

# **The 3/11 Fukushima Nuclear Accident: What Happened and Lessons learned (so far)**

**“The Nuclear Renaissance and the Risks of Nuclear  
Proliferation in Asia”**

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*note: The views expressed here are of my own and do not necessarily reflect those of the JAEC nor the government.*



# Summary

- The 3/11 Fukushima nuclear accident triggered by the East Japan Great Earthquake is one of the worst in nuclear history (and not yet under control) and can undermine entire public trust in nuclear safety not only in Japan but also in the world.
- It is Japan's responsibility to disclose and share the information as much as possible with the public and the rest of the world.
- Independent and thorough investigation should be conducted in a manner that the international community can verify and draw lessons.
- Securing safety and welfare of local public is the first priority. At the same time, assuring safety of existing nuclear power plants, including spent fuel storage, is also critically important.



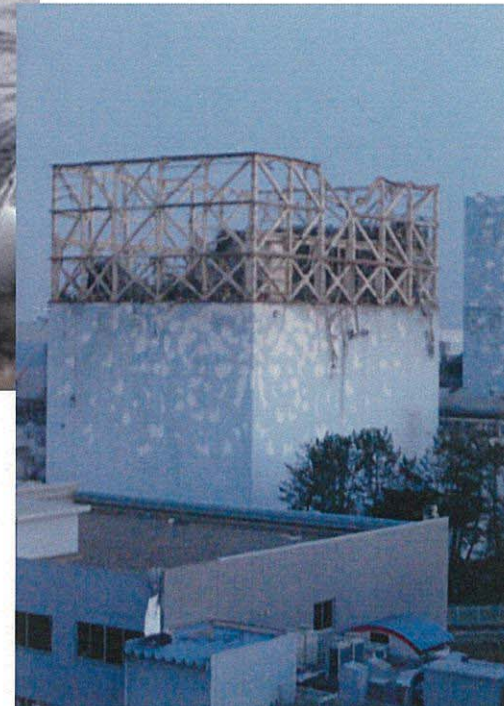
# CONTENTS

- What happened (and what is happening)?
  - The Earthquake
  - Fukushima Daiichi Reactors (Unit 1~4)
  - Impact on public and environment
- Lessons learned (so far)
  - Emergency safety measures
- What should we do from now?
  - Road Map towards cold shutdown (Tepco)
  - Investigation of the accident
  - Reassessment of energy/nuclear energy policy





# What Happened (or is happening)?





# Tsunami at Fukushima



# Nuclear Power Plants in Japan (as of March 2010)

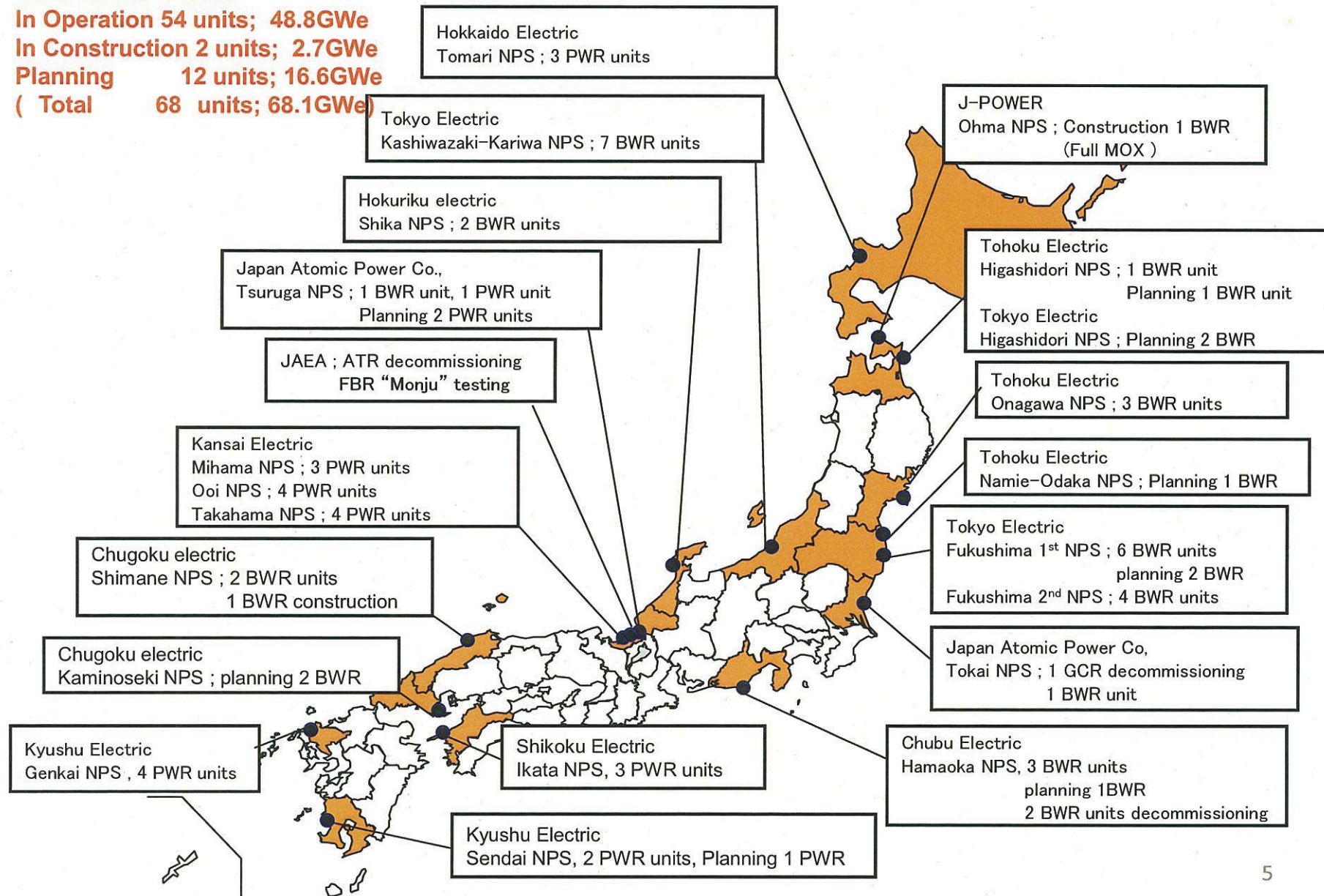
## Commercial Plants

In Operation 54 units; 48.8GWe

In Construction 2 units; 2.7GWe

Planning 12 units; 16.6GWe

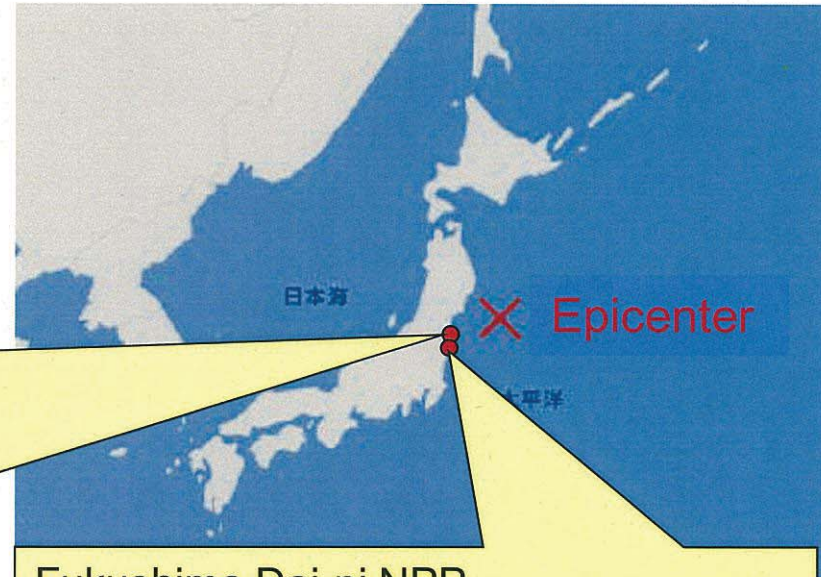
( Total 68 units; 68.1GWe)





# 2011 East Japan Great Earthquake

Fukushima Dai-ichi NPP



Fukushima Dai-ni NPP



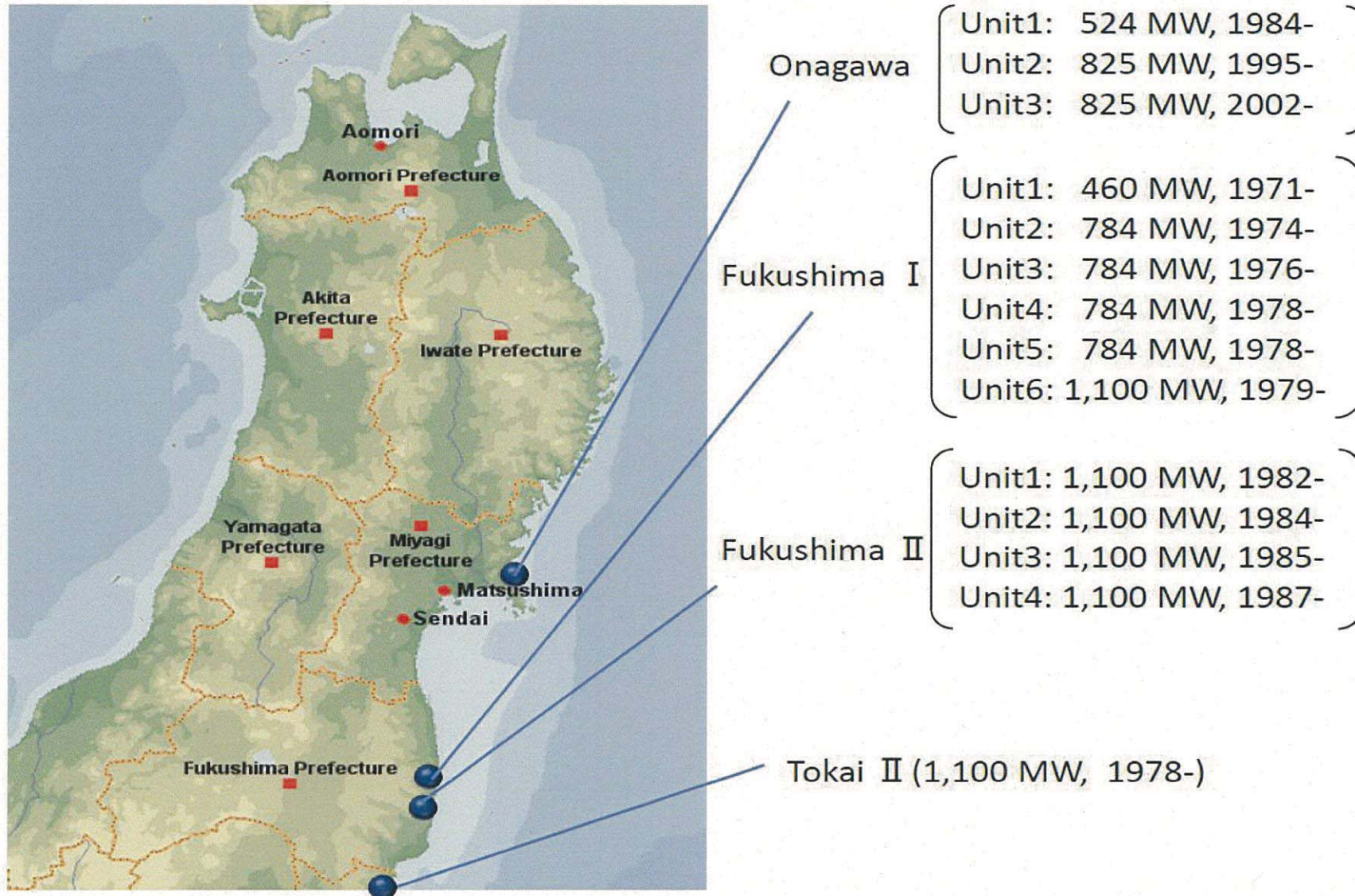
- Occurred 14:46 March 11, 2011
- Magnitude: 9.0 Mw
- Epicenter location: 38° 6"N and 142° 51"E, and 24km in depth
- It is said that the height of tsunami attacked Fukushima NPP was more than 14m





# Nuclear reactors near epicenter of the earthquake

## Location of the Nuclear Installations



## Automatic shut-down of nuclear reactors

### ● 11 reactors were automatically shut-down

- Onagawa Unit 1,2,3
- Fukushima Dai-ichi (I) Unit 1,2,3
- Fukushima-Dai-ni (II) Unit 1,2,3,4
- Tokai Dai-ni (II)

### ● 3 reactors were under periodic inspection

- Fukushima Dai-ichi (I) Unit 4,5,6

-After the automatic shut-down, the Unit 1-3 at Onagawa Nuclear Power Station, the Unit 3 at Fukushima II Nuclear Power Station, and the Unit at Tokai II Nuclear Power Station have been cold shut down safely.

-As for the unit 1,2,4 at Fukushima II Nuclear Power Station, the operator of the station reported NISA nuclear emergency situation because the temperature of the suppression pools became more than 100 °C, but afterward the three units have been cold shut down.





# Summary of Fukushima Daiichi Nuclear Power Plants

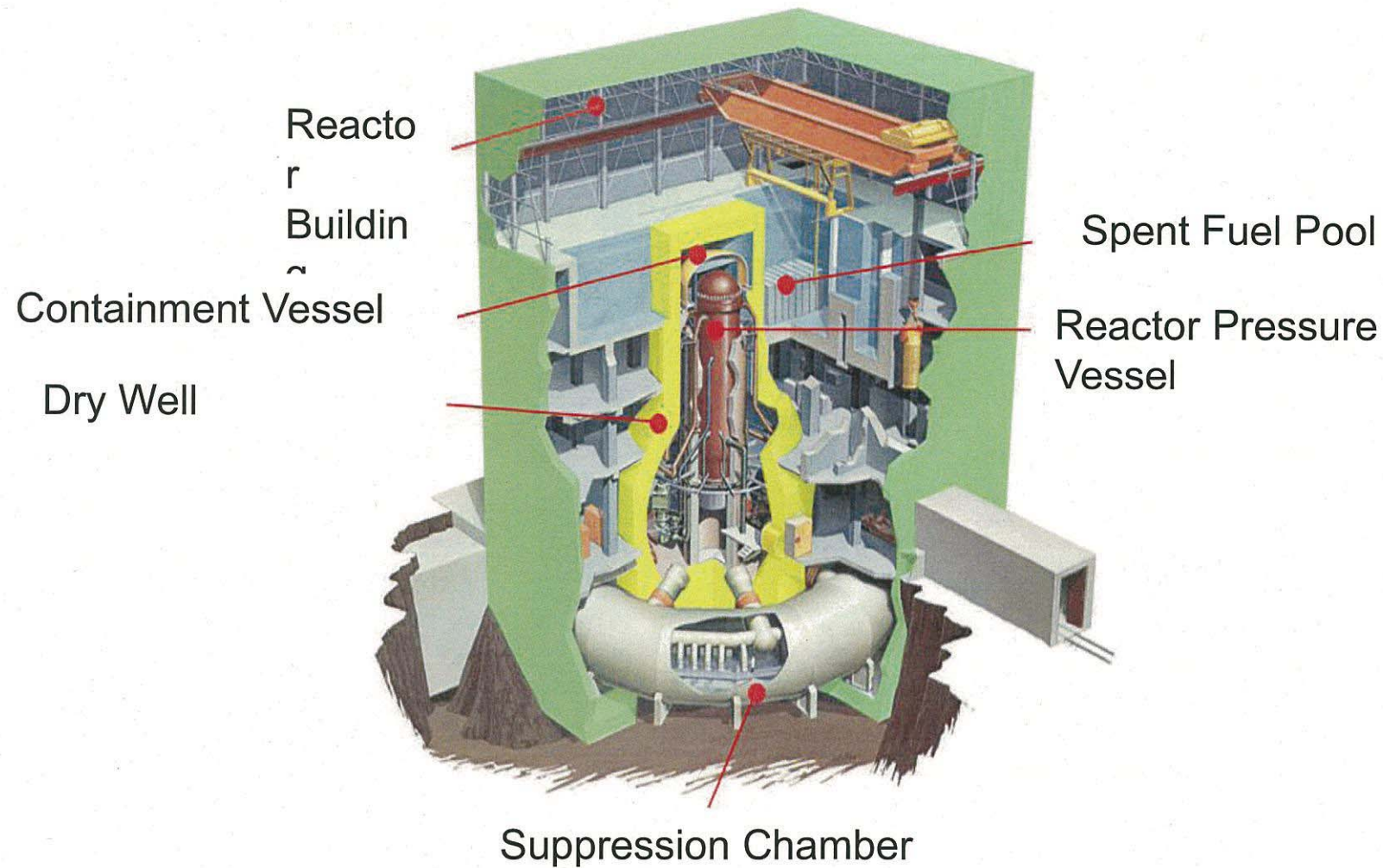
	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
	BWR-3	BWR-4	BWR-4	BWR-4	BWR-4	BWR-5
PCV Model	Mark-1	Mark-1	Mark-1	Mark-1	Mark-1	Mark-2
Electric Output (MWe)	460	784	784	784	784	1100
Max. pressure of RPV	8.24MPa	8.24MPa	8.24MPa	8.24MPa	8.62MPa	8.62MPa
Max. Temp of the RPV	300°C	300°C	300°C	300°C	302°C	302°C
Max. Pressure of the CV	0.43MPa	0.38MPa	0.38MPa	0.38MPa	0.38MPa	0.28MPa
Max. Temp of the CV	140°C	140°C	140°C	140°C	138°C	171°C(D/W) 105°C(S/C)
Commercial Operation	1971,3	1974,7	1976,3	1978,10	1978,4	1979,10
Emergency DG	2	2	2	2	2	3*
Electric Grid	275kV × 4				500kV × 2	
Plant Status on Mar. 11	In Operation	In Operation	In Operation	Refueling Outage	Refueling Outage	Refueling Outage

\* One Emergency DG is Air-Cooled





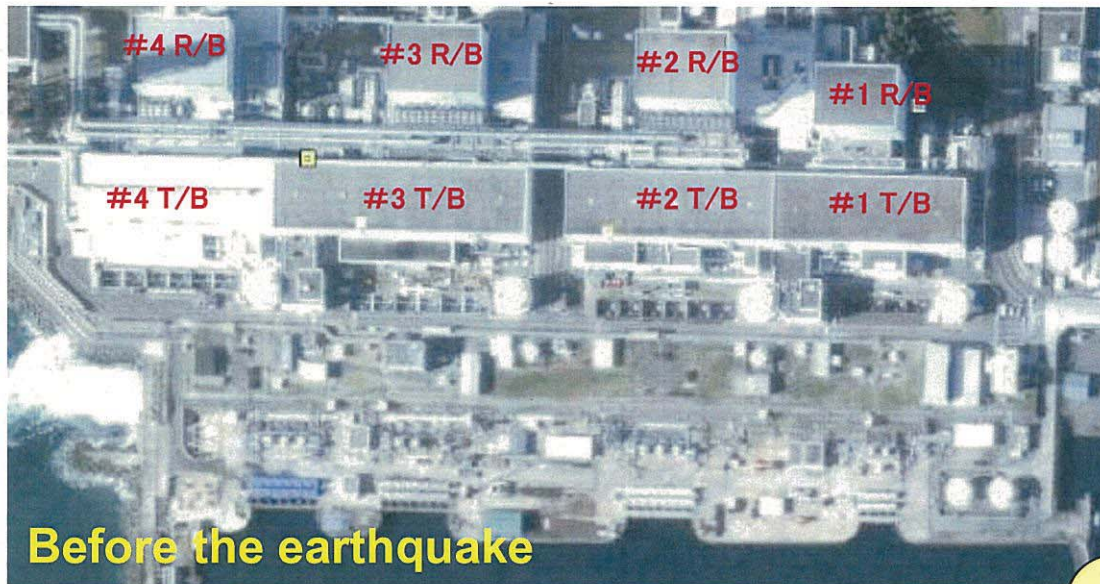
## Overview of Mark-1 Type BWR (Unit 1,2,3 and 4)



出典 : [http://nei.cachefly.net/static/images/BWR\\_illustration.jpg](http://nei.cachefly.net/static/images/BWR_illustration.jpg)



## Satellite view of Fukushima Dai-ichi NPP



Many structures facing the bay are destroyed

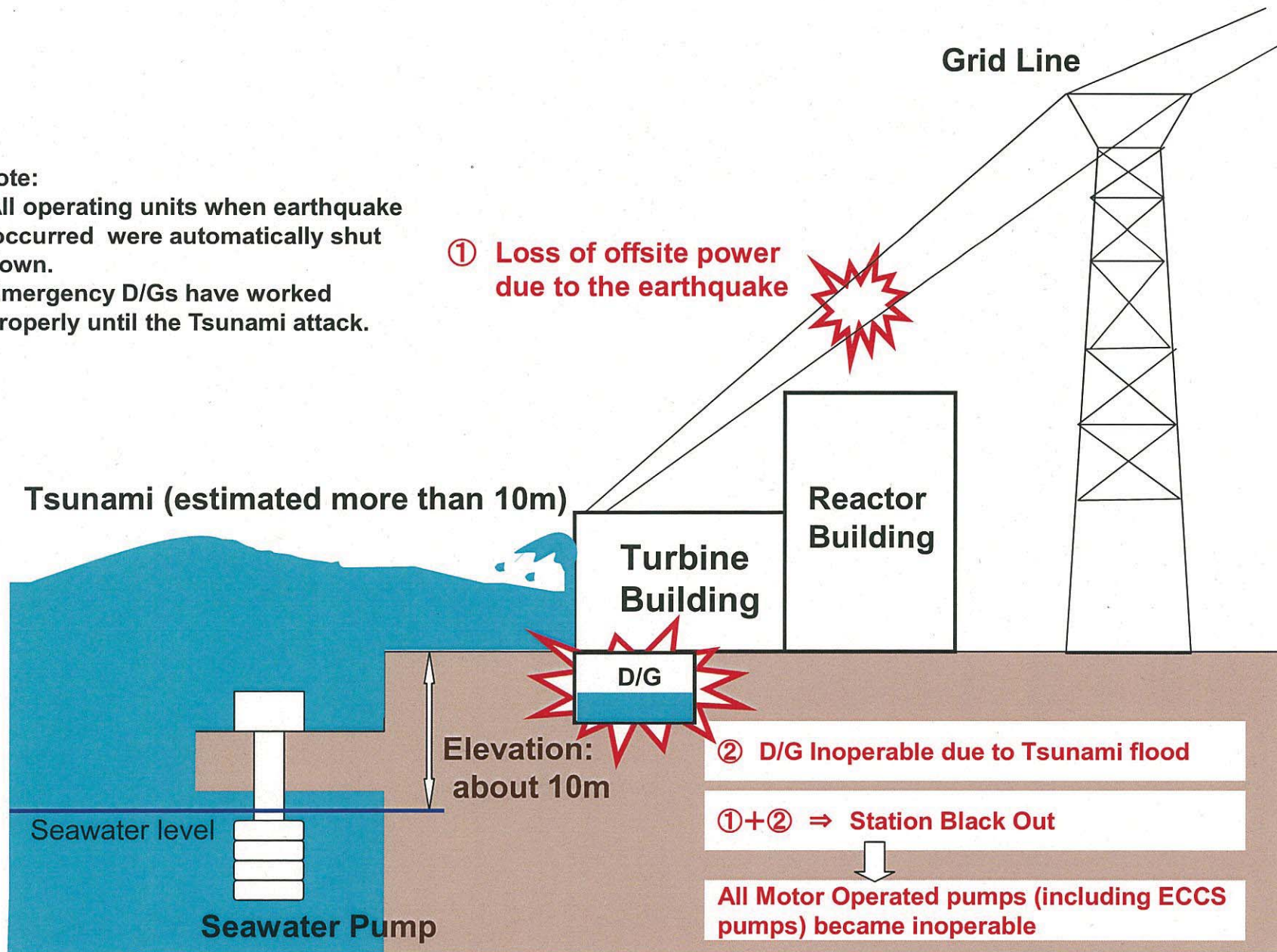




# Loss of all power sources due to the Earthquake and Tsunami

## Note:

- All operating units when earthquake occurred were automatically shut down.
- Emergency D/Gs have worked properly until the Tsunami attack.





