The 49th JAIF Annual Conference

# Current Status and Future of The Fukushima Daiichi Nuclear Power Station

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# Today's Topics

1. **Current state of Fukushima Daiichi NPS**
2. **Measures against contaminated water**
3. **Improving working environment**
4. **Fuel removal from the spent fuel pool**
5. **Toward fuel debris removal**
6. **Information sharing and communication**



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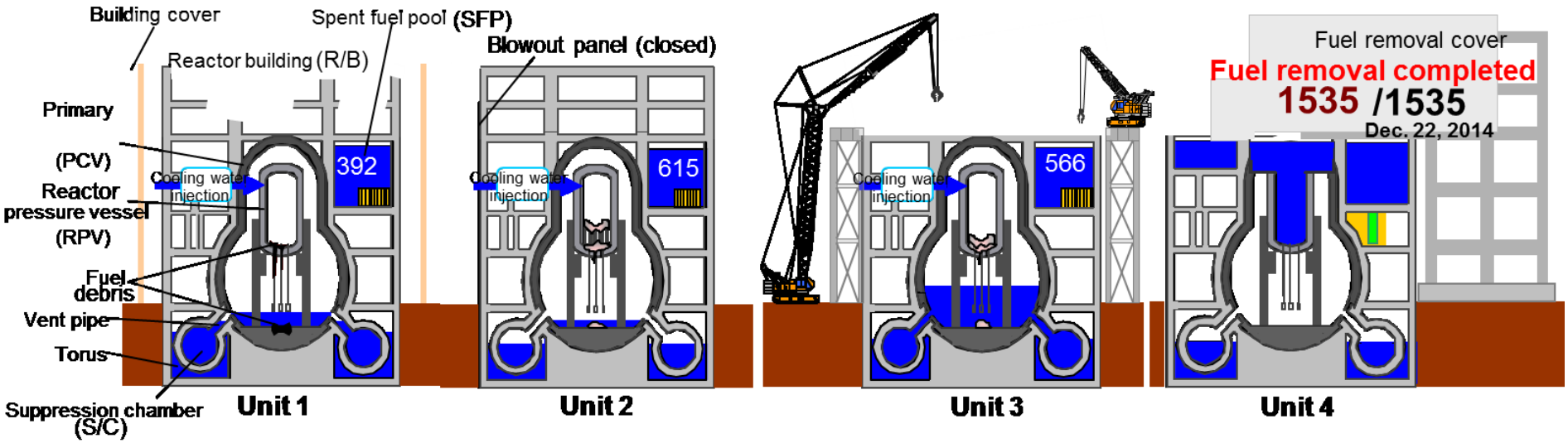
# 1. Current state on Fukushima Daiichi NPS (Status of reactors and buildings)

## All units maintain cold shutdown state




| RPV bottom temp. | |
|---|---|
| Unit 1 | Approx. 14℃ |
| Unit 2 | Approx. 19℃ |
| Unit 3 | Approx. 17℃ |

| PCV internal temp. | |
|---|---|
| Unit 1 | Approx. 14℃ |
| Unit 2 | Approx. 20℃ |
| Unit 3 | Approx. 16℃ |

| Spent Fuel Pool temp. | |
|---|---|
| Unit 1 | 14.3℃ |
| Unit 2 | 24.1℃ |
| Unit 3 | 20.0℃ |

| Amount of Water injection to reactor | |
|---|---|
| Unit 1 | 4.4m³/h |
| Unit 2 | 4.2m³/h |
| Unit 3 | 4.2m³/h |

As of February 24, 2016

* Removal of fuel rods in SFP at Unit 4 was completed on December 22, 2014.



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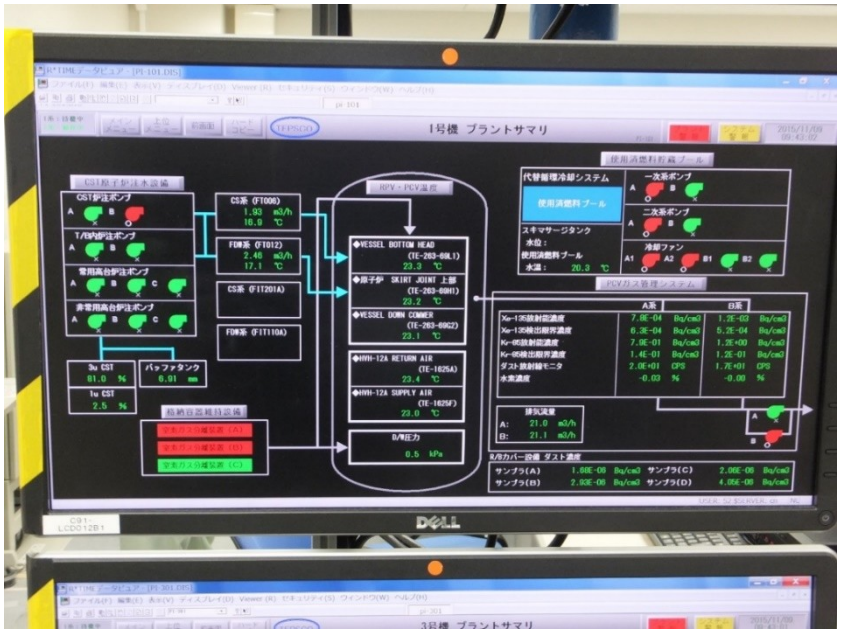
# 1. Current state on Fukushima Daiichi NPS (TSC control room)



■Plant condition is monitored in TSC control room






In order to enhance safety level, multiple water injection systems are installed.



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# 1. Current state on Fukushima Daiichi NPS (Current and future tasks)



## Unit 1

**Current status**

Building cover installed on reactor building (November 2011)

Removal of the building cover toward removal of fuels from spent fuel pool

**Tasks**

Identification of the status of debris on the operating floor and inside the pools

Countermeasures for the dispersion of radioactive materials during the removal of the building cover

Photo taken on 12 March 2011

Photo taken in Oct 2015

## Unit 2

**Current status**

Closed the blowout panel to avoid the dispersion of radioactive materials

**Tasks**

Radiation dose reduction measures

Photo taken on 10 April 2011

Photo taken on 15 Aug 2012

## Unit 3

**Current status**

Rubble removal from the top of the reactor building completed (October 2013)

**Tasks**

Due to high radiation levels, radiation dose reduction measures must be carried out safely and steadily with remote-controlled heavy machinery

Photo taken on 12 Feb 2012

Photo taken on 11 Oct 2013

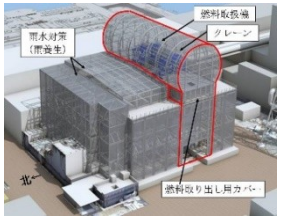


Image of cover for fuel removal

## Unit 4

**Current status**

Fuel removal from SFP completed (on December 22, 2014)

**Tasks**

Consider full scale decommission plan including demolition of the building

Photo taken on 22 Sep 2011

Photo taken on 5 Jul 2012

Photo taken on 12 Nov 2013



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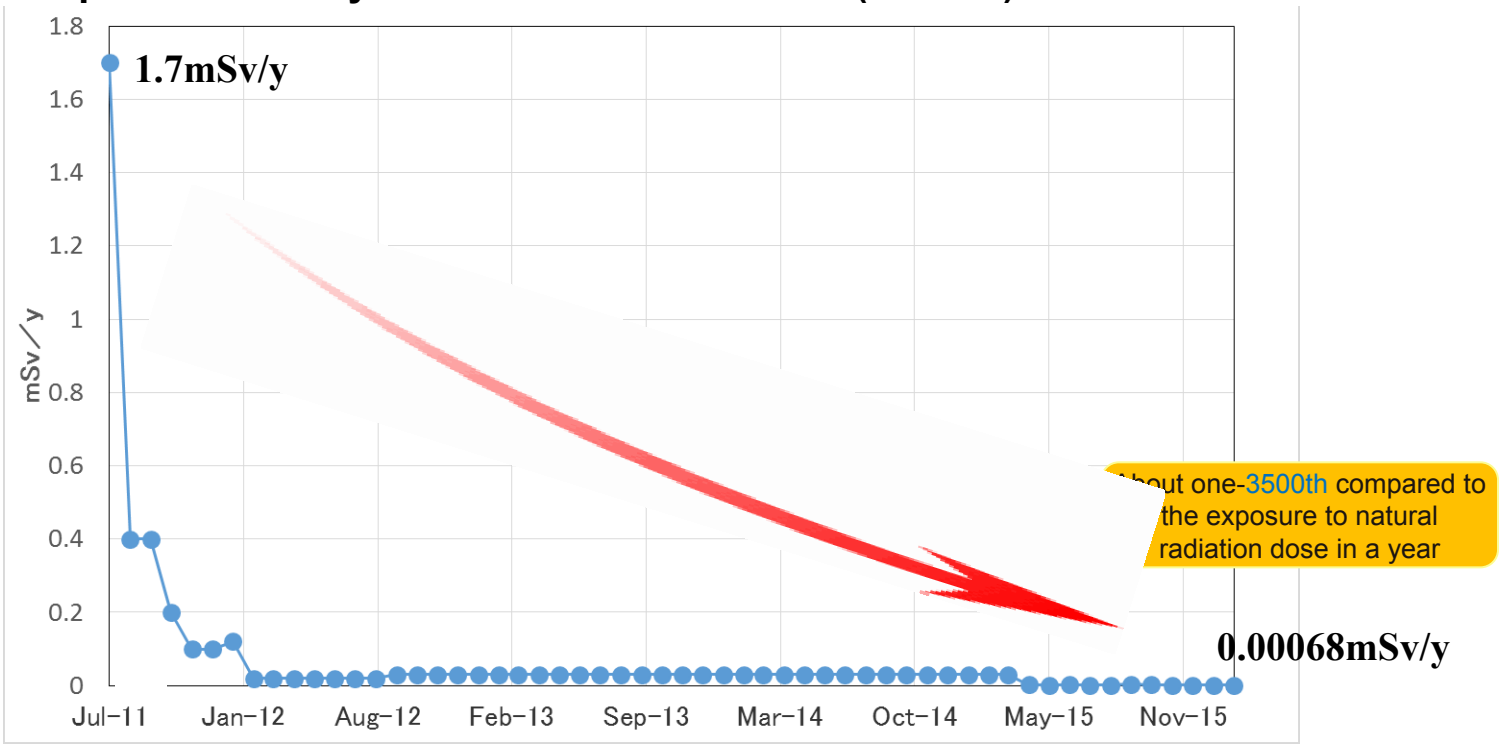
# 1. Current state on Fukushima Daiichi NPS (Level of airborne radiation)



