Current Status of Fukushima Daiichi Nuclear Power Station

April 9, 2015

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Tokyo Electric Power Company, Inc.

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1. Current Status on Fukushima Daiichi NPS

- Unit 1
- Unit 2
- Unit 3
- Unit 4

2. Measures Against Contaminated Water

- Expansion of the contaminated water purification facility
- Improvement of the tank area that stores contaminated water
- Underground water bypass
- Sub drain
- Land-side impermeable wall with frozen soil
- Removal of retained water from the seawater piping trenches of Units 2, 3 and

3. Improvement of Work Environment

4. Investigation on unconfirmed/unclear matters

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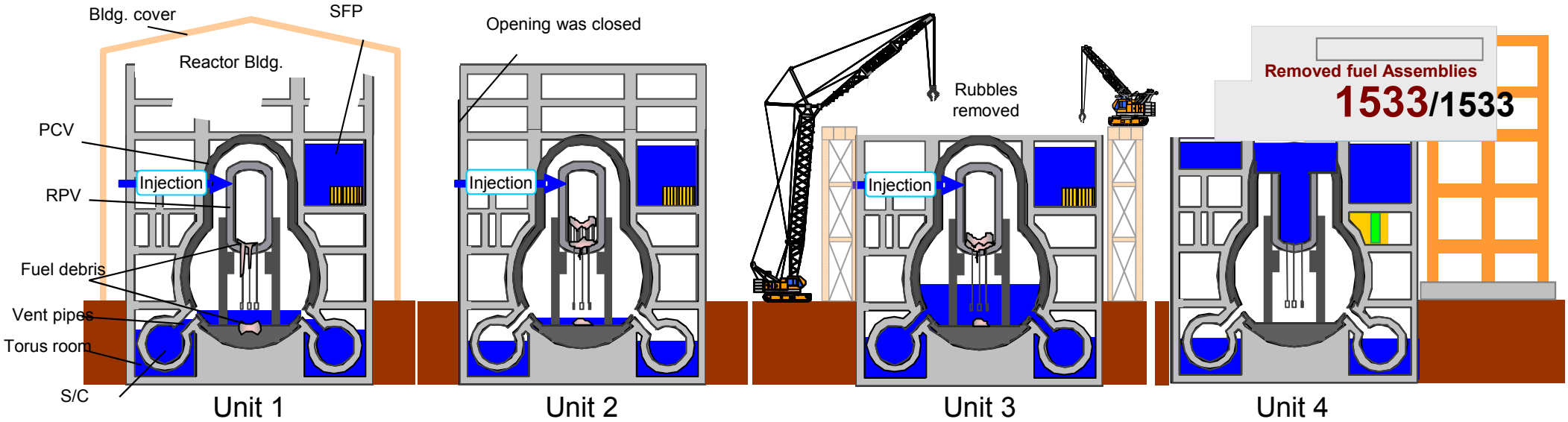
1.Current Status on Fukushima Daiichi NPS (Reactors and buildings)

■ All units maintain cold shutdown state.



Values as of 5:00 on April 1, 2015

	RPV bottom temp.	PCV internal temp.	Fuel pool temp.	Water injection to the reactor
Unit 1	~16℃	~16℃	~17℃	4.5㎥ / h
Unit 2	~22℃	~30℃	~31℃	4.4㎥ / h
Unit 3	~19℃	~19℃	~25℃	4.2㎥ / h
Unit 4	No fuel, so monitoring not required	No fuel, so monitoring not required	~12℃	–

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

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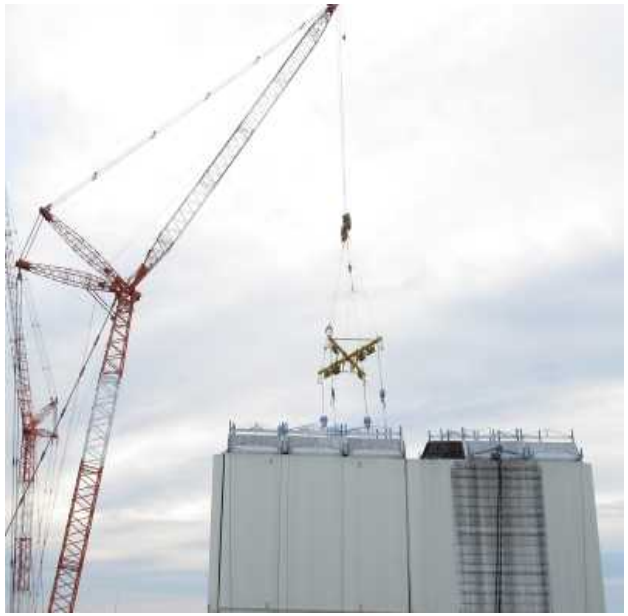
Unit 1

- In order to remove the scattered debris on the refueling floor, the reactor building cover that has been installed to prevent radioactive materials from scattering is to be dismantled.
- By removing two of the roof panels from the building, the conditions of the refueling floor was checked. The investigation did not find any dust dispersion and other conditions that would immediately damage the fuels in the spent fuel pool.

Reactor building immediately after the explosion

Covered reactor building



Recovering the cover of the reactor building

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Unit1: Status of refueling floor

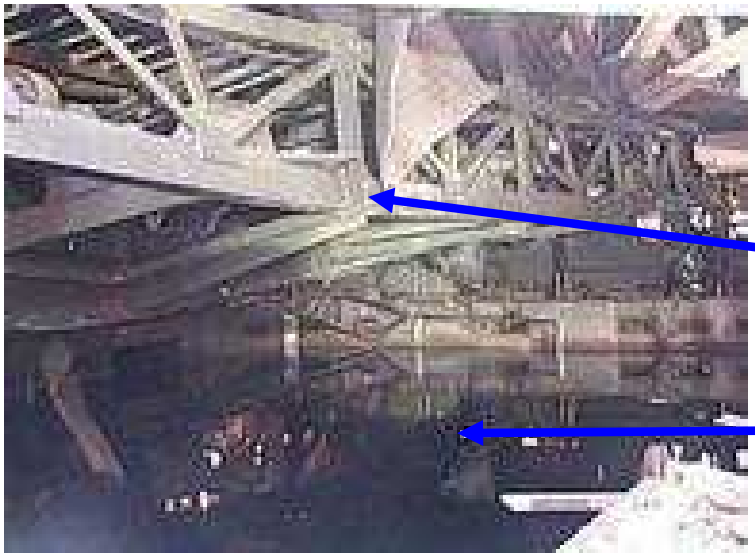
Picture 1

Overhead crane

Rubble

Picture 3

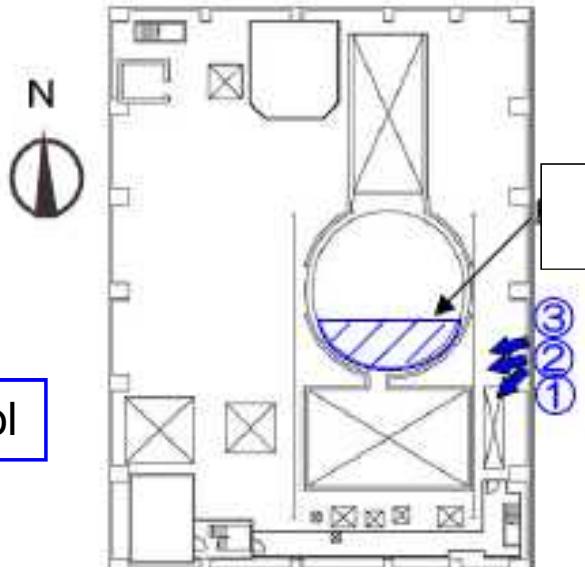
Cover of reactor well



Picture 2

Overhead crane

Surface of fuel spent pool



Location of photograph taken

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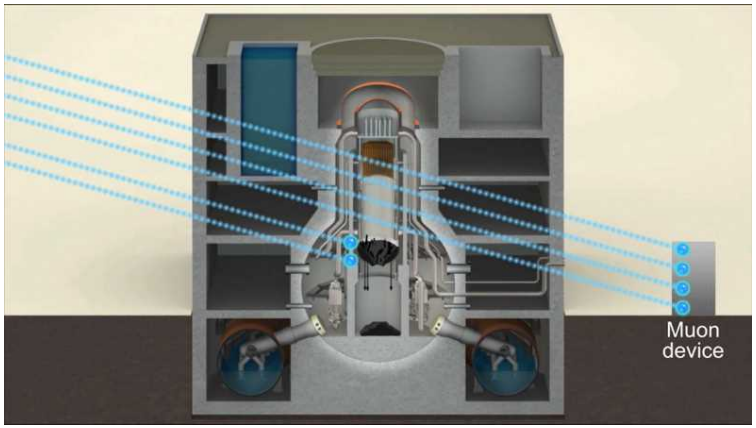
Unit 1: Fuel Debris investigation (MUON) --- Overview ---

- Fluoroscope technology development using cosmic ray muon is under progress by IRID and HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION (KEK)
- Currently, large lumps of fuel (measuring more than 1m) have not been confirmed at the reactor core where the fuel used to be located. This result is basically consistent with TEPCO's previously announced estimation of the reactor and the containment vessel conditions.



