Current Status and the Future of Fukushima Daiichi Nuclear Power Station

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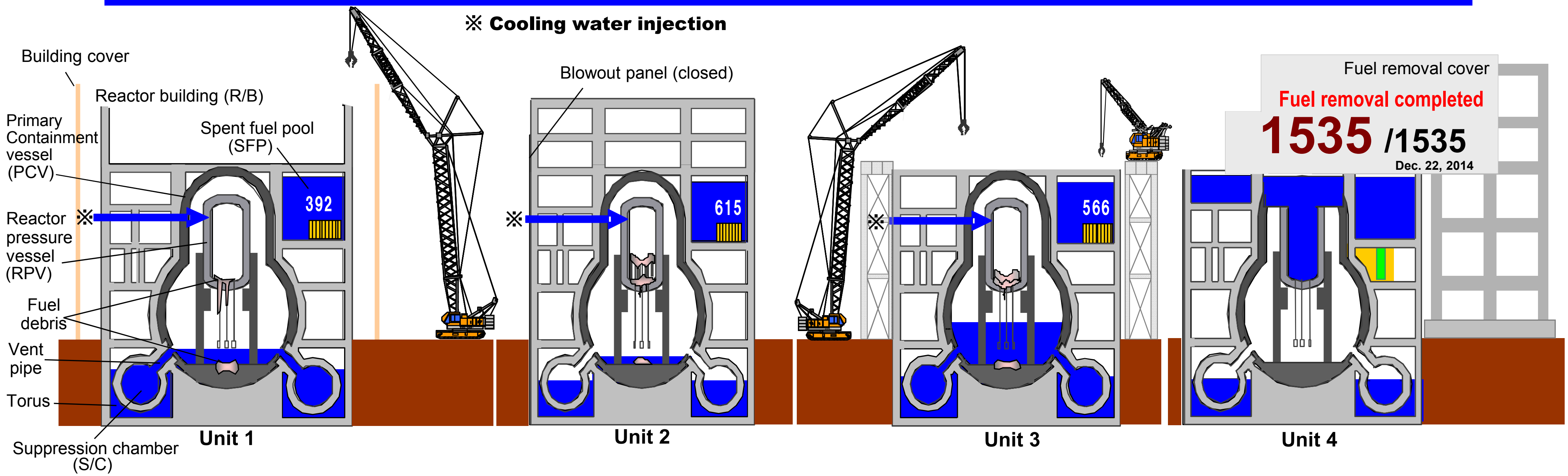
Present State & Future Response to TEPCO's Fukushima Daiichi Nuclear Power Station

(1) State of Units 1~4

All Units continue to be in cold shutdown



Values as of 5:00 on 1st March 2016

	RPV bottom temp.	PCV internal temp.	Fuel pool temp.	Water injection to the reactor
Unit 1	~15℃	~15℃	~14℃	4.5㎥ / h
Unit 2	~20℃	~21℃	~24℃	4.4㎥ / h
Unit 3	~18℃	~17℃	~21℃	4.7㎥ / h
Unit 4	No fuel, so monitoring not required	No fuel, so monitoring not required	~10℃	–

Plant parameters, including RPV and PCV temperatures, are monitored continuously 24 hours a day.

Normal cooling systems

Reactor coolant pump
Condensate storage tank
2 per unit

Cooling water injected into reactors

＜Cooling multiplexed＞

Various auxiliary means have been readied to inject cooling water into the core to maintain Units 1~3 in cold shutdown

Even if power sources fail, cooling water injection can be restarted using fire engines within three hours.

Also, multiplexing is achieved with multiple tanks ready to serve as sources for cooling water injection pumps.

(2) Current status and tasks of Units 1 – 4

■ Common task among all the units; Selecting the fuel / fuel debris removal plan from the perspective of seismic safety and workability

Unit 1

Current status

Building cover installed (October 2011)

Removal of the building cover toward removal 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

Immediately after the earthquake

Now

Unit 2

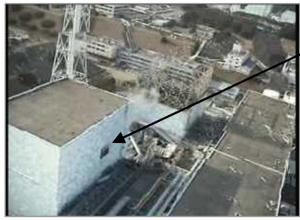
Current status

Closed the blowout panel

Very high radiation level in the building

Tasks

Radiation dose reduction measures



Blowout panel

Unit 3

Current status

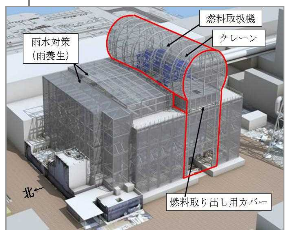
Debris removal from the top of the reactor building completed (October 2013)

Installation of fuel removal cover and fuel handling facility planned

Tasks

Radiation dose reduction measures with remote-controlled heavy machinery

Cover and fuel handling facility for Unit3 pool



Image

Assembling roof parts (Undergoing training at Onahama Port)

Unit 4

Current status

Fuel removal from SFP completed

(commenced on November 18, 2013, completed on December 22, 2014)

Cantilever structure installed

Removal of SF assemblies

Roadmap Targets (formulated Dec. 2011, revised Jun. 2013 and Jun. 2015)

Stabilization efforts	Phase 1 (from Dec. 2011)	Phase 2 (from Dec. 2013)	Phase 3 (30~40 years later)
<Cold shutdown achieved> ・Cold shutdown ・Significantly reduce radiation releaseas	Period up to the commencement of the removal of the fuel from the spent fuel pool (within 2 years)	Period up to the commencement of the removal of the fuel debris (within 10 years)	Period up to the completion of decommissioning measures (30 to 40 years in the future)

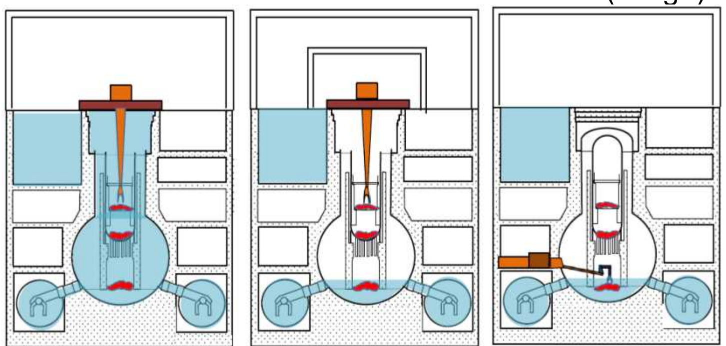
Started at #4 unit on Nov18.2013.

※Fuel debris
(Fuel, cladding and other material that melted and hardened again)

Fuel debris removal (Unit 1, 2 and 3)

In terms of reducing radiation exposure during work process, the most reliable method of fuel debris removal is to remove the fuel debris while submerged. But depending on the results of future investigations, we may adopt a substitute method of such as taking fuel debris without filling the primary containment vessel with water.

