

Current State of decommissioning and contaminated water measures at Fukushima Daiichi Nuclear Power Station

August 24, 2015

Fukushima Daiichi Decontamination & Decommissioning Engineering Company (FDEC)



東京電力

1. Measures for Contaminated Water

~ Response based on three basic policies ~

■ The water used for cooling the fuel that melted during the accident and the groundwater is mixed up, and about 300 tons^{#1} of contaminated water is generated per day. Measures are being taken based on the following three basic policies:
 #1: Due to measures such as groundwater by-pass and building waterproofing, the amount is estimated to have decreased to about 100 tons per day (as of Jan 2015)

Policy 1. Remove the source of contamination

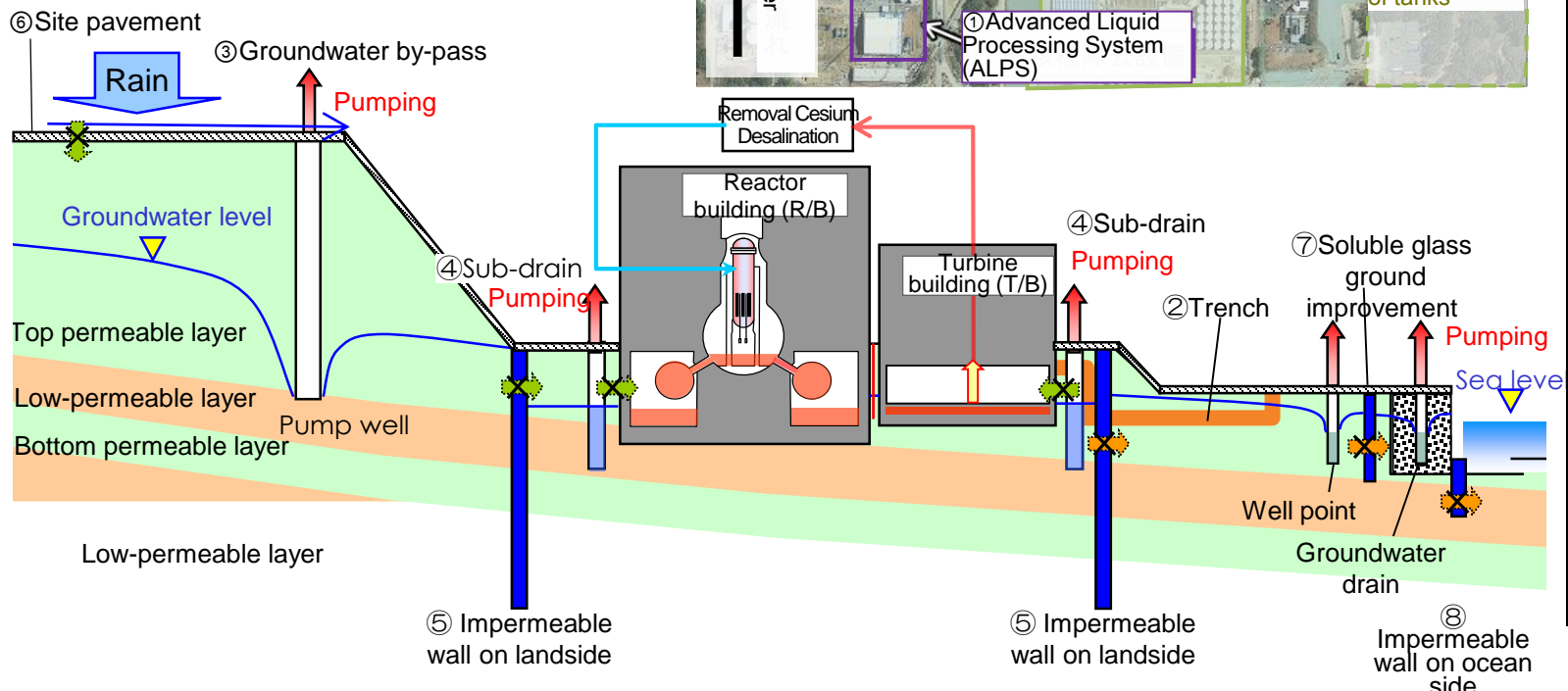
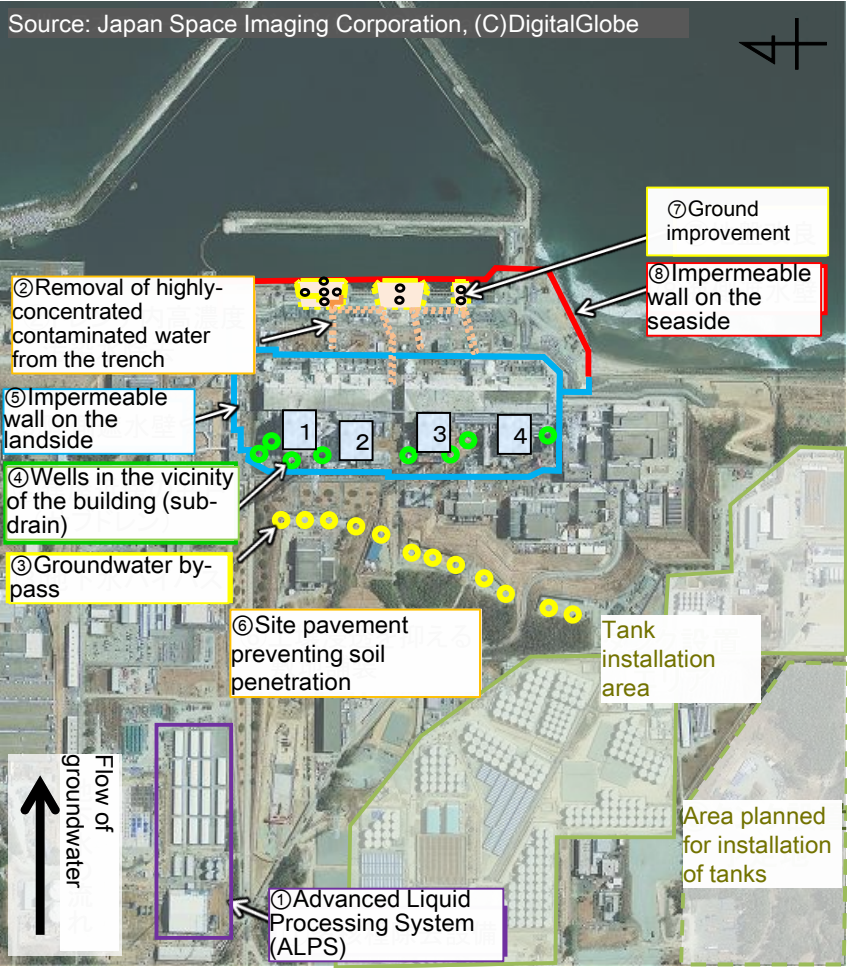
- ① Purification of contaminated water by the Advanced Liquid Processing System (ALPS)
 - ② Removal of contaminated water from the trench^{#2}
- #2: Underground tunnel with pipes

