine was issued.

5. Cooperation with the International Community

Cooperation with the International Community

(1) Experts have visited Japan from such countries as the United States, France, Russia, the Republic of Korea, China and the United Kingdom, exchanged views with relevant organizations in Japan, and given gave much advice regarding stabilizing the nuclear reactors, preventing the diffusion of radioactive materials, etc.

(2) Experts from international organizations specializing in nuclear power such as the IAEA and the OECD Nuclear Energy Agency (OECD/NEA) visited Japan, providing advice and so on. Also, international organizations such as the IAEA, the World Health Organization (WHO), the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), as well as the International Commission on Radiological Protection (ICRP) have provided necessary information to the international community from their own technical standpoints.

6. Communication with the International Community

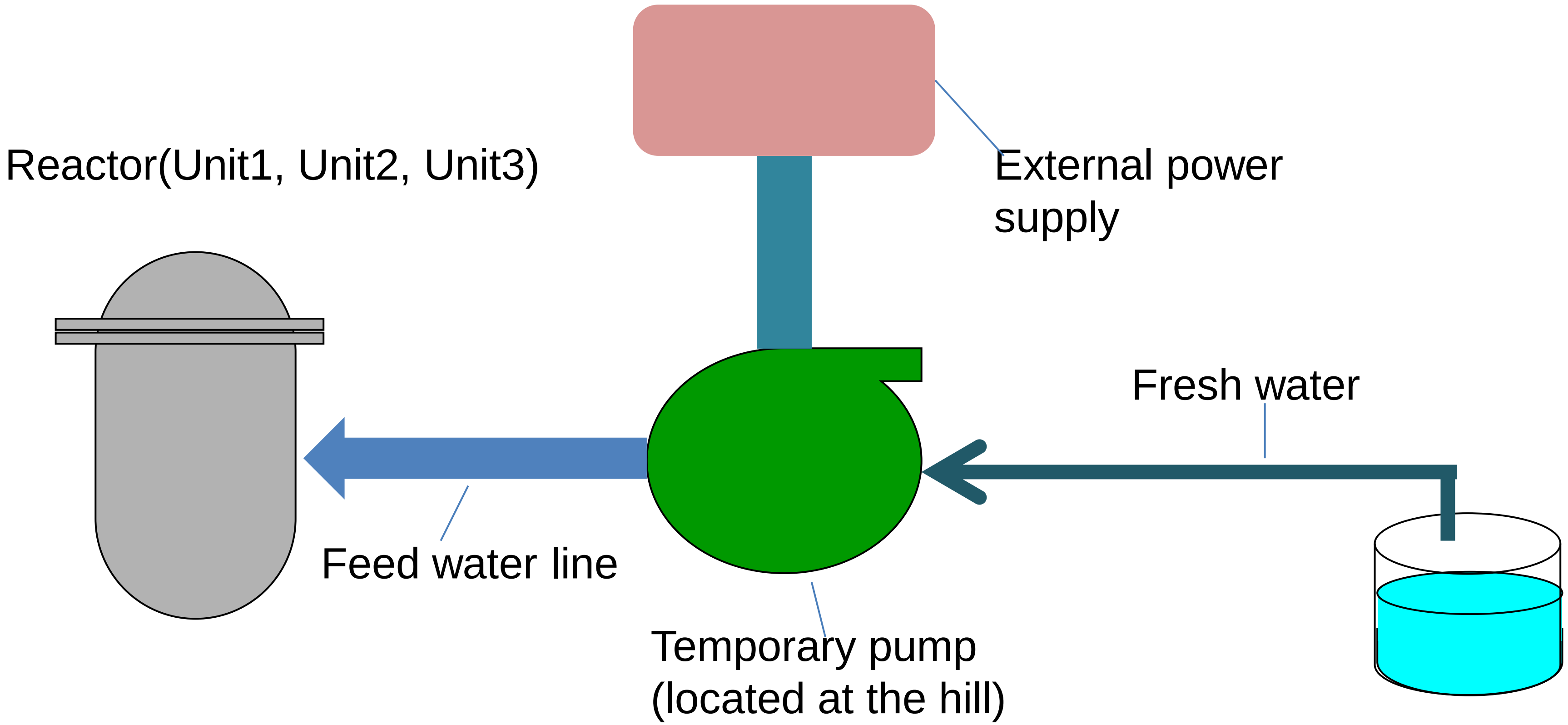
Information provision to the international community