## ■ Release rate of radioactive materials has been significantly decreased

- The amount of radioactive materials (cesium) released from Unit 1-3 PCVs is assessed based on airborne radioactive material concentrations at the top of reactor buildings
  →Estimated value of total release amount (as of Feb 2016) as about 220 thousand Bq/hr
  →About one-270th compared to those (60 million Bq/hr) of Dec 2011
- Accordingly, assessed the exposure dose at site boundary as 0.00068 mSv/yr at maximum
  (Excluding effect of already released radioactive materials)

**The exposure dose by the radioactive materials (cesium) from Units 1 to 4**



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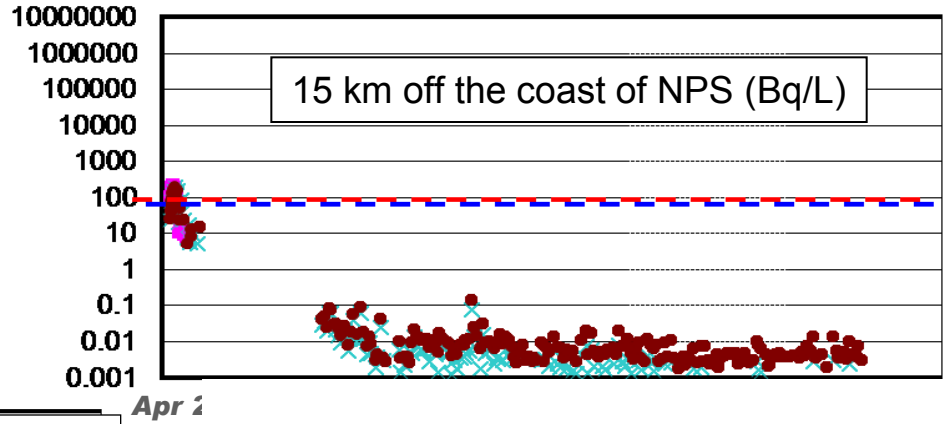
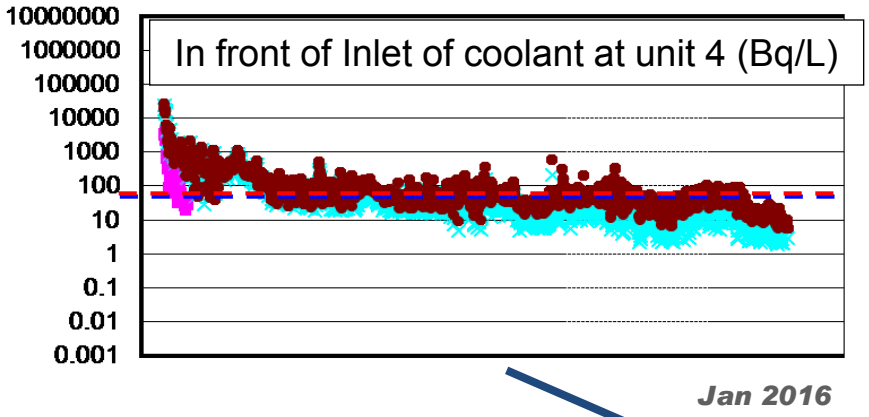
# 1. Current state on Fukushima Daiichi NPS (Monitoring level in the sea)

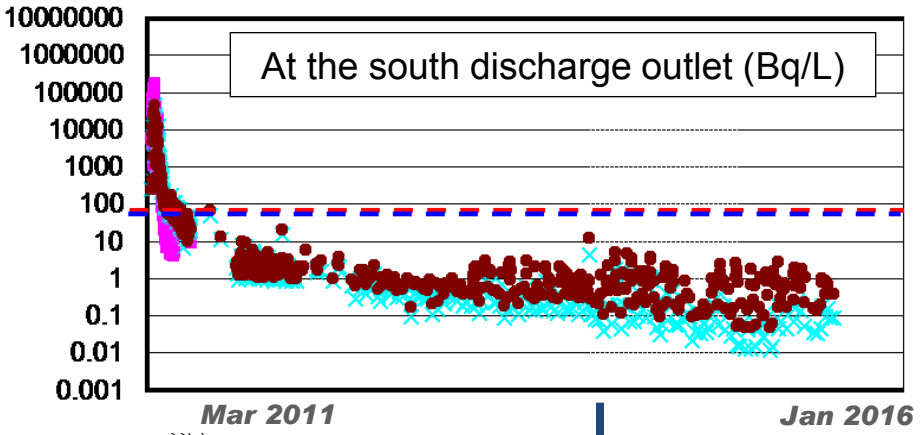


- Concentration level of radioactive materials has been gradually decreased

- About one-100 thousandth compared with the one after the accident
- Outside port are substantially below notified concentration.

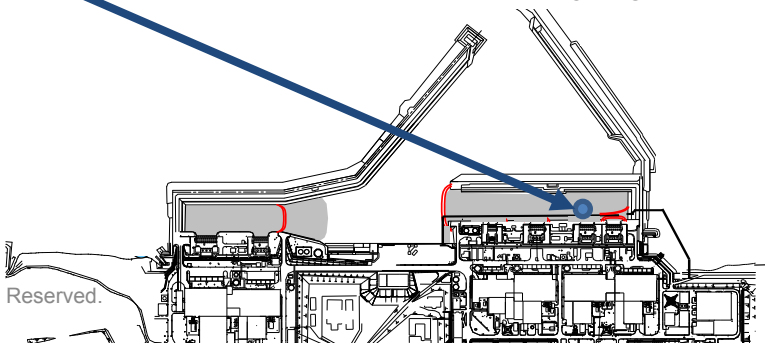



<Reference> Notified concentrations (Concentration limits for water outside environmental monitoring area)

- Cesium 137: 90 Bq/L
- Cesium 134: 60 Bq/L





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# 1. Current state on Fukushima Daiichi NPS
## (Major work steps for decommissioning)



1st Step
Fuel removal from spent fuel pool

Unit 1, 2 Unit 3

**Rubble removal, decontamination**

Rubble removal on the top floor of the building with the heavy machinery

Unit 3

**Installation of fuel removal facility**

Installation of the building cover and fuel handling machine

Unit 4

**Fuel removal**

Removal of fuels from spent fuel pool to transport to the common fuel pool

Unit 4

Unit 4

**Storage/Transport**

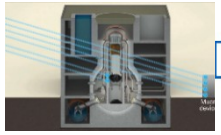
Spent fuels transported from spent fuel pool are stored in the common fuel pool.
They are subsequently stored in the dry cask storage facility to be under more safe storage condition.

2nd Step
Fuel debris removal (molten fuel)

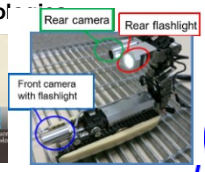
Units 1 to 3

**Decontamination, investigation inside vessels**

Decontamination, and leak identication robots are developed.
The Inside of PCV is investigated with various techno



Unit 1 Muon technology




Unit 2 PCV survey

**Fuel debris removal**

Fuel debris is removed with the facility for fuel debris removal after the necessary technology is developed.
TEPCO deliberates the method for fuel debris removal.

**Storage/Transport**

Removed fuel debris is stored in the storage canisters exclusively for fuel debris.
TEPCO deliberates the method for fuel debris storage.

3rd Step
Dismantling plant etc.

**Developing scenario and technology**

**Designing and manufacturing equipment**

**Dismantling etc.**



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# 1. Current status on Fukushima Daiichi NPS (Summary)

**Current plant condition & impact of radiation dispersion**

- **All the units are kept under stable condition with main indicators monitored 24h/365days.**
- **The amount of radioactive materials released from Fukushima Daiichi has been substantially reduced and the environment impacts are getting smaller.**
- **Fuel removal from spent fuel pool is proceeding now. Methodology of fuel debris removal is under consideration and the inside of PCV is investigated with various techniques.**



