Effects of the Earthquake and Tsunami on the Fukushima Daiichi and Daini Nuclear Power Stations

May 24, 2011

Tokyo Electric Power Company

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Outline of the Great East Japan Earthquake and Tsunami

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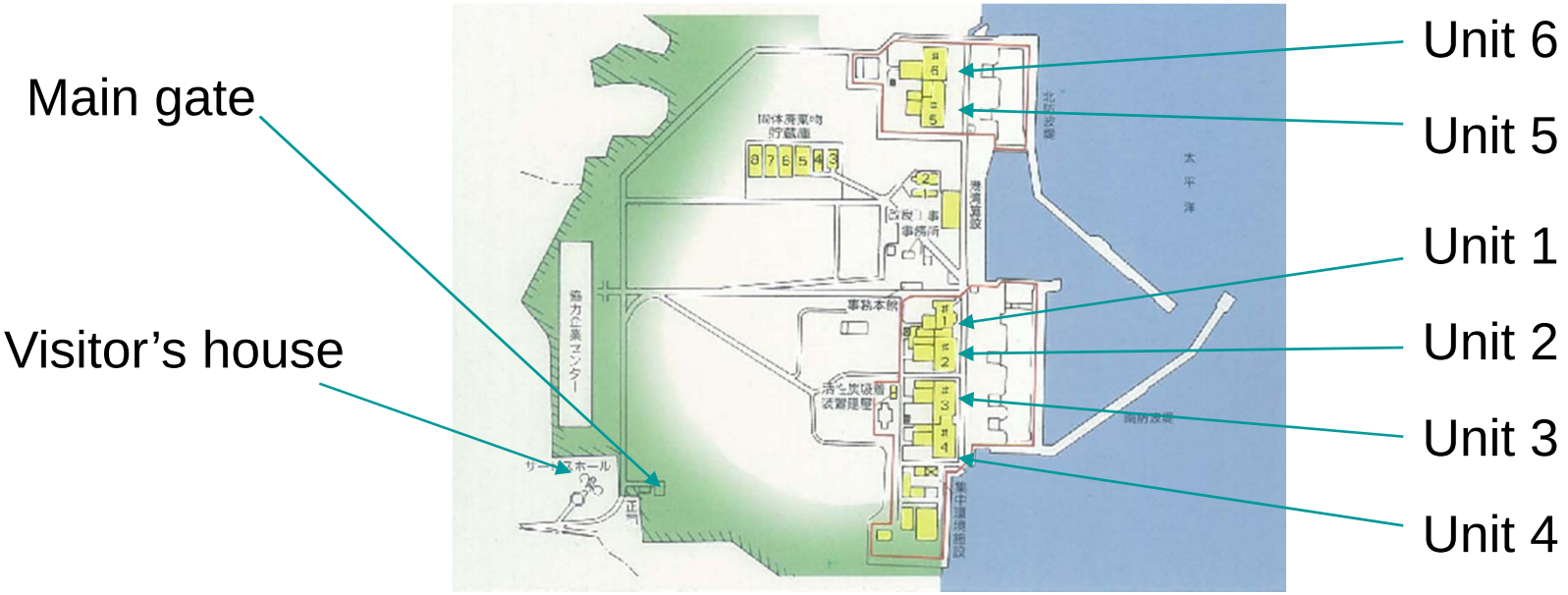
Overview of Fukushima Daiichi NPS



Location	Unit	In operation since	Plant type	Power Output (MW)	Main Contractor	Pre-earthquake status
Ohkuma	1	1971.3	BWR-3	460	GE	Operating
	2	1974.7	BWR-4	784	GE/Toshiba	Operating
	3	1976.3	BWR-4	784	Toshiba	Operating
	4	1978.10	BWR-4	784	Hitachi	Shutdown for maintenance
Futaba	5	1978.4	BWR-4	784	Toshiba	Shutdown for maintenance
	6	1979.10	BWR-5	1100	GE/Toshiba	Shutdown for maintenance

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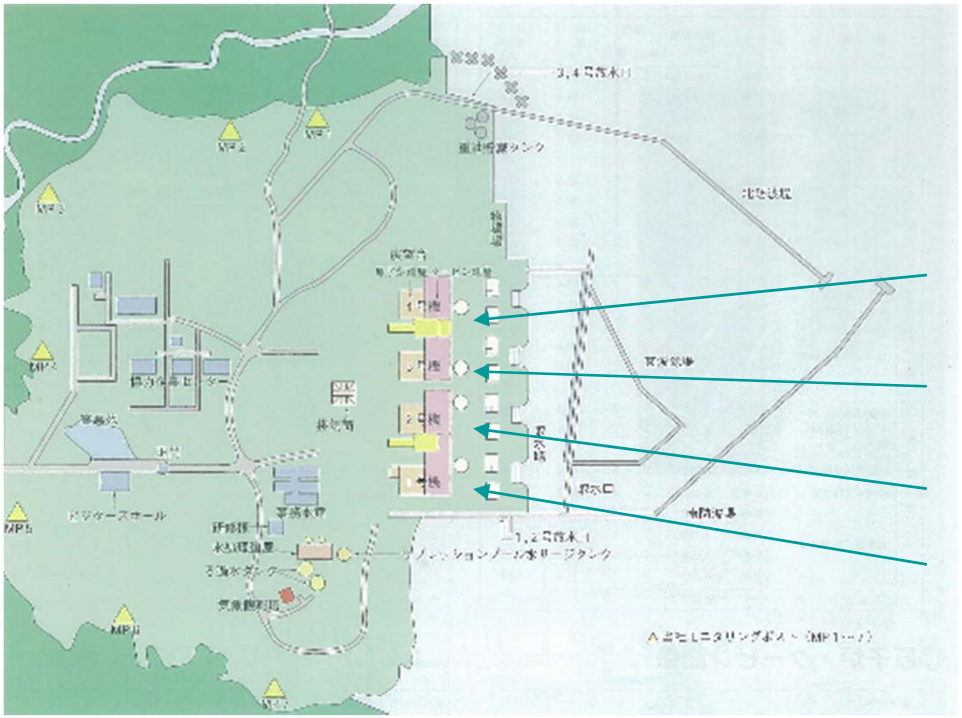
Overview of Fukushima Daini NPS



Location	Unit	In operation since	Plant type	Power Output (MW)	Main Contractor	Pre-earthquake status
Naraha	1	1982.4	BWR-5	1100	Toshiba	Operating
	2	1984.2	BWR-5	1100	Hitachi	Operating
Tomioka	3	1985.6	BWR-5	1100	Toshiba	Operating
	4	1987.8	BWR-5	1100	Toshiba	Operating

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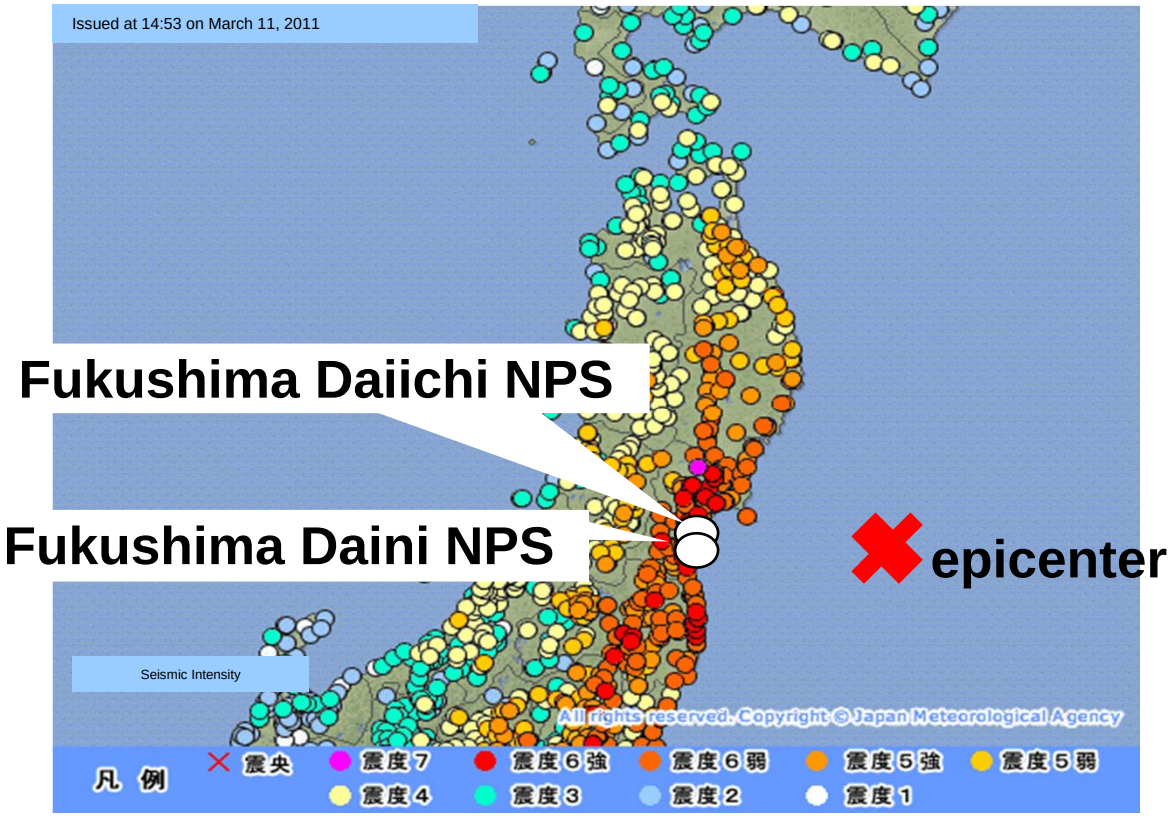
Tohoku Pacific Ocean Earthquake

- **Time:** 2:46 pm on Fri, March 11, 2011.
- **Place:** Offshore Sanriku coast (northern latitude of 38 degrees, east longitude of 142.9), 24km in depth, Magnitude 9.0
- **Intensity:** **Level 7** at Kurihara in Miyagi Miyagi prefecture
  Upper 6 at Naraha, Tomioka, Okuma, and Futaba in Fukushima pref.
  Lower 6 at Ishinomaki and Onagawa in Miyagi pref., Tokai in Ibaraki pref.
  Lower 5 at Kariwa in Niigata pref.
  Level 4 at Rokkasho, Higashidori, Mutsu and Ohma in Aomori pref., Kashiwazaki in Niigata pref.



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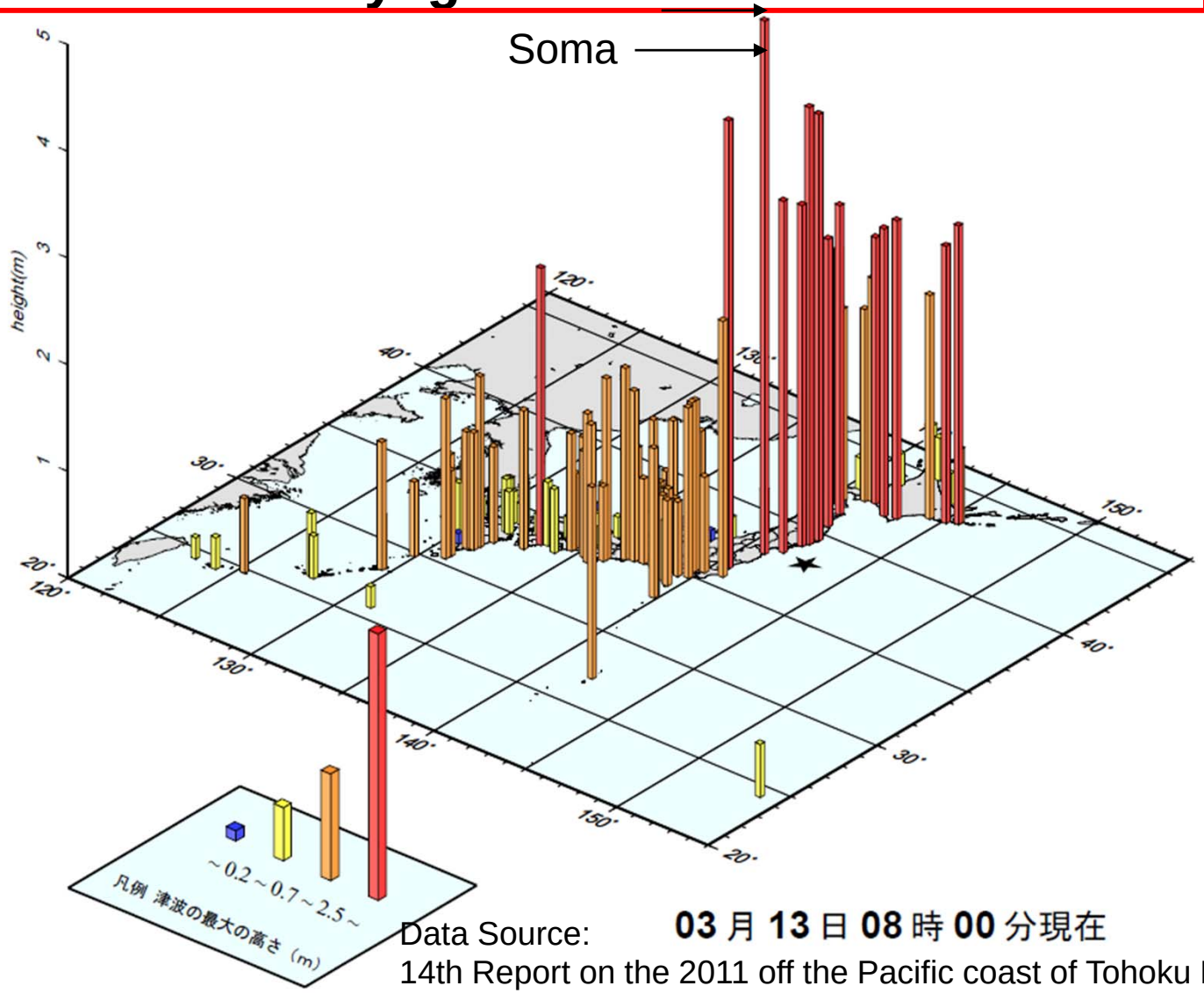
Height of Tsunami

High tsunami wave arrived on the coasts of Miyagi and Fukushima



Data Source:
14th Report on the 2011 off the Pacific coast of Tohoku Earthquake by Japan Meteorological Agency (Mar. 13 2011)

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Size of the Earthquake and Tsunami

one of the largest magnitude on record

Earthquake Magnitude：fourth-largest magnitude on record

Grade	Year	Name	Magnitude
1	1960	Chile	9.5
2	1964	Alaska	9.2
3	2004	Sumatra	9.1
4	**2011**	**Tohoku Pacific Ocean**	**9.0**
5	1952	Kamchatka	9.0

Tsunami Magnitude* ：fourth-largest magnitude on record

Grade	Year	Name	Magnitude
1	1960	Chile	9.4
2	1837	Valdivia, Chile	9.3
2	1946	Aleutians	9.3
4	**2011**	**Tohoku Pacific Ocean**	**9.1**
4	1964	Alaska	9.1
5	2004	Sumatra etc.	9.0

＊Magnitude calculated from the size of Tsunami

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The Earthquake that hit the Power Station

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Seismic Observed Data

Comparison between Basic Earthquake Ground Motion and the record of intensity

Observation Point (The lowest basement of reactor buildings)		Observed data (*interim) Maximum Response Acceleration (gal)			Maximum Response Acceleration against Basic Earthquake Ground Motion (Gal)		
		Horizontal (N-S)	Horizontal (E-W)	Vertical	Horizontal (N-S)	Horizontal (E-W)	Vertical
Fukushima Daiichi	Unit 1	460※2	447※2	258※2	487	489	412
	Unit 2	348※2	550※2	302※2	441	438	420
	Unit 3	322※2	507※2	231※2	449	441	429
	Unit 4	281※2	319※2	200※2	447	445	422
	Unit 5	311※2	548※2	256※2	452	452	427
	Unit 6	298※2	444※2	244	445	448	415
Fukushima Daini	Unit 1	254	230※2	305	434	434	512
	Unit 2	243	196※2	232※2	428	429	504
	Unit 3	277※2	216※2	208※2	428	430	504
	Unit 4	210※2	205※2	288※2	415	415	504

*1: The data above is interim and is subject to change.
*2: The recording time was about 130-150 seconds

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Photos from

Fukushima Daiichi

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Photos from Fukushima Daini

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The Tsunami that hit the Power Station

[Summary]
- Both Fukushima Daiichi and Daini suffered extensive damage due to the tsunami.
- Fukushima Daiichi experienced more flooding in comparison to Daini, and suffered more primary damage

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Tsunami Attack to Fukushima Daiichi NPS

Fukushima Daiichi

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Pictures before / after Tsunami

Fukushima Daiichi

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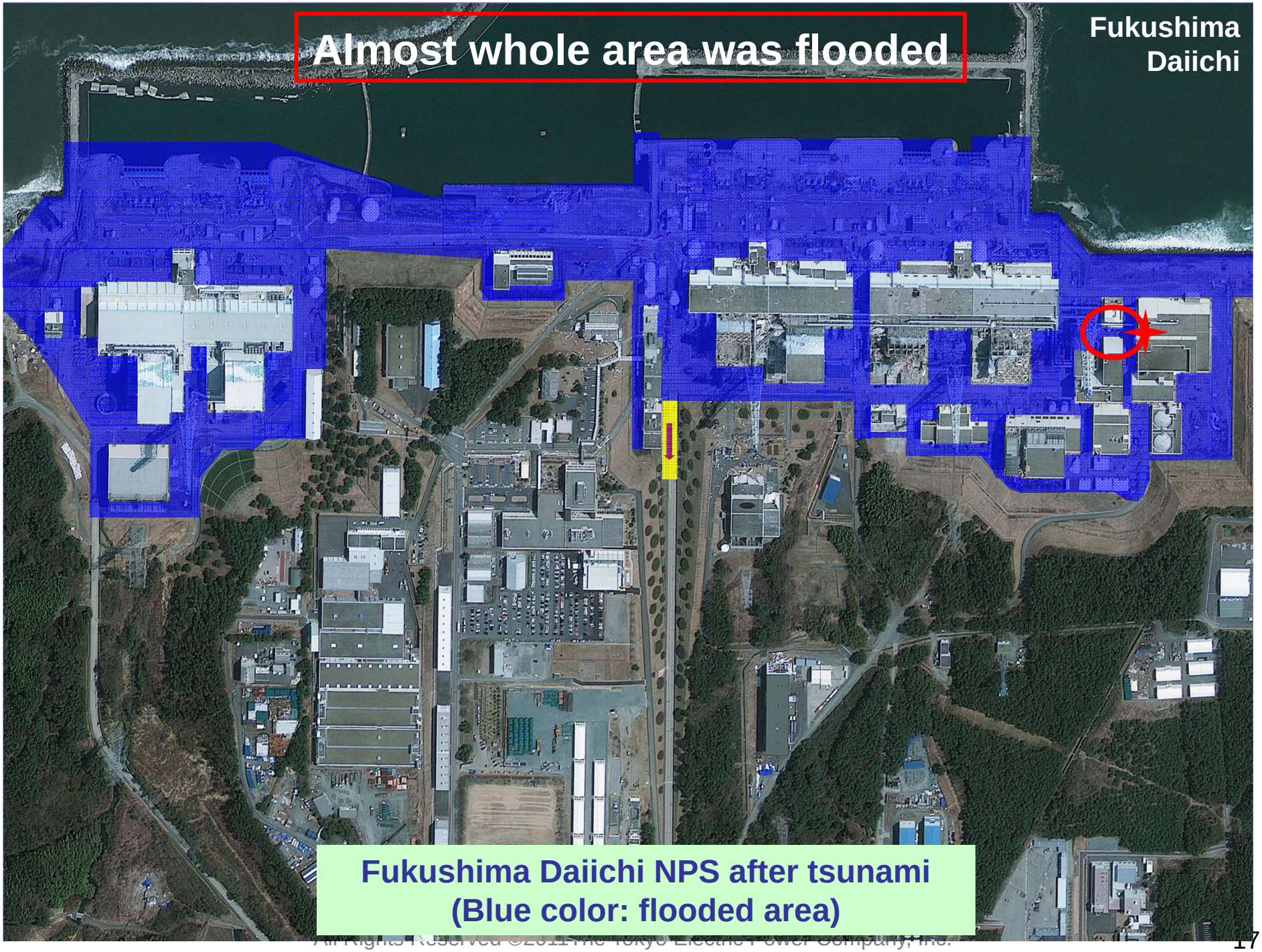
Fukushima Daiichi NPS after tsunami



