

“Roadmap towards Restoration from the Accident at
Fukushima Daiichi Nuclear Power Station, TEPCO”

October 17th, 2011

Nuclear Emergency Response Headquarters
Government-TEPCO Integrated Response Office

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I. Cooling

(1) Reactor

1. Target for Step 2 “Cold Shutdown Condition”

- Circulating water cooling will be continued and enforced, thus bringing the reactors to a “Cold Shutdown Condition” monitoring the RPV temperatures, etc.
- Maintain stable operation of accumulated water processing facility. (Implementation items are stated in II. (3))
- NISA to continue confirming operating status and related matters.

Definition of “Cold Shutdown Condition”

- Temperature of RPV bottom is, in general, below 100 °C.
- Release of radioactive materials from PCV is under control and public radiation exposure by additional release is being significantly held down. (Not exceed 1 mSv/y at the site boundary as a target.)

In order to keep satisfying the above two conditions, secure mid-term safety of the circulating water cooling system (reliability of parts and materials, redundancy and independency, assessment of slack time for emergency, detection of failure and trouble, confirmation of restoration measures and recovery time, etc.)

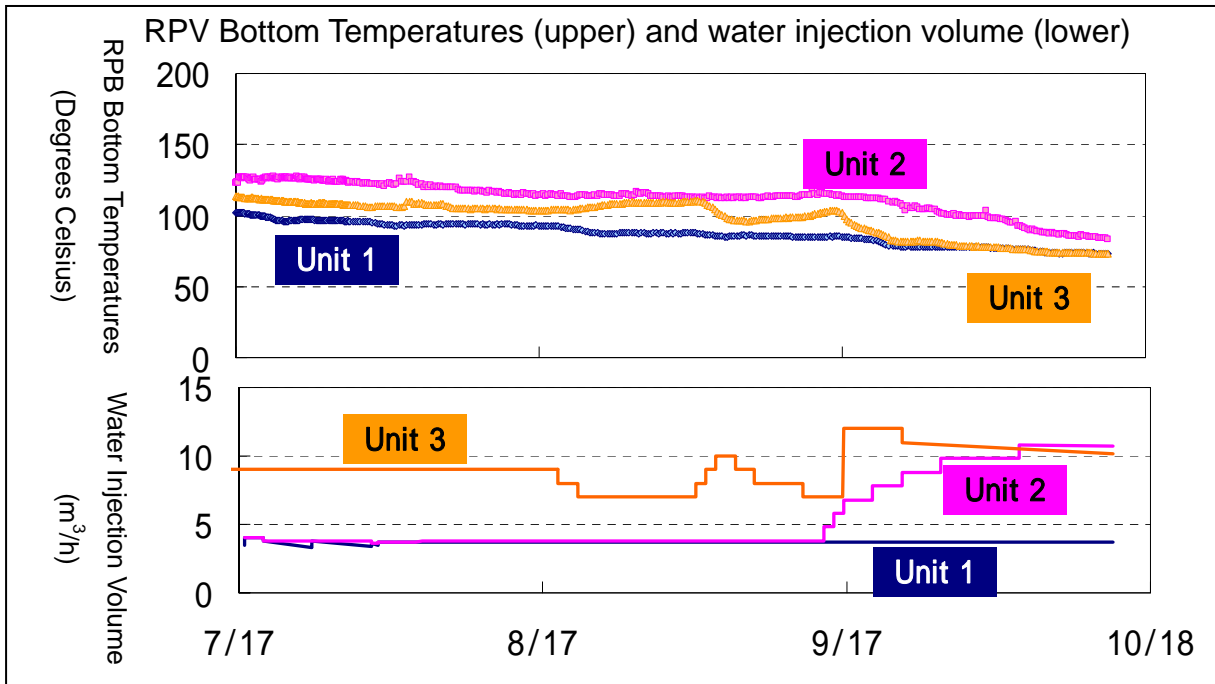
2. Current status and work implemented

Additional water injection line for more effective cooling

[Countermeasures 12, 14, 45]

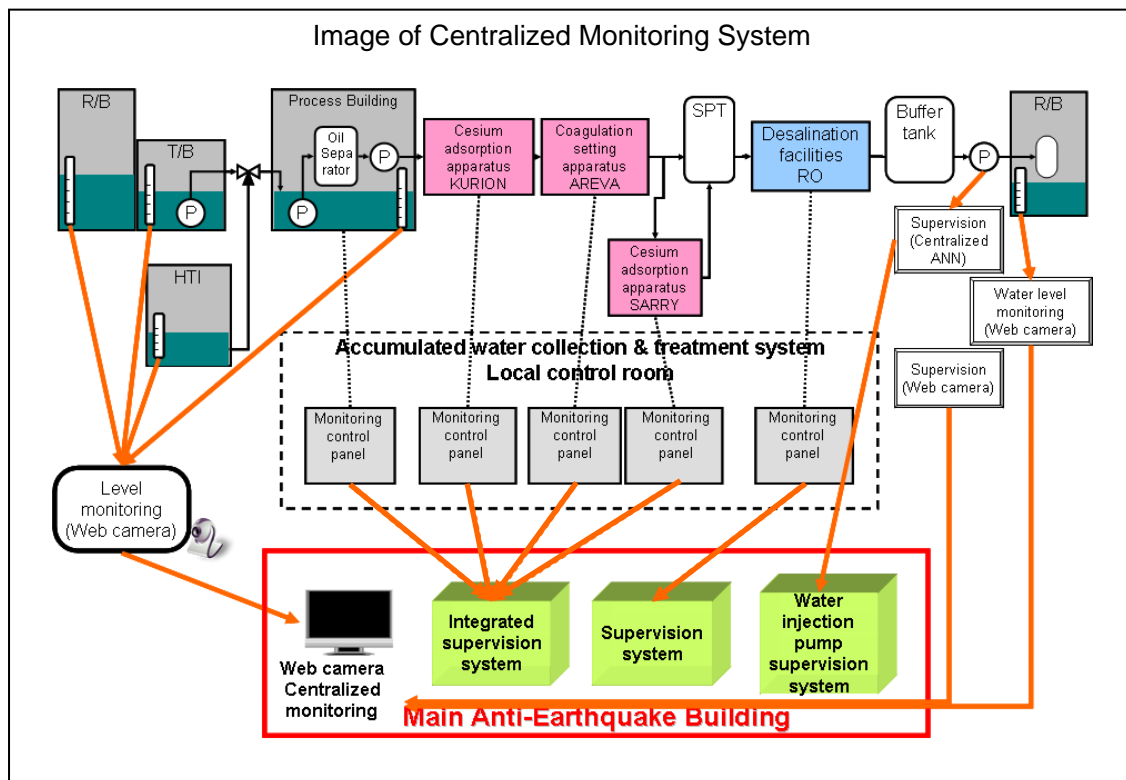
- RPV bottom temperatures was 74 °C in Unit 1, 83 °C in Unit 2 and 73 °C in Unit 3 (as of Oct.15.) RPV bottom temperatures in Units 1 and 3 have stabilized below 100 °C. By changing the water injection volume on a trial basis, it has been verified that Unit 2’s RPV bottom temperature can stabilize below 100 °C.
- Currently, water injection towards achieving cold shutdown is being implemented at the volume of approx. 3.7 m³/h for Unit 1, approx. 10.4 m³/h for Unit 2* and approx. 10.2 m³/h for Unit 3* (as of Oct. 15.)