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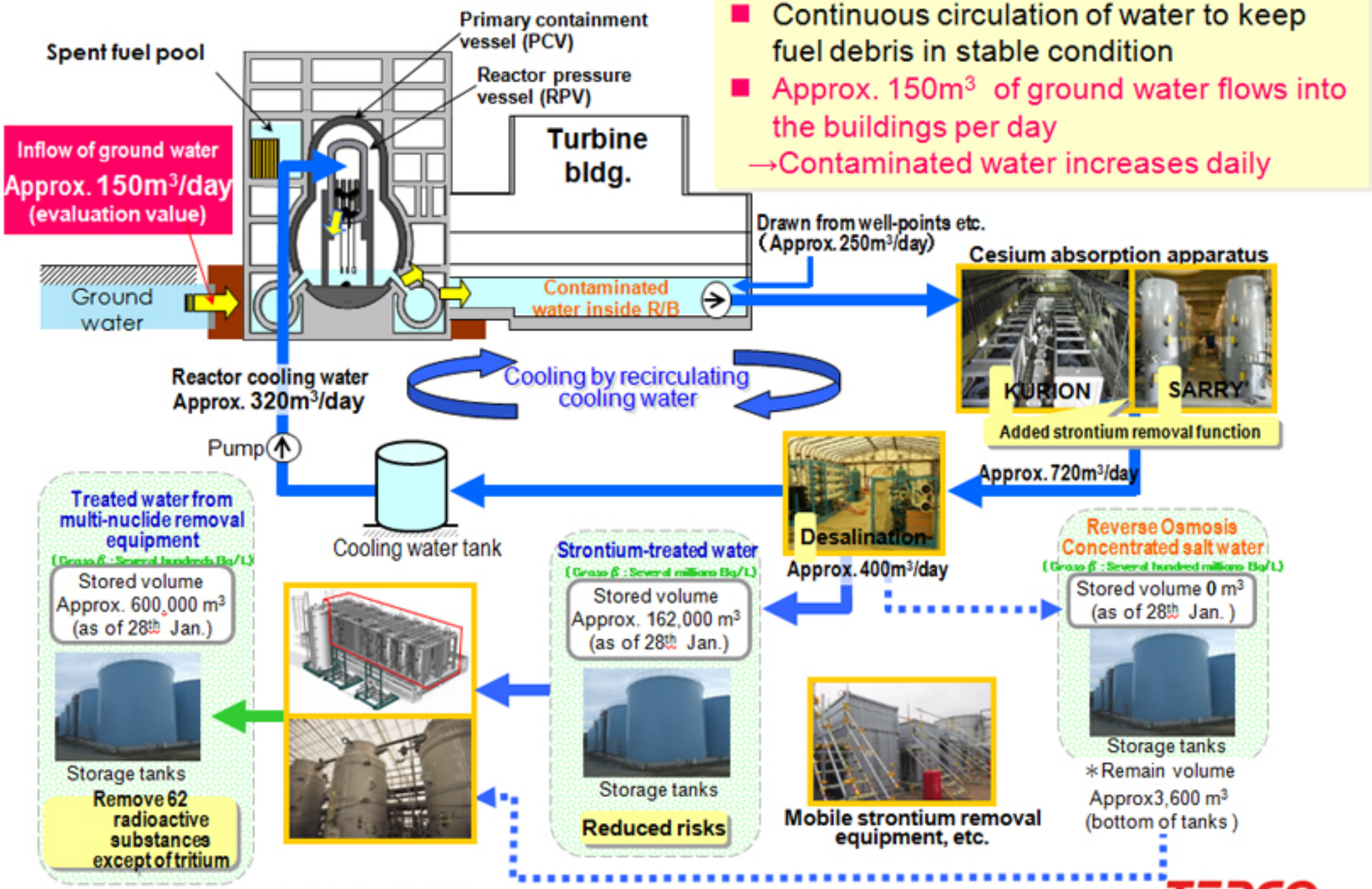
# 2. Measures against contaminated water (Recirculating cooling water)

- Continuous circulation of water to keep fuel debris in stable condition
- Approx. 150m³ of ground water flows into the buildings per day
  →Contaminated water increases daily



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# 2. Measures against contaminated water (3 Measures)



- Water to cool fuel molten during the accident and groundwater have mixed, generating approximately 150 tons of contaminated water per day. Countermeasures are being implemented based on the following three basic polices.

## 1. Remove source of contamination

① Clean up contaminated water with Multi-nuclide removal equipment (ALPS)

② Remove contaminated water in trenches (Underground tunnel with piping)

## 2. Isolating groundwater from contamination sources

③ Pumping up groundwater through bypasses

④ Pumping up groundwater through wells near buildings

⑤ Installation of frozen-soil impermeable wall on the land side

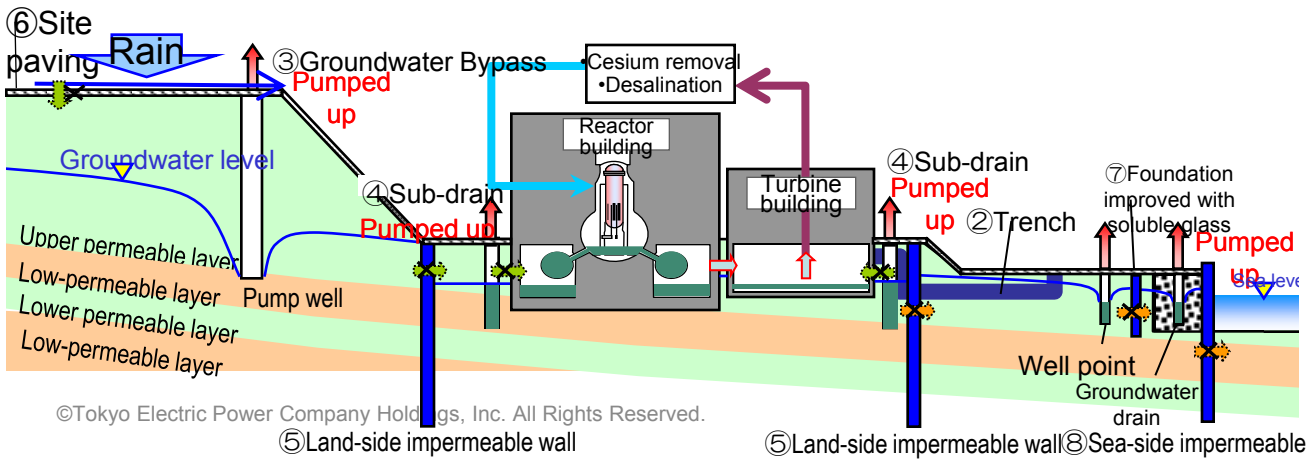
⑥ Paving of site to curb permeation of rainwater into soil

## 3. Preventing leakage of contaminated water

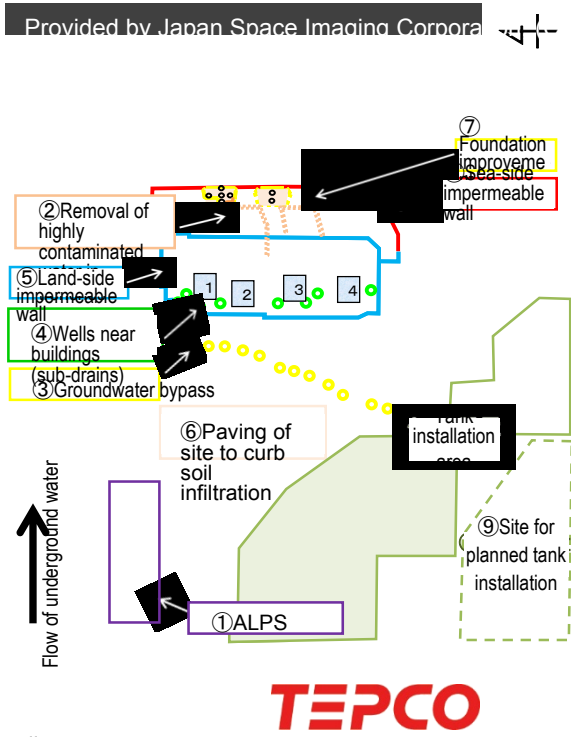
⑦ Ground improvement with water glass

⑧ Installation of impermeable walls on the sea side

⑨ Augmentation of tanks (replacement with welded tanks, etc.)



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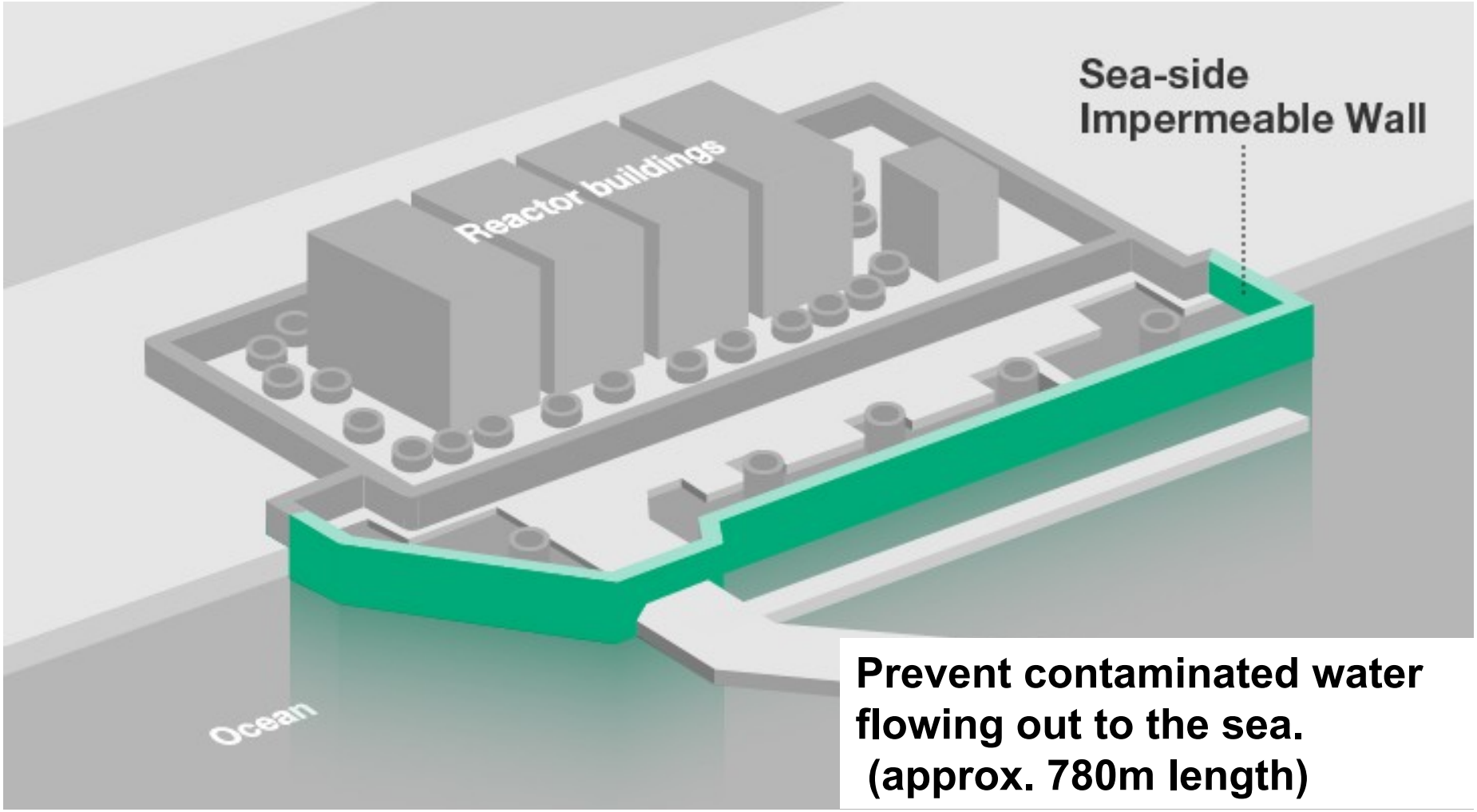
# 2. Measures against contaminated water (Sea-side impermeable wall)






The construction of sea-side impermeable wall was completed in October 2015.