Policy 2. Keep water away from the source of contamination

- ③ Pumping of groundwater with groundwater by-pass
- ④ Pumping of groundwater from the wells in the vicinity of the building
- ⑤ Installing landside impermeable walls of frozen soil
- ⑥ Site pavement that prevents the rain water from penetrating the soil

Policy 3. Contaminated water should not leak

- ⑦ Ground improvement with soluble glass
- ⑧ Installing impermeable wall on the seaside
- ⑨ Increase in tanks (replacement with welded type and so on)



	FY2013		FY2014		FY2015	
	First half	Second half	First half	Second half	First half	Second half
Policy 1: Removal	① Purification of contaminated water by the Advanced Liquid Processing System (ALPS)	Purification of contaminated water from the tanks by Advanced Liquid Processing System (ALPS)		Additional installation of high-efficiency Advanced Liquid Processing System (ALPS)		May 27, 2015 RO concentrated salt water treatment completed
	② Removal of contaminated water from the trench	Purification work		Installation of frozen ducts		Removal of frozen waterproofing/contaminated water
Policy 2: Keep away	③ Pumping of groundwater with groundwater by-pass	Accumulated amount of drainage discharge 120,613m ³		Number of times of drainage discharge 76 times		As of August 14, 2015
	④ Pumping of groundwater from the wells in the vicinity of the building (Sub-drain)	Installation of purification facility		Inspection/ restoration		Pumping of groundwater in the wells in the vicinity of the building
	⑤ Installing landside impermeable wall of frozen soil	Small-scale freezing tests		Installation work		Freezing
	⑥ Site pavement that prevents the rain water from penetrating the soil	Progress rate approx. 80% As of July 2015		Site pavement with asphalt		Groundwater influx suppressed
	⑦ Ground improvement with soluble glass	Ground improvement with soluble glass		Controlling the discharge of contaminated groundwater to the sea		Pumping of contaminated water from the contaminated area
	⑧ Installing impermeable wall on the seaside	Installation work		Discharge of groundwater to the sea suppressed		※ Timing of closing being adjusted
Policy 3: No leakage	⑨ Increase in tanks (replacement with welded type and so on)	Increase and storage of tanks		Dismantling of flange tank		Being dismantled: 6 tanks, dismantled: 7 tanks As of August 17, 2015

• The process will be reviewed as necessary based on the status of the safety improvement measures

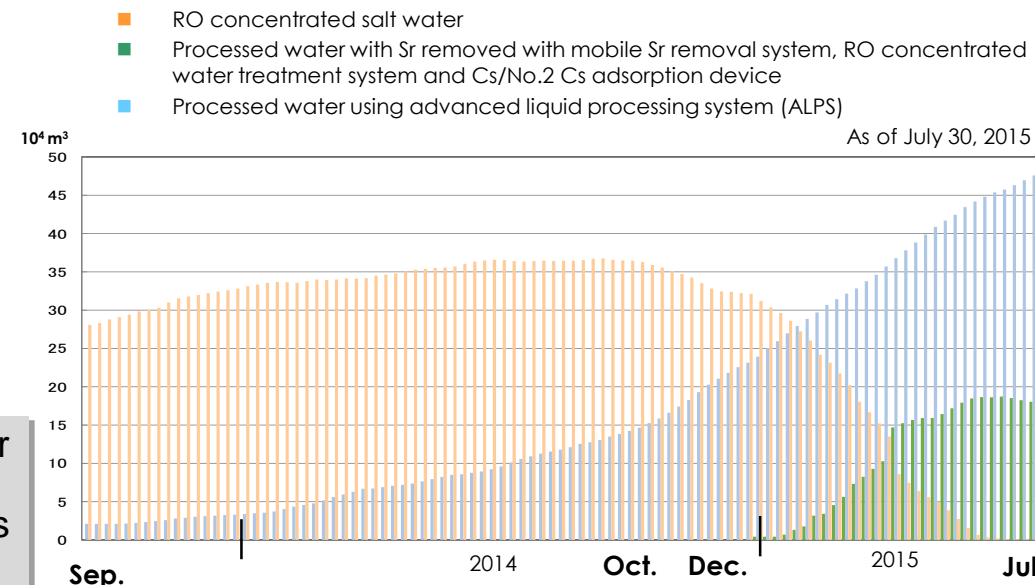
2. Main Progress in Measures for Contaminated Water (2015)

~ Removal of contaminated water ~

Purification of contaminated water (RO concentrated brine)

- The contaminated water (RO concentrated brine) was purified through seven facilities, including Advanced Liquid Processing System (ALPS), the residual water at the bottom of the tanks was removed, and the purification was completed on May 28.
- Hereafter, re-purification of the Strontium treated water and pumping and purification of the residual water at the bottom of the tanks will be implemented.

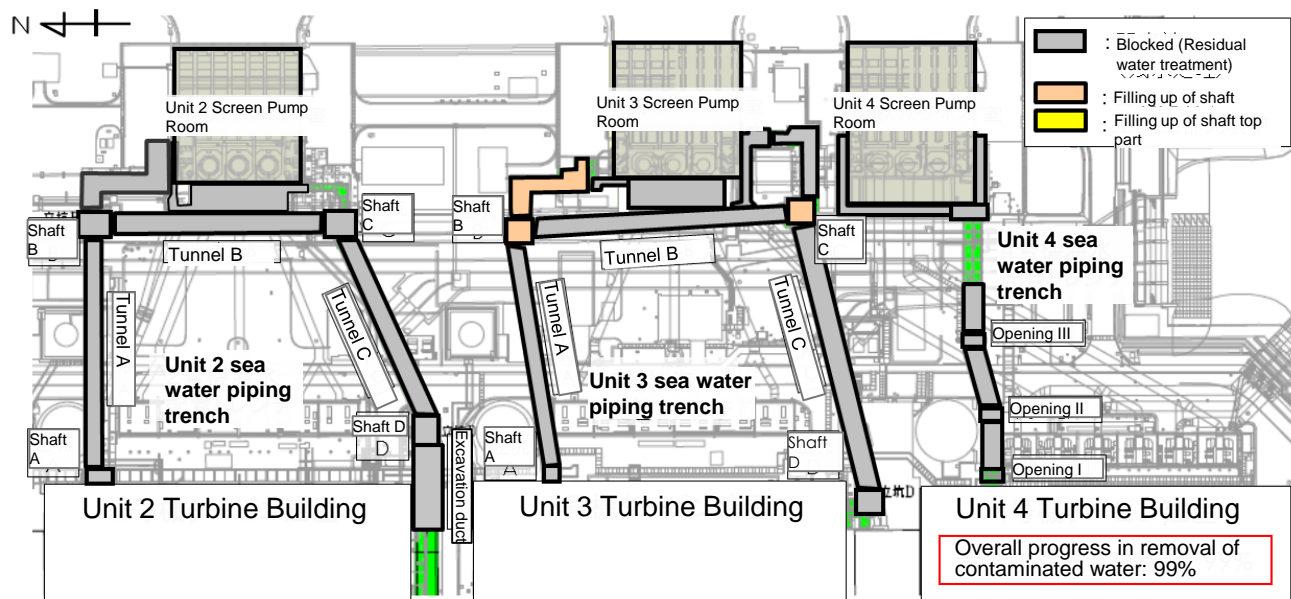
Contaminated water treatment facility	1 Advanced Liquid Processing System (ALPS)	2 Extended Advanced Liquid Processing System	3 High-performance Advanced Liquid Processing System	4 Mobile Sr removal facility	5 RO concentrated water treatment facility	6 Sr removal by installing Cesium adsorption	7 Sr removal by installing No.2 Cesium adsorption
Removal ability	Less than the notified concentration limit of 62 nuclides			1/10 ~ 1/1,000 of Strontium (SR)			
Treatment capacity	250m3/day x 3 systems	250m3/day x 3 systems	500m3/day	300m3/day x 2 series 480m3/day x 4 facilities	500 ~ 900m3/day	600m3/day	1,200m3/day
Status	Trial run in progress			Shutdown (Usage method for the next term being studied)		In operation	