Fukushima Daiichi NPS after tsunami
(Blue color: flooded area)

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Date : 2011/3/11 15:42


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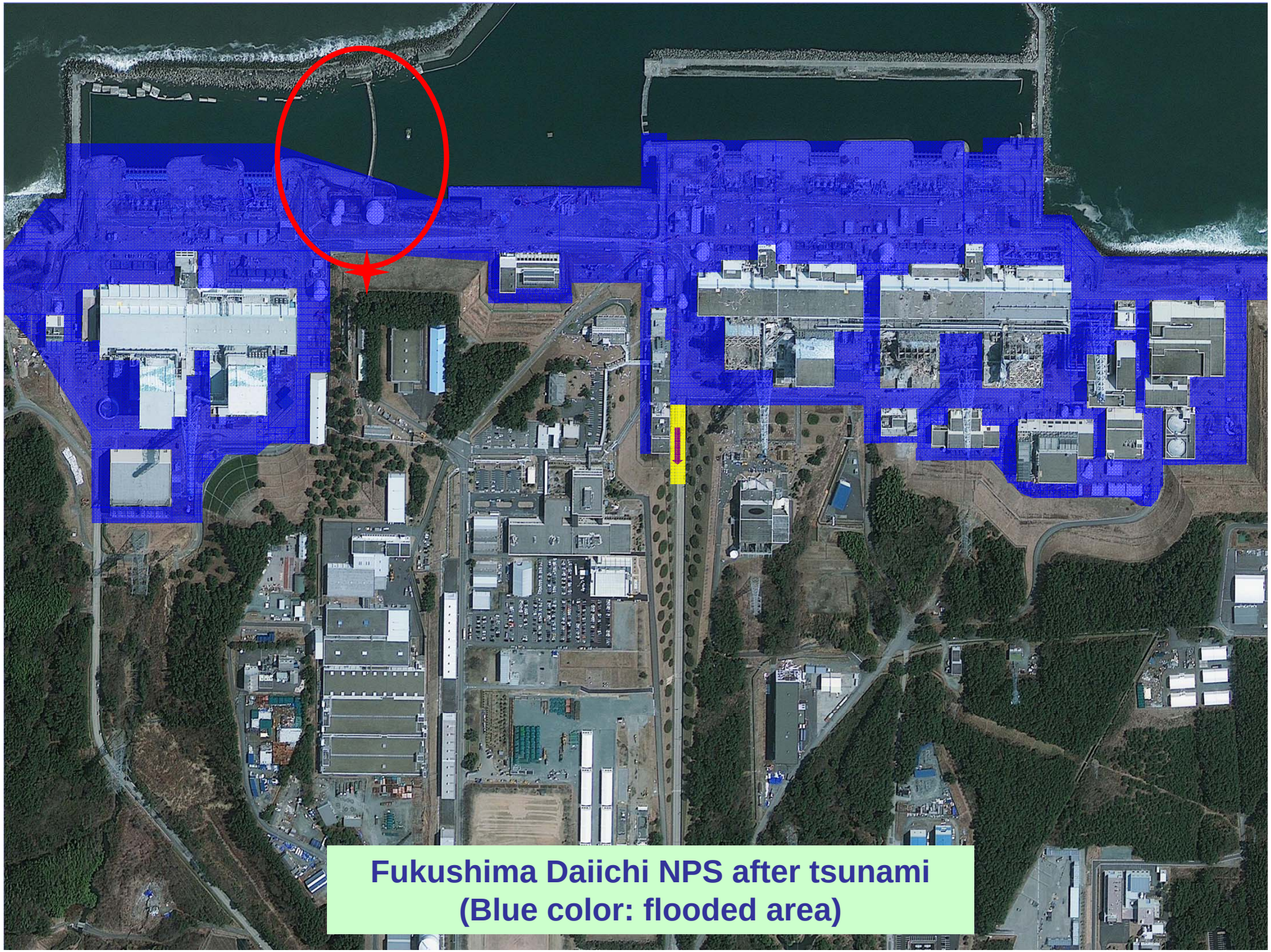
Date : 2011/3/11 15:57

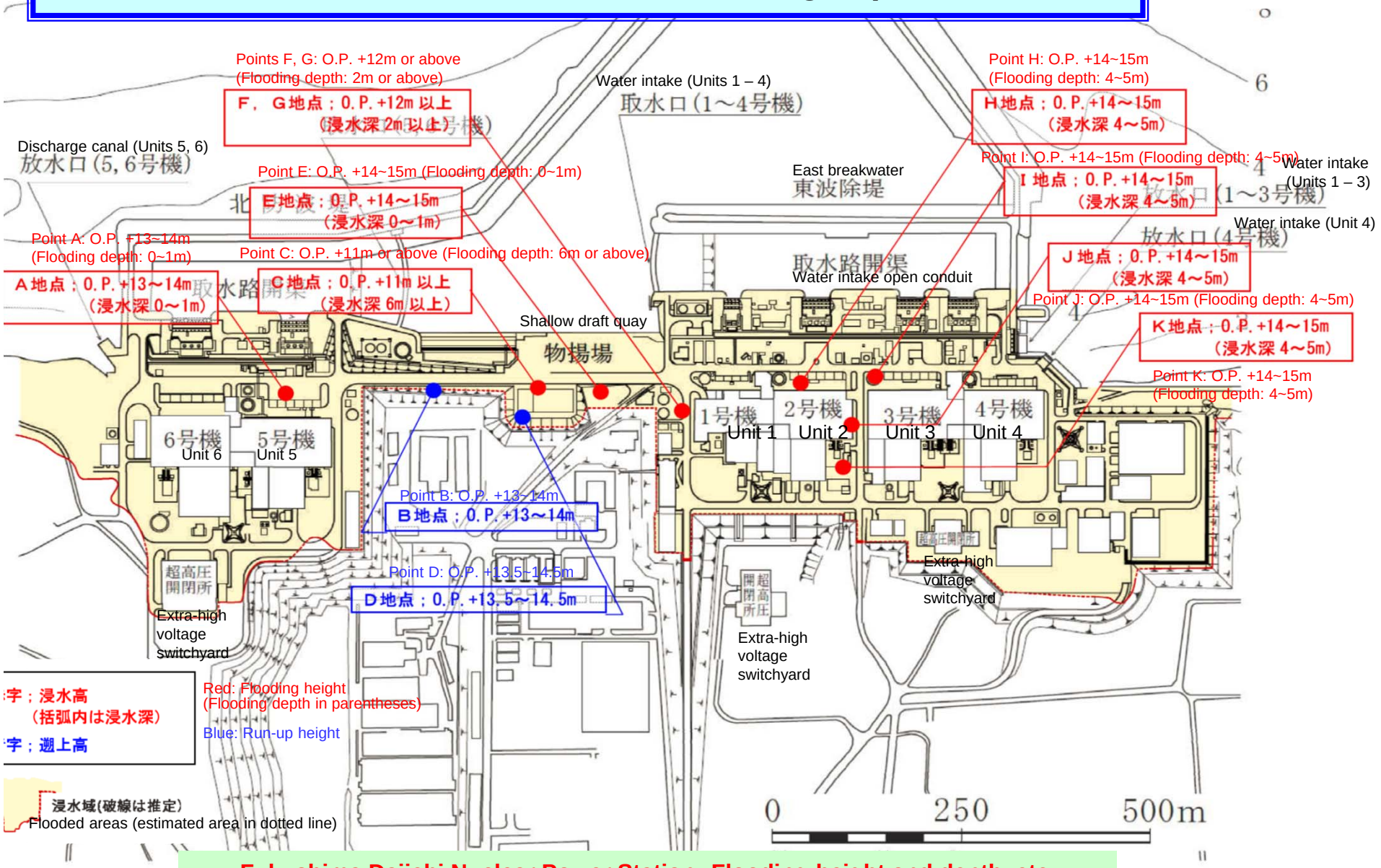


Fukushima Daiichi NPS after tsunami
(Blue color: flooded area)


池タンク
ーションタンク

A tsunami about 14m high swept over the entire site of Fukushima Daiichi, with flood waters reaching depths of 4 to 5m

Fukushima Daiichi

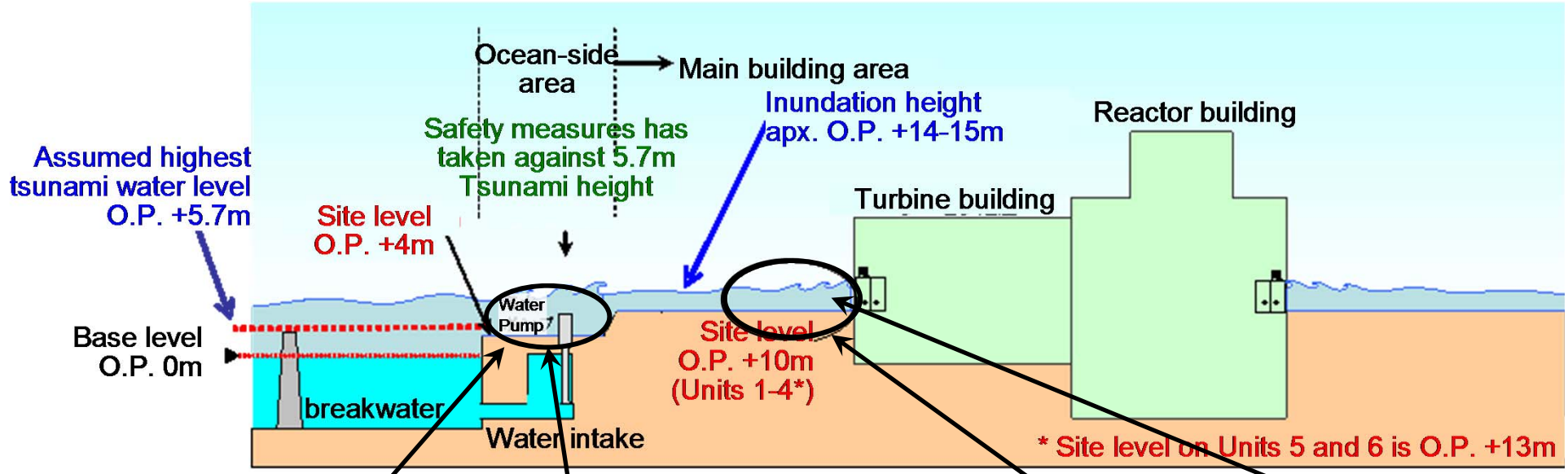


Fukushima Daiichi Nuclear Power Station Flooding height and depth, etc.
(Further investigations are currently underway)

Assumed highest tsunami water level O.P. +5.7m

→

Inundation height apx. O.P. +14-15m



Tsunami Attack at Fukushima Daiichi NPS

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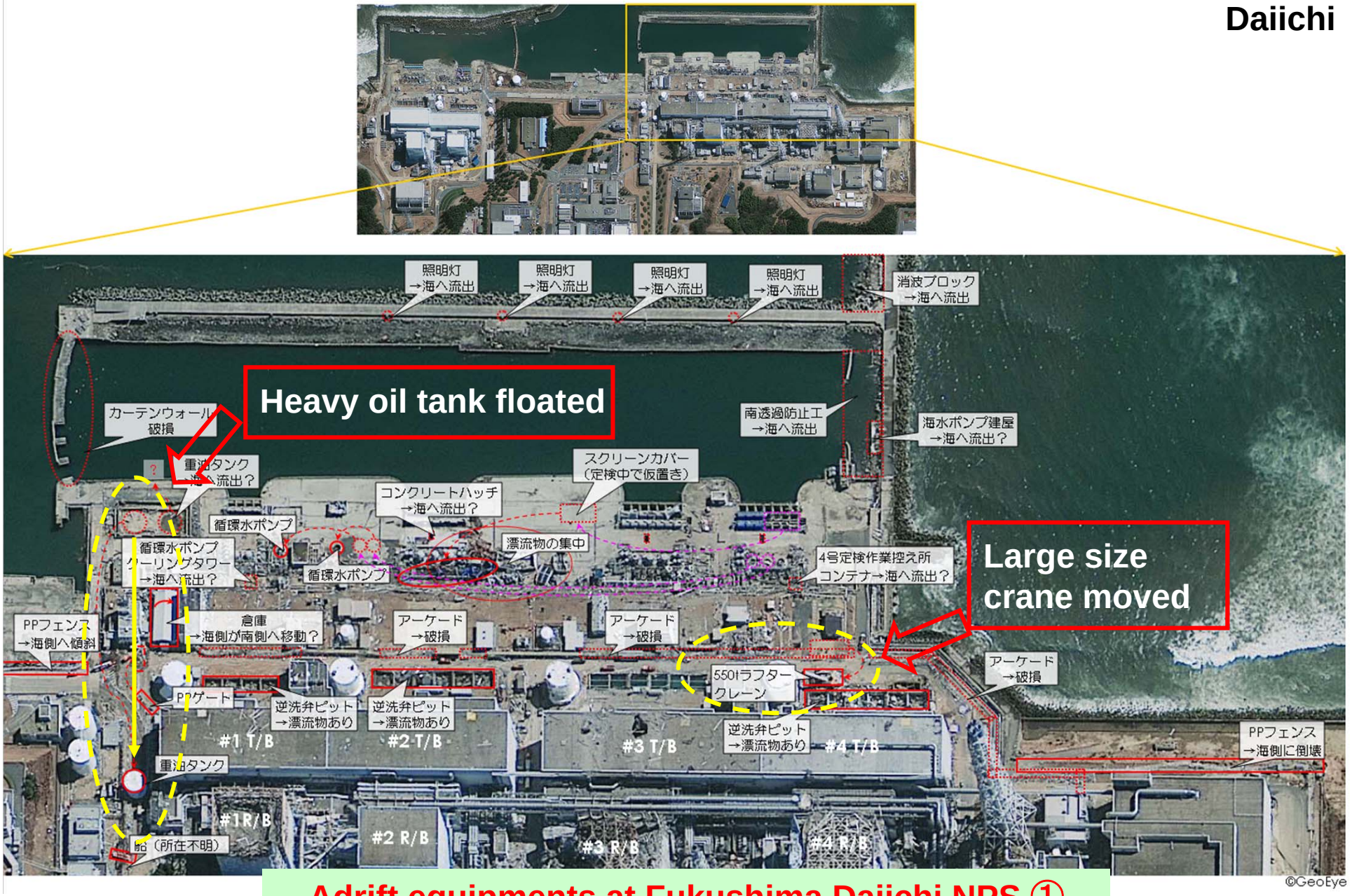

Adrift equipments at Fukushima Daiichi NPS ①

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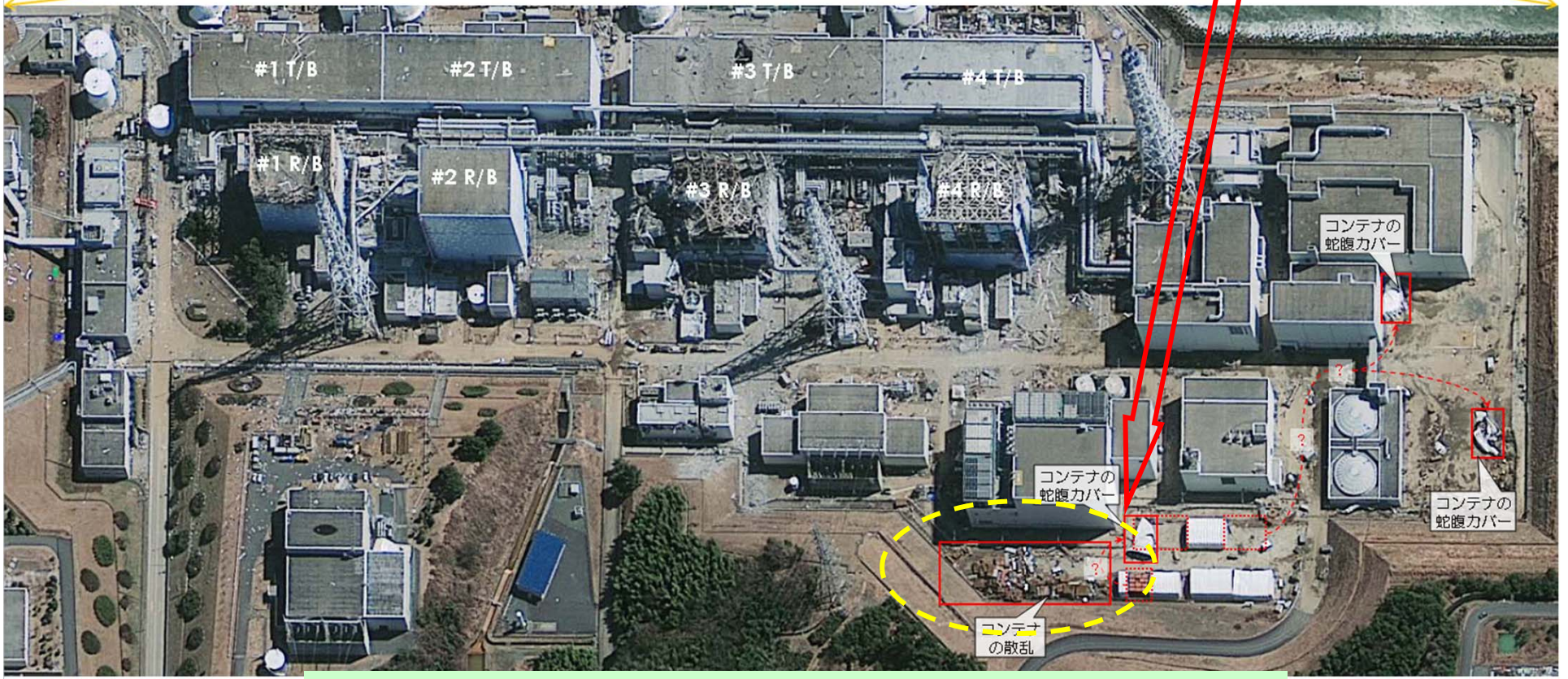
Fukushima Daiichi