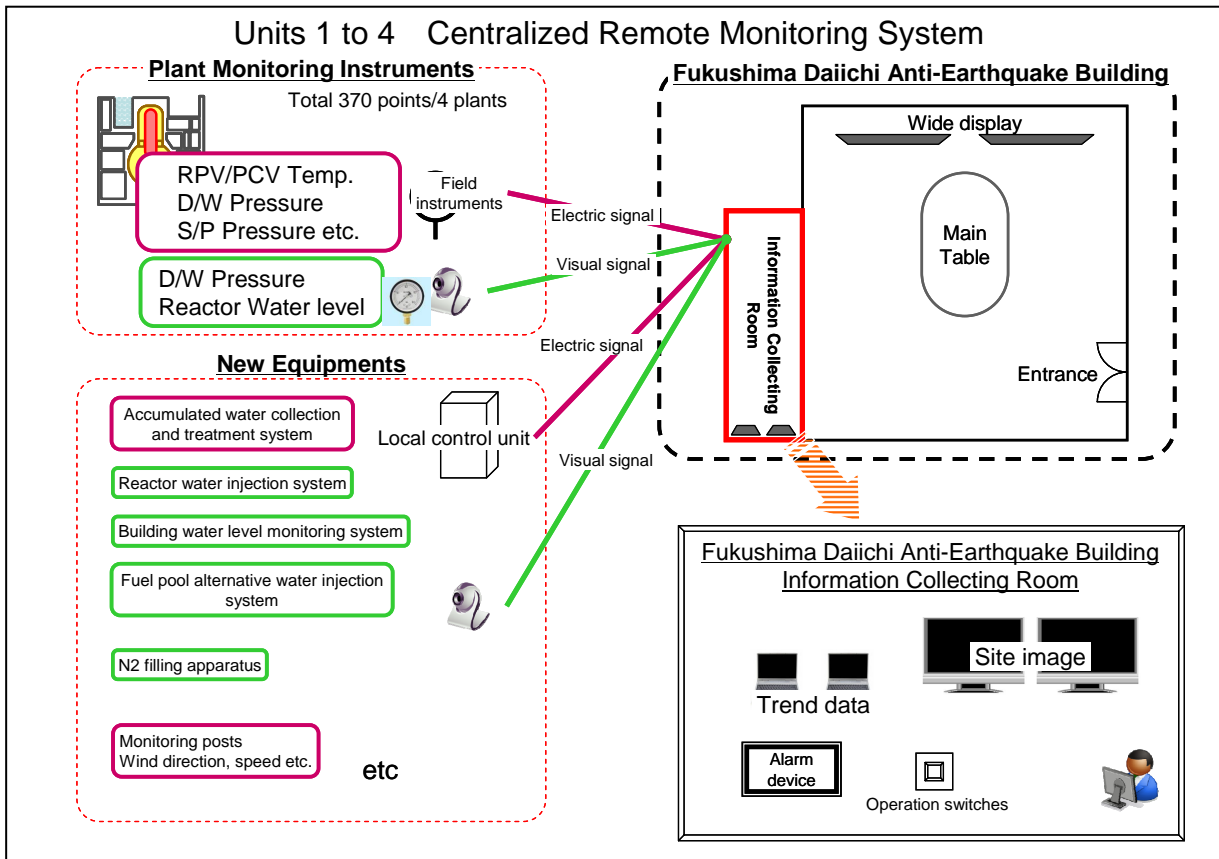
*Injecting water via Feed Water line and Core Spray line



Installation of centralized monitoring system in the Main Anti-Earthquake Building [Countermeasures 12,14,45]

- Installed a system that enables the monitoring of various parameters such as the water injection volume, injection pressure, buffer tank water level, operation status of accumulated water treatment system, etc., from monitors installed in the Main Anti-Earthquake Building (Sep. 30.)
- That enables monitoring at the place with minimum radiation exposure in the Main Anti-Earthquake Building.
- Also, the condition which enables accurate and prompt comprehension of the operation status of equipments was established.





R/B: Reactor Building, T/B: Turbine Building, HTI: High Temperature Incinerator building, RO: Reverse Osmosis membrane,
 ANN: Annunciator, RPV: Reactor Pressure Vessel, PCV: Primary Containment Vessel, D/W: Dry-well, S/P: Suppression Pool

(2) Spent Fuel Pool

1. Target for Step 2 “More stable cooling”

- “More stable cooling” (target for Step 2) for Units 2 and 3 was achieved by the end of Step 1 by having installed heat exchangers and maintaining pool water level.
- Circulating cooling systems for Units 1 and 4 have been installed, thus the target for Step 2 has been achieved in all Units. (Aug. 10.)

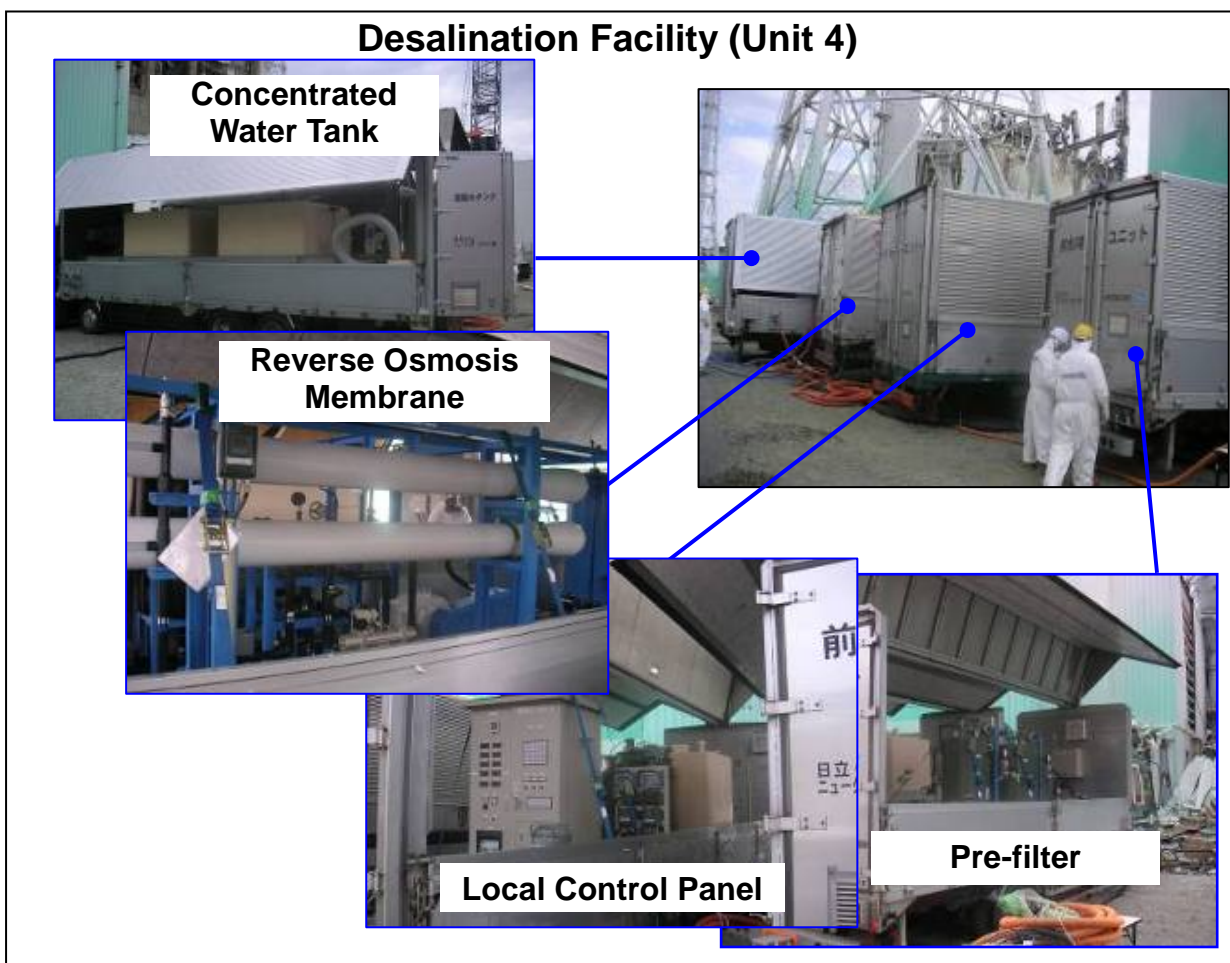
2. Current status and work implemented

Current status of Spent Fuel Pool

- Unit 1: 25 , Unit 2: 27 , Unit 3: 27 and Unit 4: 35 (as of Oct. 15)

Operation of Unit 4 desalination facility (Aug. 20) [Countermeasures 25, 27]

- In order to prevent corrosion of the spent fuel pool, the desalination facility has begun operation (Aug. 20.)
- The salt concentration of water (chloride ion concentration) in the spent fuel pool before the operation of the desalination facility was 1,944 ppm (Aug. 20), while its concentration after the operation was 410 ppm (Sep. 28.)
- The desalination for Units 2 and 3, in which sea water injections were carried out, are planned to be implemented in turn.