- **Notification to the IAEA pursuant to the Convention on Early Notification of a Nuclear Accident**
- **Briefings for diplomatic corps in Tokyo**
- **Information on the websites in 29 languages**

  (example: Reading of environmental radioactivity level (English version)
  http://www.mext.go.jp/english/incident/1303962.htm)
- **Foreign media briefings**

7. Future Efforts to Settle the Situation

Present situation of feeding water



Status of Unit1, Unit2 and Unit3 of Fukushima Dai-ichi NPS (as of May 31st)

Unit No.	Unit1	Unit2	Unit3
Situation of water injection to reactor	Injecting fresh water via the Water Supply Line. Flow rate of injected water: 6.0 m^3/h	Injecting fresh water via the Fire Extinguish and Water Supply Line. Flow rate of injected water: 7.0 m^3/h (via the fire extinguishing Line), 5.0 m^3/h (via the Feedwater Line).	Injecting fresh water via the Water Supply Line. Flow rate of injected water: 13.5m^3/h
Reactor water level	Fuel range A: Off scale Fuel range B: -1,600mm	Fuel range A: -1,500mm* Fuel range B: -2,150mm*	Fuel range A: -1,850mm* Fuel range B: -1,950mm*
Reactor pressure	0.555MPag(A) 1.508MPag(B)	-0.011MPag(A) -0.016MPag(B)	-0.132MPag(A) -0.108MPag(B)
Temperature related to Reactor Pressure Vessel(RPV)	Feedwater nozzle temperature:114.1°C Temperature at the bottom head of RPV:96.8°C	Feedwater nozzle temperature: 111.5°C Temperature at the bottom head of RPV:110.6°C	Feedwater nozzle temperature: 120.9°C Temperature at the bottom head of RPV:123.2°C
D/W Pressure, S/C Pressure	D/W: 0.1317MPa abs S/C: 0.100 MPa abs	D/W: 0.030MPa abs S/C: Off scale	D/W: 0.0999MPa abs S/C: 0.1855 MPa abs
Status	We are working on ensuring the reliability of cooling function by installing temporary emergency diesel generators and sea water pumps as well as receiving electricity from the external power supplies in each plant.		

* These data may be modified once TEPCO review the data

Roadmap of TEPCO

(17 April,17 May,17 June)