Area away from the coast was also flooded



Adrift equipments at Fukushima Daiichi NPS ②

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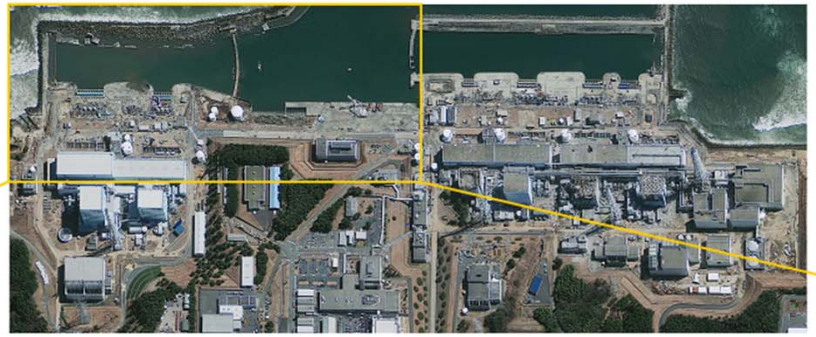
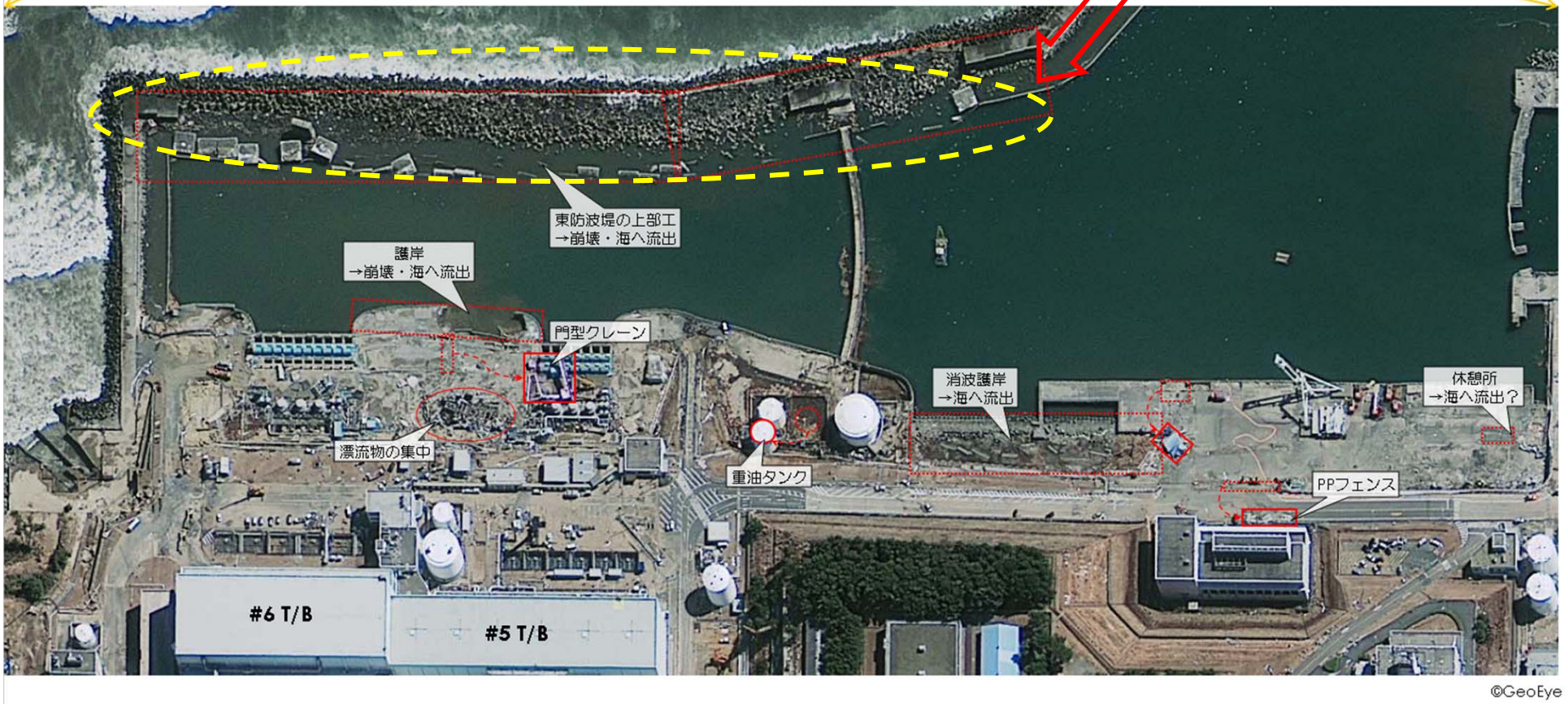
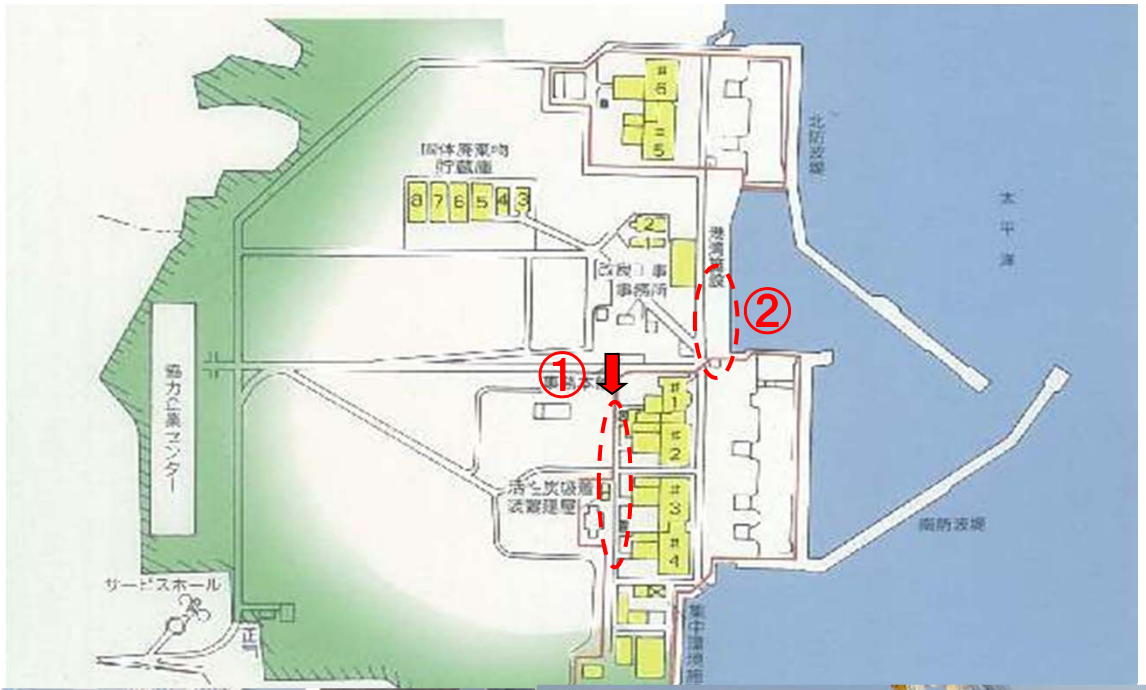
Fukushima
Daiichi

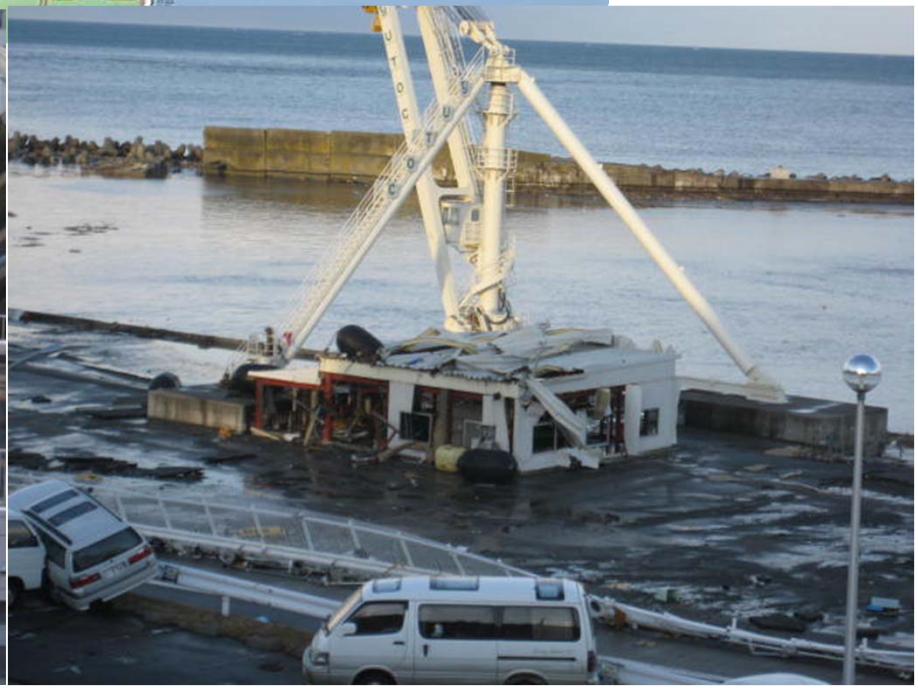




Adrift equipments at Fukushima Daiichi NPS ③

Fukushima Daiichi





Tsunami damage at Fukushima Daiichi NPS

Fukushima Daiichi

Tsunami damage at Fukushima Daiichi NPS (contd.)

Fukushima Daini NPS after tsunami

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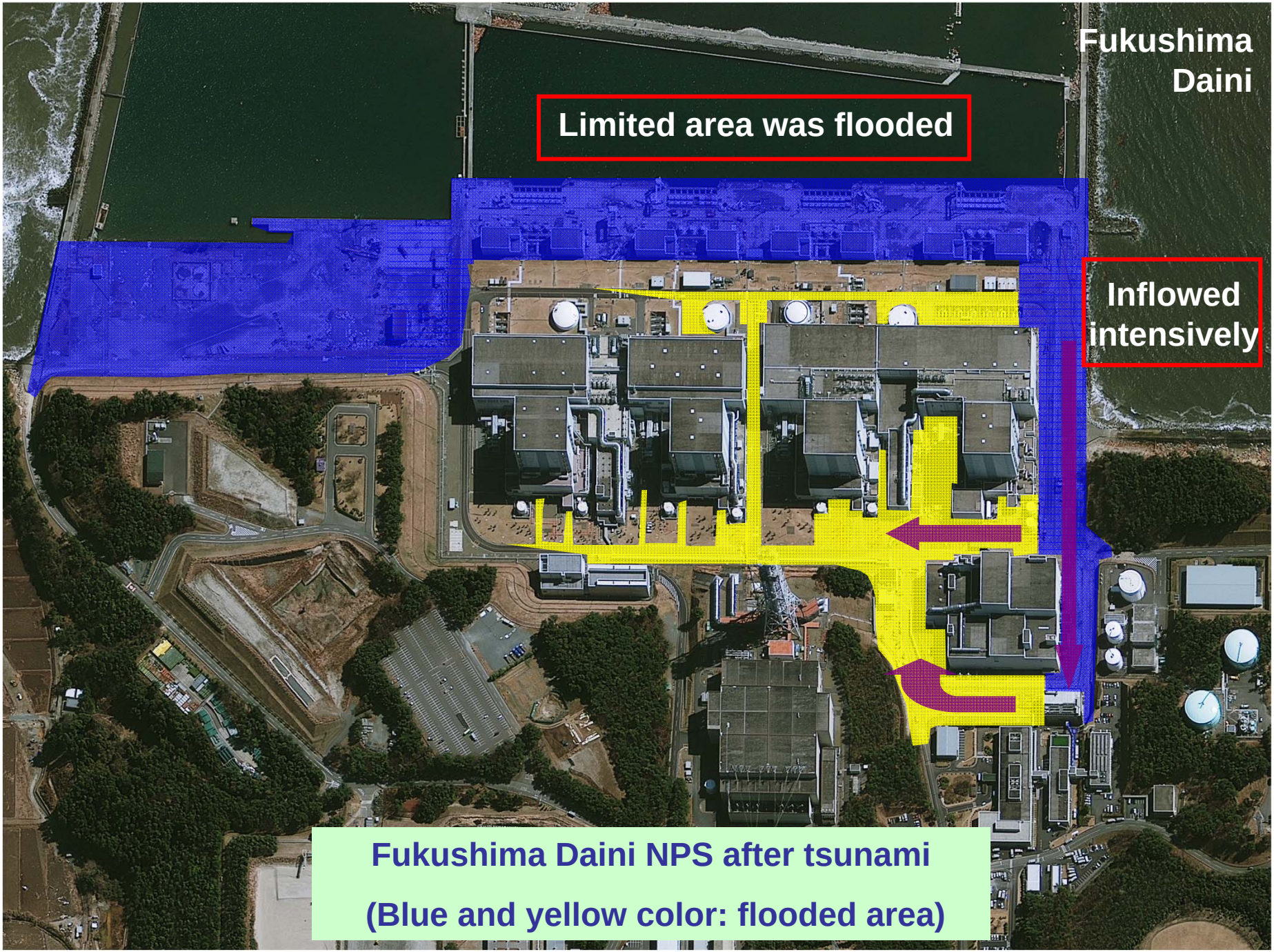

Fukushima Daini NPS after tsunami

(Blue and yellow color: flooded area)

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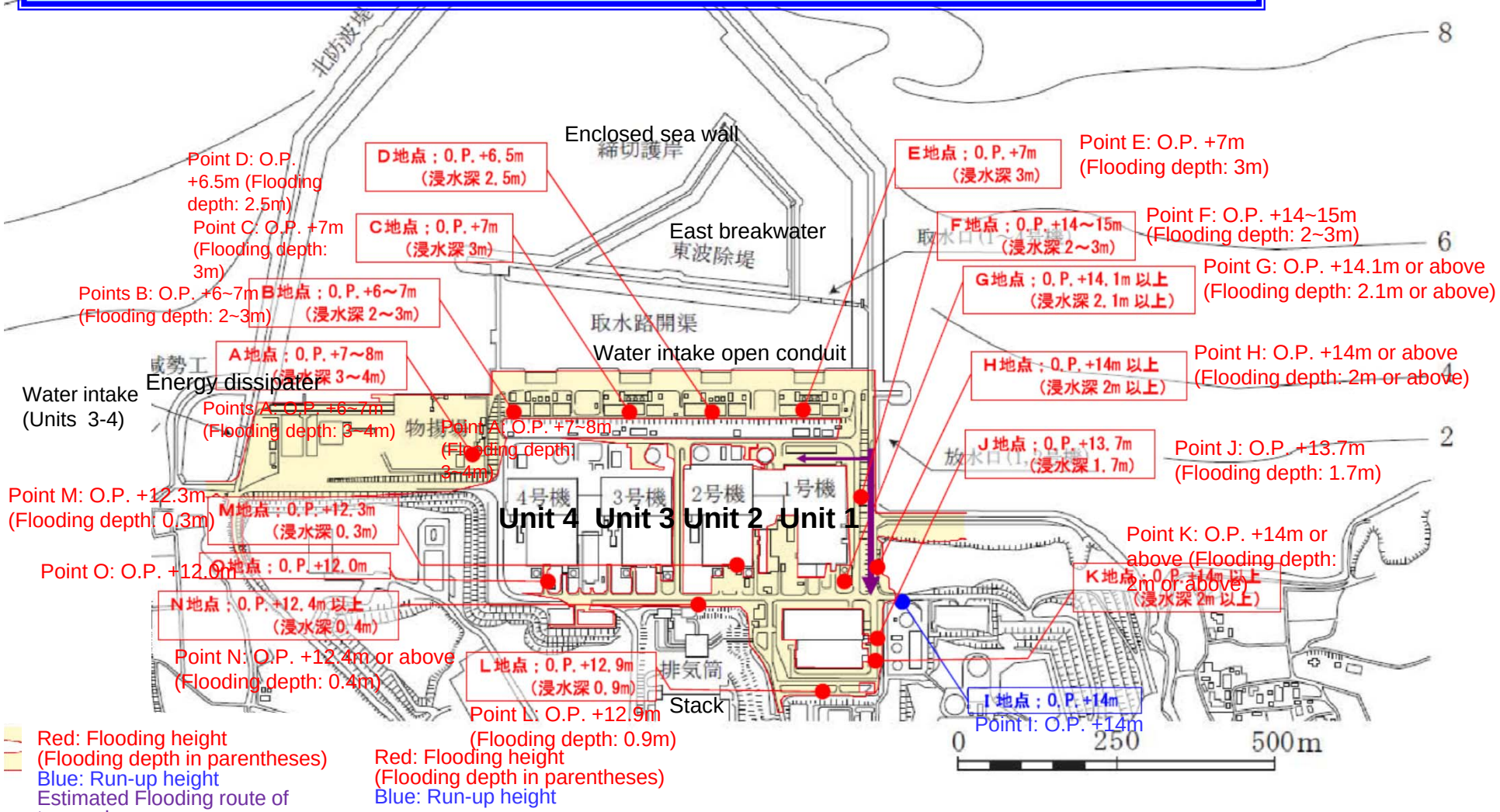
At Fukushima Daini, the height of the tsunami was about 14m on the south side of Unit 1, where it was highest, but the overall height was 7m, and the plant suffered less damage compared to Fukushima Daiichi.

Fukushima Daini

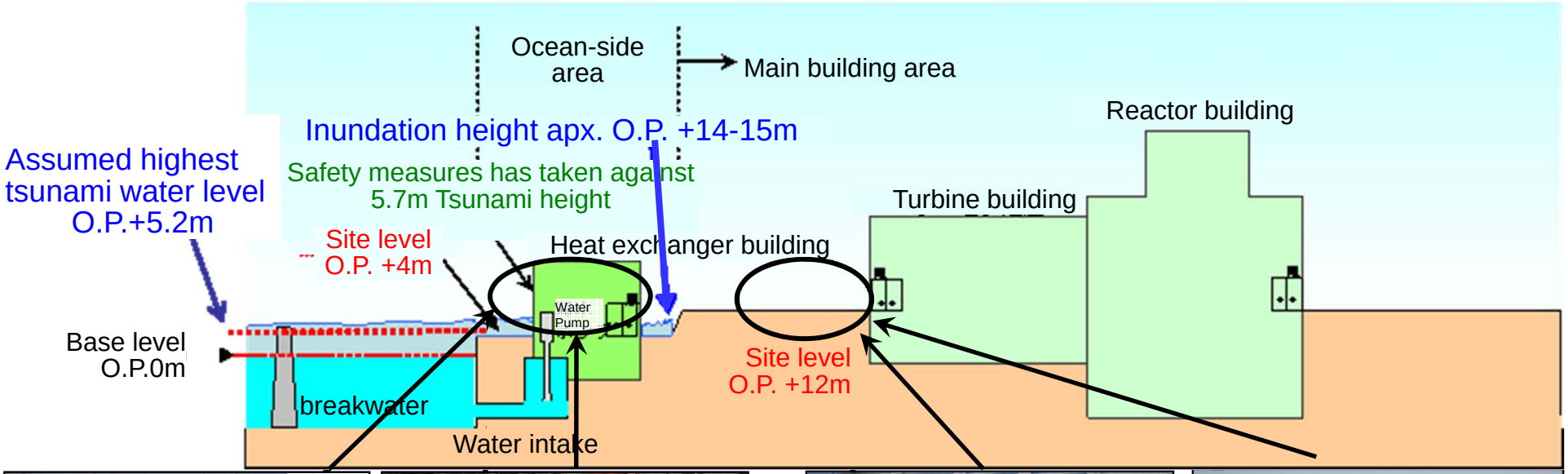


Fukushima Daini Nuclear Power Station
Flooding height and depth, etc.
(Further investigations are currently underway)

Fukushima Daini

Assumed highest tsunami water level O.P.+5.2m

Inundation height apx. O.P. 7m (South of Unit 1 O.P. +14-15m)



Tsunami Attack at Fukushima Daini NPS

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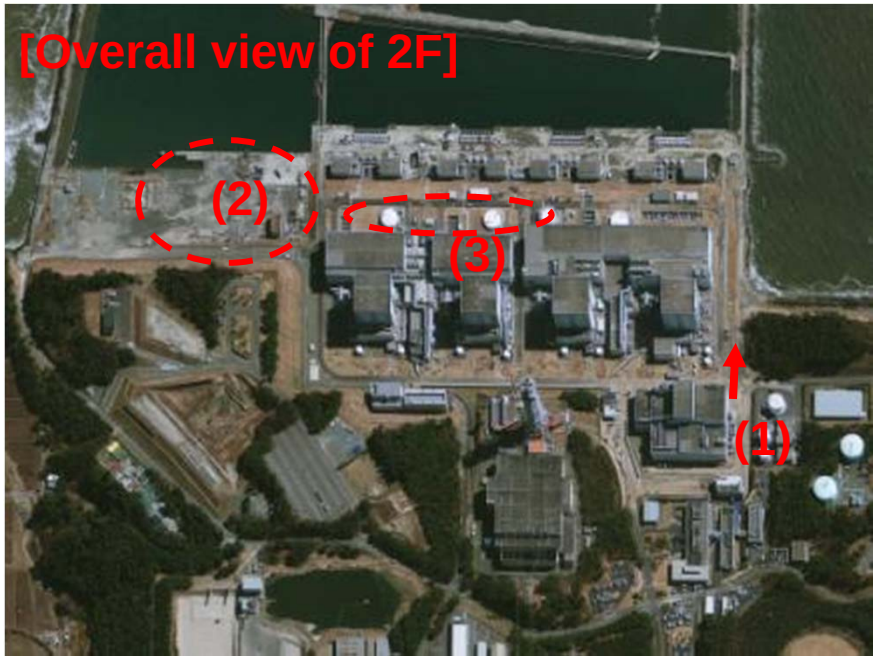
Fukushima Daini



Tsunami damage at Fukushima Daini NPS

Fukushima Daini

Flooding of the Fukushima Daini Unit 1 Annex Area from the intake louver

(1)Outside of the Unit 1 emergency fan room

(2)Inside of the Unit 1 emergency fan room

(3)Unit 1 DG(A) control room

Tsunami damage at Fukushima Daini NPS (contd.)