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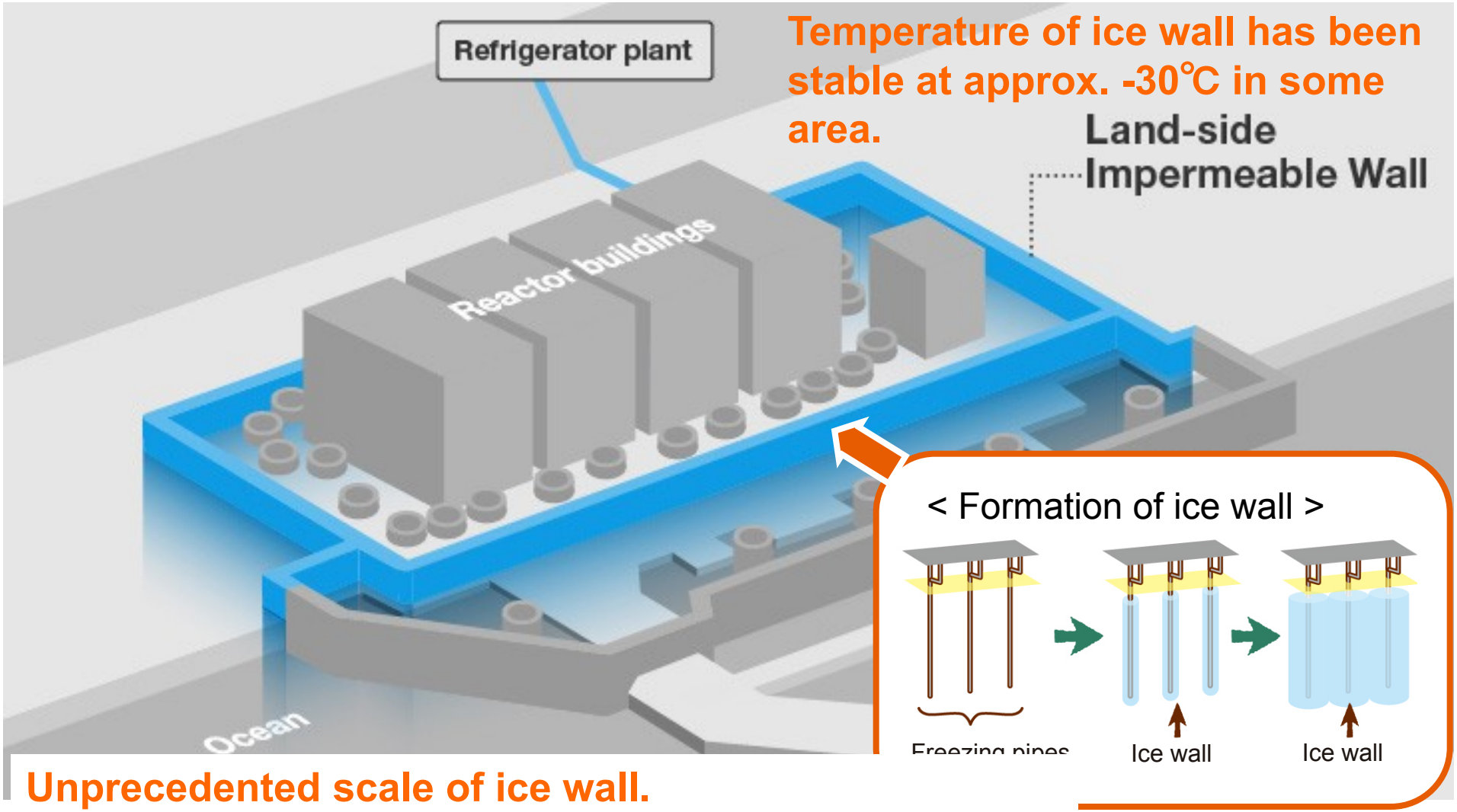
# 2. Measures against contaminated water (Land-side impermeable wall)






**Unprecedented scale of ice wall.**
**(1.5-kilometer-long, 30-meter-deep wall of frozen soil)**

**Freezing of the ice wall has started.**



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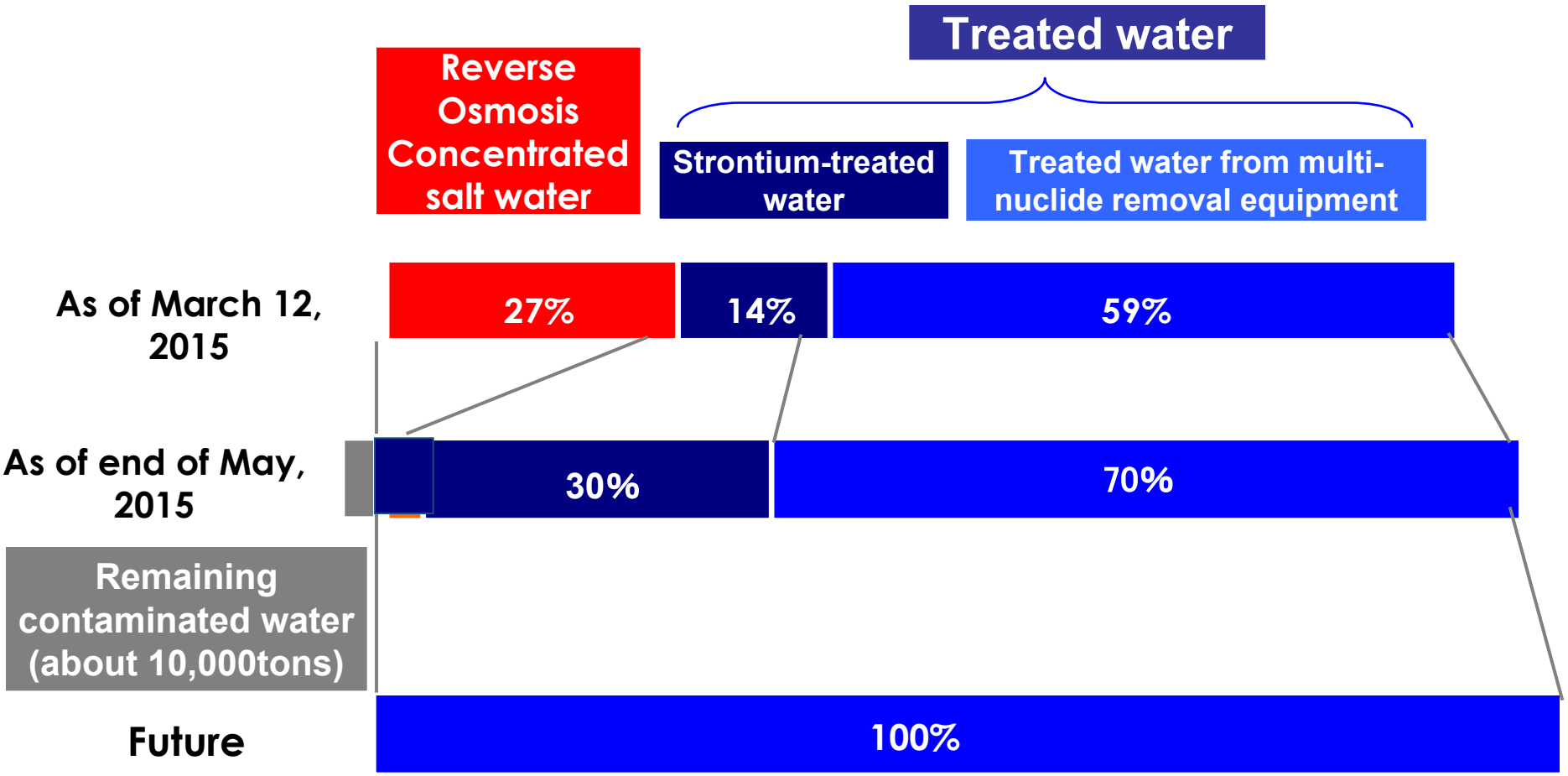
# 2. Measures against contaminated water



(Progress of contaminated water treatment)



# 2. Measures against contaminated water (Summary)



**Completion of contaminated water treatment**

- **The treatment of contaminated water stored in tanks was finally completed at the end of May last year. We continue to purify the once treated water to reduce the risk further.**
- **With several measures in place, the amount of water flowing into the buildings is being reduced.**
- **Tanks will be constructed in accordance with the amount of water to be stored and managed in an appropriate manner.**



