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Status of the Fukushima Dai-ici NPP and our contribution to its decommissioning

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ICTP Summer School on Radiation Effects on Nuclear Wasteforms
11-16 September 2016

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Fukushima Dai-ici site before March 2011

Image credit: Reuters

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Fukushima Dai-ici site March 2011

Image credit: Xinhua/AFP

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Fukushima Dai-ici site March 2016

Image credit: Japan Times / KYODO

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Fukushima Dai-ici site plan

Image credit: TEPCO

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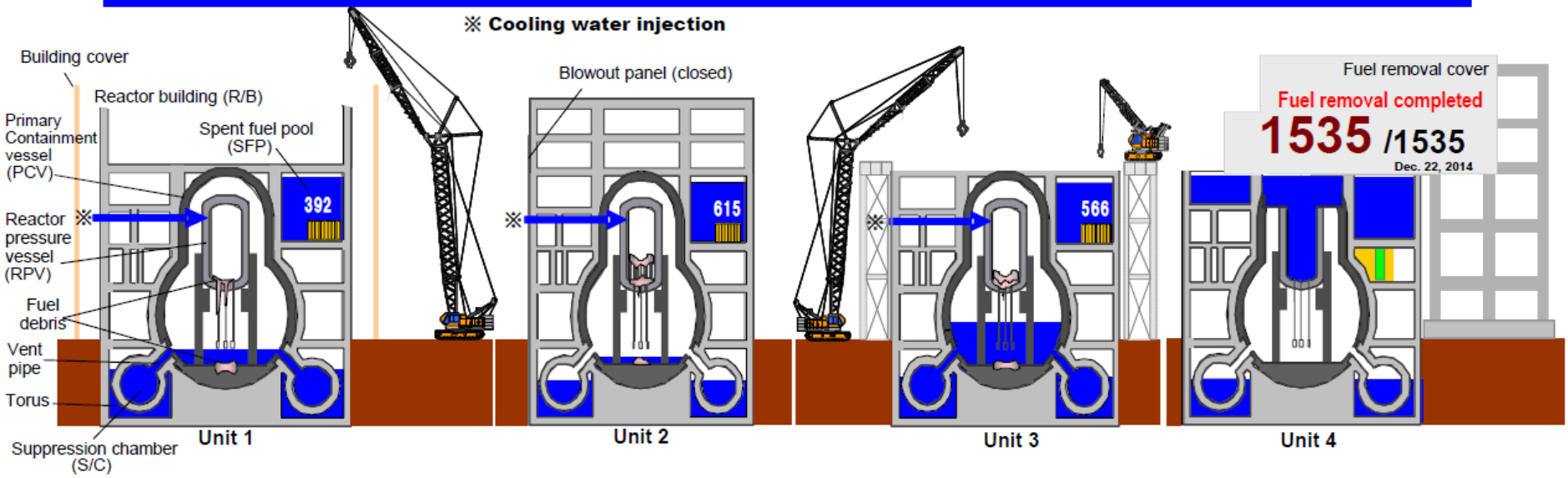
Status of Fukushima Dai-ici Units 1-4

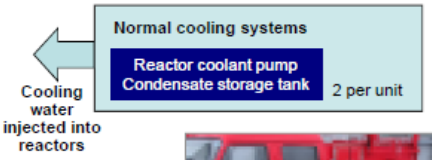
All Units continue to be in cold shutdown



Values as of 11:00 on 29th January 2016

	RPV bottom temp.	PCV internal temp.	Fuel pool temp.	Water injection to the reactor
Unit 1	~15℃	~16℃	~13℃	4.5㎥ / h
Unit 2	~20℃	~21℃	~29℃	4.3㎥ / h
Unit 3	~18℃	~18℃	~19℃	4.3㎥ / h
Unit 4	No fuel, so monitoring not required	No fuel, so monitoring not required	~8℃	—

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



＜Cooling multiplexed＞

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

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

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

Image credit: TEPCO

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Status of Fukushima Dai-ici Units 1-4

Common priority : strategy for fuel / debris removal for seismic and worker safety

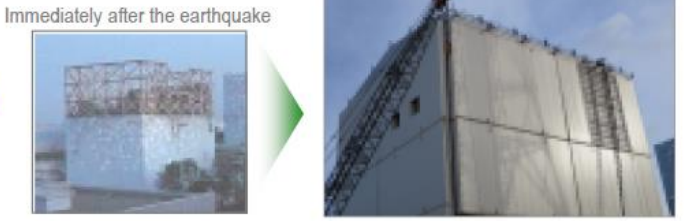
Unit 1

Current status

Building cover installed October 2011
Removal of building cover to allow removal of fuel from spent fuel pool

Tasks

Identification of debris on operating floor and inside spent fuel pool
Countermeasures for dispersion of radioactive materials during removal of building cover



