Outline of Decommissioning and Contaminated Water Management

September 24, 2020
Secretariat of the Team for Countermeasures for Decommissioning and Contaminated Water Treatment

Main decommissioning work and steps

Fuel removal from the spent fuel pool was completed in December 2014 at Unit 4 and started from April 15, 2019 at Unit 3. Dust concentration in the surrounding environment is being monitored and work is being implemented with safety first. Work continues sequentially toward the start of fuel removal from Units 1 and 2 and debris (Note 1) retrieval from Units 1-3.

(Note 1) Fuel assemblies having melted through in the accident.

Fuel Removal from SFP

Units 1 & 2: Rubble removal & dose reduction → Installing fuel removal machine

Unit 3: Fuel removal

Unit 4: Storage and handling

Units 1-6	Completion of fuel removal	Within 2031
Unit 1	Start of fuel removal	FY2027 - FY2028
Unit 2	Start of fuel removal	FY2024 - FY2026
Unit 3	Completion of fuel removal	Within FY2020
Unit 4	Completion of fuel removal	2014

Fuel Debris Retrieval

Unit 1-3: Ascertaining the status inside the PCV/ examining the fuel debris retrieval method, etc. (Note 2) → Fuel debris retrieval → Storage and handling

Unit 2

First unit	Start of fuel debris retrieval
Unit 2	Within 2021

Dismantling Facilities

Scenario development & technology consideration → Design and manufacturing of devices / equipment → Dismantling

Fuel removal from the spent fuel pool

Fuel removal from the spent fuel pool started from April 15, 2019 at Unit 3. With the aim of completing fuel removal by the end of FY2020, rubble and fuel are being removed.

Fuel removal (April 15, 2019)

Removed fuel (assemblies)
336/566
(As of September 24, 2020)

Contaminated water management proceeds with the following three efforts:

(1) Efforts to promote contaminated water management based on the three basic policies

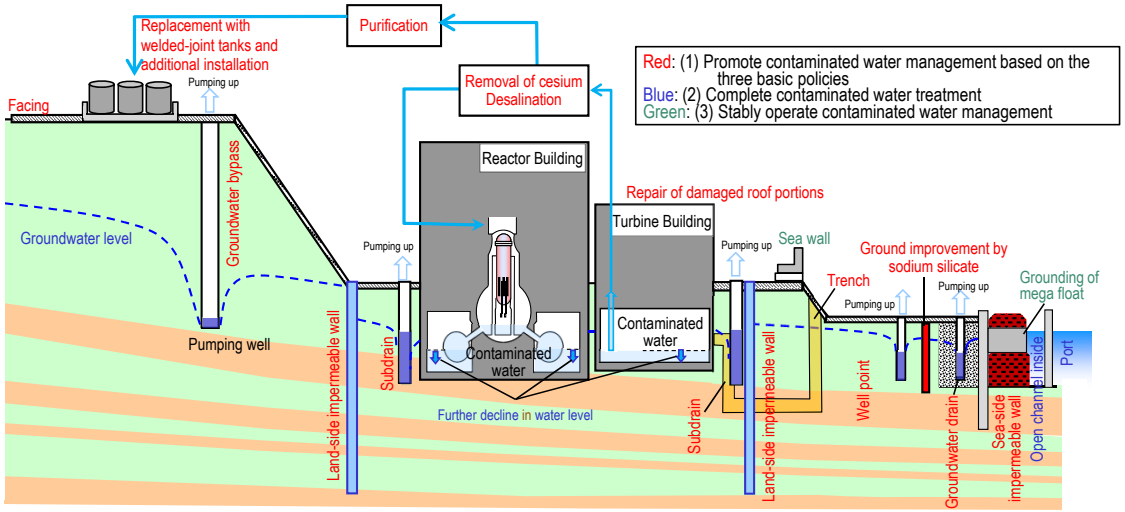
[Three basic policies]
1. "Remove" the source of water contamination
2. "Redirect" fresh water from contaminated areas
3. "Retain" contaminated water from leakage

(2) Efforts to complete contaminated water treatment

4. Treatment of contaminated water in buildings
5. Measures to remove α–nuclide and reduce the concentration in contaminated water
6. Measures to alleviate the radiation dose of Zeolite sandbags in the Process Main Building and High-Temperature Incinerator Building and examine safe management methods

(3) Efforts to stably operate contaminated water management

7. Planning and implementing necessary measures to prepare for large-scale disasters such as tsunami and heavy rain
8. Periodically inspecting and updating facilities to maintain the effect of contaminated water management going forward
9. Examining additional measures as required, with efforts to gradually expand the scale of fuel debris retrieval



(1) Efforts to promote contaminated water management based on the three basic policies

- Strontium-treated water from other equipment is being re-treated in the multi-nuclide removal equipment (ALPS) and stored in welded-joint tanks.
- Multi-layered contaminated water management measures, including land-side impermeable walls and subdrains, have stabilized the groundwater at a low level and the increased contaminated water generated during rainfall is being suppressed by repairing damaged portions of building roofs, facing onsite, etc. Through these measures, the generation of contaminated water was reduced from approx. 540 m^3/day (in May FY2014) to approx. 180 m^3/day (in FY2019).
- Measures continue to further suppress the generation of contaminated water to approx. 150 m^3/day within FY2020 and 100 m^3/day or less within 2025.

(2) Efforts to complete contaminated water treatment

- Contaminated water levels in buildings declined as planned and connected parts between Units 1 and 2 and 3 and 4 were respectively separated. For α-nuclide detected as water levels progressively declined, characteristics are being determined and treatment methods examined.
- Treatment of contaminated water in buildings will be completed within 2020, excluding Unit 1-3 Reactor Buildings, Process Main Building and High-Temperature Incinerator Building. For Reactor Buildings, the amount of contaminated water there will be reduced from the level at the end of 2020 during the period FY2022-2024.
- For Zeolite sandbags on the basement floors of the Process Main Building and High-Temperature Incinerator Building, measures to reduce the radiation dose are being examined with stabilization in mind.

(3) Efforts to stably operate contaminated water management

- To prepare for tsunamis, measures including closing building openings, installing sea walls are being implemented. For heavy rain, sandbags are being installed to suppress direct inflow into buildings while work to enhance drainage channels and other measures are being implemented as planned.

Progress Status and Future Challenges of the Mid-and-Long-Term Roadmap toward Decommissioning of TEPCO Holdings Fukushima Daiichi Nuclear Power Station (Outline)

Progress status

◆ The temperatures of the Reactor Pressure Vessel (RPV) and Primary Containment Vessel (PCV) of Units 1-3 have been maintained within the range of approx. 25-35°C[*1] over the past month. There was no significant change in the concentration of radioactive materials newly released from Reactor Buildings into the air[*2]. It was concluded that the comprehensive cold shutdown condition had been maintained.

* 1 The values varied somewhat, depending on the unit and location of the thermometer.

* 2 In August 2020, the radiation exposure dose due to the release of radioactive materials from the Unit 1-4 Reactor Buildings was evaluated at less than 0.00004 mSv/year at the site boundary. The annual radiation dose from natural radiation is approx. 2.1 mSv/year (average in Japan).

Start of preparatory work toward installing support to the Unit 1 overhead crane

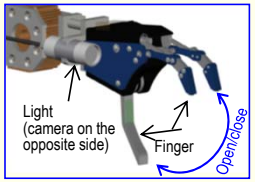
Before removing the fallen roof and other objects on the south side of the Unit 1 Reactor Building, to minimize the risk of the overhead crane shifting its position, becoming imbalanced and subsequently falling, materials to support the overhead crane from below will be installed.

Preparatory work will start from October and installation of the support will be completed in November.

Plan to investigate deposits inside the Unit 2 PCV penetration toward Unit 2 PCV inside investigation and trial retrieval

In the investigation inside the Unit 2 Primary Containment Vessel (PCV) and the trial retrieval of fuel debris, an arm-type device will be inserted from the PCV penetration (X-6 penetration) into the PCV. Before this investigation, deposits which may interfere with the work inside the X-6 penetration will be removed. To help examine the procedures of this removal work, an investigation into distribution of deposits and others inside the X-6 penetration will be implemented using a survey unit from around mid-October onward.

Toward starting the trial retrieval of Unit 2 fuel debris scheduled in 2021, work will continue while ensuring safety measures such as suppressing dust scattering are implemented.



Survey unit

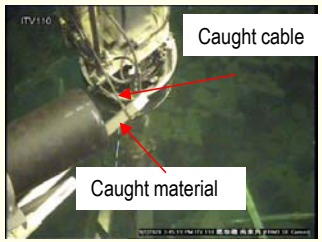
Inside the X-6 penetration (January 2017)

Examination of defect countermeasures toward resuming Unit 3 fuel removal

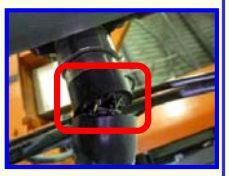
Since the resumption from May 26, Unit 3 fuel removal has continued. As of September 24, 336 of 566 fuel assemblies have been removed.

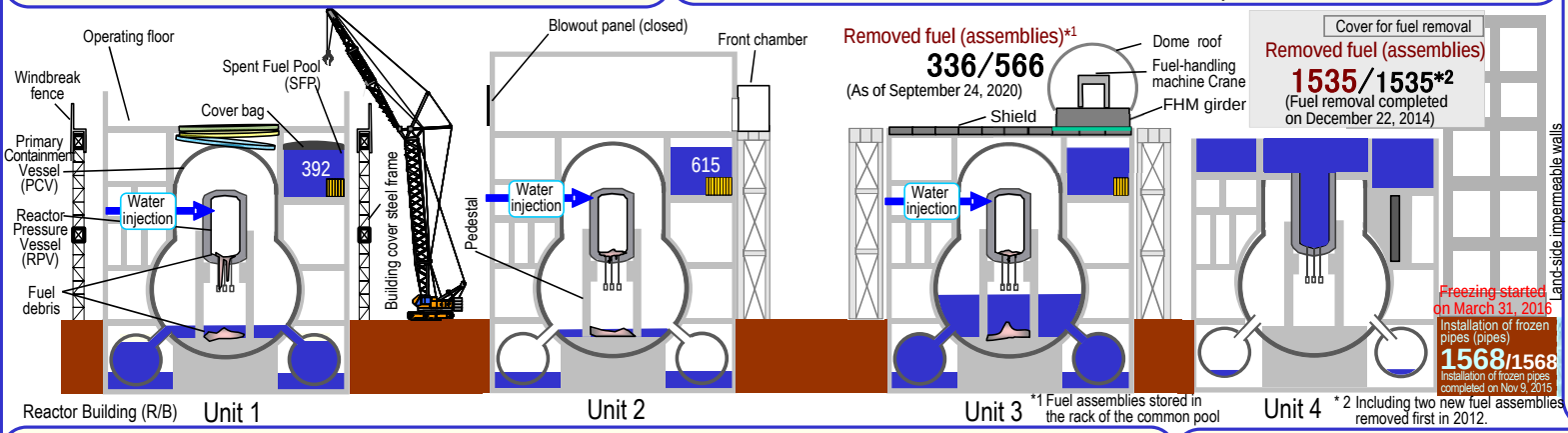
The work had been implemented steadily. On September 2, however, a cable* of the fuel-handling machine was damaged when caught by material near the wall on the south side of the pool while fuel assemblies within the pool were being transferred. The damaged cable was replaced with a spare but a subsequent operation check conducted on September 18 detected an abnormality in the signals, indicating the seating condition of the gripper or others. Repair the gripper is being examined. While fuel removal was suspended, damage to the crane hydraulic hose* was also detected, which will be replaced with a spare.

* Cable: A cable for signals indicating the opening/closure and seating conditions of the gripper
* Hydraulic hose: A hydraulic hose used to tighten the cask lid and install the flange protector



Damage of FHM cable


Damaged cable



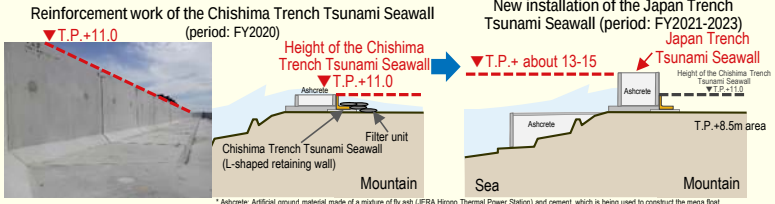
*1 Fuel assemblies stored in the rack of the common pool

* 2 Including two new fuel assemblies removed first in 2012.

Plan to newly install the Japan Trench Tsunami Seawall

In response to the new evaluation by the "Investigative Commission for the Giant Earthquake Model along the Japan and Chishima Trenches" of the Cabinet Office in April 2020 that rated the Japan Trench tsunami as an imminent emergency, the influence was reevaluated. The result showed that when the Japan Trench tsunami comes, the area around Unit 1-4 will be subject to flooding of about 0.3m (Unit 1 and 4 Reactor Buildings) - 1.4m (Unit 1 Turbine Building). To suppress this flooding by the imminent Japan Trench tsunami, prevent any increase in contaminated water due to inflow into buildings and alleviate damage to important facilities for decommissioning, the "Japan Trench Tsunami Seawall" will be constructed during the period FY2021-2023.

The construction of the Chishima Trench Tsunami Seawall, which started from the 1st half of FY2019, will be completed on September 25, 2020. However, based on the evaluation result of the Japan Trench Tsunami, reinforcement work will continue within FY2020.



<Chishima Trench Tsunami Seawall>

* Ashcrete: Artificial ground material made of a mixture of fly ash (JERA Hirono Thermal Power Station) and cement, which is being used to construct the mega float
* Filter Unit: Civil engineering structure comprising net bags, including 50-200mm stones particles, which has been used throughout the 1F site since the earthquake

Start of performance verification for the secondary treatment of ALPS-treated water

The performance test of the secondary treatment started from September 15 to verify that the sum of the ratios of the concentrations required by law* except for tritium is reduced to less than one after secondary treatment by ALPS and check the procedures and process of the nuclide analysis.