Plant Status after the Earthquake and Tsunami

[Summary]

- There were plants that lost their power supply and sea water system (heat sink) due to the tsunami, and this caused differences in the resulting damage.
- Fukushima Daini was able to secure off-site power and a portion of the sea water system after the tsunami.
- In addition, Fukushima Daiichi Units 5 & 6 were able to secure an emergency power supply (DG).
- This ultimately lead to the restoration of the sea water system and cold shutdown.
- Meanwhile, Fukushima Daiichi Units 1 through 4 suffered a total loss of power as well as the sea water system after the tsunami, which lead to an accident.

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Status of the power supply and sea water system immediately after the earthquake and tsunami

Item		Fukushima Daiichi	
		Before the earthquake	Immediately after the earthquake and tsunami
Power supply	Off-site power supply (4 lines)	Okuma Line 1, 2, 4L: ○ Okuma Line 3L: × (renovation work in progress) Yonomori Line 1, 2L: ○	Okuma Line 1~4L: × Yonomori Line 1, 2L: ×
	DG (13)	10 sea water-cooled DG: ○ (2 DG each for Units 1, 3, 5, and 6) (1 DG each for Units 2 and 4) 3 air-cooled DG: ○ (1 DG each for Units 2, 4, and 6)	10 sea water-cooled DG: × Units 2 & 4 air-cooled DG (2): × **Unit 6 air-cooled DG (1): ○**
Sea water system required for core cooling		12 RHR sea water systems: ○ (2 systems each for Units 1 to 6)	12 RHR sea water systems: × (2 systems each for Units 1 through 6)

Item		Fukushima Daini	
		Before the earthquake	Immediately after the earthquake and tsunami
Power supply	Off-site power supply (4 lines)	Tomioka Line 1, 2; Iwaido Line 2: ○ Iwaido Line 1: × (inspection in progress)	**Tomioka Line 1: ○** Tomioka Line 2; Iwaido Line 1, 2: ×
	DG (12)	12 sea water-cooled DG: ○ (3 DG each for Units 1 through 4)	**3 sea water-cooled DG:G ○** (remaining 9 DG ×) **(Unit 3 B, H; Unit 4 H)**
Sea water system required for core cooling		8 RHR sea water systems: ○ (2 systems each for Units 1 through 4)	7 RHR sea water systems: × **Unit 3 RHR sea water system (1): ○**

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[Power supply at Fukushima Daiichi: Immediately after the tsunami]

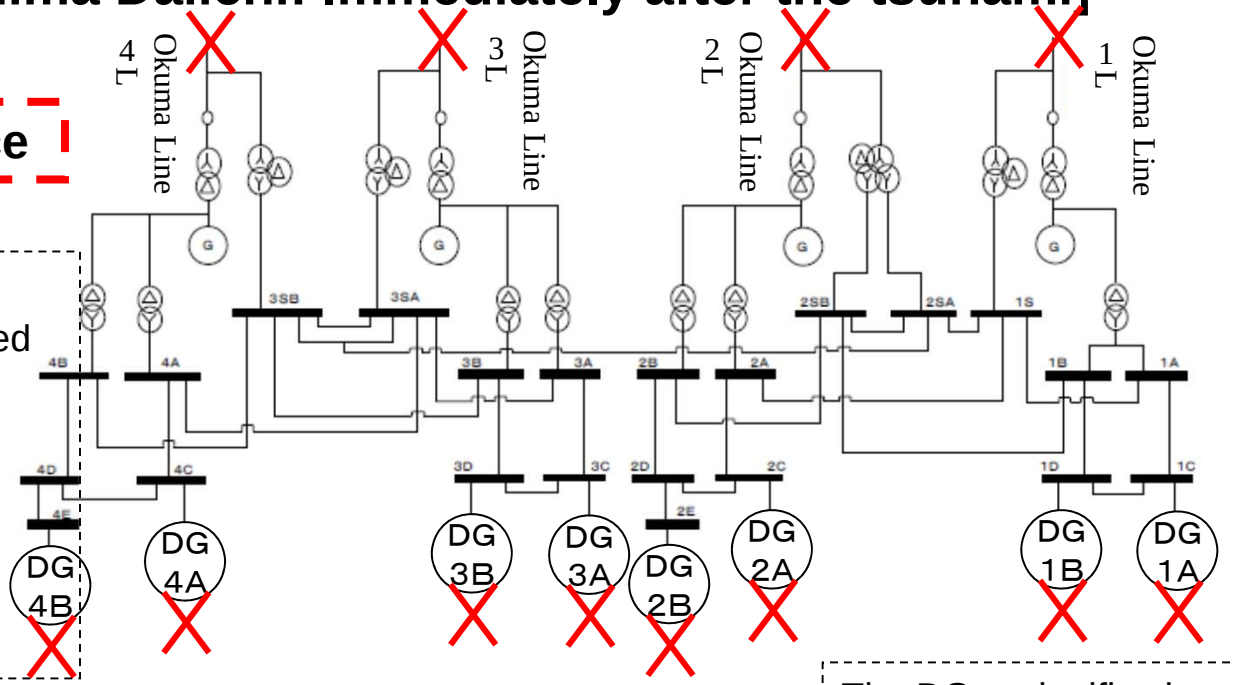
Fukushima Daiichi Units 1-4

No surviving power source

Okuma Line 1L, 2L
- Receiving circuit breaker damaged in earthquake

Okuma Line 3L
- Renovation work in progress

Okuma Line 4L
- Cause of shutdown is currently being investigated

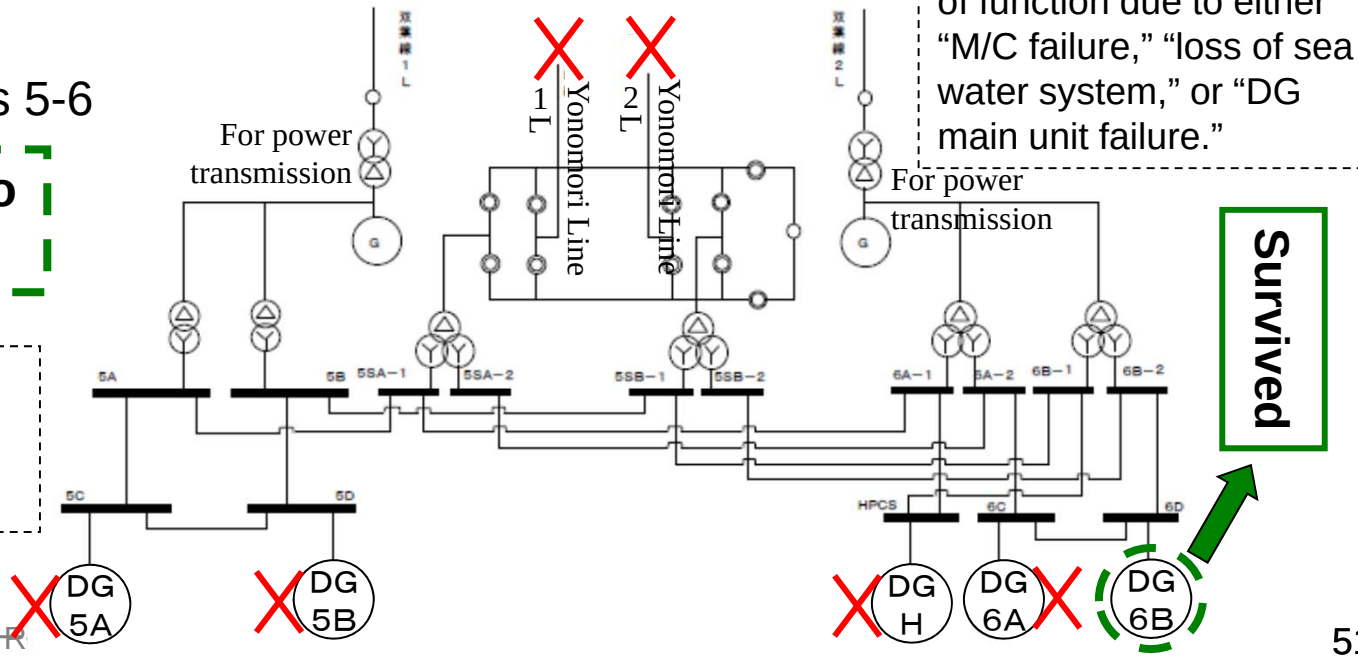


The DG × signifies loss of function due to either "M/C failure," "loss of sea water system," or "DG main unit failure."

Fukushima Daiichi Units 5-6

Only power source to survive was DG6B

Yonomori Line 1L, 2L
- Partial collapse of the iron tower



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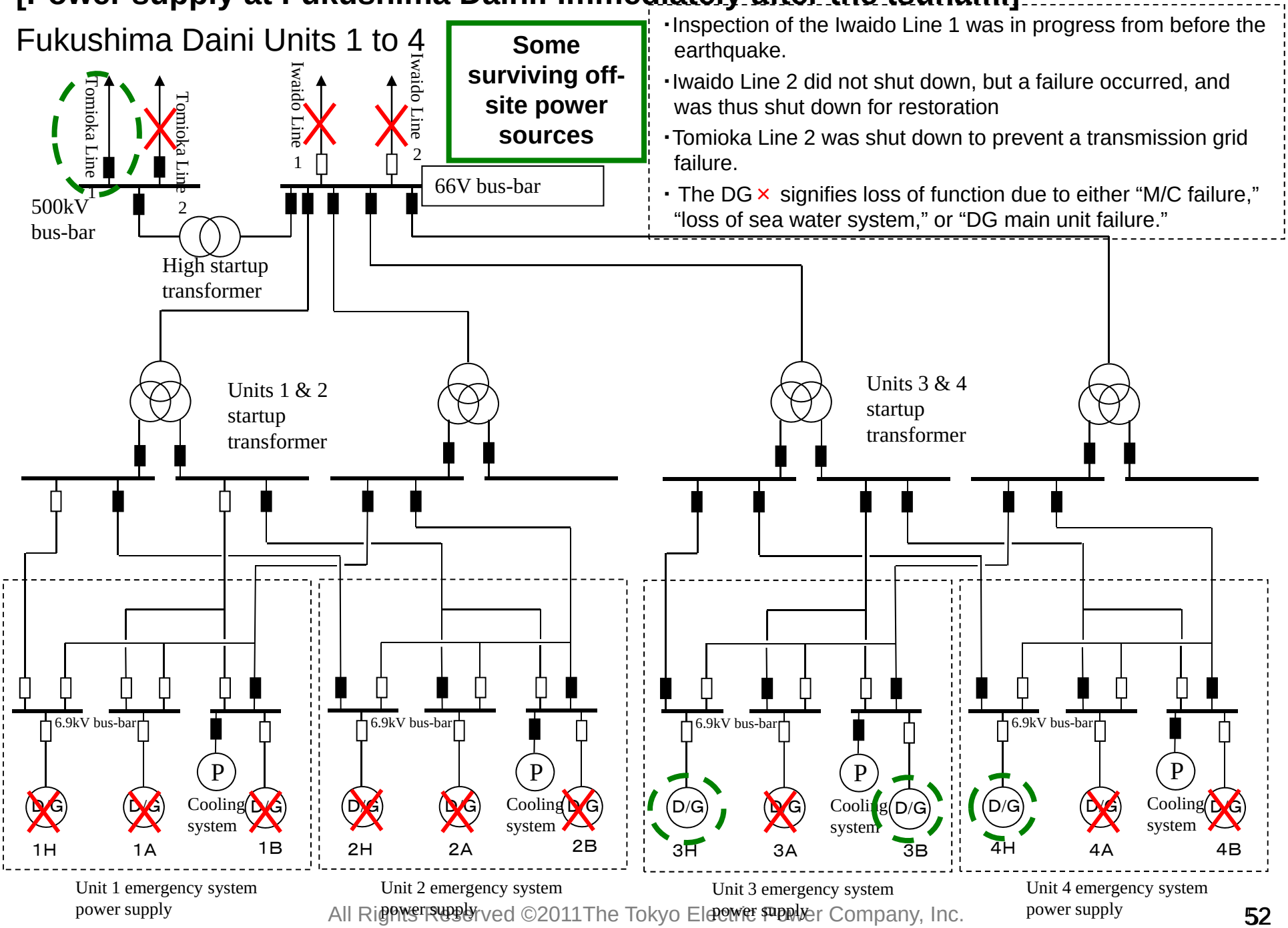
[Power supply at Fukushima Daini: Immediately after the tsunami]



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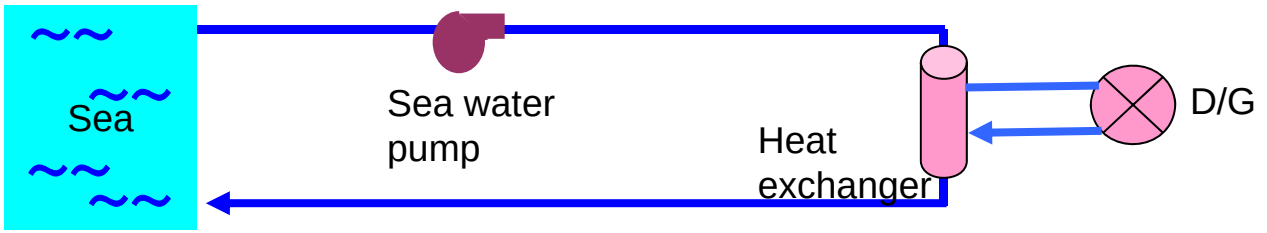
[Fukushima Daiichi: DG System Outline]

Sea water-cooled DG (10)

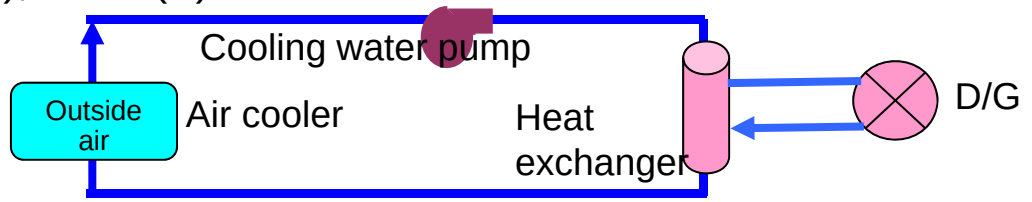
Unit 1 (A)(B), Unit 2 (A), Unit 3 (A)(B), Unit 4 (A), Unit 5 (A)(B), Unit 6 (A)(H)



All function was lost after the tsunami

Air-cooled DG (3)

Unit 2 (B), Unit 4 (B), Unit 6(B)

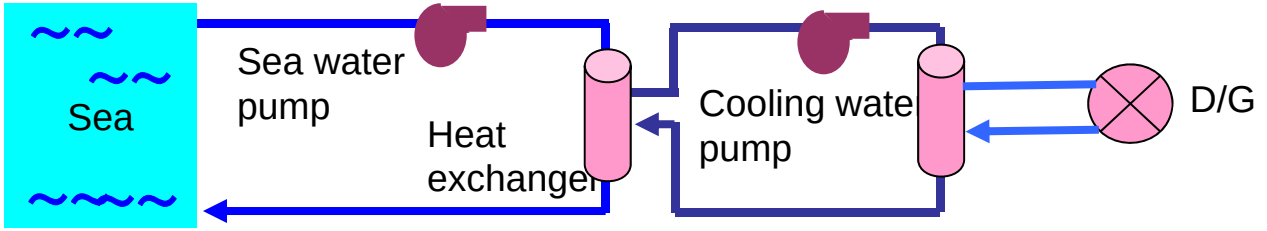


Power was secured in Unit 6 (B) only

[Fukushima Daini: DG System Outline]

Sea water-cooled DG (12)

Unit 1 to Unit 4(A)(B)(H)



Power was secured in Unit 3 (B)(H) and Unit 4 (B) only

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Progress made by each plant towards cold shutdown (outline)

Fukushima Daiichi Units 1 - 4	Fukushima Daiichi Units 5 & 6	Fukushima Daini Units 1 - 4
Units 1-3 in operation Unit 4: outage in progress	Outage in progress	In operation
[Power supply] Total loss of off-site power supply and DG [Sea water system] Total loss	[Power supply] Emergency DG 6B start up [Sea water system] Total loss	[Power supply] One off-site power supply system secured [Sea water system] Total loss apart from Unit 3
Water injection using IC, RCIC, HPCI	Increase in spent fuel pool temperature to near 70°C	Water injection using RCIC
Sea water injection	Installation of temporary RHRS Installation of temporary power supply	3/12 Unit 3 cold shutdown
Switch to freshwater	**3/19** **Alternative RHRS was started and the spent fuel pool and reactor were cooled**	Units 1, 2, 4 Water injection using MUWC
・Heat removal route is not secured **・Working towards stabilization**	**3/20** **Units 5, 6 cold shutdown**	RHRC motor was replaced Installation of temporary power supply
Sea water was initially injected into the spent fuel pool; currently injecting freshwater		**3/14** **RHR startup**
		3/14 Units 1, 2 cold shutdown **3/15 Unit 4 cold shutdown**

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Plant Status: Fukushima Daiichi

- Units 1-3: Found contaminated water with high radioactive materials in turbine buildings. Pumping out of the water into the radwaste building, etc. is in progress.
- Unit 1: Injecting N_2 into PCV to lower the possibility of hydrogen explosion. Also scheduled for Units 2&3.
- Units 5&6: Under cold shutdown.

