The 5th International Forum on the Decommissioning of the Fukushima Daiichi Nuclear Power Station

Efforts to Ensure Safety in Decommissioning (No.1)

Safety Management of the Power Station

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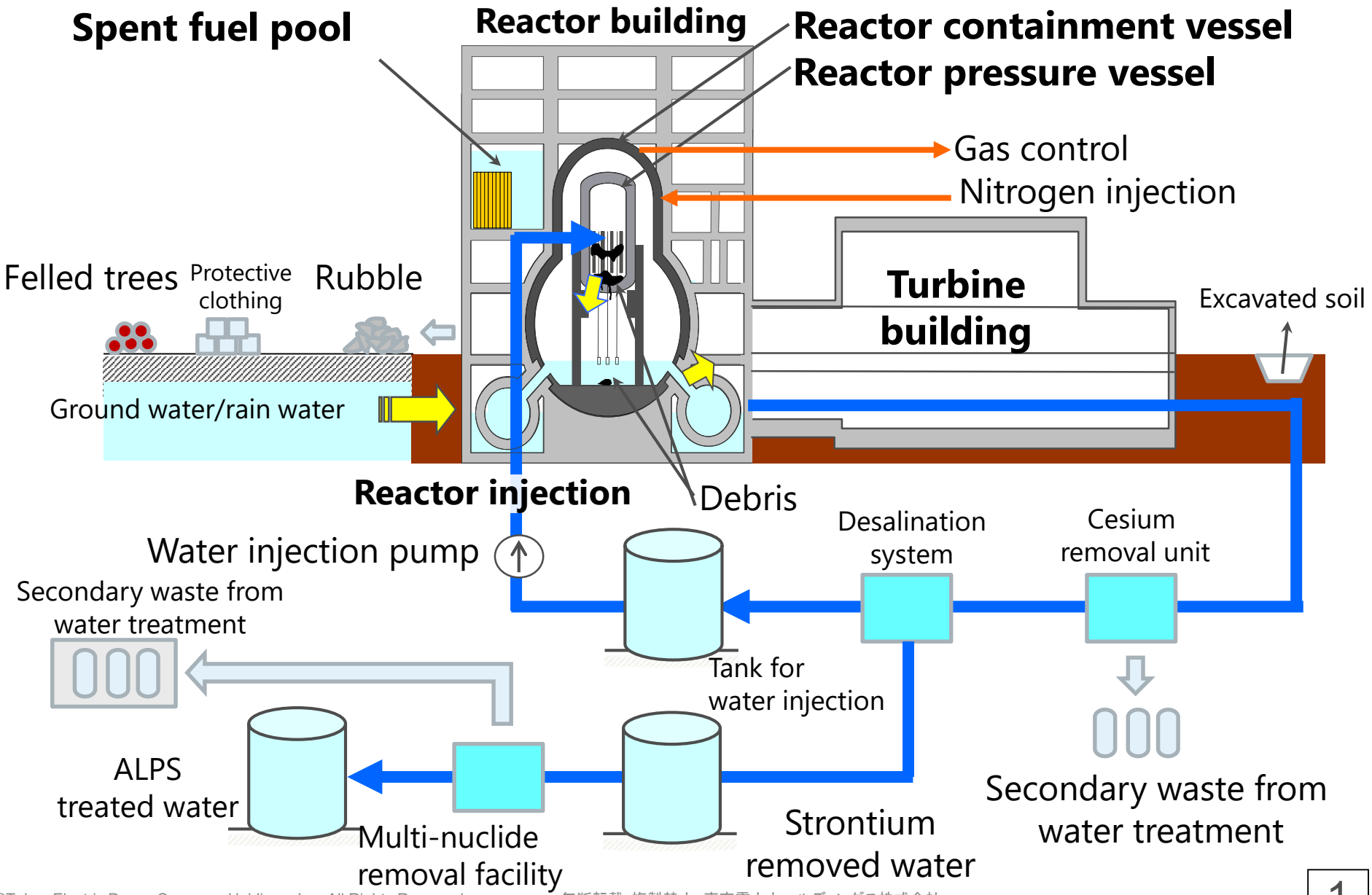
Overview of the Fukushima Daiichi Nuclear Power Station