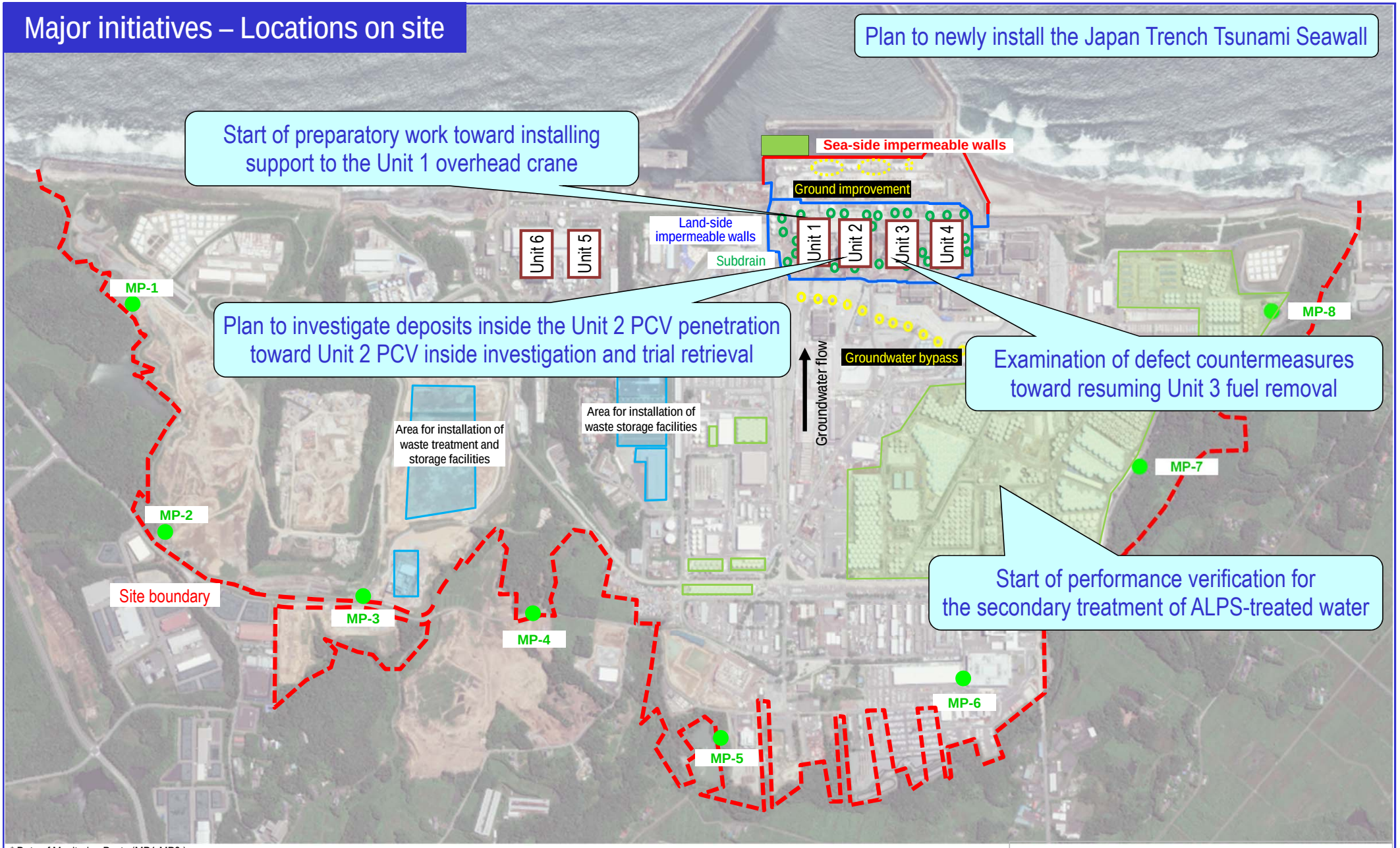
For the test, from tank areas whose sum of ratios of concentrations required by law is 100 or more, J1-C area (the sum of major seven nuclides: 3,791 (J1-C1)) and J1-G area (153 (J1-G1)) were selected as the specimen.

The performance test will be conducted until mid-October (planned) using the "Additional ALPS." Treated water will be analyzed and evaluated (for several months (planned)) concerning nuclides that must be removed (62 nuclides), radiocarbon (C-14) and tritium (H-3).


<Additional ALPS>

* The sum of concentration ratios calculated to the concentration limits required by law as specified for each radioactive material

Major initiatives – Locations on site



* Data of Monitoring Posts (MP1-MP8.)

Data (10-minute values) of Monitoring Posts (MPs) measuring the airborne radiation rate around site boundaries showed 0.324 – 1.217 μSv/h (September 1 - 22, 2020).

We improved the measurement conditions of monitoring posts 2 to 8 to measure the air-dose rate precisely. Construction work, such as tree-clearing, surface soil removal and shield wall setting, were implemented from February 10 to April 18, 2012.

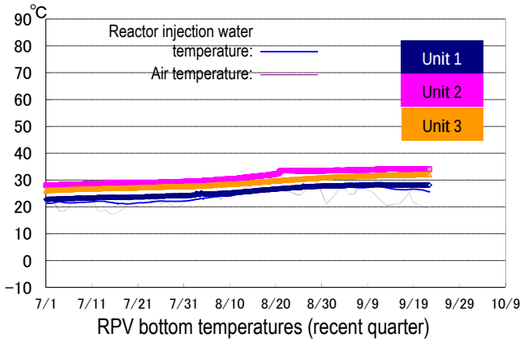
Therefore, monitoring results at these points are lower than elsewhere in the power plant site.

The radiation shielding panels around monitoring post No. 6, which is one of the instruments used to measure the radiation dose at the power station site boundary, were taken off from July 10 - 11, 2013, since further deforestation, etc. had caused the surrounding radiation dose to decline significantly.

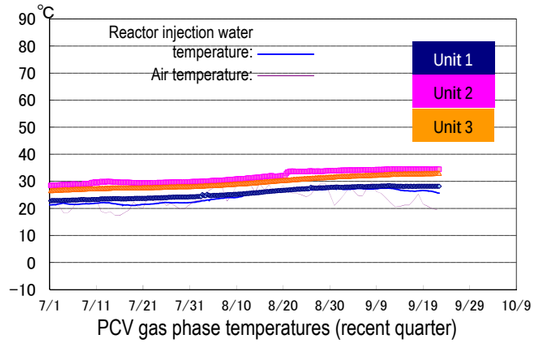
I. Confirmation of the reactor conditions

1. Temperatures inside the reactors

Through continuous reactor cooling by water injection, the temperatures of the Reactor Pressure Vessel (RPV) bottom and the Primary Containment Vessel (PCV) gas phase were maintained within the range of approx. 25 to 35°C for the past month, though it varied depending on the unit and location of the thermometer.



RPV bottom temperatures (recent quarter)



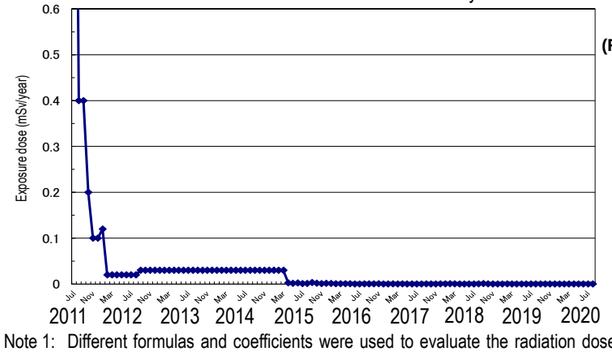
PCV gas phase temperatures (recent quarter)

* The trend graphs show part of the temperature data measured at multiple points.

2. Release of radioactive materials from the Reactor Buildings

As of August 2020, the concentration of the radioactive materials newly released from Reactor Building Units 1-4 into the air and measured at the site boundary was evaluated at approx. 1.6×10^{-12} Bq/cm³ and 1.9×10^{-12} Bq/cm³ for Cs-134 and Cs-137 respectively, while the radiation exposure dose due to the release of radioactive materials there was less than 0.00004 mSv/year.

Annual radiation dose at site boundaries by radioactive materials (cesium) released from Reactor Building Units 1-4



(Reference)

* The concentration limit of radioactive materials in the air outside the surrounding monitoring area:
[Cs-134]: 2 x 10^{-5} Bq/cm³
[Cs-137]: 3 x 10^{-5} Bq/cm³

* Data of Monitoring Posts (MP1-MP8).
Data of Monitoring Posts (MPs) measuring the air dose rate around the site boundary showed 0.324 – 1.217 μSv/h (September 1 - 22, 2020).
To measure the variation in the air dose rate of MP2-MP8 more accurately, work to improve the environment (trimming trees, removing surface soil, and shielding around the MPs) was completed.

Note 1: Different formulas and coefficients were used to evaluate the radiation dose in the facility operation plan and monthly report. The evaluation methods were integrated in September 2012. As the fuel removal from the spent fuel pool (SFP) commenced for Unit 4, the radiation exposure dose from Unit 4 was added to the items subject to evaluation since November 2013. The evaluation has been changed to a method considering the values of continuous dust monitors since FY2015, with data to be evaluated monthly and announced the following month.

Note 2: Radiation dose was calculated using the evaluation values of release amount from Units 1-4 and Units 5 and 6. The radiation dose of Unit 5 and 6 was evaluated based on expected release amount during operation until September 2019 but the evaluation method was reviewed and changed to calculate based on the actual measurement results of Units 5 and 6 from October.

3. Other indices

There was no significant change in indices, including the pressure in the PCV and the PCV radioactivity density (Xe-135) for monitoring criticality, nor was any anomaly in the cold shutdown condition or criticality sign detected.

Based on the above, it was confirmed that the comprehensive cold shutdown condition had been maintained and the reactors remained in a stabilized condition.

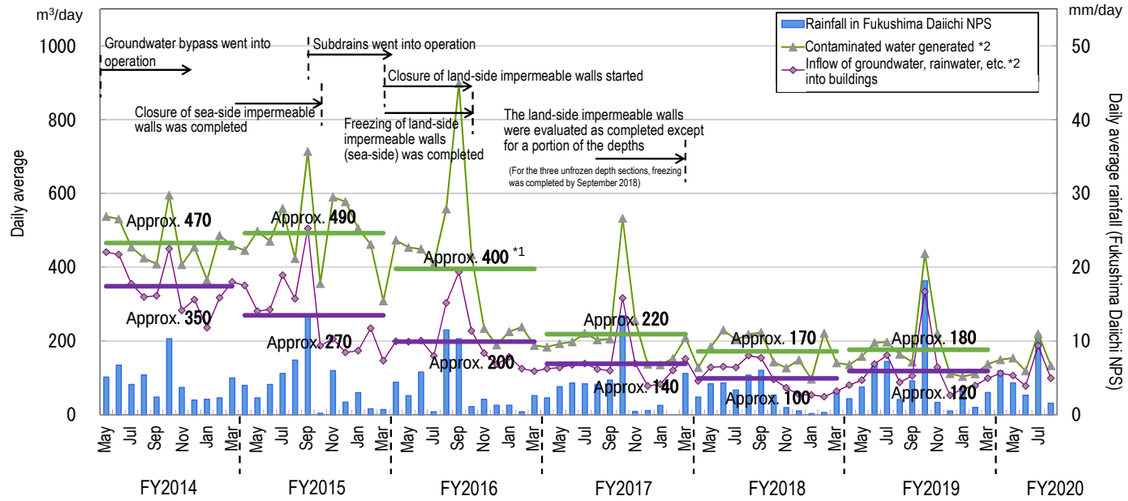
II. Progress status by each plan

1. Contaminated water management

Based on the three basic policies: "remove" the source of water contamination, "redirect" fresh water from contaminated areas and "retain" contaminated water from leakage, multi-layered contaminated water management measures have been implemented to stably control groundwater

➢ Status of contaminated water generated

- Multi-layered measures, including pumping up by subdrains and land-side impermeable walls, which were implemented to control the continued generation of contaminated water, suppressed the groundwater inflow into buildings.
- After "redirecting" measures (groundwater bypass, subdrains, land-side impermeable walls and others) were steadily implemented, the amount generated declined from approx. 470 m³/day (the FY2014 average) when the measures were first launched to approx. 180 m³/day (the FY2019 average).
- Measures will continue to further reduce the volume of contaminated water generated.



*1 Values differ from those announced at the 20th Committee on Countermeasures for Contaminated Water Treatment (held on August 25, 2017) because the method of calculating the contaminated water volume generated was reviewed on March 1, 2018. Details of the review are described in the materials for the 50th and 51st meetings of the Secretariat of the Team for Countermeasures for Decommissioning and Contaminated Water Treatment.

*2: The monthly daily average is derived from the daily average from the previous Thursday to the last Wednesday, which is calculated based on the data measured at 7:00 on every Thursday.

Figure 1: Changes in contaminated water generated and inflow of groundwater, rainwater, into buildings

➢ Operation of the groundwater bypass

- From April 9, 2014, the operation of 12 groundwater bypass pumping wells commenced sequentially to pump up groundwater. The release then started from May 21, 2014, in the presence of officials from the Intergovernmental Liaison Office for the Decommissioning and Contaminated Water Issue of the Cabinet Office. Up until September 23, 2020, 586,071 m³ of groundwater had been released. The pumped-up groundwater was temporarily stored in tanks and released after TEPCO and a third-party organization had confirmed that its quality met operational targets.
- Pumps are inspected and cleaned as required based on their operational status.

➢ Operation of the Water Treatment Facility special for Subdrain & Groundwater drains

- To reduce the level of groundwater flowing into the buildings, work began to pump up groundwater from wells (subdrains) around the buildings on September 3, 2015. The pumped-up groundwater was then purified at dedicated facilities and released from September 14, 2015, in the presence of officials from the Intergovernmental Liaison Office for the Decommissioning and Contaminated Water Issue of the Cabinet Office. Up until September 22, 2020, a total of 977,402 m³ had been drained after TEPCO and a third-party organization had confirmed that its quality met operational targets.
- Due to the rising level of the groundwater drain pond after the sea-side impermeable walls had been closed, pumping started on November 5, 2015. Up until September 23, 2020, a total of approx. 249,606 m³ had been pumped up and a volume of under 10 m³/day is being transferred from the groundwater drain to the Turbine Buildings (average for the period August 20 – September 16, 2020).

- As one of the multi-layered contaminated-water management measures, in addition to a waterproof pavement that aims to prevent rainwater infiltrating, facilities to enhance the subdrain treatment system were installed and went into operation from April 2018, increasing the treatment capacity from 900 to 1,500 m³/day and improving reliability. Operational efficiency was also improved to treat up to 2,000 m³/day for almost one week during the peak period.
- To maintain the groundwater level, work to install additional subdrain pits and recover those existing is underway. The additional pits are scheduled to start operation sequentially, from pits for which work is completed (12 of 14 new subdrain pits went into operation). To recover existing pits, work for all three pits scheduled was completed and all went into operation from December 26, 2018. Work to recover another pit started from November 2019 (No. 49 pit).
- To eliminate the need to suspend water pumping while cleaning the subdrain transfer pipe, the pipe will be duplicated. Installation of the pipe and ancillary facilities was completed.
- Since the subdrains went into operation, the inflow to buildings tended to decline to under 150 m³/day when the subdrain water level declined below T.P. 3.0 m but increased during rainfall.