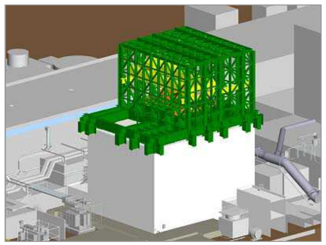
Construction method for fuel debris removal (image)



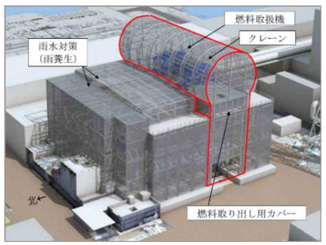
Fuel Debris	In the water	In the air	
Removal Channel	Upside		Side
Challenge	Water proof and Earthquake proof	Shielding radiation and radioactive dust	

Spent fuel removal plan (Unit 1, 2 and 3)

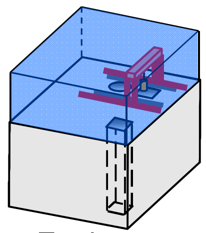
FY	2015	2016	2017	2018	2019	2020	2021	2022
Unit 1	Demolition building covers		Removal rubbles		Installation covers		Spent fuels removal	
Unit 2	Preparation / Removal rubbles	Demolition upper buildings		Plan① Installation containers / Plan② Installation covers			Spent fuels removal	
Unit 3		Installation building covers	Spent fuels removal					



Frame for Unit 1 pool



Cover for Unit 3 pool

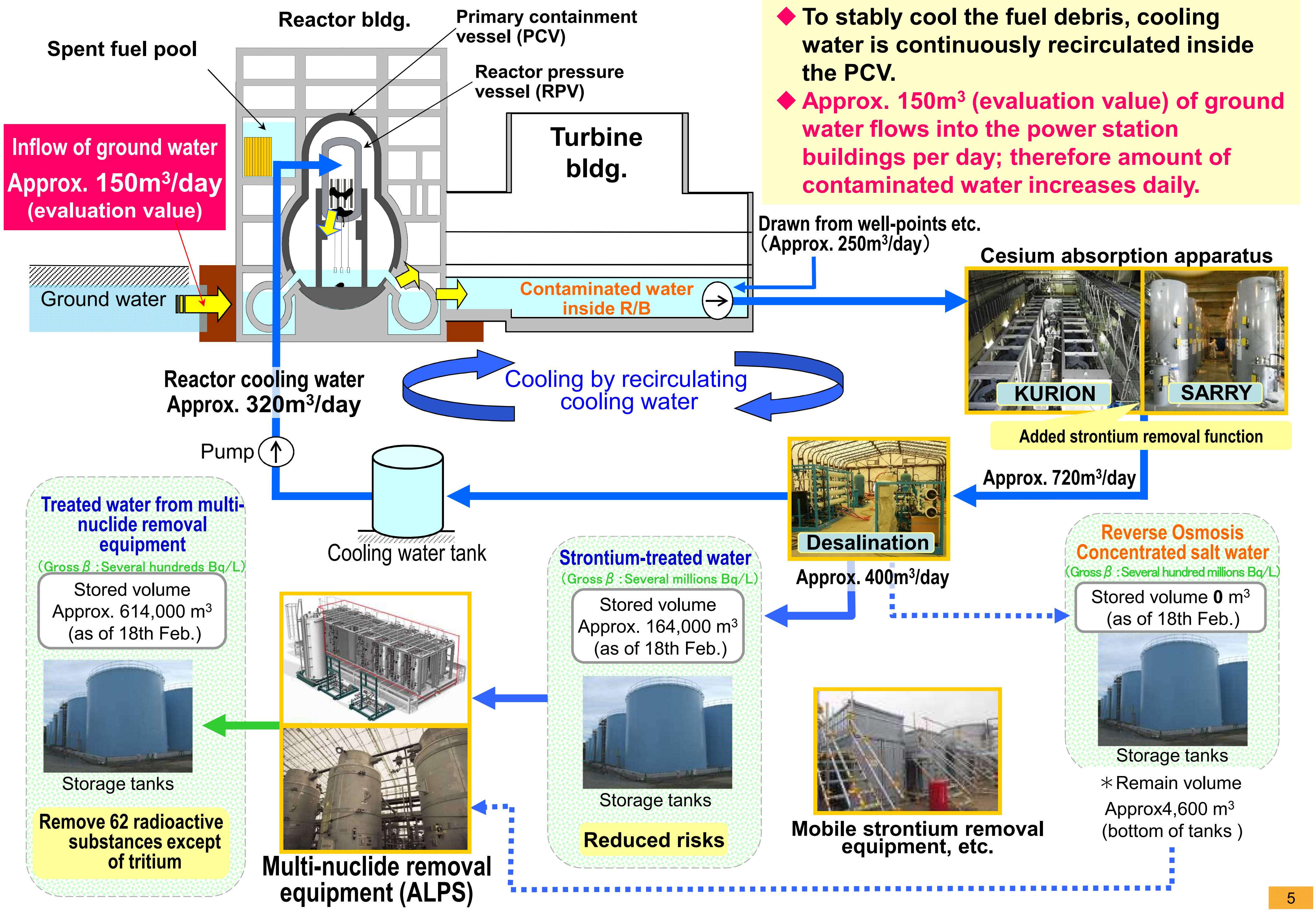


Equipment for Unit 2

To facilitate the removal of fuel assemblies and debris in the Unit 2 spent fuel pool, we decided to dismantle the whole rooftop above the highest floor of the Reactor Building.

(4) Conceptual Diagram of Reactor Circulation Cooling and Continuously Increasing Contaminated Water

- ◆ To stably cool the fuel debris, cooling water is continuously recirculated inside the PCV.
- ◆ Approx. 150m³ (evaluation value) of ground water flows into the power station buildings per day; therefore amount of contaminated water increases daily.



(5) Three Policies for Measures to Counter Contaminated Water

■ 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)

⇒ ① Treatment of highly contaminated water in the storage was completed in May 2015 (except residual water in the bottom)
② Completed in July 2015

2. Isolating groundwater from contamination sources

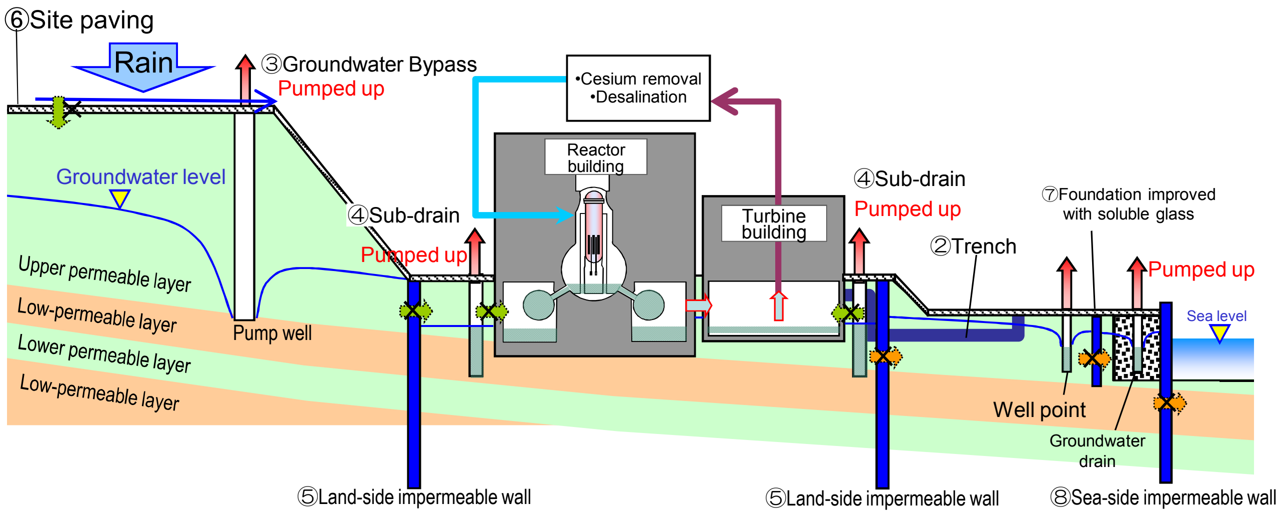
③ Pumping up groundwater through bypasses
④ Pumping up groundwater through wells near buildings
⑤ Installation of frozen-soil impermeable wall on the land side
⑥ Paving of site to curb permeation of rainwater into soil