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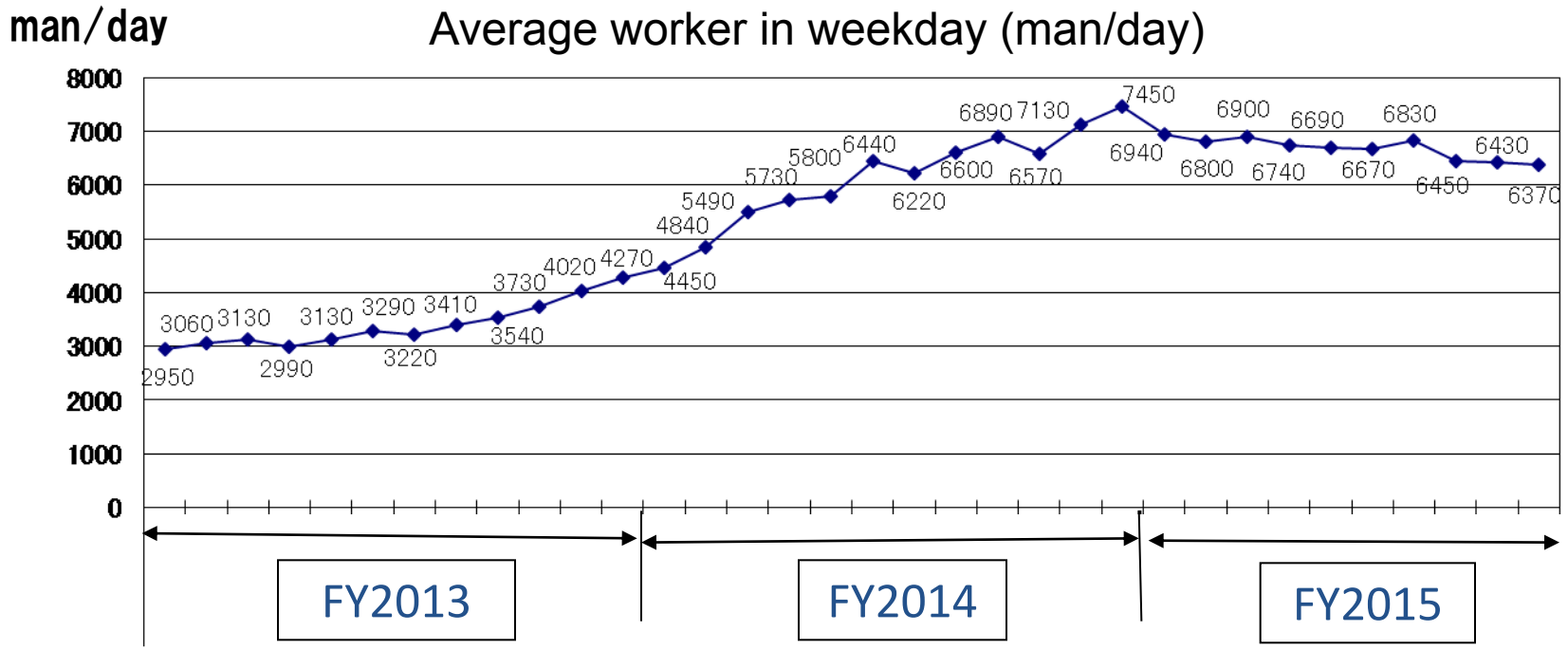
# 3. Improving working environment (Number of workers on site)



- Number of people working on site has been greatly increased




- In addition to improving working environment, currently approximately 90% of contracts are fulfilled on a negotiation basis rather than competition in order to secure work force.
- By securing long term workers, more deliberate personnel assignment and human resource development become possible.



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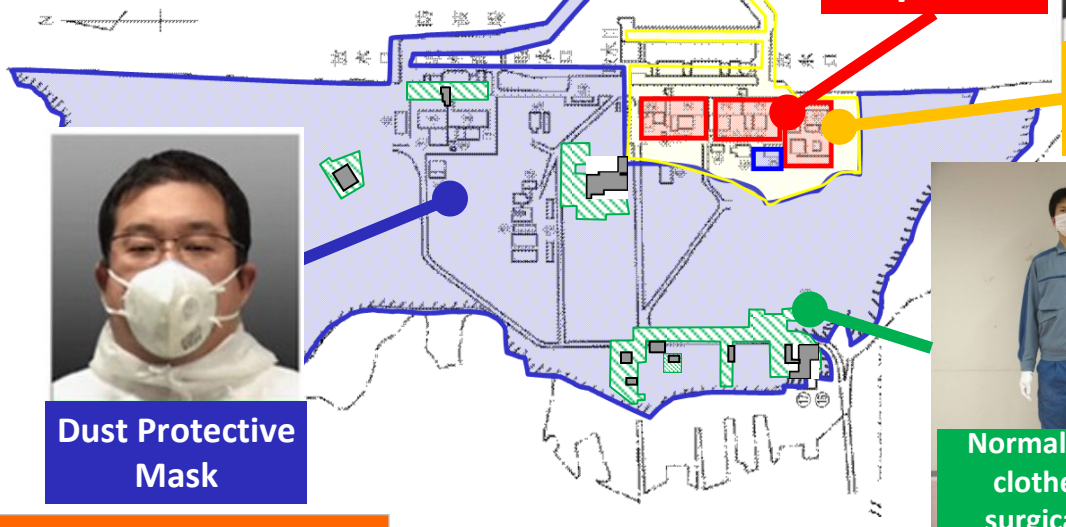
# 3. Improving working environment (Expanding working area without full face mask)



- Full-face respirator required in all site areas just after the accident
- Currently, full-face respirators are not required except for works in the buildings and related to contaminated water treatment

Full-face respirator

Half-face Respirator





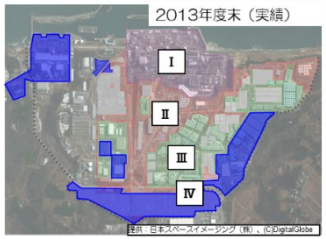
Dust Protective Mask

Normal working clothes with surgical mask

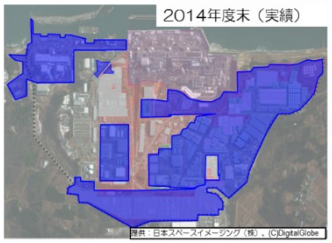
**Decreasing radiation dose at Fukushima Daiichi**

: Area confirmed below targeted radiation dose （5μSv/h）

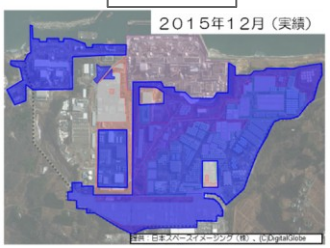
**FY2013**
40 %



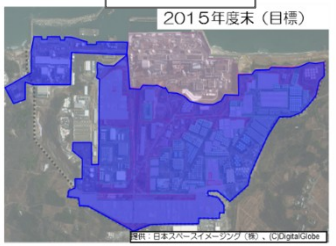

**FY2014**
77 %




**As of Dec 2015**
89 %



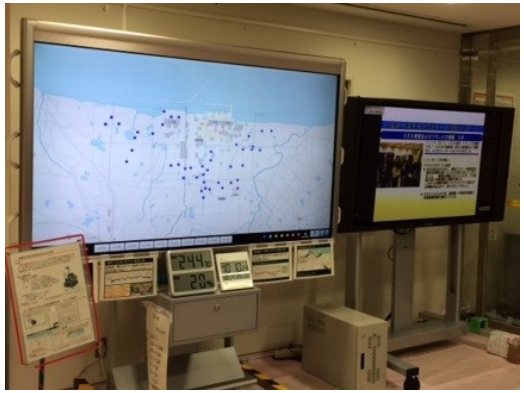

**FY2015 target**
100 %



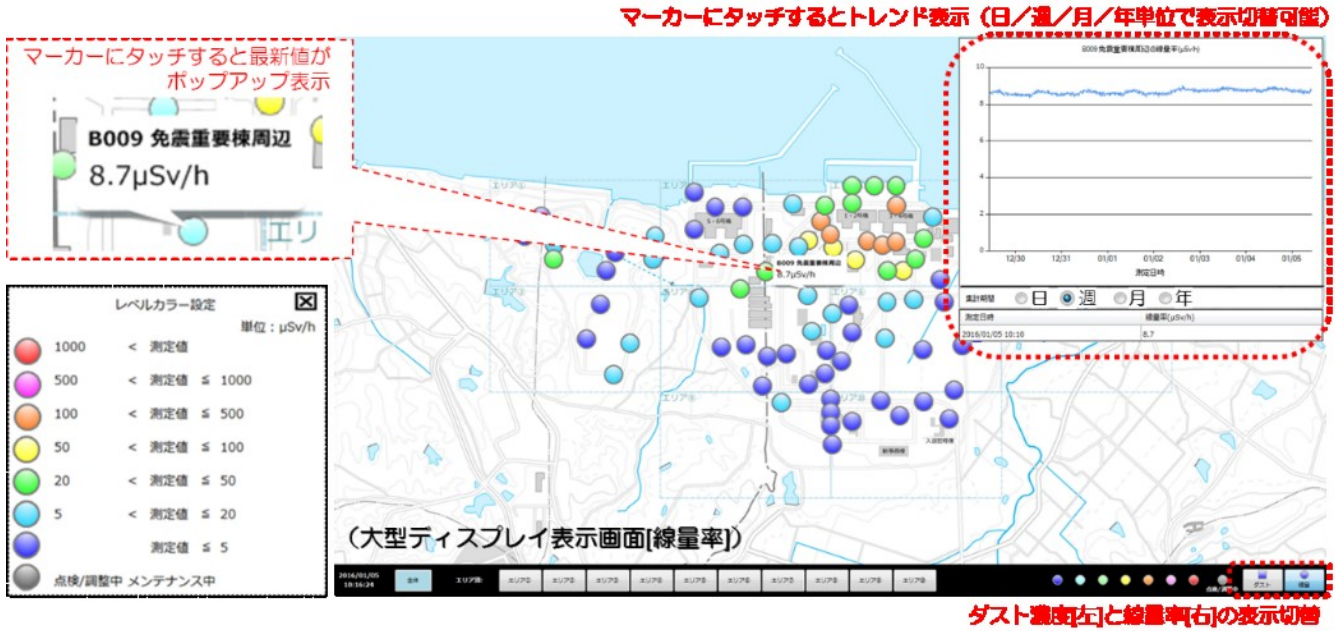
# 3. Improving working environment (Visualization of dose rate)



- The system of visualizing the real time dose data is in place by deploying 86 dose rate monitors on site.
- The display of data monitors should be placed at the point where workers can be easily accessible.  Continuous dust monitoring data is also shown on the display.