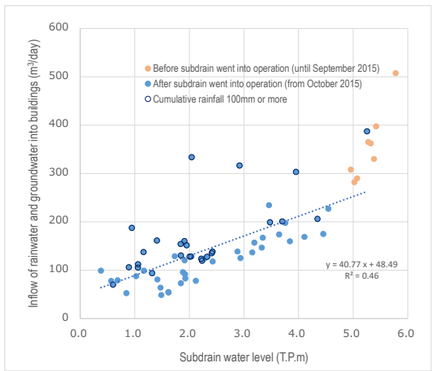


Figure 2: Correlation between inflow such as groundwater and rainwater into buildings and the water level of Units 1-4 subdrains

➢ Implementation status of facing

- Facing is a measure involving asphalting of the on-site surface to reduce the radiation dose, prevent rainwater infiltrating into the ground and decrease the amount of underground water flowing into buildings. As of the end of August 2020, 94% of the planned area (1,450,000 m² onsite) had been completed. For the area inside the land-side impermeable walls, implementation proceeds appropriately after constructing a yard from implementable zones that do not affect the decommissioning work. As of the end of August 2020, 12% of the planned area (60,000 m²) had been completed.

➢ Construction status of the land-side impermeable walls and status of groundwater levels around the buildings

- An operation to maintain the land-side impermeable walls and prevent the frozen soil from thickening further continued from May 2017 on the north and south sides and started from November 2017 on the east side, where sufficiently thick frozen soil was identified. The scope of the maintenance operation was expanded in March 2018.
- In March 2018, construction of the land-side impermeable walls was completed, except for a portion of the depth, based on a monitoring result showing that the underground temperature had declined below 0°C in almost all areas, while on the mountain side, the difference in internal and external water levels increased to approx. 4-5 m. The 21st Committee on Countermeasures for Contaminated-Water Treatment, held on March 7, 2018, evaluated that alongside the function of subdrains and other measures, a water-level management system to stably control groundwater and redirect groundwater from the buildings had been established and allowed the amount of contaminated water generated to be reduced significantly.
- A supplementary method was implemented for the unfrozen depth and it was confirmed that the temperature of this portion had declined below 0°C by September 2018. From February 2019, a maintenance operation started throughout all sections.

- The groundwater level in the area inside the land-side impermeable walls has been declining every year. On the mountain side, the difference between the inside and outside was maintained, despite varying during rainfall. The water level of the groundwater drain observation well has been maintained at approx. T.P.+1.5 m, sufficiently below the ground surface (T.P. 2.5 m).

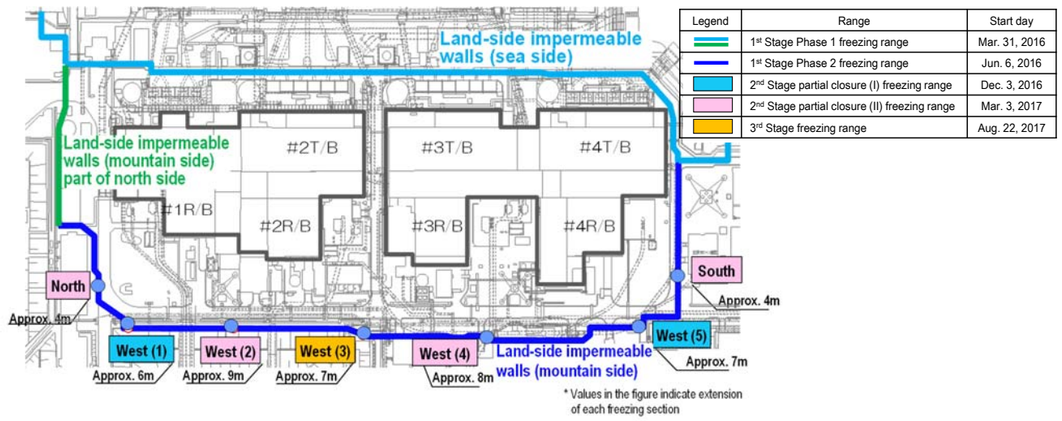


Figure 3: Closure parts of the land-side impermeable walls (on the mountain side)

➢ Operation of multi-nuclide removal equipment

- Regarding the multi-nuclide removal equipment (existing and high-performance), hot tests using radioactive water are underway (for existing equipment, System A: from March 30, 2013, System B: from June 13, 2013, System C: from September 27, 2013; and for high-performance equipment, from October 18, 2014). The additional multi-nuclide removal equipment went into full-scale operation from October 16, 2017.
- As of September 17, 2020, the volumes treated by existing, additional and high-performance multi-nuclide removal equipment were approx. 455,000, 682,000 and 103,000 m³, respectively (including approx. 9,500 m³ stored in the J1(D) tank, which contained water with highly concentrated radioactive materials at the System B outlet of the existing multi-nuclide removal equipment).
- To reduce the risks of strontium-treated water, treatment using existing, additional, and high-performance multi-nuclide removal equipment has been underway (existing: from December 4, 2015; additional: from May 27, 2015; high-performance: from April 15, 2015). Up until September 17, 2020, approx. 760,000 m³ had been treated.

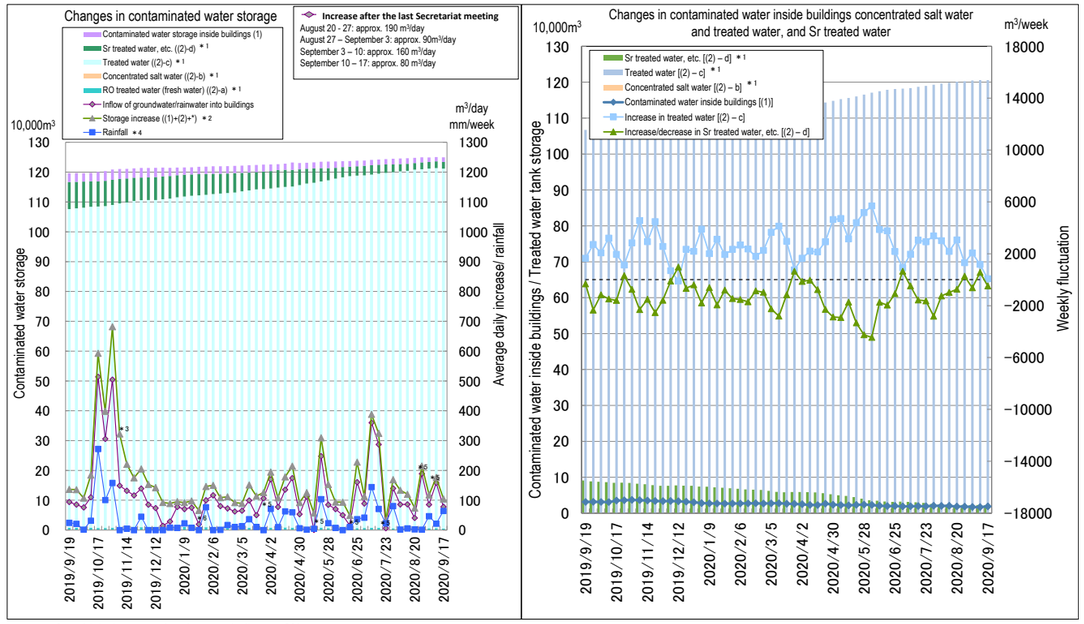
➢ Toward reducing the risk of contaminated water stored in tanks

- Treatment measures comprising the removal of strontium by cesium-absorption apparatus (KURION) (from January 6, 2015), the secondary cesium-absorption apparatus (SARRY) (from December 26, 2014) and the third cesium-absorption apparatus (SARRY II) (from July 12, 2019) are underway. Up until September 17, 2020, approx. 607,000 m³ had been treated.

➢ Measures in the Tank Area

- Rainwater accumulates and is collected inside the area of contaminated-water tanks. After removing radionuclides, the rainwater is sprinkled on the ground of the site, if the radioactivity level does not meet the standard for discharging into the environment since May 21, 2014 (as of September 21, 2020, a total of 165,376 m³).

As of September 17, 2020



*1: Water amount for which the water-level gauge indicates 0% or more

*2: To detect storage increases more accurately, the calculation method was reviewed as follows from February 9, 2017: (The revised method was applied from March 1, 2018)
[(Inflow of groundwater/rainwater into buildings) + (other transfer) + (chemical injection into ALPS)]

*3: The storage amount increased due to transfer to buildings in association with the decommissioning work.
(The transferred amount comprised (① Transfer of RO concentrated water from groundwater drains to Turbine Building: approx. 80 m³/day, ② Transfer from wells and groundwater drains: approx. 50 m³/day, ③ Transfer from Unit 5/6 SPT to Process Main Building: approx. 20 m³/day, others)

*4: Changed from December 13, 2018 from rainfall in Namie to that within the site.

*5: Considered attributable to the increased inflow of groundwater, rainwater, and others to buildings due to the decline in the level of contaminated water in buildings. (March 18, May 7-14, June 11-18, July 16-23, August 20-27, and September 3-10, 2020)

*6: From the period January 16-23, 2019, amid a decline in the water level in Unit 4 R/B, system water in S/C flowing into R/B contaminated water is reflected in the inflow of groundwater and rainwater in addition to the transferred amount generated in decommissioning work.

Figure 4: Status of contaminated water storage

➢ Secondary treatment of ALPS-treated water

- The performance test of the secondary treatment started from September 15 to verify that the sum of the ratios of the concentrations required by law* except for tritium is reduced to less than one after the secondary treatment by ALPS and check the procedures and process of the nuclide analysis.
- For the test, from the tank areas whose sum of the ratios of the concentrations required by law is 100 or more, J1-C area (the sum of major seven nuclides: 3,791 (J1-C1)) and J1-G area (153 (J1-G1)) were selected as the specimen.
- The performance test will be conducted until mid-October (planned) using the “Additional ALPS.” Treated water will be analyzed and evaluated (for several months (planned)) concerning nuclides that must be removed (62 nuclides), radiocarbon (C-14) and tritium (H-3).

  * The sum of concentration ratios calculated to the concentration limits required by law as specified for each radioactive material.

➢ Progress Status of earthquakes and tsunami countermeasures

- In response to the new evaluation by the “Investigative Commission for the Giant Earthquake Model along the Japan and Chishima Trenches” of the Cabinet Office in April 2020 that rated the Japan Trench tsunami as an imminent emergency, the influence was reevaluated. The result showed that when the Japan Trench tsunami comes, the area around Unit 1-4 will be subject to flooding of about 1.5m.
- To suppress this flooding by the imminent Japan Trench tsunami, prevent any increase in contaminated water due to inflow into buildings and alleviate the damage to important facilities for decommissioning, the “Japan Trench Tsunami Seawall” will be constructed during the period FY2021-2023.
- The construction of the Chishima Trench Tsunami Seawall, which started from the 1st half of FY2019, will be completed on September 25, 2020. However, based on the evaluation result of the Japan Trench Tsunami, reinforcement work will continue within FY2020.

➢ Leakage from the pipe connecting with the Unit 3 FSTR building CUW spent resin storage tank

- On September 1, 2020, the operator detected an increase in the contaminated water level on the basement floor of the Unit 3 FSTR building.
- The following field inspection confirmed leakage from the pipe connecting with the Reactor Water Clean-up System (CUW) spent resin storage tank.
- The leaked liquid waste was considered as remaining within the building, based on the fact that the portion with leakage was unconnected to the outside and the contaminated water level was sufficiently lower than the subdrain water level around the building. It was also confirmed that there was no significant variation in the radioactivity concentration of Subdrain No.37 located near the building.
- A method to collect leakage, including resin, will be examined taking the high-dose environment and the onsite condition congested with equipment and instruments into consideration.

2. Fuel removal from the spent fuel pools

Work to help remove spent fuel from the pool is progressing steadily while ensuring seismic capacity and safety. The removal of spent fuel from the Unit 4 pool commenced on November 18, 2013 and was completed by December 22, 2014

➢ Main work to help spent fuel removal at Unit 1

- From March 18, 2019, the removal of small rubble in the east-side area around the spent fuel pool (SFP) started using pliers and suction equipment, while small rubble removal on the south side of the SFP started from July 9.
- The well plug, which was considered misaligned from the normal position due to the influence of the hydrogen explosion at the time of the accident, was investigated for the period July 17 – August 26, 2019, by taking photos with a camera, measuring the air dose rate and collecting 3D images.
- A prior investigation on September 27, 2019 confirmed the lack of any obstacle which may affect the plan to install the cover over the SFP, the absence of any heavy object such as a concrete block on the fuel rack, as detected in Unit 3 and the fact that panel- and bar-shaped rubble pieces were scattered on the rack.
- After examining two methods: (i) installing a cover after rubble removal and (ii) initially installing a large cover over the Reactor Building and then removing rubble inside the cover, method (ii) was selected to ensure safer and more secure removal.
- Before removing the fallen roof and other objects on the south side, to minimize the risk of the overhead crane/fuel-handling machine shifting its position, becoming imbalanced and subsequently falling, materials to support the fuel-handling machine from below will be installed.
- To install the support for the fuel-handling machine, preparation started from September and the work will be completed in October.
- To install the support for the overhead crane, preparation will start from October and the work will be completed in November.
- Rubble removal and other work will proceed steadily with safety first, toward starting fuel removal during the period FY2027 to FY2028.

➢ Main work to help spent fuel removal at Unit 2

- On November 6, 2018, before investigating with a work plan to dismantle the Reactor Building rooftop and other tasks in mind, work to move and contain the remaining objects on the operating floor (1st round) was completed.
- On February 1, 2019, an investigation to measure the radiation dose on the floor, walls and ceiling inside the operating floor and confirm the contamination status was completed. After analyzing the investigative results, the “contamination concentration distribution” throughout the entire operating floor was obtained, based on which the air dose rate inside the operating floor could be evaluated. A shielding design and measures to prevent radioactive material scattering will be examined.

- From April 8, 2019, work to move and contain the remaining objects on the operating floor (second round) started, such as materials and equipment which may hinder installation of the fuel-handling facility and other work. The second round mainly included moving the remaining small objects and placing them in the container. It also included cleaning the floor to suppress dust scattering and was completed on August 21.
- From September 10, 2019, work got underway to move and contain the remaining objects on the operating floor (third round), such as materials and equipment which may hinder the installation of the fuel-handling facility and other work. The third round mainly included moving the remaining large objects and placing them in the container.
- After completing the training to practice work skills for transportation, preparatory work inside the operating floor started from July 20, 2020. Containers housing the remaining objects during the previous work will be transported to the solid waste storage facility from August 26.
- For fuel removal methods, based on the investigative results inside the operating floor from November 2018 to February 2019, a method to access from a small opening installed on the south side of the building was selected with aspects such as dust management and lower work exposure in mind (the method previously examined had involved fully dismantling the upper part of the building).