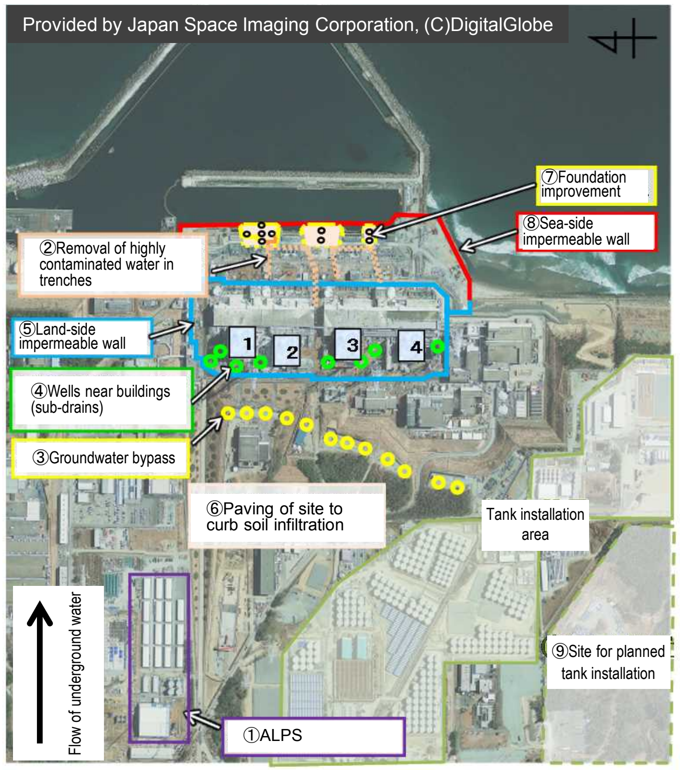
⇒ ③ Ongoing（about 100 times, total 170,000t drained so far）
④ Ongoing（about 90 times, total 70,000t drained so far）
⑤ Construction completed in February 2016
⑥ Scheduled to be mostly finished until March 2016

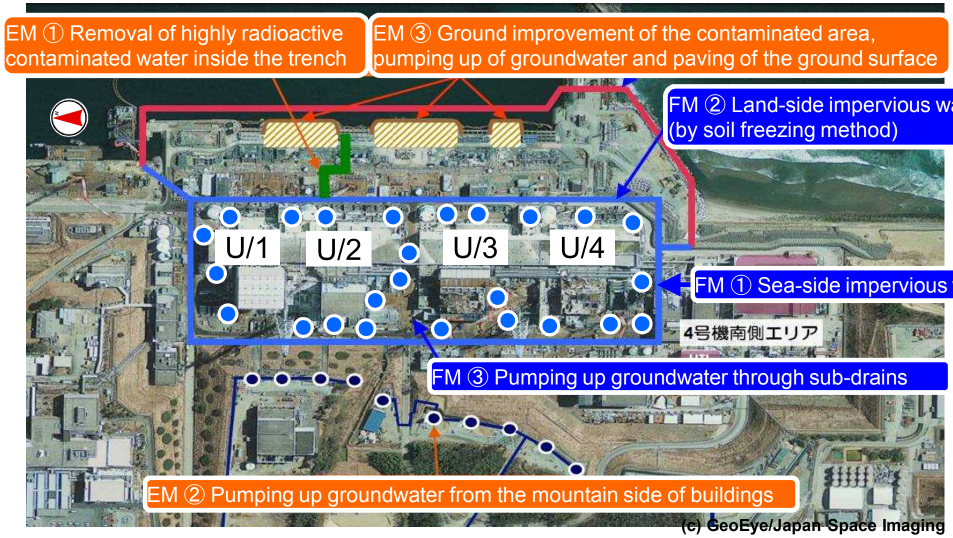
3. Preventing leakage of contaminated water

⑦ Ground improvement with water glass
⑧ Installation of impermeable walls on the sea side
⑨ Augmentation of tanks (replacement with welded tanks, etc.)

⇒ ⑦ Completed in March 2014
⑧ Construction completed in October 2015
⑨ Implementing replacement of flanged tanks with more reliable welded tanks and additional construction of welded tanks due to groundwater flowing into nuclear reactor buildings

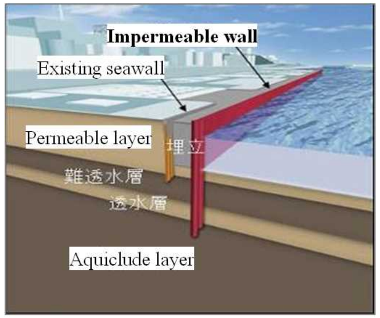


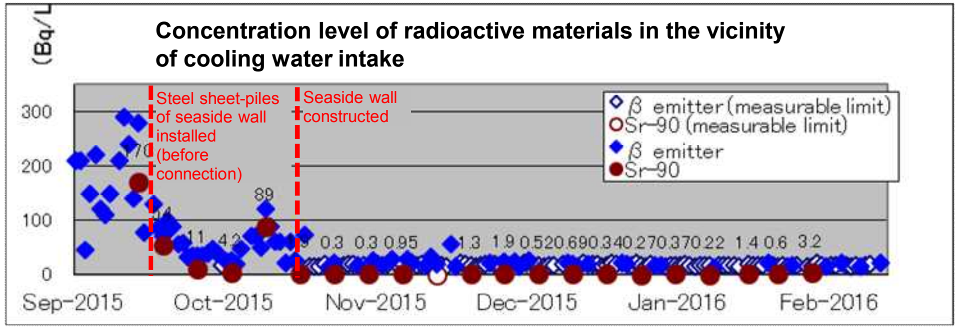




Fundamental Measure ①
Construct sea-side impermeable wall

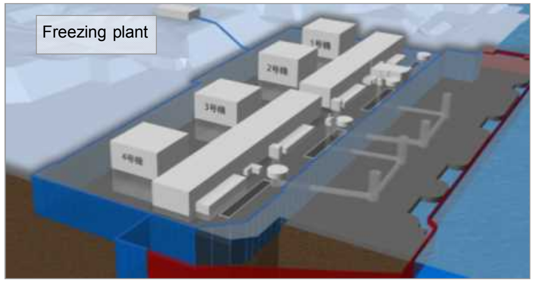
To prevent flow out into sea



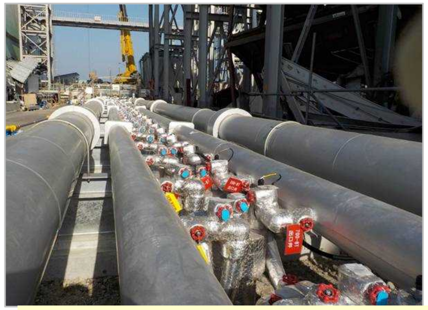


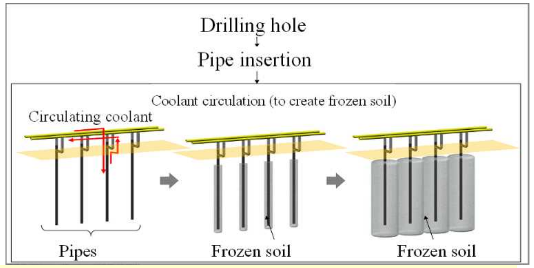
■ Construction of steel sheet-piles comprising impermeable wall was completed in October 2015. The radioactive material concentration inside the harbor has become lower