Unit 2

Current status

Blow out panel closed
Very high dose rate inside building

Tasks

Radiation dose reduction measures

Unit 3

Current status

Debris removal from top of the reactor building competed October 2013
Installation of fuel removal cover and fuel handling facility planned

Tasks

Radiation dose reduction measures
Installation of remote controlled heavy machinery

Unit 4

Current status

Fuel removal from spent fuel pond completed
Start: 18 Nov. 2013, finish 22 Dec. 2014

Image credit: TEPCO

Fukushima Dai-ici site decommissioning plan

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

Dec. 2011 Dec. 2013

30～40 years later

Stabilization efforts

＜Cold shutdown achieved＞
・Cold shutdown
・Significantly reduce radiation releaseas

Phase 1
Period up to the commencement of the removal of the fuel from the spent fuel pool (within 2 years)

Started at #4 unit on Nov18.2013.

Phase 2
Period up to the commencement of the removal of the fuel debris (within 10 years)

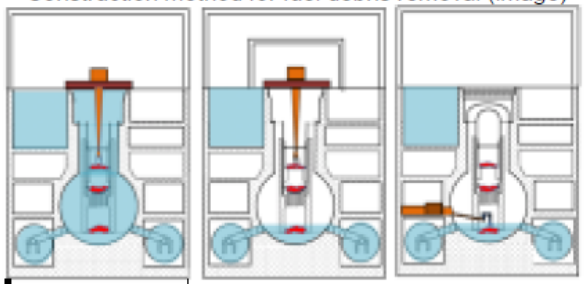
Phase 3
Period up to the completion of decommissioning measures (30 to 40 years in the future)

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

Fuel debris removal (Unit 1, 2 and 3)

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

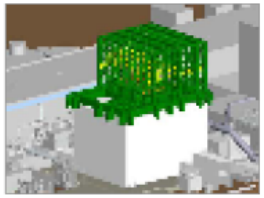
Construction method for fuel debris removal (image)



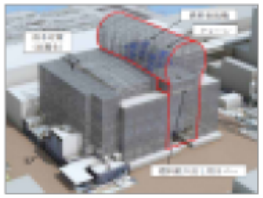
Fuel Debris	In the water	In the air
Removal Channel	Upside	Side
Challenge	Water proof and Earthquake proof	Shielding radiation and radioactive dust

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

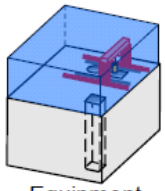
FY	2015	2016	2017	2018	2019	2020	2021	2022
Unit 1	Demolition building covers		Removal rubbles		Installation covers		Spent fuels removal	
Unit 2	Demolition upper buildings		Preparation		Plan① Installation containers		Spent fuels removal	
			Removal rubbles		Plan② Installation covers			
Unit 3		Installation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



Frame for Unit 1 pool



Cover for Unit 3 pool



Equipment for Unit 2

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

Image credit: TEPCO

Reactor cooling and water decontamination

- Water to cool fuel molten during the accident and groundwater have mixed, generating approximately 300 tons of contaminated water per day. Countermeasures are being implemented based on the following three basic polices.

Policy 1. Remove source of contamination

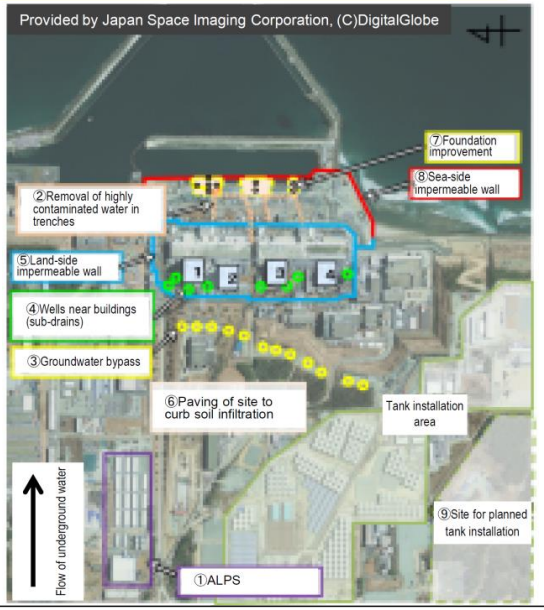
① Clean up contaminated water with Multi-nuclide removal equipment (ALPS)
② Remove contaminated water in trenches (Underground tunnel with piping)