(1) Step I

- Target
  - Radiation dose in steady decline
- Timeline
  - around 3 months

(2) Step II

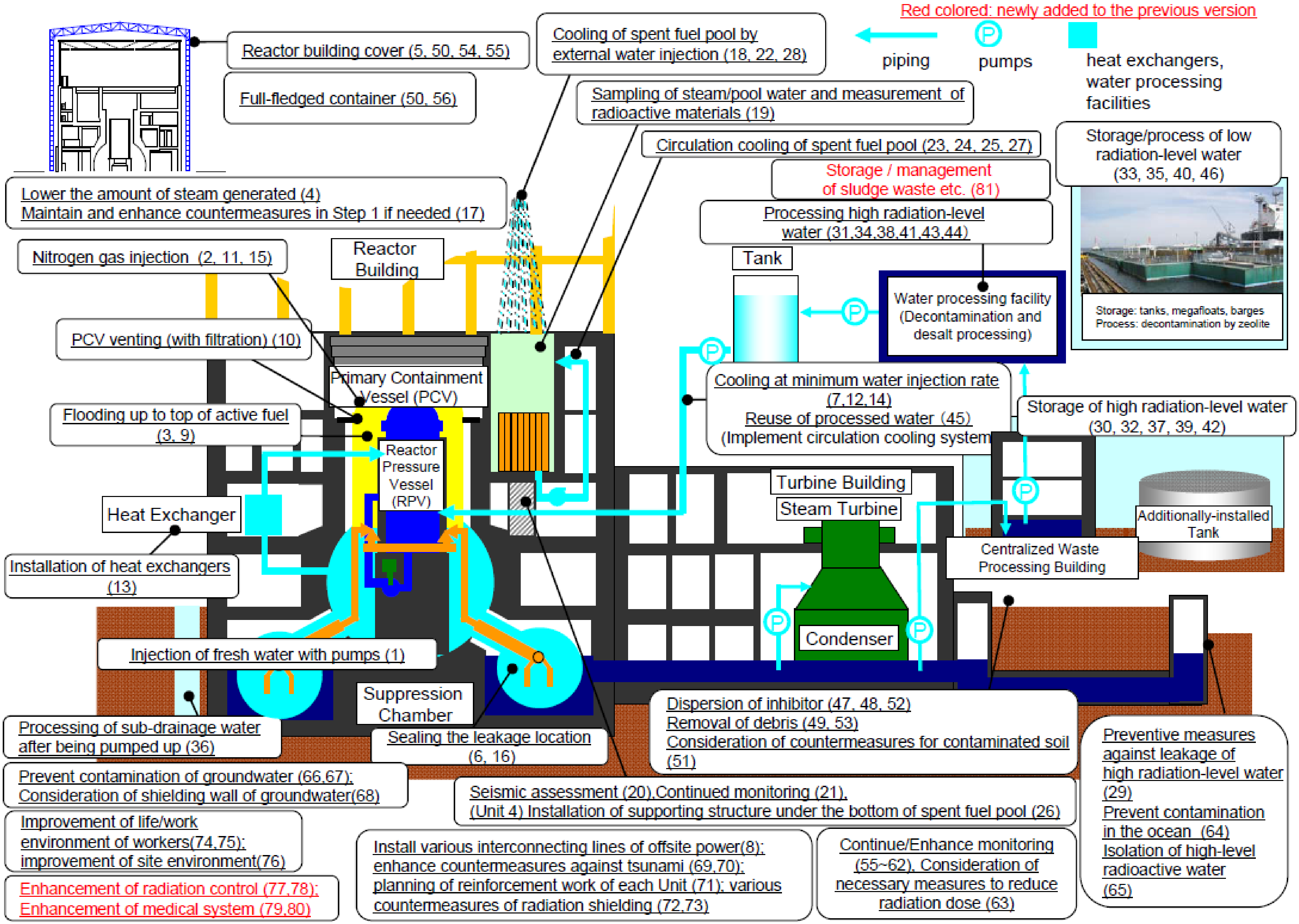
- Target
  - Release of radioactive materials is under control and radiation dose is being significantly held down.
- Timeline
  - around 3 to 6 months after achieving Step I

Efforts to restore the Accident

Red colored: newly added to the previous version, Blue colored: modified from the previous version

Issues	As of April 17	Step 1 (around 3 months)	Current status (as of June 17)	Step 2 (around 3 to 6 months after achieving Step 1)		Mid-term issues
I. Cooling – (1) Reactor	Fresh water Injection	Cooling by minimum injection rate (injection cooling) Consideration and preparation of reuse of accumulated water Circulating Injection Cooling (start) Nitrogen gas injection Consideration and implementation of sealing measure at leaking points of PCV Improvement of work environment	Stable cooling	Circulating Injection Cooing (continued) Nitrogen gas injection PCV flooding Securing heat exchange function	Cold shutdown condition	Protection against corrosion cracking of structural materials *to be partially implemented ahead of schedule
I. Cooling – (2) Spent Fuel Pool	Fresh water injection	Reliability improvement in injection operation /remote-control operation *ahead of schedule Circulation cooling system (installation of heat exchanger) *partially ahead of schedule	Stable cooling	Remote-controlled injection operation Consideration / installation of heat exchanging function	More stable cooling	Removal of fuels
II. Mitigation – (3) Accumulated Water	Transferring water with high radiation level Storing water with low radiation level	Installation of storage / processing facilities Installation of storage facilities / decontamination processing	Secure storage place	Expansion of storage / processing facilities Decontamination / Desalt processing (reuse), etc Storage / management of sludge waste etc. Mitigation of contamination in the ocean	Reduction of total amount of contaminated water	Installation of full-fledged water processing facilities Completion of processing of accumulated water in buildings Processing of sludge waste etc. Mitigation of contamination in the ocean (continued)
II. Mitigation – (4) Ground water		Mitigation of contamination of groundwater	Mitigate ocean contamination	(Sub-drainage management with expansion of storage / processing facilities) Consideration of shielding wall of groundwater	Mitigate ocean contamination (continued)	Solidification of contaminated soil, etc Establishment of shielding wall of groundwater
II. Mitigation – (5) Atmosphere / Soil	Dispersion of inhibitor Removal of debris	Dispersion of inhibitor Removal of debris	Mitigate scattering	Dispersion of inhibitor Removal of debris Installing reactor building cover (with ventilation system) Consideration of reactor building container	Mitigate scattering (continued)	Installation of reactor building container