Fundamental Measure②
Install land-side (frozen soil) impermeable wall



To mitigate the increase in contaminated water and to prevent its flow into port

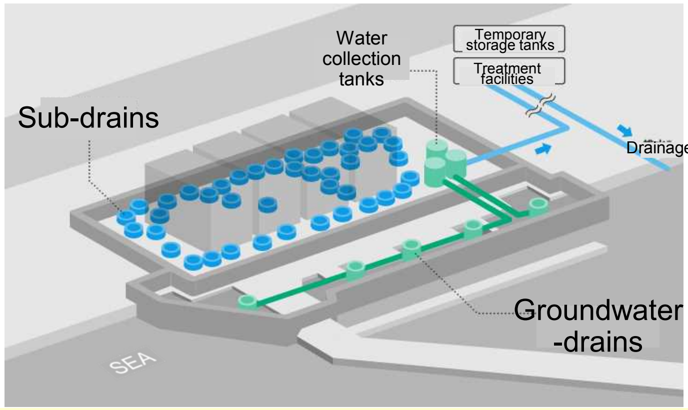




- ■ Buildings will be enclosed by ice wall to curb inflow of groundwater into buildings
- ■ Full-scale construction began in June 2014
- ■ Construction of the mountain side was completed in September, 2015. As for the sea side, setting of freezing pipes was completed in February, 2016

Fundamental Measure ③
To pump up groundwater from sub-drains

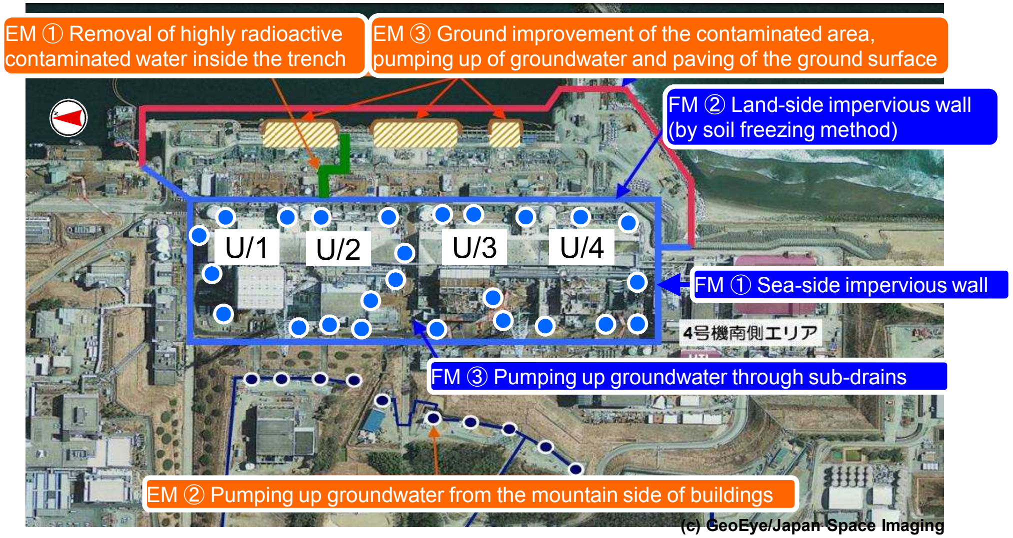
Curb inflow of groundwater into R/B, etc.



New sub-drain pit

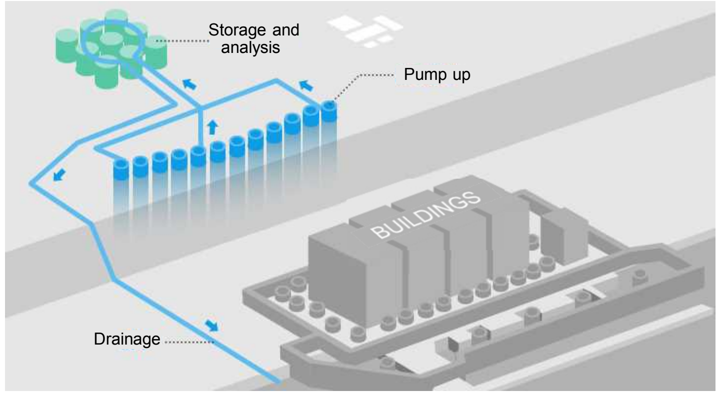
- ■ Wells (sub-drains) installed near buildings were rehabilitated and groundwater around buildings is being pumped up to control inflow into the buildings
- ■ Pumping up groundwater and draining cleanup water were initiated from September 2015 （About 90 times, total 70,000t drained so far）

(7) Contaminated Water Countermeasures: Emergency Measures



Emergency Measure② To pump up groundwater on mountain side of buildings (groundwater bypass)

To control increase in contaminated water



Temporary storage tank analysis results (collected on Feb. 10)

	Cesium 134	Cesium 137	Total Beta radiation	Tritium
TEPCO	ND (0.65)	ND (0.58)	ND (0.70)	180
Third-party agency	ND (0.71)	ND (0.64)	ND (0.51)	190
TEPCO's limit	1	1	5	1,500
Legally notifiable limit	60	90	-	60,000
WHO drinking water quality guideline	10	10	-	10,000

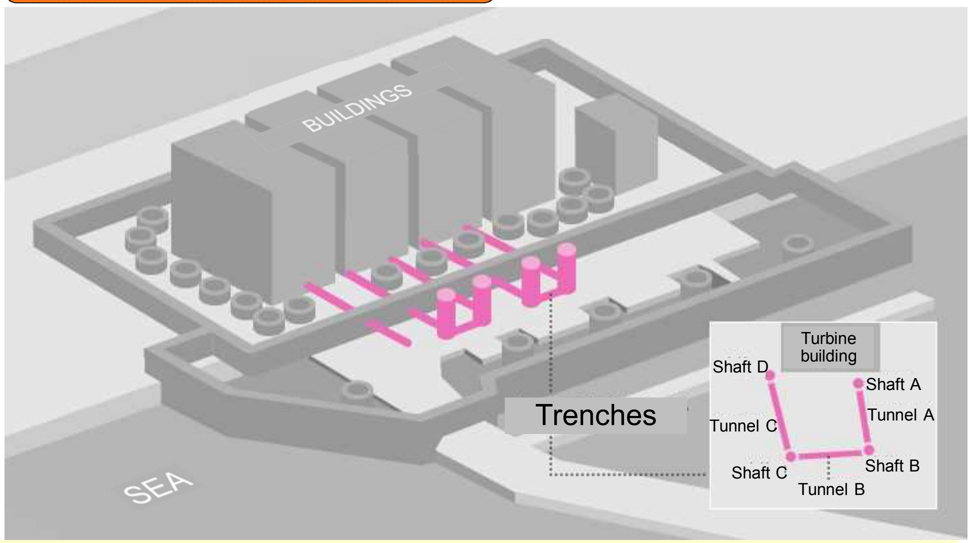
•TEPCO; Tokyo Electric Power Company

•ND indicates "not detectable" (below the limit of detection, which is stated in parentheses)

- Groundwater inflow into the buildings is reduced by pumping up and bypassing groundwater, flowing from the hill side, on the upstream side of the buildings
- Start of water drainage on May 2014（About 100 times, total 170,000t drained so far）

Emergency Measure ① To remove highly contaminated water in trenches

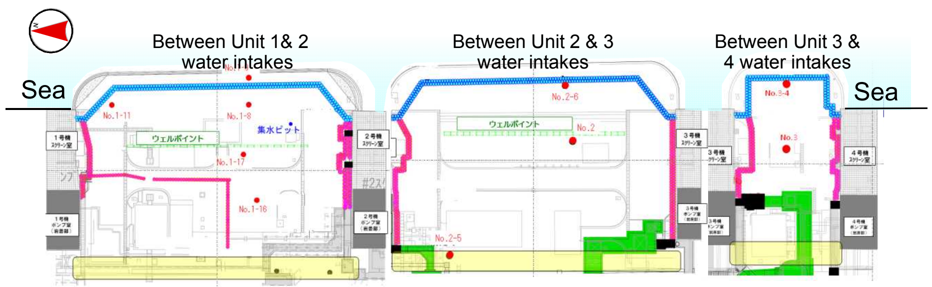
To remove contamination source



- Highly contaminated water remained in underground tunnels (trenches) on sea side of buildings
- Highly contaminated water, which poses a risk of infiltrating or spreading into surrounding area, was removed (Finished removing the water - Unit 2; June 2015, Unit 3; July 2015, Unit 4; December 2015)