Policy 2. Isolating groundwater from contamination sources

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

Policy 3. Preventing leakage of contaminated water

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



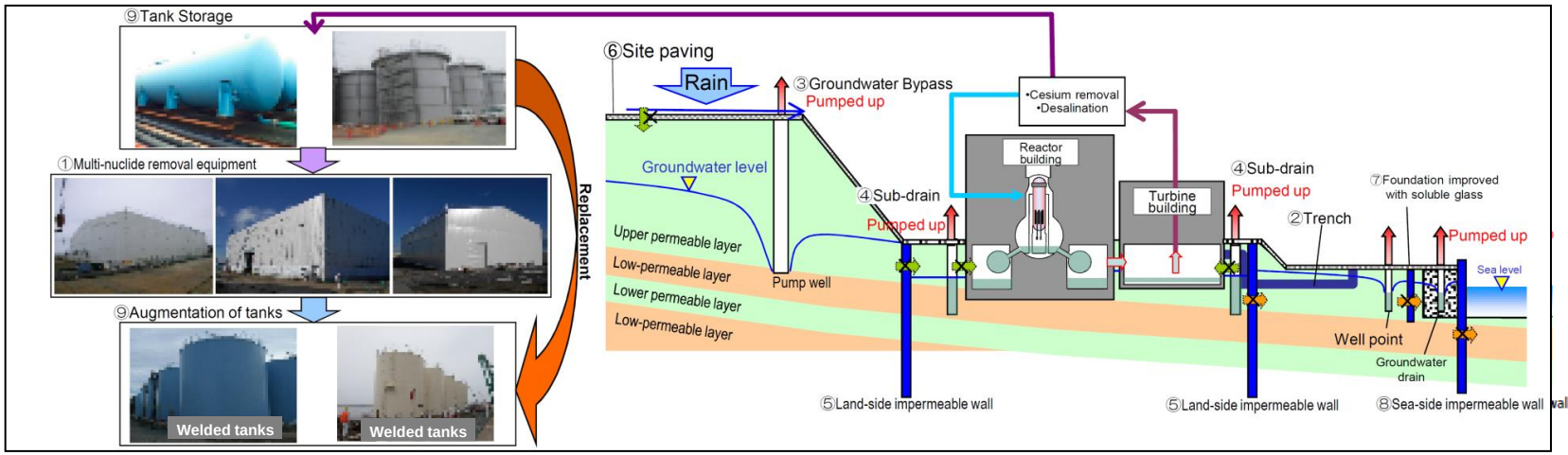
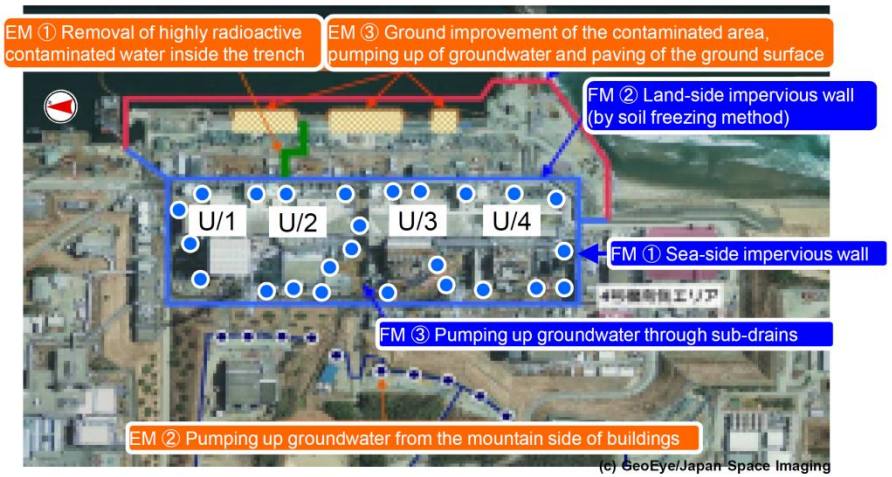