Monitor of dose rate




Display and its image

# 3. Improving working environment (Improving welfare facilities)



- A large on-site resting area completed in May 2015 （ for approximately 1,200 workers)
- New office building was completed in October 2014 (for approximately 1200 TEPCO/FDEC employees)
- Fukushima Revitalization Meal Service Center commenced to provide warm meals to working people at the Fukushima Dai-ichi site in June 2015

  →Expansion of local employment as well as consumption of agricultural products in Fukushima

Large resting facility

Meal Service Center

# 3. Improving working environment (Summary)



Improving working conditions

- Improving working conditions is essential to reduce accidents/troubles at site and to enhance work quality.
- Welfare facilities including resting area are important for team building through good communication.
- Reduced dose level will mitigate the workers' anxiety over the safety of working at Fukushima Daiichi.



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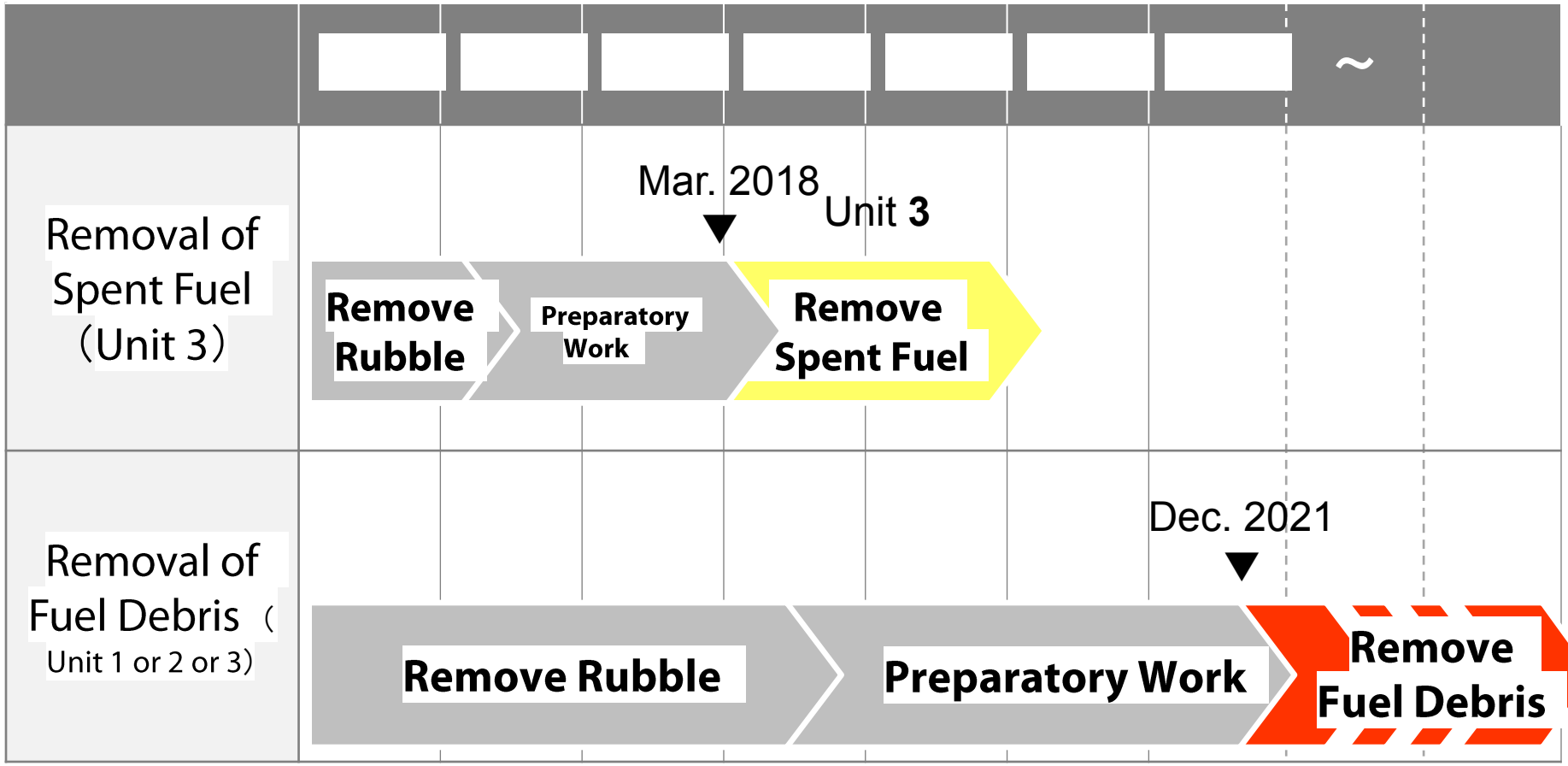
# 4.Fuel removal from the spent fuel pool (Long term schedule)



- Unit 4: Removal of spent fuel completed (Dec. 2014)
- Units 1-3: Removal of spent fuel and fuel debris in preparation



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# 4.Fuel removal from the spent fuel pool (Unit 4)

- Fuel removal from the spent fuel pool started on November 18, 2013
- Removal of 1535 fuel bundles completed on December 22, 2014 as scheduled
- No risks from fuel remains at unit 4. This gives confidence to proceed to fuel removal at units 1, 2 and 3

**September 22, 2011**

**July 5, 2012**

**November 12, 2013: Completion of building steel framework (The volume of steel used is *equivalent* to those of Tokyo Tower.)**


**Process of removing fuel rods at SFP Unit 4**



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# 4.Fuel removal from the spent fuel pool (Status of Unit 3)

- Almost all of large rubbles have been removed on the refueling floor and from the SFP.
- Installing shield on the floor in progress

**Before removing large rubble**

Photo taken in March 2011

**Current status (decontamination work in progress)**

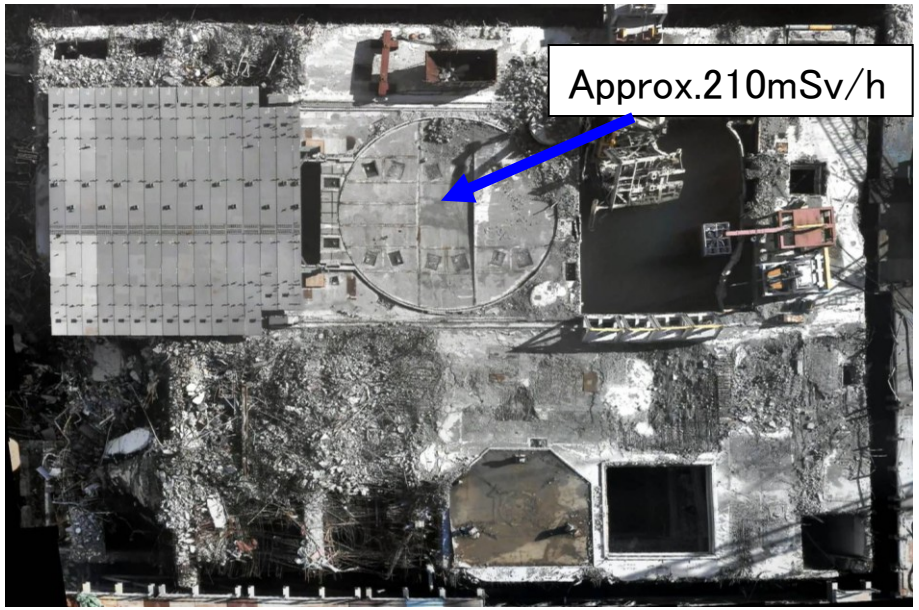


Photo taken in December 2014



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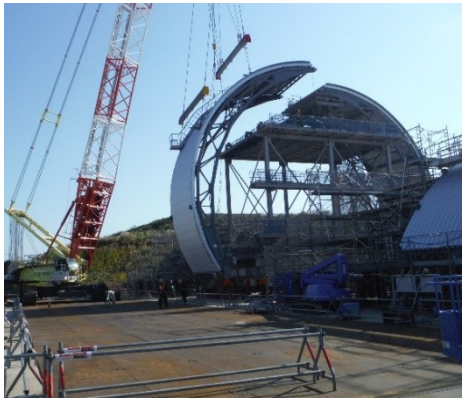
# 4.Fuel removal from the spent fuel pool (Preparation status of Unit 3)

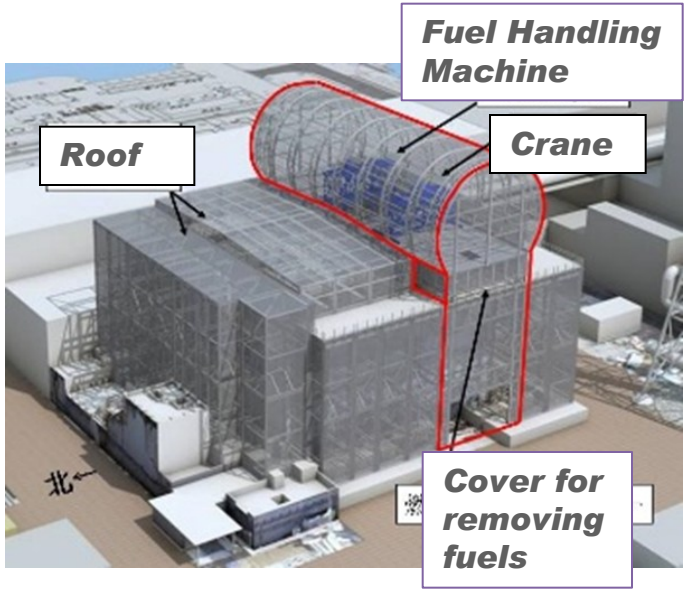


- Preparation of fuel removal cover:
- ✓ Most of the cover components including steel frame and girder were transported to the Onahama Port, more than 50 km away from Fukushima Daiichi.
- ✓ The cover components were once assembled there in order to confirm work procedure
- ✓ Partially assembled modules are kept there to reduce work hours and occupational dose at the site