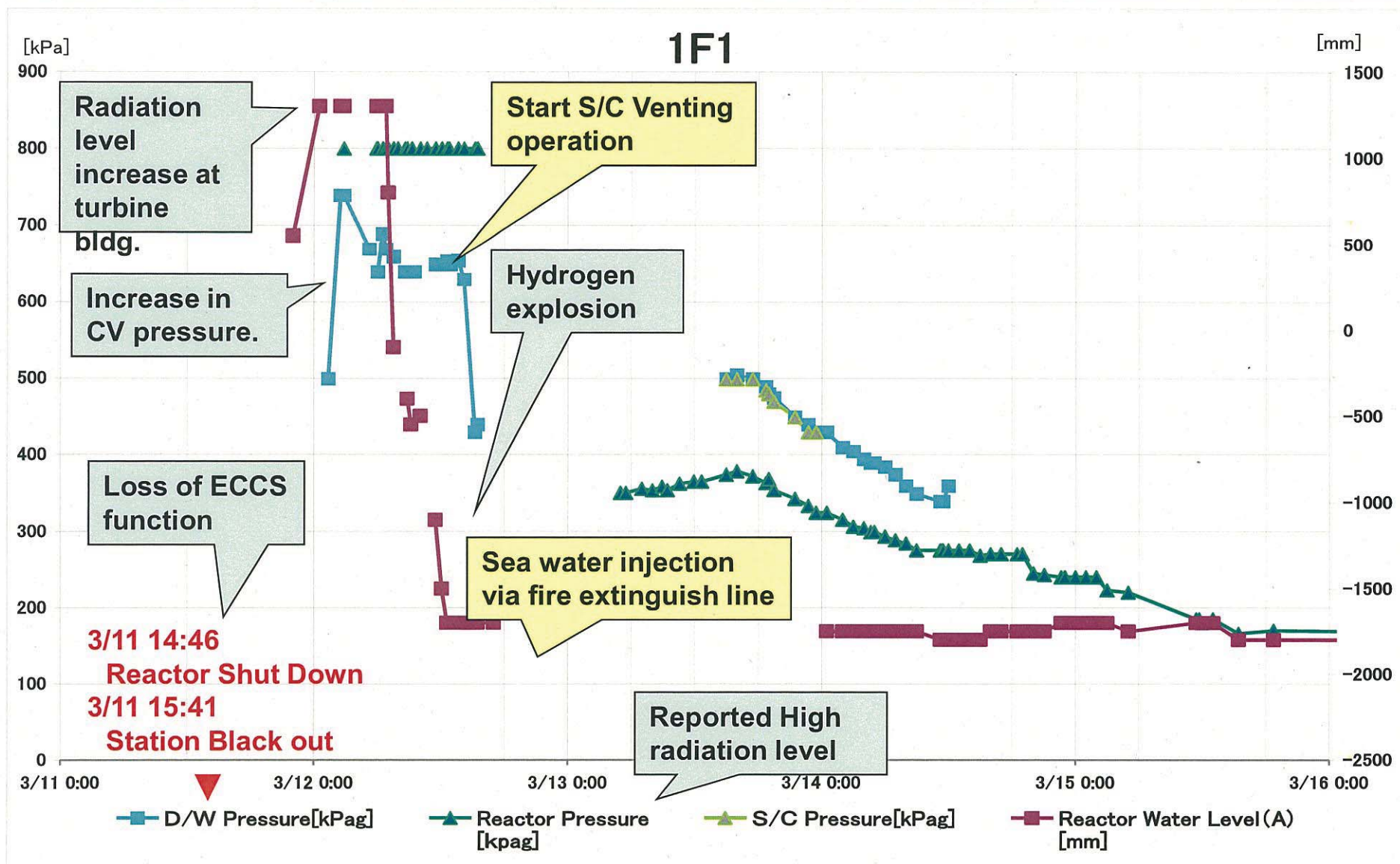
## Chronology of Unit 1 after the earthquake

### ● **Unit 1**

- 11<sup>th</sup> ● Under operation, Automatic shutdown by the earthquake (14:46)
  - Loss of A/C power (15:42)
  - Loss of water injection function
- 12<sup>th</sup> ● Unusual increase of PCV pressure
  - Started to vent (10:17)
  - Sound of explosion (15:36)
  - Started of injection of seawater and borated water to the core
- 22<sup>nd</sup> ● Rise of reactor temperature (383°C) → Drop (26th 05:00 144.3°C)
- 23<sup>rd</sup> ● Water supply line in addition to the Fire Extinguish line. Switched to water supply line only.(Flow rate: 7m<sup>3</sup>/h)
- 24<sup>th</sup> ● Lighting in the Central Control Room was recovered.
- 25<sup>th</sup> ● Started fresh water injection
- 29<sup>th</sup> ● Switched to the water injection to the core using a temporary motor operated pump.
- 31<sup>st</sup> ● White smoke was confirmed to generate continuously
  - Freshwater is being injected into the RPV

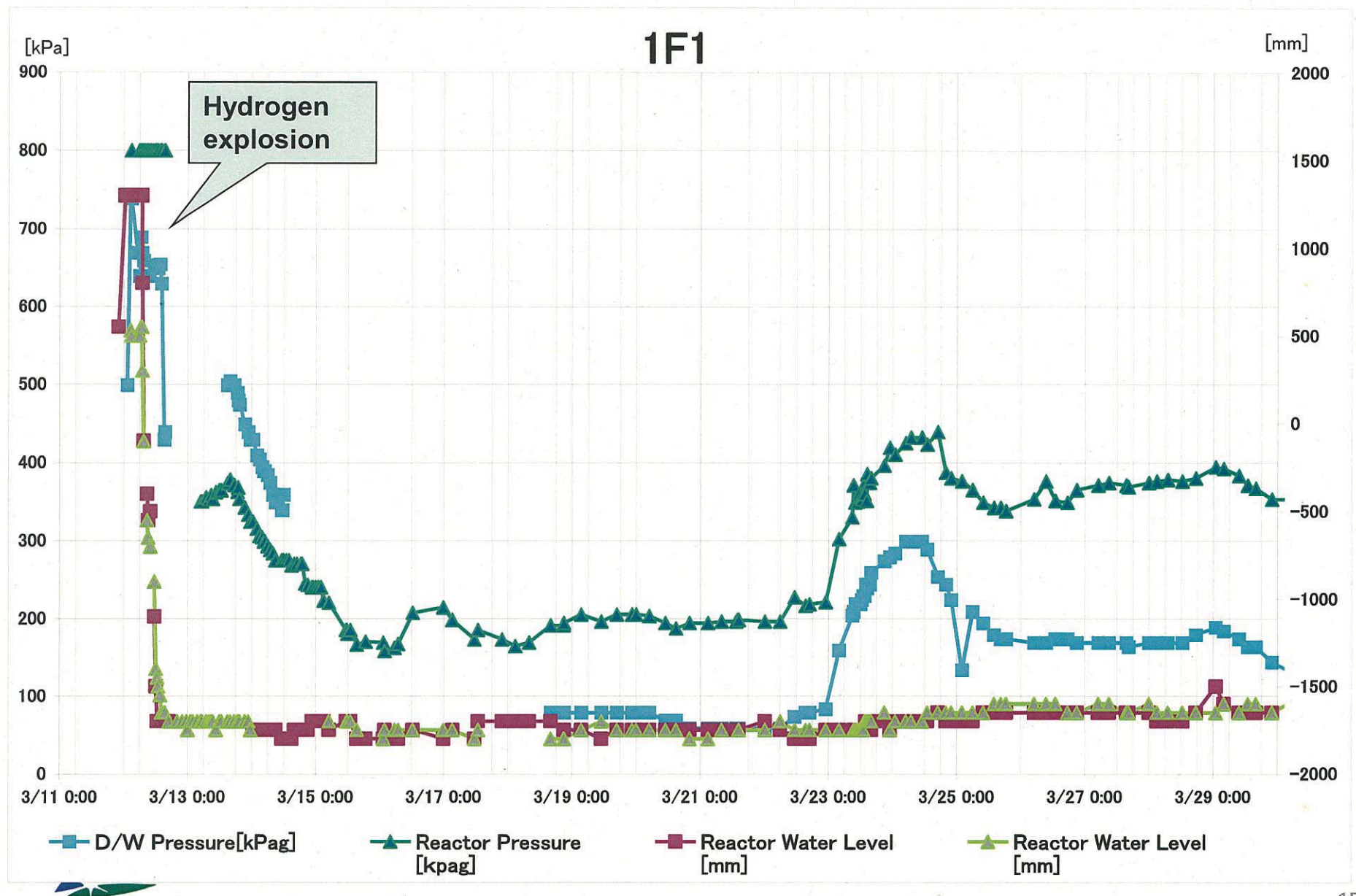


# Trend data (pressure and water level) of Unit 1 until March 15





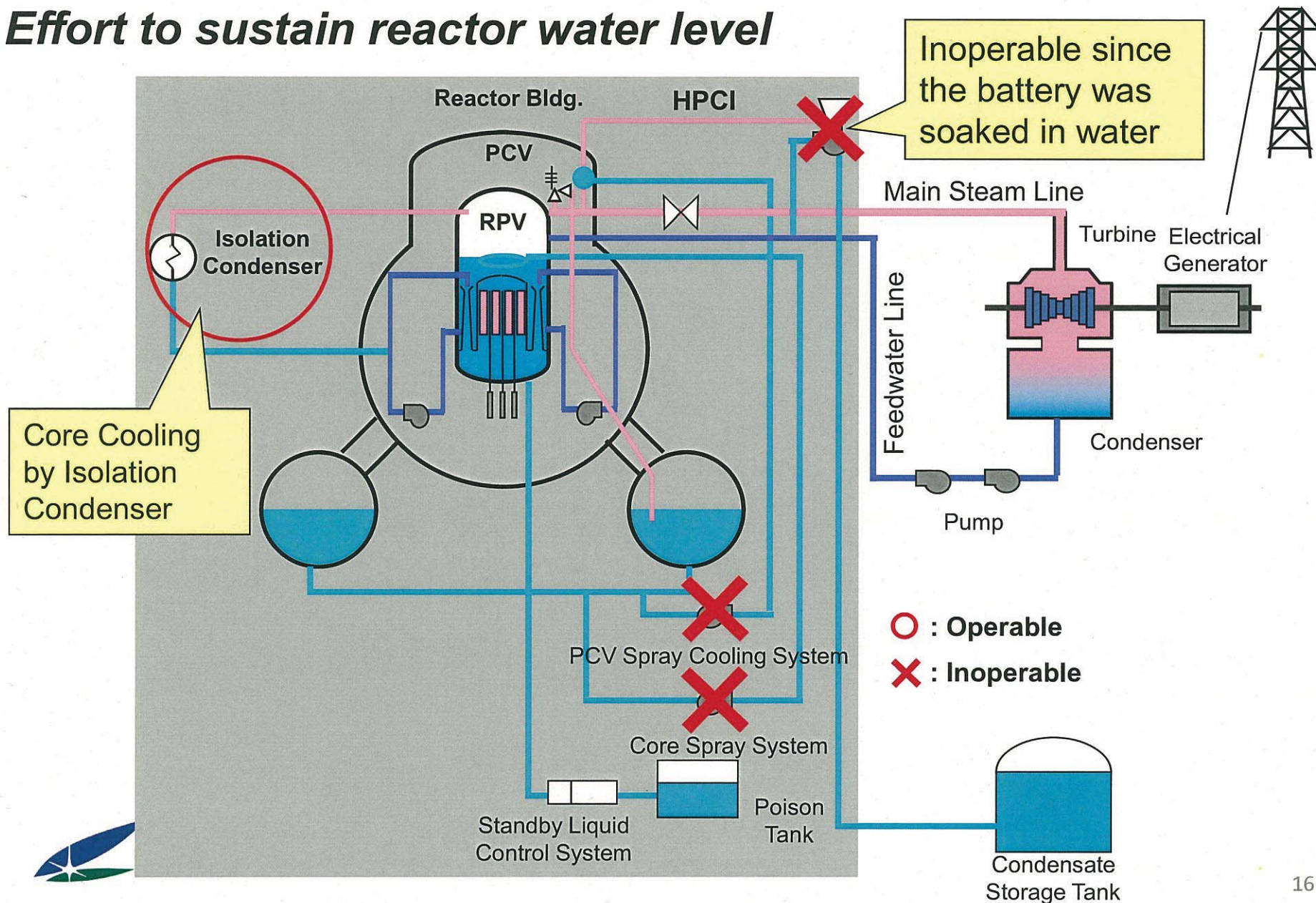
## Trend data of Unit 1 until March 30





## Major event progression at Unit 1 (1/4)

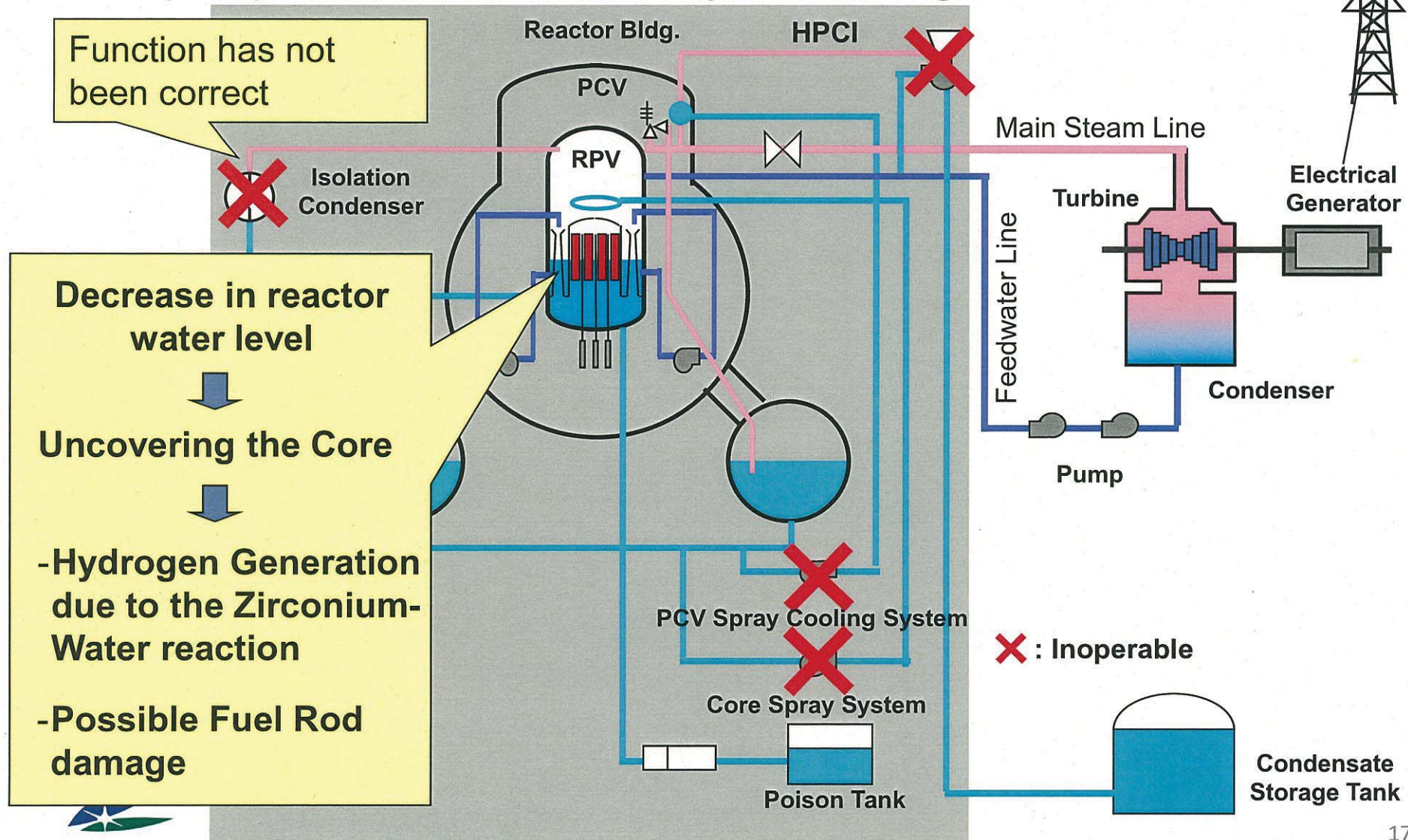
### *Effort to sustain reactor water level*





## Major event progression at Unit 1 (2/4)

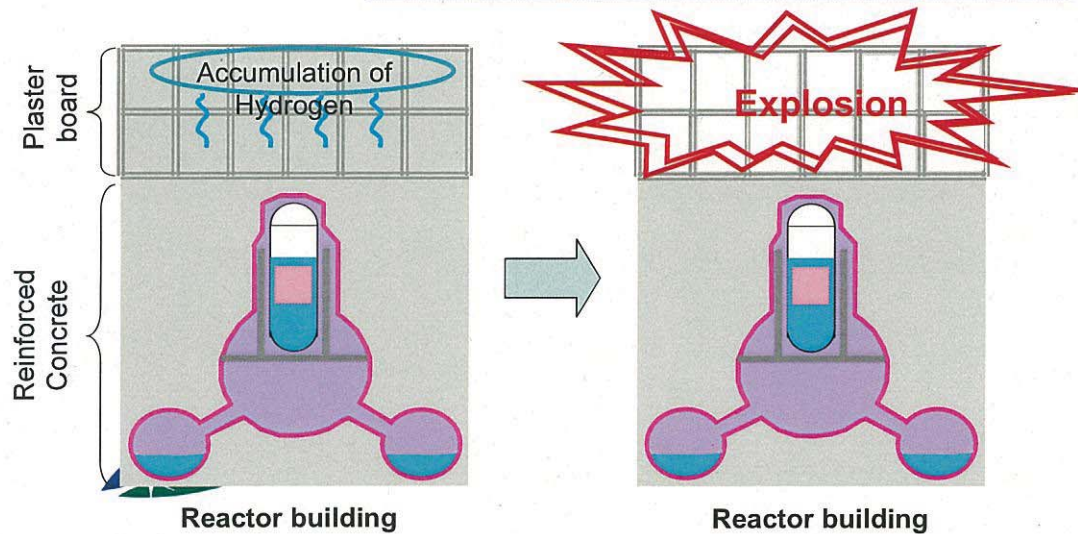
***Decrease in reactor water level due to loss of cooling capability of emergency condenser, followed by uncovering the core***





## Major event progression at Unit 1 (3/4)

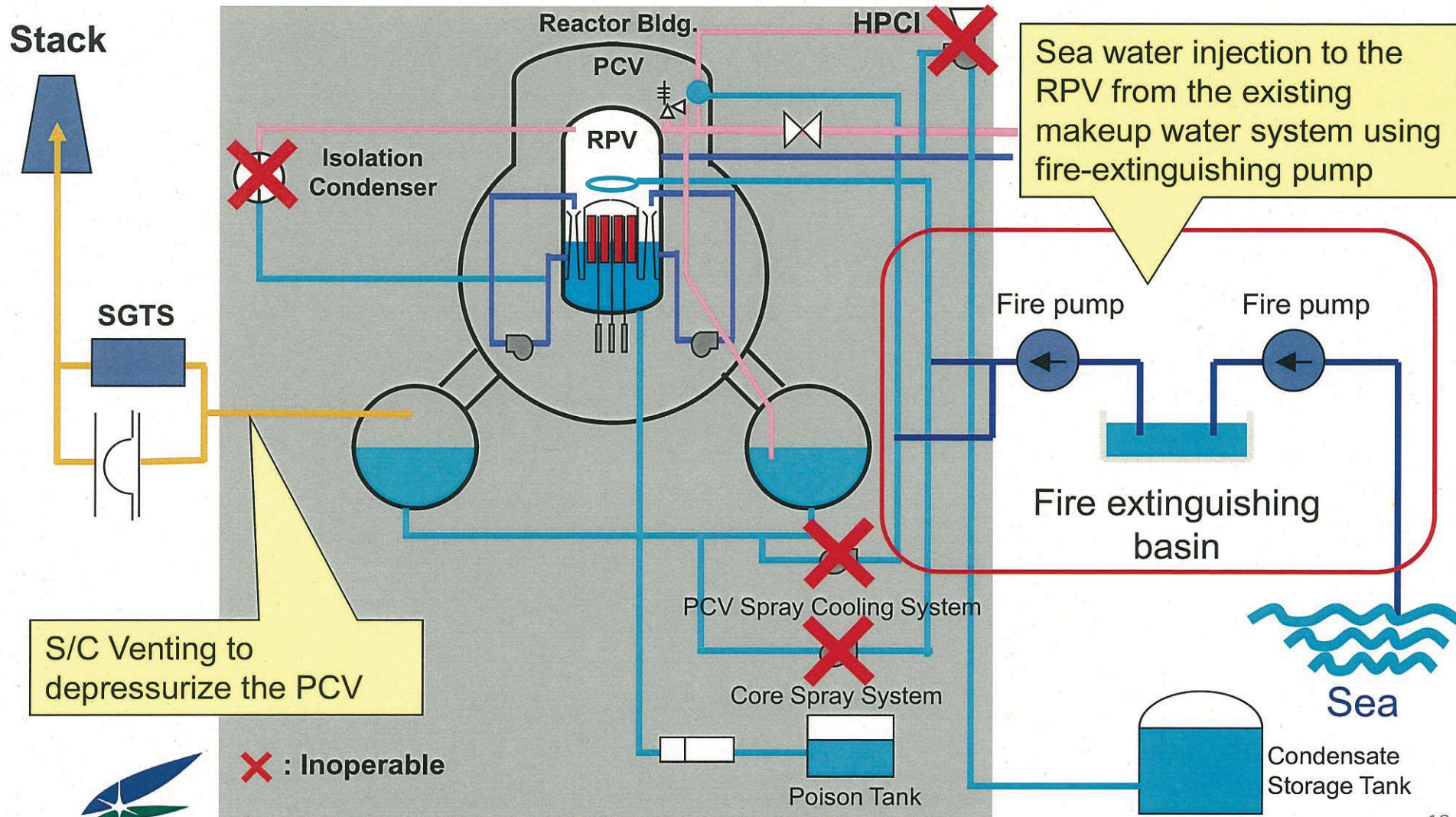
### *Hydrogen explosion in the operation floor*