Installing the measuring equipment

PC for accumulating data

Courtesy of the International Research Institute for Nuclear Decommissioning (IRID)

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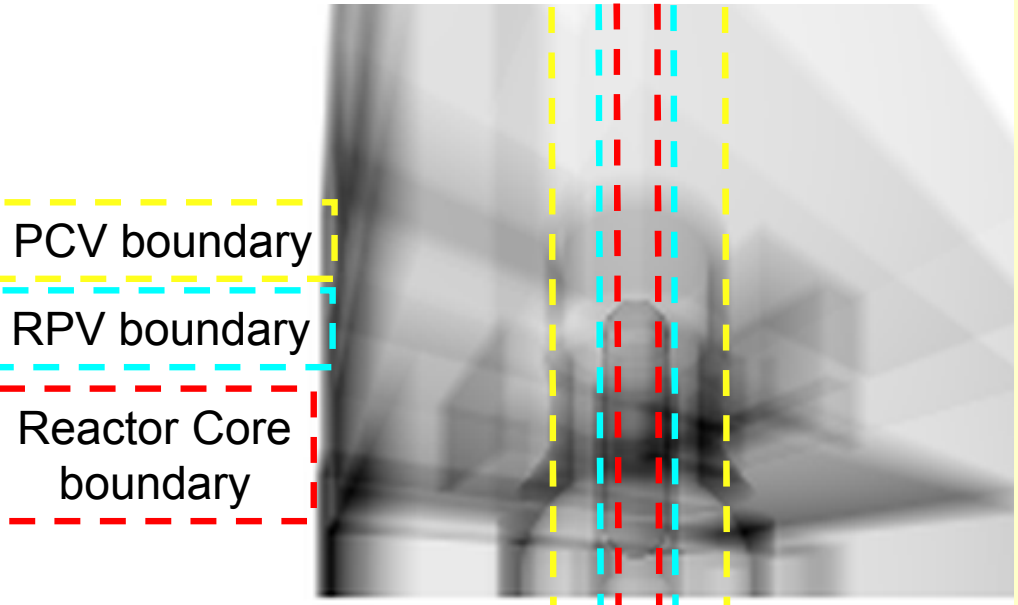
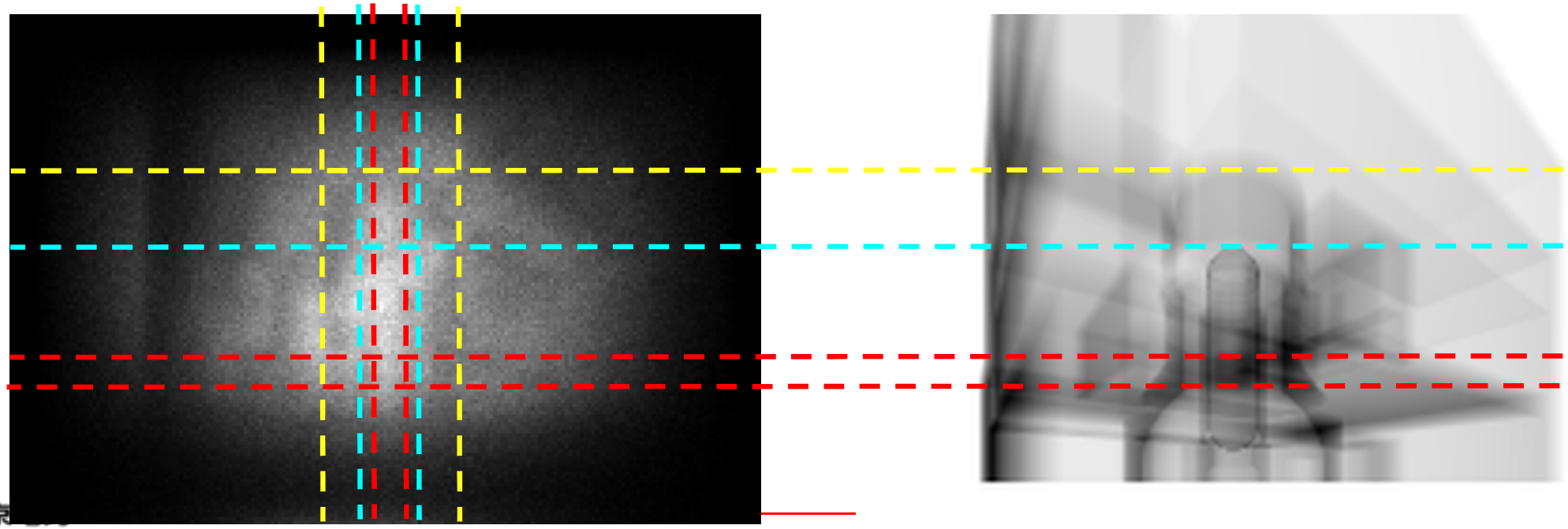
Unit 1: Fuel Debris investigation (MUON) ---Primary result ---



- The image of the measurement data shows that the PCV, the PRV and the core are in positions where they should be.
- Boundaries of the PCV and RPV on the design drawings are consistent with the measured data.
- However, the measured data do not show the existence of high-density substances (fuels) in the original position of the reactor core.



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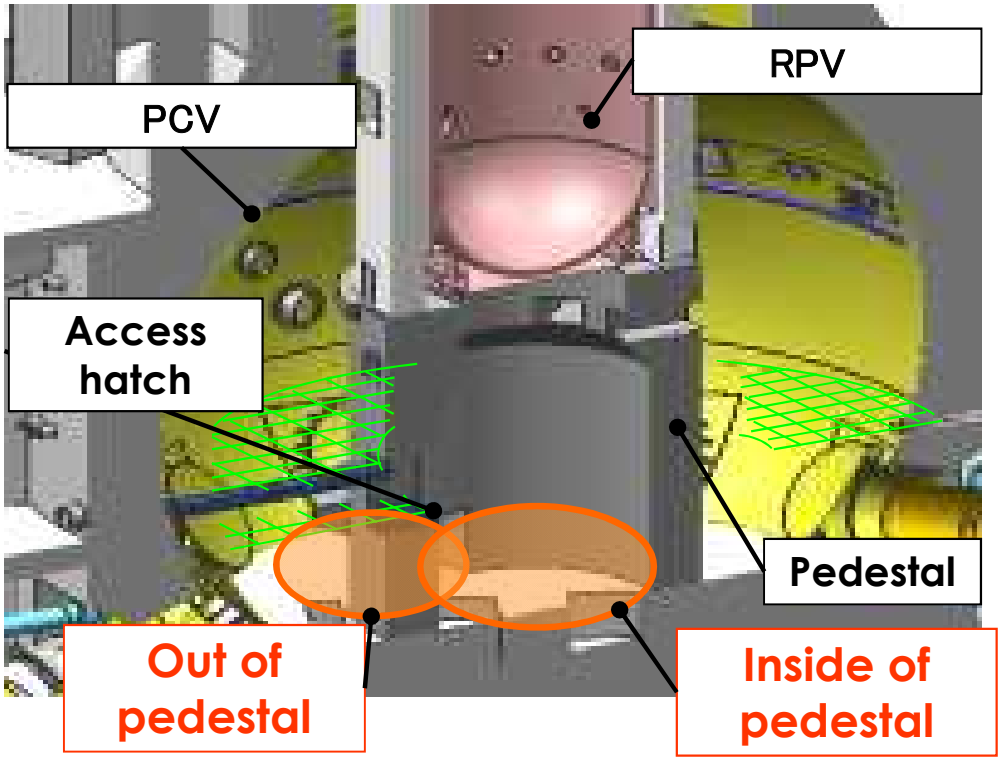
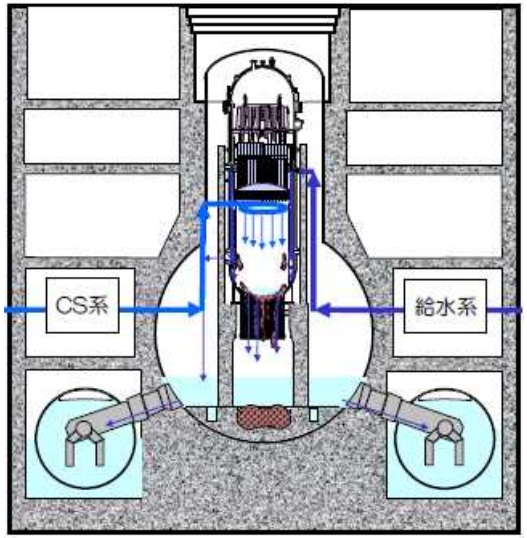
Unit1: PCV Investigation --- Objectives ---

- Fuel debris is assumed to be spread out to pedestal thus priority is put on the survey for out side of the pedestal.

Target locations



Estimated core and PCV status (UNIT1)



According accident analysis by MAAP estimates all the fuel in the core region fell to the lower prenum and most of the fuel fell to the pedestal area then core-concrete reaction occurred. 。

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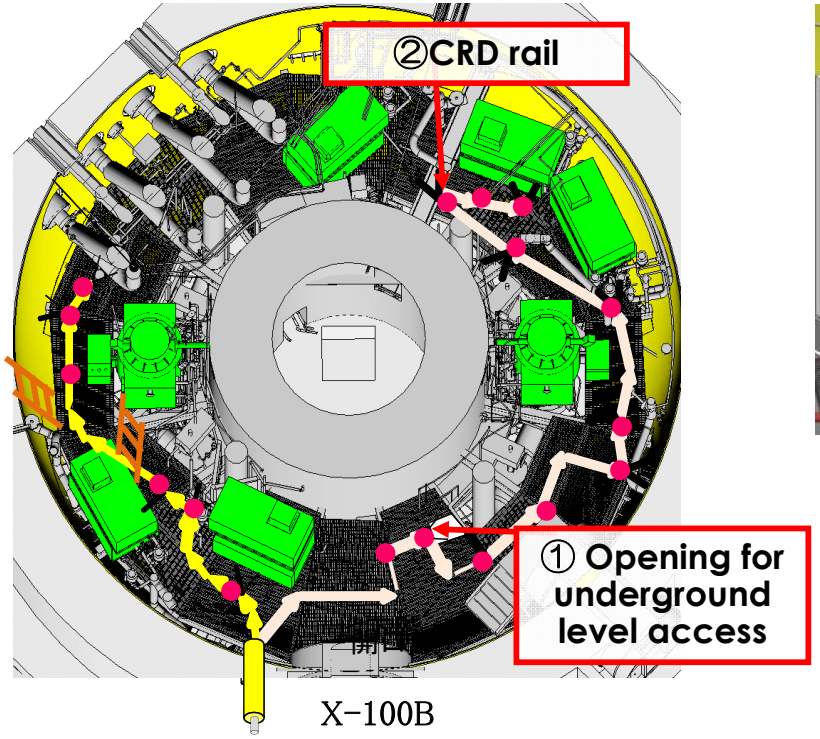
Unit1: PCV Investigation --- Methodology ---

- Investigation will be carried out twice in crock-wise and anti-crock-wise directions using a crawler devise.
- Information such as visual image, temperature and dose will be obtained at each point.