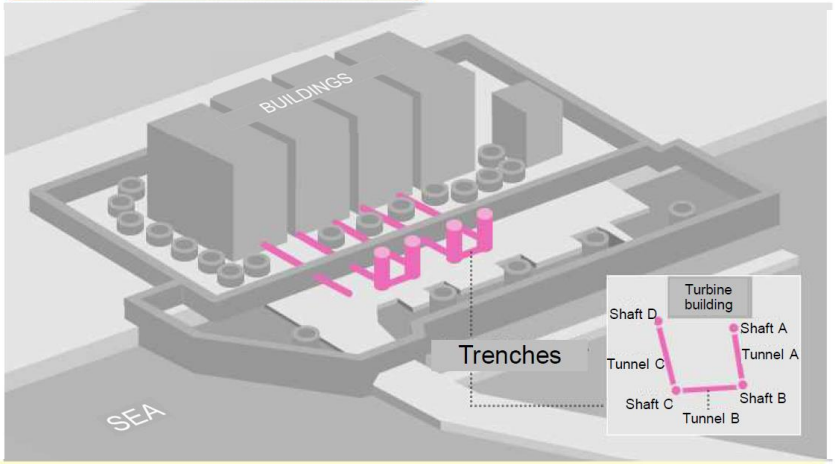
Image credit: TEPCO

Management of contaminated water



Emergency Measure ①
To remove highly contaminated water in trenches

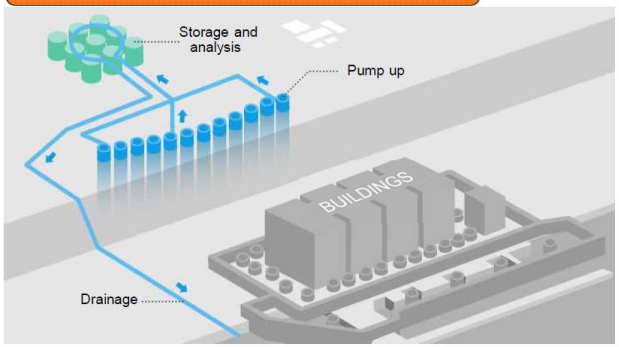
To remove contamination source



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

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

To control increase in contaminated water



Temporary storage tank analysis results (collected on Feb. 24)

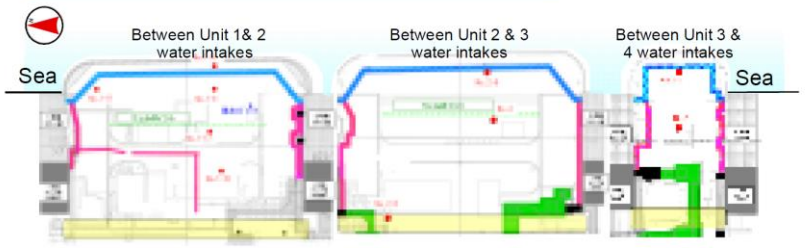
	Cesium 134	Cesium 137	Total Beta radiation	Tritium
TEPCO	ND (0.66)	ND (0.60)	ND (0.92)	180
Third-party agency	ND (0.59)	ND (0.55)	ND (0.53)	170
TEPCO's limit	1	1	5	1,500
Legally notifiable limit	60	90	-	60,000
WHO drinking water quality guideline	10	10	-	10,000

- Groundwater inflow into the buildings is reduced by pumping up and bypassing groundwater, flowing from the land side, on the upstream side of the buildings.
- Start of water drainage on May 21, 2014.

•TEPCO; Tokyo Electric Power Company
•ND indicates "not detectable" (below the limit of detection, which is stated in parentheses)

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

To prevent outflow into port



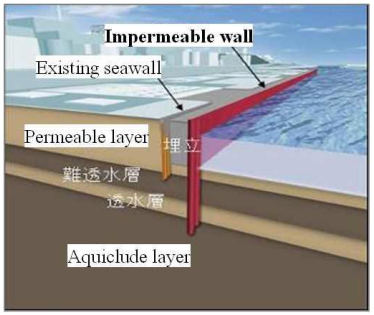
- Chemical grouting will be used to improve the foundation and control outflow of contaminated groundwater
- To inhibit infiltration of rainwater, surface will be paved with asphalt or other material

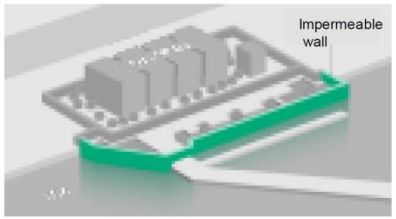
Image credit: TEPCO

Management of contaminated water

Fundamental Measure ①
Construct sea-side impermeable wall

To prevent flow out into sea

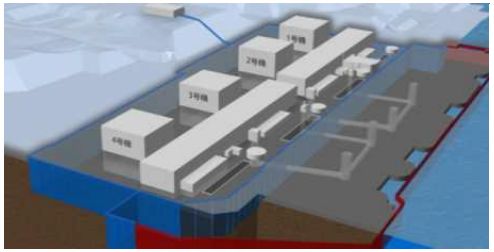


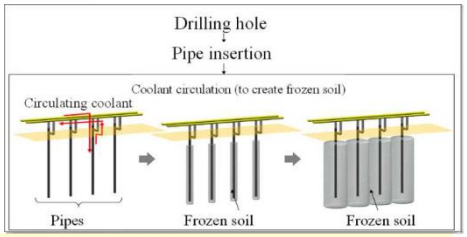


- Impermeable wall will be constructed along the sea side of Units 1~4 to prevent outflow of contaminated groundwater into sea
- Construction of steel sheet-piles comprising impermeable wall was completed in October 2015. The radioactive material concentration inside the harbor has become lower