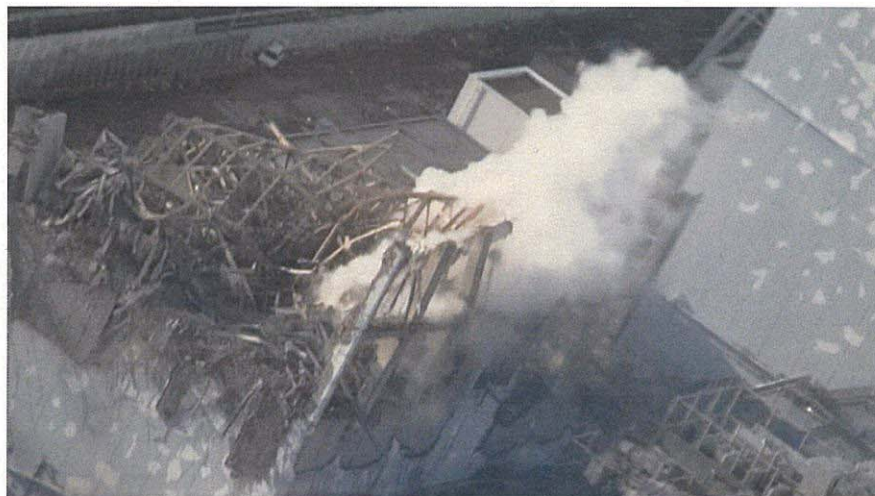
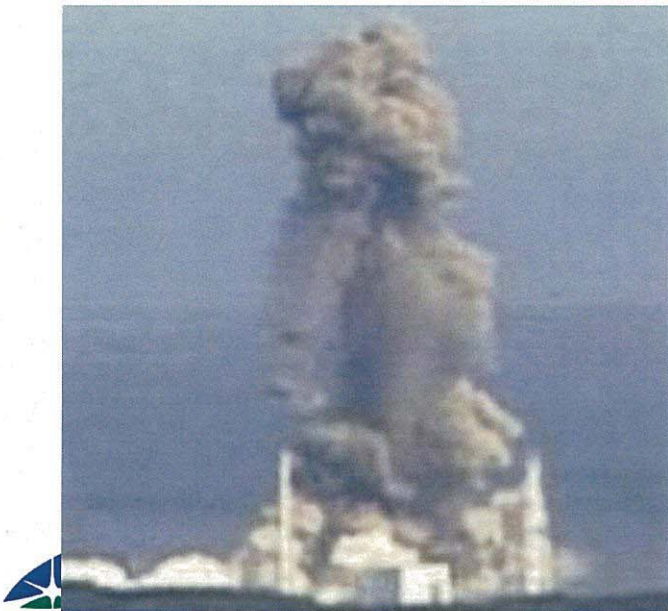
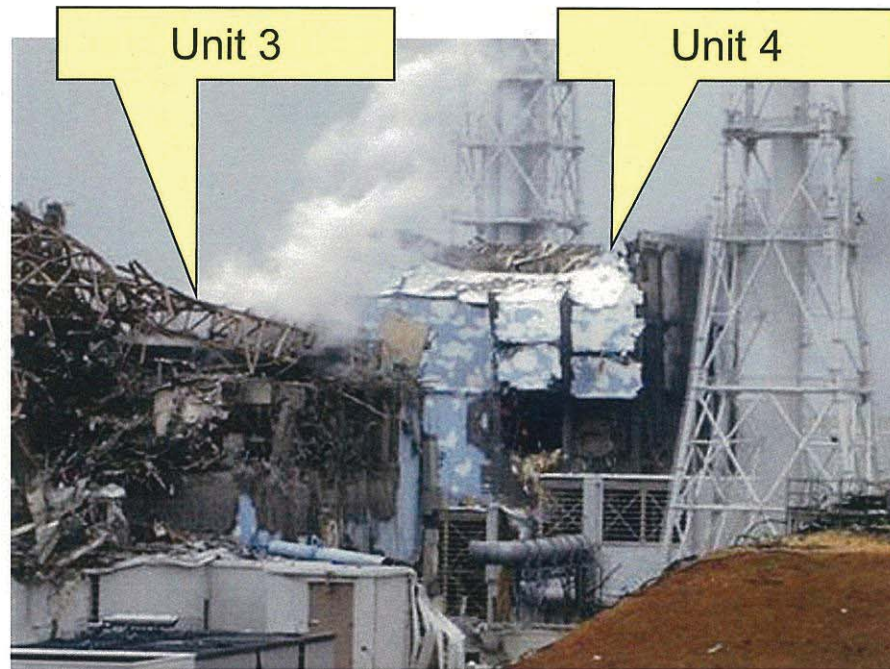
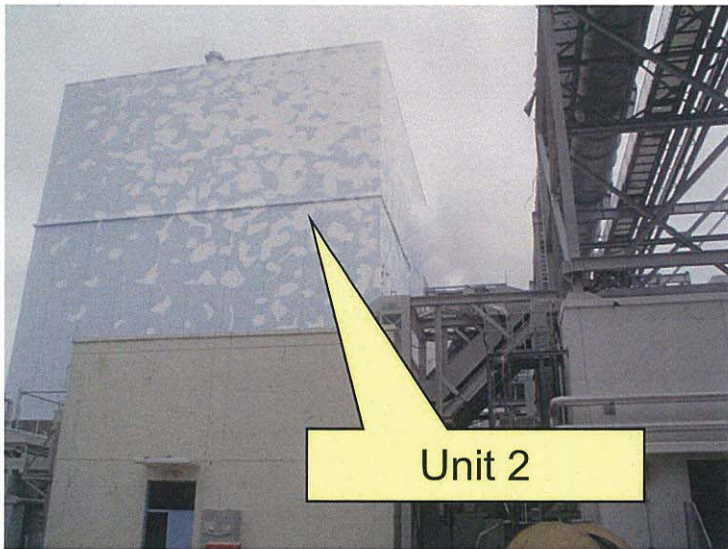
## Major event progression at Unit 1 (4/4)

- **Sea water injection using fire water pump**
- **S/C Venting to depressurize the PCV**





## Accident Progression at Unit 2 through 4 reactors



## 3-9. Chronology of Unit 2 after the earthquake (1/2)

### ● *Unit 2*

- 11<sup>th</sup> ● Under operation, Automatic shutdown by the earthquake
  - Loss of A/C power
  - Loss of water injection function
- 14<sup>th</sup> ● Loss of water cooling function
  - Unusual increase in PCV pressure
- 15<sup>th</sup> ● **Sound of explosion(06:10)**
  - Possible damage of the suppression chamber
- 20<sup>th</sup> ● Injection of about 40 tons of seawater into SFP through fire extinguishing system.
  - Injection of seawater to the Spent Fuel Pool (SFP)
- 21<sup>st</sup> ● White smoke generated
- 22<sup>nd</sup> ● Injection of seawater to the Spent Fuel Pool (SFP)
- 25<sup>th</sup> ● Injection of seawater to SFP





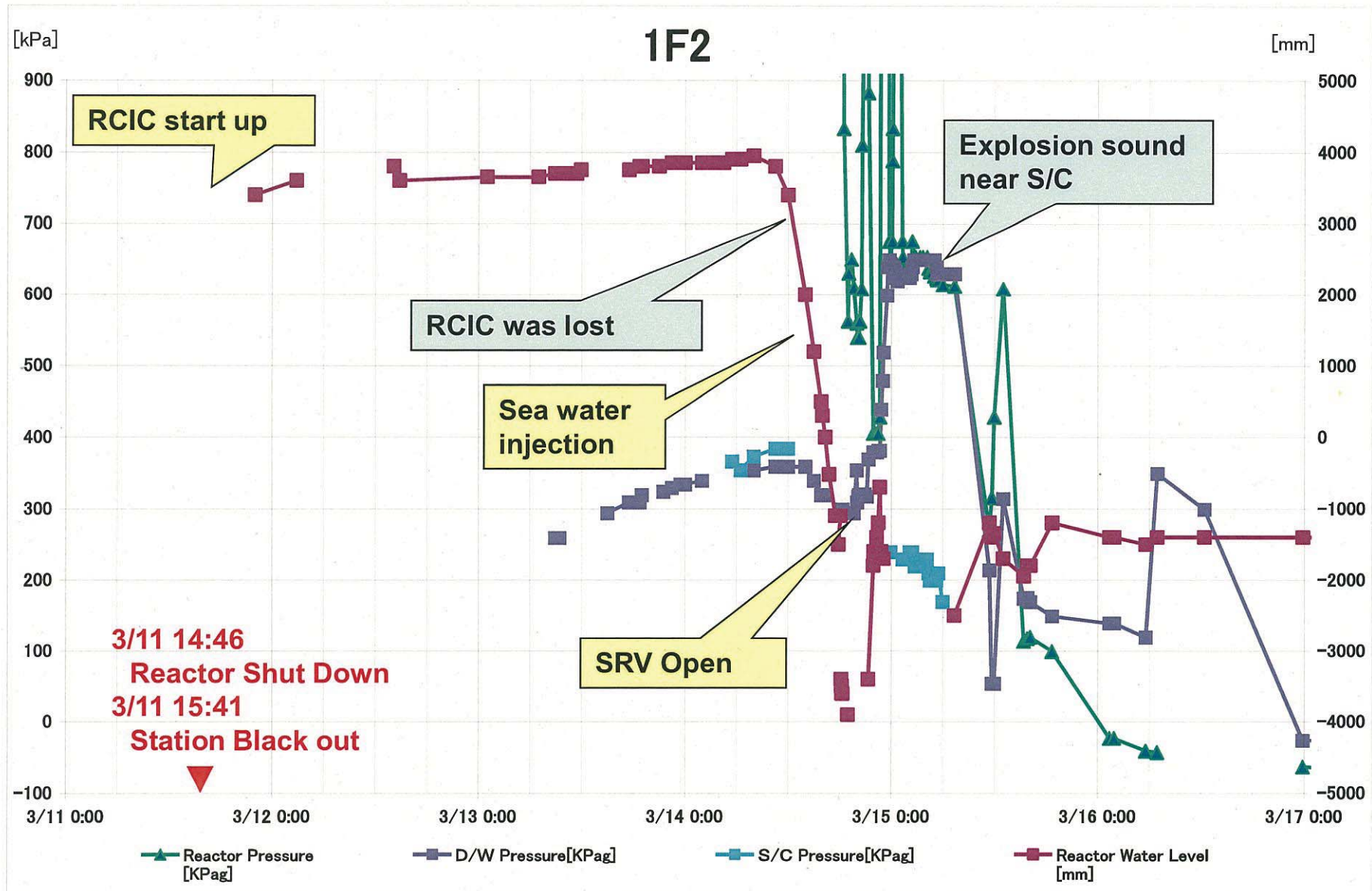
## Chronology of Unit 2 after the earthquake (2/2)

### ● **Unit 2(Continued)**

- 26<sup>th</sup> ● Lighting in the Central Control Room was recovered
- 27<sup>th</sup> ● Switched to the water injection to the core using a temporary motor-driven pump.
- 29<sup>th</sup> ● The Seawater injection to the Spent Fuel Pool using the Fire Pump Truck was switched to the fresh water injection using the temporary motor-driven pump
- In order to prepare for transferring the stagnant water on the basement floor of turbine building to the Condenser, the water in the Condensate Storage Tank is being transferred to the Surge Tank of Suppression Pool Water.
- 30<sup>th</sup> ● The injection pump was switched to the Fire Pump Truck. However, because cracks were confirmed in the hose (12:47 and 13:10 March 30<sup>th</sup>), the injection was suspended. The injection of fresh water resumed at 19:05 March 30<sup>th</sup>.
- 31<sup>st</sup> ● White smoke was confirmed to generate continuously.
- Fresh water is being injected to the spent fuel pool and the RPV

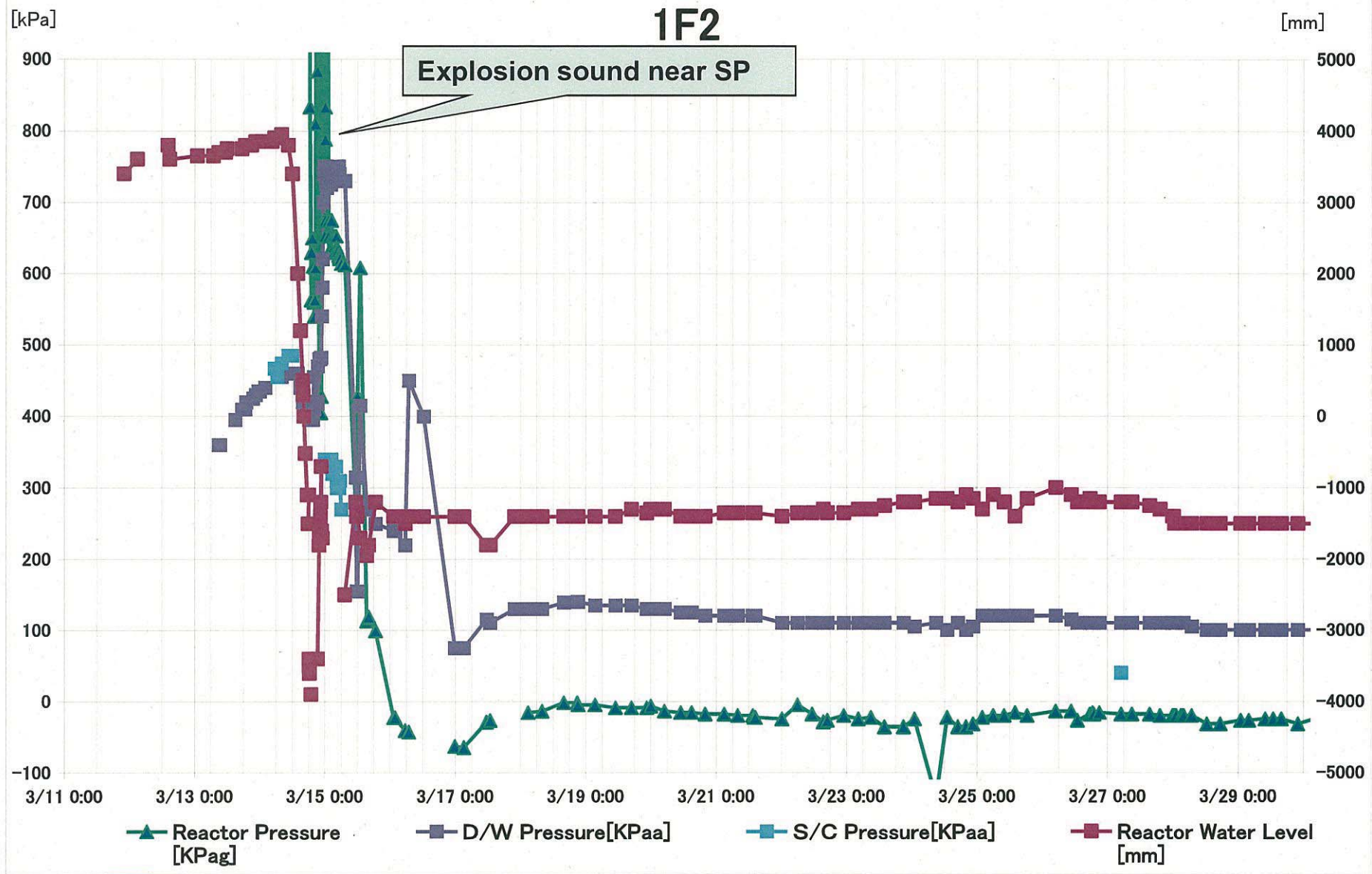


# Trend data of Unit 2 until March 17





## Trend data of Unit 2 until March 30



## Chronology of Unit 3 after the earthquake (1/2)

### ● **Unit 3**

- 11<sup>th</sup> ● Under operation, Automatic shutdown by the earthquake  
● Loss of A/C power
- 13<sup>th</sup> ● Loss of water injection function  
● Started to vent
- 14<sup>th</sup> ● Unusual increase in PCV pressure  
● **Sound of explosion (11:01)**
- 16<sup>th</sup> ● White smoke generated
- 17<sup>th</sup> ● Water discharge by the helicopters of Self-Defense Force(4 times)  
● Water spray from the ground by High pressure water-cannon trucks  
(Police: once, Self-Defense Force: 5 times)
- 18<sup>th</sup> ● Water spray from the ground by same trucks (Self-Defense Force: 6 times)  
Water spray from the ground by US water-cannon trucks  
(US armed force:1 time)
- 19<sup>th</sup> ● Water spray from the ground by High pressure water-cannon trucks by  
Hyper Rescue Unit of Tokyo Fire Department.





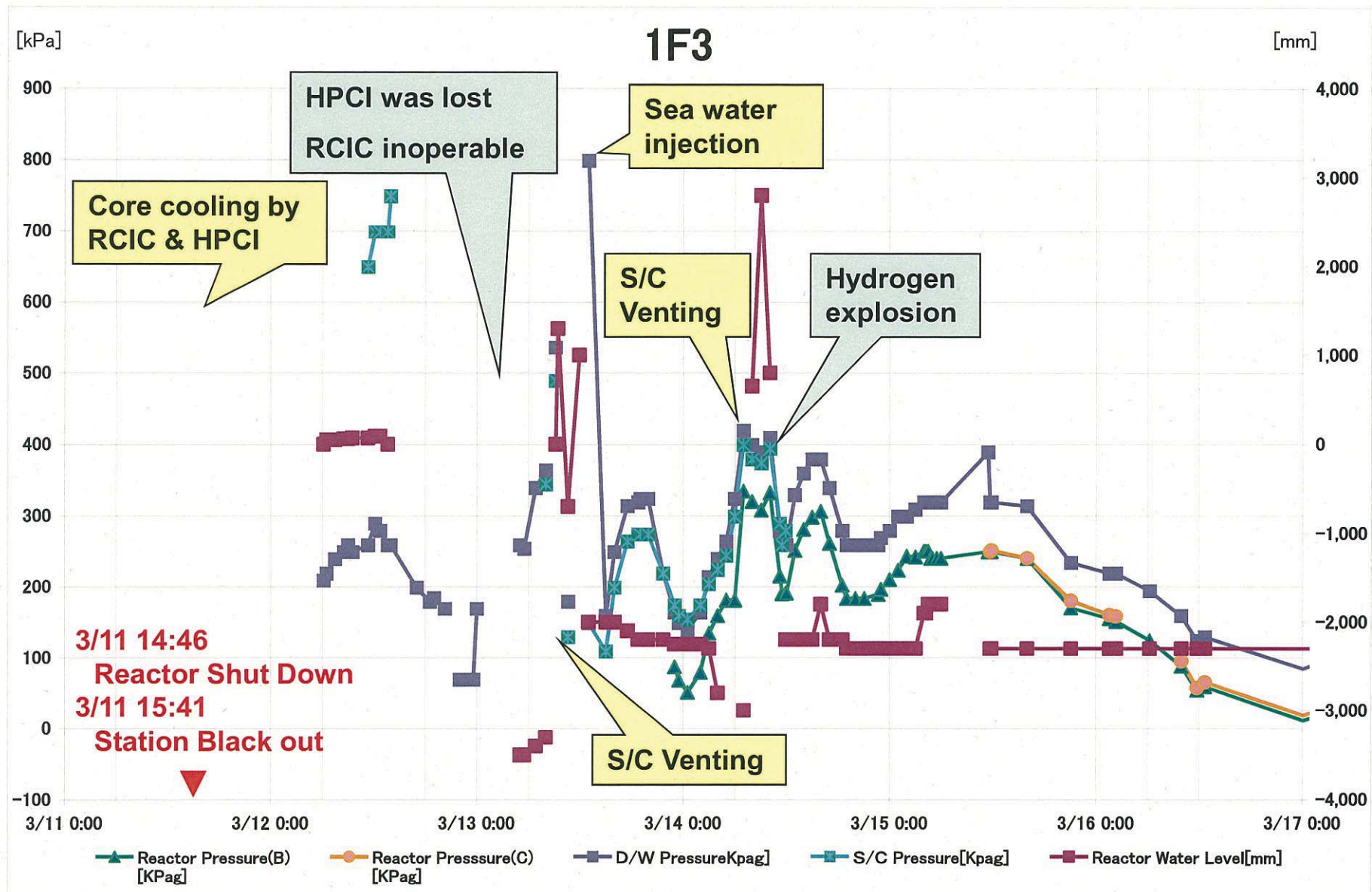
## Chronology of Unit 3 after the earthquake (2/2)

### ● **Unit 3(Continued)**

- 20<sup>th</sup> ● Sprayed by Hyper Rescue Unit of Tokyo Fire Department
- 22<sup>nd</sup> ● Lighting in the Central Control Room was recovered.
- 23<sup>rd</sup> ● Injection of seawater to the SFP
- 24<sup>th</sup> ● Injection of seawater to the SFP
- 25<sup>th</sup> ● Water spray (Emergency fire support team)  
● Started fresh water injection
- 27<sup>th</sup> ● Water spray by Concrete Pump Truck
- 28<sup>th</sup> ● Switched to the water injection to the core using a temporary motor-driven pump  
● In order to prepare for transfer the stagnant water on the basement floor of turbine building to the Condenser, the water in the Condensate Storage Tank is being transferred to the Surge Tank of Suppression Pool Water
- 29<sup>th</sup> ● Started to spray freshwater by Concrete Pump Truck
- 31<sup>st</sup> ● White smoke was confirmed to generate continuously  
● Fresh water is being injected to the spent fuel pool and the RPV