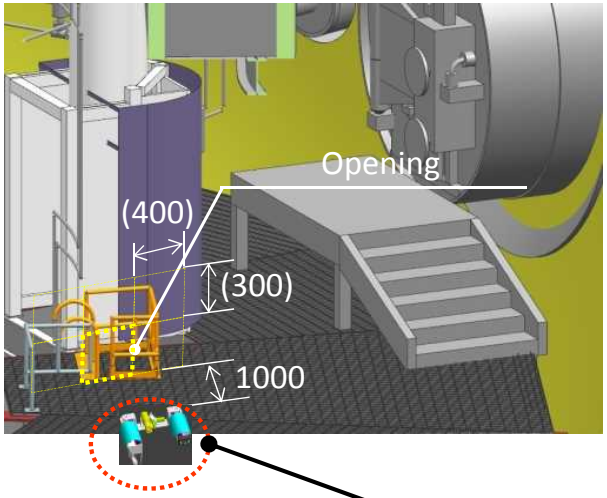
Data points



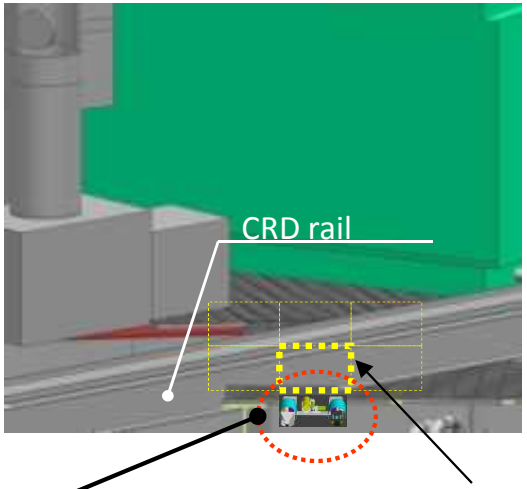
Anti-crock-wise
Crock-wise

Example

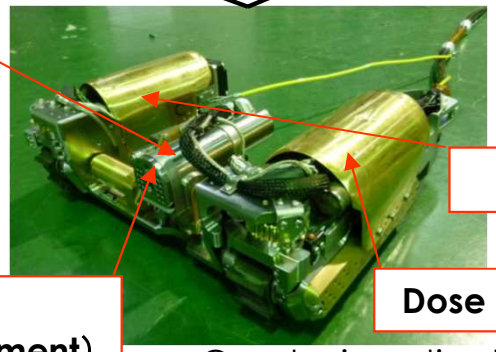
① Opening for underground level access



② CRD rail



Area of imaging at 1m distance



Crawler investigation devise

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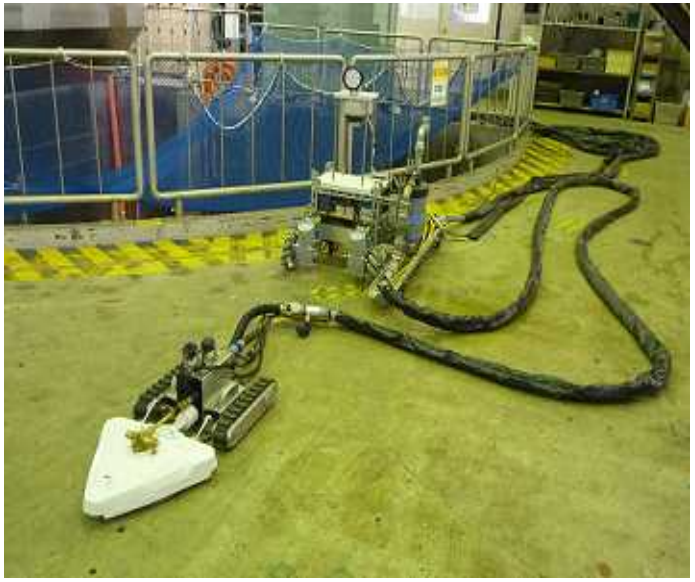
Unit 2

- Decontamination of the floor of the first level in the reactor building was started. The decontamination work is carried out by the remote decontamination equipment RACCOON that can supply water on the floor surface while vacuuming up discharged water.
- A thermometer installed on the bottom of the reactor pressure vessel broke down in February 2014. Replacement work in April 2014 was not successful due to rust. Then by injecting the derusting agent and finished pulling out the broken thermometer on January 19, 2015.



The remote decontamination equipment RACCOON with a jet head

The remote decontamination equipment RACCOON with a brush head

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Unit 3

- Completed to take out major rubbles from the top level of the refueling floor in the reactor building.
- Currently, dose reduction efforts are underway in order to install the cover for removing fuels and equipment that handles fuels on the refueling floor.

White smoke coming out of the reactor building immediately after the explosion

Reactor building before major debris was removed

Reactor building after major debris was removed

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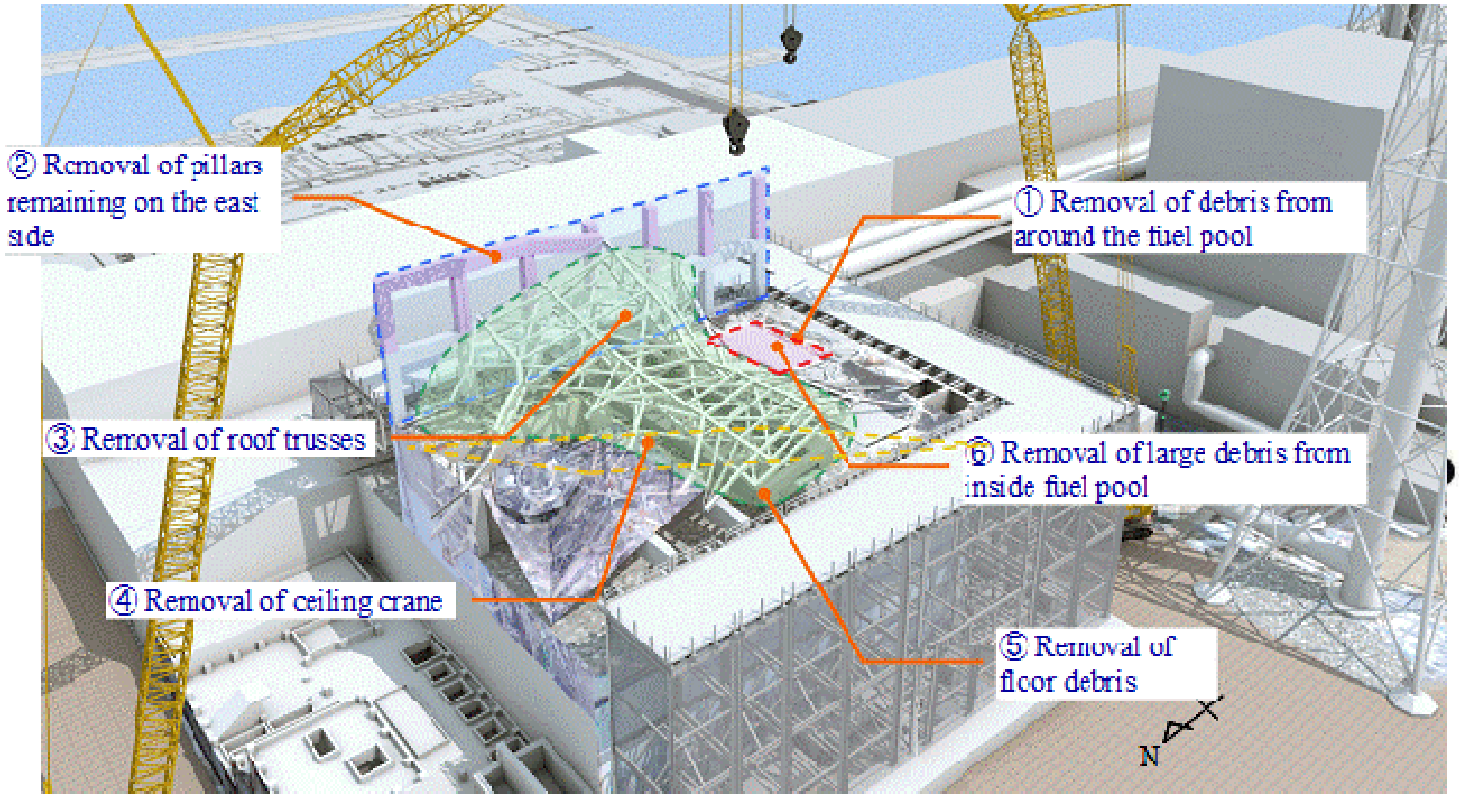
Unit3: Progress of rubble removal

- Rubble removal from the refueling floor was carried out using remotely operated machineries.



Before large debris removal

After removal of large debris

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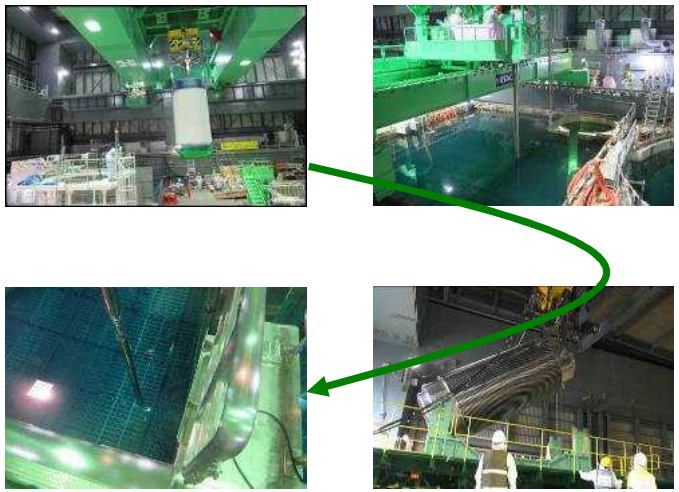
Unit 4

■Completed fuel removal from the spent fuel pool in December 2014.