Emergency Measure ③ To improve foundation of contamination area, pump up groundwater, pave surface

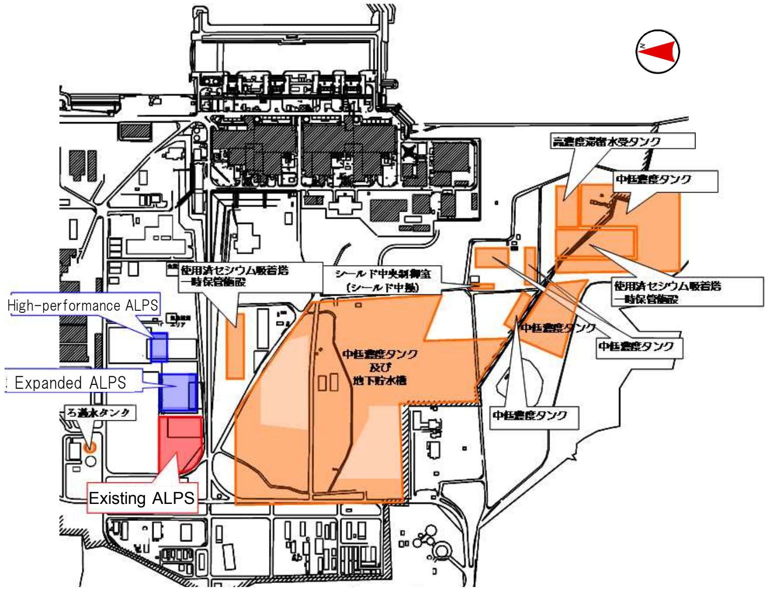
To prevent outflow into port



- Chemical grouting was used to improve the foundation and control outflow of contaminated groundwater
- To inhibit infiltration of rainwater, the surface of the ground was paved with asphalt or other material

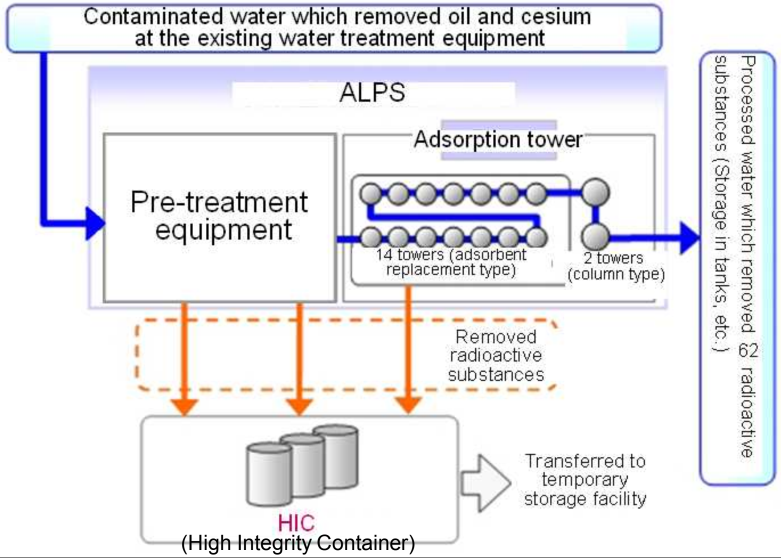
(8) The Status of the Advanced Liquid Processing System (ALPS)（Existing／Expanded／High-performance ）

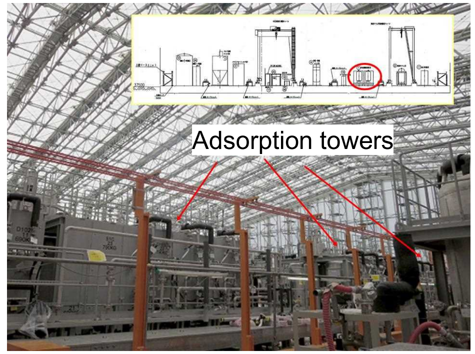
Installation Positions for the Expanded ALPS and High-performance ALPS



Summary of the Existing ALPS Facilities

- Introduce ALPS to enhance the processing of contaminated water
- ALPS is able to remove 62 radioactive substances (with the exception of tritium), in addition to Cesium
- The system is now being operational to clean up the contaminated water.





Adsorption tower

Installation of Expanded ALPS and High-performance ALPS

- In addition to Existing ALPS facilities, the following two facilities were introduced for early treatment of RO-concentrated saltwater*1 stored at Fukushima Daiichi NPS
  - Expanded radionuclide removal systems, improved on the basis of operating experience from the current ALPS (changed adsorbent, extra adsorption towers) to reduce the radioactive concentration
  - High-performance ALPS (project subsidized by the Ministry of Economy, Trade and Industry)
- These are running now

Basic specifications comparison

Item	Existing ALPS	**Expanded ALPS**	**High-performance ALPS**
Treatment volume	250m3/day/system	At least 250m3/day/system	At least 500m3/day/system
Number of systems	3 systems	3 systems	1 system
Pre-treatment method	Coagulating sedimentation method	Coagulating sedimentation method	Filter type
No. of adsorption towers	14 + 2 towers	18 towers	20 towers
Seismic resistance class	Equivalent to class B	As on left	As on left
Radionuclide purification capacity	62 radionuclides to ND level	As on left	As on left
Waste generation	–	–	Around 1/20 of current ALPS facilities

*1 RO-concentrated saltwater is a byproduct left after accumulated water containing high-concentration radioactive substances has been treated by the cesium-removal system and the desalination system.


Building for expanded ALPS


High-performance ALPS

(9) Dust dispersion suppression measures during Unit 1 building cover demolition and rubble clearance

The state of Unit 1 reactor building

- The building cover was built in October 2011 to suppress the airborne dispersion of radioactive materials
- There is still an accumulation of scattered debris on top of the refueling level within the building cover
- The collapsed roof remains dropped onto the refueling level in a nearly flat shape

Building cover

Photographed around October 2011

Removal the roof panels

Removing (photographed in Oct 2015)

After

Overview of the refueling level (northwest side)

Photographed around June 2011

Removal the obstacles

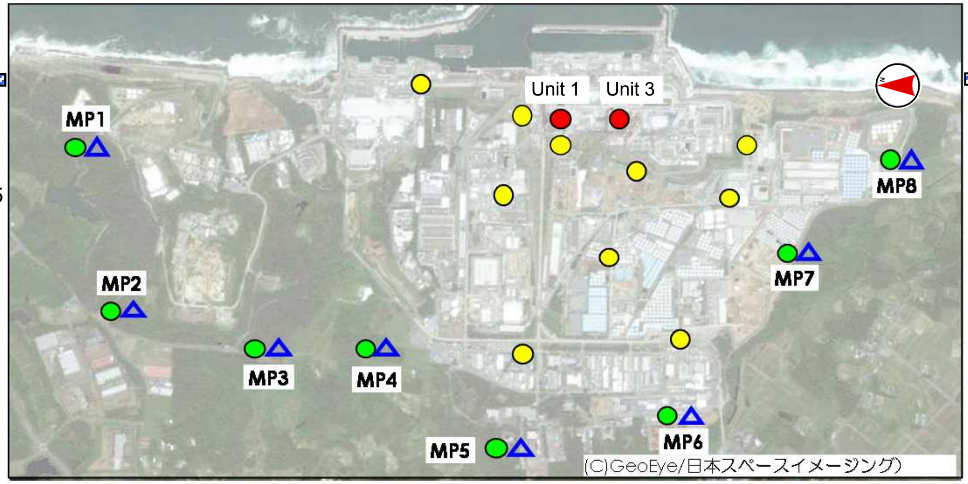
Steel frames

Training facilities

Monitoring framework for radioactive material concentrations

- Not only in work but also night and day off, the dust situation is monitored

Approx. 25km to the Minami-Soma City Hall



Approx. 20km to J Village

● Dust monitors on the operating floor	Alert level: 0.005 Bq/cm³
● Dust monitors within the site (10 locations)	Alert level: 0.0001 Bq/cm³
● Dust monitors close to site boundaries (8 locations)	Alert level: 0.00001 Bq/cm³
△ Monitoring posts (MP) close to site boundaries (8 locations)	