			#1 460MW	#2 784MW	#3 784MW	#4 784MW	#5 784MW	#6 1,100MW
Pre-Earthquake Status			Operating			Shutdown for Outage		
After Earthquake	Shutdown		○ Automatic Shutdown			—	—	—
	Cooling	Reactor	△ Offsite Power Freshwater	△ Offsite Power Freshwater	△ Offsite Power Freshwater	— Fuels have been removed	○ Cold Shutdown	○ Cold Shutdown
		Pool	△	△	△	△	○	○
	*Containment		X Highly contaminated water	X Highly contaminated water	X Highly contaminated water	△	○	○

○ :functioning △: non-functioning (work in progress) X:non-functioning (not working)

*There are damages on upper part of the Reactor buildings of Unit 1,3 and 4. There is a possibility of malfunction of containment in suppression chamber of Unit2. Holes are drilled on the roof of reactor buildings of Units 5 and 6 to prevent hydrogen accumulation.

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Plant Status: Fukushima Daini

- Unit1-4: Automatic Shutdown, although operating at the time of the earthquake
- Unit 3: Cold Shut down in 22hrs after the quake
- Unit1,2 & 4: Although offsite power maintained, heat removal facilities for reactors were submerged due to the Tsunami. The heat removal functions were restored by the following recovery work.

		Fukushima Daini Nuclear Power Station			
		# 1 1,100MW	# 2 1,100MW	# 3 1,100MW	# 4 1,100MW
Pre-Earthquake Status		Operating			
After Earthquake	Shutdown	○			
	Cooling	○ (Cold Shutdown)			
	Containment	○			

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Progression of events at Fukushima Daiichi Unit 1 (Quick report based)

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Chronology of Major Events at Fukushima Daiichi Unit 1

Before the earthquake		In rated output operation
March 11, 2011	14:46	Great East Japan Earthquake
		Off-site power lost
		Reactor scram
	14:47	All control rods fully inserted
		Emergency DG startup (circuit breaker actuated)
	14:52	Isolation condenser startup
	15:41	Station black out due to the tsunami (subsequent AM response)
		Main Control Room power supply cut off
		Instrumental power supply cut off
March 12	5:46	Freshwater injection using fire pumps started
	10:17	PCV venting started
	14:30	Decrease in D/W pressure. Successful containment vessel venting
	15:36	Hydrogen explosion
	around 19:00	Sea water injection started
	around 19:25	Sea water injection stopped
	around 20:20	Sea water injection started

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Plant Response to Earthquake (Fukushima Daiichi Unit 1)

Event	Expected plant response	1F1 status	Remarks (2F1 status)
Earthquake	Scram	○	○
	All control rods inserted	○	○
Loss of external power	Emergency DG startup	○	N/A
	Main Steam Isolation Valves (MSIV) all closed	○	N/A
	Isolation condenser startup	○	N/A
	(HPCI started up if water level decreases to L2)	– (No major decrease in water level)	

Plant response to earthquake was normal

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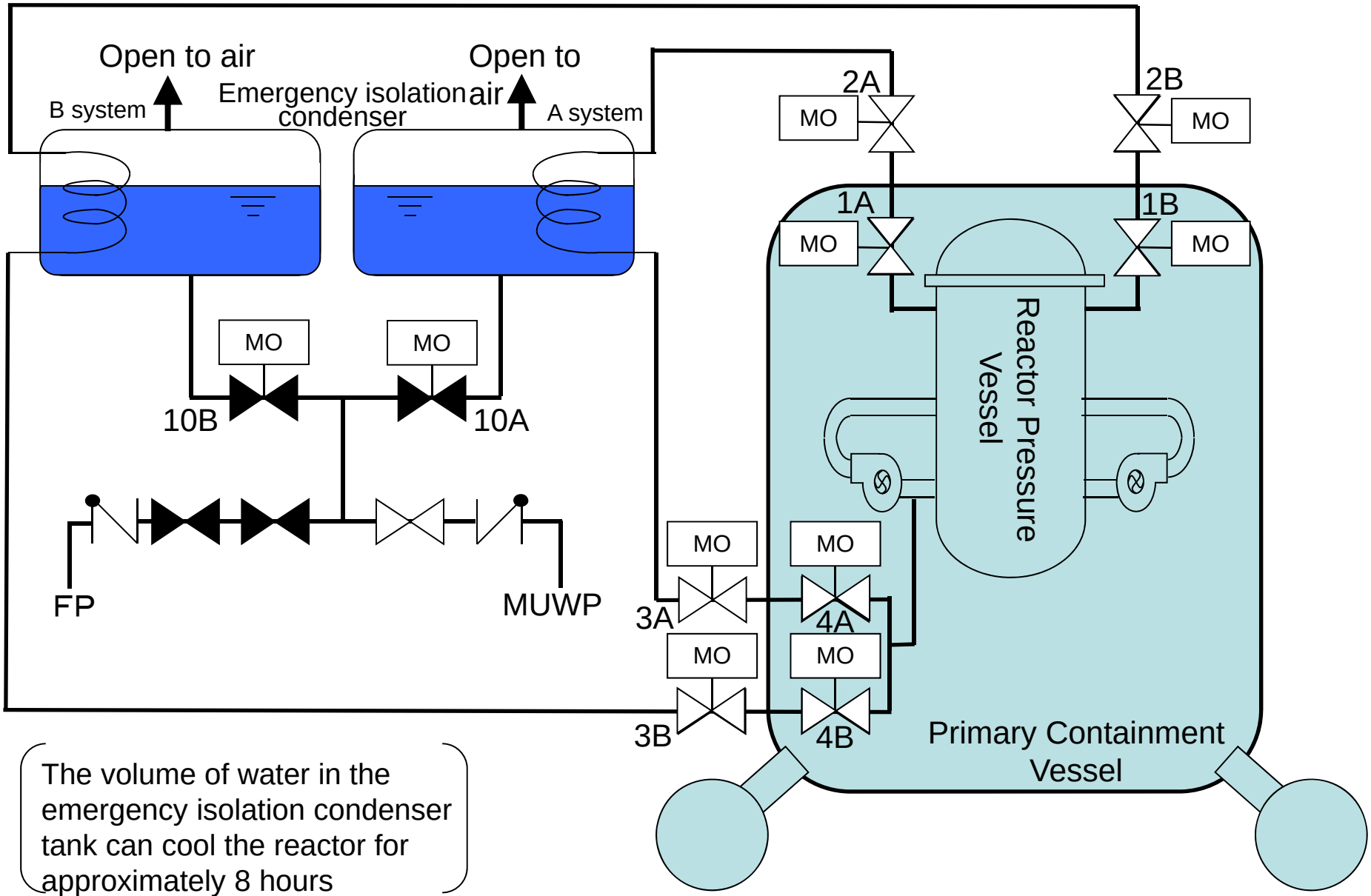
Mechanism of the Isolation Condenser



The volume of water in the emergency isolation condenser tank can cool the reactor for approximately 8 hours

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Behavior of Plant Data at the time of the Earthquake (1F1)

Main records obtained from the site at this time

- ✓Alarm typer
- ✓Charts
- ✓Nuclear plant Advanced Transient data Recording and Analysis Support system

Data has only been recorded up to the point that power was lost.

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Effects on the Plant due to the Tsunami (Fukushima Daiichi Unit 1)

Event	Plant damage	Results		Remarks (2F1)	
Tsunami	Loss of sea water system	Final heat removal is lost	×	Lost	×
	Station black out	Inability to use electrically-powered equipment	×	Off-site power secured	○
		MCR lighting lost	×	Lighting on	○
		Instrument Air System (IA) lost	×	Not lost	○
	DC125V power lost	Inability to use control and instrument systems (Monitoring/operation difficulty in MCR)	×	Can be used	○
	Same damage to neighboring plant	No power access	×	Excluded	–

Enter accident management with the majority of the monitoring and operation functions of the MCR lost

Unless conditions improve, as time passes:

- •Core pressure increase ⇒ Pressure is maintained through SRV operation
- •SRV operation ⇒ S/C temperature increase/reactor water level decrease
- •S/C temperature increase ⇒ D/W and S/C pressure increase

⇒ Risk of core damage

⇒ Risk of PCV damage

Alternative water injection, venting, and sea water system restoration are essential

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Implications of the Effects of the Tsunami on the Plant

Phenomenon	Results	Implications
Loss of sea water system	Dysfunction of hardware Heat cannot be released to the sea	(1) Loss of cold shutdown function Difficulty in cooling for cold shutdown
Station black out	Dysfunction of hardware ・Equipment required to maintain the reactor water level does not function ・Valves required for containment vessel venting do not operate	(2) Power to maintain the water level and secure the containment vessel is lost Difficulty in maintaining the reactor water level Difficulty in venting the containment vessel
	Dysfunction of software ・Lights in the Main Control Room are lost ・Reduction in communication functions	(3) Main Control Room function loss Loss of MCR monitoring and operation functions Loss of communication functions
Loss of the DC power system	Disturbance in measurement and control functions ・Shutdown of instruments and control equipment ・Drive current of solenoid valves lost	

Status of Fukushima Daiichi and Daini

Fukushima Daiichi Units 1 through 4	Fukushima Daini Units 1 through 4
(1) Cold shutdown function **(2) Power to maintain the water level and secure the containment vessel** **(3) Functions of the Main Control Room** were all affected, and lost/deteriorated.	**(1) Cold shutdown function** was affected and deteriorated.

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Outline of Electrical Power Equipment

Name of power source		Outline
High-voltage power supply M/C 6.9kV	For emergency use	Supplies power to loads required in an emergency and supplies power to low-voltage power sources (P/C, MCC) Power supplied from emergency DG when off-site power is lost Main supply destinations: ECCS pumps such as CS & RHR; RCW/RSW pump
	For normal use	Supplies power for loads required routinely, and supplies power to low-voltage power sources (P/C, MCC) Power is lost when off-site power is lost Main supply destinations: Condensate pump, circulating water pump, feed water pump
Low-voltage power supply P/C MCC 480V	For emergency use	Supplies power to low-voltage loads required in an emergency Power supplied from emergency DG when off-site power is lost Main supply destinations: MO valve of ECCS, SLC pump, CRD pump
	For normal use	Supplies power to low-voltage loads required routinely Power is lost when off-site power is lost Main supply destinations: MUWC pump, FPC pump
125V DC		RCIC control power, etc.; initial excitation of emergency DG; supplies power to the MCR ANN panel and various instruments, etc.

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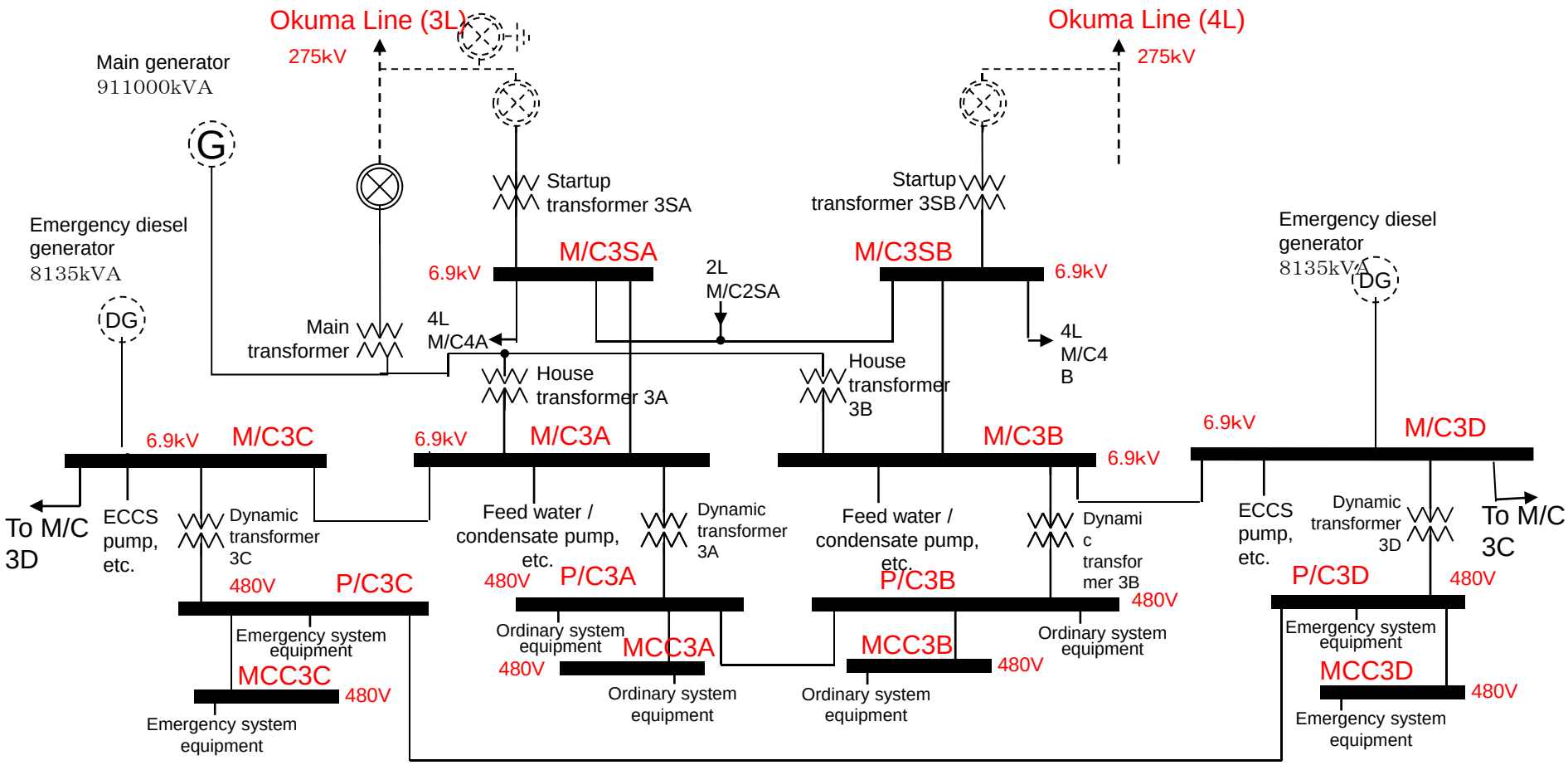
Outline of Power Configuration Example （E.g.: Fukushima Daiichi Unit 3）



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Integrity of electricity supply system after the tsunami attack

		Fukushima Daiichi												Fukushima Daini							
		Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Unit 6		Unit 1		Unit 2		Unit 3		Unit 4	
		Power panel	Can/can not be used	Power panel	Can/can not be used	Power panel	Can/can not be used	Power panel	Can/can not be used	Power panel	Can/can not be used	Power panel	Can/can not be used	Power panel	Can/can not be used	Power panel	Can/can not be used	Power panel	Can/can not be used	Power panel	Can/can not be used
Emergency DG		DG 1A	×	DG 2A	×	DG 3A	×	DG 4A	×	DG 5A	×	DG 6A	×	DG 1A	×	DG 2A	×	DG 3A	×	DG 4A	×
		DG 1B	×	DG 2B	×	DG 3B	×	DG 4B	×	DG 5B	×	DG 6B	○	DG 1B	×	DG 2B	×	DG 3B	○	DG 4B	×
		—	—	—	—	—	—	—	—	—	—	HPCS DG	×	DG 1H	×	DG 2H	×	DG 3H	○	DG 4H	○
M/C	Emergency use	M/C 1C	×	M/C 2C	×	M/C 3C	×	M/C 4C	×	M/C 5C	×	M/C 6C	○	M/C 1C	×	M/C 2C	○	M/C 3C	○	M/C 4C	○
		M/C 1D	×	M/C 2D	×	M/C 3D	×	M/C 4D	×	M/C 5D	×	M/C 6D	○	M/C 1D	○	M/C 2D	○	M/C 3D	○	M/C 4D	○
		—	—	M/C 2E	×	—	—	M/C 4E	×	—	—	HPCS DG M/C	○	M/C 1H	×	M/C 2H	○	M/C 3H	○	M/C 4H	○
	Regular use	M/C 1A	×	M/C 2A	×	M/C 3A	×	M/C 4A	×	M/C 5A	×	M/C 6A-1	×	M/C 1A-1	○	M/C 2A-1	○	M/C 3A-1	○	M/C 4A-1	○
												M/C 6A-2	×	M/C 1A-2	○	M/C 2A-2	○	M/C 3A-2	○	M/C 4A-2	○
		M/C 1B	×	M/C 2B	×	M/C 3B	×	M/C 4B	×	M/C 5B	×	M/C 6B-1	×	M/C 1B-1	○	M/C 2B-1	○	M/C 3B-1	○	M/C 4B-1	○
												M/C 6B-2	×	M/C 1B-2	○	M/C 2B-2	○	M/C 3B-2	○	M/C 4B-2	○
		M/C 1S	×	M/C 2SA	×	M/C 3SA	×	—		M/C 5SA-1	×	—		M/C 1SA-1	○	—		M/C 3SA-1	○	—	
										M/C 5SA-2	×			M/C 1SA-2	○			M/C 3SA-2	○		
				M/C 2SB	×	M/C 3SB	×			M/C 5SB-1	×			M/C 1SB-1	○			M/C 3SB-1	○		
										M/C 5SB-2	×			M/C 1SB-2	○			M/C 3SB-2	○		
P/C	Emergency use	P/C 1C	×	P/C 2C	○	P/C 3C	×	P/C 4C	○	P/C 5C	×	P/C 6C	○	P/C 1C-1	×	P/C 2C-1	○	P/C 3C-1	○	P/C 4C-1	○
		P/C 1D	×	P/C 2D	○	P/C 3D	×	P/C 4D	○	P/C 5D	×	P/C 6D	○	P/C 1C-2	×	P/C 2C-2	×	P/C 3C-2	×	P/C 4C-2	×
		—	—	P/C 2E	×	—	—	—	—	—	—	P/C 6E	○	P/C 1D-1	○	P/C 2D-1	○	P/C 3D-1	○	P/C 4D-1	○
	Regular use	P/C 1A	×	P/C 2A	○	P/C 3A	×	P/C 4A	○	P/C 5A	×	P/C 6A-1	×	P/C 1D-2	×	P/C 2D-2	×	P/C 3D-2	○	P/C 4D-2	×
				P/C 2A-1	×	HVAC P/C 3A	△	HVAC P/C 4A	△	P/C 5A-1	○	P/C 6A-2	×	P/C 1A-1	○	P/C 2A-1	○	P/C 3A-1	○	P/C 4A-1	○
		P/C 1B	×	P/C 2B	○	P/C 3B	×	P/C 4B	○	P/C 5B	×	P/C 6B-1	×	P/C 1A-2	○	P/C 2A-2	○	P/C 3A-2	○	P/C 4A-2	○
		—	—	—	—	HVAC P/C 3B	△	HVAV P/C 4B	△	P/C 5B-1	○	P/C 6B-2	×	P/C 1B-1	○	P/C 2B-1	○	P/C 3B-1	○	P/C 4B-1	○
		P/C 1S	×	—	—	P/C 3SA	×	—	—	P/C 5SA	×	—	—	P/C 1B-2	○	P/C 2B-2	○	P/C 3B-2	○	P/C 4B-2	○
		—	—	—	—	—	—	—	—	P/C 5SA-1	×	—	—	P/C 1SA	○	—		P/C 3SA	○	—	
		—	—	P/C 2SB	×	P/C 3SB	×	—	—	P/C 5SB	×	—	—	P/C 1SB	○			P/C 3SB	○		
		—	—	—	—	—	—	—	—	—	—	—	—	Water intake equipment P/C	×			Water intake equipment P/C	×		
DC power supply	125V DC	DC125V main bus panel A	×	DC125V P/C 2A	×	DC125V main bus panel 3A	○	DC125V main bus panel 4A	×	DC125V P/C 5A	○	DC125V DIST CENTER 6A	○	DC125V main bus panel A	○	DC125V main bus panel A	○	DC125V main bus panel A	○	DC125V main bus panel A	○
		DC125V main bus panel B	×	DC125V P/C 2B	×	DC125V main bus panel 3B	○	DC125V main bus panel 4B	×	DC125V P/C 5B	○	DC125V DIST CENTER 6B	○	DC125V main bus panel B	○	DC125V main bus panel B	○	DC125V main bus panel B	○	DC125V main bus panel B	○
Sea water system	A	CCS A	×	RHRS A	×	RHRS A	×	RHRS A	×	RHRS A	×	RHRS A	×	RHRS A	×	RHRS A	×	RHRS A	×	RHRS A	×
	B	CCS B	×	RHRS B	×	RHRS B	×	RHRS B	×	RHRS B	×	RHRS B	×	RHRS B	×	RHRS B	×	RHRS B	○	RHRS B	×

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1F1 Equipment status after the tsunami (equipment used for water injection to the reactor and PCV venting)

Equipment name		Status	Damage status	Applied operations	Remarks (2F1)
Water injection equipment	High Pressure Coolant Injection system (HPCI)	×	Loss of power (oil pump)	–	○ Timely water injection is possible using the MUWC
	Condensate and Feed Water System (FDW)	×	Water injection not possible due to isolation signal	–	
	Core Spray System (CS)	×	Power and sea water system loss	–	
	Shut down Cooling system (SHC)	×	Power and sea water system loss	–	
	Make Up Water Condensate (MUWC)	×	Loss of power, motor water damage	Fire engine used	
	Fire Protection System (FP)		D/D FP* startup not possible		
PCV Venting equipment	S/C vent valve Valve number: AO-1601-72	×	DC power loss/low air pressure	Temporary battery Temporary air compressor	○ Valves can be operated when necessary
	S/C vent bypass valve Valve number: AO-1601-90	×	DC power loss/low air pressure		
	D/W vent valve Valve number: AO-1601-1	×	DC power loss/low air pressure		
	D/W vent bypass valve Valve number: AO-1601-83	×	DC power loss/low air pressure		
	PCV vent valve Valve number: MO-1601-210	×	Power loss	Manual operation	

Applied operations were required as the above-mentioned equipment could not immediately be used after the tsunami.