Change in the amount of treated contaminated water due to the contaminated water purification facilities

Removal of accumulated water from the seawater piping trench

- The removal of the highly-concentrated contaminated water accumulated in the seawater piping trench was completed for Unit 2 on June 30 and for Unit 3 on July 30.
- Due to this, the risk of the discharge of highly-concentrated contaminated water has reduced considerably. (The total radioactivity of the accumulated water in the seawater piping trench and Turbine building (T/B) reduced to 1/10)
- For Unit 4, excluding some areas, the removal of contaminated water has been completed on April 28.



Unit	Unit 2	Unit 3	Unit 4
Residual accumulated water	0 m ³	0 m ³	About 60 m ³
Amount of fill	About 4,610 m ³	About 5,780 m ³	About 630 m ³
Situation	<ul style="list-style-type: none"> • Filling of tunnel area: completed on December 18, 2014 • Filling of shaft: completed on July 10 	<ul style="list-style-type: none"> • Filling of tunnel area: completed on April 8 • Filling of shaft: started on May 2 and ongoing 	<ul style="list-style-type: none"> • Filling of tunnel area (between openings I and III): completed on March 21 • Filling of openings II and III: completed on April 28

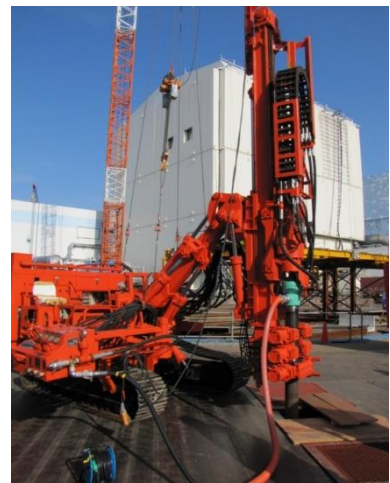
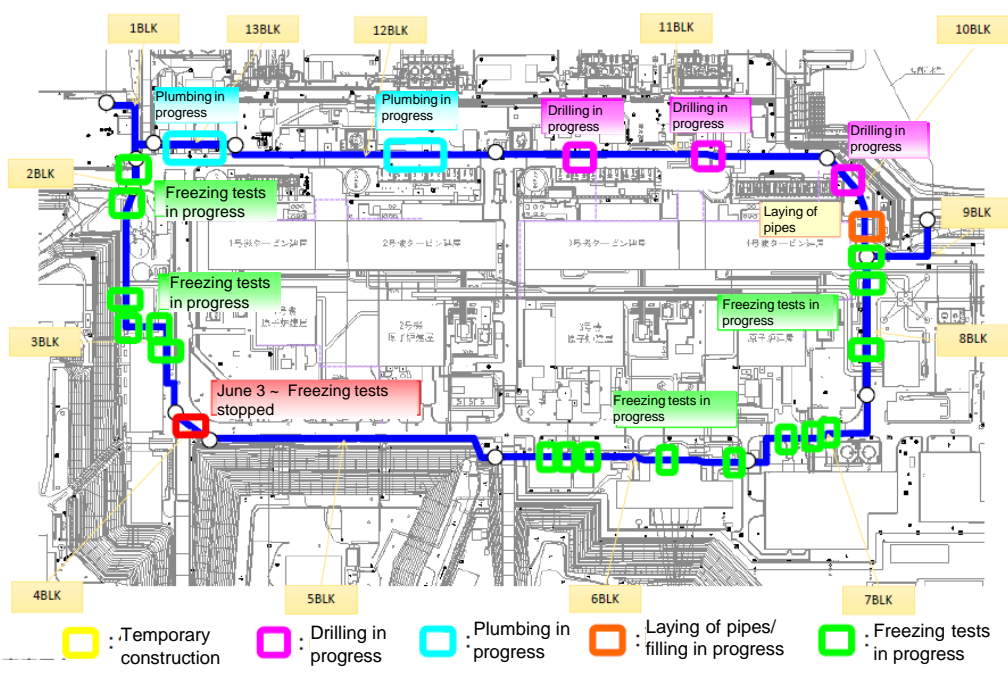
As of August 17, 2015

2. Main Progress in Measures for Contaminated Water (2015)

~ Suppression of increase of contaminated water, ensured storage ~

Progress and freezing tests for the work on landside impermeable walls of frozen soil

- Among the frozen ducts of the landside impermeable walls, the installation of the frozen ducts for the three regions on the mountain side to be frozen on priority was completed on July 28.
- For the seaside parts, the implementation plan was approved by the regulatory commission on July 31, so we plan to proceed with work sequentially.
- Freezing tests were started at 18 places from April 30 with the purpose of verifying the operating status of the entire coolant circulating system and the effect of the groundwater discharge. Currently, the coolant supply temperature is stable near -30°C without any refrigerator failure. For the underground temperature in the vicinity of the frozen ducts, a trend of fall in temperature is being confirmed depending on the layout of the frozen ducts, and isolation from sight tubes.