II. Mitigation

(3) Accumulated Water

1. Target for Step 2 “Reducing the total amount of accumulated water”

- Reduction of the total amount of accumulated water by processing the accumulated water in the buildings via the stable operation of processing facility.
- Augmentation of reuse by expansion of high-level contaminated water processing facility, steady operation and desalination of decontaminated water.
- Begin consideration of full-scale water processing facilities for high-level contaminated water.
- Storage/management of sludge waste generated from high-level contaminated water processing facility.
- Implement steel pipe sheet pile installation work at the port to mitigate contamination in the ocean.

2. Current status and work implemented

Status of the accumulated water processing

- Regarding accumulated water processing performance, approx.128,140 tons have been processed in total (as of Oct. 13.)
- The accumulated water level is being kept at the present target level (O.P 3,000.) In other words, the total amount of accumulated water is at the level where it is able to withstand heavy rains as well as long-term processing facility outages.
- Decontamination factor* of the processing facility for cesium is 10^6 in the apparatus of Kurion-Areva (as of Aug.9), 10^4 in Kurion (as of Sep.26) and 10^6 in SARRY (as of Sep 26.) *Decontamination factor = cesium concentration of a sample before processing / cesium concentration of a sample after processing

Implemented reliability enhancement countermeasures towards stable processing [Countermeasure 43]

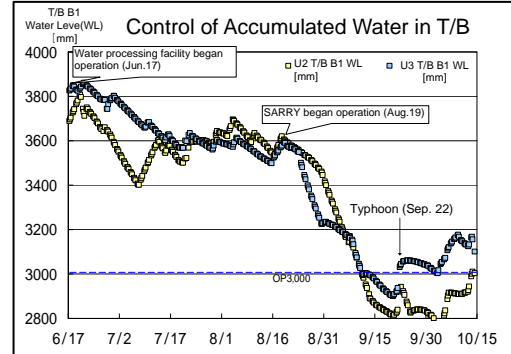
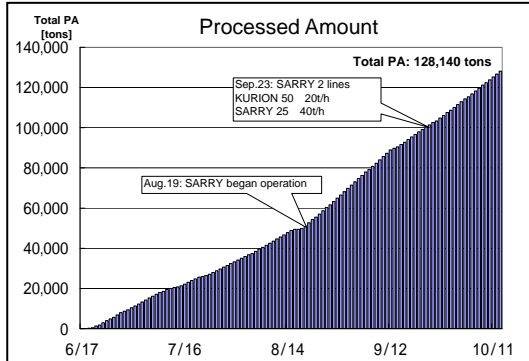
- Installed cesium adsorption apparatus (SARRY) and completed the augmentation of decontamination facility (Aug.18.)

Completed augmenting desalination processing facility [Countermeasure 43]

- Installed the evaporative concentration apparatus (two lines, Aug.7 and 31) in addition to the reverse osmosis membrane method (Jun.17.)
- Confirmed that chlorine concentration had been decreased from 6,000 ppm to approx. 20ppm by the reverse osmosis equipment (per the Aug. 9 results) and that had been decreased from 12,000 ppm to less than 1 ppm by the

evaporative concentration apparatus (per the Aug. 16 results).

- Completed augmentation of desalination processing facility via the evaporative concentration apparatus (Oct.9), enabling more stable water injection into the reactors.



Storage/management of sludge waste, etc. [Countermeasure

81]

- Sludge waste with high radioactive concentration generated by processing the high-level contaminated water and high radioactive used-adsorption tower are properly being secured and managed respectively in the Centralized Waste Processing Building and the adsorption tower storage facility.
- Implementing preparation work to install storage facility for sludge waste in order to expand storage capacity for sludge waste.
- Implementing installation work for used-adsorption tower storage facility in order to expand storage capacity for used-adsorption tower.

Securing storage [Countermeasure 42]

- Installed tanks for high-level contaminated water (2,800 tons) in order to expand storage facility for high-level contaminated water (Sep.17.)

Prevent contamination in the ocean [Countermeasure 64]

- Completed the placement of the steel pipe sheet pile in order to block the damaged parts of permeation prevention structure due to the tsunami at the south side of the intake canal of Units 1 to 4 as a countermeasure to mitigate contamination in the ocean (Sep.28.)

Status of steel pipe sheet pile



(4) Groundwater

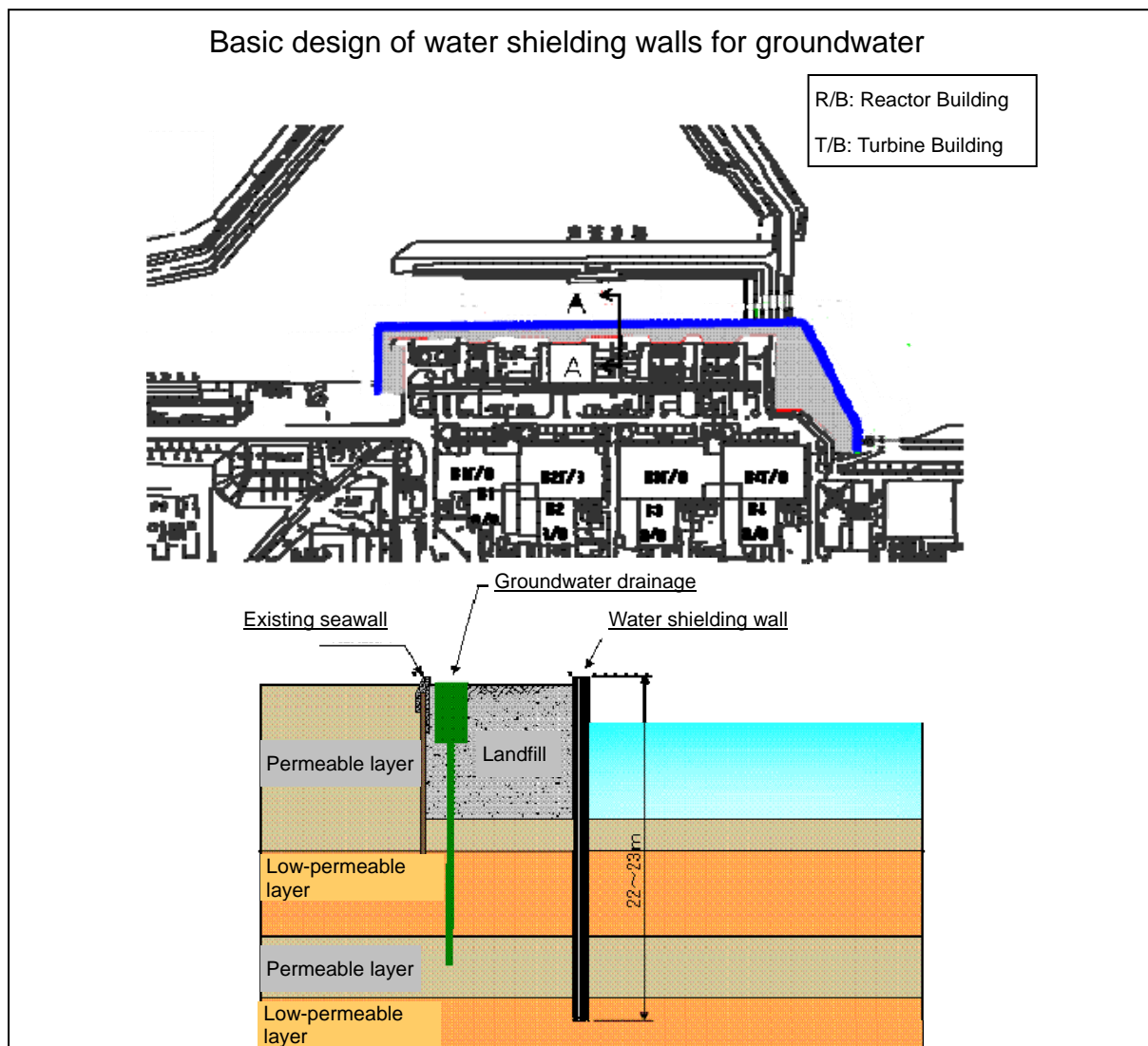
1. Target for Step 2 “Mitigating contamination in the ocean”