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

To control increase in contaminated water and prevent its flow into port

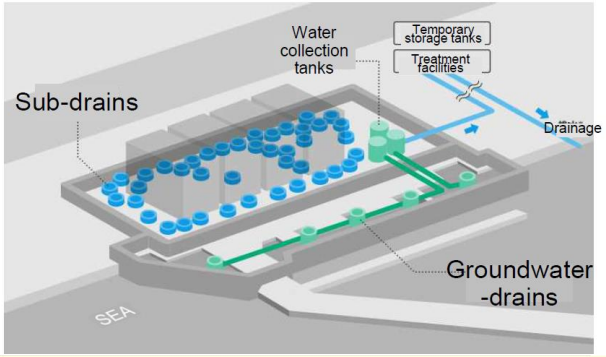




- Buildings will be enclosed by ice wall to curb inflow of groundwater into buildings
- Full-scale construction began in June 2014
- Construction of the mountain side was completed in September, 2015. As for the sea side, freeze pipe etc. setting construction was completed in January, 2016

Fundamental Measure ③
To pump up groundwater from sub-drains

Curb inflow of groundwater into R/B, etc.



New sub-drain pit

- Wells (sub-drains) installed near buildings will be rehabilitated and groundwater around buildings will be pumped up to control inflow into the buildings
- To start pumping up groundwater and draining cleanup water from September 2015

Image credit: TEPCO

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Reactor cooling and water decontamination