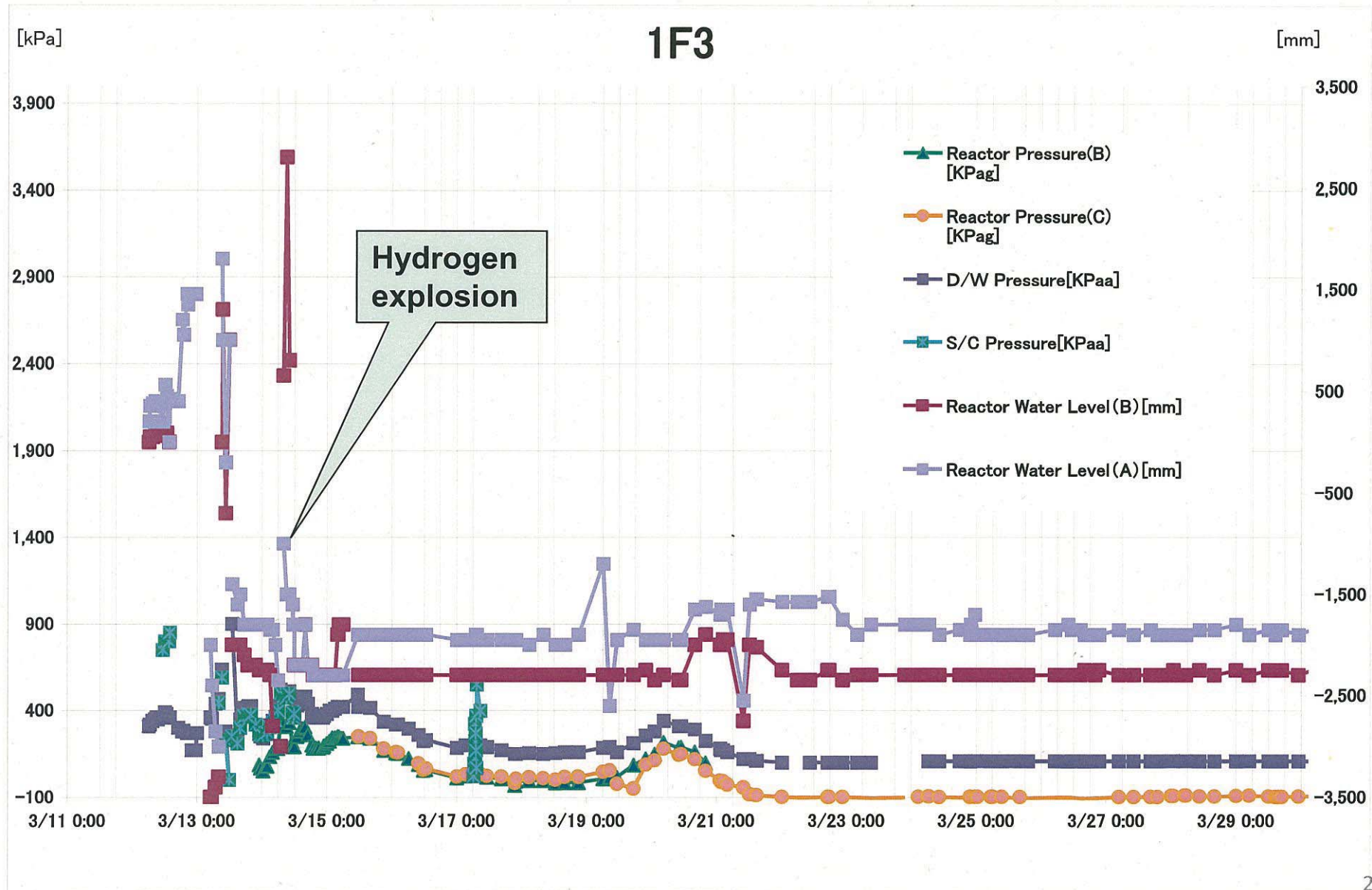


# Trend data of Unit 3 until March 17





# Trend data of Unit 3 until March 30



## Hydrogen explosion at Unit 1 & 3



Unit 1

Unit 3





## Chronology of Unit 4 after the earthquake

### ● Unit 4

- 14<sup>th</sup> ● Water temperature in the Spent Fuel Pool, 84°C
- 15<sup>th</sup> ● Damage of wall in the 4<sup>th</sup> floor confirmed  
● Fire occurred in the 3<sup>rd</sup> floor (12:25 extinguished)
- 16<sup>th</sup> ● Fire occurred. TEPCO couldn't confirm any fire on the ground.
- 20<sup>th</sup> ● Water spray over the spent fuel pool by Self Defense Force
- 21<sup>st</sup> ● Water spray over the spent fuel pool by Self Defense Force
- 22<sup>nd</sup>-24<sup>th</sup> ● Water spray (Concrete Pump Truck (3 times)
- 25<sup>th</sup> ● Injection of seawater to SFP via the Fuel Pool Cooling Line (FPC)  
● Water spray (Concrete Pump Truck)
- 27<sup>th</sup> ● Water spray (Concrete Pump Truck)
- 29<sup>th</sup> ● Lighting in the Central Control Room was recovered.
- 30<sup>th</sup> ● White smoke was confirmed to generate continuously.  
● Spray of fresh water (Around 140t) over the Spent Fuel Pool using Concrete Pump Truck (50t/h) was carried out.  
● Fresh water is being injected to the spent fuel pool



## Chronology of Unit 5 & 6 after the earthquake

### ● **Unit 5&6**

- 20<sup>th</sup> ● Unit 5 under cold shutdown (Water temperature of reactor water is less than 100°C)
- Unit 6 under cold shutdown (Water temperature of reactor water is less than 100°C)
- 21<sup>st</sup> ● Water spray over the Common Spent Fuel Pool started
- 22<sup>nd</sup> ● Recovering power supply of unit 5 and 6 is completed.
- 24<sup>th</sup> ● The power was started to be supplied. Cooling also started
- 30<sup>th</sup> ● Backup power of Unit 6 is in working condition and external power was supplied to Unit 5 as of March 30<sup>th</sup>



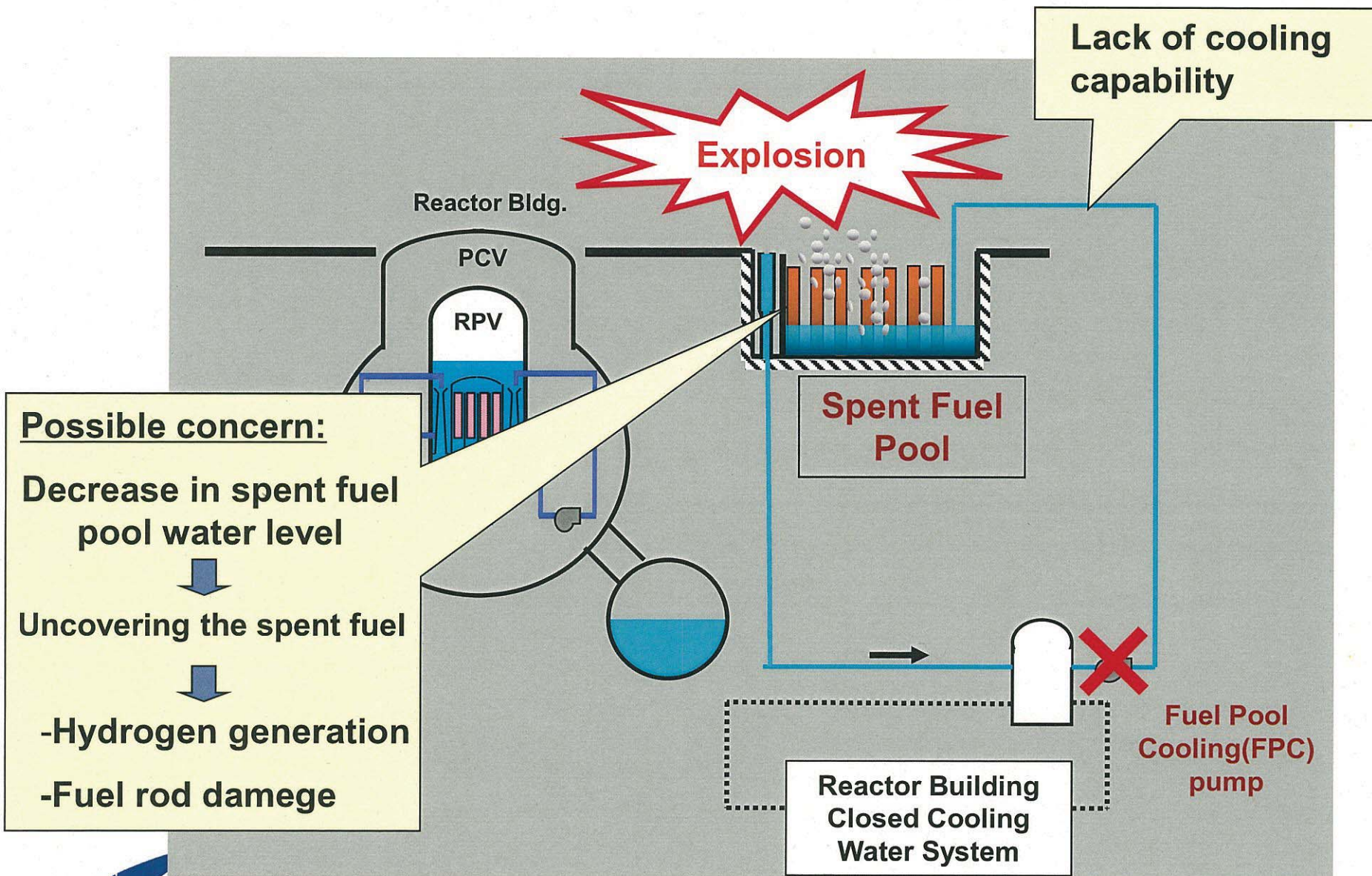


#### 4. Report concerning incidents at spent fuel pools in the Fukushima Dai-ichi NPS



**Photo: Water spray into the SFP in Unit 4 using concrete pump truck**

## Possible concerns about Spent Fuel Pool





## Status of the Fuel as of March 11, 2011

Unit	1	2	3	4	5	6
Number of Fuel Assembly in the Core	400	548	548	-	548	764
Number of Spent Fuel Assembly in the Spent Fuel Pool	292	587	514	1,331	946	876
Number of New Fuel Assembly in the Spent Fuel Pool	100	28	52	204	48	64
Water Volume (m <sup>3</sup> )	1,020	1,425	1,425	1,425	1,425	1,497

### Condition of the fuel in the Spent Fuel Pool

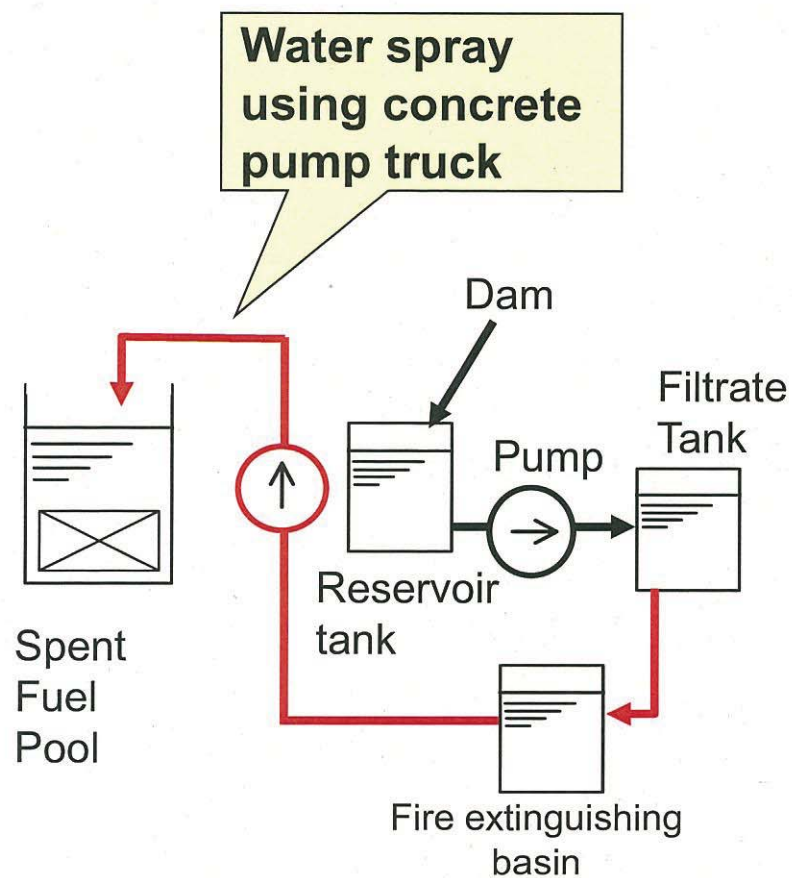
Unit 1	Unit 2	Unit 3	Unit 4
-Most recent shut down was on Sep.27,2010	- Most recent shut down was on Nov.18,2010	- Most recent shut down was on Sep.23,2010	-Most recent shut down was on Nov.29,2010 -All fuel assembly was removed from the core and located in the pool due to the core shroud replacement



# Measures taken to cool the Spent Fuel Pool

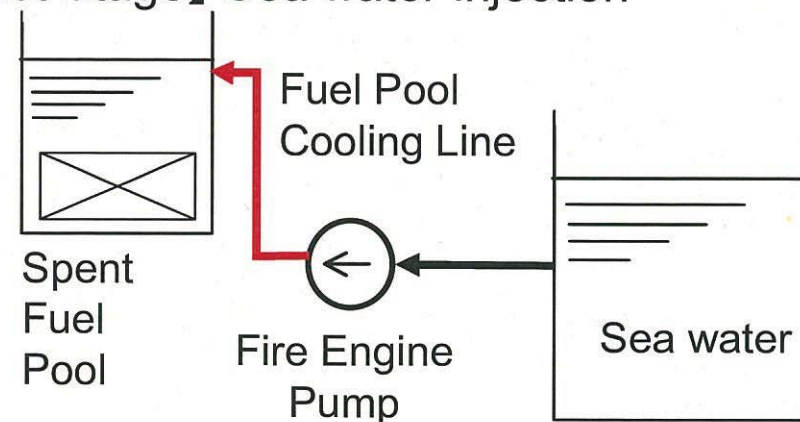
## Unit 1

Fresh water injection

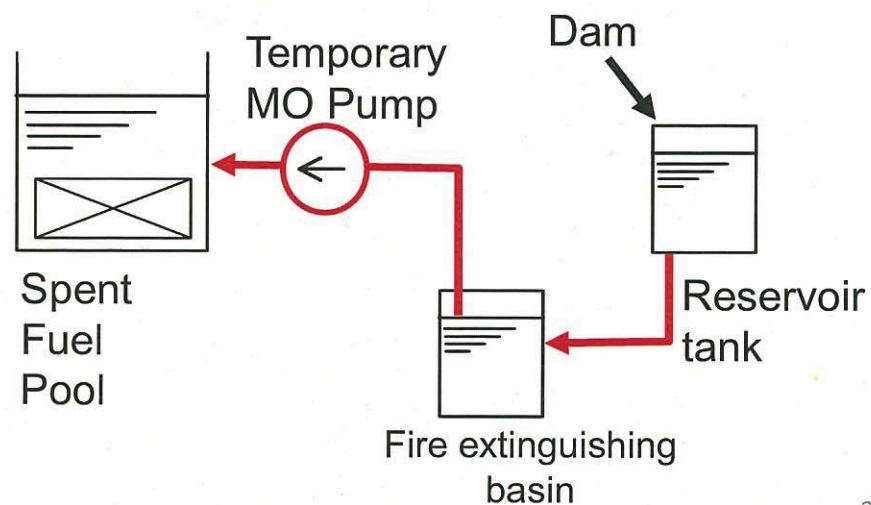


## Unit 2

【1st Stage】 Sea water injection



【2nd Stage】 Fresh water injection





# Measures taken to cool the Spent Fuel Pool

## Unit 3

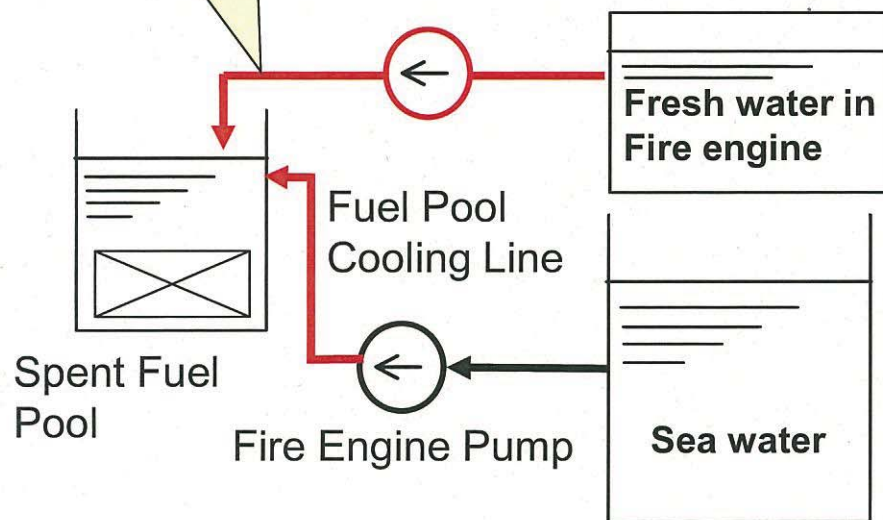
### 【1st Stage】 Sea water injection

#### Water Spray

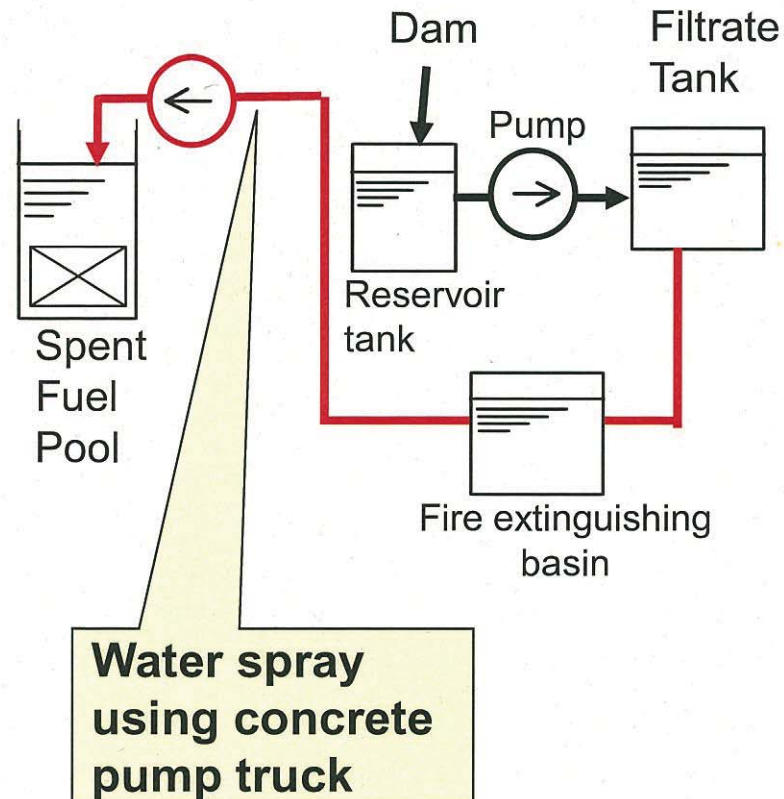
by  
-Self-Defense Force  
-Fire Department  
-Police



Source: Asahi.com



### 【2nd Stage】 Fresh water injection



\* Sea water discharge by helicopters  
of the Self Defense Force

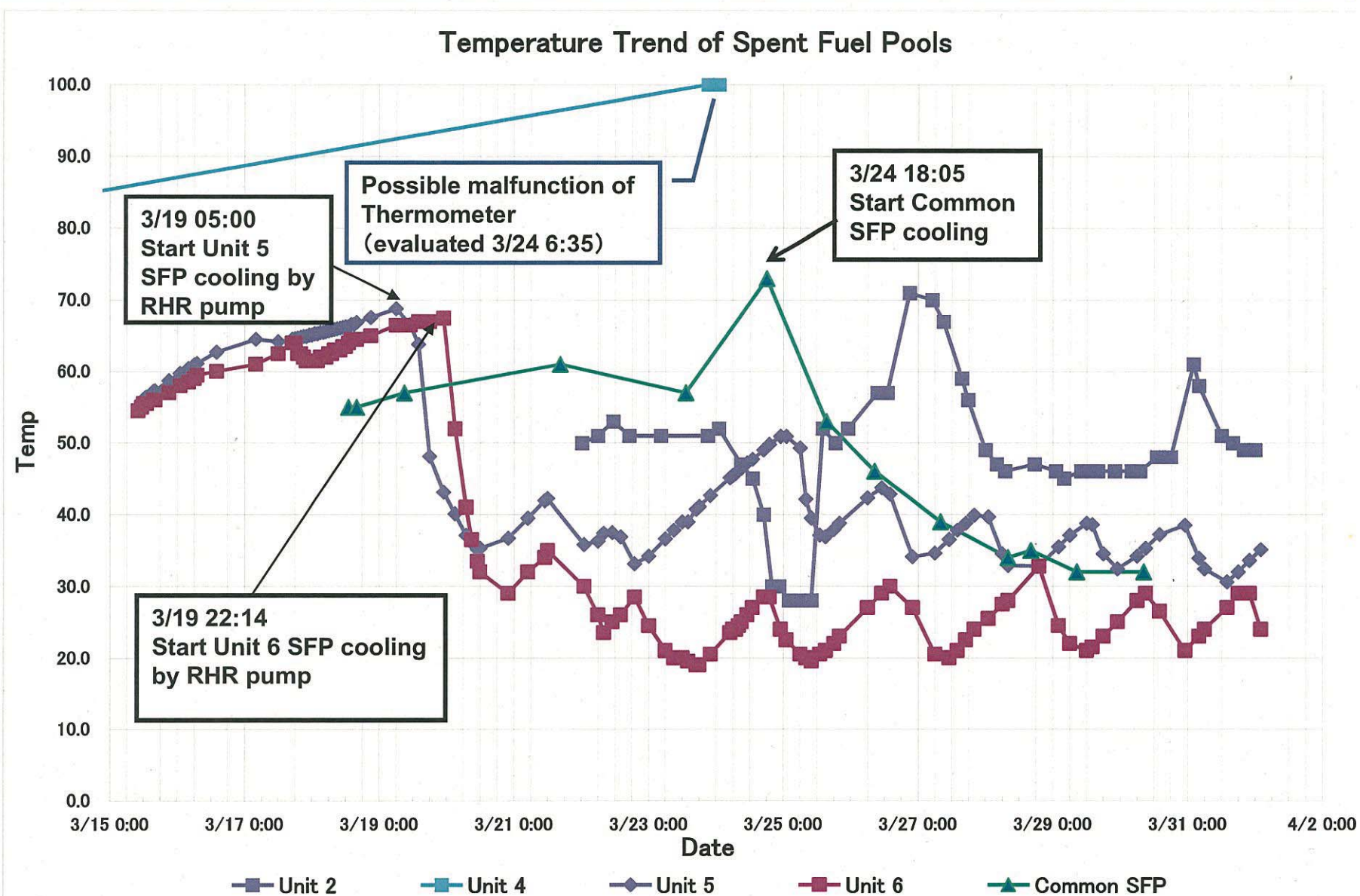




Pictures of Unit 4: <http://www.tepco.co.jp/en/news/110311/index-e.html><sup>37</sup>



# Temperature Trend of Spent Fuel Pools



# Impact on Public and Environment





## Implementation Status of Radiation Monitoring(1/2)

### **(1) On-site monitoring (1F) (conducted by TEPCO)**

#### **① Measurement of air dose rates**

- On site, air dose rates were measured at 1 point using monitoring car and at 3 points using portable dosimeter.