- Mitigate contamination in groundwater as well as contamination in the ocean via groundwater by controlling accumulated water inflow into groundwater.
- Commencing installation work for water shielding wall in front of existing seawalls of Units 1 to 4, with the expectation of mitigating contamination in the ocean via groundwater.

2. Current status and work implemented

Consideration of water shielding wall [Countermeasure 68]

- In order to further ensure the mitigation of contamination in the ocean, the basic design for installing the water-proof steel pipe sheet piles in front of the existing seawalls of Units 1 to 4 has been completed (Aug. 31.)
- Currently the design specifications for construction are under consideration. Construction work will commence from around the end of October.



Implementation of prevention against expansion of contamination in groundwater [Countermeasure 67]

- Installed pumps at sub-drainage pit on the turbine building side at seven places (Jul. 29.)

(5) Atmosphere/Soil

1. Target for Step 2 “Mitigating dispersion of radioactive materials”

- Reduce dispersion of radioactive materials deposited in the site.
- Continue dust inhibitor spraying as well as removal of debris.
- Install the reactor building cover (Unit 1.)
- Commence removal of debris on top of the reactor buildings (Units 3 and 4.)
- Consider containers for the reactor buildings.

2. Current status and work implemented

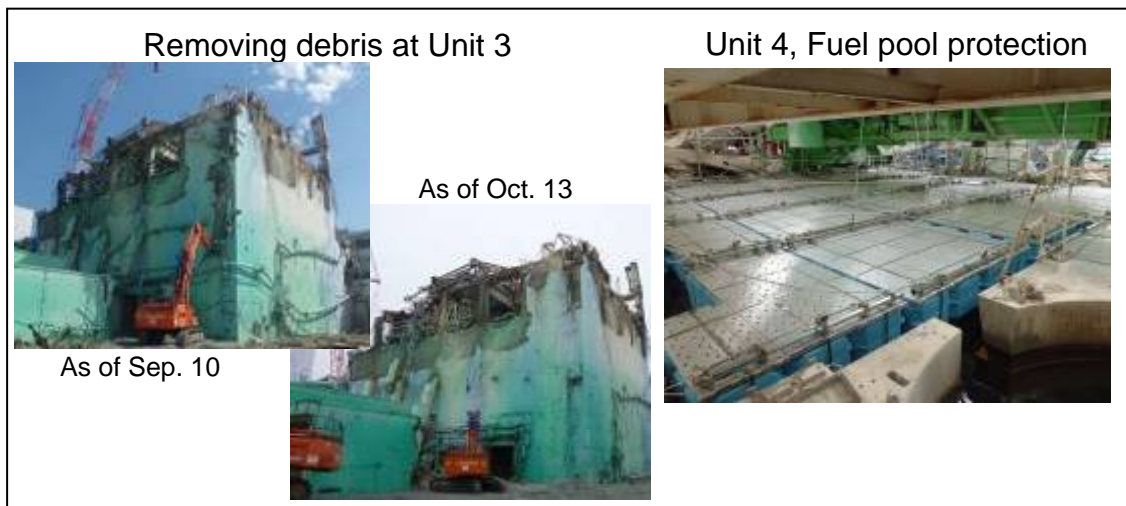
Installation of the Unit 1 reactor building cover [Countermeasures 54, 55]

- Steel frames has been installed (Sep. 9.)
- Installing panels between steel frames is under construction. The work will be completed around the end of October.



Removal of debris at the upper part of the reactor buildings (Units 3 and 4) [Countermeasure 84]

- Began removing debris at the upper part of the reactor building of Unit 3 (Sep. 10.)
- Began removing debris at the upper part of the reactor building of Unit 4 (Sep.21). Covered the fuel pool by floats against drop of debris (Oct. 14.)



Removal and management of debris [Countermeasures 53, 84, 87]

<Removal of debris>

- The volume of approx. 900 containers of debris has been removed (as of Oct. 17.) [Countermeasures 53, 84]
- The waste such as the removed debris and the trees cut down for site preparation are classified according to their kinds as well as the amount of radiation dose in the storage area and transported.

<Management of debris>

- Debris are stored in the containers and reserved in the buildings according to the amount of radiation dose.
- The approach lane to the waste storage area is marked off and a No Entry sign was posted to prevent entrance of unauthorized personnel.
- Except for the radioactive accumulated water treatment facilities and the other areas under construction, the storage areas are secured, fully utilizing the land within the site.



<Water spray in the site>

- Purified water, which satisfies the guideline for bathing water, is reused to spray in the site in order to prevent lumber from firing spontaneously and dust

from dispersing.

Result of purified water analysis and guideline for the bathing water

(Unit: Bq/cm³)

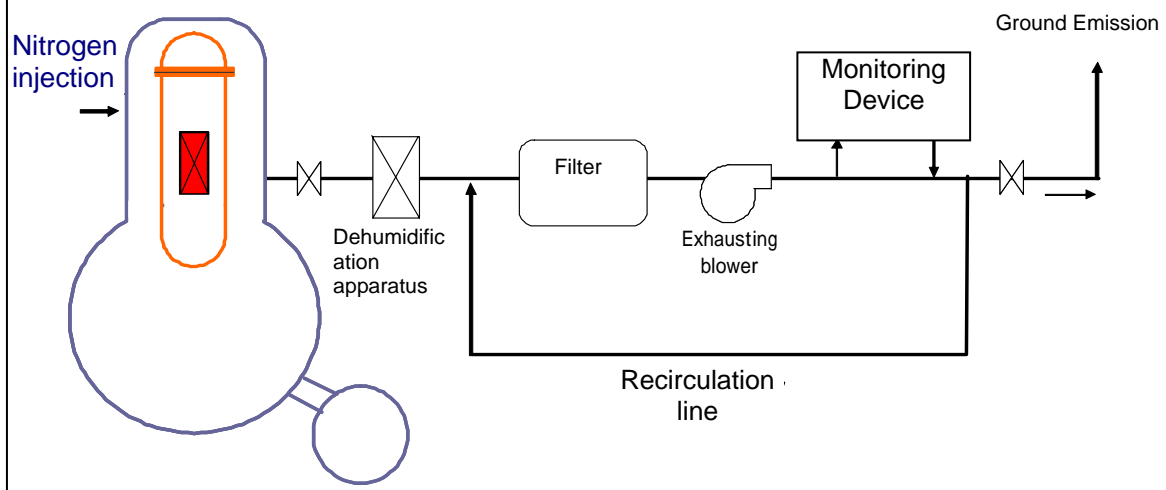
Nuclide	Result of purified water analysis	Guideline for radioactive materials in the bathing water (Ministry of the Environment)
Iodine 131	ND (<4.7E-03)	3.0E-02
Cesium 134	ND (<9.7E-03)	5.0E-02 (Sum of Cesium 134&137)
Cesium 137	ND (<1.2E -02)	

Installation of PCV gas control system [Countermeasure 86]

- Installation of PCV gas control system started (Unit 1-Oct 7, Unit 2-Oct 10, Unit 3 (preparation work)-Sep 30).
- Careful measures were taken such as nitrogen injection and the adoption of static electricity resistant hose since highly concentrated hydrogen was detected in the Unit 1's piping arrangement on which were to be worked. (Oct 10.)