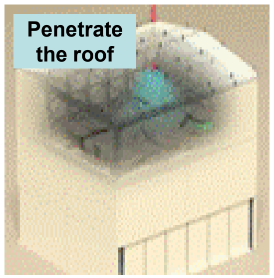
Dismantle the Unit 1 building cover

- Nov. – Dec. 2015, removed two roof panels and investigated
- From March 16, 2015, started preparing construction
- From May 15, 2015, started dismantle work
  May 15 – 20 : Sprayed anti-scattering agent
- July 28, 2015, started removal of the roof panels
- Oct. 5, 2015, finished removal of the roof panels

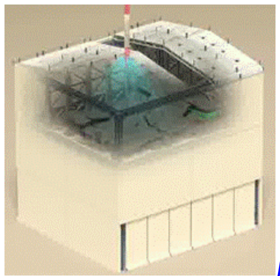
* The processes may be changed by process adjustment with other constructions, other progresses, the reinforcement of scattering restraint measures

Dust dispersion suppression measures

- Spray anti-scattering agent

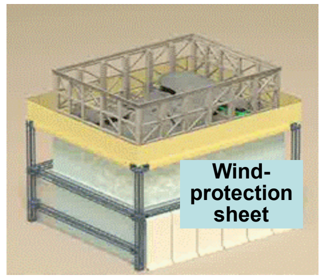


- Spray anti-scattering agent during removal



- Suction the dust and rubbles
- Set sprinkling facilities

- Set wind-protection sheets (after removal of wall panels)



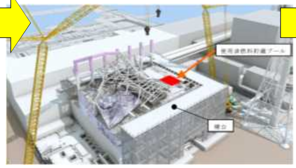
(10) Related topics

Debris removal situation on the Unit 3 operating floor

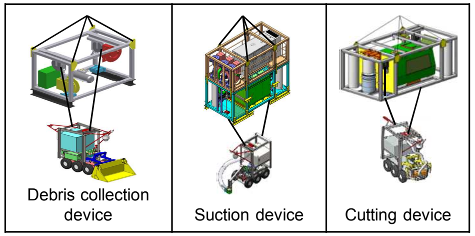
- It is necessary to complete the removal of debris from the upper part of the reactor building, decontaminate and remove debris from the spent fuel pool in order to prepare for the extraction of the Unit 3 spent fuel.
- Debris removal work shall be carried out carefully with the utmost priority placed on the safety of those engaged in the work and the public.

Situation on the refueling floor prior to debris removal (taken from directly above)

Remove debris using remote-controlled heavy equipment



Situation on the refueling floor after debris removal (taken from directly above)

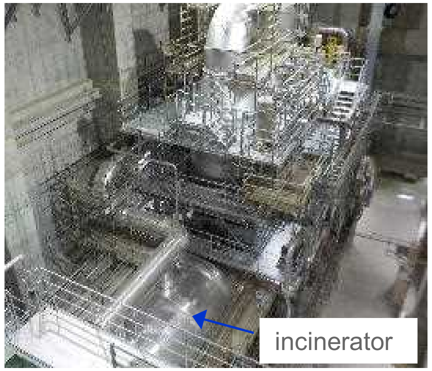


Self-propelled decontamination device

Removal a Fuel Handling Machine from the spent fuel pool (Aug, 2015)

Installation of radioactive waste incinerator

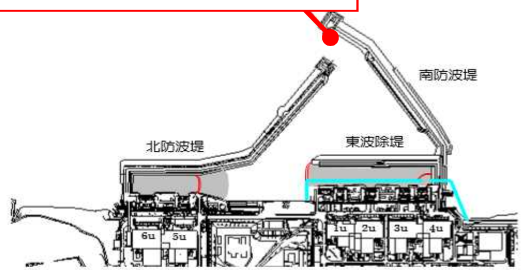
- Radioactive waste incinerator which will incinerate used protective clothing and other radioactive waste temporarily stored on site was installed.
- After conducting the hot test, operation will start within this fiscal year



Installation of a seawater radiation monitor

- A seawater radiation monitor targeting major nuclides such as Cesium-134, Cesium-137, and beta radiation nuclides was installed in front of the port entrance on April 1st, 2015.
  The purposes are understanding the impact if by any chance a new leak to the ocean from the site of Fukushima Daiichi and increasing the frequency of trend monitoring by performing ocean monitoring at all times rather than periodically.

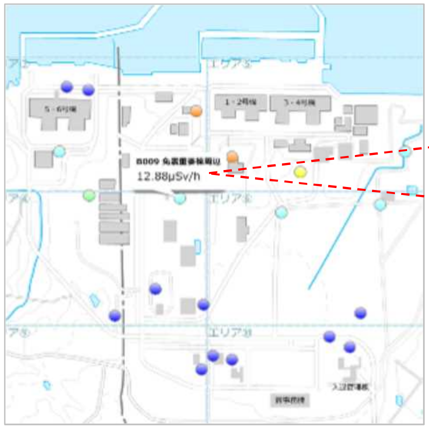
Port entrance seawater monitor

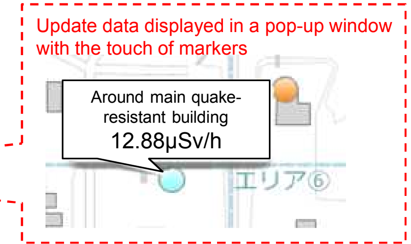


- Measurement: every hour
- Results disclosure: every day on TEPCO website

Additional installation of dose-rate monitors

- The system of visualizing the real time dose data is in place.
- 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.





- Color variation of markers by the range of measured values
- Data trends could be displayed with the touch of markers.
  （Changeable among daily/weekly/monthly/yearly）

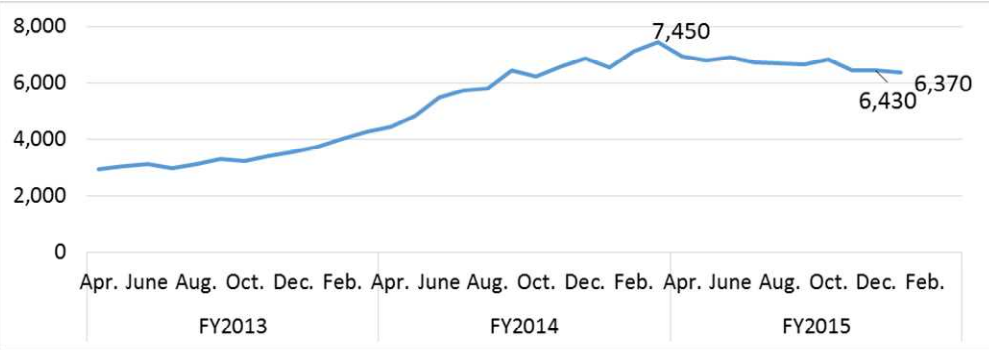
Image of dose-rate monitors

(11) Efforts for securing workers and improving work environment

- Efforts are being made to secure personnel over the long term while being sure to manage the amount of workers' radiation exposure.
- Further efforts are made for continuous improvement of the working environment while understanding the needs of the workers.