**Removal of Fuel Handling Machine from SFP (Aug. 2015)**



**Assembling roof parts at Onahama Port (October 2014)**




**Fuel removing cover (Image)**



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# 4. Fuel removal from the spent fuel pool (Unit 1 refueling floor)



- Many rubbles were scattering on the refueling floor untouched inside the reactor building cover which was installed soon after the accident in 2011
- Current and future work: with measures against dust dispersion
  - ✓ Building cover removal in progress
  - ✓ Removal of rubble
  - ✓ Decontamination and shielding work for dose reduction
  - ✓ Installation of deck and fuel handling equipment for fuel removal

Overview of refueling level
Photo taken in June 2012

Overview of refueling level


Conditions of the top of operating

Reactor building cover

# 4.Fuel removal from the spent fuel pool (Summary)



**Removing spent fuels from SFP**

- **Successful removal of spent fuels at unit 4 becomes the bench mark for decommissioning work and gives confidence for removing fuels at other units.**
- **Due to high dose level, additional measures including usage of remote control machinery, decontamination and shielding must be considered to reduce radiation exposure at units 1 to 3.**



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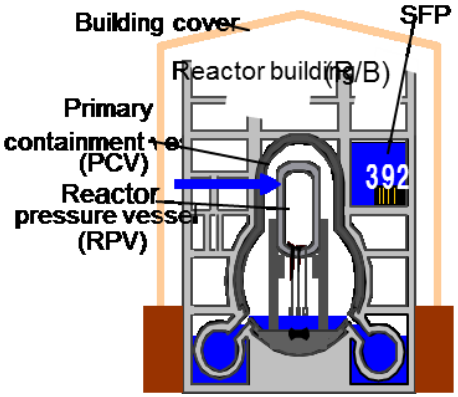
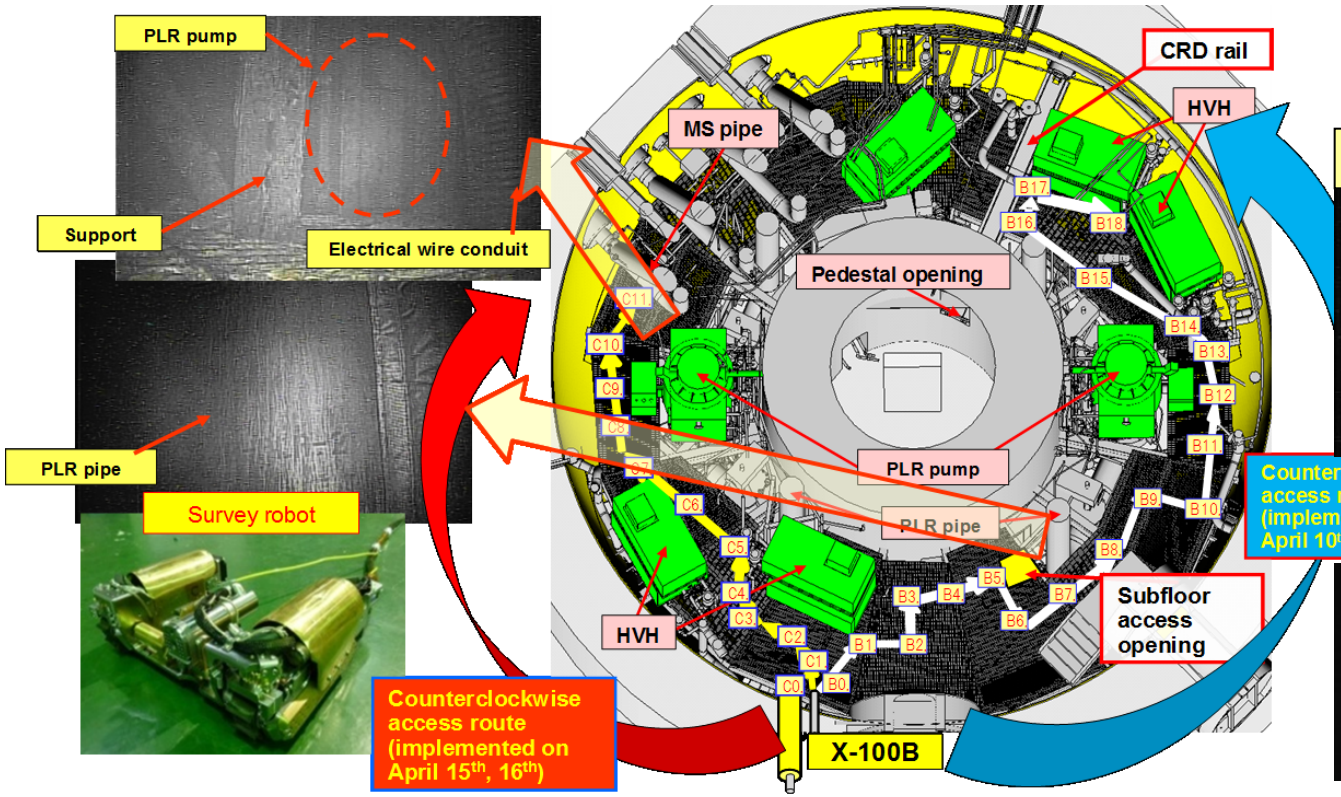
# 5. Toward fuel debris removal (Survey robots deployed at Unit 1)

- Survey robots were deployed through penetration (X-100B) in order to obtain information inside PCV (1st floor grating) in April 2015
- A lot of video footage was taken along with dose and temperature data



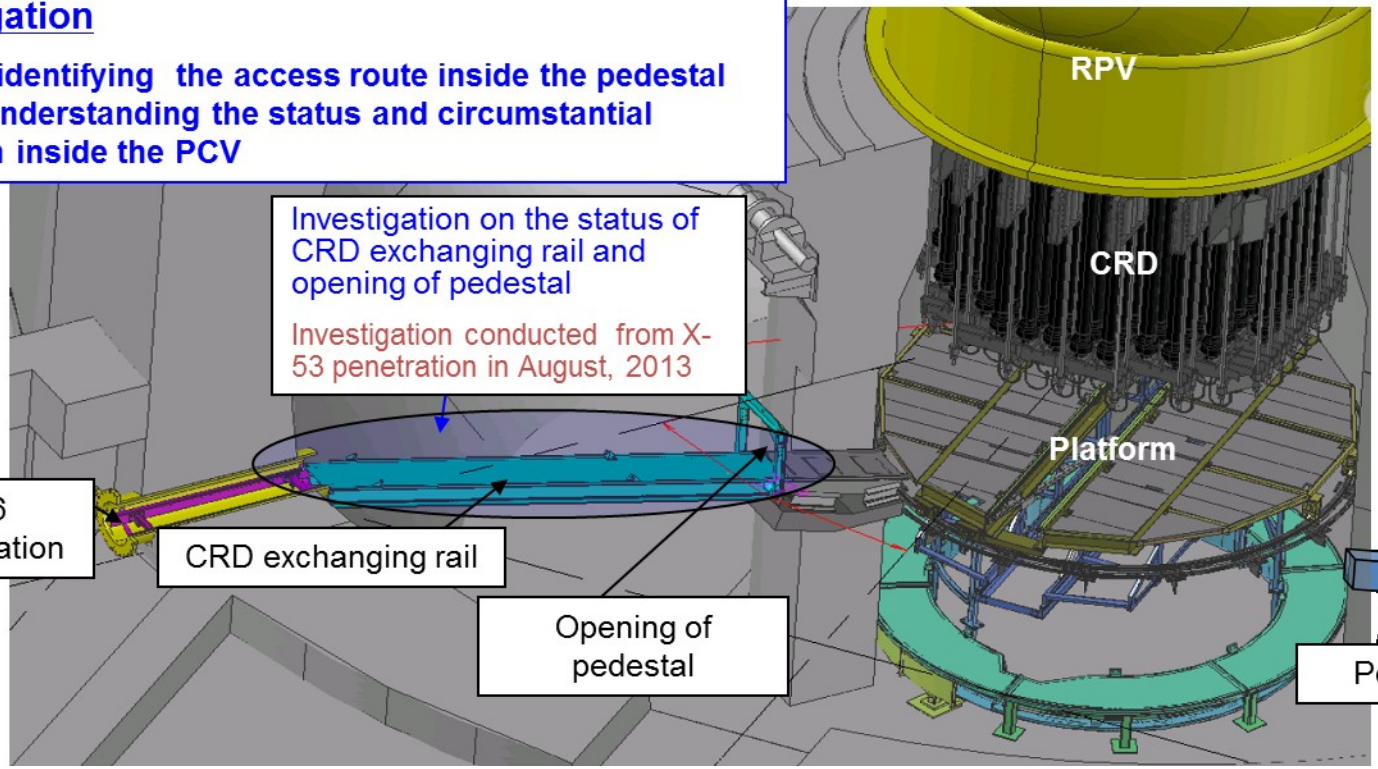
# 5. Toward fuel debris removal (Preparation plan for fuel debris removal at Unit 2)



- RPV pedestal investigation in PCV is planned
- Putting a remote device into pedestal via X-6 penetration, CRD exchanging rail and opening of pedestal so that distribution of fuel debris under RPV could be identified

**Investigation**

**Both for identifying the access route inside the pedestal and for understanding the status and circumstantial condition inside the PCV**