Overview of Major Countermeasures in the Power Station as of June 17



Main points of Roadmap

Issues		Main points
I. Cooling	Reactor	• Nitrogen gas injection (Step I) • Circulation cooling system in which contaminated water accumulated in buildings is reused for reactor cooling (Step I, II)
	Spent fuel pool	• Circulation cooling system (Step I)
II. Mitigation	Accumulated water	• Installation of storage/processing facilities (Step I)
	Ground water	• Mitigation of contaminated ground water (Step I, II)
	Atmosphere /Soil	• Dispersion of inhibitor (Step I, II) • Removal of debris (Step I, II)

Lifting the designation of evacuation areas

To enhance and implement appropriate environmental monitoring

- To prepare for future dose assessment and evaluation of accumulation of radioactive materials
- To maintain continuous monitoring based on the Environmental Monitoring Enhancement Plan

Radiation protection criteria for public in accident

To examine revision of evacuation areas

- When systems to enable sound and long-term cooling of both nuclear reactors and spent fuel pools are assumed.
- When nuclear reactors are in a cold shutdown state and the release of radioactive materials are basically under control.

8. Responses at Other Nuclear Power Stations

Responses at other Nuclear Power Stations

1. Emergency Safety Measures

- NISA instructed all electric power companies to implement emergency safety measures. (30 March)
- Based on the report from each electric utilities, NISA has confirmed that emergency safety measures had been appropriately implemented.(6 May)

2. Additional Emergency Safety Measures

- NISA and other relevant ministries are to improve and strengthen the emergency safety measures based on lessons learned from the accidents which are stated within this report. (7 June)

3. Hamaoka NPS shutdown

- The government requested Chubu Electric Power Company to halt the operation of all units of Hamaoka NPS due to high possibility of large-scale tsunami resulting from the envisioned earthquake within mid to long term countermeasures. (6 May)

Outline of Emergency Safety Measures

Phase	Emergency Safety Measures	
	Short Term	Mid Term
Expected Time to Completion	Done	One to three years
Goals(Desired Level/Extent)	Preventing fuel damage and spent fuel damage even if (1) AC power supplies, (2) seawater cooling functions and (3) spent-fuel storage pool cooling functions are all lost.	Enhancing reliability of emergency safety measures (short term) (Securing/speeding up achievement of cold shutdown; measures against tsunami)
Examples of Specific Measures	【Securing Equipment】 ● Deploying power generator vehicles (to support cooling reactors and spent fuel pools) ● Deploying fire engines (to supply cooling water) ● Deploying fire hoses (to secure water supply routes from freshwater tanks, seawater pits, etc.) 【Preparing Procedural Manuals, Etc.】 ● Preparing procedural manuals for emergency responses utilizing the above-mentioned equipment 【Training to Respond】 ● Implementing training for emergency responses based on the procedural manuals 【Measures Against Flooding】 ● Measures to prevent flooding at reactor buildings assuming approx. 15-meter-high tsunami	【Measures Against Assumed approx.15-Meter Tsunami】 ● Building seawalls ● Installing water-tight doors 【Measures to Secure/Speed Up Achievement of Cold Shutdown】 ● Installation of air-cooled diesel power generators ● Securing back-up electric motors for seawater pumps ● Actions needed for other necessary equipment

Implementation of Preparatory Measures for Severe Accidents

- Based on Lessons in Category 2 in the government's report to the IAEA, actions were identified as needed to enable prompt responses even if a severe accident (e.g., major core damage) has begun.
- Of them, electric power companies and others were instructed to implement the following five measures immediately and report on their implementation, which was done and confirmed. Other measures will be implemented as medium- and long-term measures.