Conceptual Diagram of PCV Gas Control System

- A system to adjust the pressure in the PCV to the almost same level as the atmospheric pressure by extracting almost the same amount of gas as the nitrogen fill ration in the PCV in order to reduce the amount of radioactive materials released from PCV after the temperature at the bottom of the reactor is kept below 100°C.
- The system is designed to monitor the extracted and filtered gas before releasing it.
- The amount of radioactive materials released from PCV will be further reduced using the system, while it is expected to reduce due to the decline in the temperature of the reactor.



III . Monitoring and decontamination

(6) Measurement, reduction, disclosure

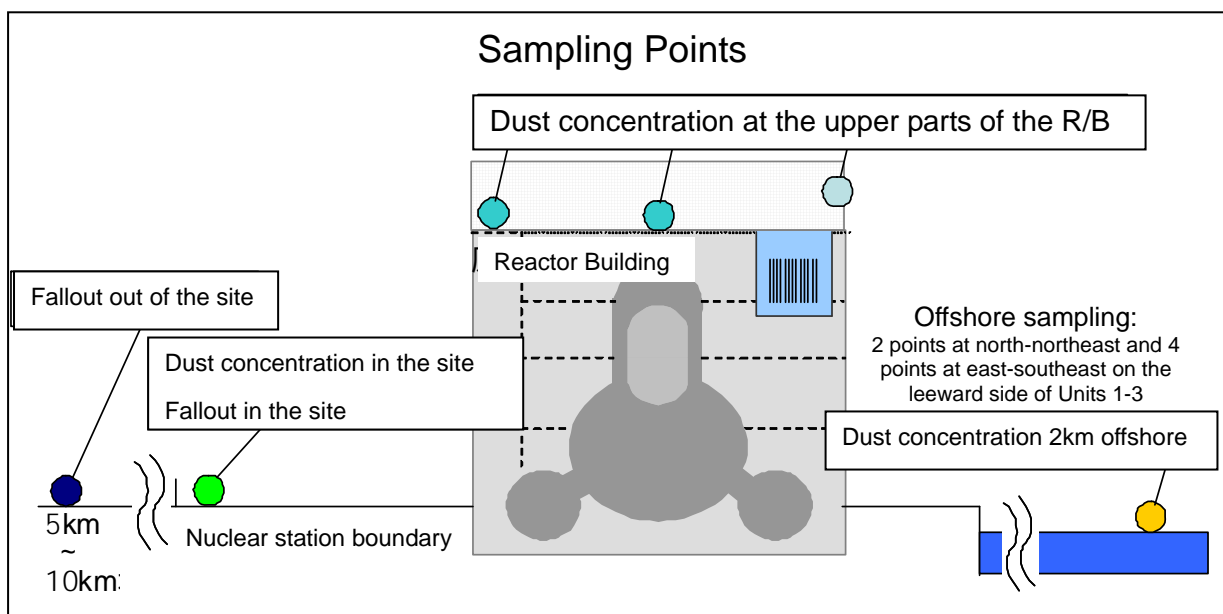
1. Target for Step 2 “Sufficient reduction of radiation dose”

- Expansion and enhancement of monitoring, and continuation of disclosure.
- Monitoring by government, prefectures, municipalities and operators.
- Commencement of full-scale decontamination.

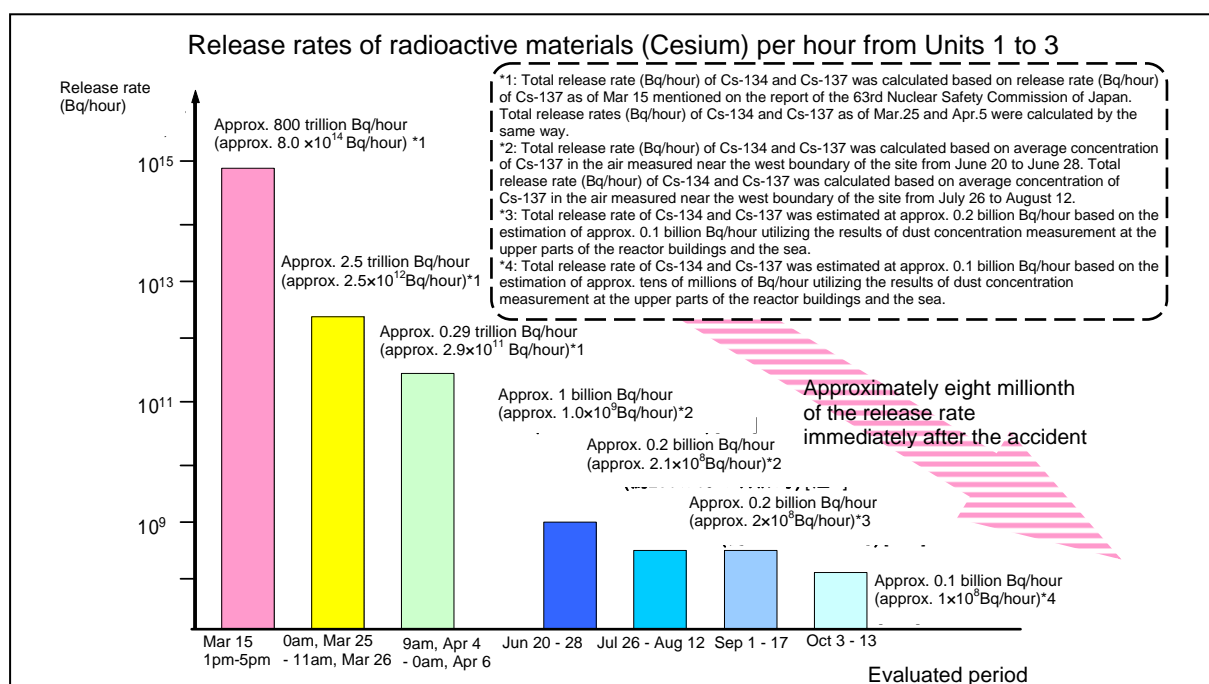
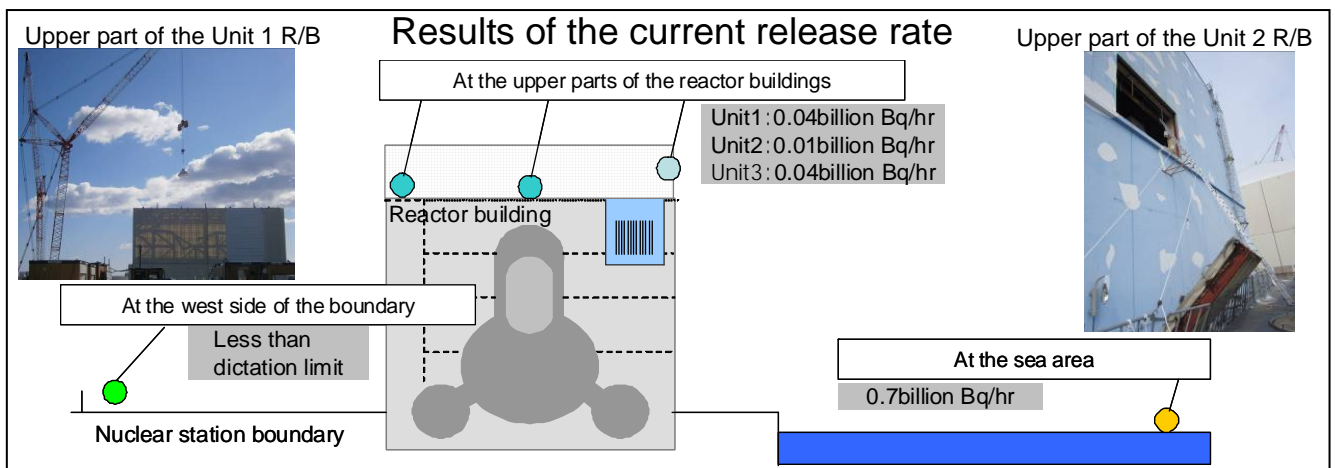
2 . Current status and work implemented