Situation of installation of frozen ducts



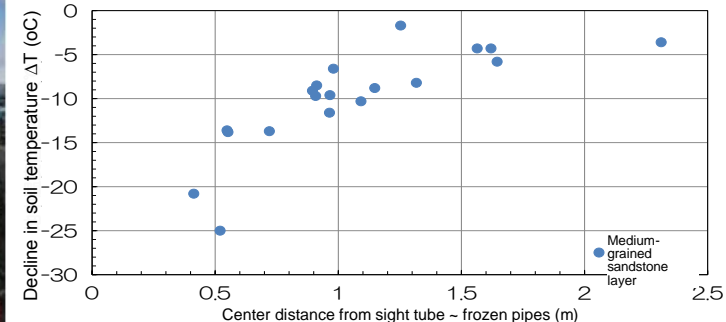
Situation of installation of cooling pipes



Situation of trial freezing



Freezer plant building



Isolation from the frozen ducts and underground temperature

Construction and replacement of tanks

- To make sure that the receiving capacity for contaminated water is adequate, the construction of cylindrical steel tanks (welded joints (welded-type tanks)) was implemented in sequence keeping a margin in the plan, and in March 2015, 2 years ahead of schedule from the plan in the mid/ long-term road map, a total tank capacity of $800,000\text{m}^3$ was ensured. In continuation, the plan is to ensure $900,000\text{m}^3$ by March 2016.
- To improve the reliability of tanks, we are replacing (removing and installing) the flange-type tanks with welded-type tanks.



Tank construction and removal progress report



Advance internal coating



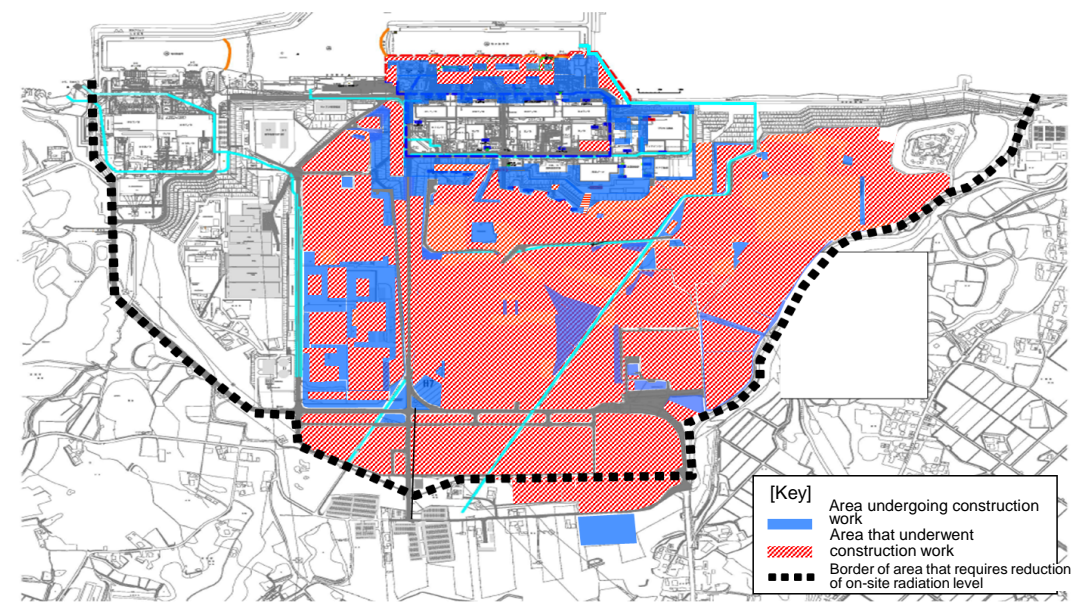
Flange-type tank Disassembly state
 [Dismantled: 7 tanks
 Being dismantled: 6 tanks]

2. Main Progress in Measures for Contaminated Water (2015)

~ Rainwater measure ~

Suppression of penetration of rainwater into soil

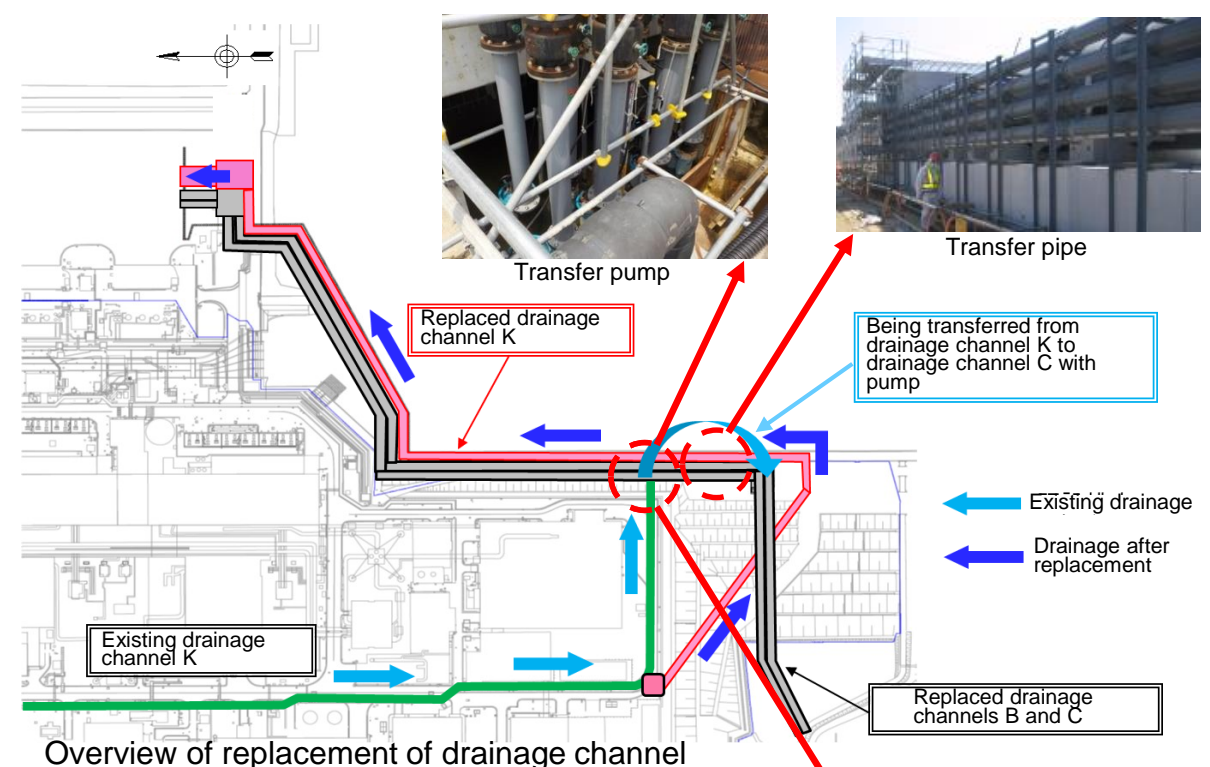
- Area subject to pavement (1.45 million m²) on the power station premises is being paved and progress rate as of July is approximately 80%.
- It is evaluated that groundwater will gradually decrease over 2-3 years due to pavement, and it is projected that groundwater flowing into the building will decrease to 160m³/d.