#### **② Analysis of soil samples**

- Soils were sampled at 5 on-site points and analyzed.

#### **③ Measurement of water in Turbine Bldg basement and Trench**

- Measured concentration of radioactive substances in Turbine Bldg basement and Trench.

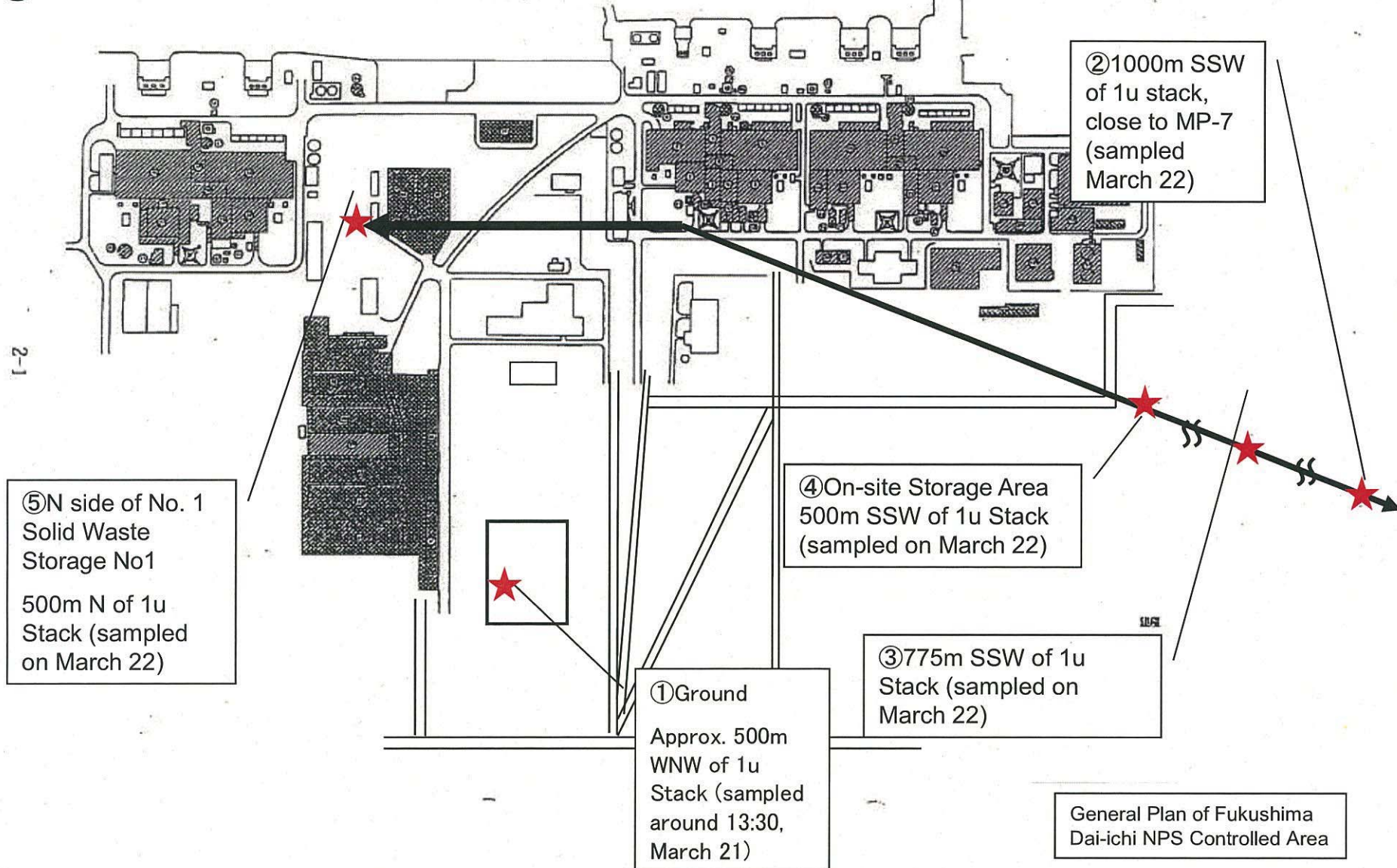
#### **④ Sampling of seawater**

- Measured concentration of radioactivity around South Flood Gate.



## Monitoring On-site(1F) (conducted by TEPCO)(2/7)

### ②Detection of radioactive material in the soil on the site of Fukushima Dai-ichi NPS



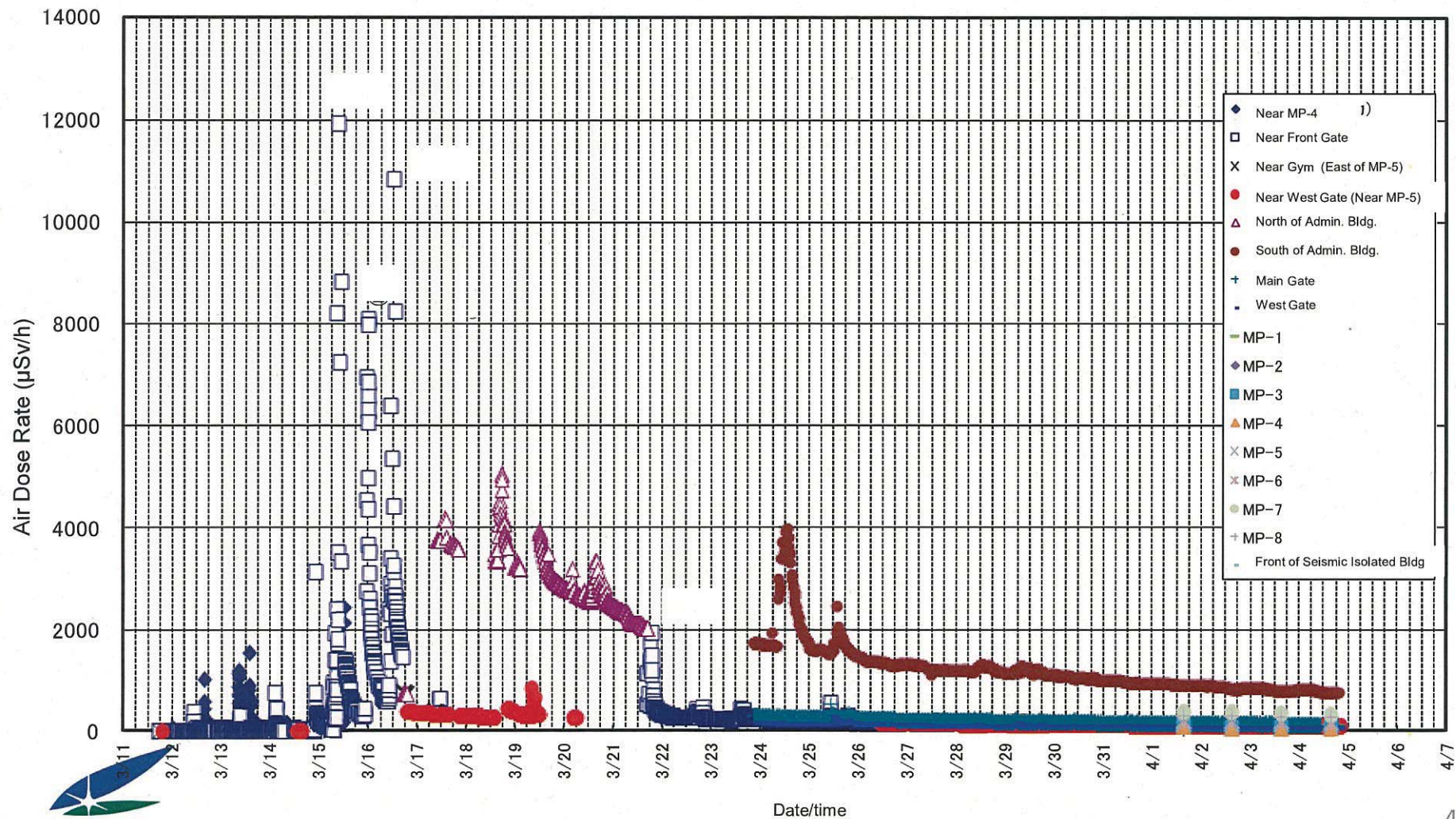


# Monitoring On-site(1F) (conducted by TEPCO)(1/7)

## ① Measurement of air dose rate

○Registered 11930 $\mu$ Sv/h around Front Gate on March 15.

1F Monitoring Trend



## Monitoring On-site(1F) (conducted by TEPCO)(3/7)

### ②Detection of radioactive materials in the soils on the site of Fukushima Dai-ichi

- Density of detected Pu-238, Pu-239 and Pu-240 are within the same level of the fallout observed in Japan after the atmospheric nuclear test in the past.
- Activity ratio of Pu-238 detected at the site field and solid waste storage against Pu-239 and Pu-240 are 2.0 and 0.94 respectively. Those Pus are considered to come from the recent incident.

(Unit: Bq/km<sup>2</sup>•dry soil)

Sampling Spot	Time of sampling	Pu-238	Pu-239, Pu-240
①Site field	13:30, March 21	$(5.4 \pm 0.62) \times 10^{-1}$	$(2.7 \pm 0.42) \times 10^{-1}$
②1km away from Unit 1/2 exhaust stack	7:00, March 22	N.D	$(2.6 \pm 0.58) \times 10^{-1}$
③0.75km away from Unit 1/2 exhaust stack	7:10, March 22	N.D	$1.2 \pm 0.12$
④0.5 km away from unit 1/2 exhaust stack	7:18 March 22	N.D	$1.2 \pm 0.11$
⑤Solid waste storage	7:45 March 11	$(1.8 \pm 0.33) \times 10^{-1}$	$(1.9 \pm 0.34) \times 10^{-1}$
Ordinary domestic soil		N.D $\sim 1.5 \times 10^{-1}$	N.D $\sim 4.5$





## Monitoring On-site(1F) (conducted by TEPCO)(5/7)

### ③ Stagnant Water in Trench

- High level of radiation dose was measured at the surface of water in the vertical pit of the tunnel called “trench” which extends from turbine bldg towards the sea.
- In particular, at Unit 2 ambient dosage around the vertical pit is 100~300mSv/h and dosage in surface water 1,000mSv/h, which are far greater than in Units 1 and 3.

	Unit 1	Unit 2	Unit 3
Location of trench	○Approx. 56m to sea ○162m from turbine bldg (length of trench)	○Approx. 55m to sea ○76m from turbine bldg (length of trench)	○Approx. 69m to sea ○74m from turbine bldg (length of trench)
Trench volume (incl. vertical pit)	3,100m <sup>3</sup>	6,000m <sup>3</sup>	4,200m <sup>3</sup>
Depth of vertical pit	16.9m	16.3m	21.7m
Depth of water in vertical pit	16.8m	15.3m	20.2m
Dosage at water surface	0.4~1.9mSv/h	Above 1000mSv/h	Impossible to measure due to debris
Ambient dosage in vertical pit	0.4~1.0mSv/h	100~300mSv/h	0.8mSv/h

## Monitoring On-site(1F) (conducted by TEPCO)(4/7)

### ③Water in Turbine Bldg Basement (Results of nuclide analysis in the stagnant water in turbine building basement of each Unit)

- There is pool of water with high radioactive substance concentration in turbine bldg basement of Units 1~4. Above 1,000mSv/h dose has been measured at water surface in Unit 2.
- Water with approx. 100,000 times normal radioactivity concentration in reactor water was confirmed in turbine bldg basement of Unit 2.

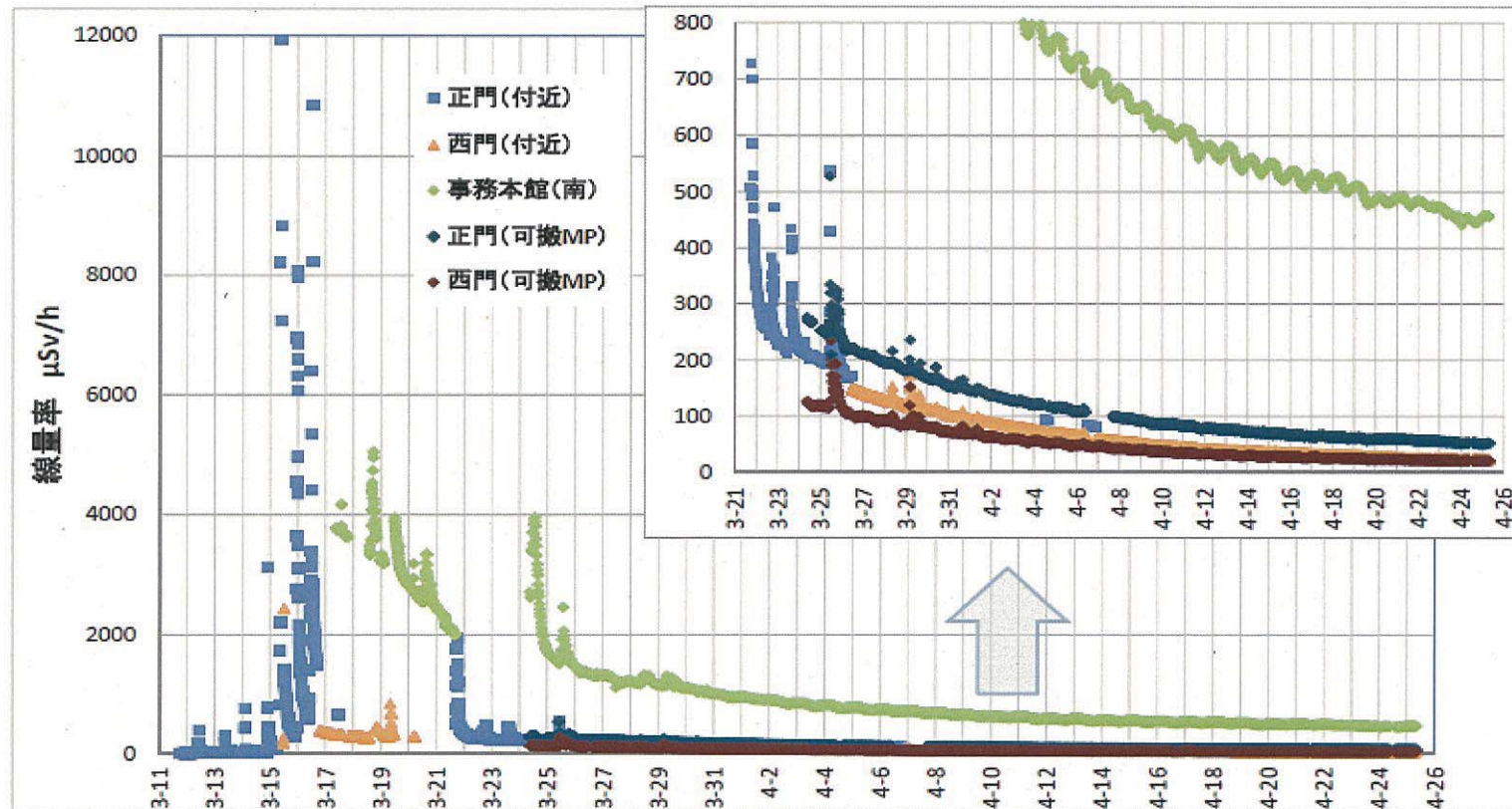
Nuclide (half- life time)	Concentration of Radioactivity (Bq/cm <sup>3</sup> )			
	Unit 1 (2nd time) Sampled on March 26	Unit 2 Sampled on March 26	Unit 3 (2nd time) Sampled on March 26	Unit 4 Sampled on March 24
	Water level 195mm	Water level 1,000mm	Water level 1,500mm	Water level 940mm
	Dose rate on the surface of the water 60 mSv/h	Dose rate on the surface of the water >1,000 mSv/h	Dose rate on the surface of the water 750 mSv/h	Dose rate on the surface of the water 0.50 mSv/h
Co-56 (about 77 days)	N.D	N.D	N.D	N.D
Co-58 (about 71 days)	N.D	N.D	N.D	$2.7 \times 10^{-1}$
Co-60 (about 5 years)	N.D	N.D	$2.7 \times 10^2$	N.D
Mo-99 (about 66 hours)	N.D	N.D	N.D	$1.0 \times 10^0$
Tc-99m (about 6 hours)	N.D	$8.7 \times 10^4$	$2.2 \times 10^3$	$6.5 \times 10^{-1}$
Ru-106 (about 370 days)	N.D	N.D	N.D	$3.3 \times 10^0$
Ag-108m (about 418 years)	N.D	N.D	N.D	N.D
Te-129 (about 70 minutes)	N.D	N.D	N.D	$2.6 \times 10^1$
Te-129m (about 34 days)	N.D	N.D	N.D	$1.3 \times 10^1$
Te-132 (about 3 days)	N.D	N.D	N.D	$1.4 \times 10^1$
I-131 (about 8 days)	$1.5 \times 10^5$	$1.3 \times 10^7$	$3.2 \times 10^5$	$3.6 \times 10^2$
I-132 (about 2 hours)	N.D	N.D	N.D	$1.3 \times 10^1$
I-134 (about 53 minutes)	N.D	N.D	N.D	N.D
Cs-134 (about 2 years)	$1.2 \times 10^5$	$2.3 \times 10^6$	$5.5 \times 10^4$	$3.1 \times 10^1$
Cs-136 (about 13 days)	$1.1 \times 10^4$	$2.5 \times 10^5$	$6.5 \times 10^3$	$3.7 \times 10^0$
Cs-137 (about 30 years)	$1.3 \times 10^5$	$2.3 \times 10^6$	$5.6 \times 10^4$	$3.2 \times 10^1$
Ba-140 (about 13 days)	N.D	$4.9 \times 10^5$	$1.9 \times 10^4$	N.D
La-140 (about 2 days)	N.D	$1.9 \times 10^5$	$3.1 \times 10^3$	$7.4 \times 10^{-1}$



# Monitoring Data Trends at Fukushima-1

福島第一原子力発電所 現地モニタリングデータ

4月25日 08:00現在



# Contaminated water discharge to the sea

Discharge amount of the stagnant water with low-level radioactivity, etc. from the Fukushima Dai-ichi NPS

< Table 1 >

	Radioactive Concentration (Bq/cm <sup>3</sup> )				Discharge Amount (m <sup>3</sup> )	Periods of Discharge
	I-131	Cs-134	Cs-137	sum		
Stagnant water in the Radioactive Waste Treatment Facilities	6.3E+00	4.4E+00	4.4E+00	1.5E+01	9,070	4/4 19:03 - 4/6 6:30 4/6 18:00 - 4/8 22:20 4/8 23:45 - 4/10 17:40
Water in the Sub Drain Pit of the Unit 5	1.6E+00	2.5E-01	2.7E-01	2.1E+00	950	4/5 17:20 - 4/8 12:14
Water in the Sub Drain Pit of the Unit 6	2.0E+01	4.7E+00	4.9E+00	3.0E+01	373	4/4 21:00 - 4/9 18:52

※Radioactive Concentration (Bq/cm<sup>3</sup>) of the stagnant water in the Radioactive Waste Treatment Facilities is assessed by the maximum value of the samples in the two Facilities shown in the following table.