Changes in the number of workers

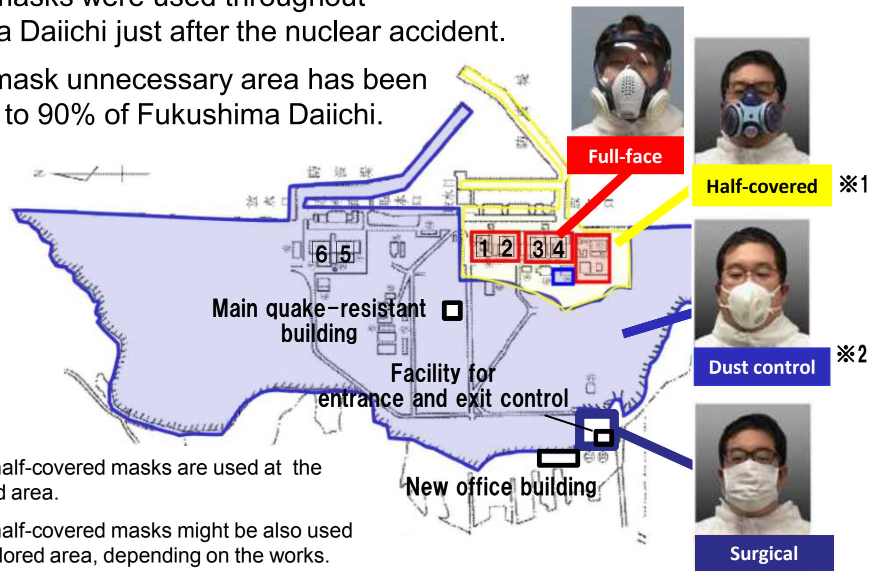
- The number of workers per weekday (employees from TEPCO and contractors) engaged in work during March is assumed to be approximately 6,670 people.
- The percentage of locally born workers is approximately 50% in Jan..



Change in the average number of workers (actual value) per weekday in the months following 2013.

Expansion of full-face mask unnecessary area

- Full-face masks were used throughout Fukushima Daiichi just after the nuclear accident.
- Full-face mask unnecessary area has been expanded to 90% of Fukushima Daiichi.



※1 Full-face or half-covered masks are used at the yellow-colored area.

※2 Full-face or half-covered masks might be also used at the blue-colored area, depending on the works.

Improving the work environment

- New buildings at Fukushima Daiichi
  - A large rest house with a capacity of approx. 1,200 workers (from May 2015)
    →A convenience store "Lawson" was opened on March 1, 2016
  - A new office building close to the field (from 2014)

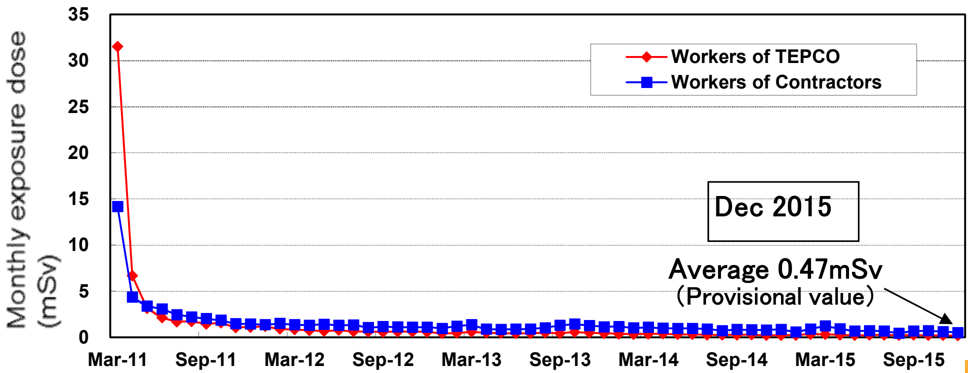
Large rest house

- Fukushima Revitalization Meal Service Center (from March 2015)
  - Providing warm meals to Fukushima Daiichi
  - Creation of employment opportunities
  - Dispelling of harmful rumors about Fukushima foods

Ensuring stable employment over the long term

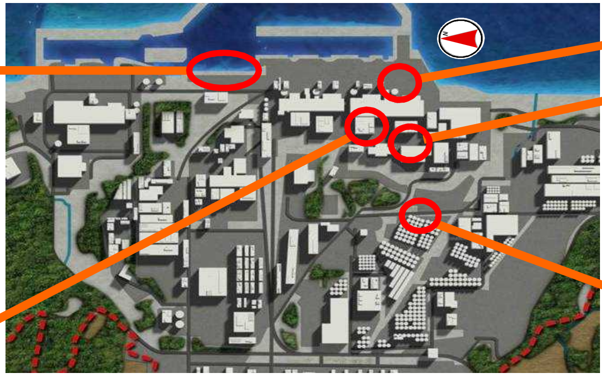
- The importance of arranging for an environment in which the people from contracting companies can work over the long term was confirmed in order to steadily move forward with decommissioning work for 40 years.
- Currently, approximately 90% of orders are fulfilled by negotiated contracts.
- By securing long term workers, more deliberate personnel assignment and human resource development is possible.

Trend of monthly exposure dose rate



(11) Efforts for securing workers and improving work environment

Restoration of revetment at shallow draft quay



Removal of tsunami debris

In front of turbine building of Unit 4

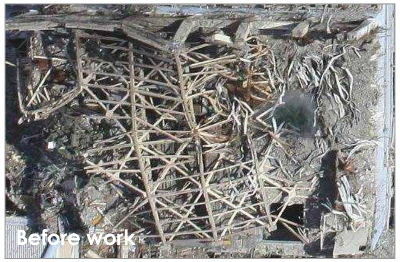
Installation of land-side (frozen soil) impermeable wall

Mountain side of Unit 4

Underdraining the ditches to preventing from rainwater inflow

Drainage ditch In front of H4 tank area

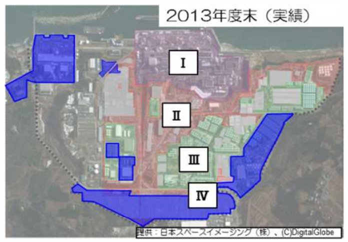
Removal of scattered debris on top of Unit 3

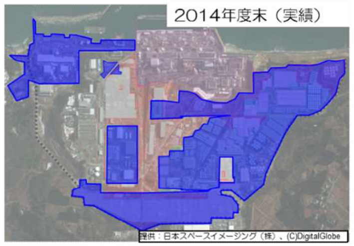


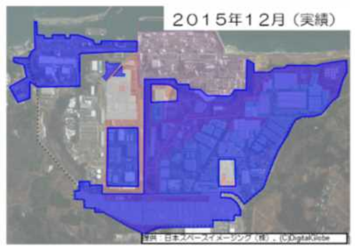
Decreasing radiation dose at Fukushima Daiichi

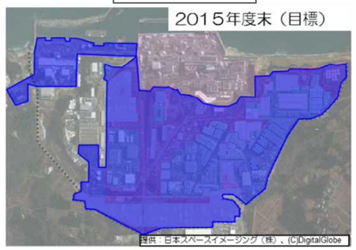
Performance
(Area comparison with FY2015 target)

	FY2013	FY2014	Now	FY2015 target
Performance (Area comparison with FY2015 target)	40 %	77 %	89 %	100 %