A concrete pumping truck is injecting cooling water to the fuel pool immediately after the accident

Reactor building after debris was removed

Reactor building after installed the cover for removing fuels



Removing fuels from the spent fuel pool prepared for the operation

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2. Measures against Contaminated Water

- At Fukushima Daiichi NPS, approximately 300 tons of ground water is flowing into buildings and become contaminated.
- Based on the three basic policies of "Removing the contamination source," "Isolating water from the contamination source," and "Preventing leakage of contaminated water," the following measures are being implemented.
  - Expansion of the contaminated water purification facility
  - Improvement of the tank area that stores contaminated water
  - Underground water bypass
  - Pumping of underground water by a sub drain
  - Frozen soil water sealing wall
  - Removal of retained water from the seawater piping trenches of Units 2, 3 and 4, etc.
- About 400 tons of ground water was initially flowing into buildings. The efforts such as bypassing groundwater decreased the amount at about 100 tons.

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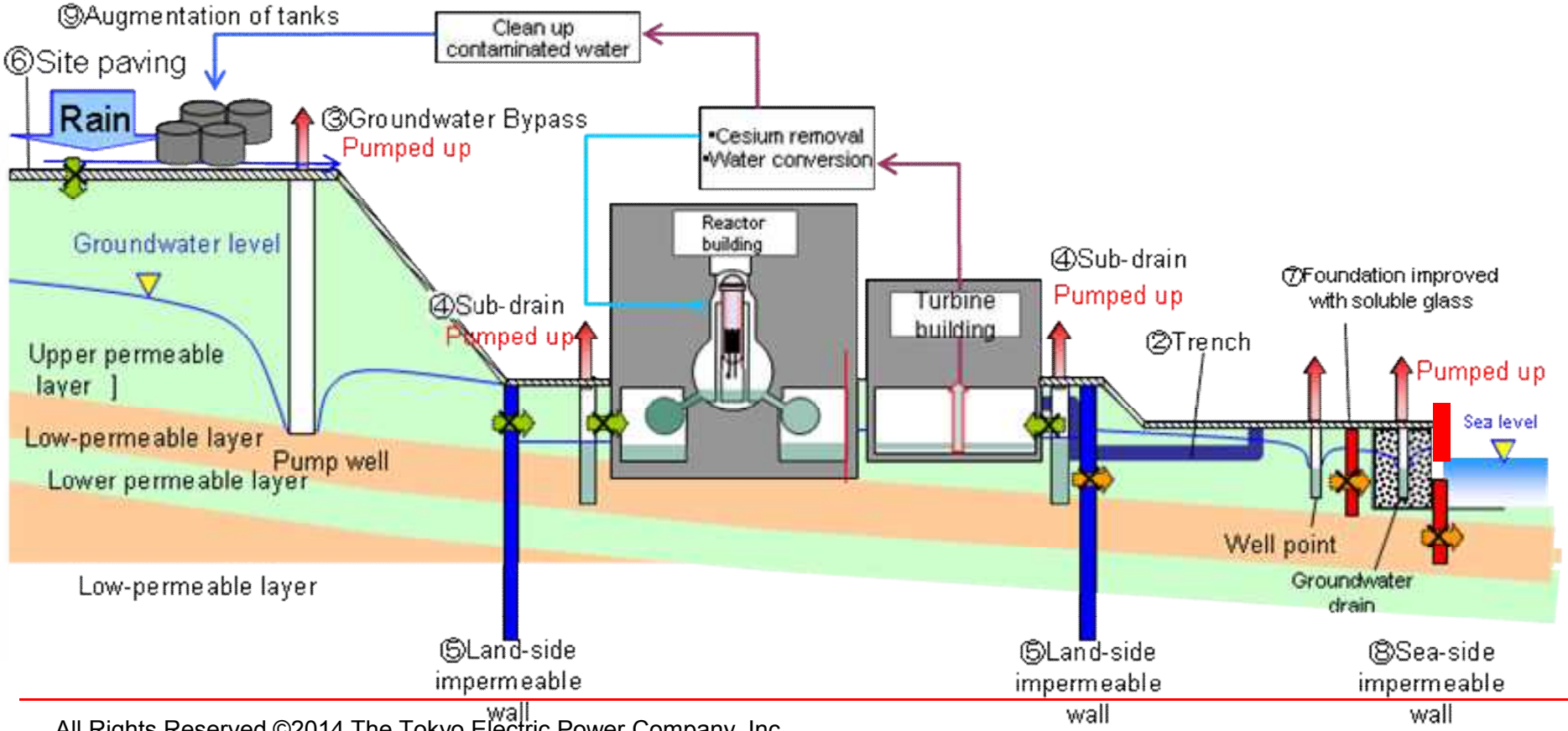
2. Measures against Contaminated Water (Overview)

Policy 1 : Remove sources of contamination	Policy 2 : Isolating groundwater from contamination sources	Policy 3 : Preventing leakage of contaminated water
①Clean up contaminated water with Multi Nuclides Removal Facility (ALPS) ②Remove contaminated water in trenches	③Pumping up groundwater through groundwater bypasses ④Pumping up groundwater through wells near buildings ⑤Installation of land side impermeable wall with frozen soil ⑥Paving of site to curb permeation of rainwater into soil	⑦Ground improved with chemical materials ⑧Installation of impermeable walls on the sea side ⑨Augmentation of tanks (replacement with welded tanks, etc.)



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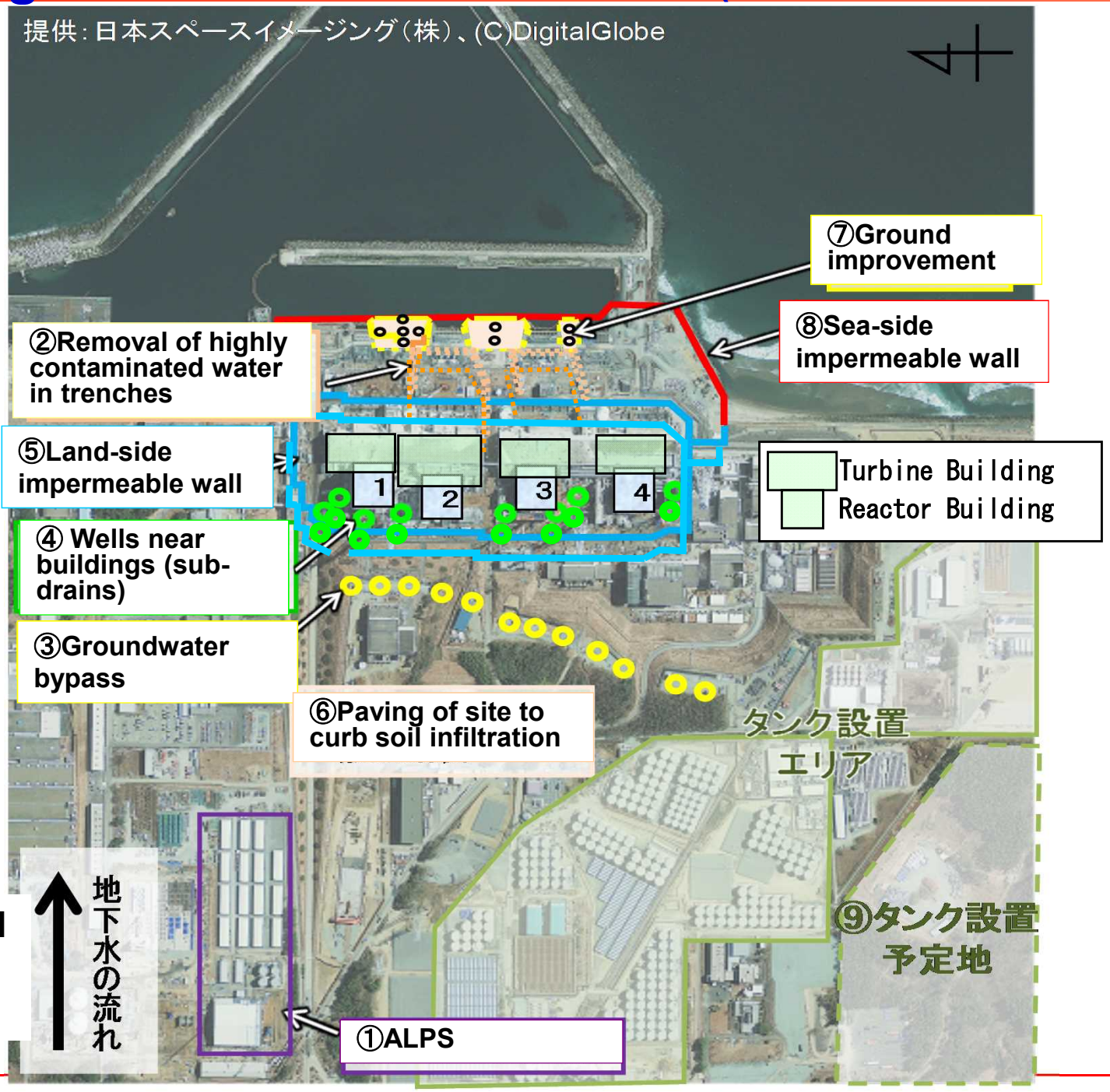
2. Measures against Contaminated Water (Locations of facilities)



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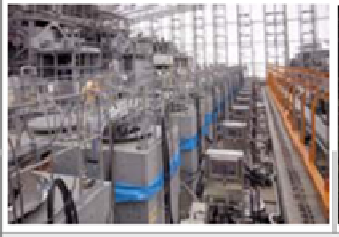
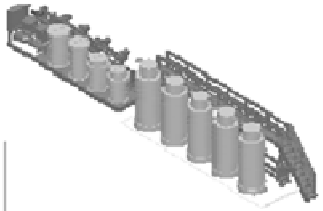
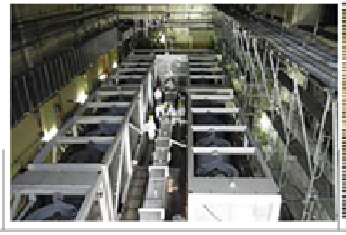
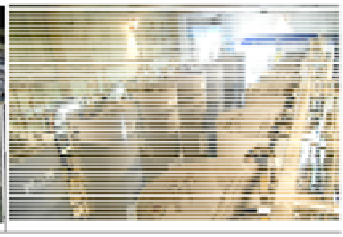
Expansion of the facility for purifying contaminated water