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

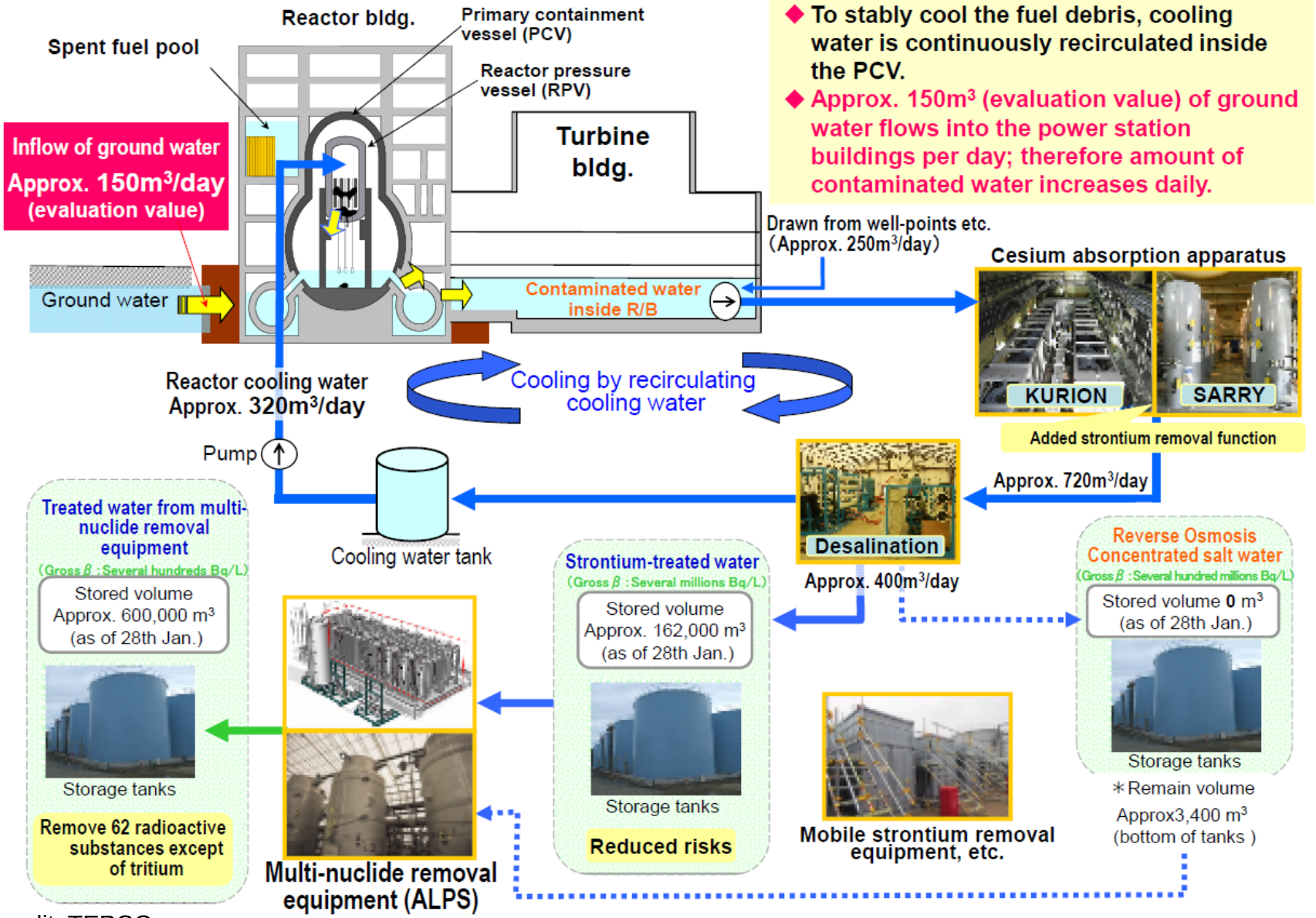


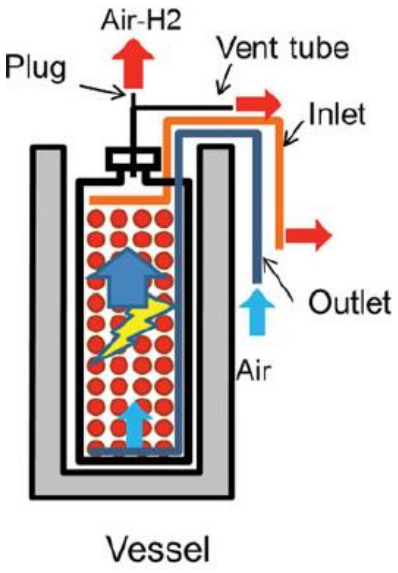
Image credit: TEPCO

High Dose Spent Adsorbents

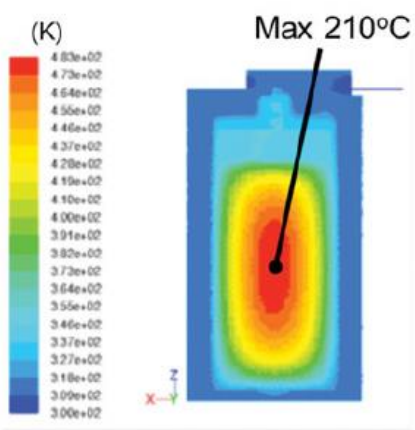
Challenges associated with High Dose Spent Adsorbents

- Several ion-specific microporous materials
- Key nuclides include: ^{90}Sr, ^{137}Cs, ^{60}Co
- Granular dispersible materials
- Self heating – steam production
- Radiolysis – hydrogen production
- Stress corrosion cracking – sea salt aggravated

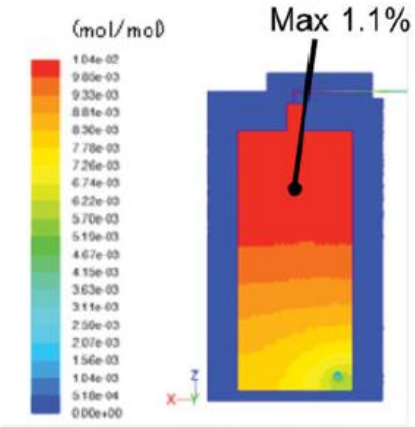
➢ **HDSAs require waste conditioning process**