➢ Main process to help fuel removal at Unit 3

- From April 15, 2019, work got underway to remove 514 spent fuel assemblies and 52 non-irradiated fuel assemblies (566 in total) stored in the spent fuel pool. Seven non-irradiated fuel assemblies were then loaded into the transportation cask and transported to the common pool on April 23. The first fuel removal was completed on April 25.
- The periodical inspection of the fuel-handling facility, which started on July 24, 2019, was completed on September 2, 2019. Some defective rotations of the tensile truss and mast were detected during the following adjustment work toward resumption of the fuel removal. In response, parts were replaced, and the operation checked to confirm no problem.
- Fuel removal work was resumed from December 23, 2019 and has proceeded as planned.
- By February 14, 2020, a visual check of all fuel handles was completed.
- The inspection of the fuel-handling machine and other equipment and additional training for added workers, which had been conducted since March 30, 2020, were completed without issue by May 23, whereupon fuel removal resumed from May 26. At present, 336 of 566 fuel assemblies have been removed. Removal work has progressed steadily with 9 assemblies remaining, for which rubble needs to be removed from the fuel top.
- At the same time, rubble removal also proceeded steadily. On August 24, a lifting test was conducted for one fuel assembly with a deformed handle, which was excluded from the previous lifting test in May, and one fuel assembly, with which a deformed handle was detected after the previous lifting test. Based on the test results it was confirmed that both fuel assemblies could be lifted.
- The work had been implemented steadily. On September 2, however, a cable indicating the opening/closure and seating conditions of the gripper was damaged when caught by material near the wall on the south side of the pool while fuel assemblies within the pool were being transferred. The damaged cable was replaced with a spare, but a subsequent operation check conducted later detected an abnormality was detected in the signals indicating the seating condition of the gripper or others. Repair of the gripper is being examined.
- On September 19, damage to the crane hydraulic hose was also detected, which will be replaced with a spare.

3. Retrieval of fuel debris

➢ Status of obstacle cutting work related to the Unit 1 PCV inside investigation

- As part of efforts to investigate inside the Unit 1 Primary Containment Vessel (PCV), work to cut obstacles inside the PCV on the route for the investigation equipment started from May 26 and cutting of the grating was completed on August 25.
- On August 26, in preparation for cutting steel materials under the grating, a tool for the camera was installed. When the isolation valve was opened, the PCV pressure decreased and the work was suspended.
- After investigating the usage record of the tool and others, the damage was assumed attributable to external force, such as collision with other objects, applied on the flange base of the tool during transportation and storage.
- The tool was replaced with a spare. As countermeasures, a protective cover should be installed over the flange base during transportation and storage and a pressurization leak test should be implemented before opening the isolation valve.
- On September 4, when the AWJ equipment was activated to start the cutting work of steel materials under the grating, a defect in the abrasive supply part was detected and work has been suspended. After implementing measures to correct the defect, the cutting work will be resumed.

➢ Status of preparation for the Unit 2 PCV inside investigation and trial retrieval

- In the investigation inside the Unit 2 Primary Containment Vessel (PCV) and the trial retrieval of fuel debris, an arm-type device will be inserted from the PCV penetration (X-6 penetration) into the PCV. Before this investigation, deposits which may interfere with the work inside the X-6 penetration will be removed.
- To help examine the procedures of this removal work, an investigation into distribution of deposits and others inside the X-6 penetration will be implemented using a survey unit from around mid-October onward.
- Toward starting the trial retrieval of Unit 2 fuel debris scheduled in 2021, work will continue while ensuring safety measures such as suppressing dust scattering are implemented.

➢ Status of water sampling from the Unit 3 suppression chamber (S/C)

- To reduce the water level in the Unit 3 PCV in a phased manner, water sampling inside the S/C started on July 21 to determine the water quality. To sample water from the instrumentation pipes connecting the existing pipes, water sampling, analysis and release were repeated. Based on the analytical results after sampling a prescribed amount from existing pipes, water quality in the S/C (at the bottom) was assumed.
- The sampling was completed by confirming that the prescribed amount had been sampled and that there was no significant variation, despite slight variation detected in a portion of the water quality. The water quality results obtained from this examination will be utilized, not only when designing and constructing the PCV intake facility, but also for the operation plan after installing the facility.

4. Plans to store, process and dispose of solid waste and decommission of reactor facilities

Promoting efforts to reduce and store waste generated appropriately and R&D to facilitate adequate and safe storage, processing and disposal of radioactive waste

➢ Management status of the rubble and trimmed trees

- As of the end of August 2020, the total storage volume for concrete and metal rubble was approx. 299,700 m³ (+2,000 m³ compared to at the end of July with an area-occupation rate of 72%). The total storage volume of trimmed trees was approx. 134,400 m³ (±0 m³, with an area-occupation rate of 77%). The total storage volume of used protective clothing was approx. 32,300 m³ (-3,500 m³, with an area-occupation rate of 47%). The increase in rubble was mainly attributable to work related to rubble removal around the Unit 1-4 buildings, site preparation work and decontamination work of onsite general waste and flange tanks, while the decrease in used protective clothing was attributable to the incinerator operation.

➢ Management status of secondary waste from water treatment

- As of September 3, 2020, the total storage volume of waste sludge was 421 m³ (area-occupation rate: 60%), while that of concentrated waste fluid was 9,402 m³ (area-occupation rate: 91%). The total number of stored spent vessels, High-Integrity Containers (HICs) for multi-nuclide removal equipment and other vessels, was 4,909 (area-occupation rate: 77%).

5. Reactor cooling

The cold shutdown condition will be maintained by cooling the reactor by water injection and measures to complement the status monitoring will continue

➢ Ventilation check of the new Unit 2 Reactor Pressure Vessel nitrogen injection line

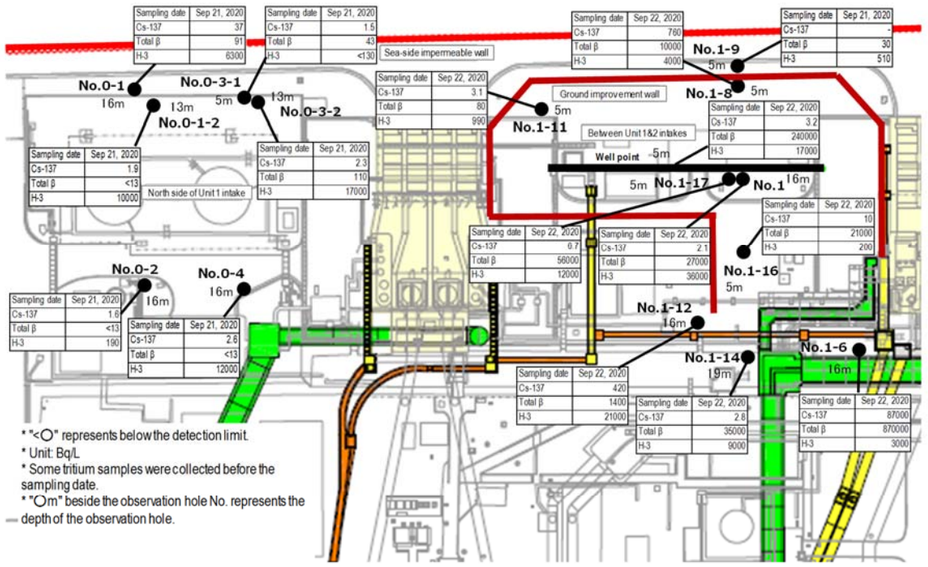
- The Unit 2 Reactor Pressure Vessel (RPV) nitrogen injection point is a single configuration. There are plans to install an additional line to improve the reliability of the Unit 2 nitrogen injection line.
- To select an additional line, taking ventilation, maintainability and other related factors of nitrogen injection into consideration, the ventilation of four candidate lines for the new injection point were checked from August 31 to September 4.
- Based on the results of the ventilation check that showed no influence on the parameters related to the PCV and dust monitor values, it was considered that ventilation was available in all four lines.

6. Reduction in radiation dose and mitigation of contamination

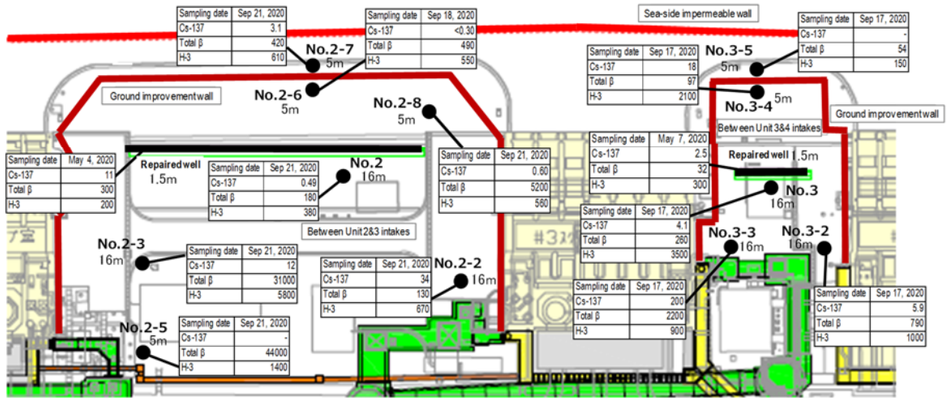
Effective dose-reduction at site boundaries and purification of port water to mitigate the impact of radiation on the external environment

➢ Status of groundwater and seawater on the east side of Turbine Building Units 1-4

- In the Unit 1 intake north side area, the H-3 concentration was below the legal discharge limit of 60,000 Bq/L at all observation holes and remained constant or has been declining. The concentration of total β radioactive materials had remained constant overall but increased temporarily from April. The trend will continue to be monitored.
- In the area between the Unit 1 and 2 intakes, the H-3 concentration has remained below the legal discharge limit of 60,000 Bq/L at all observation holes. It increased temporarily at No. 1-14 but is currently declining and remained constant or been declining at many observation holes overall. The concentration of total β radioactive materials has remained constant or been declining at many observation holes overall.
- In the area between the Unit 2 and 3 intakes, the H-3 concentration has been below the legal discharge limit of 60,000 Bq/L at all observation holes and remained almost constant or been declining, though it has been increasing or decreasing at No. 2-3. The concentration of total β radioactive materials has been increasing at No. 2-3 located on the east side of No. 2-5 at the highest location.
- In the area between Unit 3 and 4 intakes, the H-3 concentration has been below the legal discharge limit of 60,000 Bq/L at all observation holes and remained constant or been declining. The concentration of total β radioactive materials has also remained constant or been declining overall.
- The concentration of radioactive materials in drainage channels has remained constant, despite increasing during rainfall.
- In the Units 1-4 open channel area of seawater intake for Units 1 to 4, the concentration of radionuclides in seawater has remained below the legal discharge limit, despite increases in Cs-137 and Sr-90 noted during rainfall. They have also been declining following the completed installation and the connection of steel pipe sheet piles for the sea-side impermeable walls. The concentration of Cs-137 has remained slightly higher in front of the south side impermeable walls and slightly lower on the north side of the east breakwater since March 20, 2019, when the silt fence was transferred to the center of the open channel due to mega float-related construction.
- In the port area, the concentration of radionuclides in seawater has remained below the legal discharge limit, despite increases in Cs-137 and Sr-90 observed during rainfall. They have remained below the level of those in the Units 1-4 intake open channel area and been declining following the completed installation and connection of steel pipe sheet piles for the sea-side impermeable walls.
- In the area outside the port, regarding the concentration of radioactive materials in seawater, those of Cs-137 and Sr-90 declined and remained low after steel pipe sheet piles for the sea-side impermeable walls were installed and connected.



<Unit 1 intake north side, between Unit 1 and 2 intakes>



<Between Unit 2 and 3 intakes, between Unit 3 and 4 intakes>

Figure 5: Groundwater concentration on the Turbine Building east side

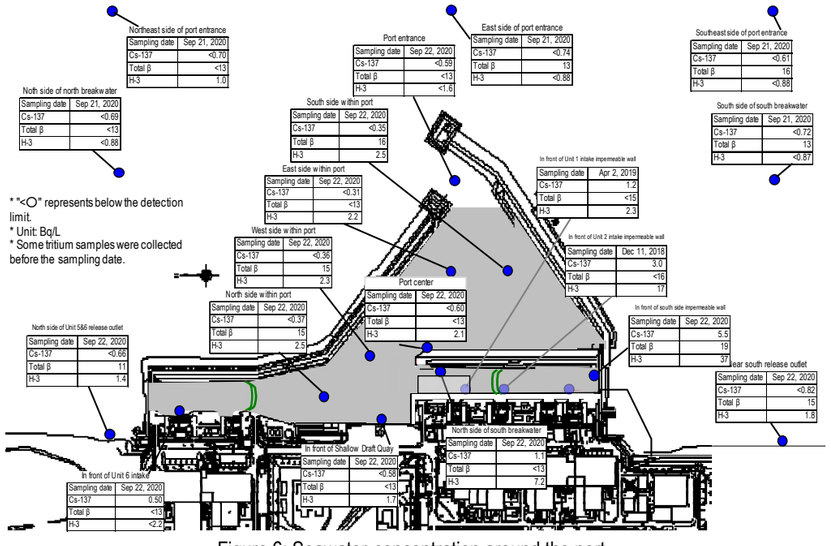


Figure 6: Seawater concentration around the port

7. Outlook of the number of staff required and efforts to improve the labor environment and conditions

Adequate number of staff will be secured in the long-term, while firmly implementing radiation control of workers. The work environment and labor conditions will be continuously improved by responding to the needs on the site.

➢ Staff management

- The monthly average total of personnel registered for at least one day per month to work on site during the past quarter from May to July 2020 was approx. 8,900 (TEPCO and partner company workers), which exceeded the monthly average number of actual workers (approx. 6,500). Accordingly, sufficient personnel are registered to work on site.
- It was confirmed with the prime contractors that the estimated manpower necessary for the work in October 2020 (approx. 3,800 per day: TEPCO and partner company workers) would be secured at present. The average numbers of workers per day per month (actual values) were maintained, with approx. 3,400 to 4,400 since FY2018 (see Figure 7).
- The number of workers from both within and from outside Fukushima Prefecture decreased. The local employment ratio (TEPCO and partner company workers) as of August 2020 also remained constant at around 65%.
- The monthly average exposure doses of workers remained at approx. 0.22, 0.20 and 0.21 mSv/month during FY2017, FY2018 and FY2019, respectively. (Reference: Annual average exposure dose 20 mSv/year ≒ 1.7 mSv/month)
- For most workers, the exposure dose was sufficiently within the limit and allowed them to continue engaging in radiation work.