Evaluated the amount of radioactive materials currently released from PCVs [Countermeasures 60, 61]

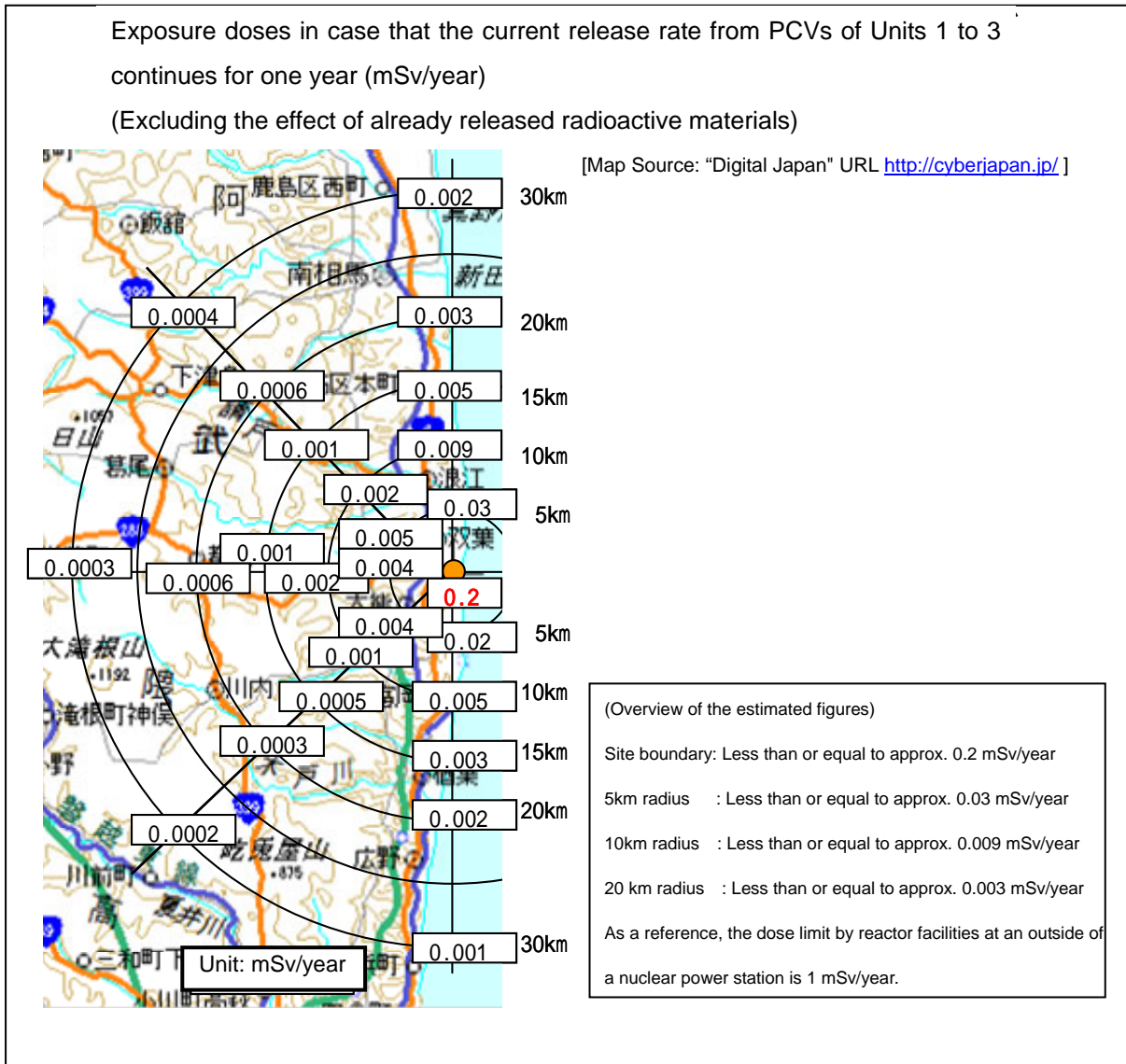
- In order to estimate the amount of radioactive materials currently released from PCVs, implemented the measurement of the airborne radioactivity concentration (dust concentration) at the upper part of the reactor buildings and at land and sea.
- Measured dust concentration in the site area and sea area (15 points.) As the dust concentration in the site such as near the west gate and monitoring posts in 15 points is showing decreasing trend, and is almost below detectable limit, we did not employ these data for estimating current release rate of radioactive materials from PCVs.
- Implemented sampling of radioactive fallout (12 points in and out of the site.) As we estimated that almost all of samples were occupied by re-suspended radioactive materials which were released in the past, we did not employ these data for estimating current release rate of radioactive materials from PCVs.



- The current release rate from PCVs of Units 1 to 3 has been estimated utilizing the airborne radioactivity concentration (dust concentration) at the upper parts of the reactor buildings and in the sea.
- The current release rate for each Unit is estimated at, Unit 1: approx. 0.04 billion Bq/h, Unit 2: approx. 0.01 billion Bq/h and Unit 3: approx. 0.04 billion Bq/h, respectively, using dust concentration at the upper parts of the reactor buildings. The total release rate from Units 1 to 3 is estimated at approx. 0.08 billion Bq/h (Release rate for each Unit is rounded up.)
- The current total release rate from Units 1 to 3 is estimated at approx. 0.07 billion Bq/h using dust concentration at the 2km offshore from the site, and there might be little effect of radioactive materials that released previously.
- Therefore, the current total release rate from Units 1 to 3 is assessed at approx. 0.1 billion Bq/h at the maximum (provisional figure), which is 1/8,000,000 of that at the time of the accident.



- The radiation exposure per year at the site boundaries is assessed at approx. 0.2 mSv / year provisionally (The target is 1 mSv / year, excluding the effect of the radioactive materials already released up until now.)



- Continuously implement the measurement of airborne radioactivity concentration at the upper parts of the reactor buildings and in surrounding area (land and sea), thus grasping the reduction tendency of the radioactivity release rate due to the mitigation countermeasures.

Joint monitoring by the central government, prefectures, municipalities and the operator [Countermeasure 62]

- Having instructions from the Ministry of Education, Culture, Sports, Science and Technology, the operator has implemented sampling and measurement at land and sea as below.