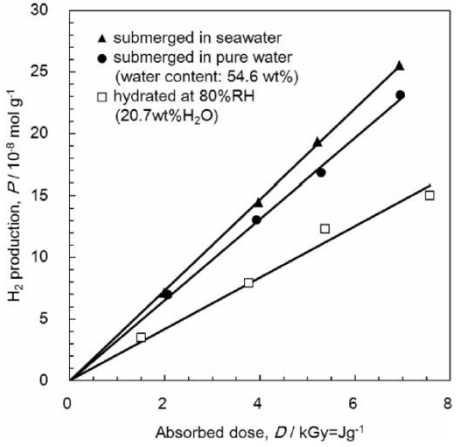
Vessel



Temperature



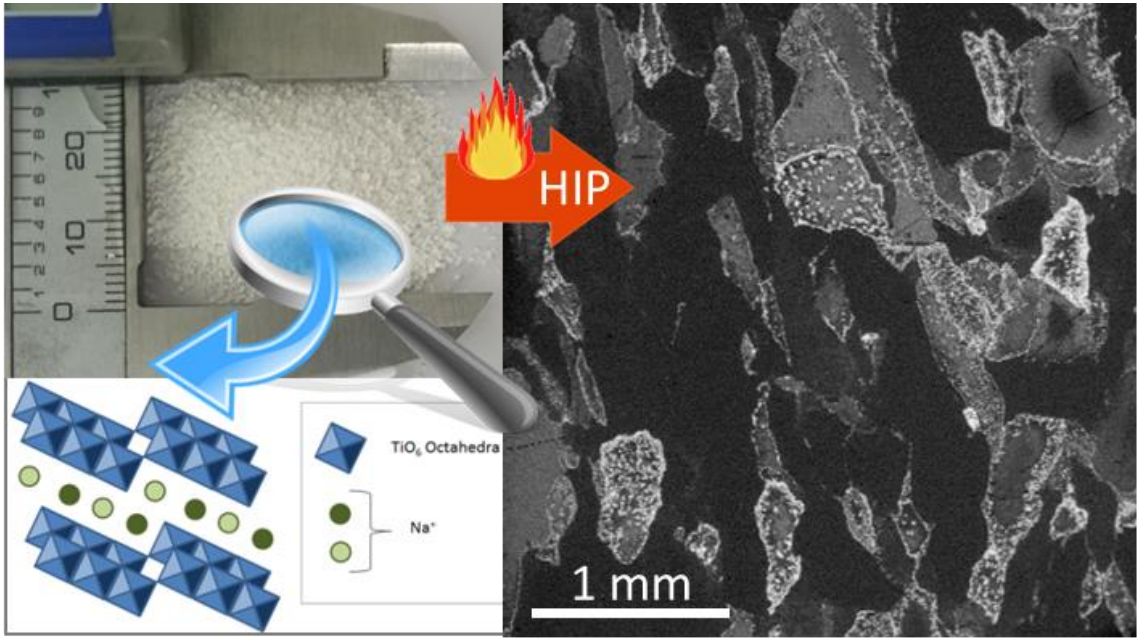
Hydrogen



Yamagishi JNST 51 (2014) 1044.

Example: HIP conditioning of Sr-Treat® HDSA

Cs/Sr exchanged Na titanate – HIPPed without additives, i.e. 100 % waste loading
SPFT log q/S = -7.0, 90 °C



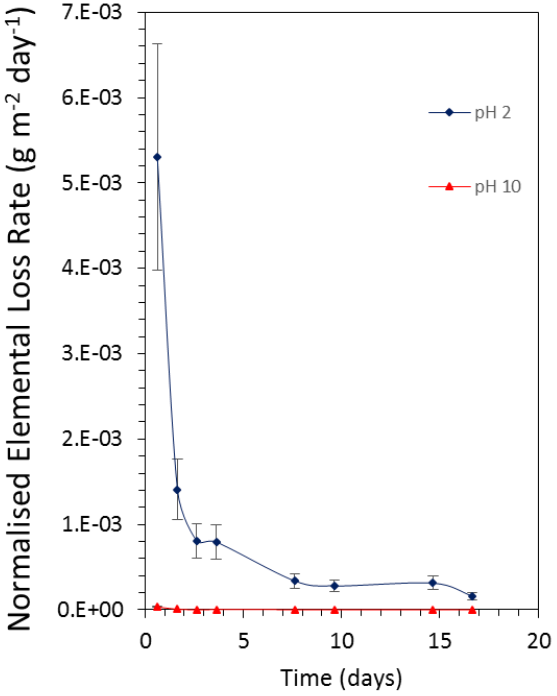


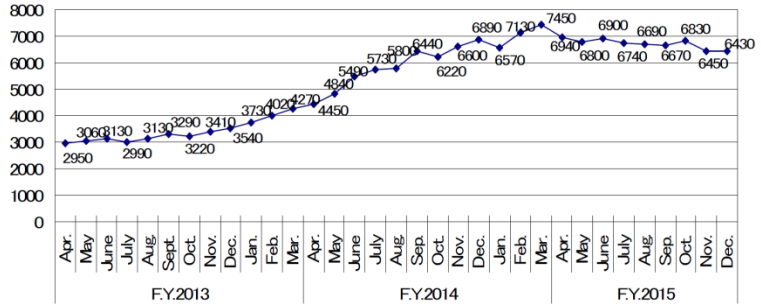
Figure 1. Sr Treat granules with layered titanate structure ($Na_2Ti_6O_{13}$), transformed into dense ceramic wasteform as shown by back scattered SEM. Bright areas correspond to Sr rich phases, the inhomogeneous Sr distribution reflects the different Sr uptake during ion exchange.

Site improvements for decommissioning

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

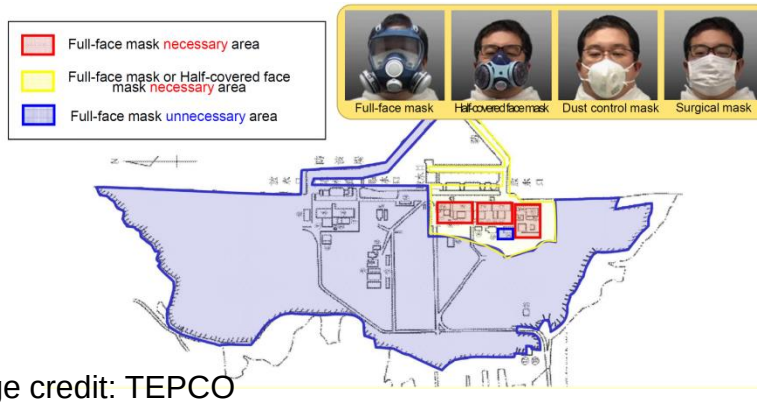
Changes in the number of workers

- The number of workers per weekday (employees from TEPCO and contractors) engaged in work during January is assumed to be approximately 6,460 people.
- The percentage of locally born workers is approximately 50% in Dec..