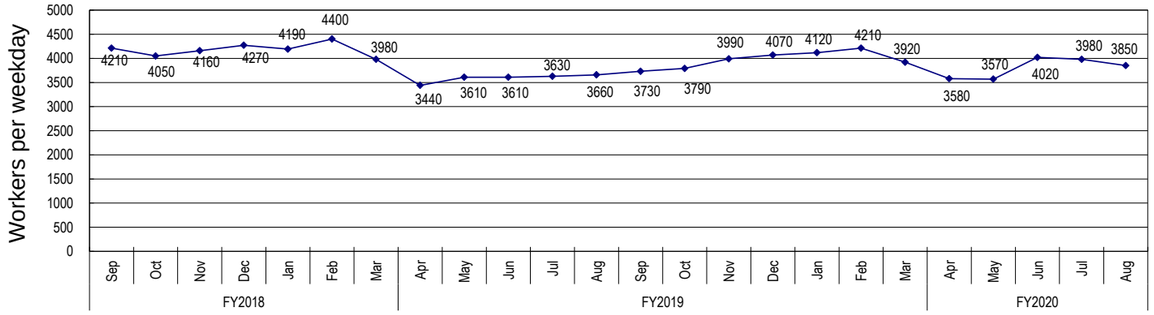


Figure 7: Changes in the average number of workers per weekday for each month since FY2018 (actual values)

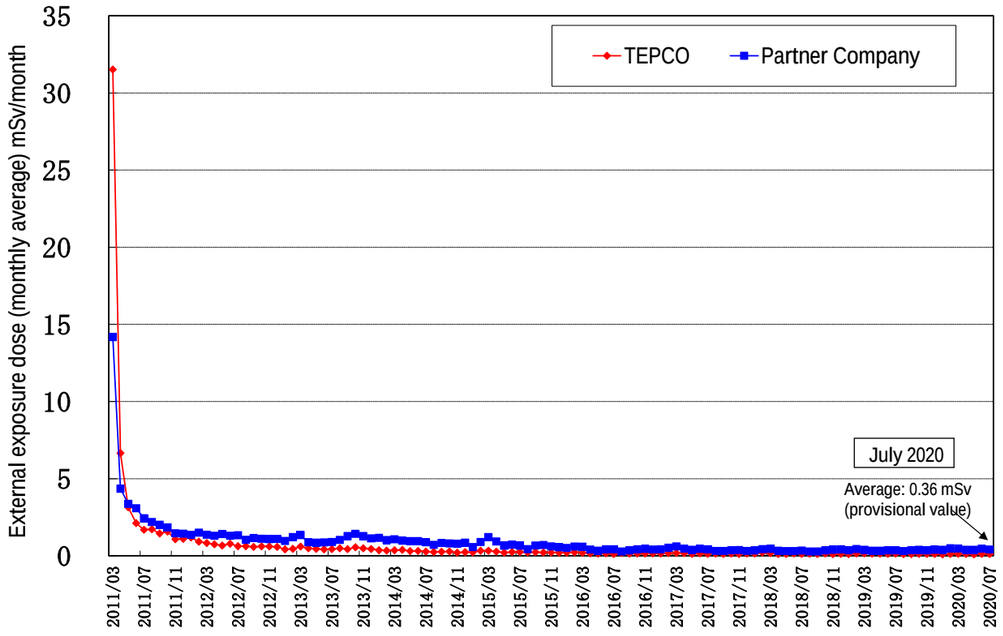


Figure 8: Changes in monthly individual worker exposure dose
(monthly average exposure dose since March 2011)

➢ Status of heat stroke cases

- Measures to further prevent heat stroke commenced from April 2020 to cope with the hottest season.
- In FY2020, six workers suffered heat stroke due to work up until September 22 (in FY2019, 13 workers up until the end of September). Continued measures will be taken to prevent heat stroke.

➢ COVID-19 infectious disease prevention countermeasures at the Fukushima Daiichi NPS

- At the Fukushima Daiichi Nuclear Power Station (NPS), countermeasures continue to be implemented according to the local infection status to prevent the COVID-19 infection spreading, such as requiring employees to take their temperature prior to coming to the office, wear masks at all times and avoid the “Three Cs” (Closed spaces, Crowded places, Close-contact settings) by shift-use of the rest house, etc.
- As of September 22, 2020, no TEPCO HD employees or cooperative firm laborers of the Fukushima Daiichi NPS had contracted COVID-19, nor was any significant influence on decommissioning work, such as a delay to the work processes, identified.

8. Status of Units 5 and 6

➢ Status of spent fuel storage in Units 5 and 6

- Regarding Unit 5, fuel removal from the reactor was completed in June 2015. A total of 1,374 spent and 168 non-irradiated fuel assemblies, respectively, were stored in the spent fuel pool (storage capacity: 1,590 assemblies).
- Regarding Unit 6, fuel removal from the reactor was completed in November 2013. A total of 1,456 spent and 198 non-irradiated fuel assemblies (180 of which were transferred from the Unit 4 spent fuel pool) are stored in the spent fuel pool (storage capacity: 1,654), while 230 non-irradiated fuel assemblies are stored in the non-irradiated fuel storage vault (NFV) (storage capacity: 230).

➢ Status of contaminated water treatment in Units 5 and 6

- Contaminated water in Units 5 and 6 is transferred from Unit 6 Turbine Building to the outdoor tanks and sprinkled after undergoing oil separation and RO treatment and confirming the concentration of the radioactive materials.

Status of seawater monitoring within the port (comparison between the highest values in 2013 and the latest values)

"The highest value" → "the latest value (sampled during September 16-21)"; unit (Bq/L); ND represents a value below the detection limit

Source: TEPCO website Analysis results on nuclides of radioactive materials around Fukushima Daiichi Nuclear Power Station http://www.tepco.co.jp/nu/fukushima-np/f1/smp/index-j.html

Sea side impermeable wall
Silt fence
Silt fence for construction

【Port entrance】

Cesium-134: 3.3 (2013/10/17) →ND(0.38) Below 1/8
Cesium-137: 9.0 (2013/10/17) → 0.45 Below 1/20
Total β: 74 (2013/ 8/19) →ND(13) Below 1/5
Tritium: 67 (2013/ 8/19) → 2.2 Below 1/30

【South side in the port】

Cesium-134: ND(0.46)
Cesium-137: ND(0.59)
Total β: ND(14)
Tritium: 2.1 *1

Cesium-134: 3.3 (2013/12/24) →ND(0.54) Below 1/6
Cesium-137: 7.3 (2013/10/11) →ND(0.58) Below 1/10
Total β: 69 (2013/ 8/19) → 15 Below 1/4
Tritium: 68 (2013/ 8/19) →ND(1.6) Below 1/40

【East side in the port】

Cesium-134: 4.4 (2013/12/24) →ND(0.34) Below 1/10
Cesium-137: 10 (2013/12/24) → 0.69 Below 1/10
Total β: 60 (2013/ 7/ 4) → 16 Below 1/3
Tritium: 59 (2013/ 8/19) → 2.3 Below 1/20

Cesium-134: 3.5 (2013/10/17) → ND(0.30) Below 1/10
Cesium-137: 7.8 (2013/10/17) → 0.28 Below 1/20
Total β: 79 (2013/ 8/19) → ND(13) Below 1/6
Tritium: 60 (2013/ 8/19) → 2.5 Below 1/20

【Port center】

Cesium-134: 5.0 (2013/12/2) → ND(0.28) Below 1/10
Cesium-137: 8.4 (2013/12/2) → ND(0.31) Below 1/20
Total β: 69 (2013/8/19) → 14 Below 1/4
Tritium: 52 (2013/8/19) → 2.5 Below 1/20

Cesium-134: 32 (2013/10/11) →ND(0.45) Below 1/70
Cesium-137: 73 (2013/10/11) → 1.8 Below 1/40
Total β: 320 (2013/ 8/12) → 21 Below 1/10
Tritium: 510 (2013/ 9/ 2) → 7.2 Below 1/70
From February 11, 2017, the location of the sampling point was shifted approx. 50 m south of the previous point due to the location shift of the silt fence.

【West side in the port】

Cesium-134: 2.8 (2013/12/2) → ND(0.52) Below 1/5
Cesium-137: 5.8 (2013/12/2) → ND(0.54) Below 1/10
Total β: 46 (2013/8/19) → ND(13) Below 1/3
Tritium: 24 (2013/8/19) → ND(2.2) Below 1/10

【North side in the port】

Cesium-134: ND(0.62)
Cesium-137: 5.5
Total β: 19
Tritium: 37 *1

【In front of shallow draft quay】

【In front of Unit 6 intake】

*4 *2 *3

Unit 1 Unit 2 Unit 3 Unit 4

	Legal discharge limit	WHO Guidelines for Drinking Water Quality
Cesium-134	60	10
Cesium-137	90	10
Strontium-90 (strongly correlate with Total β)	30	10
Tritium	60,000	10,000

Cesium-134: 5.3 (2013/8/ 5) → ND(0.57) Below 1/9
Cesium-137: 8.6 (2013/8/ 5) → ND(0.43) Below 1/20
Total β: 40 (2013/7/ 3) → 21
Tritium: 340 (2013/6/26) → 1.7 Below 1/200

*1: Monitoring commenced in or after March 2014. Monitoring inside the sea-side impermeable walls was finished because of the landfill.

*2: For the point, monitoring was finished from December 12, 2018 due to preparatory work for transfer of mega float.

*3: For the point, monitoring point was moved from February 6, 2019 due to preparatory work for transfer of mega float.

*4: For the point, monitoring was finished from April 3, 2019 due to preparatory work for transfer of mega float.

Summary of TEPCO data as of September 22, 2020

Note: The Total β measurement values include natural potassium 40 (approx. 12 Bq/L). They also include the contribution of yttrium 90, which radioactively balance strontium 90.

Status of seawater monitoring around outside of the port
(comparison between the highest values in 2013 and the latest values)

(The latest values sampled during September 16-21)

Unit (Bq/L); ND represents a value below the detection limit; values in ( ) represent the detection limit; ND (2013) represents ND throughout 2013

	Legal discharge limit	WHO Guidelines for Drinking Water Quality
Cesium-134	60	10
Cesium-137	90	10
Strontium-90 (strongly correlate with Total β)	30	10
Tritium	60,000	10,000

【Northeast side of port entrance(offshore 1km)】

Cesium-134: ND (2013) → ND(0.82)
Cesium-137: ND (2013) → ND(0.70)
Total β: ND (2013) → ND(13)
Tritium: ND (2013) → 1.0

【East side of port entrance (offshore 1km)】

Cesium-134: ND (2013) → ND(0.84)
Cesium-137: 1.6 (2013/10/18) → ND(0.74) Below 1/2
Total β: ND (2013) → 13
Tritium: 6.4 (2013/10/18) → ND(0.88) Below 1/7

【Southeast side of port entrance(offshore 1km)】

Cesium-134: ND (2013) → ND(0.69)
Cesium-137: ND (2013) → ND(0.61)
Total β: ND (2013) → 16
Tritium: ND (2013) → ND(0.88)

Cesium-134: ND (2013) → ND(0.61)
Cesium-137: ND (2013) → ND(0.69)
Total β: ND (2013) → ND(13)
Tritium: 4.7 (2013/ 8/18) → ND(0.88) Below 1/5

【North side of north breakwater(offshore 0.5km)】

【Port entrance】

【South side of south breakwater(offshore 0.5km)】

Cesium-134: ND (2013) → ND(0.57)
Cesium-137: ND (2013) → ND(0.72)
Total β: ND (2013) → 13
Tritium: ND (2013) → ND(0.87)

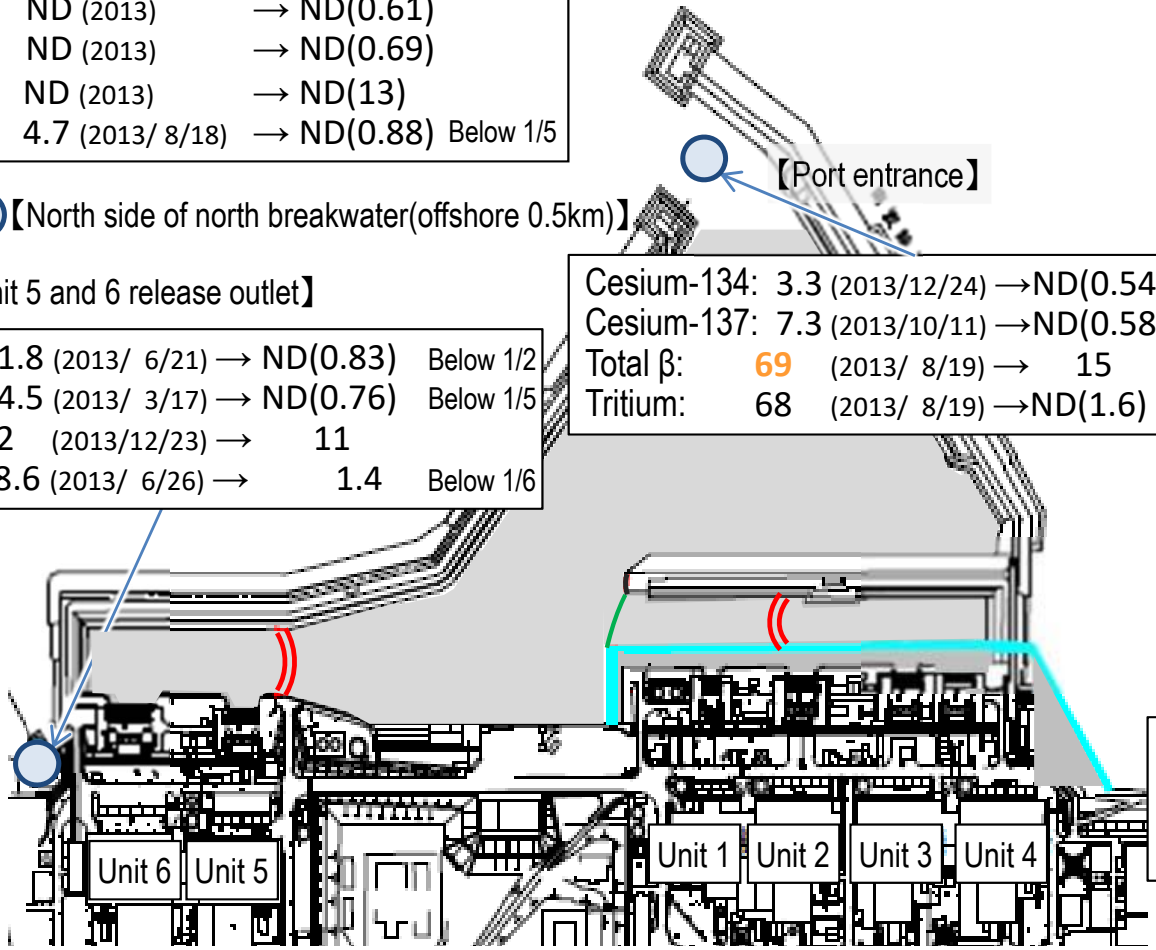
【North side of Unit 5 and 6 release outlet】

Cesium-134: 1.8 (2013/ 6/21) → ND(0.83) Below 1/2
Cesium-137: 4.5 (2013/ 3/17) → ND(0.76) Below 1/5
Total β: 12 (2013/12/23) → 11
Tritium: 8.6 (2013/ 6/26) → 1.4 Below 1/6

Cesium-134: 3.3 (2013/12/24) → ND(0.54) Below 1/6
Cesium-137: 7.3 (2013/10/11) → ND(0.58) Below 1/10
Total β: 69 (2013/ 8/19) → 15 Below 1/4
Tritium: 68 (2013/ 8/19) → ND(1.6) Below 1/40

【Near south release outlet】

Cesium-134: ND (2013) → ND(0.57)
Cesium-137: 3.0 (2013/ 7/15) → ND(0.66) Below 1/4
Total β: 15 (2013/12/23) → 9.3
Tritium: 1.9 (2013/11/25) → ND(0.93) Below 1/2



Note: The Total β measurement values include natural potassium 40 (approx. 12 Bq/L). They also include the contribution of yttrium 90, which radioactively balance strontium 90.