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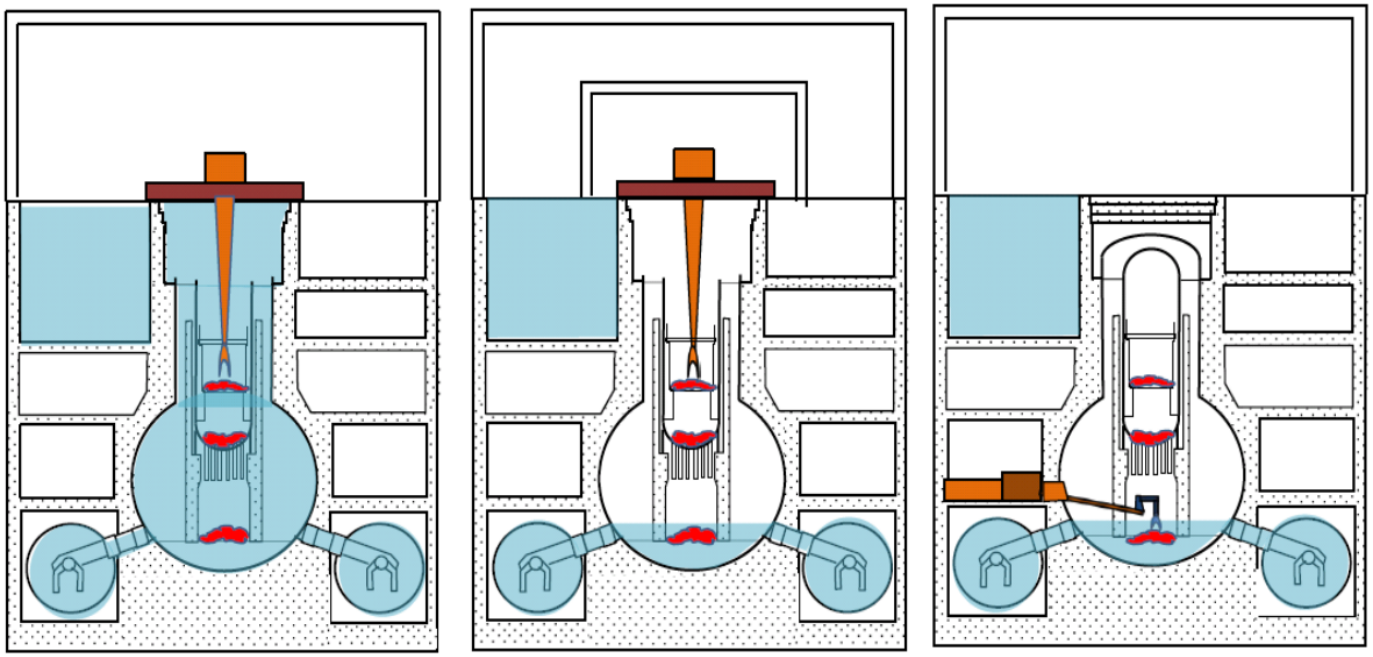
# 5. Toward fuel debris removal (Concept of fuel debris retrieval methods)



- Examination of fuel debris retrieval methods in consideration of water submersion cases



| Ful Debris | Submersion | Partial submersion | Partial submersion |
|---|---|---|---|
| Access | Top | Top | Side |
| Challenge | Water tightness, Seismic integrity | Radioactive dust dispersion, Radiation shielding | |



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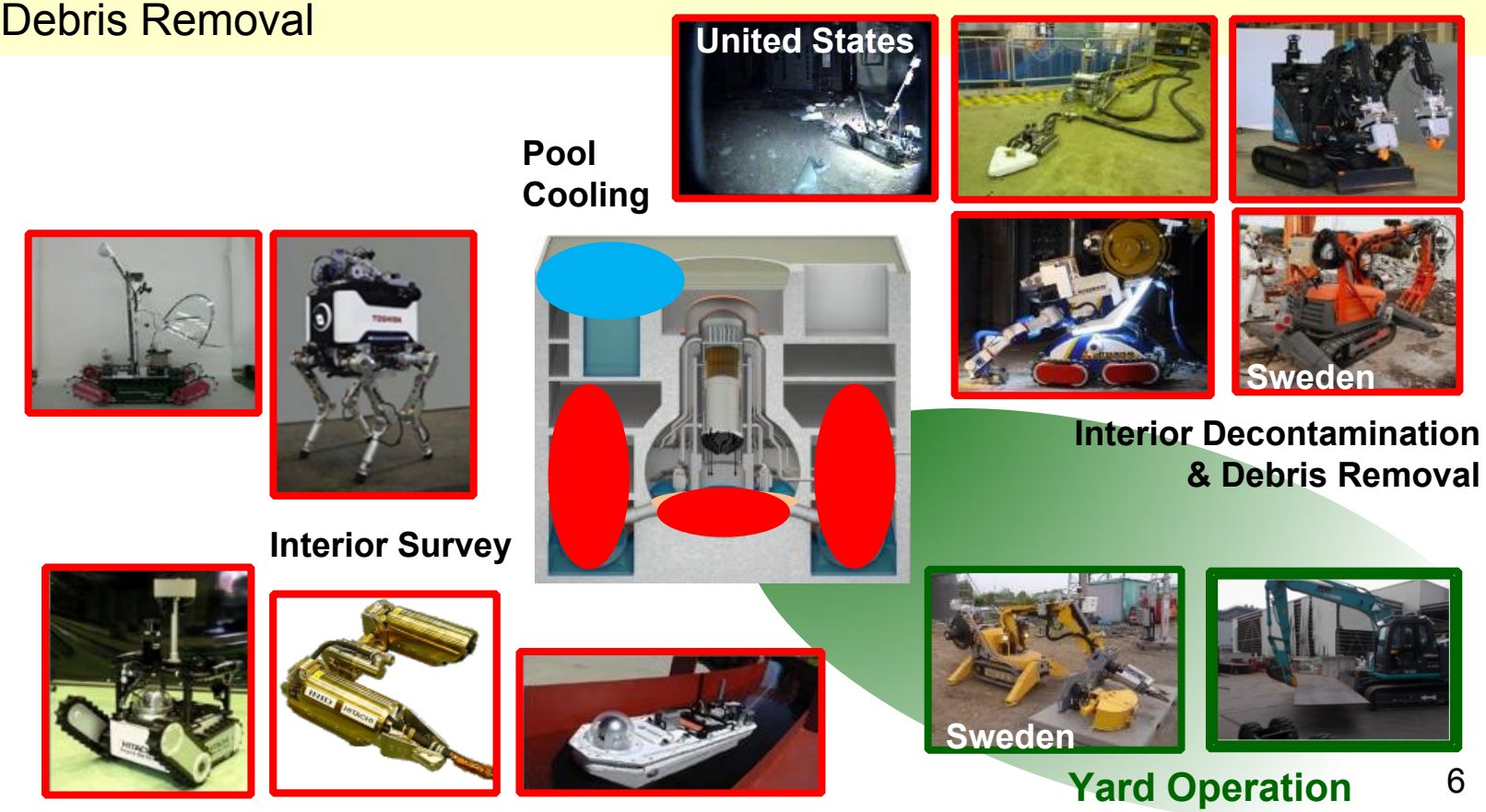
# 5. Toward fuel debris removal (Robotics developed at Fukushima Daiichi)



- State-of-the-art robotics technologies applied for:
  - ✓ Survey (interior, radiation dose, temperature, water leakage, etc.)
  - ✓ Decontamination
  - ✓ Debris Removal



# 5. Toward fuel debris removal (Summary)

## Debris fuel retrieval

- In order to consider the methodology of removing the fuel debris, various robots were deployed to identify the conditions inside of reactor buildings and locations of the debris.
- As no one ever has similar experiences, the debris removal at Fukushima Daiichi is so challenging and we send out as much information as possible to collect useful technologies/ideas from all over the world.
- In considering further steps, we must take into account the balance of the dose exposure of workers and the risk reduction of the public.



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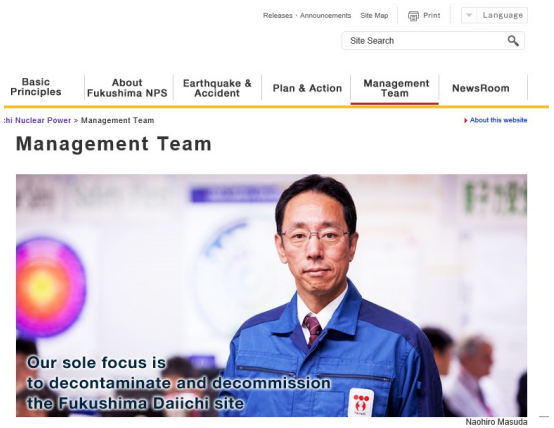
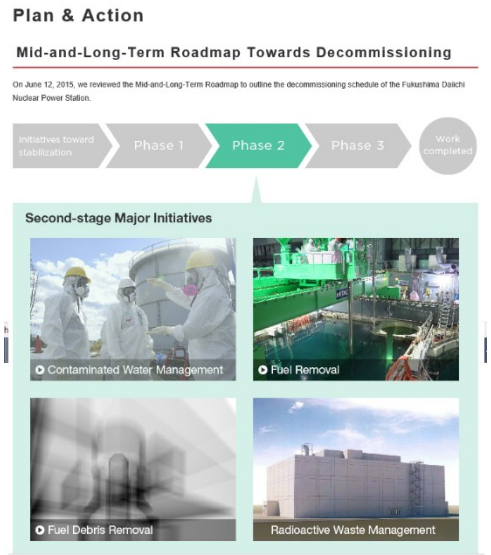
# 6. Information sharing and communication

- In accordance with agreements, TEPCO reports to local governments about the progress of decommission tasks.  TEPCO also informs them of any accidents and troubles at Fukushima site.
- TEPCO reviewed how to report the results of data analysis so that the latest data of radioactive dose can be easily accessible.
- More visualized information and video footage is available to enhance the understanding of decommission work.
- The layout of website （ http://www.tepco.co.jp/nu/fukushima-np/index-j.html ） is reviewed to make search of specific topics easily.


＜Results for radiation dose ＞




＜Example of website＞


# Thank you for your attention



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