(1) Securing work environment at main control rooms

In order to secure work environments in emergencies at central control rooms (radiation protection, etc.), emergency ventilation and air conditioning systems (circulation systems) for such control rooms must be operable with power from vehicle-mounted power generators even if all AC power supplies are lost.

(2) Securing means of emergency communication within plant premises

In order to smoothly carry out work on plant premises during emergencies, robust means of communication must be secured even if all AC power supplies are lost.

(3) Securing supplies and equipment, including high-dose protective suits, and establishing a system to manage radiation

In order to ensure protection of workers against radiation and radiation management in emergencies, supplies and materials, including high-dose protective suits and individual dosimeters must be maintained, including arrangements for mutual accommodations among operators. Systems to increase personnel for radiation management at times of emergencies must be established.

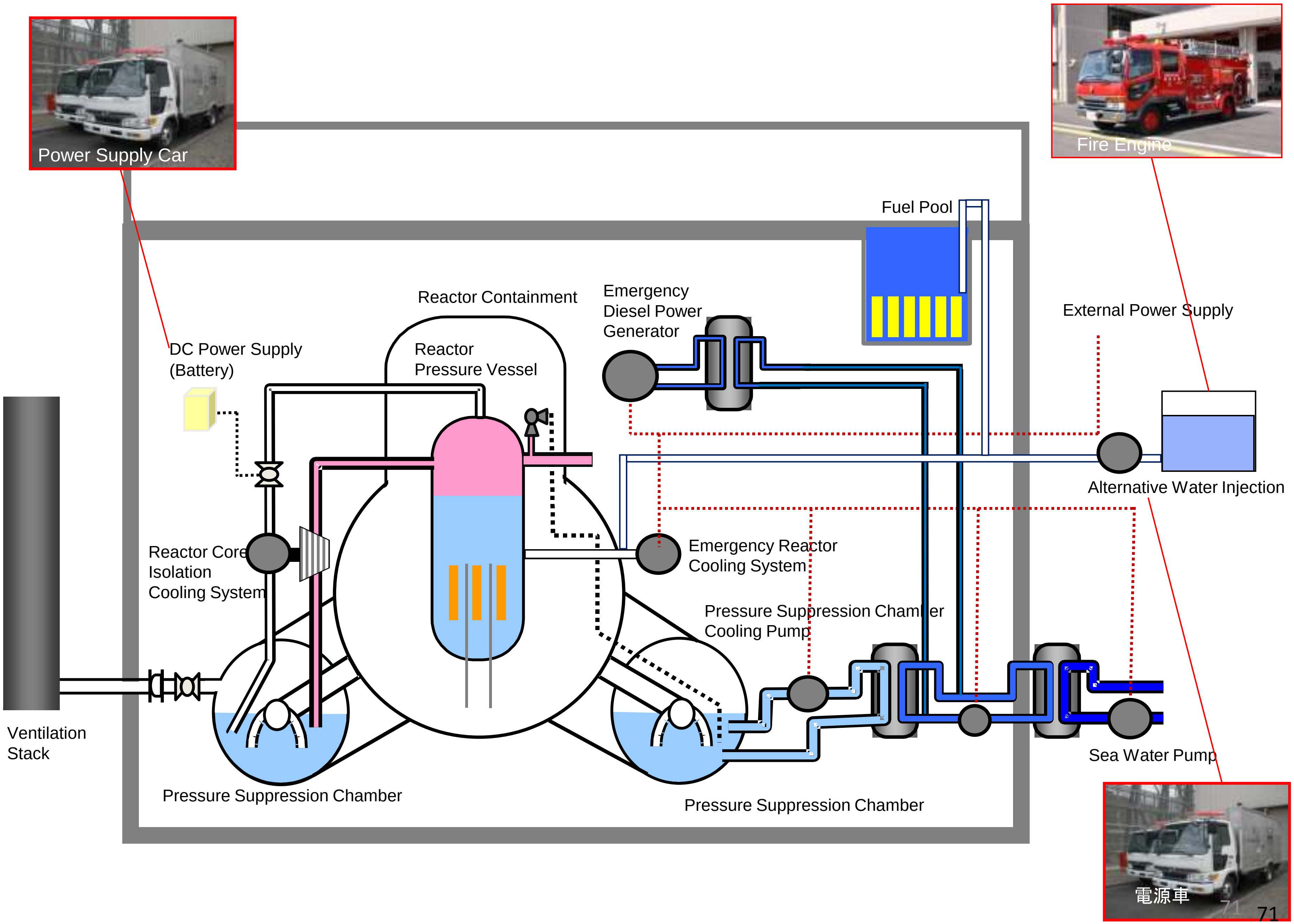
(4) Measures to prevent hydrogen explosions