Progress of on-site pavement

Rainwater measure for general drainage channel (drainage channel K)

- On July 16, due to heavy rain, dirty rainwater was discharged to the sea. No significant change was found from monitoring value near the port mouth and south discharge outlet, and said value will continued to be monitored.
- The following measures are implemented as measures against rainwater discharge from drainage channel K to the sea.
 - ✓ Pump transfer to drainage channel C which connects to port
 - ✓ Replacement of drainage channel K to port
 - ✓ Reduction of contamination of drainage channel K (cleaning of drainage channel and removal of contamination source)
- Contamination source surveys revealed a contamination source on the roof of the Unit 2 R/B truck bay. Countermeasures were implemented and the search for other contamination sources will continue.



Overview of replacement of drainage channel



Prior to countermeasures



After countermeasures



Cleaning of side ditch that leads to drainage channel K



Cleaning of drainage channel K and installation of purification material



Drainage channel K/C pump (Monitoring camera)

Removal of contamination source on roof of Unit 2 reactor building truck bay entrance

3. Decommissioning work

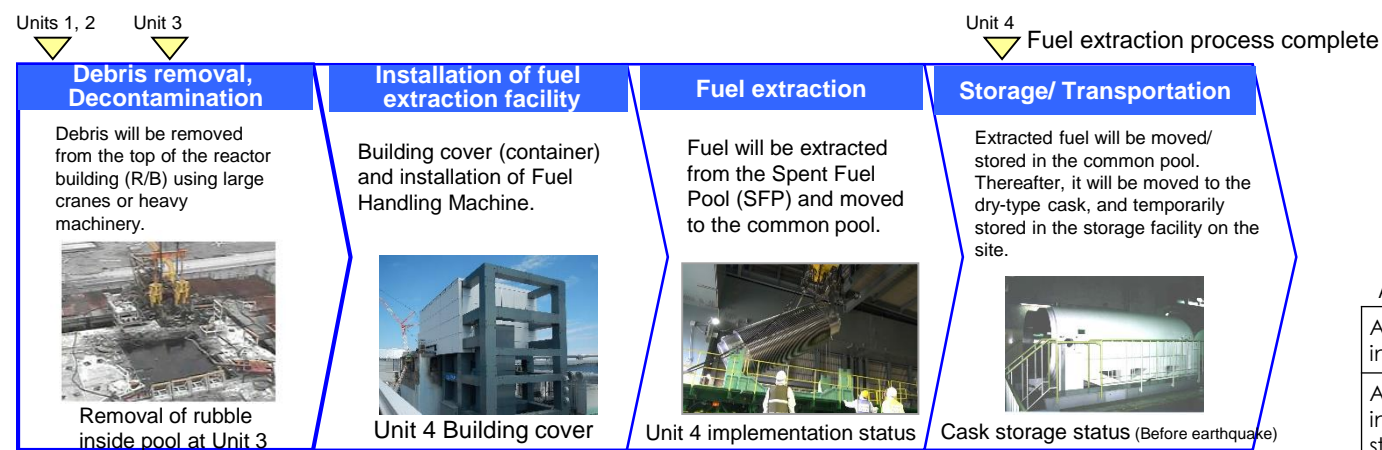
~ Overall image of the decommissioning work ~

- Decontamination of the building and investigation of PCV leak locations is in progress for the extraction fuel and fuel debris from the Spent Fuel Pools (SFP) for Units 1 ~ 3 .
- For the extraction of fuel from the Spent Fuel Pools (SFP), operations, such as start of dismantling of covers in Unit 1 and completion of removal of large debris from the pool in Unit 3, are steadily under way.
- New knowledge regarding fuel debris extraction was obtained through the inspection of the state of the fuel debris in the reactors by using muon particles, and the internal inspection of PCVs using robots in Unit 1.
- The mid/long-term roadmap which is an indicator of the reactor decommissioning work was revised on June 13 (Decided in the cabinet meeting on reactor decommissioning and measures for contaminated water). In this revision, points have been placed on stressing risk reduction and clarification of target processes.

Extraction of fuel from the Spent Fuel Pool (SFP)

Major developments

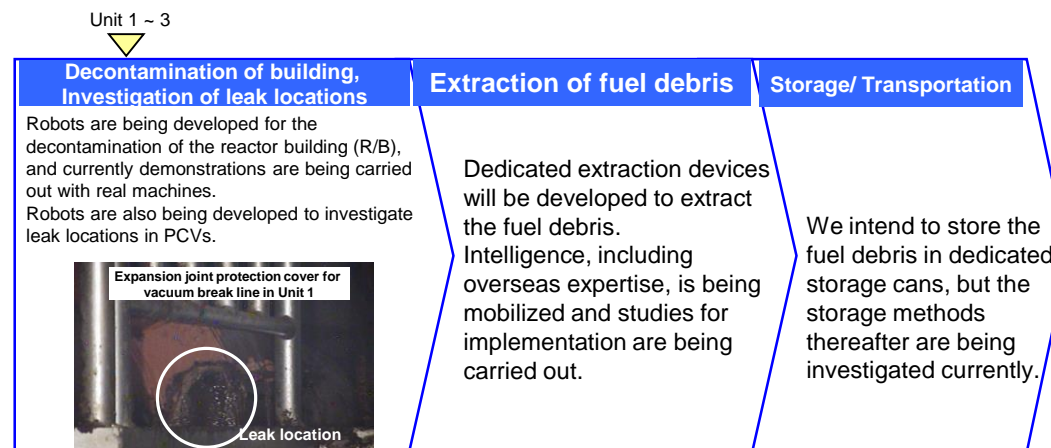
- December 22, 2015
All fuel was removed from spent fuel pool at Unit 4
- May 15, 2015-
Dismantling work of building cover restarted at Unit 1
Second roof panel was removed on August 3.
- August 2, 2015
Large rubble (refueling equipment) inside the pool was removed at Unit 3.



Fuel debris (melted fuel) extraction

Major developments

- February 12, 2015-
In order to investigate existence of fuel debris at Unit 1, measurement was conducted using muon
- April 10-20, 2015
Interior of containment vessel was investigated at Unit 1 using a robot



Dismantling of the reactor facility

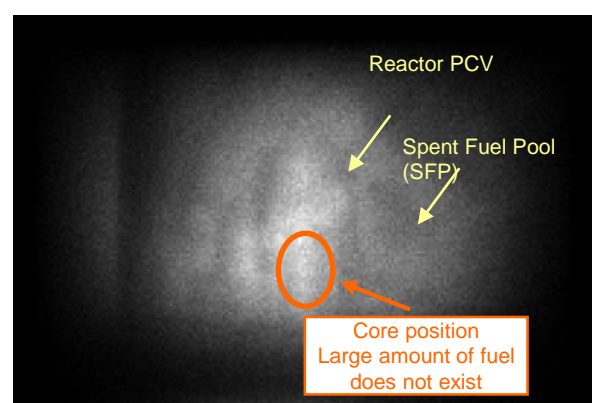


4. Main Progress in Decommissioning Work (2015)

~ Removal of fuel debris ~

Muon tomography (Unit 1)

- To inspect the state of the fuel debris in the Unit 1 reactor, the position of the fuel debris was measured using cosmic ray muons.
- Due to the measuring of results from two directions and assessing them three dimensionally, we could verify the large absorbers (fuel in the Spent Fuel Pool (SFP)), which were expected to be seen, but the large fuel mass inside the reactor could not be verified.