	Radioactive Concentration (Bq/cm <sup>3</sup> )			
	I-131	Cs-134	Cs-137	Sum
Stagnant water in the Radioactive Waste Treatment Facilities (In the Non-Controlled)	6.3E+00	2.7E+00	2.8E+00	1.2E+01
Stagnant water in the Radioactive Waste Treatment Facilities (In the Controlled Area)	8.7E-01	4.4E+00	4.4E+00	9.7E+00

Source: NISA April 15, 2011, <http://www.nisa.meti.go.jp/english/files/en20110416-10.pdf>

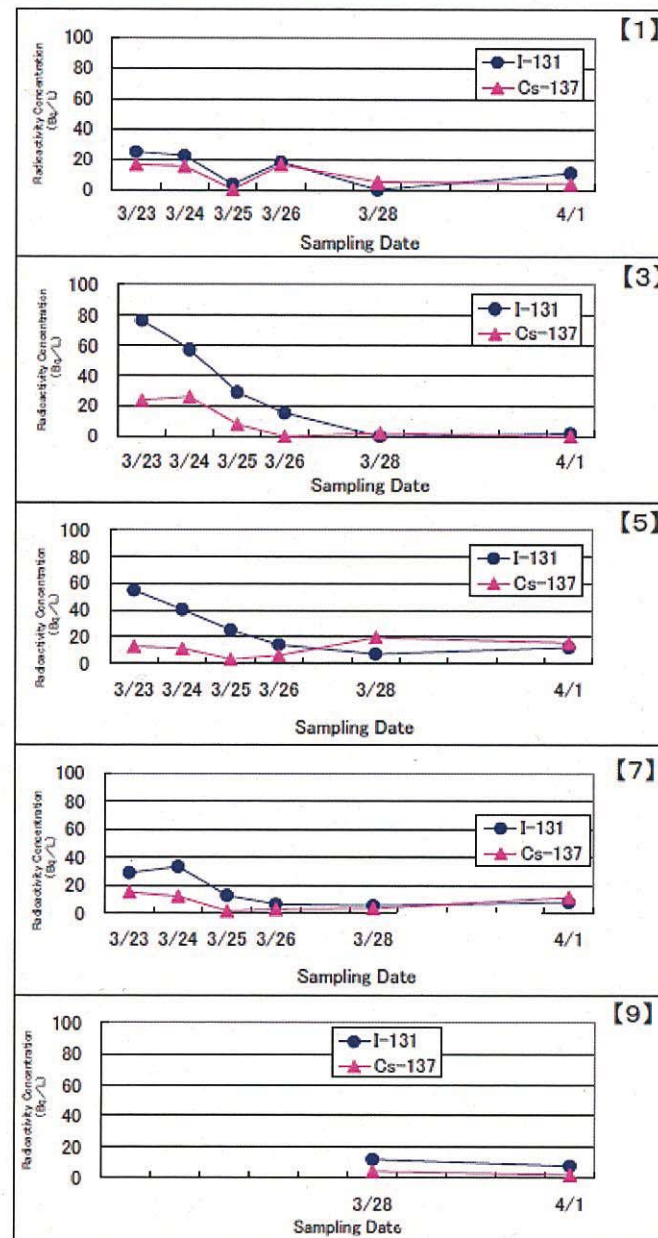
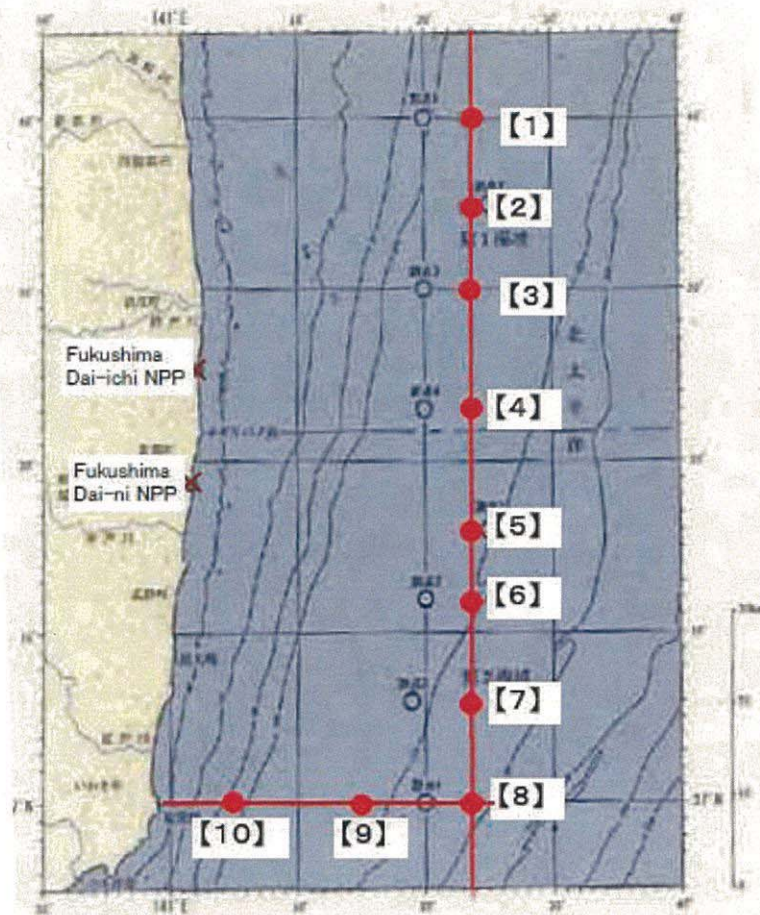




## Monitoring by MEXT and local nuclear emergency response HQ(5/6)

### ④ Sea Water Monitoring Around Fukushima Dai-ichi NPS

● Concentration of radioactive materials at location #3 peaked at 76.8Bq/L, exceeding the limit for the environmental monitoring area.



Note: "Not Detectable" is illustrated as 0Bq/L.

## Monitoring by MEXT and local nuclear emergency response HQ(6/6)

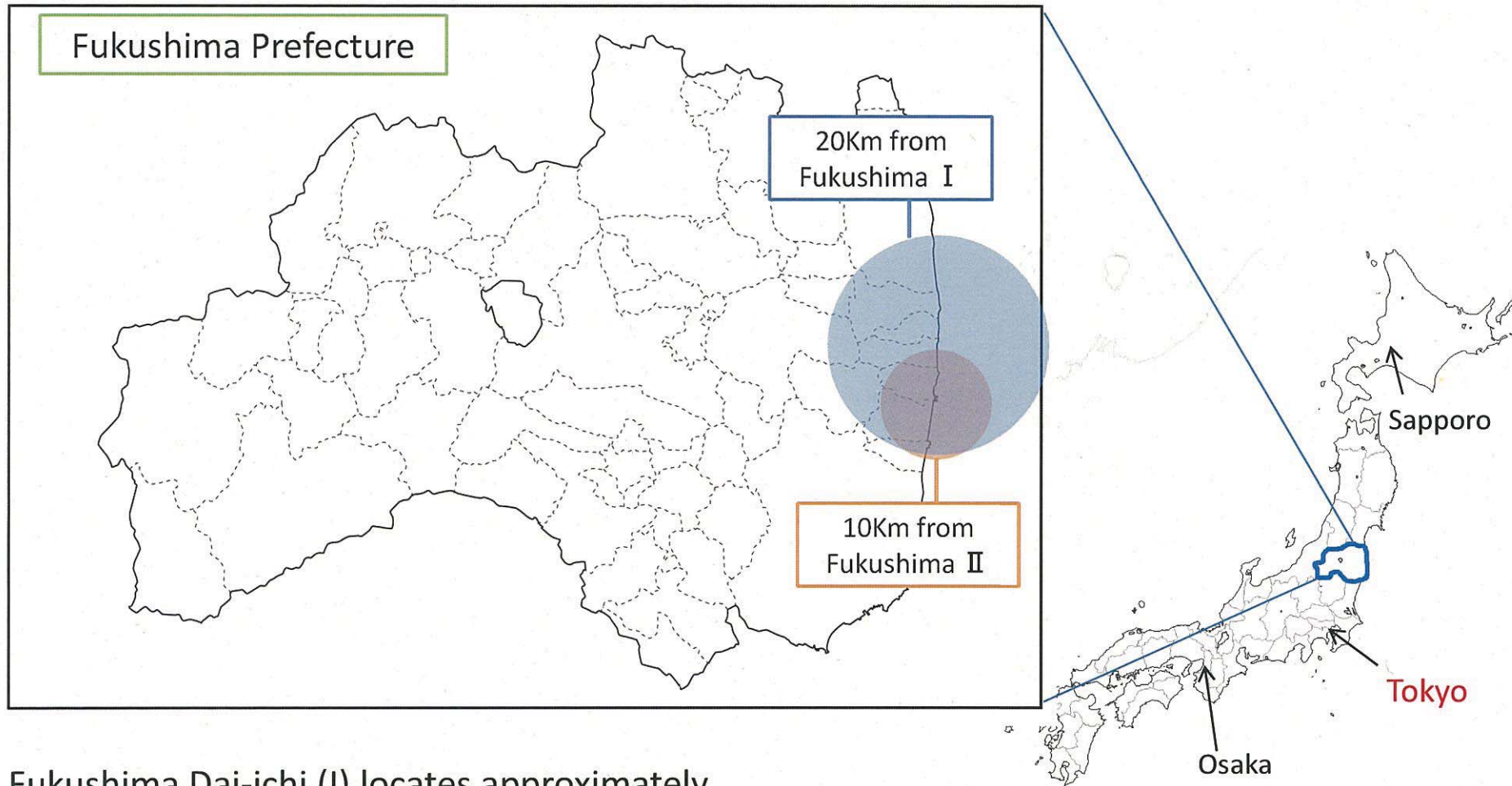
### ⑤Aerial Monitoring

- Flight Details : April 1<sup>st</sup>, from 11:02 to 13:45, cloudless skies with S winds  
Average altitude 1070 meters above sea, average speed 220km/h

Main Reading Point	City	Latitude longitude	Altitude above sea level [ above ground level] (m)	Monitoring Time	Readings(μ Sv/h)
【1】	Shirakawa (Fukushima Prefecture)	37° 03.39 ' N 140° 17.38 ' E	1193 [851]	11:45	0.0409
【2】	Iwaki (Fukushima Prefecture)	36° 32.19 ' N 140° 53.19 ' E	1209 [1203]	11:57	0.0261
【3】	Tamura (Fukushima Prefecture)	37° 27.16 ' N 140° 34.19 ' E	1267 [844]	12:13	0.0281
【4】	Shinchi-cho (Fukushima Prefecture)	37° 46.46 ' N 140° 52.50 ' E	1182 [1117]	12:23	0.0275
【5】	Fukushima (Fukushima Prefecture)	37° 47.12 ' N 140° 29.47 ' E	900 [842]	12:37	0.0234
【6】	Kooriyama (Fukushima Prefecture)	37° 26.33 ' N 140° 22.46 ' E	933 [691]	12:47	0.0402
【7】	Shirakawa (Fukushima Prefecture )	37° 09.40 ' N 140° 12.59 ' E	898 [502]	12:56	0.0402
【8】	Utsunomiya (TochigiPrefecture)	36° 35.02 ' N 140° 00.49 ' E	888 [737]	13:14	0.0147



## Current Situation on Resident Evacuation(2/2)



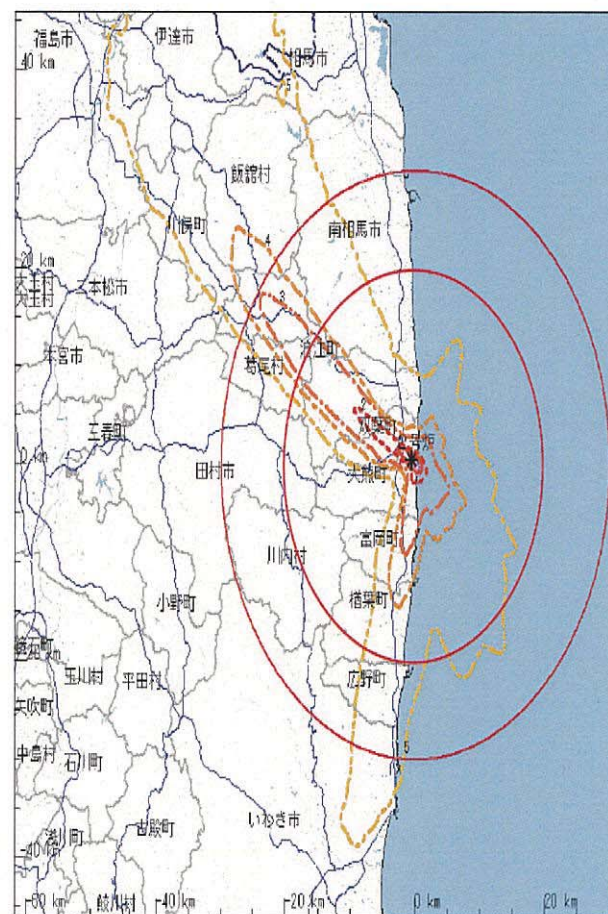
Fukushima Dai-ichi (I) locates approximately

- 230 km from Tokyo
- 580 km from Osaka
- 600 km from Sapporo

# Estimated Exposure by SPEEDI (2011/03/23, 04/05)



(評価)  
本試算は、福島第一原子力発電所の事故発生後、連続して一日中屋外で過ごすという保守的な条件を仮定して、甲状腺の被ばく線量を試算した



Source: Nuclear Safety Commission, 2011/03/23, [http://www.nsc.go.jp/info/110323\\_top\\_siryo.pdf](http://www.nsc.go.jp/info/110323_top_siryo.pdf)  
2011/04/10: <http://www.nsc.go.jp/anzen/shidai/genan2011/genan022/siryo1-3.pdf>



# Monitoring by MEXT and local nuclear emergency response HQ(3/6)

## ②Cumulative Doses Measured

- Air dose rate cumulatively measured since April 3 topped 10,340 $\mu$ Sv at #32, approximately 30km North West from 1F.

Readings of Integrated Dose at Monitoring Post out of Fukushima Dai-ichi NPP



Monitoring Time

- March 23th ~ April 3rd  
(Monitoring Post: 7, 31 ~ 34, 79)
- March 23 th ~ 28th, April 3rd  
(Monitoring Post: 71)
- March 24 th ~ April 3rd  
(Monitoring Post: 1, 15)
- March 25 th ~ April 1st, April 3rd  
(Monitoring Post: 84)
- March 31 th ~ April 1 st, April 3rd  
(Monitoring Post: 38)
- April 1 th ~ April 3rd  
(Monitoring Post: 39)
- April 2 th ~ April 3rd  
(Monitoring Post: 76)
- Monitoring Post

(explanatory note)

【 Monitoring Post number】  
Readings of Integrated Dose ※  
<increment from the last monitoring>  
(average dose per hour)

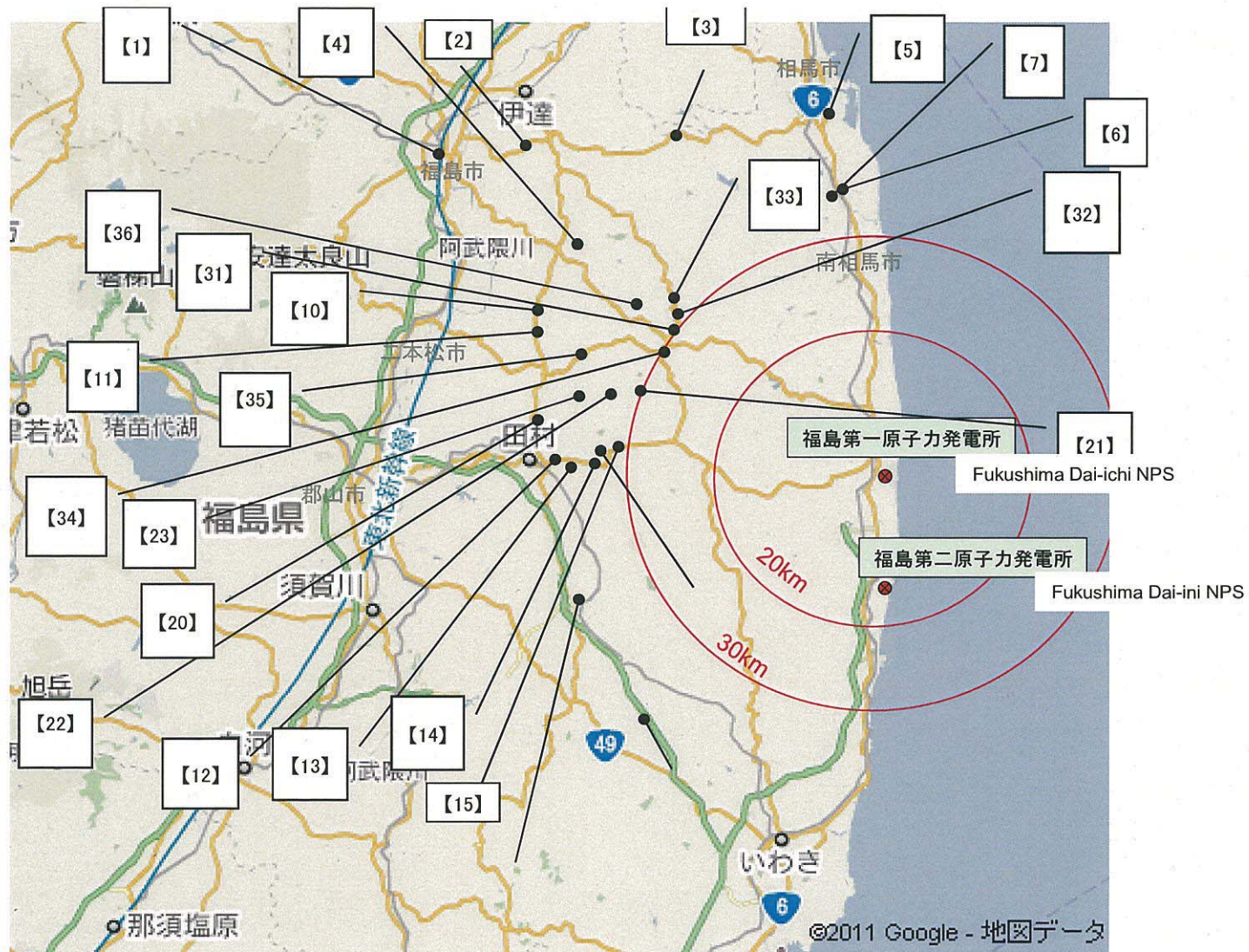
Readings of Integrated Dose  
indicate that accumulation of  
dose from each starting date till  
April 2nd, for 1 day to 10days.

Unit:  $\mu$  Sv per hour



## Monitoring by MEXT and local nuclear emergency response HQ(1/6)

### ① Air Dose Rate Measuring Locations Using Monitoring Vehicles



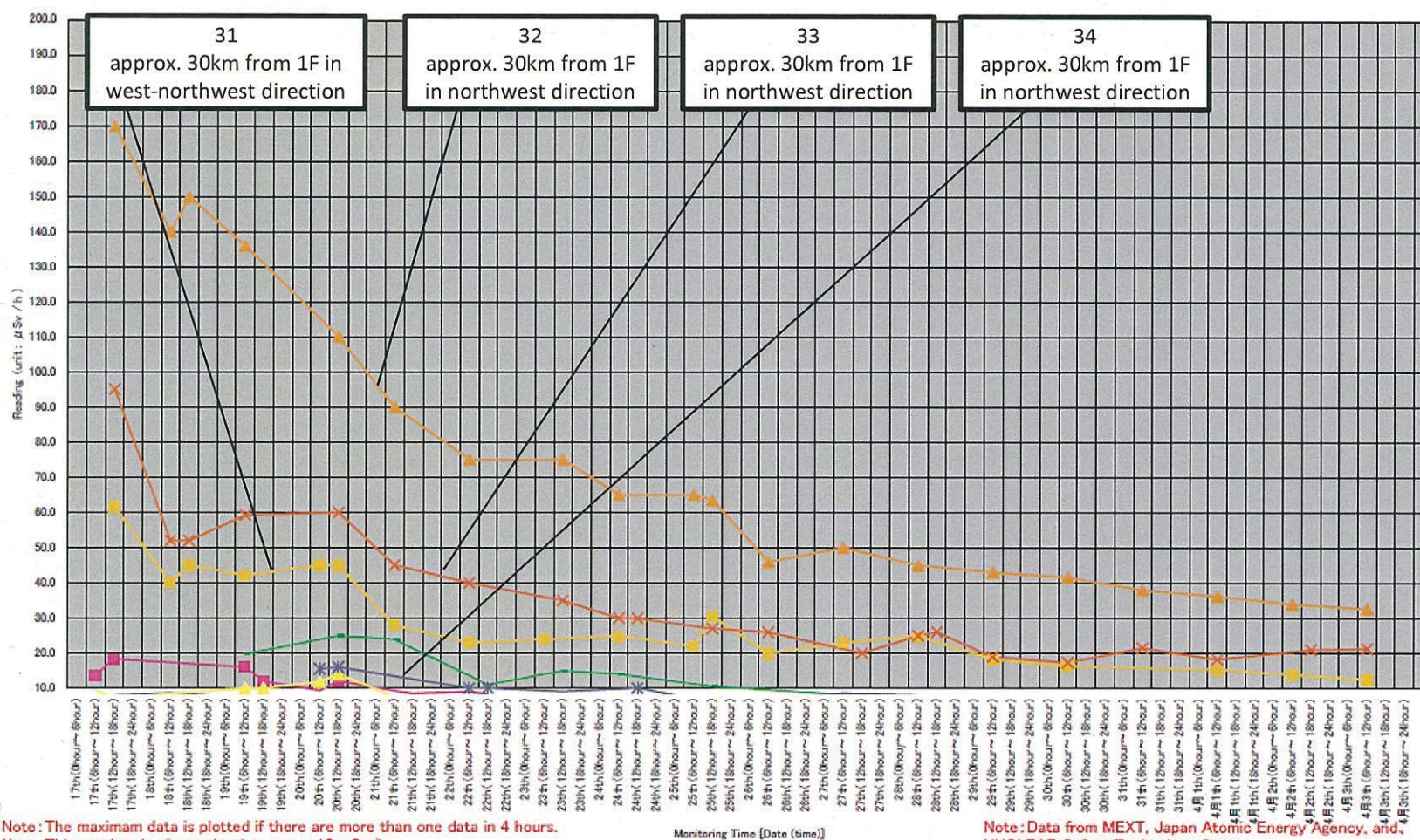


## Monitoring by MEXT and local nuclear emergency response HQ(2/6)

### ① Air Dose Rate Measured Using Monitoring Vehicles

- Overall dose rate trending down since March 17<sup>th</sup>.
- E.g. The highest value recorded at Monitoring Point #32 has peaked out at approx. 170 $\mu$ Sv/h and has been declining since, rendering no immediate health hazard.