In order to prevent damage to facilities by hydrogen explosions as a result of core damage, etc., large amounts of hydrogen generated in emergencies as a result of core damage, etc., must not be allowed to accumulate in reactor buildings, etc. (Operating annulus circulation and exhaust systems, etc.)

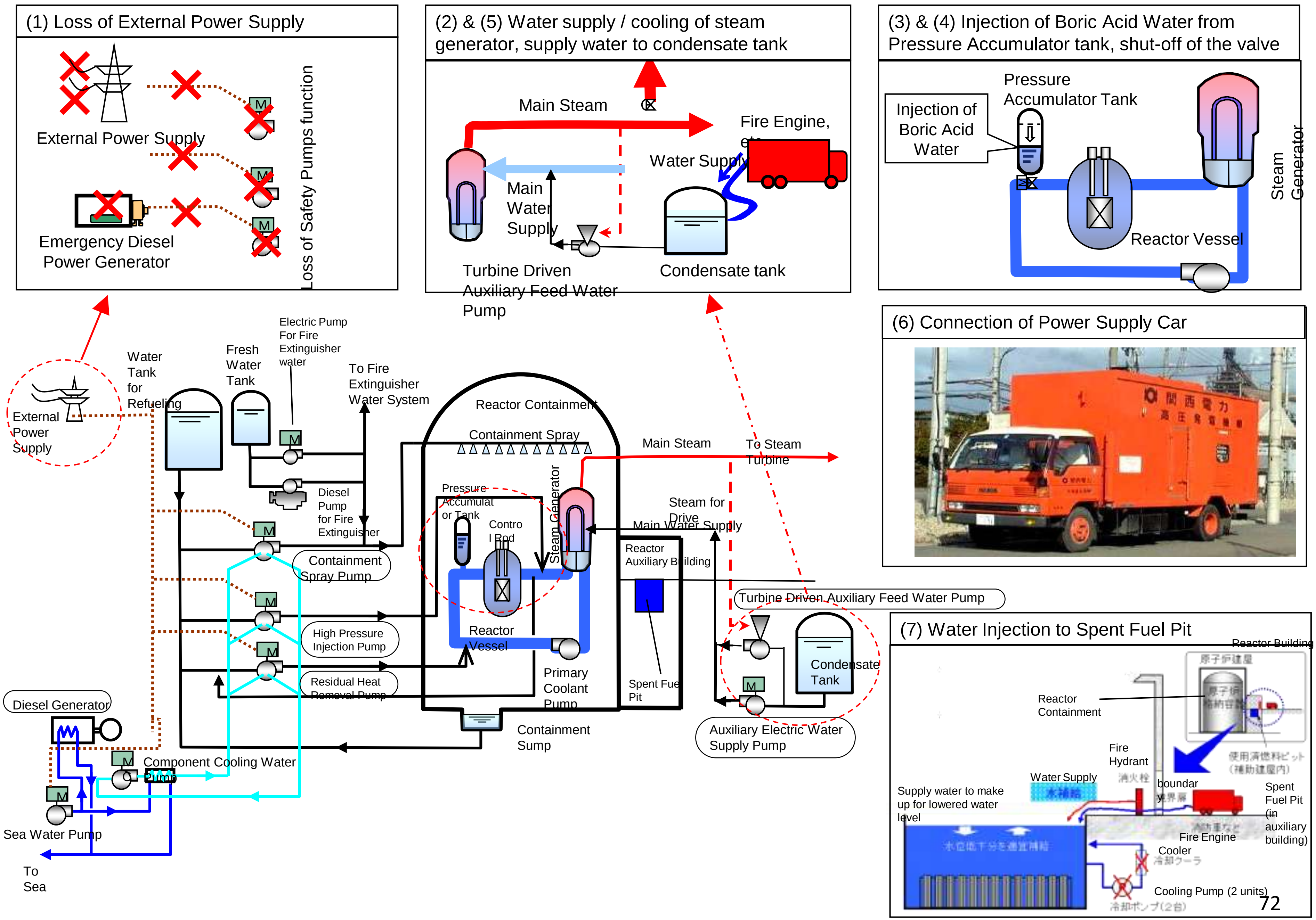
(5) Deploying heavy machinery to remove debris

In order to promptly remove debris in emergencies, created by tsunami, etc., heavy machinery, including wheel loaders, must be deployed.