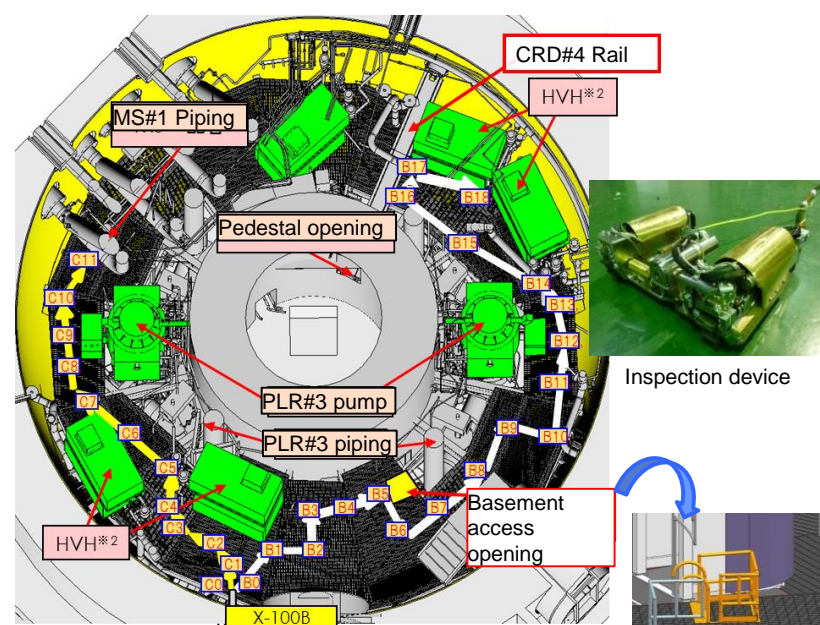
Measurement results



X-ray image created from drawing

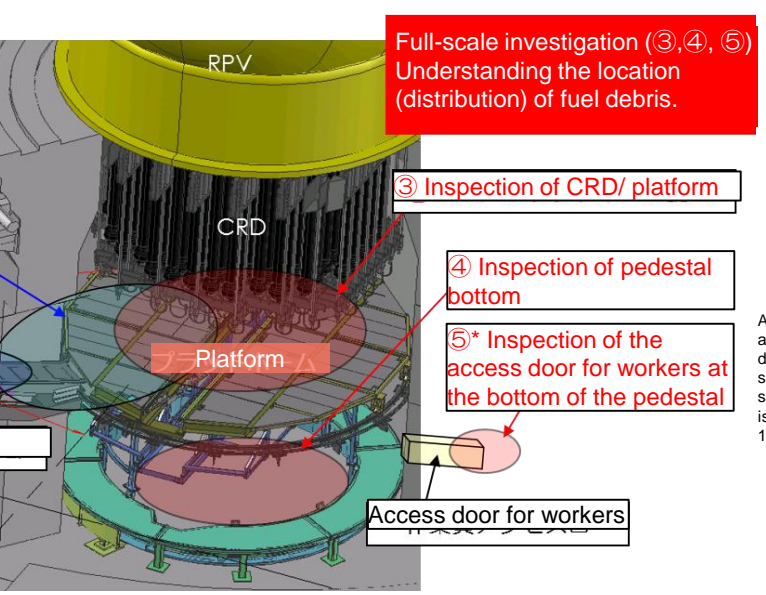
Investigation of interior of containment vessel using a robot (Unit 1 / 2)

- At Unit 1, from April 10 to 20, the state of the environment of the grating periphery and existing structures on the 1st floor outside the pedestal in the reactor containment vessel was inspected using robots. Valuable information, such as the state of damage and temperature inside the PCV and radiation level information, was obtained.
- Hereafter, we are planning to put in a different robot from the opening to the basement where absence of obstacles was confirmed during this inspection, and inspect the floors under PCV.
- At Unit 2, in order to grasp the location (distribution) of fuel debris inside pedestal, it is planned to put in the inspection device from containment vessel penetration (X-6 penetration).
- The remote removal of the shield block installed in front of X-6 penetration section where the inspection device is installed, was started, but the operation has been suspended with 7 blocks that are stuck fast and cannot be removed. We intend to resume the removal as soon as the preparations are in place.



Inspection access route inside Unit PCV

Preliminary survey (①,②)
Obtaining the access route inside the pedestal and the status and environmental conditions inside PCV.



① Inspection of the state of CRD rail/ pedestal opening
Implemented with inspection from X-53 penetration (August 2013)

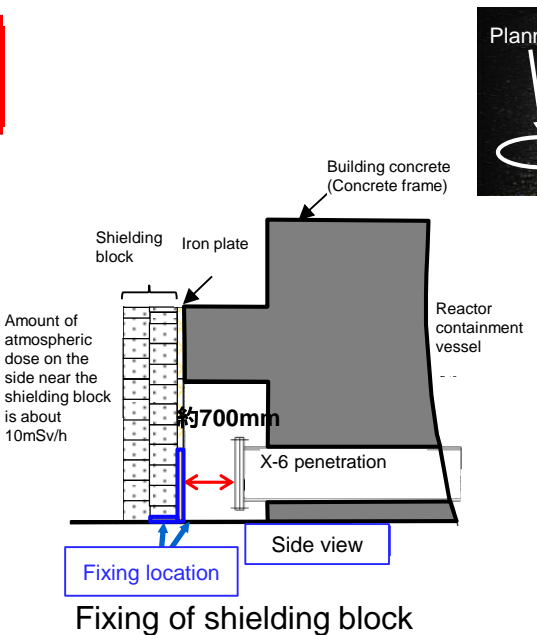
② State/ environmental inspection inside pedestal
Inspection from X-6 penetration is planned

③ Inspection of CRD/ platform

④ Inspection of pedestal bottom

⑤* Inspection of the access door for workers at the bottom of the pedestal

Plan of investigation inside Unit 2 pedestal (image)