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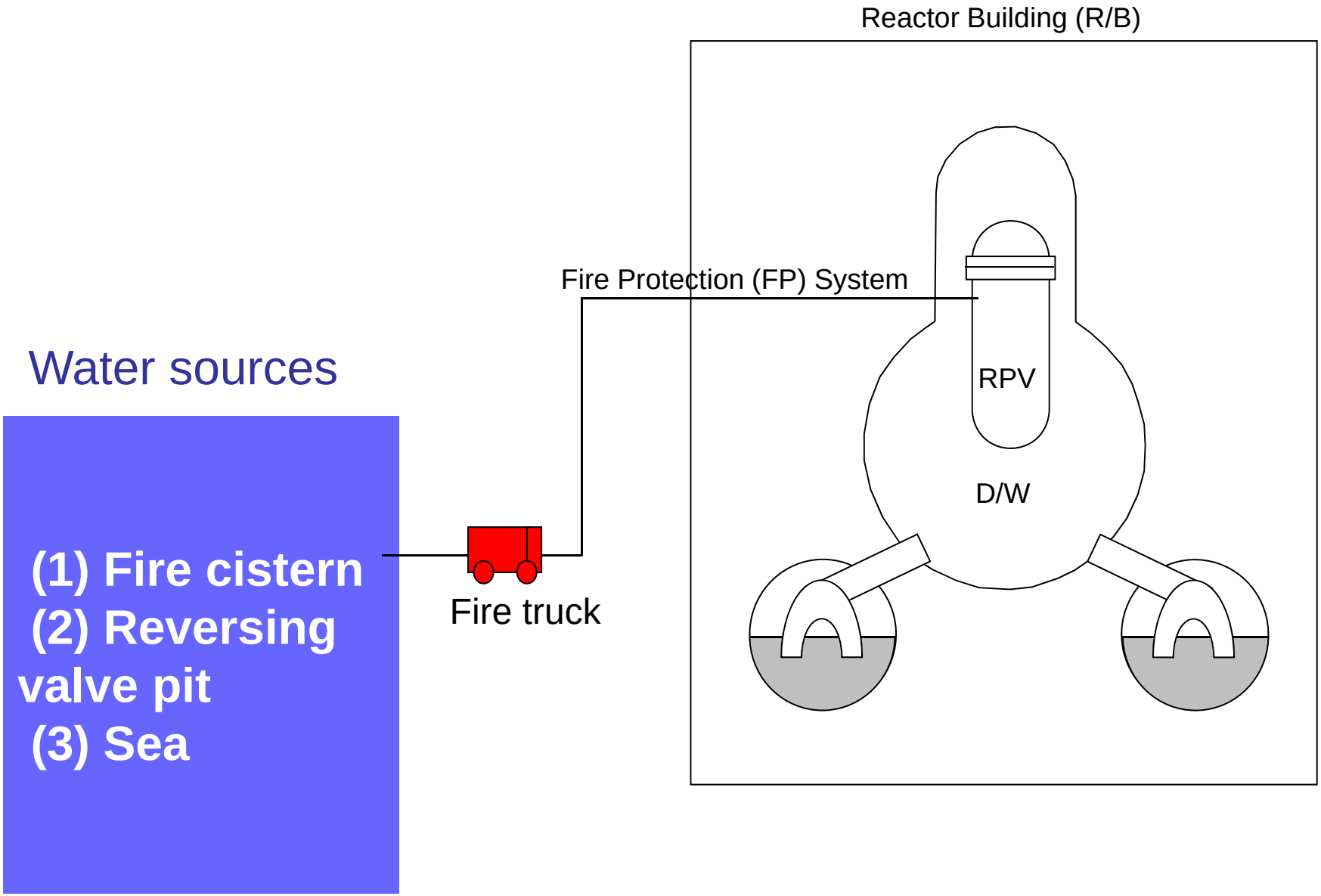
Outline of Reactor Water Injection Method



Water sources

(1) Fire cistern
(2) Reversing valve pit
(3) Sea

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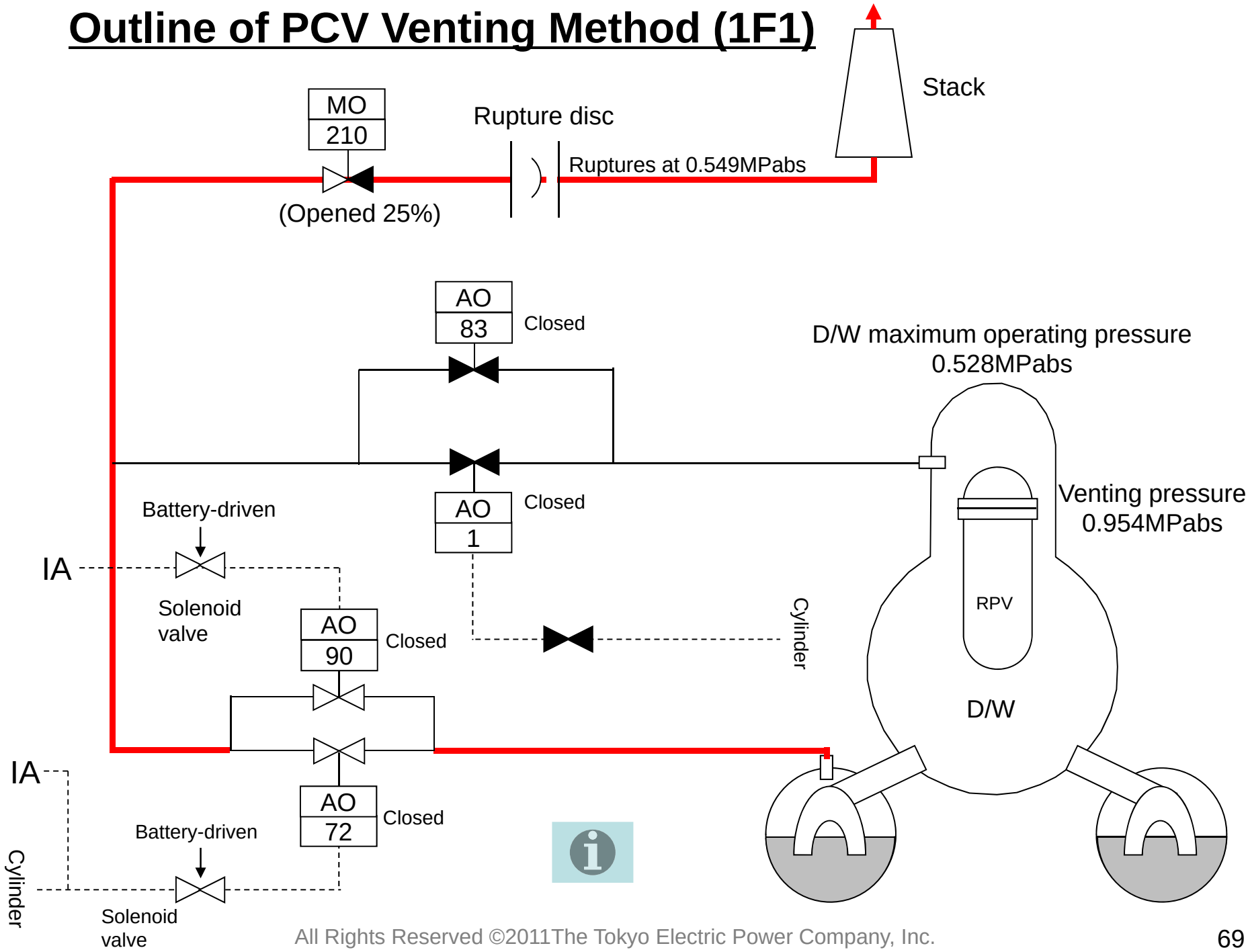
Outline of PCV Venting Method (1F1)



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External factors that made field work difficult (yard)

- During the initial response, there were several aftershocks, and work was conducted in extremely poor conditions, with uncovered manholes and cracks and depressions in the ground (in particular, nighttime work was conducted in the dark).
- There were also many obstacles blocking access routes.

Depressions in roads, etc.

Areas that were dangerous even to walk. Particularly dangerous at night.

Obstacles on access routes

Fire hoses, etc., were laid around access routes. After the explosion, rubble and damaged fire tucks became additional obstacles.

Access to lay temporary power sources

In order to enter the building, the large object delivery entrance was destroyed using heavy equipment.

Laying of temporary power sources

Employees other than electricity-related personnel helped in laying the cables.

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External factors that made field work difficult (inside the building)

- As there was no power, work inside the building was conducted in complete darkness.
- As there was no power, temporary instrument power had to be installed separately for each instrument.

Work in complete darkness

Photo of the Service Building entrance taken from inside the building. Objects were scattered on the floor.

Temporary instrument power

As there was no power, temporary batteries were connected and used as a power supply for instruments.

Monitoring by the assistant shift supervisor

Confirmed readings in complete darkness using a light

Monitoring by the assistant shift supervisor

Condition of the assistant shift supervisor's desk. Monitoring in complete darkness wearing a full-face mask

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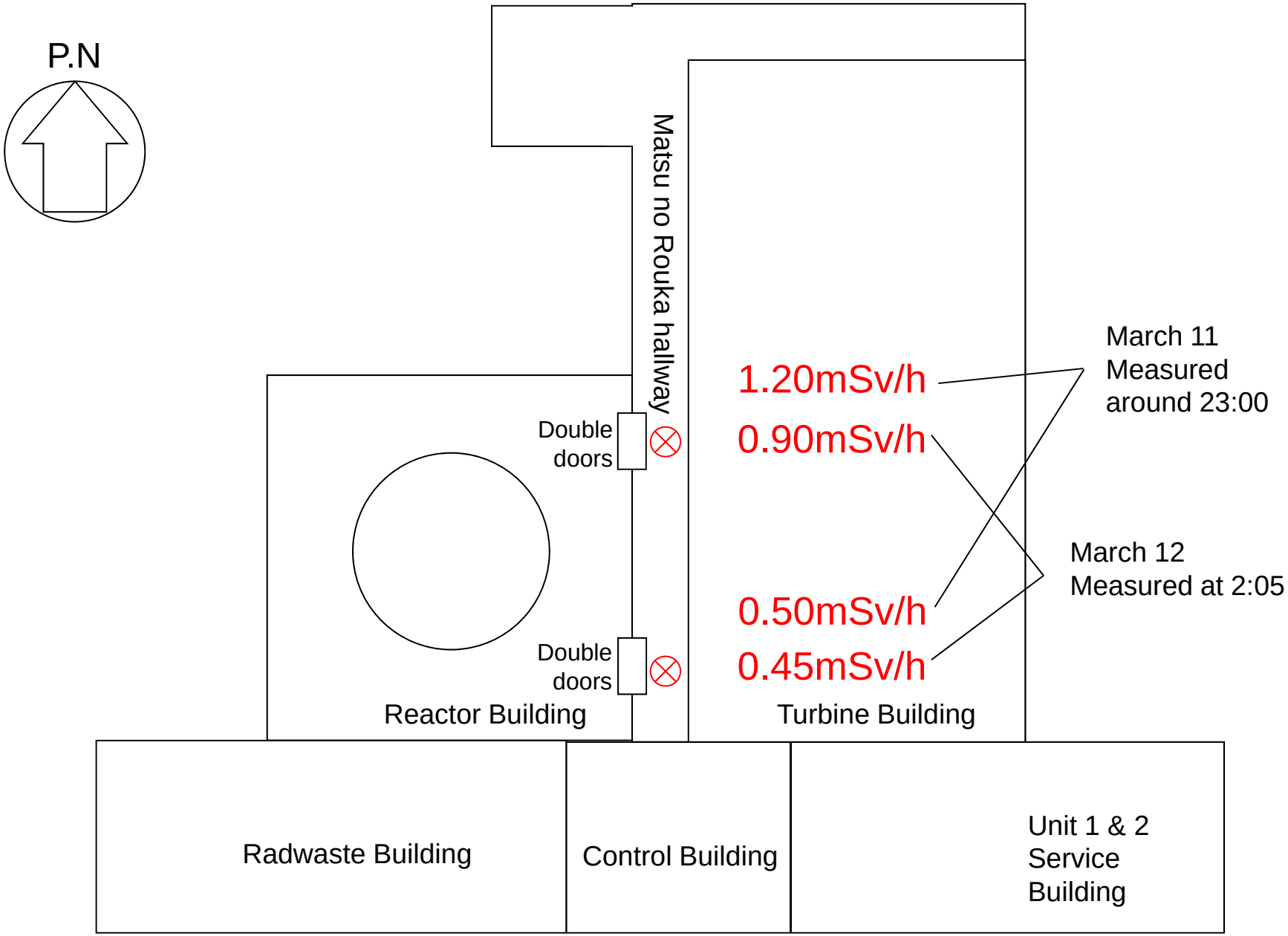
Dosage in front of the double doors at the Unit 1 T/B Matsu no Rouka hallway leading to R/B (March 11, 12)



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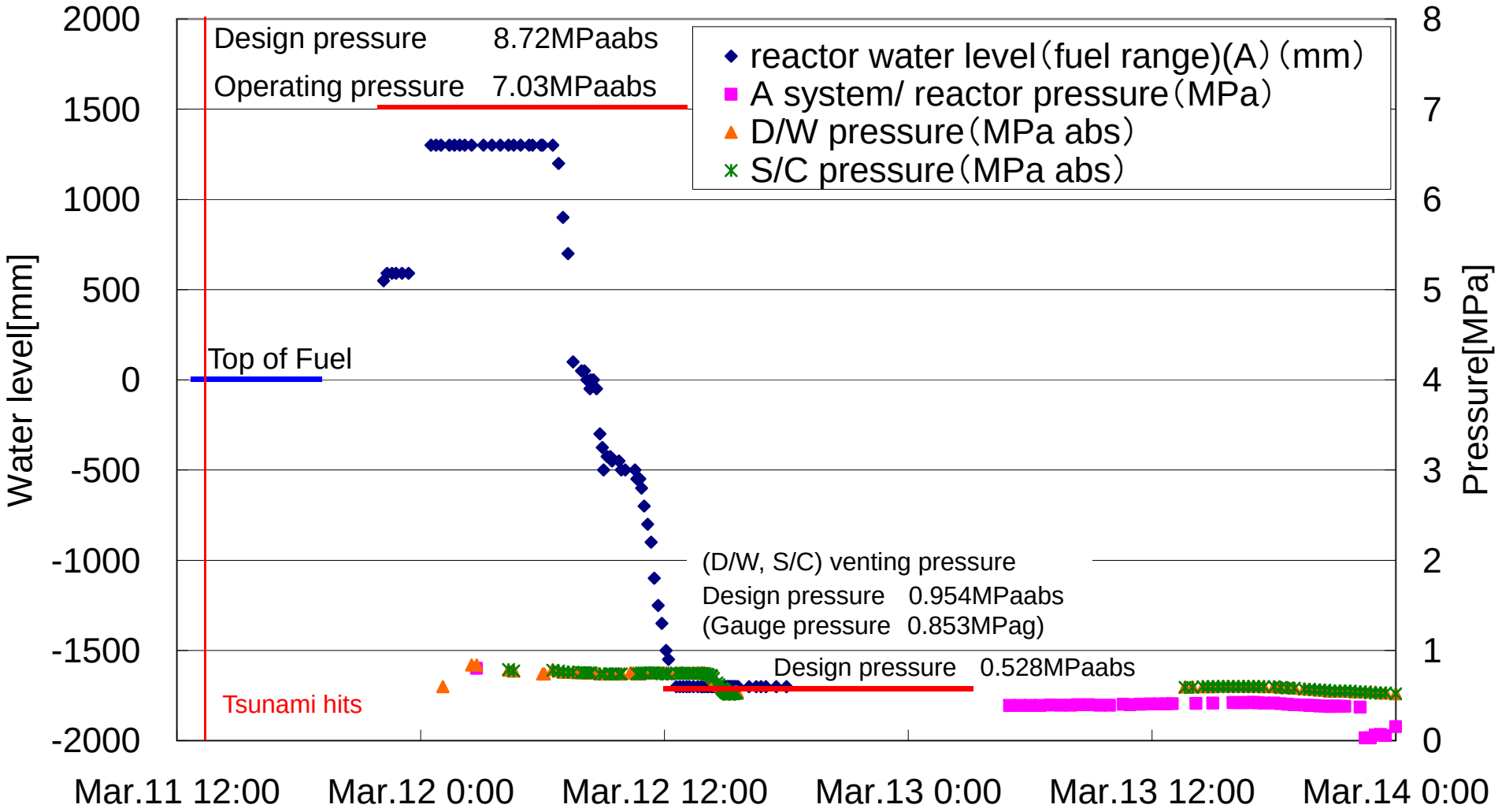
Movement in Plant Data after the Tsunami