Contaminated water treatment facility	1 Multi-nuclide removal equipment	2 Extended multi-nuclide removal equipment	3 High-performance multi-nuclide removal equipment
			
Removal capability	Applicable to 62 nuclides, down to less than announced density limit		
Treatment capability	250 m^3/day x 3 systems	250 m^3/day x 3 systems	500 m^3/day
Current state	Test run (from March 30)	Test run (from September 17)	Test run (from October 18)

4 Mobile-type Sr removal system	5 RO concentrated water treatment system	6 Sr removal by KURION	7 Sr removal by SARRY
			
Strontium (Sr) amount: 1/100 to 1/1000			
300 m^3/day x 2 systems 480 m^3/day x 4 units	500-900 m^3/day	600 m^3/day	1,200 m^3/day
Operation (from October 2)	Operation (from January 10, 2015)	Operation (from January 6, 2015)	Operation (from December 26)

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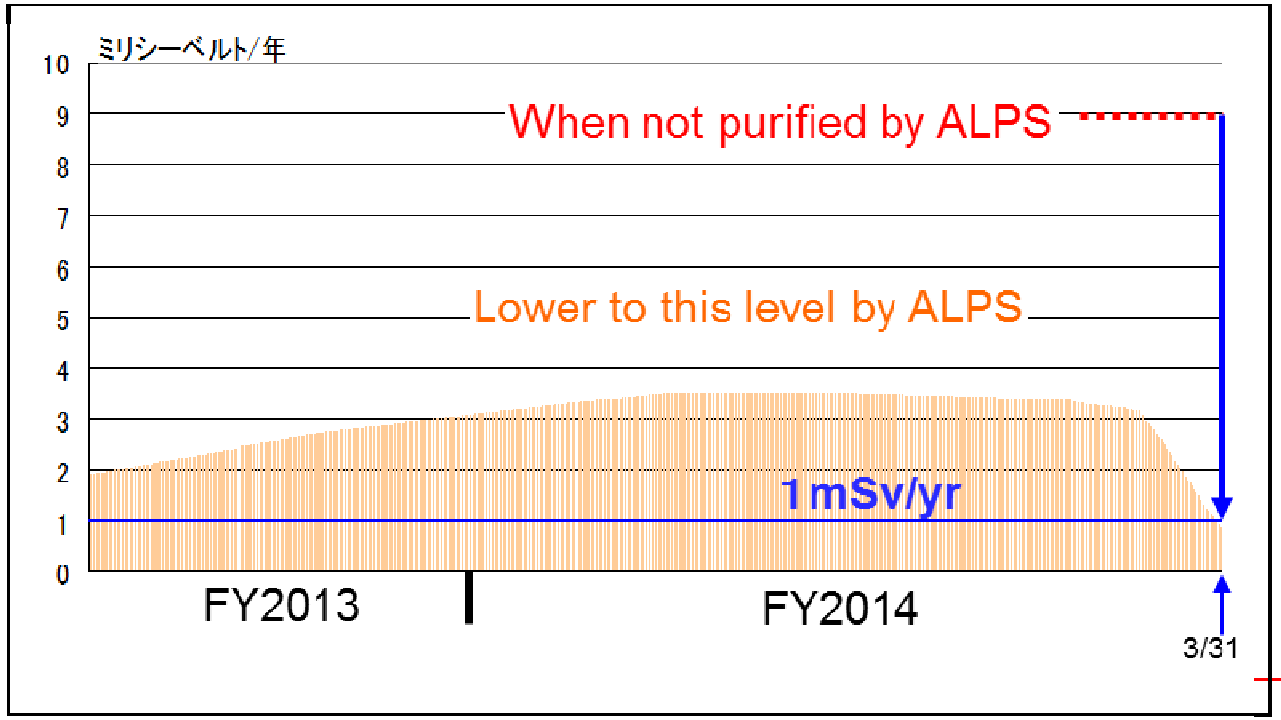
Prospect of contaminated water purification

Treatment of contaminated water stored in tanks

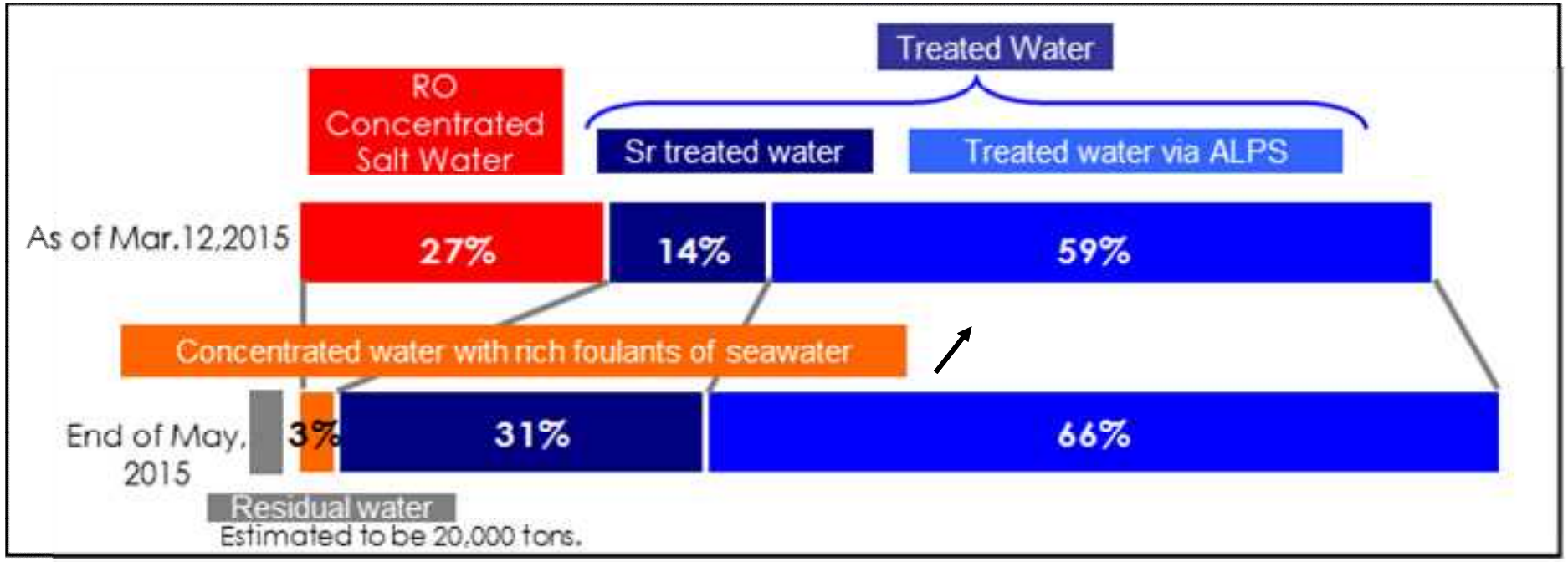
- Target of effective dosage at the site boundary attributed to tanks (evaluated value) is less than 1mSv/year by the end of March 2015.
- The treatment of RO contaminated salt water, with the exception of 3 percent of the total (approximately, 20, 000 tons) which includes rich sea water foulants produced at an early phase of the accident, will be completed by the end of May 2015.

Transition of the effective dosage at the site boundary attributed to tanks



- Contaminated water with rich foulants of seawater produced at an early phase of the accident requires additional time to process as calcium and magnesium hinder the rated flow operation to work normally.

Condition of contaminated water purification



Further decontamination of Strontium-removed water

- In order to further reduce risk, the water which has had strontium removed through non-ALPS facilities and water which was treated through ALPS during the period in the past when the facility was not performing optimally will be re-treated through the ALPS facility.

Continued treatment of groundwater accumulating in the reactor buildings

- Groundwater and other water (Approx. 300 tons/day of groundwater + 100 ton/day of water pumped up from well points) accumulating in the reactor buildings will be put through the cesium adsorption devices (Kurion and Sarry) in order to remove Strontium, and then further decontaminated through ALPS.

Residual water at the bottom of tanks

- Due to the structure of the facility, residual water will be produced as contaminated water retained at the bottom of a tank is hard to be pumped up completely.
- The total volume of residual water is estimated to be approx. 20,000 tons.
- The residual water will be removed when dismantling each tank following the preventive measures for dust scattering/ radiation exposure.

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Improvement of the tank area

- Cylindrical welded were installed on the south side of the premise.
- In order to suppress rainwater from flowing into the weir, rainwater guttering and a weir cover were installed on the top panel of the tanks.
- Furthermore, to minimize the leakage of contaminated water from the storage tank to the environment, the weir of the tank was doubled and extra coating was applied inside the weir.

Improvement status [1]: The way tanks were installed before the improvement of H1 area

Improvement status [1]: Welded tanks installed in the H1 area

Improvement status [2]: Flange type tanks before the improvement

Improvement status [2]: Flange type tanks after the weir covers were installed

Improvement status [3]: Circumference of weir of flange type tanks before the improvement

Improvement status [3]: Doubling the weir of flange type tanks and applying coating in the weir