Fixing of shielding block



Access opening

Measurement result of temperature and dose rate inside Unit 1 containment vessel

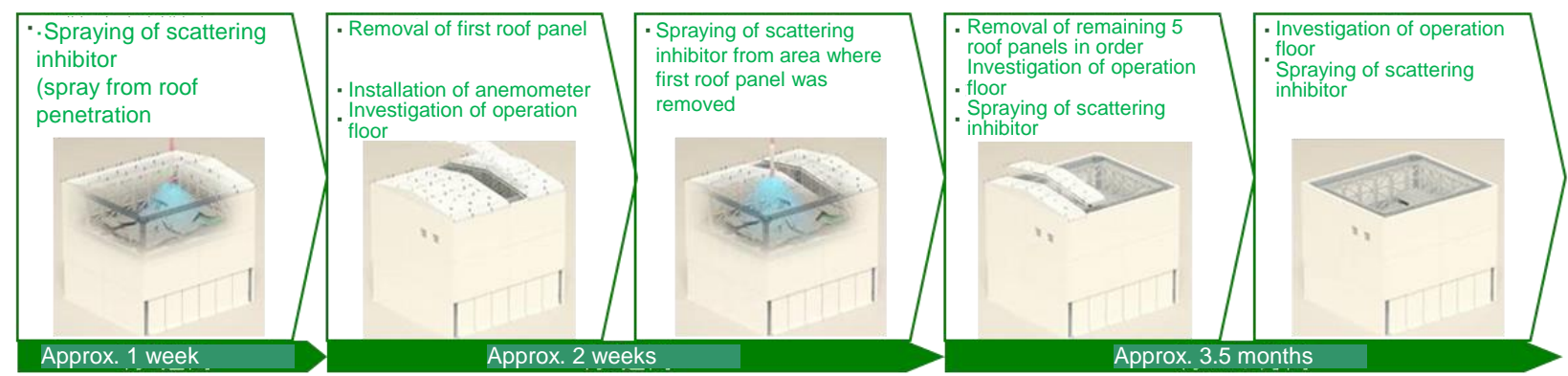
Dose rate (Sv/h)	Temperature (°C)
5.3~9.7	17.8~21.1

4. Main Progress in Decommissioning Work (2015)

~ Removal of fuel from spent fuel pool ~

Action toward removal of fuel from Unit 1 spent fuel pool

- Removal of cover began on October 22, 2014. Investigation of dust after removal of 2 roof panels found no scattering of dust or situation that could immediately cause damage to fuel inside spent fuel pool. (roof panel restored on December 4, 2014)
- Removal of cover restarted on July 28. Removal of rubble will be steadily advanced.



Removal of roof panel

Action toward removal of fuel from Unit 3 spent fuel pool

- Work to remove refueling equipment (approximately 20t) which is the largest rubble inside Unit 3 spent fuel pool was conducted on August 2.
- Detailed removal plan which had been examined (investigation of situation inside pool and situation of rubble, development of dedicated hoisting tool, mock-up test, preparation of various risk measures) bore fruit and removal work was safely completed.
- Work to remove rubble inside spent fuel pool and work to install fuel removal cover will be continued for fuel removal. At the same time, fuel removal training is conducted with remote operation.