Fukushima Daiichi Unit 1

Initial plant parameters at the time of the accident
(reactor pressure, D/W pressure, S/C pressure, water level)



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Progression of events at Fukushima Daiichi Unit 5 (Quick report based)

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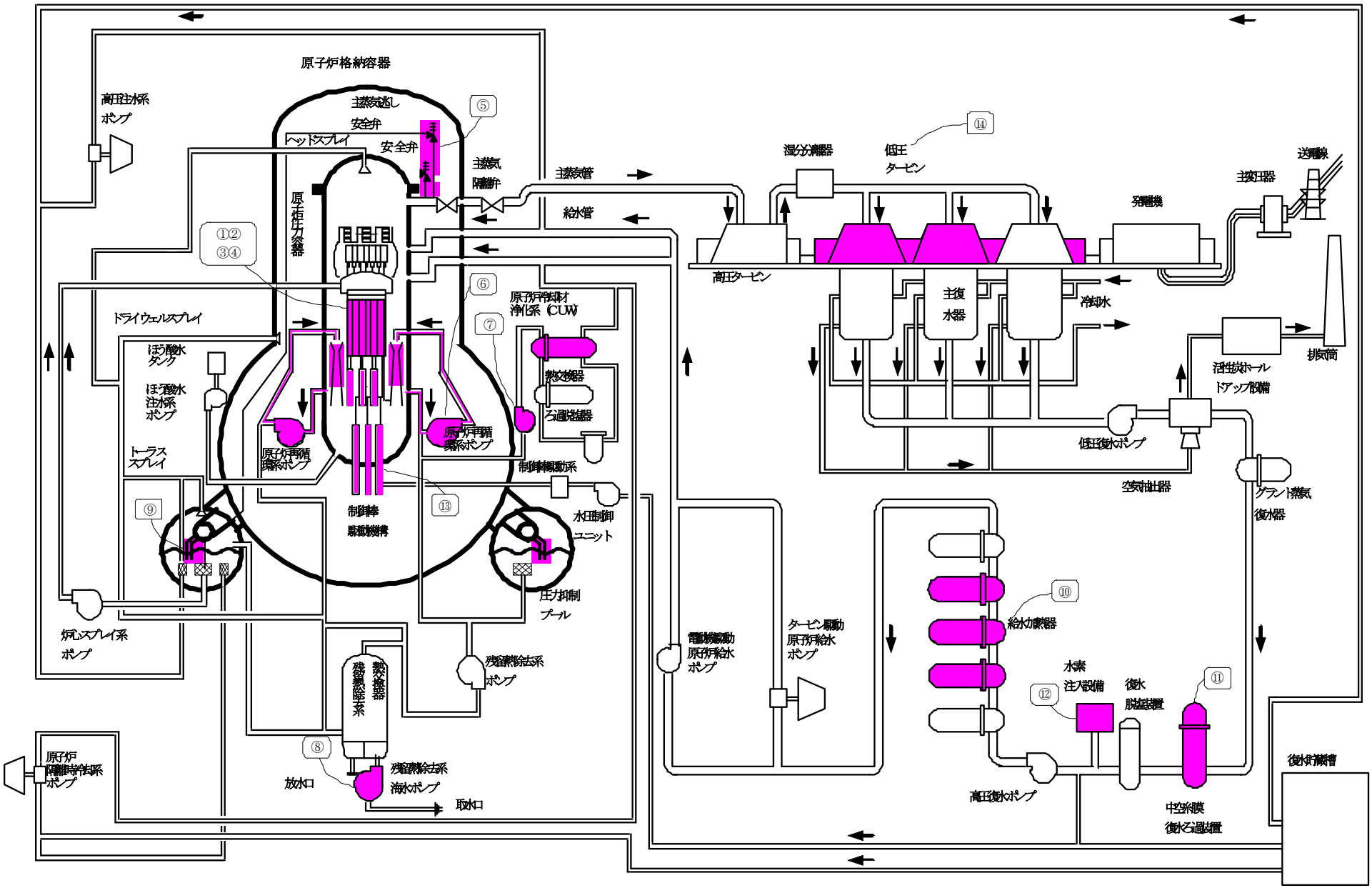

Schematic Flow Diagram of Fukushima Daiichi Unit 5

Chronology of Major Events at Fukushima Daiichi Unit 5

Before the earthquake		In rated output operation
March 11, 2011	14:46	Great East Japan Earthquake
	14:48	Off-site power lost Emergency DG startup
	15:41	Station black out due to the tsunami (subsequent AM response) Sea water system lost
March 12～		Power supplied to Unit 5 from Unit 6, which had a functioning emergency DG
March 13		MUWC startup
March 18		Alternate RHRS system started using a temporary underwater pump and temporary power source

Subsequent heat removal possible ⇒ Cold shutdown on March 20

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Fukushima Daiichi Unit 5
Plant Response to Earthquake

Event	Expected plant response	Fukushima Daiichi Unit 5 status
Earthquake (Off-site power is lost)	Emergency DG startup	○

Effects of the tsunami on the plant

Event	Plant damage	Results
Tsunami	Station black out	Inability to use electrically-operated equipment
	Loss of the sea water system	Loss of final heat removal MCR lighting lost (except the Unit 6 side)

- Plant response to the earthquake was normal.
- Loss of off-site power was handled by obtaining access to power as stipulated in Accident Management, etc. Quick restoration of the sea water system is required.

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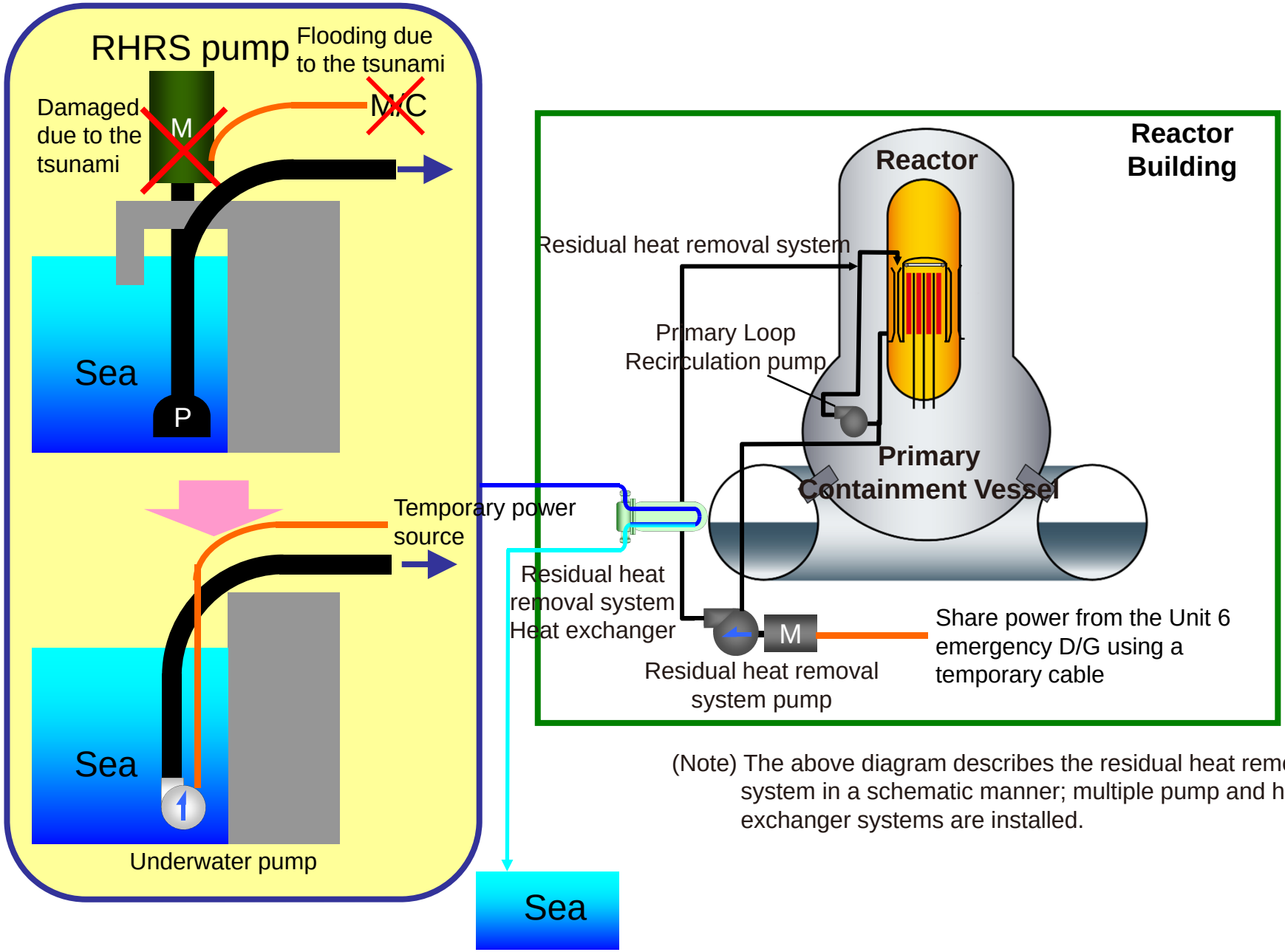
Installation of a Backup RHRS pump



(Note) The above diagram describes the residual heat removal system in a schematic manner; multiple pump and heat exchanger systems are installed.

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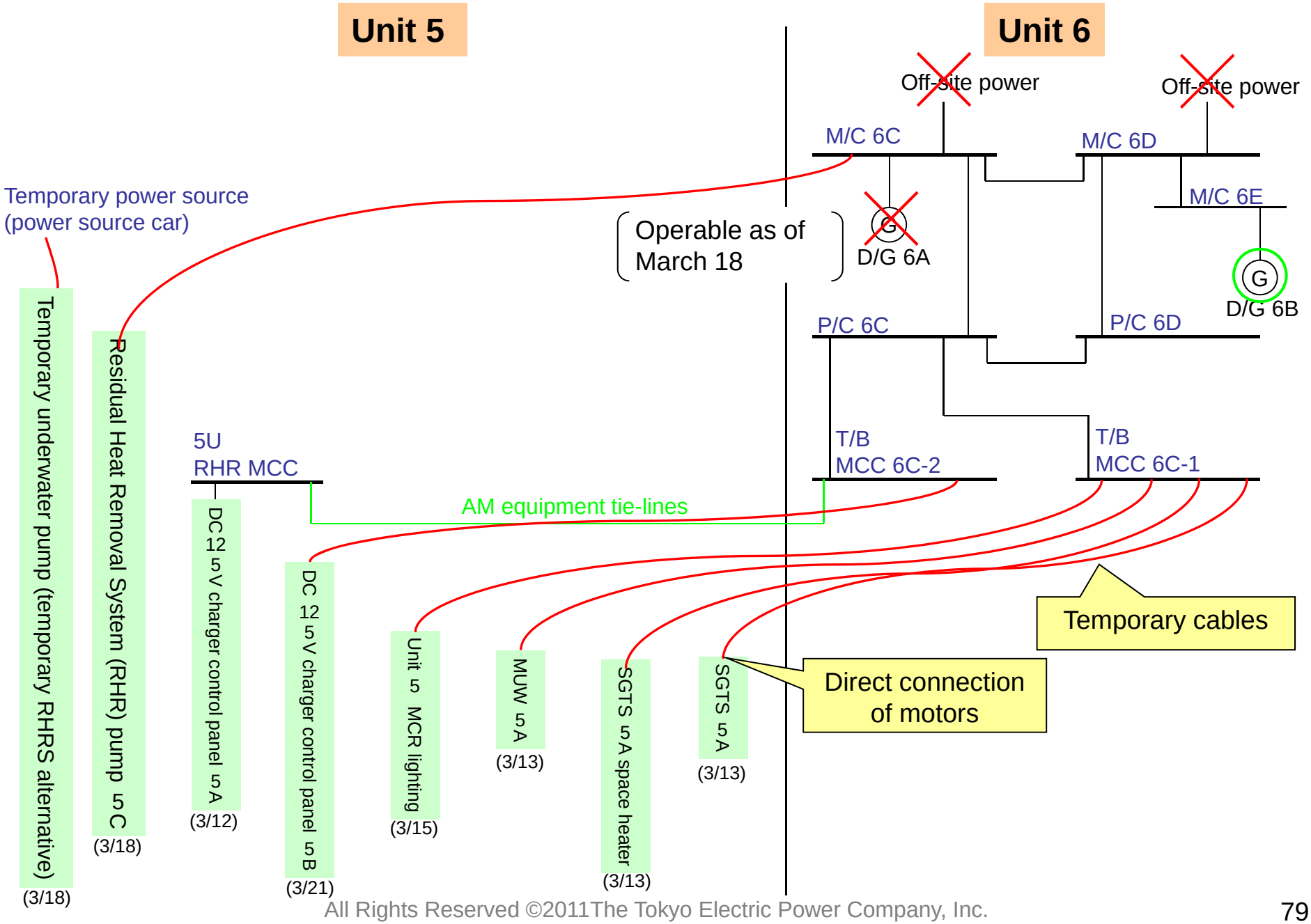
Providing Access to Power from Unit 6 to Unit 5



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Progression of Events at Fukushima Daiichi Unit 5 Summary

Fukushima Daiichi Unit 5 was restored and achieved cold shutdown by getting access to power from the emergency DG of Unit 6 and installing a temporary underwater pump to replace the RHRS pump of the sea water system.

Reference: Main data

Item	Temperature
Reactor water temperature	196.5° C (As of 6:00 on March 19)
Spent fuel pool water temperature	68.8° C (As of 0:00 on March 18)

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Reference materials

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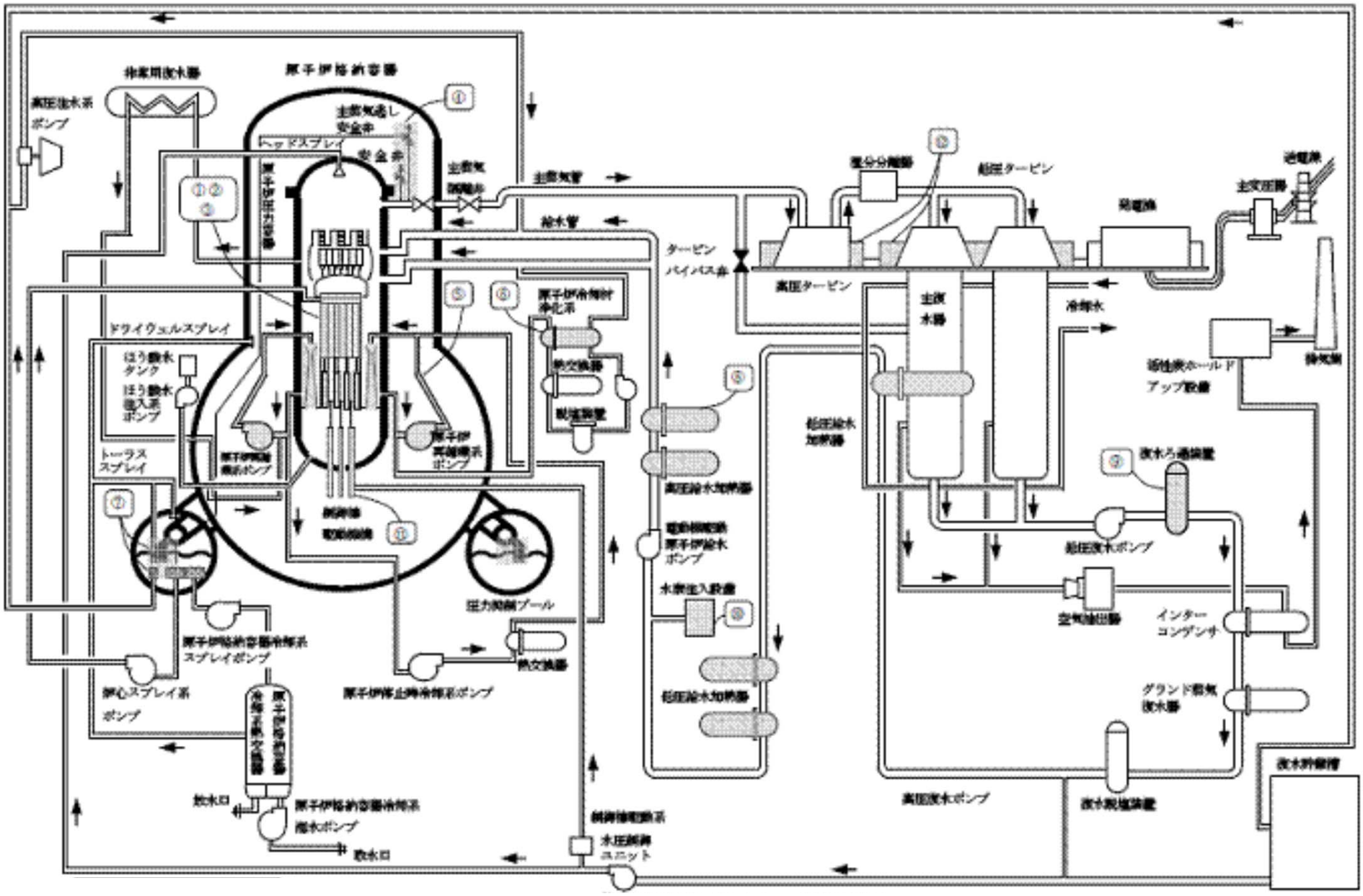


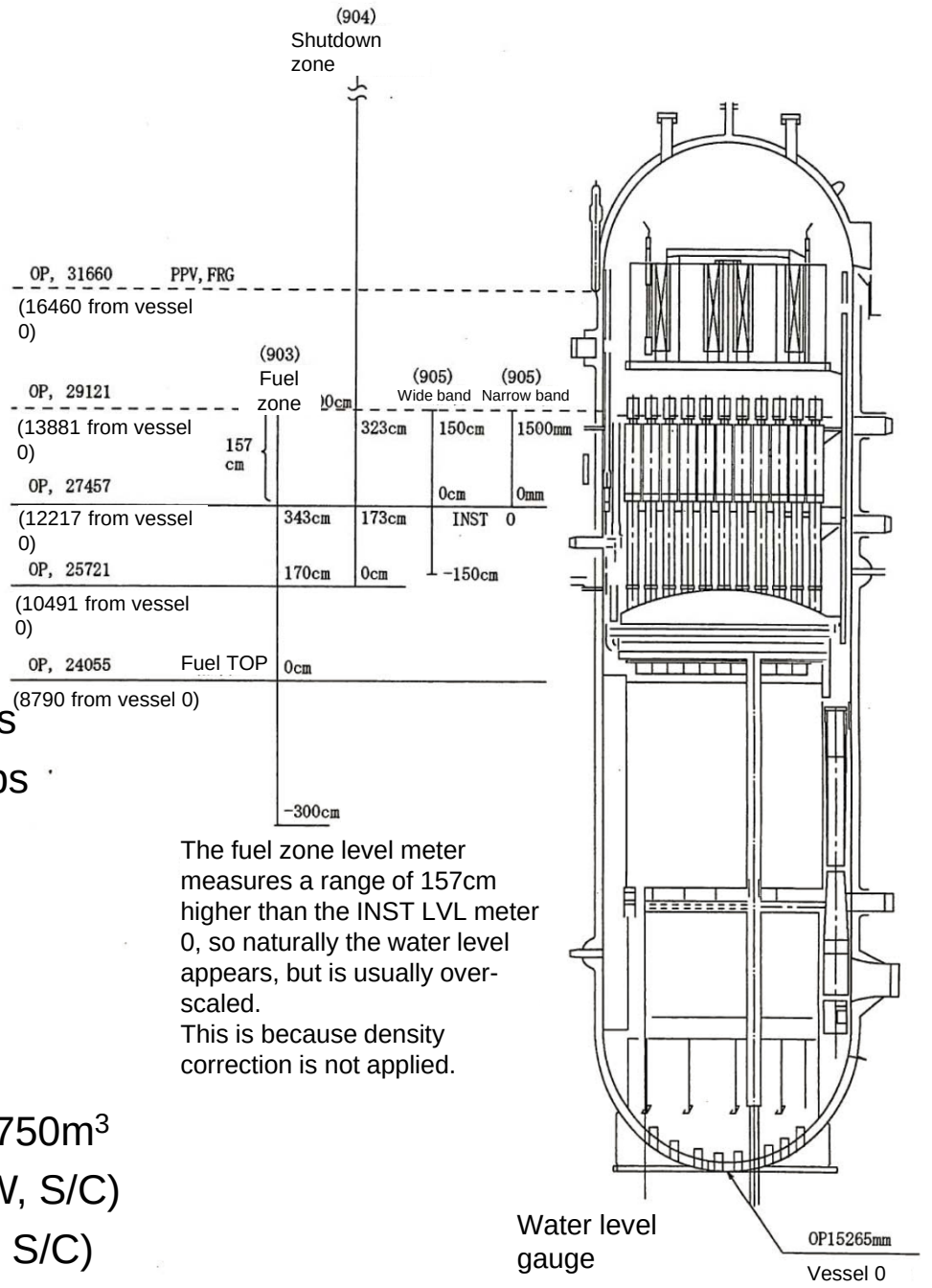
Schematic Flow Diagram of Fukushima Daiichi Unit 1