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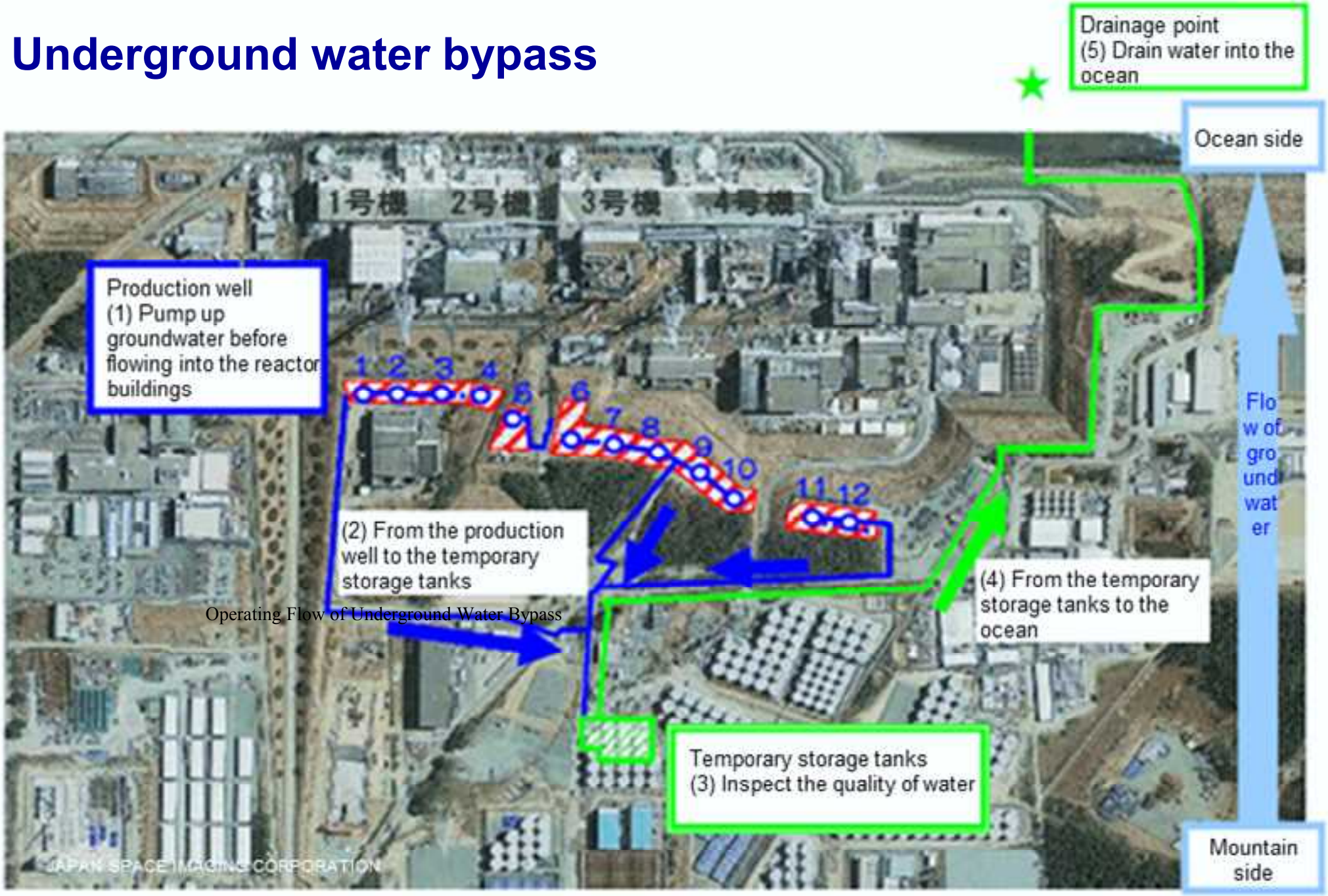
Underground water bypass



Operating Flow of Underground Water Bypass

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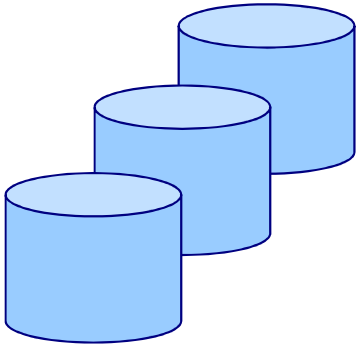
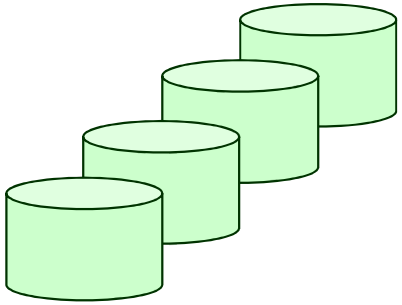
- Since May 21, 2014, underground water pumped up on the mountainside of the building has been discharged intermittently.
- Currently, 300 to 350 m^3 per day of underground water are pumped by bypassing the underground water.
- The water level of the observation pit was confirmed to be lowered (approx. 15 to 20 cm) after about 2 to 3 months from the start of the operation, and the flow of underground water into the building is gradually decreasing. The evaluation shows that the underground water into the building decreases about 100 m^3 per day.

Pump up groundwater → **Inspection of the water quality** → **Discharge**



Criteria for discharge of pumped water Unit: Bq/l

	Cesium 134	Cesium 137	Total Beta radiation	Tritium
TEPCO	ND (0.63)	ND (0.64)	ND (0.85)	130
Third-party agency	ND (0.86)	ND (0.76)	ND (0.51)	120
TEPCO's limit	1	1	5 (1)※	1,500
Legally notifiable limit	60	90	-	60,000
WHO drinking water quality guideline	10	10	-	10,000



※Confirm that 1Bq/l is met about once in ten days

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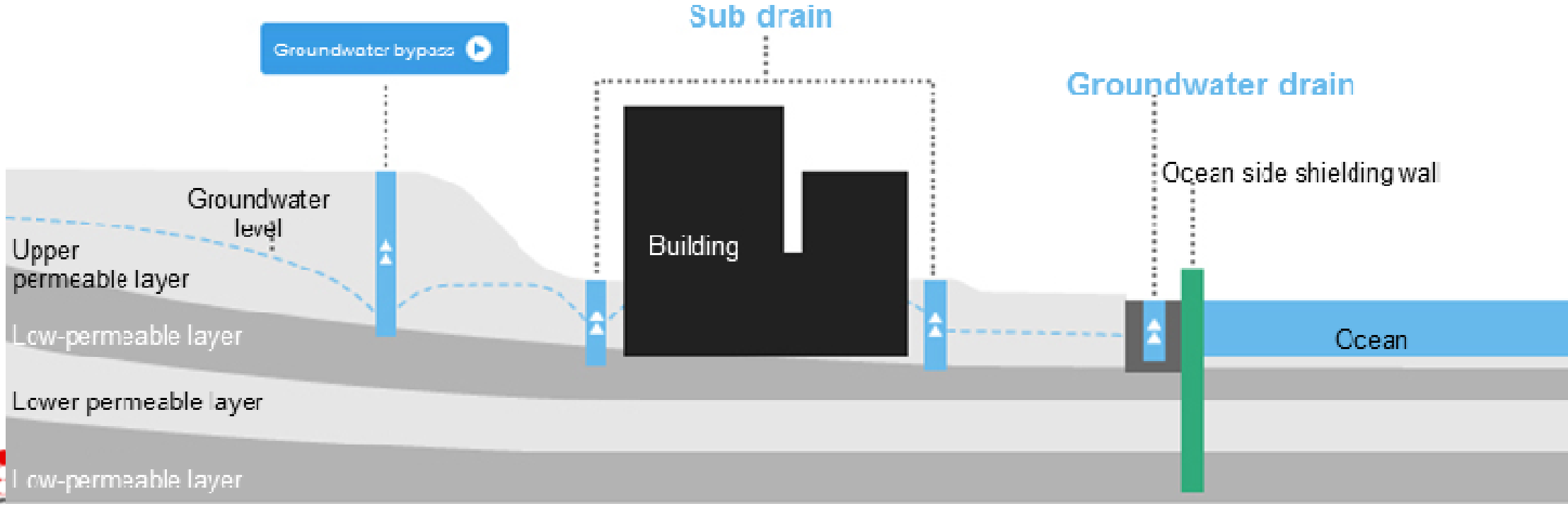
Sub Drain

- In order to further reduce the groundwater inflow into the buildings, lowering the underground water level around the building by the sub drain wells is being prepared.
- A dedicated purification facility was installed to reduce the radioactive materials contained in the sub drain water to about 1/1,000 to 1/10,000.
- The processed sub drain water will be drained to the port after checked to satisfy the water quality standards. The draining will be carried out after obtaining understanding of the relevant authorities, the parties concerning fishery, etc.



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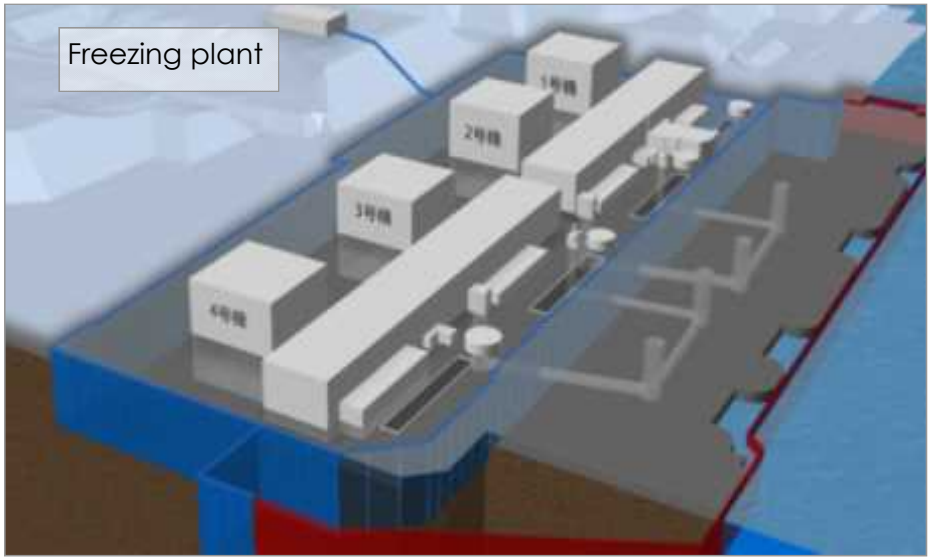
Land side impermeable wall with frozen soil

- Buildings will be enclosed by ice wall to curb inflow of groundwater into buildings
- Since August 2013, field tests have been conducted and full-scale construction began in June 2014
- Freezing (mountain side) is planned to start from May 2015