Removal of refueling equipment

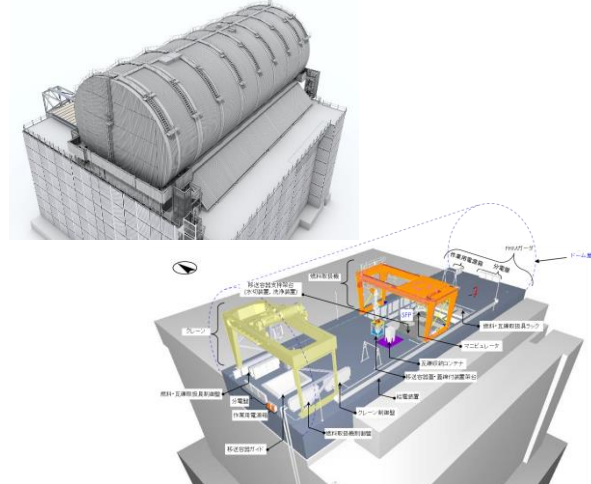


Image of fuel removal equipment

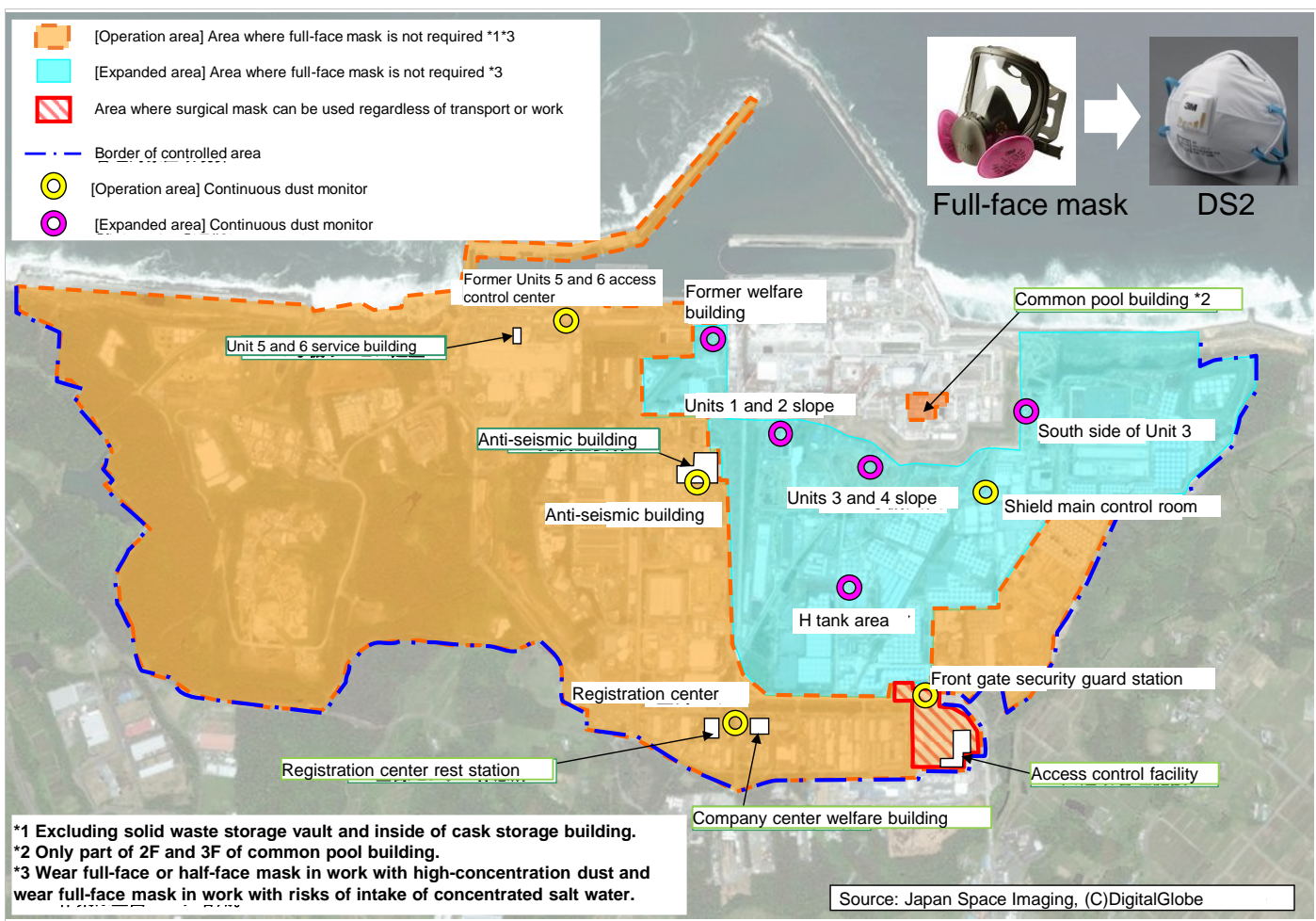


Cover platform material preparations (at Onahama)

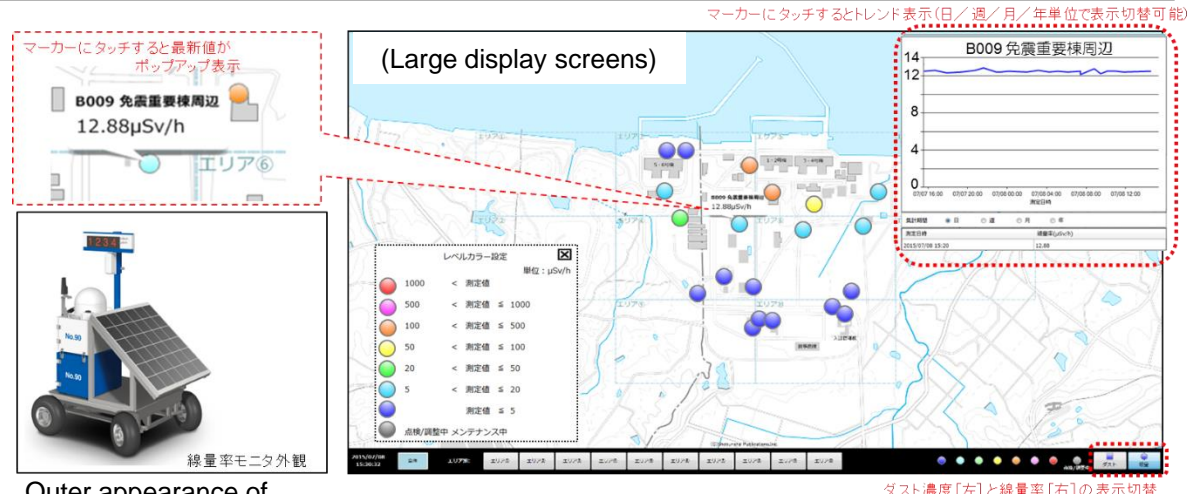
Photo taken on 3.10.2015

Expansion of area where full-face mask is not required

- As continuous dust monitors have been increased in the H tank area and the area is now monitored with a total of 10 monitors, area where disposable dust-proof mask can be used instead of full-face mask was expanded on May 29 (90% of site area in total).
- 70 dose rate monitors will be installed on-site (until September 2015) to visualize on-site dose rate.
- Protective equipment will be adjusted to reduce heat stroke risks and work load in the summer and improve work efficiency.



Area where full-face mask is not required



Outer appearance of dose rate monitor

Food service centre and large rest house completed and provision of warm meals started

- On March 31, 2015, the Fukushima food service centre was completed in the Ookawara district of the town of Okuma, and from April 20 meals started being provided in the dining hall space in the new office building.
- From June 1, meals were provided in the large rest house, but in order to further improve the hygiene for continuing operations over a long period of time, the food service was discontinued and repair work was done on a part of the building. From August 3, food service was resumed.



Food service centre



Meals



Large rest house

6. Recent accidents at Fukushima Daiichi

Grounding alarm in the power-supply facility and generation of white smoke from Eflex pipes

- Around 8:30 on July 28, 2015, in the vicinity of the notch tanks to the west side of the Advanced Liquid Processing System (ALPS) building, when the weed-proof sheet for cogon grass measures was being fixed with pins and laid, the internal power panel grounding alarm rang and emission of smoke from the Eflex pipes in the vicinity was confirmed.
- It was found that when pins were hammered and fixed into the weed-proof sheet laid for the cogon grass measures, a pin penetrated an Eflex pipe under the sheet, and damaged the power cable housed within, due to which grounding occurred and led to a burnout.
- Since this event has possibility of severely affecting facilities and becoming a fatal accident, problems will be examined in depth and measures to prevent recurrence will be implemented.

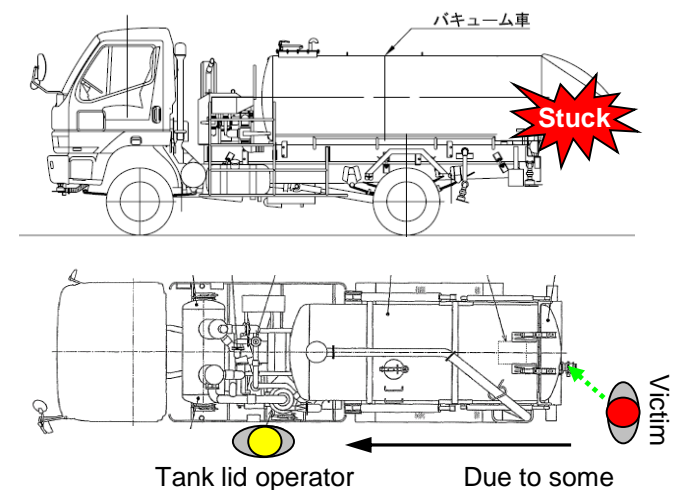


Catch accident during operation of the vacuum truck rear tank cover closed

- Around 6:25 on August 8, 2015, the upper half of the body of a contractor worker who was cleaning the construction vehicle used for land-side impermeable wall construction work near the soil disposal area on Fukushima Daiichi Nuclear Power Station premises was caught in the tank cover at the rear of the vehicle and said worker died.
- There are unclear points in the situation at the time of the accident since the person involved in the accident had died, but the cause will be steadily investigated and countermeasures will be implemented based on facts that can be confirmed from the site situation.
- Due to the accident, work is temporarily stopped and review committee of similar cases of heavy machinery accident and general inspection of heavy machinery are carried out. In addition, message to call for attention is delivered from 1F station director to all station workers (August 9 and 17).



Arrangement of personnel during operation of tank cover



Due to some reason, the victim moved between the tank and its lid and got stuck