Series of Events and Countermeasures in case of tsunami, for BWR



Series of Events and Countermeasures in case of tsunami, for PWR



9. Lessons Learned from the Accident Thus far

Lessons in Category 1
Strengthen preventive measures against a severe accident

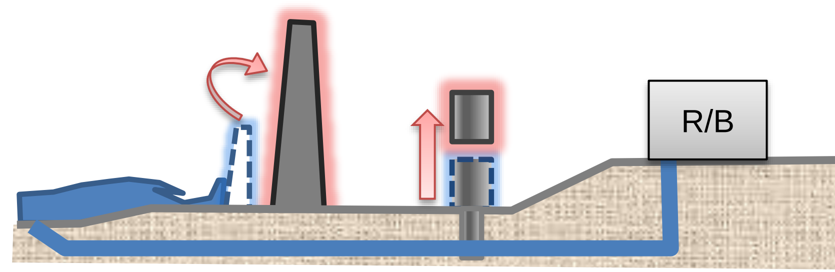
(1) Strengthen measures against earthquakes and tsunamis

- Measures against large-scale tsunamis were not prepared adequately.

- To assume appropriate frequency and adequate height of tsunamis in consideration of a sufficient recurrence period for attaining a safety goal
- To perform a safety design of structures, etc. to prevent the impact of flooding of the site caused by tsunamis of adequately assumed height

Photo: TEPCO

Watertight door



Sea wall   Sea water pumps

Lessons in Category 1
Strengthen preventive measures against a severe accident

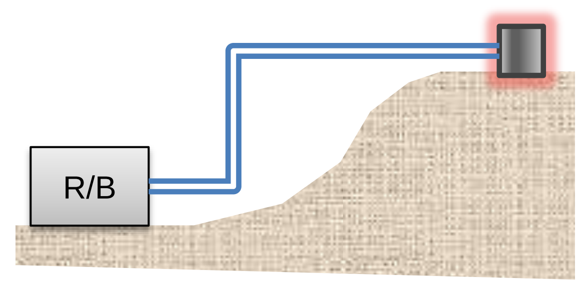
(2) Ensure power supplies

- Power supply sources were not diversified against common cause failures arising from an external event.

- To secure a power supply at sites for a longer time set forth as a goal, even severe circumstances, through diversification of power supply