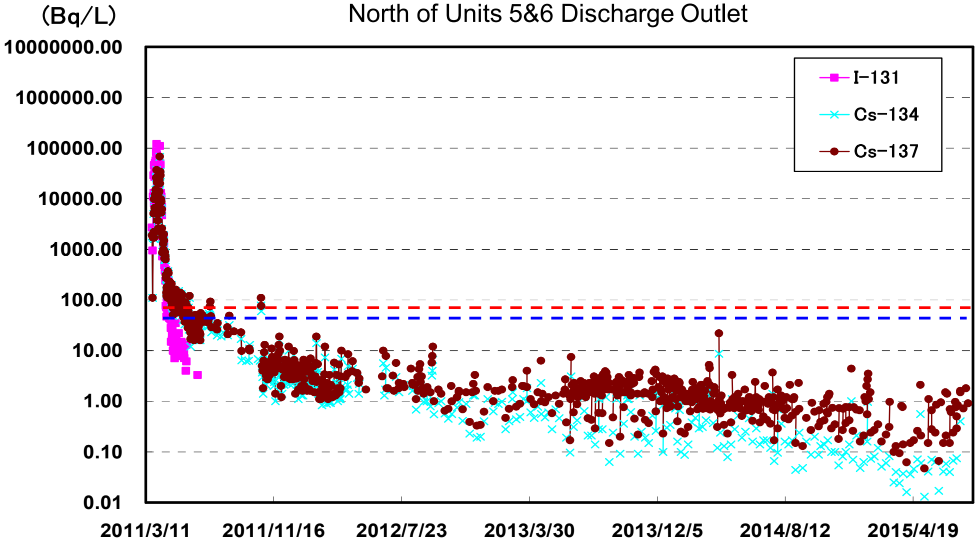


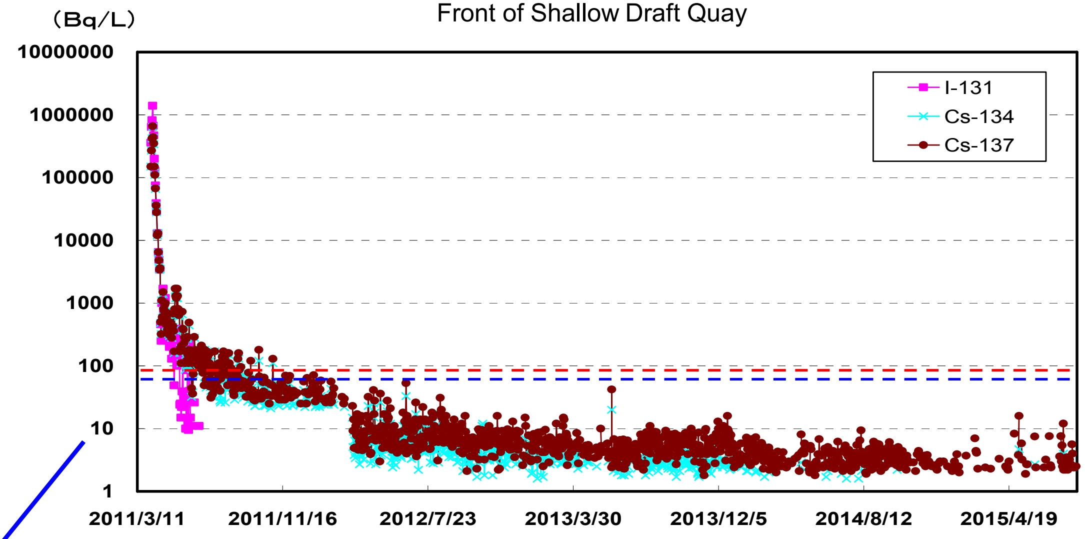


: Area confirmed below targeted radiation dose（5μSv/h）
（confirmed at breast or on the surface of the ground）

(12) Sea Area Monitoring Status

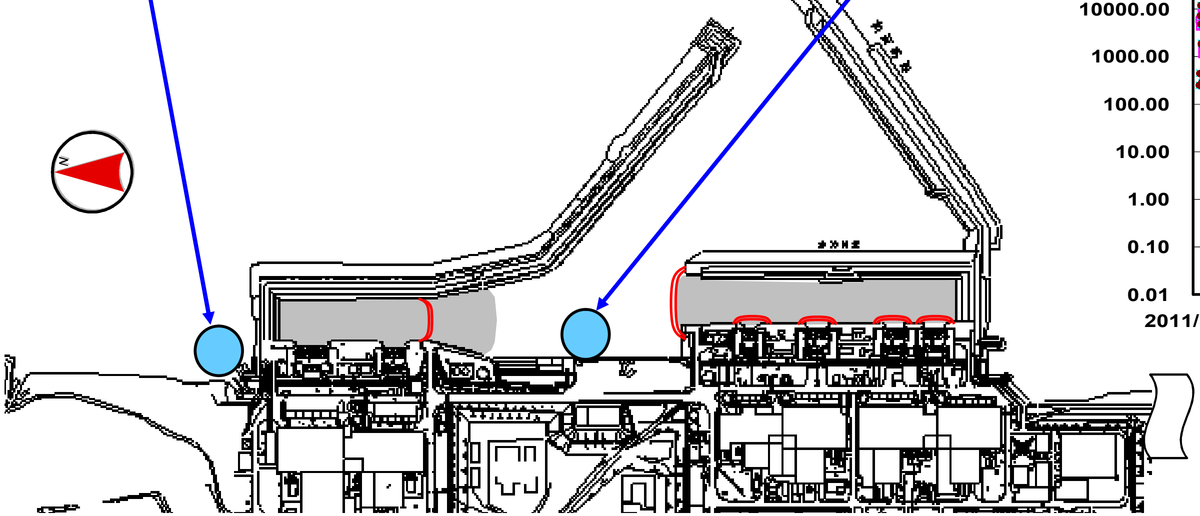
- The radioactive material concentration in the sea area decreased by one- 100,000th ~ 1,000,000th after the accident

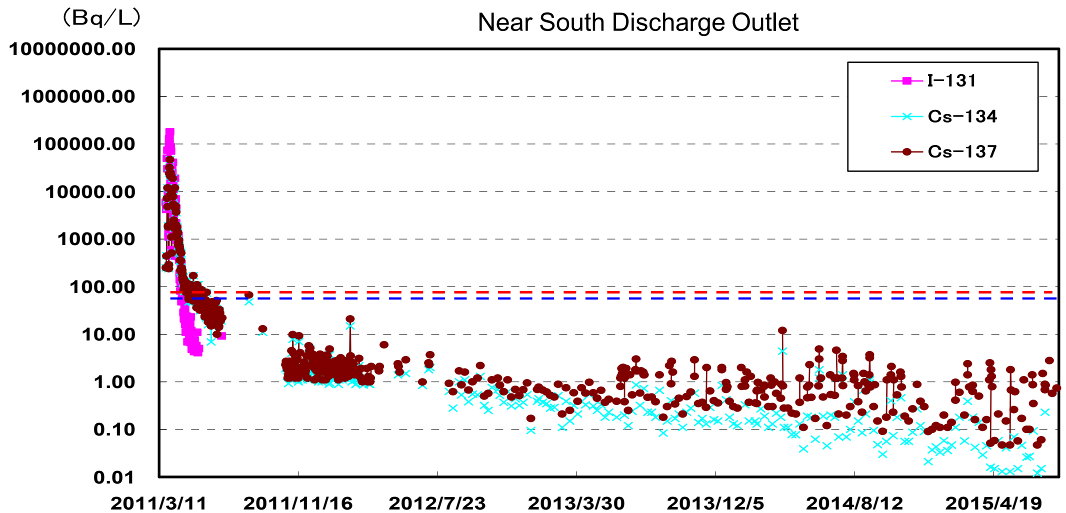




Concentration Limit Specified by the Rule

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





Fukushima Daiichi NPS Map

提供：日本スペースイメージング㈱, (C)DigitalGlobe