Readings at Monitoring Post out of 20 Km Zone of Fukushima Dai-ichi NPP





## Monitoring by MEXT and local nuclear emergency response HQ(4/6)

### ③Concentration of Radioactive Materials

#### ●Soil Samples

Sampling Point	Address of Sampling Point	Sample	Sort or Region	Sampling Time and Date	Radioactivity Concentration (Bq/kg)	
					$^{131}\text{I}$	$^{137}\text{Cs}$
【2-1】 (About 40km North West)	Iitate Village	Land Soil	Soil	2011/3/19 11:40	300,000	28,100
	Iitate Village	Land Soil	Soil	2011/3/20 12:40	1,170,000	163,000
	Iitate Village	Land Soil	Soil	2011/3/21 12:32	207,000	39,900
	Iitate Village	Land Soil	Soil	2011/3/22 12:00	256,000	57,400
	Iitate Village	Land Soil	Soil	2011/3/23 12:25	135,000	32,200
	Iitate Village	Land Soil	Soil	2011/3/24 13:05	45,500	1,870
	Iitate Village	Land Soil	Soil	2011/3/25 13:05	265,000	27,900
	Iitate Village	Land Soil	Soil	2011/3/26 12:00	564,000	227,000
	Iitate Village	Land Soil	Soil	2011/3/26 15:20	82,000	28,000
	Iitate Village	Land Soil	Soil	2011/3/27 11:40	169,000	29,100
	Iitate Village	Land Soil	Soil	2011/3/27 12:00	69,800	20,800
	Iitate Village	Land Soil	Soil	2011/3/28 11:50	14,000	2,040
	Iitate Village	Land Soil	Soil	2011/3/28 12:10	23,100	860
	Iitate Village	Land Soil	Soil	2011/3/29 11:50	53,700	5,650
	Iitate Village	Land Soil	Soil	2011/3/29 12:10	58,400	25,100
	Iitate Village	Land Soil	Soil	2011/3/30 12:25	89,000	32,300
	Iitate Village	Land Soil	Soil	2011/3/30 12:45	11,900	408
	Iitate Village	Land Soil	Soil	2011/3/31 11:30	149,000	27,600
	Iitate Village	Land Soil	Soil	2011/3/31 11:45	60,800	26,500
	Iitate Village	Land Soil	Soil	2011/4/1 11:30	146,000	43,700
	Iitate Village	Land Soil	Soil	2011/4/1 12:05	21,400	1,410
	Iitate Village	Land Soil	Soil	2011/4/2 11:24	55,500	8,140
	Iitate Village	Land Soil	Soil	2011/4/2 11:48	61,900	30,800



## Monitoring by MEXT and local nuclear emergency response HQ(4/6)

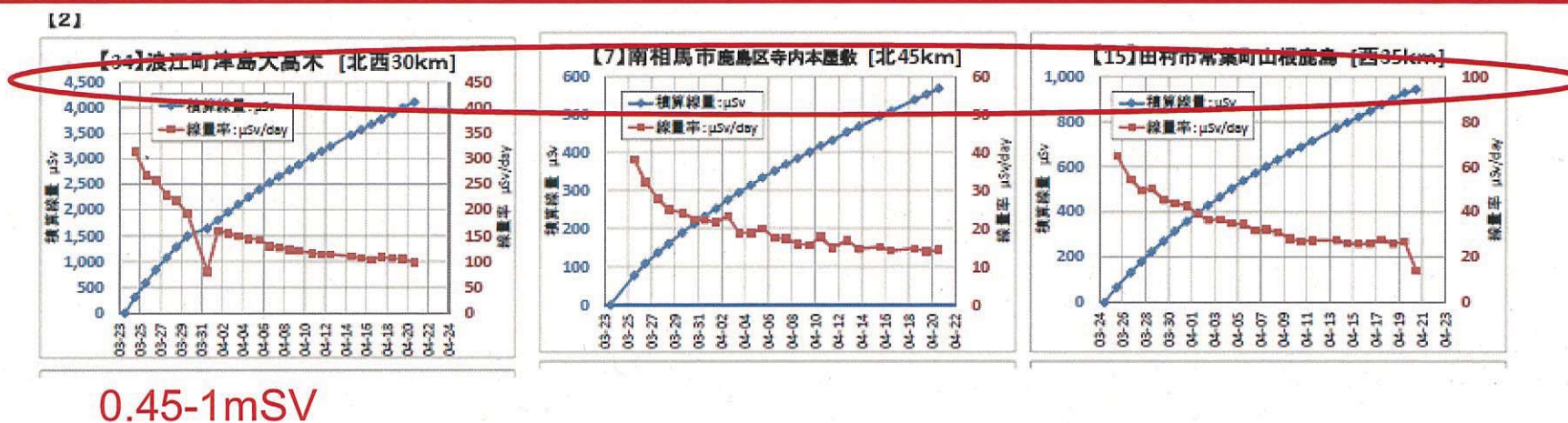
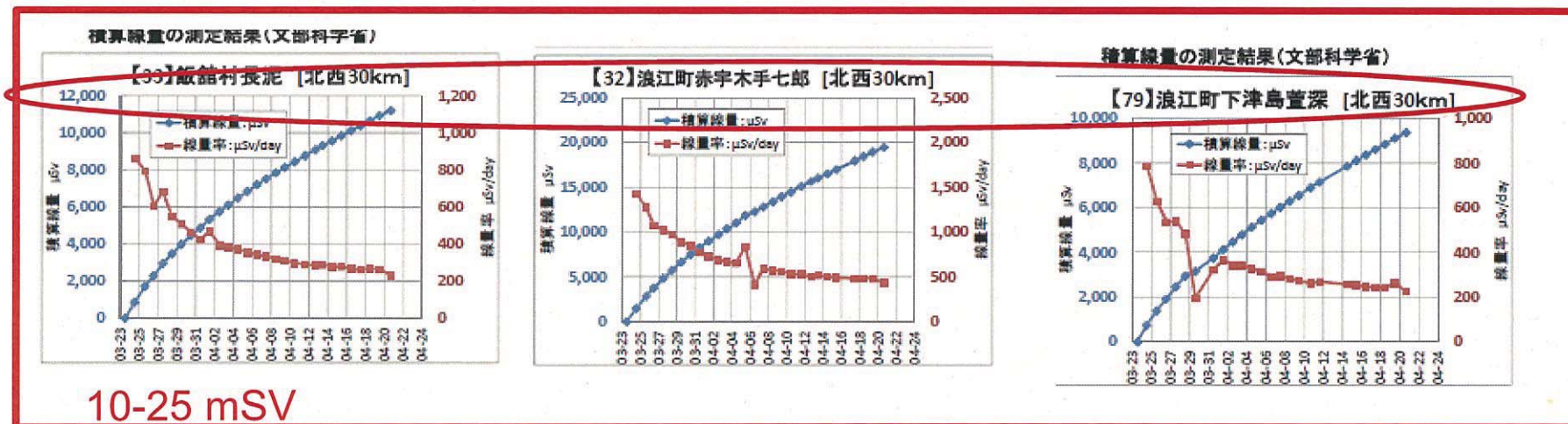
### ③Concentration of Radioactive Materials

#### ● Dust Samples

Sampling Point	Sampling Time and Date	Radioactivity Concentration(Bq/m3)		Reading ( $\mu$ Sv/h)
		$^{131}\text{I}$	$^{137}\text{Cs}$	
【2-1】(About40 kmNorthWest)	3/21 13:00~13:20	12.80	2.37	4.1
	3/22 12:26~12:46	5.87	ND	4.2
	3/23 12:50~13:10	2.99	ND	16.8
	3/24 13:30~13:50	5.80	1.51	10.0
	3/25 12:45~13:05	5.87	ND	12.3
	3/26 12:26~12:46	5.39	1.33	7.8
	3/27 12:06~12:26	2.22	ND	11.2
	3/28 12:05~12:25	1.66	ND	9.6
	3/29 12:07~12:27	2.42	6.79	9.2
	3/30 13:22~13:42	3.47	LTD	8.5
	3/31 11:50~12:10	1.74	LTD	8.0
	4/1 12:00~12:20	1.78	1.69	7.7
	4/2 11:46~12:06	0.84	ND	8.6

# Cumulative exposure is increasing

- One order difference depending on the areas



Source: JAEC based on MEXT data

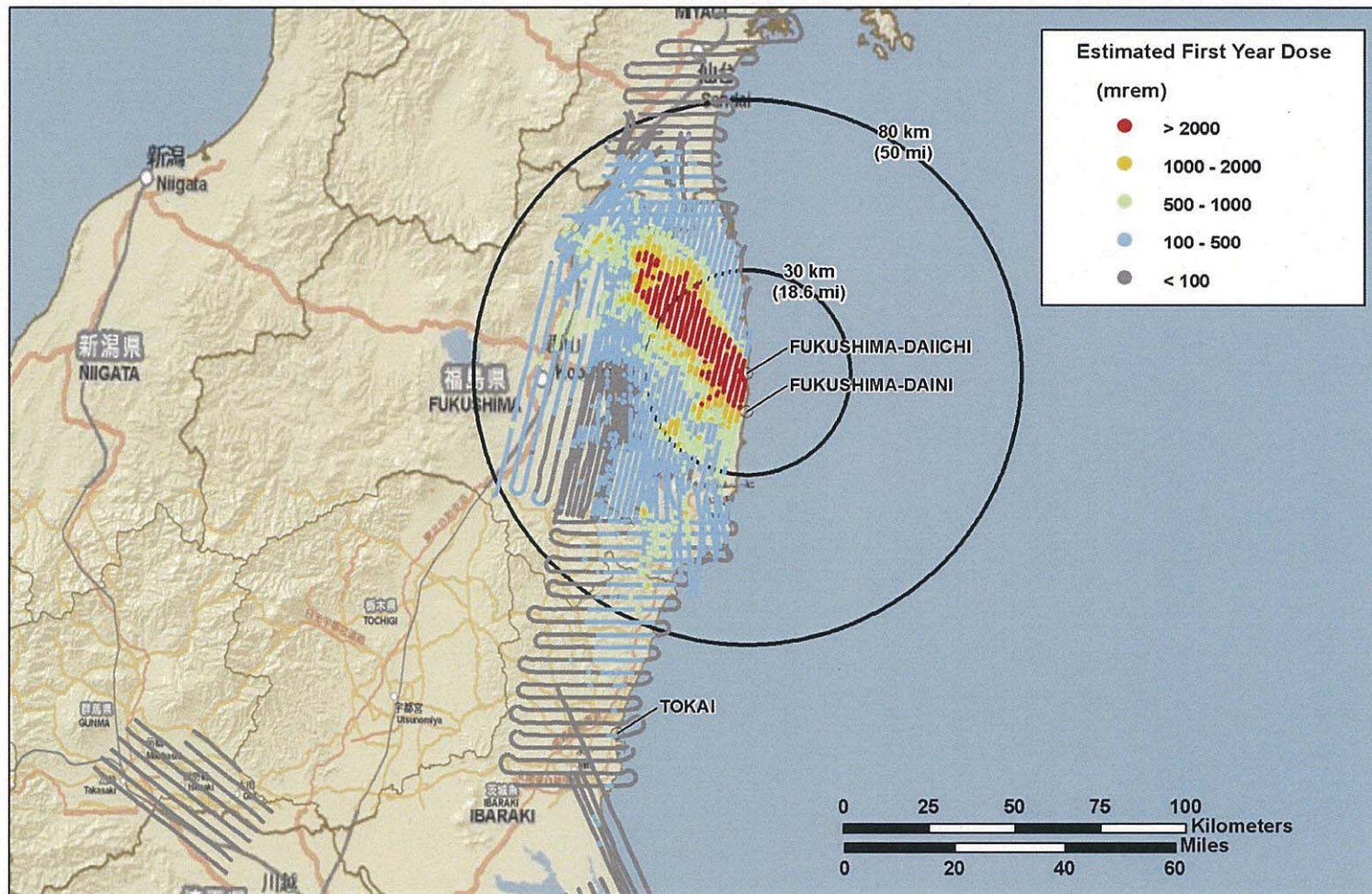


# First Year Dose Estimate



First-Year Dose Estimate  
Dose Commencing March 16, 2011 for 365 Days

FUKUSHIMA DAIICHI  
JAPAN





# “Deliberate Evacuation Area” and “Evacuation-Prepared Area” newly set (2011/04/11)

## 1. “Deliberate Evacuation Area”

- A Deliberate Evacuation Area should be set up, such that it includes the beyond-20 km areas where annual cumulative dose after the onset of the accident would potentially reach 20 mSv, having regard to the band of reference levels for emergency exposure situations, 20 to 100 mSv per year, as recommended by the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA).
  - The zone includes: Kuzuo village, Namie cho, Iitate-village, a part of Kawamata-cho and Minami-Soma

## 2. “Evacuation-Prepared Area”

- For the area between 20 and 30 km radius from the power station possibilities still remain for emergency sheltering or evacuation since the plants have not yet reached stable conditions. We hereby propose the potential emergency needs, and the current circumstances of sheltering, that the subject area, excluding its parts to be included in the Deliberate Evacuation Area, should be designated an Evacuation-Prepared Area.
  - The zone includes: Hirono-cho, Naraha-cho, Kawauchi-cho, a part of Tamura-city and Minami-soma city

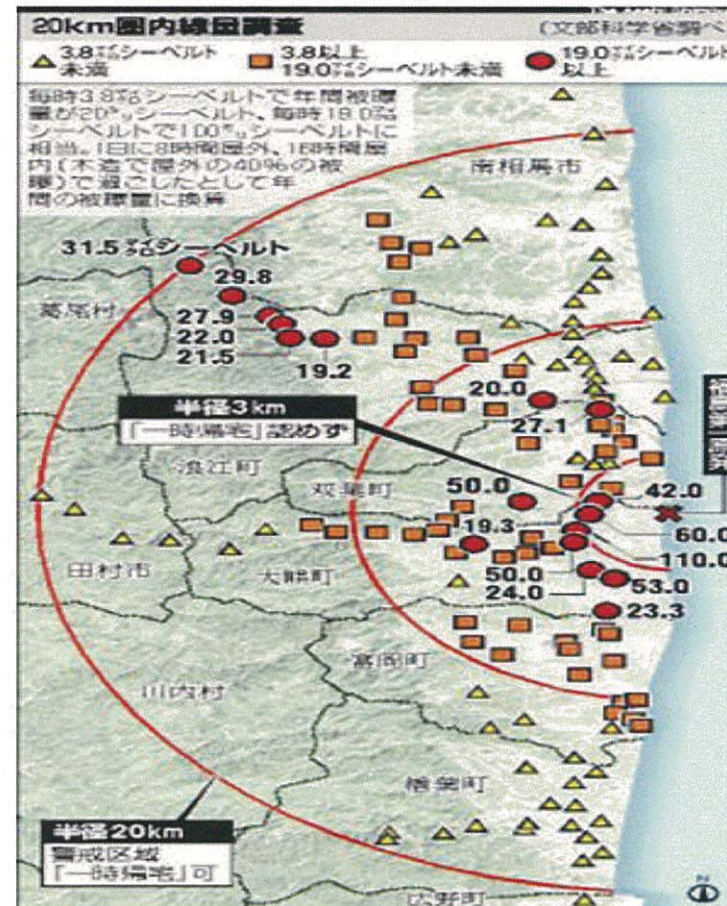
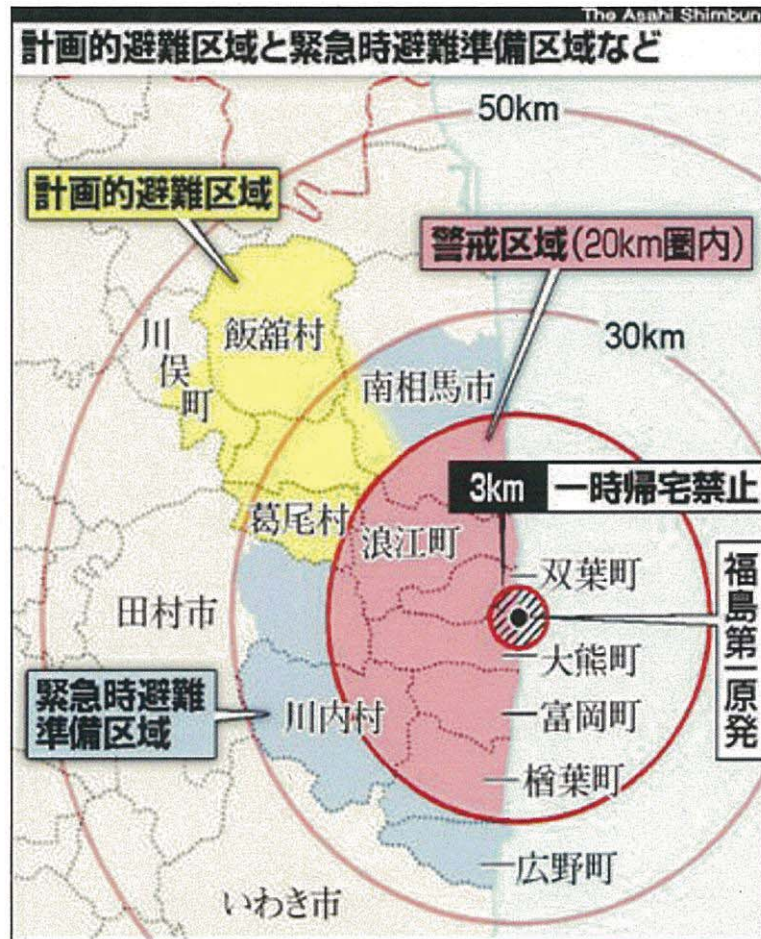
Source: Nuclear Safety Commission, April 10, 2011,

<http://www.nsc.go.jp/NSCenglish/geje/2011%200410%20sugges.pdf>





# “Deliberate Evacuation Area” and “Evacuation-Prepared Area” newly set (2011/04/11)



Source: Asahi Shimbun, April 22, 2011

<http://www.asahi.com/special/10005/TKY201104220102.html>,  
<http://www.asahi.com/special/10005/TKY201104210447.html>

## INES Level is now 7

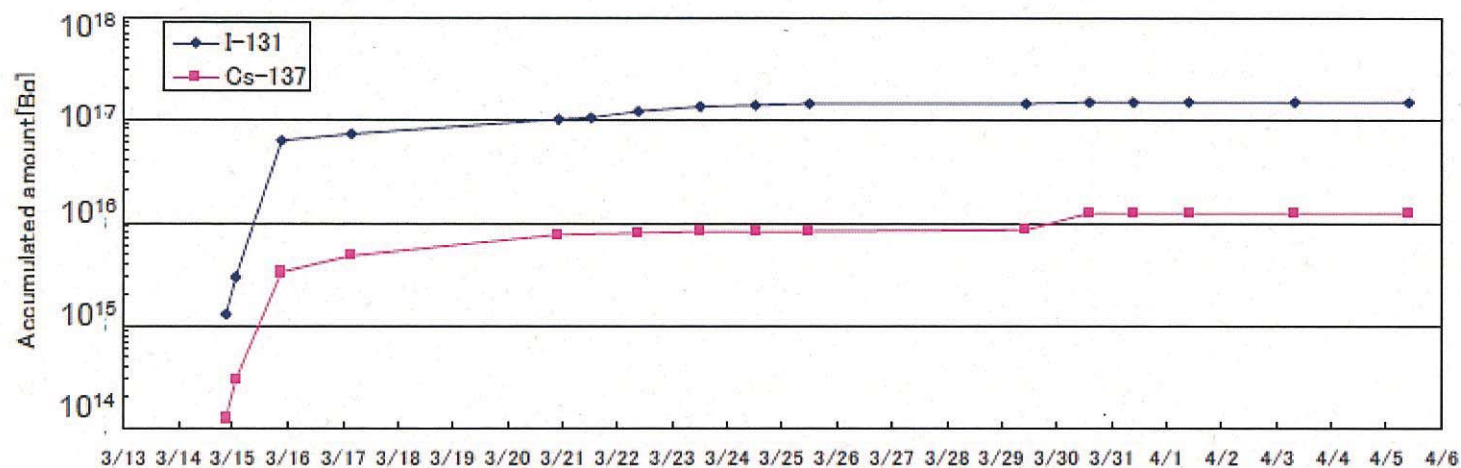
	Assumed amount of the discharge from Fukushima Dai-ichi NPS		(Reference) Amount of the discharge from the Chernobyl accident
	Estimated by NISA	Announced by NSC	
$^{131}\text{I}$ ... (a)	$1.3 \times 10^{17} \text{ Bq}$	$1.5 \times 10^{17} \text{ Bq}$	$1.8 \times 10^{18} \text{ Bq}$
$^{137}\text{Cs}$	$6.1 \times 10^{15} \text{ Bq}$	$1.2 \times 10^{16} \text{ Bq}$	$8.5 \times 10^{16} \text{ Bq}$
(Converted value to $^{131}\text{I}$ ) ... (b)	$2.4 \times 10^{17} \text{ Bq}$	$4.8 \times 10^{17} \text{ Bq}$	$3.4 \times 10^{18} \text{ Bq}$
(a) + (b)	$3.7 \times 10^{17} \text{ Bq}$	$6.3 \times 10^{17} \text{ Bq}$	$5.2 \times 10^{18} \text{ Bq}$

Source: NISA, April 12, 2011 <http://www.nisa.meti.go.jp/english/files/en20110412-4.pdf>





# Cumulative amount of radioactivity



Note) Emission amount into the atmosphere accumulated from the occurrence of the accident to the specific day.  
Not the amount emitted within the day.

Source: Nuclear Safety Commission,  
<http://www.nsc.go.jp/NSCenglish/geje/2011%200412%20press.pdf>



## Directive regarding foods and drinks

### (1) Agricultural Goods

- Ministry of Health, Labor and Welfare (MHLW) set provisional regulatory standards for foods detected with radioactive substances and notified prefectures, etc. as “Handling of food contaminated by radioactivity”.
- MHLW notified prefectures, etc. regarding points to be mindful of in examining foods detected with radioactive substances.
- Prime Minister instructed local governments concerned to restrict distribution and/or consumption of foods concerned in accordance with Special Law of Nuclear Emergency Preparedness.
  - Fukushima Pref. (Distribution restricted→spinach, kakina, raw milk, etc.)
  - Ibaraki, Tochigi, Gunma Prefs. (Distribution restricted→spinach, kakina)

### (2) Drinking Water

- MHLW notified water suppliers in prefectures concerned the followings regarding response to radioactive substances in tap water caused by the nuclear accident.
  - Refrain from drinking tap water exceeding index values (300Bq/kg for radioactive Iodine, 200Bq/kg for radioactive Cesium) .
  - In case radioactive Iodine exceeds 100Bq/kg, refrain from giving tap water to infants, including preparing infant formula.
  - There is no problem in using tap water for other domestic uses.
  - Lack of substitute drinking water.