[Land]

<Monitoring within 20km radius>

- Measurement of airborne radioactivity concentration by the support team from the Federation of Electric Power Companies at 50 points (once a week)
- Dust sampling at 5 points near 10km radius by the same team (once a month)

[Sea]

<Fukushima Prefecture>

- Seawater at 11 points within the site bay (once a day)
- Seawater at 4 points along the coast (once a day)
- Seawater at 8 points within 20km radius (every two days)
- Seawater at 3 points within 30km radius (once a week)
- Seawater at 10 points outside 30km radius (once a week)
- Seabed soil survey at 25 points (once a month)

<Ibaraki Prefecture>

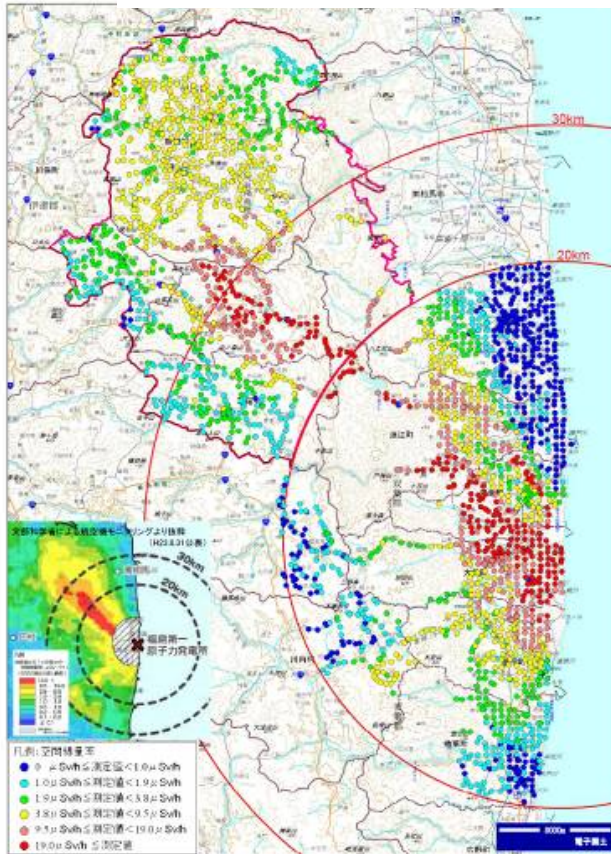
- Seawater at 5 points (once a week)

<Miyagi Prefecture>

- Seawater at 6 points (twice a month)
- Sampling of seawater and seabed soil at a few kilometers offshore in front of the power station will be implemented with an unmanned survey boat.

- The Cabinet Office and the Ministry of Education, Culture, Sports, Science and Technology announced the implementation of “Wide Area Monitoring” at restricted areas and deliberate evacuation areas (Sep. 1.)

Wide Area Monitoring results map (height: 1m) and selection method of monitoring points



Divide the target areas by 2km x 2km meshes, selected approx. 20 points^{*1} from each mesh based on the basic data collection results^{*2} and monitor the airborne radioactivity concentration (Jul.4 – Aug.20.)

*1 Various places such as 16 points by dividing each mesh 500m x 500m as well as crowded places (schools, public facilities, parks, shopping malls, supermarkets, shrines and temples, etc.) were selected.

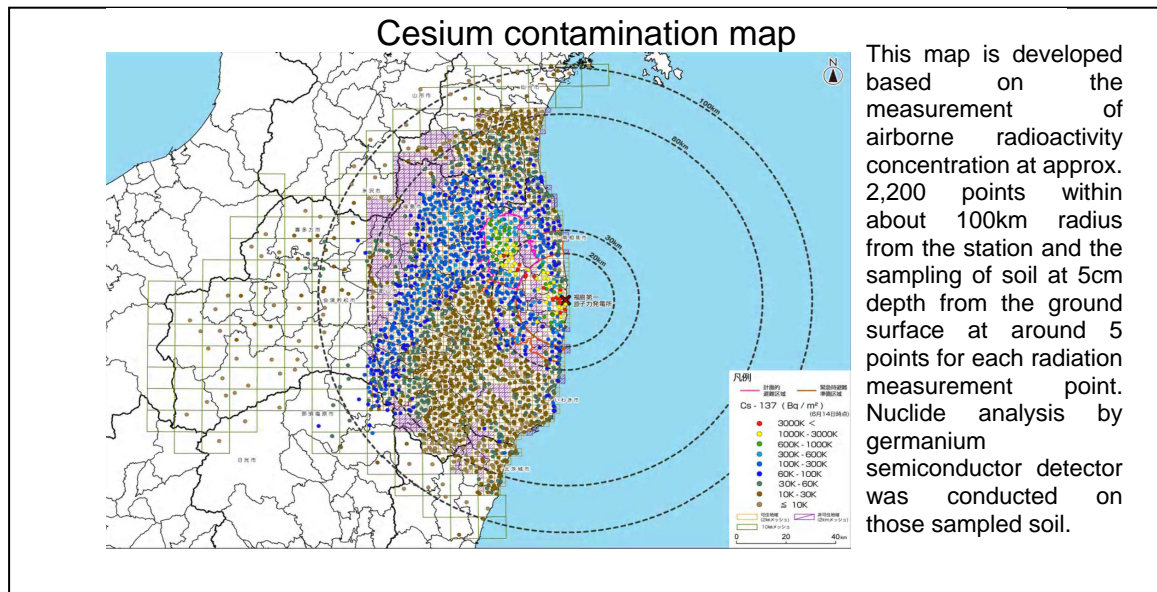
*2 Airborne radioactivity concentration was monitored at around Namie Station and Tomioka Town Station which have various types of environments. The distribution of air dose rate was developed based on the density of radioactive materials that were discharged by the accident and accumulated in the soil etc.

- The operator also developed the “Wide Area Monitoring” plan and conducted monitoring together (approx. 800 persons in total.)

Measurement work of Wide Area Monitoring



- Based on the result of Wide Area Monitoring, the “Individual Detailed Monitoring” on houses, roads and school grounds is being implemented in order to collect the basic data for the development of implementation plan to improve the environment in these areas (from mid-June to the end of October.)
- The Ministry of Education, Culture, Sports, Science and Technology published “Map of radioactive contamination (Cesium contamination map)” (Aug. 30.)



- Measurement of airborne radioactivity concentration and soil sampling were conducted by universities, Japan Atomic Energy Agency, National Institute of Radiological Sciences, Japan Chemical Analysis Center and the team from Federation of Electric Power Companies.

Consideration and commencement of full-scale decontamination

[Countermeasure 63]

[Countermeasures implemented by the central government]

- The decontamination support team (composed of Ministry of the Environment and Cabinet Office etc.) for Fukushima prefecture started providing municipals with advice on the development of municipal decontamination plans and allocating experts (Japan Atomic Energy Agency, TEPCO) (Oct. 3.)
- Utilizing the Great East Japan Earthquake Recovery and Reconstruction Reserve Fund, the central government is swiftly preparing the model project of decontamination at the areas that possibly have over 20mSv of additional exposure dose per year (restricted areas and deliberate evacuation areas). Currently, the preliminary monitoring is underway.
- The central government started planning of the interim storage facilities that would stably store the contaminated soil for a certain period. The roadmap will be developed by the end of October.

[Activities where the operators are participating]

- Through the Wide Area Monitoring and the “Individual Detailed Monitoring, the operator collects information that would contribute to the effective decontamination work. (With these outputs and the knowledge about the radioactivity management, the operator will support the decontamination test conducted by the central government at the restricted area.)
- In order to support the developments of municipal decontamination plans, the operator started personnel support for the experts allocation program by the central government (Oct. 3.)
- The operator also provided Fukushima Prefecture with personnel support for the model project for reduction of radiation at general residential areas (Aug. 25 and 26.)

IV. Countermeasures against aftershocks, etc.

(7) Tsunami and reinforcement, etc.