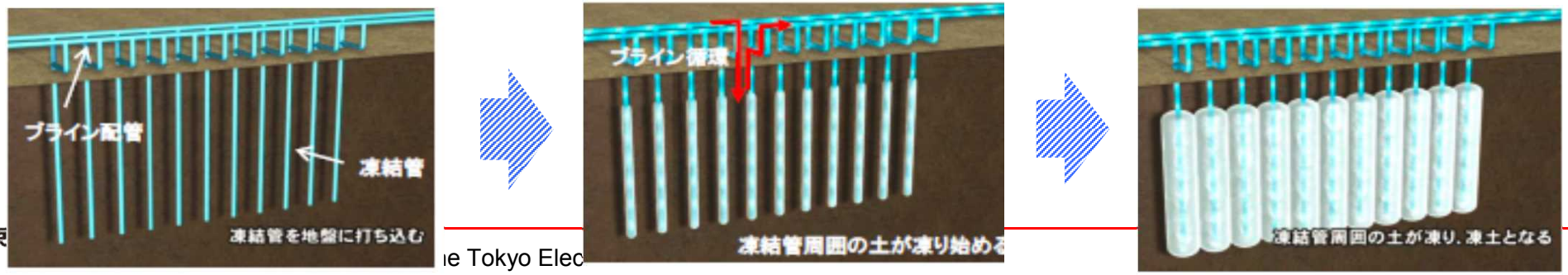


Freezer plant building where freezers are installed

Construction work

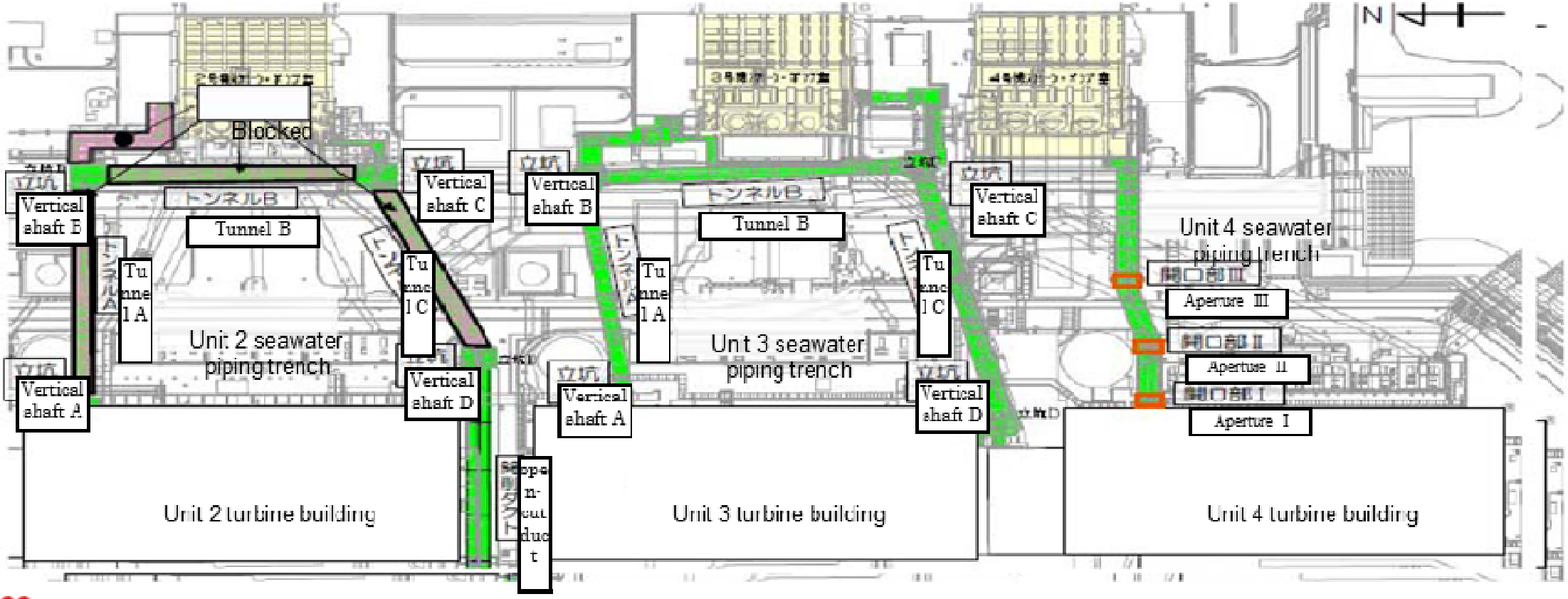
Image of constructing land side impermeable wall

Frozen soil will be formed by circulating coolant



Removal of retained water from seawater piping trench in Units 2, 3 and 4

- Highly contaminated water from immediately after accident remains in trenches on sea side area.
- Highly contaminated water, which poses a risk of infiltrating or spreading into surrounding area, will be removed



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3. Improvement of Work Environment

- After removal of debris and clean up of waste, working environment is substantially improved.

Removal of debris

Before work

After work

In front of the Unit 2 T/B

Radioactive Waste Management Building

In front of the Unit 4 T/B

Sort out in tank areas

Before work

After work

Pavement at coastal side

Before work

After work

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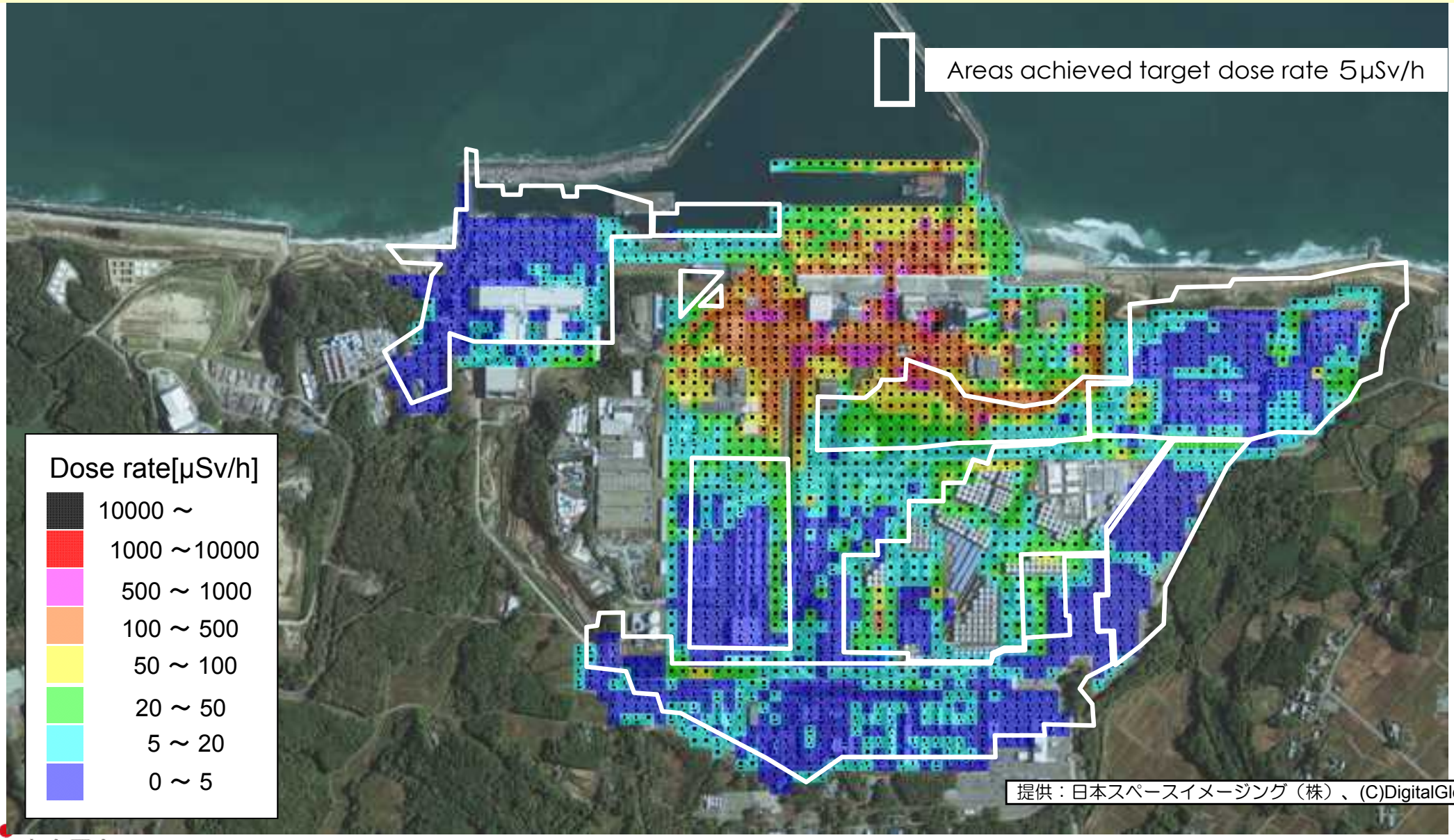
Current dose rate at the site

- Dose reduction target (< 5μSv/h) are achieved in many areas.
- Full face mask is not required in most of the site area.



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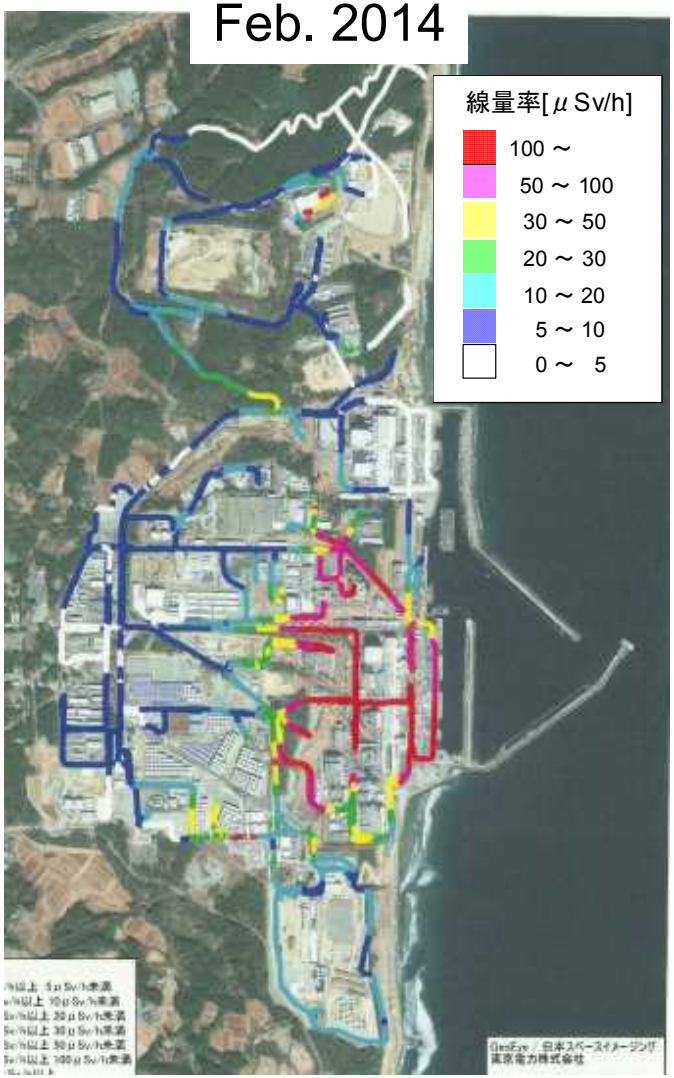
Progress of decontamination at the site