Note: Because safety of the sampling points was unassured due to the influence of Typhoon No. 10 in 2016, samples were taken from approx. 330 m south of the Unit 1-4 release outlet. Samples were also taken from a point approx. 280m south from the same release outlet from January 27, 2017 and approx. 320m from March 23, 2018

Summary of TEPCO data as of September 22, 2020

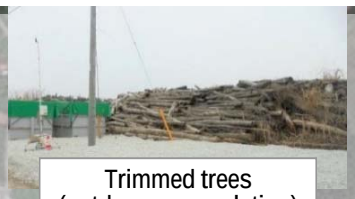
Source: TEPCO website, Analysis results on nuclides of radioactive materials around Fukushima Daiichi Nuclear Power Station, http://www.tepco.co.jp/nu/fukushima-np/f1/smp/index-j.html

Appendix 2

September 24, 2020

TEPCO Holdings Fukushima Daiichi Nuclear Power Station Site Layout

- Rubble storage area
- Rubble storage area (planned)
- Used protective clothing
- Trimmed trees area
- Mid-/ low-level contaminated water tank (existing)
- Mid-/ low-level contaminated water tank (planned)
- Secondary waste from water treatment (existing)
- Secondary waste from water treatment (planned)
- Waste treatment facility
- Non-controlled facility
- Analysis and research facility



Trimmed trees (outdoor accumulation)

Temporary trimmed trees storage pool

Temporary soil-covered type storage facility

Rubble storage tent

Rubble (outdoor accumulation)

Inside the rubble storage tent

Rubble (covered by sheet)

Solid waste storage facility

Rubble (container storage)

Futaba town

Okuma town

Radioactive Waste Incinerator

Used protective clothing

Trimmed trees

Vehicles maintenance site

Unit 6

Unit 5

Periodical inspection material storage (cut of flange tank)

Unit 1

Unit 2

Unit 3

Unit 4

Mega float

Town boundary

Chiller for reactor water injection facility

Land-side impermeable walls with frozen soil

Sea side impermeable wall

Water desalinations (RO)

Cesium absorption apparatus (Incineration Workshop Building)

Decontamination instruments (Process Building)

3rd cesium adsorption apparatus (Onsite Bunker Building)

2nd cesium adsorption apparatus (HTI Building)

Cesium absorption vessel temporary storage

JAEA Site Management Building

Vehicle screening and decontamination site

Partner Companies' Building

Temporary rest house outside the site

New Administration Office Building

Large rest house

Access control facility

Groundwater bypass temporary storage tank

Water desalinations (evaporative concentration)

Water desalinations (RO)

Water treatment facility for Subdrain and others

Temporary Cask Custody Area

Main Anti-Earthquake Building

Large equipment decontamination facility

Pipe route

Multi-nuclide removal equipment

Additional multi-nuclide removal equipment

High-performance multi-nuclide removal equipment

Spent absorption vessel temporary storage

Underground reservoirs

Land-side impermeable walls freezing plant

Common pool

Temporary trimmed trees storage pool

Site boundary

Tank installation status

Temporary waste sludge storage

Spent adsorption vessel temporary storage facility

Provided by Japan Space Imaging, photo taken on June 14, 2018
Product(C) [2018] DigitalGlobe, Inc.

0m 100m 500m 1000m

Progress toward decommissioning: Fuel removal from the spent fuel pool (SFP)

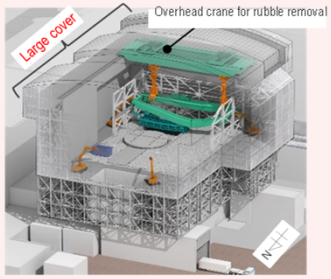
September 24, 2020
Secretariat of the Team for Countermeasures for Decommissioning and Contaminated Water Treatment

Immediate target Commence fuel removal from the Unit 1-3 Spent Fuel Pools

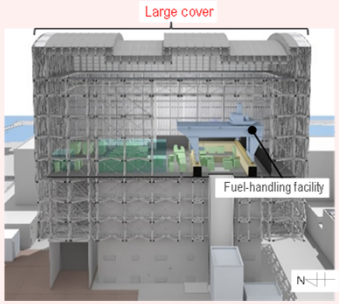
Unit 1

Toward fuel removal from the Unit 1 spent fuel pool, investigations have been implemented to ascertain the conditions of the fallen roof on the south side and the contamination of the well plug. Based on the results of these investigations, "the method to initially install a large cover over the Reactor Building and then remove rubble inside the cover" was selected to ensure a safer and more secure removal.
Work continues to complete installation of a large cover by around FY2023 and start fuel removal from FY2027 to FY2028.

<Reference> Progress to date
Rubble removal on the north side of the operating floor started from January 2018 and has been implemented sequentially. In July and August 2019, the well plug, which was misaligned from its normal position, was investigated and in August and September, the conditions of the overhead crane were checked. Based on the results of these investigations, as the removal requires more careful work taking dust scattering into consideration, two methods were examined: installing a cover after rubble removal and initially installing a large cover over the Reactor Building and then removing rubble inside the cover.



Rubble removal (image)

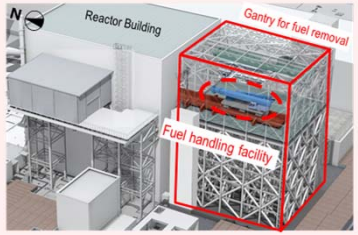


Fuel removal (image)

Unit 2

Toward fuel removal from the Unit 2 spent fuel pool, based on findings from internal operating floor investigations from November 2018 to February 2019, instead of fully dismantling the upper part of the building, the decision was made to install a small opening on the south side and use a boom crane. Examination continues to start fuel removal from FY2024 to FY2026.

<Reference> Progress to date
Previously, potential to recover the existing overhead crane and the fuel handling machine was examined. However, the high radiation dose inside the operating floor meant the decision was taken to dismantle the upper part of the building in November 2015. Findings from internal investigations of the operating floor from November 2018 to February 2019 underlined the potential to conduct limited work there and the means of accessing from the south side had been examined.

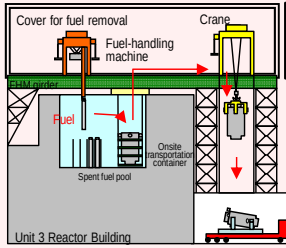


Overview of fuel removal (bird's-eye view)

Unit 3

Prior to the installation of a cover for fuel removal, removal of large rubble from the spent fuel pool was completed in November 2015. To ensure safe and steady fuel removal, training of remote control was conducted at the factory using the actual fuel-handling machine which will be installed on site (February – December 2015). Measures to reduce dose on the Reactor Building top floor (decontamination, shields) were completed in December 2016. Installation of a cover for fuel removal and a fuel-handling machine is underway from January 2017. Installation of the fuel removal cover was completed on February 23, 2018.
Toward fuel removal, the rubble retrieval training inside the pool, which was scheduled in conjunction with fuel removal training, started from March 15, 2019, and started fuel removal from April 15, 2019.

Installation of dome roof (February 21, 2019)



Overview of the fuel-handling facility inside the cover

Removed fuel (assemblies)
336/566
(as of September 24, 2020)

Onsite transportation
To common pool


Fuel removal status (April 15, 2019)

Unit 4

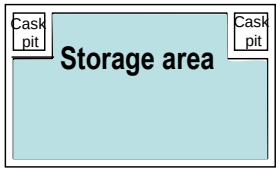
In the Mid- and-Long-Term Roadmap, the target of Phase 1 involved commencing fuel removal from inside the spent fuel pool (SFP) of the 1st Unit within two years of completion of Step 2 (by December 2013). On November 18, 2013, fuel removal from Unit 4, or the 1st Unit, commenced and Phase 2 of the roadmap started.


Fuel removal status

On November 5, 2014, within a year of commencing work to fuel removal, all 1,331 spent fuel assemblies in the pool had been transferred. The transfer of the remaining non-irradiated fuel assemblies to the Unit 6 SFP was completed on December 22, 2014. (2 of the non-irradiated fuel assemblies were removed in advance in July 2012 for fuel checks)
This marks the completion of fuel removal from the Unit 4 Reactor Building.
Based on this experience, fuel assemblies will be removed from Unit 1-3 pools.

* A part of the photo is corrected because it includes sensitive information related to physical protection.

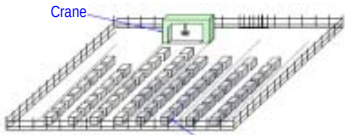
Common pool



An open space will be maintained in the common pool (Transfer to the temporary cask custody area)

Progress to date
- The common pool has been restored to a condition allowing it to re-accommodate fuel to be handled (November 2012)
- Loading of spent fuel stored in the common pool to dry casks commenced (June 2013)
- Fuel removal from the Unit 4 spent fuel pool began to be received (November 2013 - November 2014)
- Fuel removal from the Unit 3 spent fuel pool began to be received (from April 2019)

Temporary cask (*2) custody area



Spent fuel is accepted from the common pool

Operation commenced on April 12, 2013; from the cask-storage building, transfer of 9 existing dry casks completed (May 21, 2013); fuel stored in the common pool sequentially transferred.

<Glossary>
(*1) Operating floor: During regular inspection, the roof over the reactor is opened while on the operating floor, fuel inside the core is replaced and the core internals are inspected.
(*2) Cask: Transportation container for samples and equipment, including radioactive materials.

Progress toward decommissioning: Works to identify the plant status and toward fuel debris retrieval

Immediate target | Identify the plant status and commence R&D and decontamination toward fuel debris retrieval

Investigation into TIP Room of the Unit 1 Reactor Building

- To improve the environment for future investigations inside the PCV, etc., an investigation was conducted from September 24 to October 2, 2015 at the TIP Room(*1). (Due to high dose around the entrance in to the TIP Room, the investigation of dose rate and contamination distribution was conducted through a hole drilled from the walkway of the Turbine Building, where the dose was low)
- The investigative results identified high dose at X-31 to 33 penetrations(*2) (instrumentation penetration) and low dose at other parts.
- As it was confirmed that work inside the TIP room would be available, the next step will include identification of obstacles which will interfere the work inside the TIP Room and formulation of a plan for dose reduction.

Investigation in the leak point detected in the upper part of the Unit 1 Suppression Chamber (S/C(*3))

Investigation in the leak point detected in the upper part of Unit 1 S/C from May 27, 2014 from one expansion joint cover among the lines installed there. As no leakage was identified from other parts, specific methods will be examined to halt the flow of water and repair the PCV.

Leak point

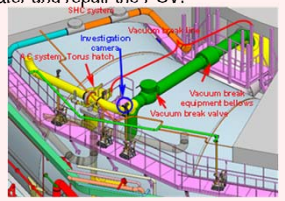
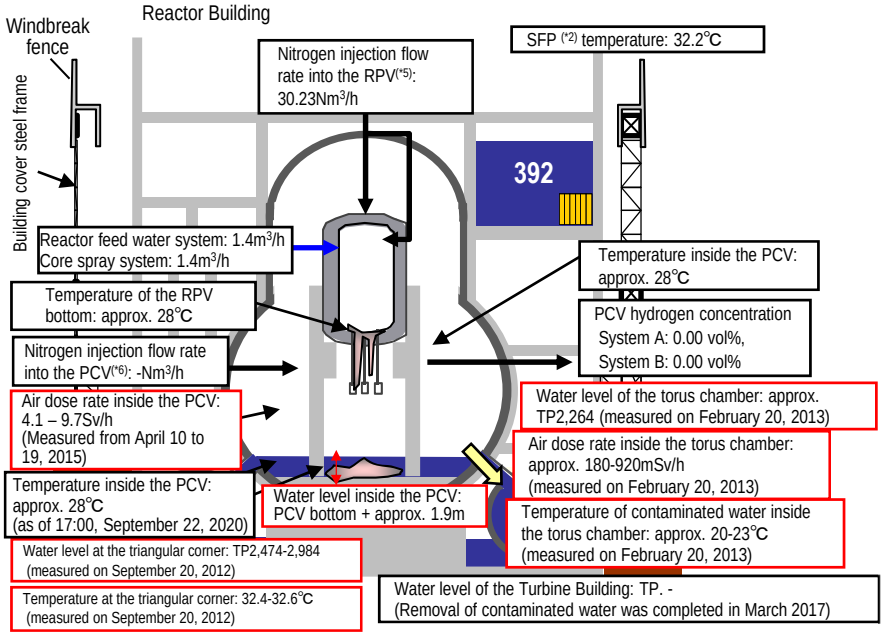


Image of the S/C upper part investigation

Unit 1

Air dose rate inside the Reactor Building:
Max. 5,150mSv/h (1F southeast area) (measured on July 4, 2012)



* Indices related to the plant are values as of 11:00, September 23, 2020

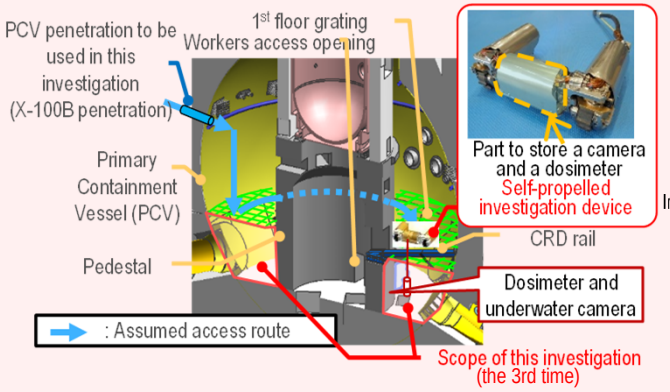
Investigations inside PCV	1st (Oct 2012)	- Acquiring images - Measuring air temperature and dose rate - Measuring water level and temperature - Sampling contaminated water - Installing permanent monitoring instrumentation
	2nd (Apr 2015)	Confirming the status of PCV 1st floor - Acquiring images - Measuring air temperature and dose rate - Replacing permanent monitoring instrumentation
	3rd (Mar 2017)	Confirming the status of PCV 1st basement floor - Acquiring images - Measuring and dose rate - Sampling deposit - Replacing permanent monitoring instrumentation
Leakage points from PCV	- PCV vent pipe vacuum break line bellows (identified in May 2014) - Sand cushion drain line (identified in November 2013)	

Status of investigation inside the PCV

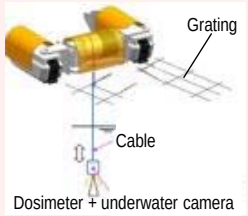
Prior to fuel debris retrieval, an investigation inside the PCV will be conducted to inspect the status there including the location of fuel debris.