# Emergency Safety Measures directed by NISA (2011/03/30)

## Short Term Measures (~ within 1 month)

1. Inspection of emergency equipments
2. Inspection of emergency plan and implementation of simulation training
3. Securing emergency power supplies
4. Securing ultimate heat removal capability
5. Securing cooling capability of spent fuel storage pool
6. Measures specific to each site condition



# Statement by 16 experts

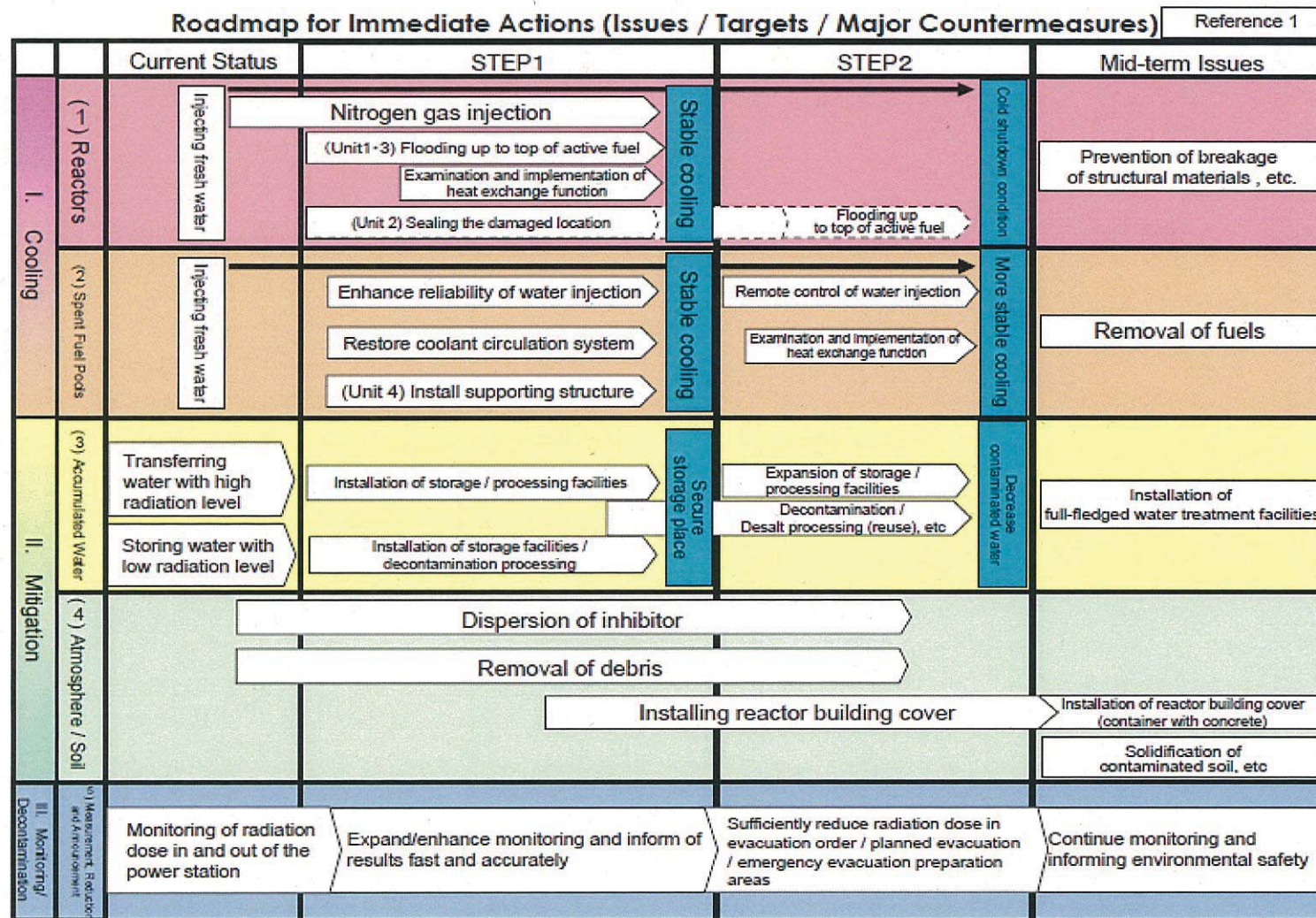
- Moreover, hindsight shows that relatively inexpensive improvements, detectable by more extensive analysis beforehand, may have avoided these accidents altogether.
- Appropriate measures to further strengthen the international nuclear safety regime should be identified and implemented after proper discussions

Source: Statement by 16 experts, "NEVER AGAIN: An Essential Goal for Nuclear Safety", April, 4, 2011





# Roadmap to stabilization and cold shutdown (2011/04/17)



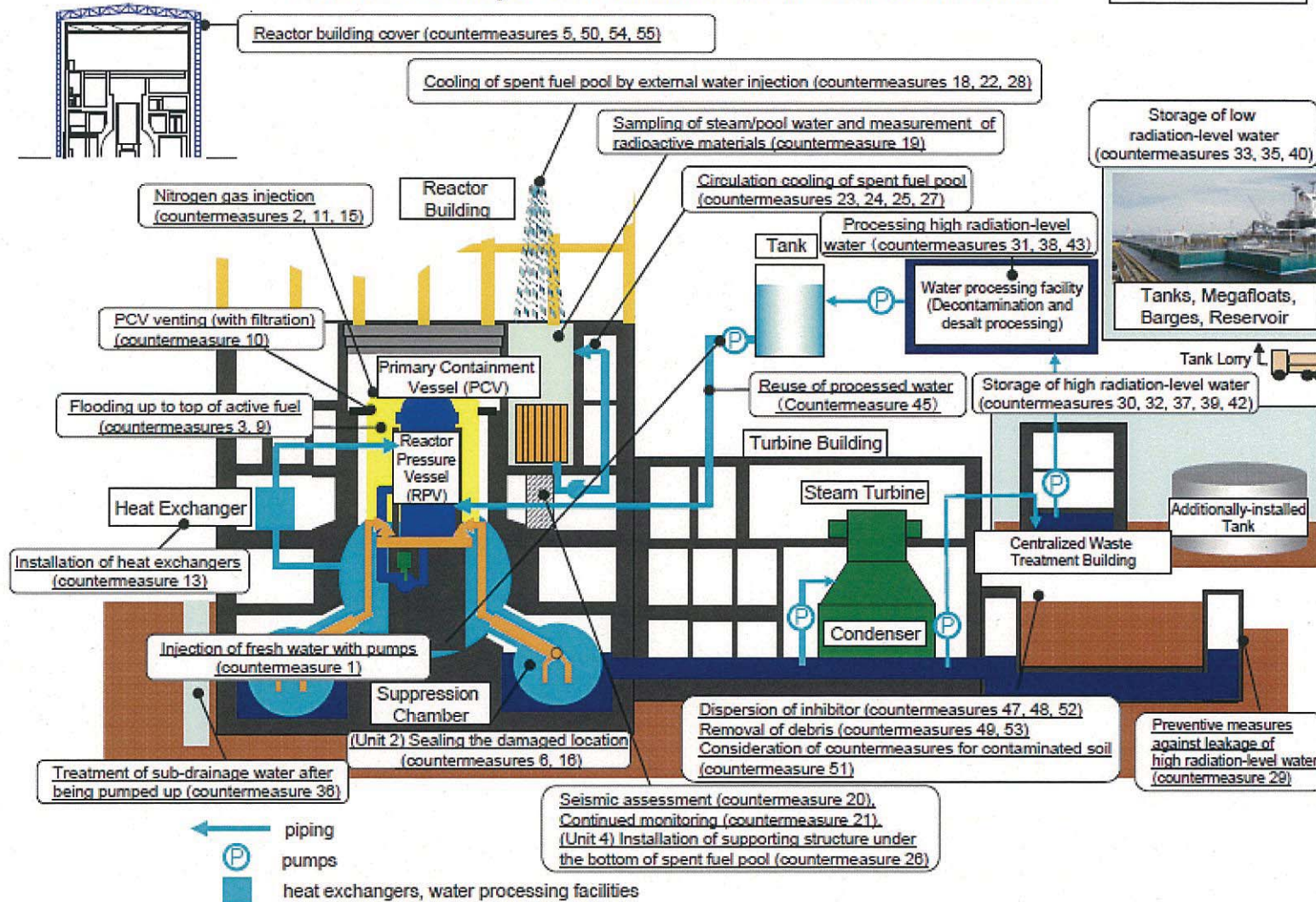
Source: [http://www.tepco.co.jp/en/press/corp-com/release/betu11\\_e/images/110417e14.pdf](http://www.tepco.co.jp/en/press/corp-com/release/betu11_e/images/110417e14.pdf)





## Overview of Major Countermeasures in the Power Station

Reference 2



Source: TEPCo, [http://www.tepco.co.jp/en/press/corp-com/release/betu11\\_e/images/110417e15.pdf](http://www.tepco.co.jp/en/press/corp-com/release/betu11_e/images/110417e15.pdf)





# Main Issues

## Nuclear Accidents :

- Lessons learned based on the records so far
- Setting up investigation committee
- Review of safety regulatory scheme
- Long term plan for final decommissioning
- Secure funding for compensation and decommissioning

## Energy (and Nuclear Energy) policy :

- Short term energy supply plan
- Securing safety of existing nuclear power plants
  - Securing safety of spent fuel storage
- Setting up arena for comprehensive energy policy debate
  - Energy Basic Plan (2010) needs to be revised
  - Framework for Nuclear Energy Policy (2005) needs to be revised
  - Climate change policy (CO2 reduction targets etc.)



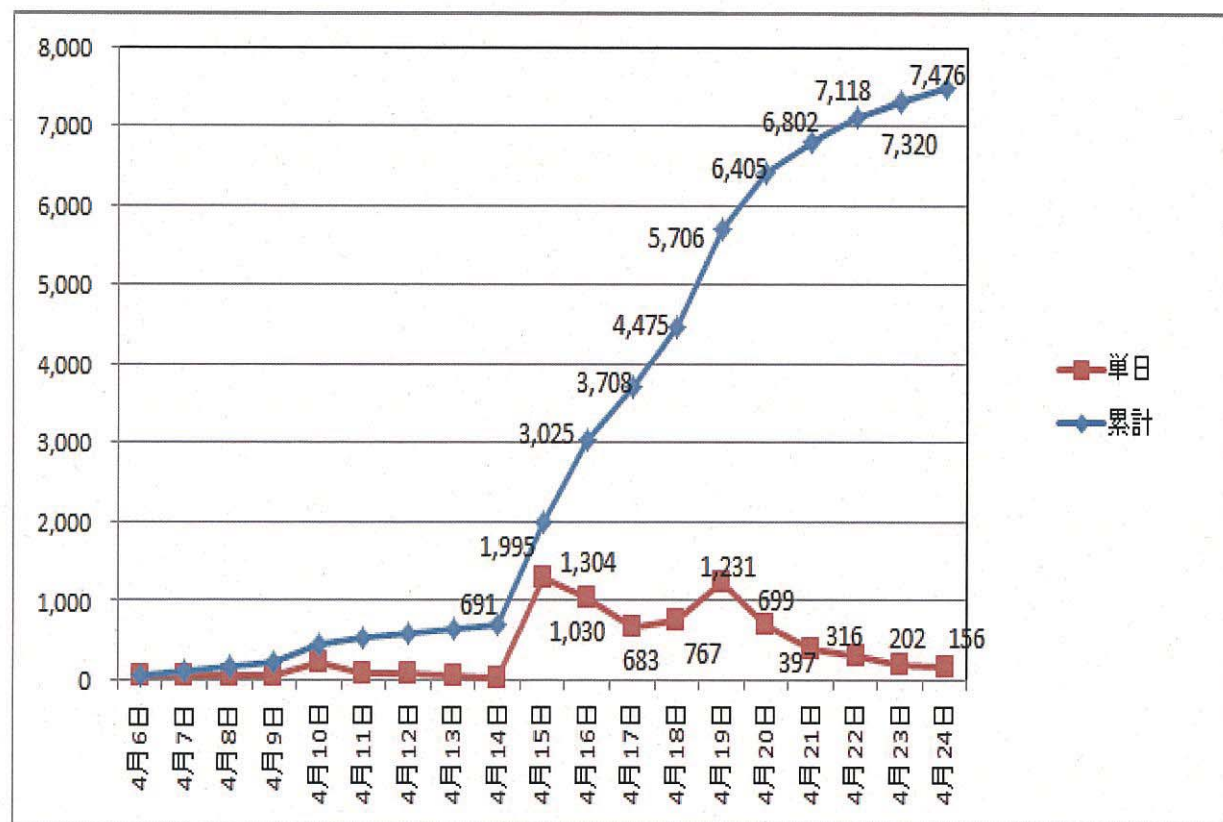
# Statement by JAEC (2011/04/05)

- “We are gravely concerned about this accident which can fundamentally undermine public trust in safety measures, not only in Japan but also in other countries”
- “...we have decided to suspend this (deliberation) process (of new Framework for Nuclear Energy Policy) for the foreseeable future.”
- “It is our intention to take appropriate measures when all safety measures necessary are identified comprehensively, based on thorough investigation of the causes of the accident, as well as on the results of a nationwide public debate on overall energy policy.”





# Public Comments Delivered to JAEC



Daily  
Cumulative



# Commissioner(Tatsujiro Suzuki) calls for verifiable probe of Fukushima nuke crisis

(Kyodo News, 2011/04/14)

- Japan should thoroughly investigate the nuclear crisis at the Fukushima Daiichi power plant in an internationally verifiable manner, possibly by involving experts from other countries to help guarantee the openness and transparency of the probe.
- Japan would otherwise lose fundamental trust from other countries, citing many negative views about its response to the ongoing crisis in comments he has received from abroad.



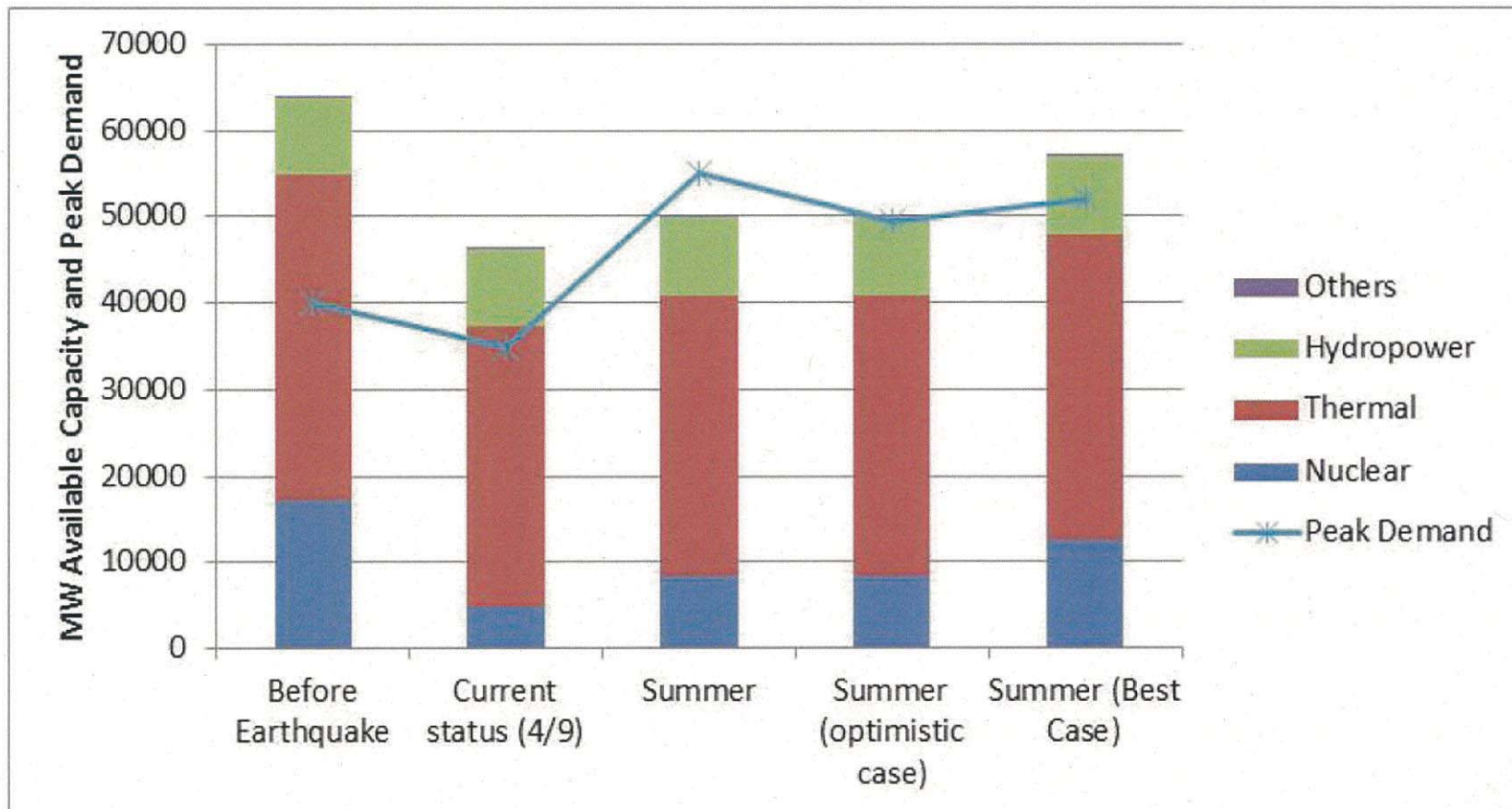


# Prime Minister Kan's Message (April 16, 2011)

- “..the Japanese government will promptly and thoroughly verify the cause of this incident, as well as share information and the lessons learned with the rest of the world to help prevent such accidents in the future..”
- “..I would like to present a clear vision to the world — that includes the aggressive promotion of clean energy — that may contribute to solving global energy issues.”
  - Naoto Kan, “Japan's Road to Recovery and Rebirth”, *The New York Times*, April, 16, 2011

# Short Term Electricity Supply Issue

Figure 6: Comparison of TEPCO Available Capacity and Peak Demand During Summer, 2011 (MW)



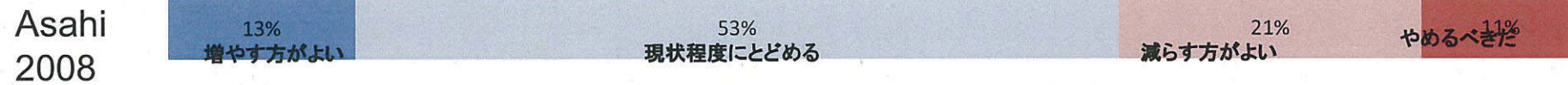
Source: David von Hippel and Kae Takase, "The Path from Fukushima: Short and Medium-term Impacts of the Reactor Damage Caused by the Japan Earthquake and Tsunami on Japan's Electricity Systems, April 11, 2011"





# Public Opinion Poll after 3/11

Increase                      Status quo                      Reduce                      Phase out



# World Public Opinion Poll (2011)

## Global Views before the Japan Earthquake:

	Globally	Japan
Favorable:	57%	62%
Unfavorable	32%	28%
Net Favor	25%	34%
No Response	11%	10%

## Global Views after the Japan Earthquake:

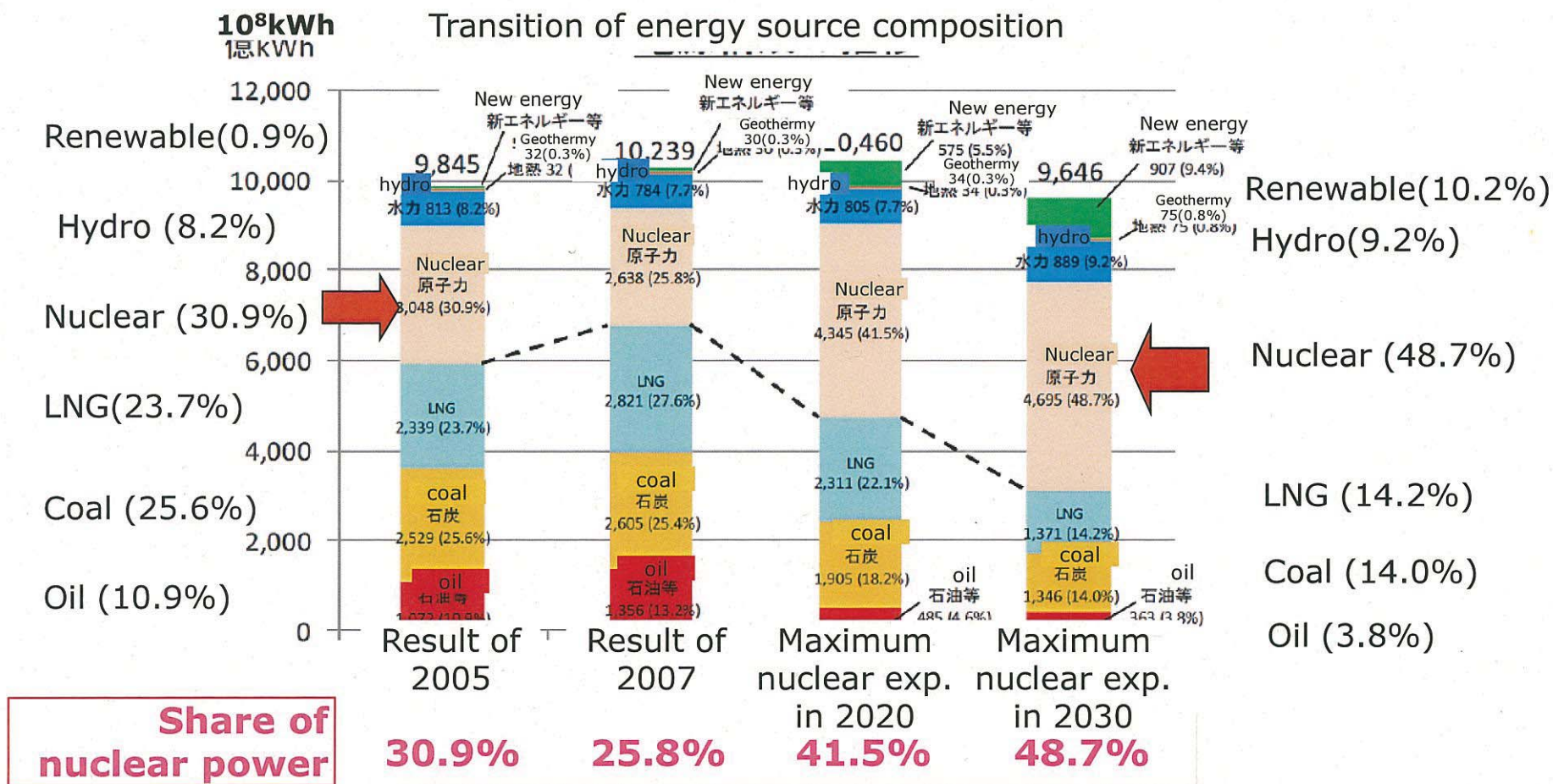
	Globally	Japan
Favorable	49%	39%
Unfavorable	43%	47%
Net Favor	6%	-7%
No Response	8%	14%
Total	100%	100%

Source: WIN/Gallop poll, "JAPAN EARTHQUAKE JOLTS GLOBAL VIEWS ON NUCLEAR ENERGY"  
April, 19, 2011





# Goal of Power Production Mix in 2030



Source: Institute of Energy Economics, March 2010

# Information Source

- **Japan's Countermeasures**

- 1. <http://www.kantei.go.jp/foreign/incident/index.html>
- 2. <http://www.meti.go.jp/english/index.html>
- 3. <http://www.nisa.meti.go.jp/english/>

- **Measurement of Radioactivity Level**

- 1. [http://www.mext.go.jp/english/radioactivity\\_level/detail/1303986.htm](http://www.mext.go.jp/english/radioactivity_level/detail/1303986.htm)
- 2. <http://www.nisa.meti.go.jp/english/>
- 3. [http://www.worldvillage.org/fia/kinkyu\\_english.php](http://www.worldvillage.org/fia/kinkyu_english.php)
- 4. <http://www.tepco.co.jp/en/press/corp-com/release/index-e.html>

- **Drinking Water Safety**

- 1. <http://www.mhlw.go.jp/english/topics/2011eq/index.html>
- 2. <http://www.waterworks.metro.tokyo.jp/press/shinsai22/press110324-02-1e.pdf>

- **Food Safety**

- 1. <http://www.maff.go.jp/e/index.html>
- 2. <http://www.mhlw.go.jp/english/topics/2011eq/index.html>

- **Ports and Airports Safety**

- 1. [http://www.mlit.go.jp/page/kanbo01\\_hy\\_001428.html](http://www.mlit.go.jp/page/kanbo01_hy_001428.html)
- 2. [http://www.mlit.go.jp/koku/flyjapan\\_en/index.html](http://www.mlit.go.jp/koku/flyjapan_en/index.html)