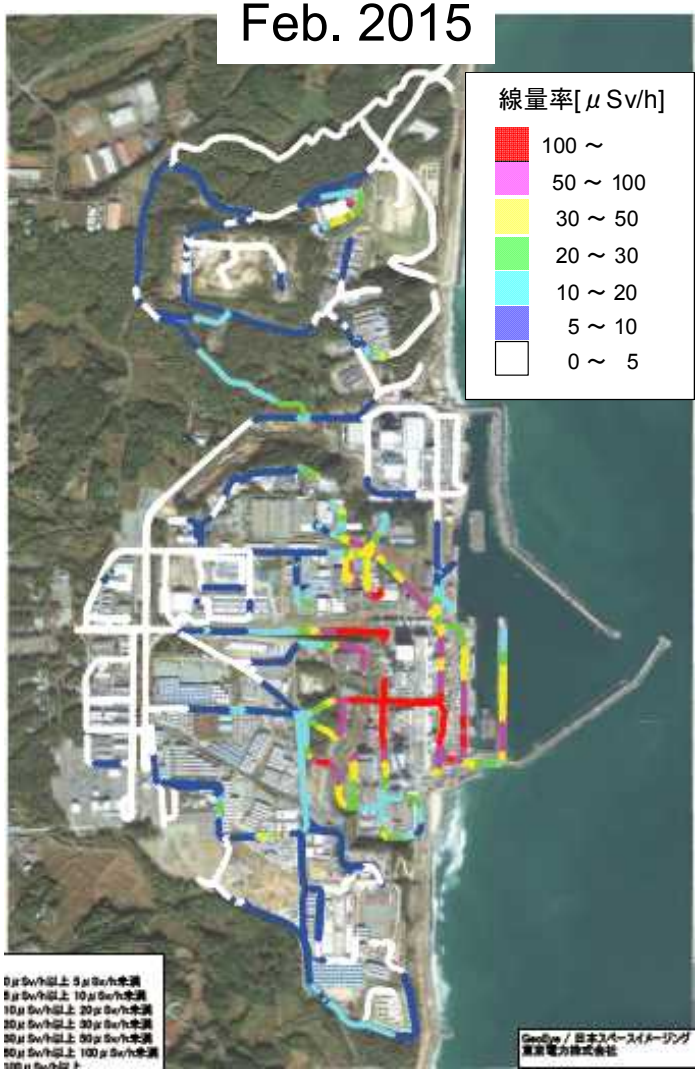
■Dose rate distribution on main roads are decreasing year by year.

Feb. 2013

Feb. 2014



Feb. 2015



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Annual dose April 2013-March 2014

- About 96% was below 20mSv/yr in April 2013- March 2014
- No one exceeded 50mSv/yr. About 4% was 20mSv-50mSv/yr
- Controls are given for all workers not to exceed 50 mSv/yr once they reach at 18mSv

(mSv)	April 2013～March 2014		
	TEPCO	Contractor	Total
250>	0	0	0
200>～250<=	0	0	0
150>～200<=	0	0	0
100>～150<=	0	0	0
75>～100<=	0	0	0
50>～75<=	0	0	0
20>～50<=	31	629	660
10>～20<=	95	2067	2162
5>～10<=	195	1897	2092
1>～5<=	670	3739	4409
1<=	702	4722	5424
Total	1693	13054	14747
Max(mSv)	41.90	41.40	41.90
Avarage(mSv)	3.24	5.51	5.25

Below 20mSv
Approx.96%

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Improved welfare facilities

- An off-site temporary resting area with capacity of approximately 1,000 workers started operation in April 2014.
- A large on-site resting area capable of being used by approximately 1,200 workers to be completed in the beginning of 2015.
- The construction work of a new office building was completed in October 2014 where approximately 1200 TEPCO/FDEC employees are working, allowing for smooth communication with areas close to the field.
- Fukushima Revitalization Meal Service Center completed construction to provide warm food to workers at the site. Local employment as well as use of local products consumption will be enhanced.

Off-site temporary resting area

Large resting area under construction

New office building

Meal Service Center

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4. Investigation on unconfirmed/unclear matters --- Purpose ---

Explaining what actually happened in the Fukushima Daiichi Nuclear Power Station accident will help improve the safety of power generating facilities in Japan and the rest of the world

As the operator of the nuclear power station and the main party responsible for the accident, we are fully committed to clarifying all aspects of the accident

Solving reactor decommissioning issues and accumulating information

Improvement in safety measures and heightened safety at Kashiwazaki-Kariwa Nuclear Power Station

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Report on progress made in investigating and studying unconfirmed/unclear matters

Verified the accident's details based on information obtained, as far as possible, through on-site verifications, records, interviews and data collection in combination with analysis techniques.

↓

Compiled and released in TEPCO's study reports on the Fukushima Accident (December 2011, June 2012). Study is still ongoing.

↓

52 unconfirmed/unclear matters identified

- Matters on which TEPCO has completed review
  - Almost complete: **10**
    [Contents of the first progress report]
- Matters on which TEPCO has yet to complete review
  - 10 high-priority issues
  - 34 lower-priority issues

*

- **Review to continue Second time onwards**
- **Reviewed with a flexible system ar with the cooperation of external researchers**
- **Analysis to begin with higher-priority matters**

We will report on progress on a semi-annual basis,
and aim to produce conclusions on higher-priority matters within two years

*** We continue to study 2 matters from the previous results as a starting point**

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Progress made in the study of ten high-priority issues

Issues covered by the present report

- Factors in the shutdown of the reactor core isolation cooling system at Unit 3 — Unit 3-1
- Evaluation of HPCI system operational state at Unit 3 and its impact on the accident's progression — Unit 3-5
- Rise in reactor pressure following forced depressurization at Unit 2 — Unit 2-7
- Improving the accuracy of our estimate of the volume of cooling water injections from fire engines into the nuclear reactor — Shared-2

Issues under review (investigated by TEPCO)

- Study of safety relief valve operation after reactor core damage — Shared-1
- Vent operation and rupture disk status at Unit 2 — Unit 2-9

Issues under review (government R&D projects, etc.)

- Melted core's behavior in dropping to the lower plenum — Shared-6
- Thermal stratification in the suppression pool at Unit 3 — Unit 3-3

Issues on which review has yet to begin

- Release of radioactive materials from March 20 onwards — Shared-9
- Identification of causes for the high-dose contamination of pipes in the reactor cooling water system at Unit 1 — Unit 1-9

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Ten issues on which review was virtually completed in the first progress report

- Tsunami arrival evaluation and the fact that the tsunami was a factor in causing the loss of cooling function	Shared-14
- Relationship between the earthquake and flooding in Unit 1's reactor building (R/B)	Unit 1-4
- Cooling water injected into the reactor from fire engines and leakage routes	Unit 1-9
- RCIC flow rate after loss of control power at Unit 2	Unit 2-1
- State of the RHR system after the tsunami's arrival at Unit 2	Unit 2-4
- Decrease behavior of PCV pressure temporarily decreased after RCIC shutdown at Unit 2	Unit 2-5
- State of HPCI operation estimated based on reactor water level behavior during HPCI operation at Unit 3	Unit 3-4
- Process of reactor core damage estimated based on reactor water level behavior after HPCI shutdown at Unit 3	Unit 3-5
- Possibility of rapid reactor depressurization due to ADS triggered at Unit 3	Unit 3-6
- Steep increase in reactor pressure following rapid depressurization at Unit 3, and its relationship to the process of reactor core damage	Unit 3-7

On the basis of past results, we will continue to review and reflect the results onto the second progress report (Shared-2 Unit 3-5)

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Activity for sharing the insights obtained from investigation and Discussion with researchers in the world

The Atomic Energy Society of Japan meetings / International meetings

We have given presentations on study results at academic or international meetings. Fortunately we received technical awards at some meetings. We will continue the study considering comments and other results obtained from these activities.

＜Presentation＞
AESJ meeting：2013 Spring, 2013 Fall, 2014 Spring meeting
International meeting：
NURETH (Nuclear Reactor Thermal Hydraulics) 10th meeting
NUTHOS (Nuclear Thermal Hydraulics, Operation and Safety) 9th meeting
International Workshop on Severe Accident Research, Tokyo Univ.

OECD/NEA BSAF project

We have shared our study results and accident information among the BSAF project members. Comparing simulation results of domestic and foreign researchers and exchanging opinions are helpful for us to study the unsolved issues

OECD/NEA：The Organization for Economic Co-operation and Development/The Nuclear Energy Agency
BSAF：“Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Station” has been established to improve severe accident codes and analyze accident progression and current core status in detail for preparation of fuel debris removal, as a part of the R&D projects for the mid-to-long term response for decommissioning of the Fukushima Daiichi

Nuclear Regulation Authority, JAPAN The Committee on Accident Analysis

We explained our evaluation of tsunami arrival time and the cause of losing all power sources, which is mentioned in Interim report (DRAFT) made by NRA. We will continue the study reflecting the field investigations and analysis results performed by the Committee.

Niigata Prefecture Technical Committee

We have explained the issues regarding questions and interests from the governor or committee members for the discussion at Niigata Prefecture's technical committee on verification of Fukushima Daiichi accident and safety measures at Kashiwazaki-Kariwa Nuclear Power station.

We are continuing our investigation reflecting the discussions and opinions from various parties and researchers

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Thank you for your attention

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