[Investigative outline]

- In April 2015, a device, which entered the inside of the PCV through a narrow access opening (bore: ϕ 100 mm), collected information such as images and airborne dose inside the PCV 1st floor.
- In March 2017, the investigation using a self-propelled investigation device, conducted to inspect the spreading of debris to the basement floor outside the pedestal, took images of the PCV bottom status for the first time. The status inside the PCV will continue to be examined based on the collected image and dose data.



<Image of investigation inside the PCV>



Dosimeter + underwater camera
Image of hanging of dosimeter and camera

Image near the bottom

Capturing the location of fuel debris inside the reactor by measurement using muons

Period	Evaluation results
Feb - May 2015	Confirmed that there was no large fuel in the reactor core.

<Glossary>
(*1) TIP (Traversing In-core Probe)
(*2) Penetration: Through-hole of the PCV
(*3) S/C (Suppression Chamber): Suppression pool, used as the water source for the emergent core cooling system.
(*4) SFP (Spent Fuel Pool):
(*5) RPV (Reactor Pressure Vessel)
(*6) PCV (Primary Containment Vessel)

Progress toward decommissioning: Works to identify the plant status and toward fuel debris retrieval

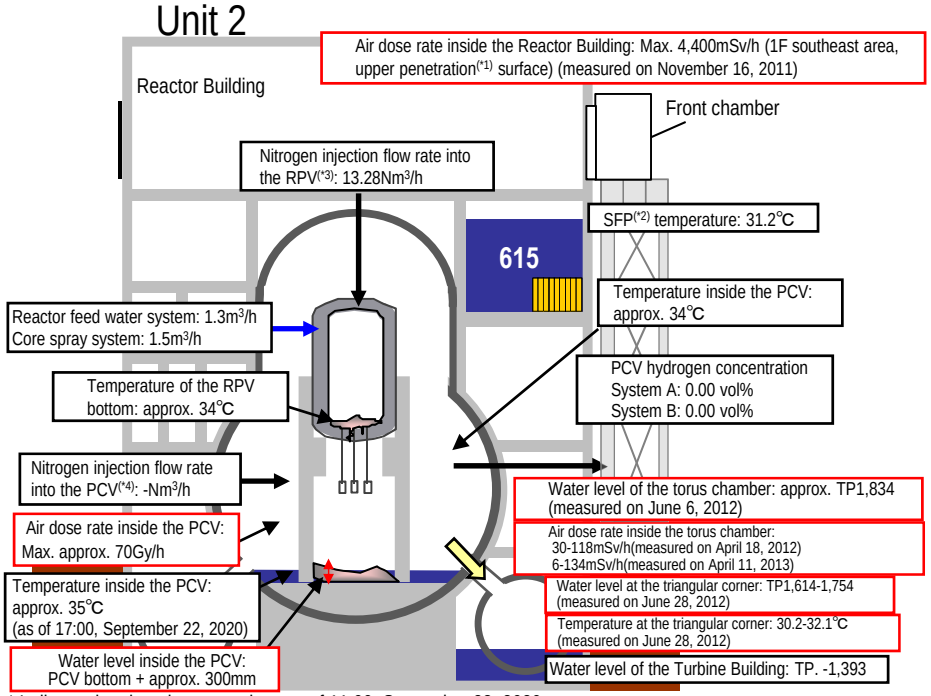
September 24, 2020
Secretariat of the Team for Countermeasures for Decommissioning and Contaminated Water Treatment
3/6

Immediate target | Identify the plant status and commence R&D and decontamination toward fuel debris retrieval

Installation of an RPV thermometer and permanent PCV supervisory instrumentation

(1) Replacement of the RPV thermometer
- As the thermometer installed at the Unit 2 RPV bottom after the earthquake had broken in February 2014, it was excluded from the monitoring thermometers.
- In April 2014, removal of the broken thermometer failed and was suspended. Rust-stripping chemicals were injected and the broken thermometer was removed in January 2015. A new thermometer was reinstalled in March. The thermometer has been used as a part of permanent supervisory instrumentation since April.

(2) Reinstallation of the PCV thermometer and water-level gauge
- Some of the permanent supervisory instrumentation for PCV could not be installed in the planned locations due to interference with existing grating (August 2013). The instrumentation was removed in May 2014 and new instruments were reinstalled in June 2014. The trend of added instrumentation will be monitored for approx. one month to evaluate its validity.
- The measurement during the installation confirmed that the water level inside the PCV was approx. 300mm from the bottom.

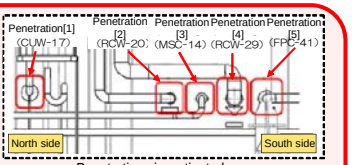


* Indices related to plant are values as of 11:00, September 23, 2020

Investigations inside PCV	1st (Jan 2012)	- Acquiring images - Measuring air temperature
	2nd (Mar 2012)	- Confirming water surface - Measuring water temperature - Measuring dose rate
	3rd (Feb 2013 – Jun 2014)	- Acquiring images - Sampling contaminated water - Measuring water level - Installing permanent monitoring instrumentation
	4th (Jan – Feb 2017)	- Acquiring images - Measuring dose rate - Measuring air temperature
	5th (Jan 2018)	- Acquiring images - Measuring dose rate - Measuring air temperature
	6th (Feb 2019)	- Acquiring images - Measuring dose rate - Measuring air temperature - Grasping characteristics of a portion of deposit
Leakage points from PCV	- No leakage from torus chamber rooftop - No leakage from all inside/outside surfaces of S/C	

Investigative results on torus chamber walls

- July 2014, the torus chamber walls were investigated (on the north the east-side walls) using equipment specially developed for that purpose (a swimming robot and a floor traveling robot).
- At the east-side wall pipe penetrations (five points), "the status" and "existence of flow" were checked.
- A demonstration using the above two types of underwater wall investigative equipment showed how the equipment could check the status of penetration.
- Regarding Penetrations 1 - 5, the results of checking the sprayed tracer (*5) by camera showed no flow around the penetrations. (investigation by the swimming robot)
- Regarding Penetration 3, a sonar check showed no flow around the penetrations. (investigation by the floor traveling robot)



Penetrations investigated

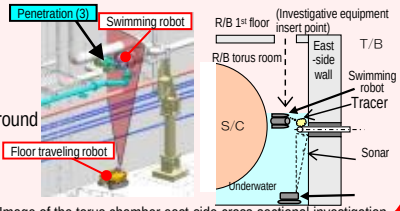


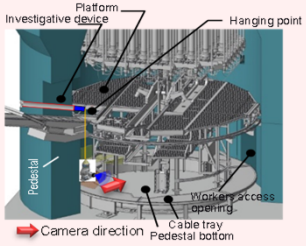
Image of the torus chamber east-side cross-sectional investigation

Status of investigation inside the PCV

Prior to fuel debris retrieval, an investigation inside the PCV will be conducted to inspect the status there including the location of fuel debris.

[Investigative outline]
- Investigative devices such as a robot will be injected from Unit 2 X-6 penetration(*1) and access the inside of the pedestal using the CRD rail.

[Progress status]
- On January 26 and 30, 2017, a camera was inserted from the PCV penetration to inspect the status of the CRD replacement rail on which the robot will travel. On February 9, deposit on the access route of the self-propelled investigative device was removed and on February 16, the inside of the PCV was investigated using the device.
- The results of this series of investigations confirmed fallen and deformed gratings and a quantity of deposit inside the pedestal.
- On January 19, 2018, the status below the platform inside the pedestal was investigated using an investigative device with a hanging mechanism. From the analytical results of images obtained in the investigation, deposits probably including fuel debris were found at the bottom of the pedestal. In addition, multiple parts higher than the surrounding deposits were also detected. We presumed that there were multiple routes of fuel debris falling. Obtained data were processed in panoramic image visualization to acquire clearer images.
- On February 13, 2019, an investigation touching the deposits at the bottom of the pedestal and on the platform was conducted and confirmed that the pebble-shaped deposits, etc. could be moved and that hard rock-like deposits that could not be gripped may exist.
- In addition, images, etc. would help determine the contour and size of the deposits could be collected by moving the investigative unit closer to the deposits than the previous investigation.



Investigative status (image)

Bottom of the pedestal (after being processed in panoramic image visualization)

Capturing the location of fuel debris inside the reactor by measurement using muons

Period	Evaluation results
Mar – Jul 2016	Confirmed the existence of high-density materials, which was considered as fuel debris, at the bottom of RPV, and in the lower part and the outer periphery of the reactor core. It was assumed that a large part of fuel debris existed at the bottom of RPV.

<Glossary> (*1) Penetration: Through-hole of the PCV (*2) SFP (Spent Fuel Pool) (*3) RPV (Reactor Pressure Vessel)
(*4) PCV (Primary Containment Vessel) (*5) Tracer: Material used to trace the fluid flow. Clay particles

Progress toward decommissioning: Works to identify the plant status and toward fuel debris retrieval

September 24, 2020
Secretariat of the Team for Countermeasures for Decommissioning and Contaminated Water Treatment
4/6

Immediate target | Identify the plant status and commence R&D and decontamination toward fuel debris retrieval

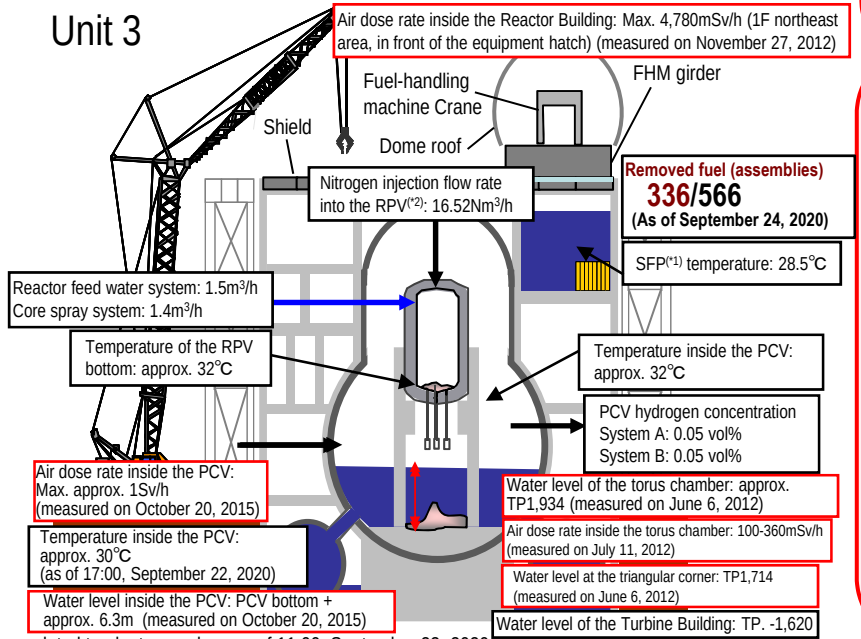
Water flow was detected from the Main Steam Isolation Valve* room

On January 18, 2014, a flow of water from around the door of the Steam Isolation Valve room in the Reactor Building Unit 3 1st floor northeast area to the nearby floor drain funnel (drain outlet) was detected. As the drain outlet connects with the underground part of the Reactor Building, there is no possibility of outflow from the building.

From April 23, 2014, image data has been acquired by camera and the radiation dose measured via pipes for measurement instrumentation, which connect the air-conditioning room on the Reactor Building 2nd floor with the Main Steam Isolation Valve Room on the 1st floor. On May 15, 2014, water flow from the expansion joint of one Main Steam Line was detected.

This is the first leak from PCV detected in the Unit 3. Based on the images collected in this investigation, the leak volume will be estimated and the need for additional investigations will be examined. The investigative results will also be utilized to examine water stoppage and PCV repair methods.

* Main Steam Isolation Valve: A valve to shut off the steam generated from the Reactor in an emergency



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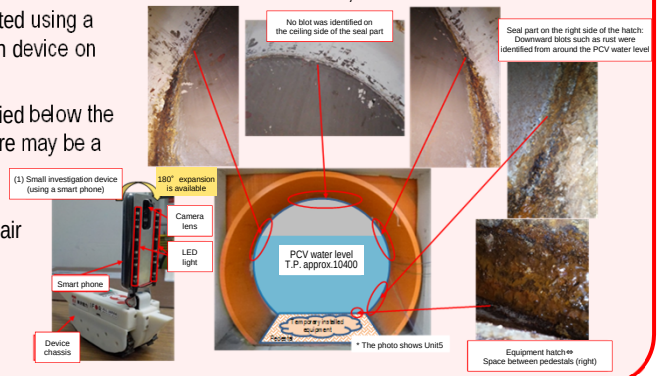
Investigations inside PCV	1st (Oct – Dec 2015)	- Acquiring images - Measuring air temperature and dose rate - Measuring water level and temperature - Sampling contaminated water - Installing permanent monitoring instrumentation (December 2015)
	2nd (Jul 2017)	- Acquiring images - Installing permanent monitoring instrumentation (August 2017)
Leakage points from PCV	- Main steam pipe bellows (identified in May 2014)	

Investigative results into the Unit 3 PCV equipment hatch using a small investigation device

- As part of the investigation into the PCV to facilitate fuel debris retrieval, the status around the Unit 3 PCV equipment hatch was investigated using a small self-traveling investigation device on November 26, 2015.
- Given blots such as rust identified below the water level inside the PCV, there may be a leakage from the seal to the extent of bleeding.
  Methods to investigate and repair the parts, including other PCV penetrations with a similar structure, will be considered.

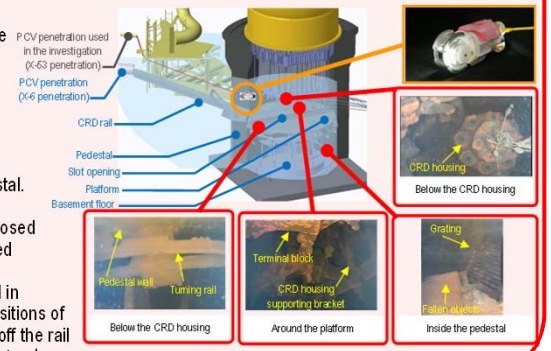


Investigation inside the PCV

Prior to fuel debris retrieval, the inside of the Primary Containment Vessel (PCV) was investigated to identify the status there including the location of the fuel debris.

[Investigative outline]

- The status of X-53 penetration(*4), which may be under the water and which is scheduled for use to investigate the inside of the PCV, was investigated using remote-controlled ultrasonic test equipment. The results showed that the penetration was not under the water (October 22-24, 2014).
- For the purpose of confirming the status inside the PCV, an investigation device was inserted into the PCV from X-53 penetration on October 20 and 22, 2015 to obtain images, data of dose and temperature and sample contaminated water. No damage was identified on the structure and walls inside the PCV and the water level was almost identical with the estimated value. In addition, the dose inside the PCV was confirmed to be lower than in other Units.
- In July 2017, the inside of the PCV was investigated using the underwater ROV (remotely operated underwater vehicle) to inspect the inside of the pedestal.
- Analysis of image data obtained in the investigation identified damage to multiple structures and the supposed core internals. Consideration about fuel removal based on the obtained information will continue.
- Videos obtained in the investigation were reproduced in 3D. Based on the reproduced images, the relative positions of the structures, such as the rotating platform slipping off the rail with a portion buried in deposits, were visually understood.