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

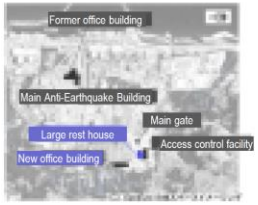
Workplace environment improvements



Improving the work environment

- Improving convenience
- A large rest house with a capacity of approx. 1,200 workers was established and its operation commenced on May 31, 2015.
- A new office building was constructed in 2014 allowing for smooth communication with areas close to the field.


Large rest house



New office building and office

- Fukushima Revitalization Meal Service Center
  Construction was finished on 31st March, 2015
- Providing warm meals
- Creation of employment opportunities in association with the construction and operation of the meal service center
- Dispelling of harmful rumors through the usage of Fukushima - produced cooking ingredients and the local employment.

Ensuring stable employment over the long term

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

Image credit: TEPCO

Contamination of sea water in quay area

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

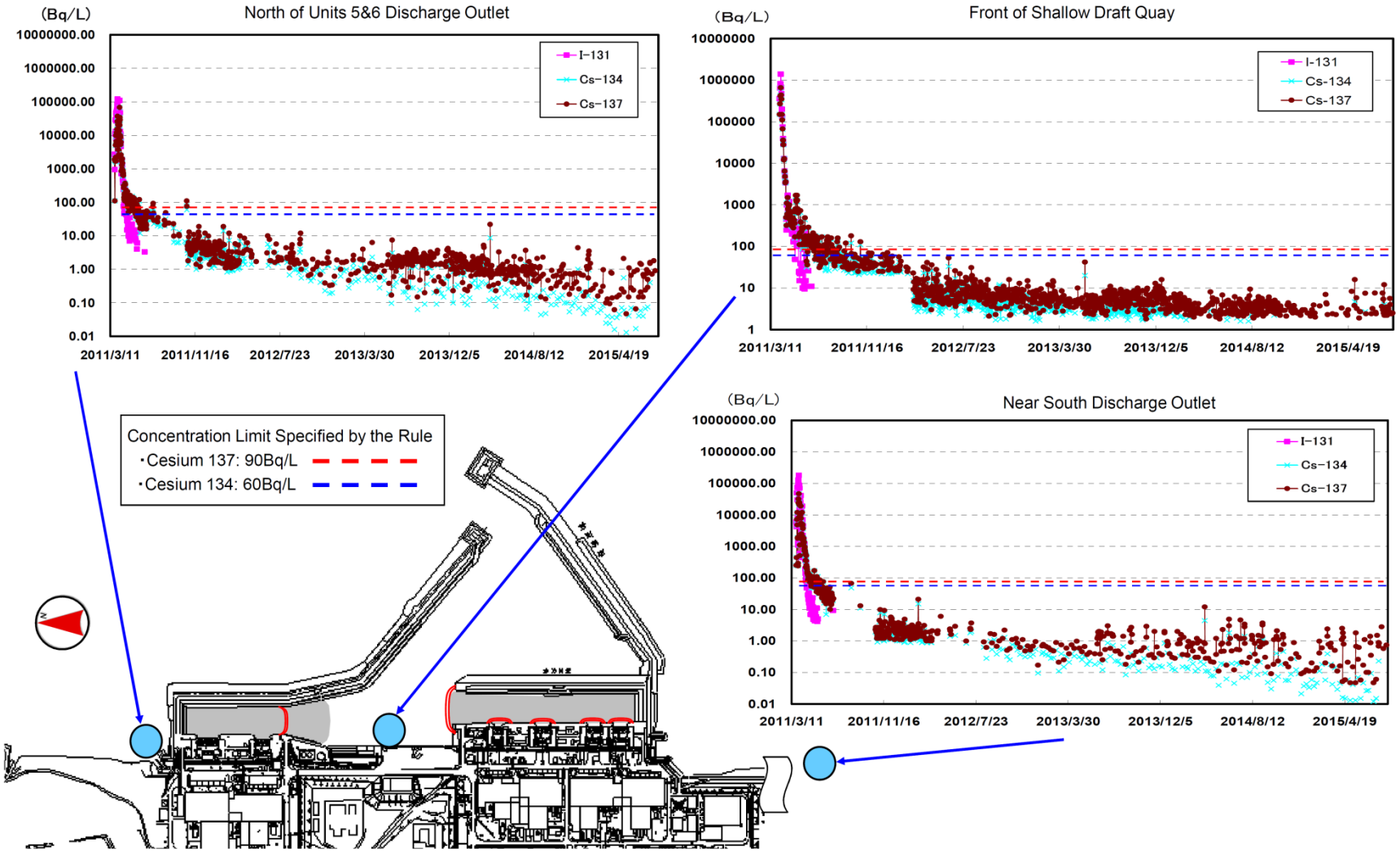


Image credit: TEPCO