Power supply car

Power generator for disaster preparedness

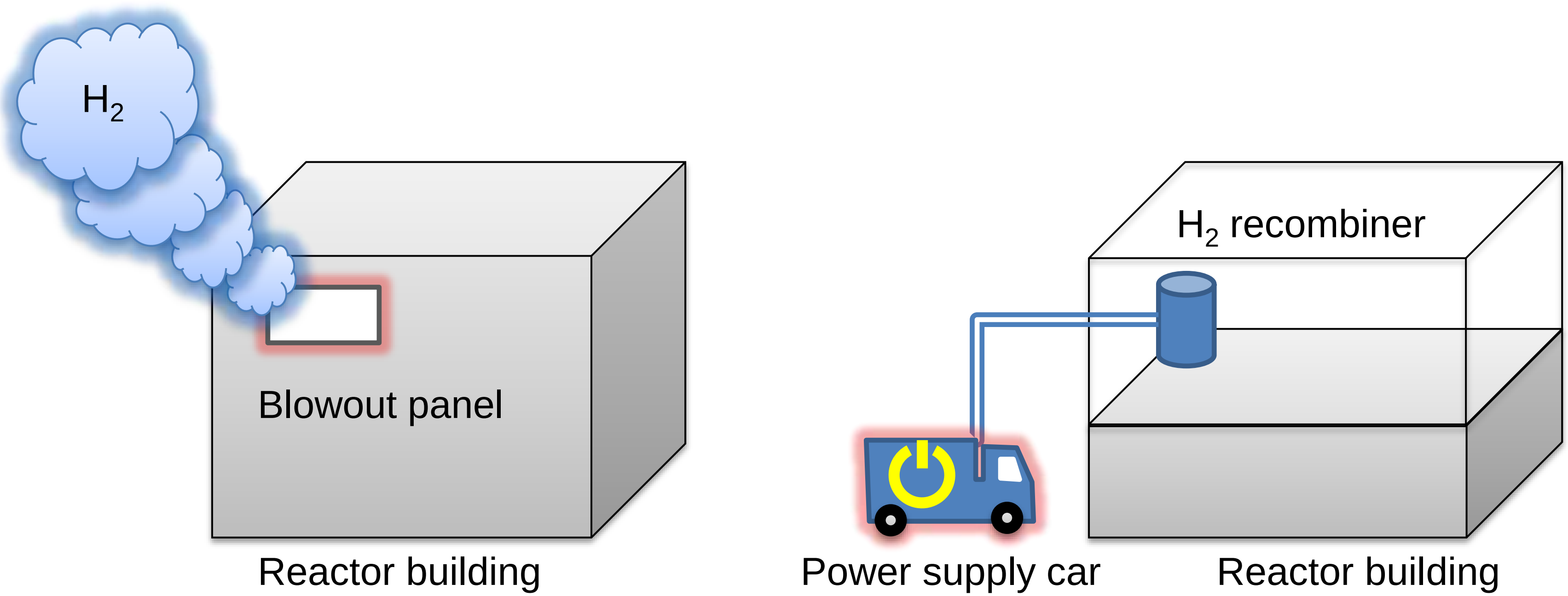


Location of power generator for disaster preparedness

(9) Enhancement of measures to prevent hydrogen explosions

- Hydrogen measures for reactor building were not taken.

- To enhance measures to prevent hydrogen explosions in the event of a severe accident in reactor buildings



Lessons in Category 3
Enhancement of nuclear emergency responses

(16) Response to combined emergencies of both large-scale natural disasters and prolonged nuclear accident

- Tremendous difficulty in communication, mobilizing human resources and procuring supplies when addressing the nuclear accident that coincided with a massive natural disaster

- To prepare the structures and environments where appropriate communication tools and devices and channels to procure supplies in the case of both a massive natural disaster and a prolonged nuclear accident

Photo: TEPCO

Lessons in Category 4
Reinforcement of safety infrastructure

(23) Reinforcement of safety regulatory bodies

- It was not clear where the primary responsibility lies in ensuring citizens' safety in an emergency.

- The Japanese Government will separate NISA from METI and start to review implementing frameworks, including the NSC and relevant ministries, for the administration of nuclear safety regulations and for environmental monitoring.

Lessons in Category 5
Thoroughly instill a safety culture

(28) Thoroughly instill a safety culture

- Have the operators been serious in introducing appropriate measures for improving safety, when they are not confident that risks concerning the public safety of the plant remain low?

- Have the regulators been serious in addressing new knowledge in a responsive and prompt manner, not leaving any doubts in terms of safety?

- To establish a safety culture by going back to the basics, namely that pursuing defense-in-depth is essential for ensuring nuclear safety, by constantly learning professional knowledge on safety, and by maintaining an attitude of trying to identify weaknesses as well as room for improvement in the area of safety

10. Conclusion

Conclusion

- The Japanese Government is determined to make its utmost efforts to support the people engaged in this work at the accident site.

- Japan has recognized that a fundamental revision of its nuclear safety preparedness and response is inevitable.

- Japan will promote the “Plan to Enhance the Research on Nuclear Safety Infrastructure” to promote research to enhance preparedness and response against severe accidents through international cooperation.

Thank you for your attention

We express our deepest gratitude to the support towards restoration from the accident received from many countries around the world.

We would sincerely appreciate continued support from the IAEA and countries around the world.

We will be able to overcome this accident by uniting the wisdom and efforts of not only Japan but also the world.

Reference

The access to the report:

http://www.kantei.go.jp/foreign/kan/topics/201106/iaea_houkokusho_e.html