Status inside the pedestal

Capturing the location of fuel debris inside the reactor by measurement using muons

Period	Evaluation results
May – Sep 2017	The evaluation confirmed that no large lump existed in the core area where fuel had been placed and that part of the fuel debris potentially existed at the bottom of the RPV.

<Glossary>
(*1) SFP (Spent Fuel Pool) (*2) RPV (Reactor Pressure Vessel) (*3) PCV (Primary Containment Vessel) (*4) Penetration: Through-hole of the PCV

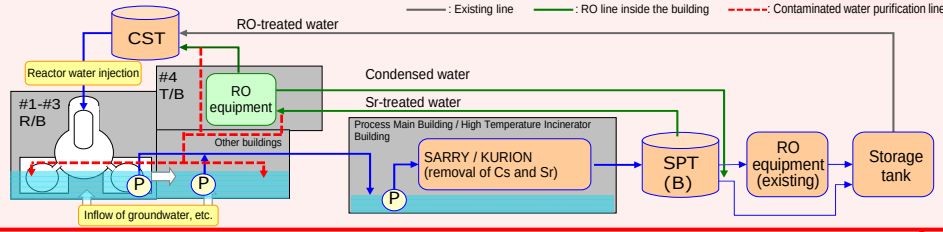
Progress toward decommissioning: Work related to circulation cooling and contaminated water treatment line

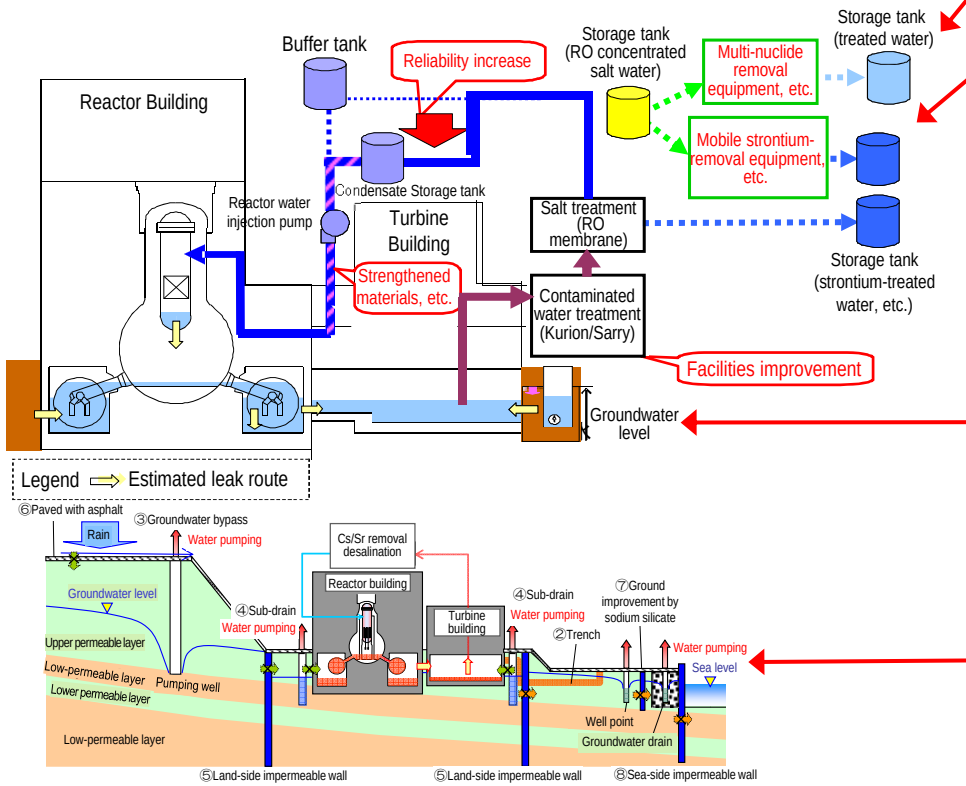
Immediate target | Stably continue reactor cooling and contaminated water treatment, and improve reliability

Work to improve the reliability of the circulation water injection cooling system and pipes to transfer contaminated water.

- Operation of the reactor water injection system using Unit 3 Condensate Storage Tank (CST) as a water source commenced (from July 5, 2013). Compared to the previous systems, the reliability of the reactor water injection system was enhanced, e.g. by increasing the amount of water-source storage and enhancing durability.
- To reduce the risk of contaminated-water leakage, the circulation loop was shortened by installing a reverse osmosis (RO) device in the Unit 4 Turbine Building within the circulation loop, comprising the transfer of contaminated water, water treatment and injection into the reactors. Operation of the installed RO device started from October 7 and 24-hour operation started from October 20. Installation of the new RO device inside the building shortened the circulation loop from approx. 3 to 0.8 km.
- To accelerate efforts to reduce the radiation density in contaminated water inside the buildings, circulating purification of contaminated water inside the buildings stared on the Unit 3 and 4 side on February 22 and on the Unit 1 and 2 side on April 11.
- For circulating purification, a new pipe (contaminated water purification line) divided from the water treatment equipment outlet line was installed to transfer water purified at the water treatment equipment to the Unit 1 Reactor Building and the Unit 2-4 Turbine Buildings.
- The risks of contaminated water inside the buildings will continue to be reduced in addition to reduction of its storage.

* The entire length of contaminated water transfer pipes is approx. 2.1km, including the transfer line of surplus water to the upper heights (approx. 1.3km).





Progress status of dismantling of flange tanks

- To facilitate replacement of flanged tanks, dismantling of flanged tanks started in H1 east/H2 areas in May 2015. Dismantling of all flanged tanks was completed in H1 east area (12 tanks) in October 2015, in H2 area (28 tanks) in March 2016, in H4 area (56 tanks) in May 2017, in H3 B area (31 tanks) in September 2017, in H5 and H5 north areas (31 tanks) in June 2018, in G6 area (38 tanks) in July 2018, H6 and H6 north areas (24 tanks) in September 2018 and G4 south area (17 tanks) in March 2019.


Start of dismantling in H1 east area

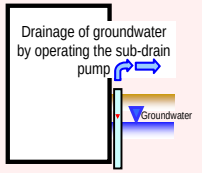

After dismantling in H1 east area

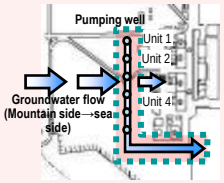
Completion of purification of contaminated water (RO concentrated salt water)

Contaminated water (RO concentrated salt water) is being treated using seven types of equipment including the multi-nuclide removal equipment (ALPS). Treatment of the RO concentrated salt water was completed on May 27, 2015, with the exception of the remaining water at the tank bottom. The remaining water will be treated sequentially toward dismantling the tanks.

The strontium-treated water from other facilities than the multi-nuclide removal equipment will be re-purified in the multi-nuclide removal equipment to further reduce risks.

Preventing groundwater from flowing into the Reactor Buildings





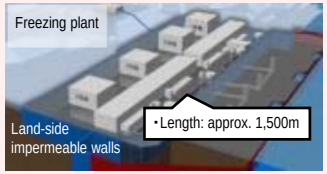
Reducing groundwater inflow by pumping sub-drain water

To reduce groundwater flowing into the buildings, pumping-up of groundwater from wells (subdrains) around the buildings started on September 3, 2015. Pumped-up groundwater was purified at dedicated facilities and released after TEPCO and a third-party organization confirmed that its quality met operational targets.

Via a groundwater bypass, reduce the groundwater level around the Building and groundwater inflow into the Building

Measures to pump up groundwater flowing from the mountain side upstream of the Building to reduce the groundwater inflow (groundwater bypass) have been implemented.
The pumped up groundwater is temporarily stored in tanks and released after TEPCO and a third-party organization have confirmed that its quality meets operational targets.
Through periodical monitoring, pumping of wells and tanks is operated appropriately.
At the observation holes installed at a height equivalent to the buildings, the trend showing a decline in groundwater levels is checked.
The analytical results on groundwater inflow into the buildings based on existing data showed a declining trend.

Installing land-side impermeable walls with frozen soil around Units 1-4 to prevent the inflow of groundwater into the building



To prevent the inflow of groundwater into the buildings, installation of impermeable walls on the land side is planned. Freezing started on the sea side and at a part of the mountain side from March 2016 and at 95% of the mountain side from June 2016. Freezing of the remaining unfrozen sections advanced with a phased approach and freezing of all sections started in August 2017.

In March 2018, construction of the land-side impermeable walls was completed, except for a portion of the depth, based on a monitoring result showing that the underground temperature had declined below 0℃ in almost all areas, while on the mountain side, the difference between the inside and outside increased to approx. 4-5 m. The 21st Committee on Countermeasures for Contaminated Water Treatment, held on March 7, 2018, evaluated that together with the function of sub-drains, etc., a water-level management system to stably control groundwater and isolate the buildings from it had been established and had allowed a significant reduction in the amount of contaminated water generated.

For the unfrozen depth, a supplementary method was implemented and it was confirmed that temperature of the part declined below 0℃ by September 2018. From February 2019, maintenance operation started at all sections.

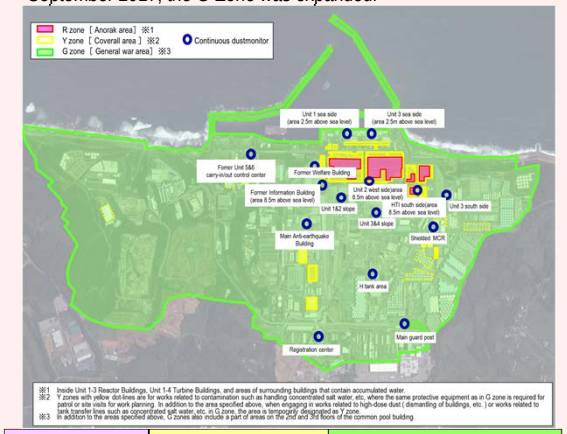
Progress toward decommissioning: Work to improve the environment within the site

Immediate targets	・Reduce the effect of additional release from the entire power station and radiation from radioactive waste (secondary water treatment waste, rubble, etc.) generated after the accident, to limit the effective radiation dose to below 1mSv/year at the site boundaries. ・Prevent contamination expansion in sea, decontamination within the site

Optimization of radioactive protective equipment

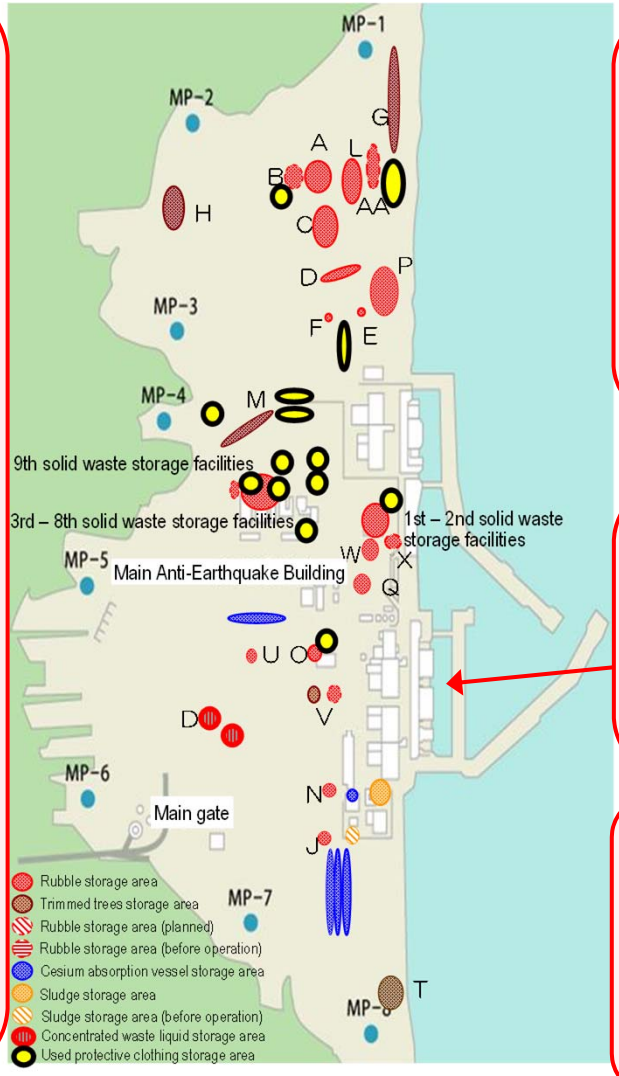
Based on the progress of measures to reduce environmental dosage on site, the site is categorized into two zones: highly contaminated area around Unit 1-4 buildings, etc. and other areas to optimize protective equipment according to each category aiming at improving safety and productivity by reducing load during work.

From March 2016, limited operation started. From March and September 2017, the G Zone was expanded.



R zone (Anorak area)	Y zone (Coverall area)	G zone (General wear)
Full-face mask	Full-face or half-face masks *1 *2	Disposable disposable mask
Anorak on coverall Or double coveralls	Coverall	General*3 / Dedicated on-site wear

*1 For works in buildings including water-treatment facilities [multi-nuclide removal equipment, etc.] (excluding site visits), wear a full-face mask.
*2 For works in tank areas containing concentrated salt water or Sr-treated water (excluding works not handling concentrated salt water, etc., patrol, on-site investigation for work planning, and site visits) and works related to tank transfer lines, wear a full-face mask.
*3 Specified light works (patrol, monitoring, delivery of goods brought from outside, etc.)



Installation of dose-rate monitors

To help workers in the Fukushima Daiichi Nuclear Power Station precisely understand the conditions of their workplaces, a total of 86 dose-rate monitors were installed by January 4, 2016.

These monitors allow workers to confirm real time on-site dose rates at their workplaces.

Workers are also able to check concentrated data through large-scale displays installed in the Main Anti-Earthquake Building and the access control facility.


Installation of Dose-rate monitor

Installation of sea-side impermeable walls

To prevent the outflow of contaminated water into the sea, sea-side impermeable walls have been installed.

Following the completed installation of steel pipe sheet piles on September 22, 2015, connection of these piles was conducted and connection of sea-side impermeable walls was completed on October 26, 2015. Through these works, closure of sea-side impermeable walls was finished and the contaminated water countermeasures have been greatly advanced.


Installation of steel pipe sheet piles for sea-side impermeable wall

Status of the large rest house

A large rest house for workers was established and its operation commenced on May 31, 2015.

Spaces in the large rest house are also installed for office work and collective worker safety checks as well as taking rest.

On March 1, 2016 a convenience store opened in the large rest house. On April 11, operation of the shower room started. Efforts will continue to improve convenience of workers.