Fukushima Daiichi Unit 1 Plant data

1. Pressure vessel
   - Design pressure: 8.7 MPa abs
   - Design temperature: 302°C
   - Operating pressure: 7.0 MPa abs
   - Operating temperature: 285°C

2. Safety relief valve
   - Safety valves: 3
     - Opening pressure: 8.61 ~ 8.72 MPa abs
   - Safety-relief valves: 4
     - Opening pressure
       - Relief valve function: 7.38 ~ 7.52 MPa abs
       - Safety valve function: 7.75 ~ 7.82 MPa abs

3.Primary Containment Vessel
   - Volume Drywell space: 3,000m^3
   - (Vent lines: 3,410m^3)
   - Suppression chamber space: 2,620m^3
   - Suppression chamber pool water volume: 1,750m^3
   - Design pressure: 528 kPa abs (same for D/W, S/C)
   - Design temperature: 138°C (same for D/W, S/C)



The fuel zone level meter measures a range of 157cm higher than the INST LVL meter 0, so naturally the water level appears, but is usually over-scaled.
This is because density correction is not applied.

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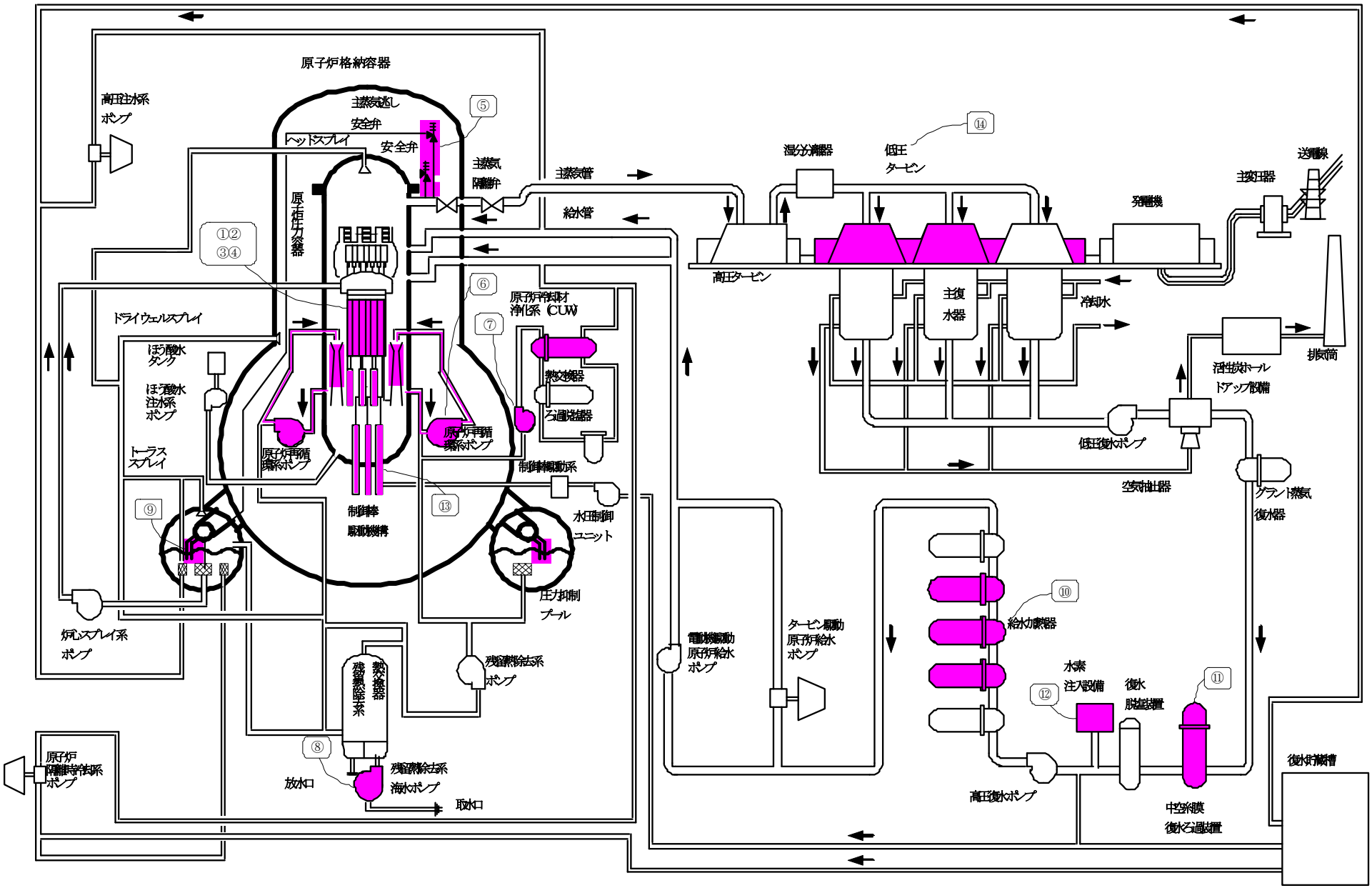


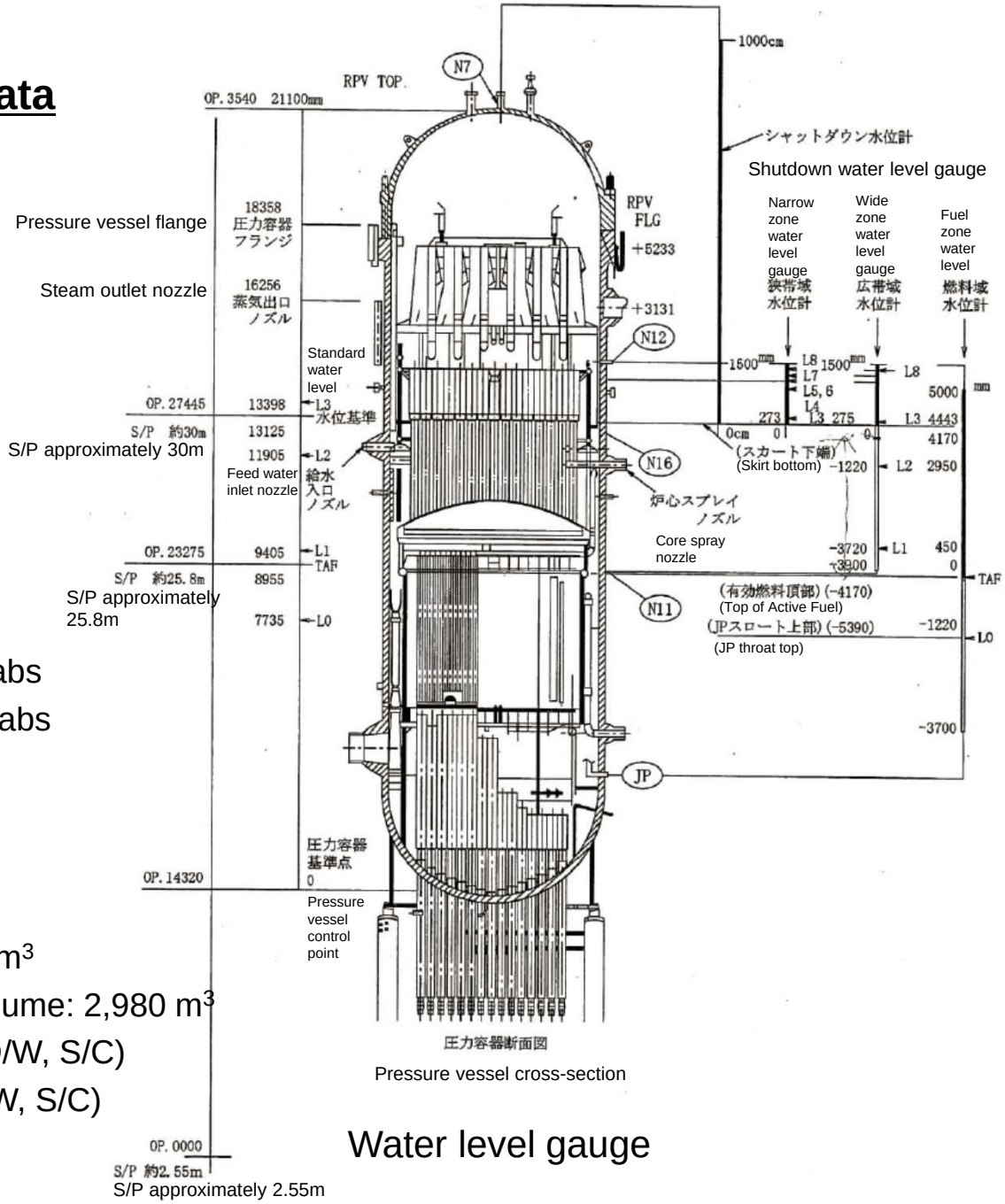
Schematic Flow Diagram of Fukushima Daiichi Unit 3

Fukushima Daiichi Unit 3 Plant Data

1. Pressure vessel
   - Design pressure: 8.7 MPa abs
   - Design temperature: 302°C
   - Operating pressure: 7.1 MPa abs
   - Operating temperature: 286°C

2. Safety relief valve
   - Safety valves: 3
     - Opening pressure: 8.65 MPa abs
   - Safety-relief valves: 8
     - Opening pressure
       - Relief valve function: 7.54 ~ 7.68 MPa abs
       - Safety valve function: 7.75 ~ 7.89 MPa abs

3. Primary Containment Vessel
   - Volume　Drywell space: 3,770 m^3
     - (Vent lines: 4,240 m^3)
     - Suppression chamber space: 3,160 m^3
     - Suppression chamber pool water volume: 2,980 m^3
   - Design pressure: 486 kPa abs (same for D/W, S/C)
   - Design temperature: 138°C (same for D/W, S/C)



圧力容器断面図

Pressure vessel cross-section

Water level gauge

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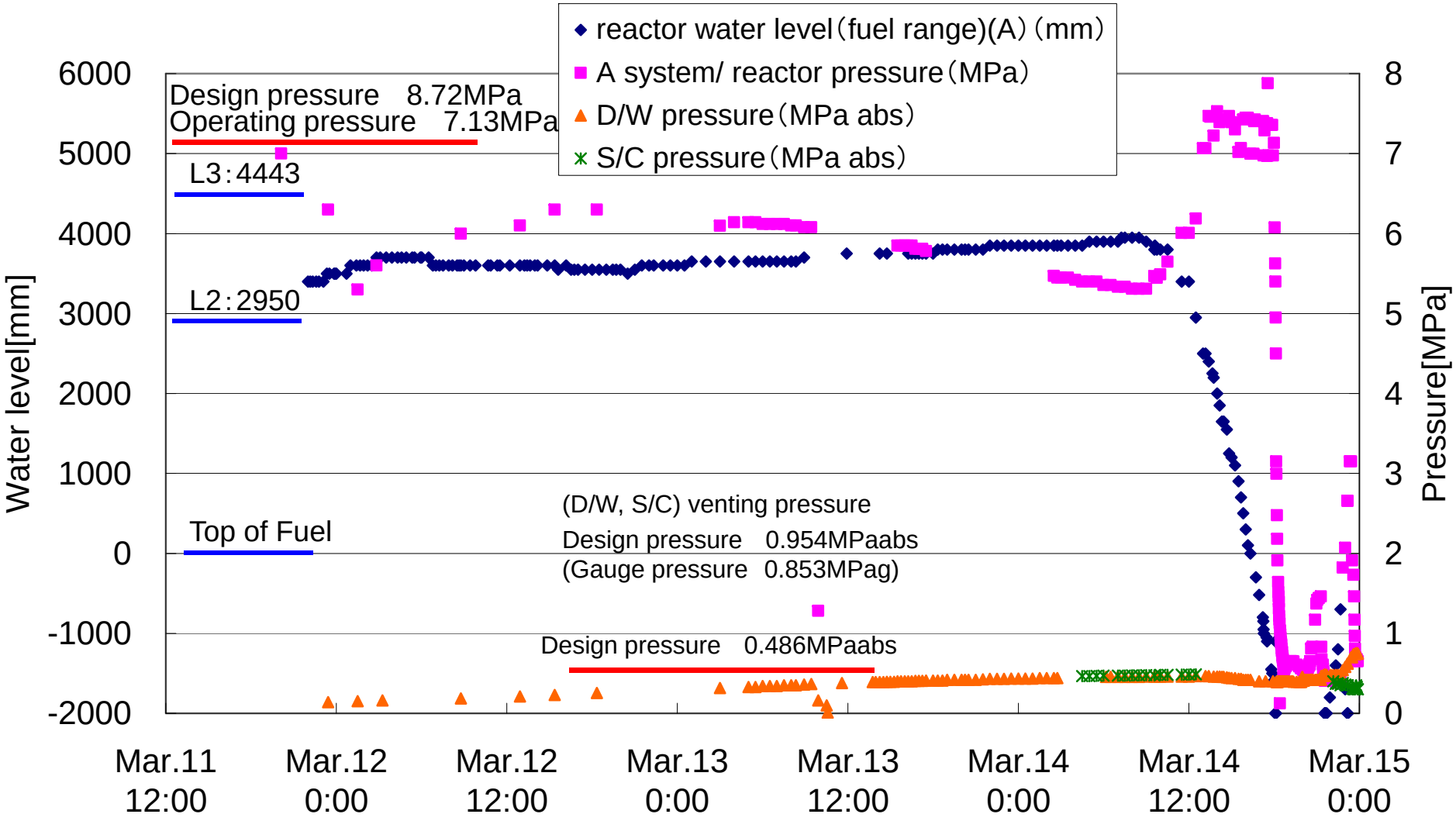
Fukushima Daiichi Unit 2

Initial plant parameters at the time of the accident (reactor pressure, D/W pressure, S/C pressure, water level)



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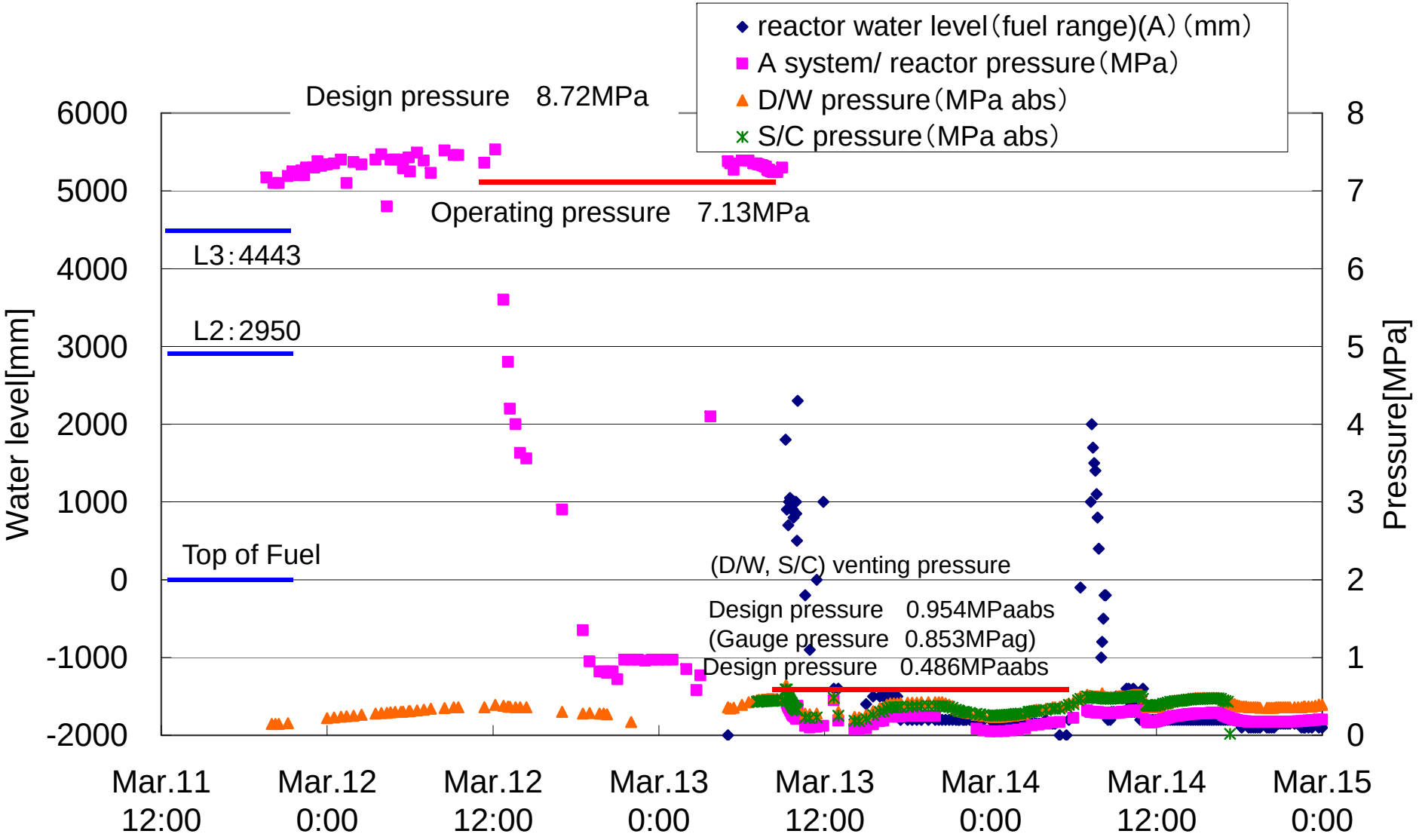
Fukushima Daiichi Unit 3

Initial plant parameters at the time of the accident (reactor pressure, D/W pressure, S/C pressure, water level)



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