1. Target for Step 2 “Mitigation of further disasters”

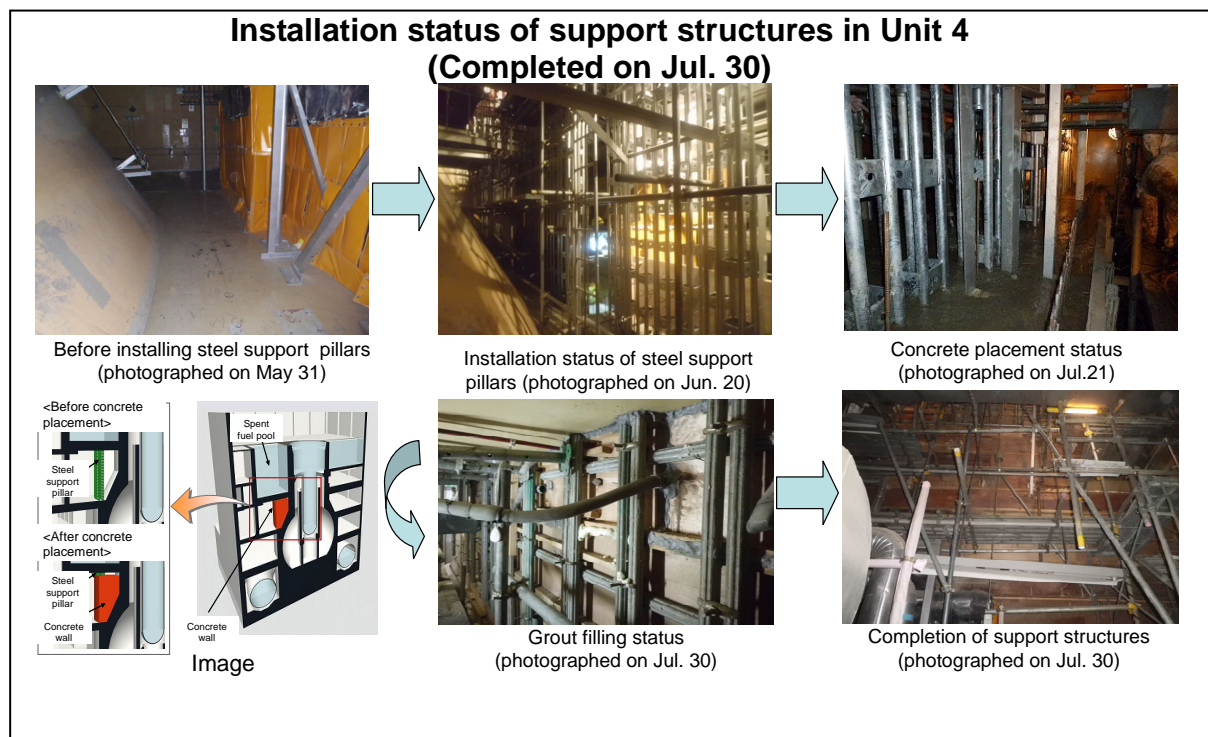
- Prevent situation from deterioration by mitigating disasters with countermeasures against emergencies (earthquakes and tsunami, etc.)
- Consideration of reinforcement work of each unit as necessary.
- Continue implementing various radiation shielding measures.

2. Current status and work implemented

Implementation of seismic resistance evaluation for each unit

[Countermeasure 71]

- Consideration of current seismic resistance and reinforcement, etc. for reactor buildings of Unit 2, Unit 5 and Unit 6 was implemented and evaluated by Aug. 26 (Unit 1 and Unit 4 were completed by May 28 and Unit 3 was completed by Jul. 13.)
- As a result of the analysis, it was evaluated that seismic resistance can be secured without any reinforcement.
- A survey inside the buildings will be conducted after implementation of measures to reduce radiation dose.



V . Environment improvement

(8) Living/ working environment

1. Target for Step 2 “Enhancement of Environment Improvement”

- Improve workers’ living/working environment that had been harsh during the initial phase of the accident, thus leading to maintaining workers’ motivation.
- Expansion of temporary dormitories and on-site rest stations.
- Improvement of environment such as meals, bath, laundry, etc.

2. Current status and work implemented

Expansion status of temporary dormitories [Countermeasure 75]

- Completed construction of temporary dormitory able to accommodate 1,600 persons (Aug. 31). Approx. 1,100 persons have already moved in (as of Oct. 1.)

Establishment status of on-site rest stations [Countermeasure 75]

- Twenty on-site rest stations have been established (approx. 4,400m² in size with a capacity to accommodate approx. 1,500 persons) (as of Oct. 5.)

Exterior (left) and interior (right) appearances of on-site rest stations



Inside of on-site rest stations (from left: drinking water, etc., restroom and air shower)



(9) Radiation Control/Medical Care

1. Target for Step 2 “Enhancement of Healthcare”

- Thorough radiation exposure control and countermeasures against heat stroke and influenza.
- Reinforcement of radiation control by NISA.
- Increase in the number of whole body counters, monthly measurement of internal exposure.
- Automated recording of personal radiation dose, report of personal exposure dose in writing, introduction of workers’ certificates with photos.
- Consideration of a long-term healthcare such as enhancement of workers’ safety training and establishment of a database.

2. Current status and work implemented

Expansion of whole body counters (WBC) [Countermeasure 78]

- Increased WBCs as planned (12 units have already been added as of Oct. 3.)
- Started measuring internal exposure once a month from September.

Written notification of exposure dose etc. [Countermeasure 78]

- Provided recording format of personal exposure in every entry (Aug. 16.)
- Started to use workers’ certificates with photos step by step (July 29.)
- Automated recording of personal exposure is under preparation. (Exposure data are currently manually secured in preparation for the use in future.)

Consideration for long-term healthcare such as establishing a database [Countermeasure 78]

- Announced the report of expert committee on the database creation and long-term health management (Sep. 26.)
- Obligate utilities to submit exposure dose records and health check records for long-term health management by revision of the Ordinance on Prevention of Ionizing Radiation Hazards, and announced a guideline regarding implementation of examination, etc. according to exposure dose (Oct. 11.)

Continuous reinforcement of medical system [Countermeasure 80]

- Changed Units 5/6’s emergency medical room’s period of operations from summer-only to all year round and emergency doctors, etc. have continuously been in place after September.
- Assigned nurses and radiation specialists (not regular basis in the meantime).
- Reinforcement of medical facility and decontamination facility to enable the speedy

Preparation of Ambulance
(near Units 5/6’s emergency medical
room)



transportation of patients and also the direct transportation of non-contaminated severely ill or injured patients to hospitals.

- Ambulance has been prepared (Sep. 16.) * Three transportation cars in total.
- Implementation of prevention and mitigation countermeasures against influenza (Start of protective vaccination, etc. from Nov. 1).

(10) Staff training/personnel allocation

1. Target for Step 2 “Systematic staff training and personnel allocation”

- Promotion of staff training in conjunction with the Government and utility operators, etc.

2. Current status and work implemented

Promote staff training, etc. in conjunction with the government and utility operators in order to train and allocate staffs systematically.

[Countermeasure 85]

- Conducting training for staffs engaged in radiation related work, who will be in great demand.
- TEPCO has been conducting “radiation survey staff training” targeted for employees and TEPCO group companies’ employees and has already trained approx. 3,000 personnel.
- The government has been conducting “radiation survey staff training” (7 times till Oct. 7 and approx. 200 personnel were trained.), “radiation protection staff training” (approx. 10 personnel were trained from Aug. 8 to 12, approx. 30 personnel were trained from Sep. 26 to 30) and will continue these trainings.
- According to affiliated companies needs, launched a new framework of looking for workers widely through Japan Atomic Industrial Forum (JAIF).

Radiation survey staff training



The operator shall report to NISA in accordance with the instructions

- Reported on operation plan and safety assessment results regarding circulating water cooling system (Oct. 17.)
- Other systems, etc. shall be reported on as well in a rapid manner.

END