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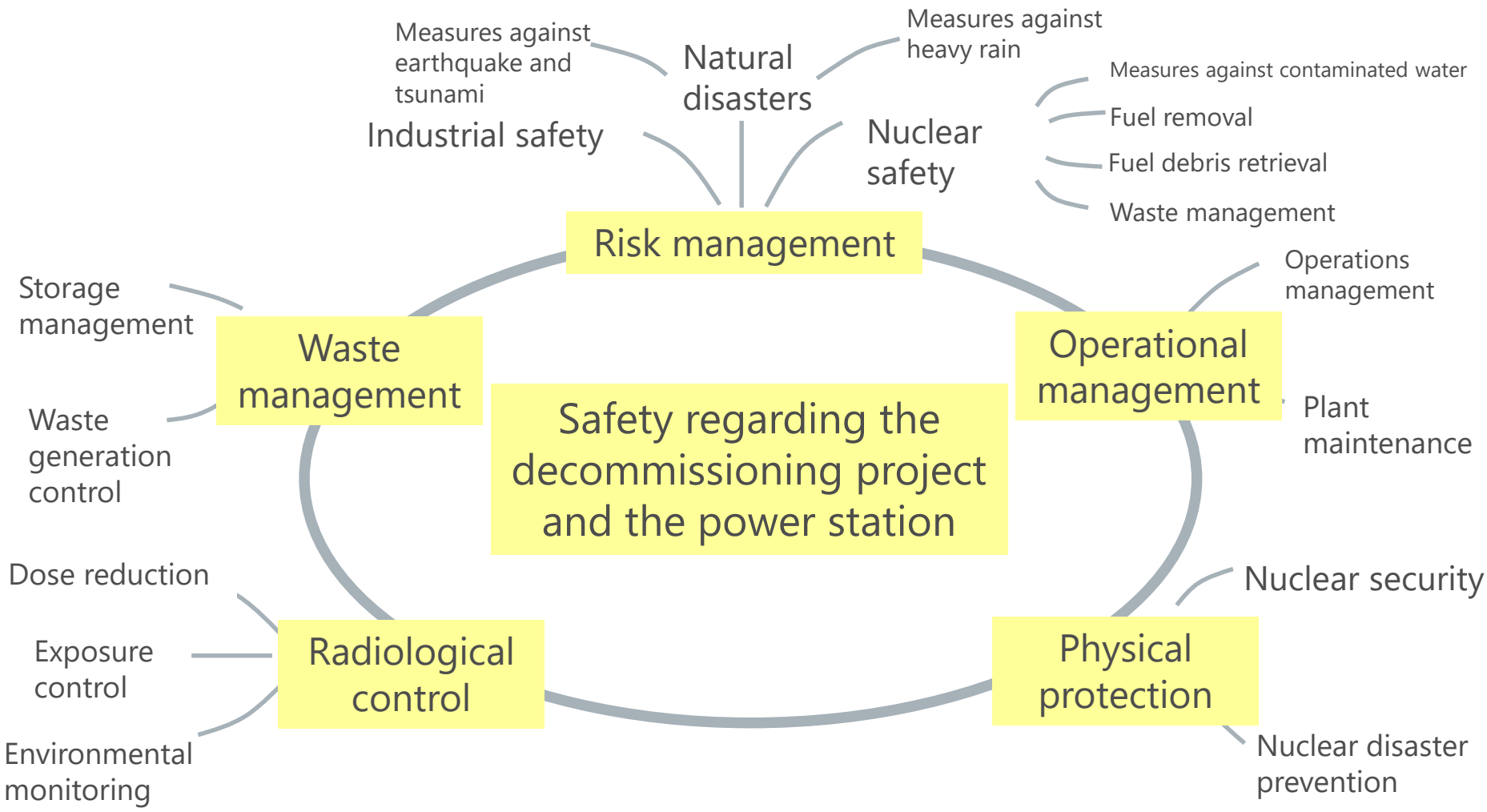
Safety Management of the Power Station



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1. Risk Management (risk reduction)

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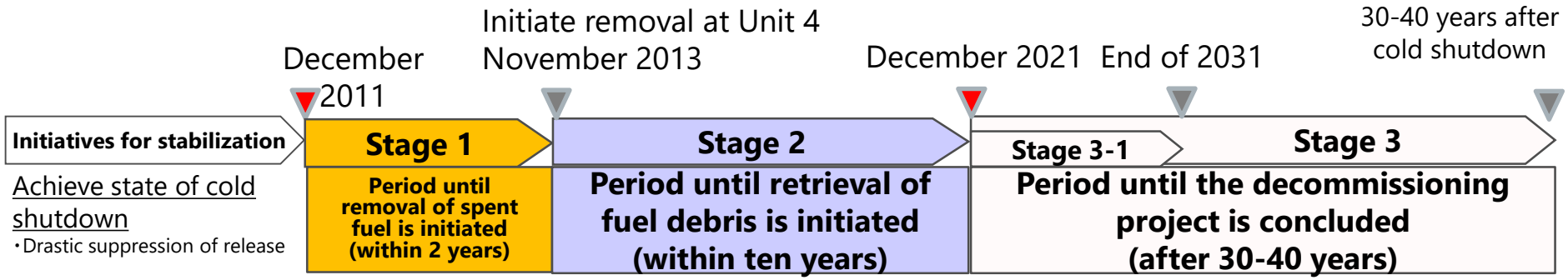
1-1. Mid-and-long-term Roadmap

Revised Mid-and-long-term Roadmap (December 27, 2019), schedule for goals (milestones)



Measures against contaminated water

- Suppress volume of contaminated water generated to approx. 150 m^3/day
  By the end of 2020
- Suppress volume of contaminated water generated to 100 m^3/day or less
  By the end of 2025
- Complete treatment of stagnant water in buildings
  By the end of 2020
- Reduce the volume of stagnant water in the Reactor Building by about half
  FY2022-2024

Removal of fuel in spent fuel pool

- Complete installation of large cover on Unit 1 — around FY2023
- Initiate fuel removal in Unit 1 — FY2027-2028
- Initiate fuel removal in Unit 2 — FY2024-2026
- Complete fuel removal in Units 1-6 — within 2031

Retrieval of fuel debris

- Initiate retrieval of fuel debris from the initial unit
  By the end of 2021

(Start with Unit 2. Expand the scale of retrieval in stages)

Radioactive solid waste management

- Technical outlook regarding measures for treatment/disposal and their safety — Around FY2021
- Eliminate temporary outdoor storage of rubble etc.
  By the end of FY2028

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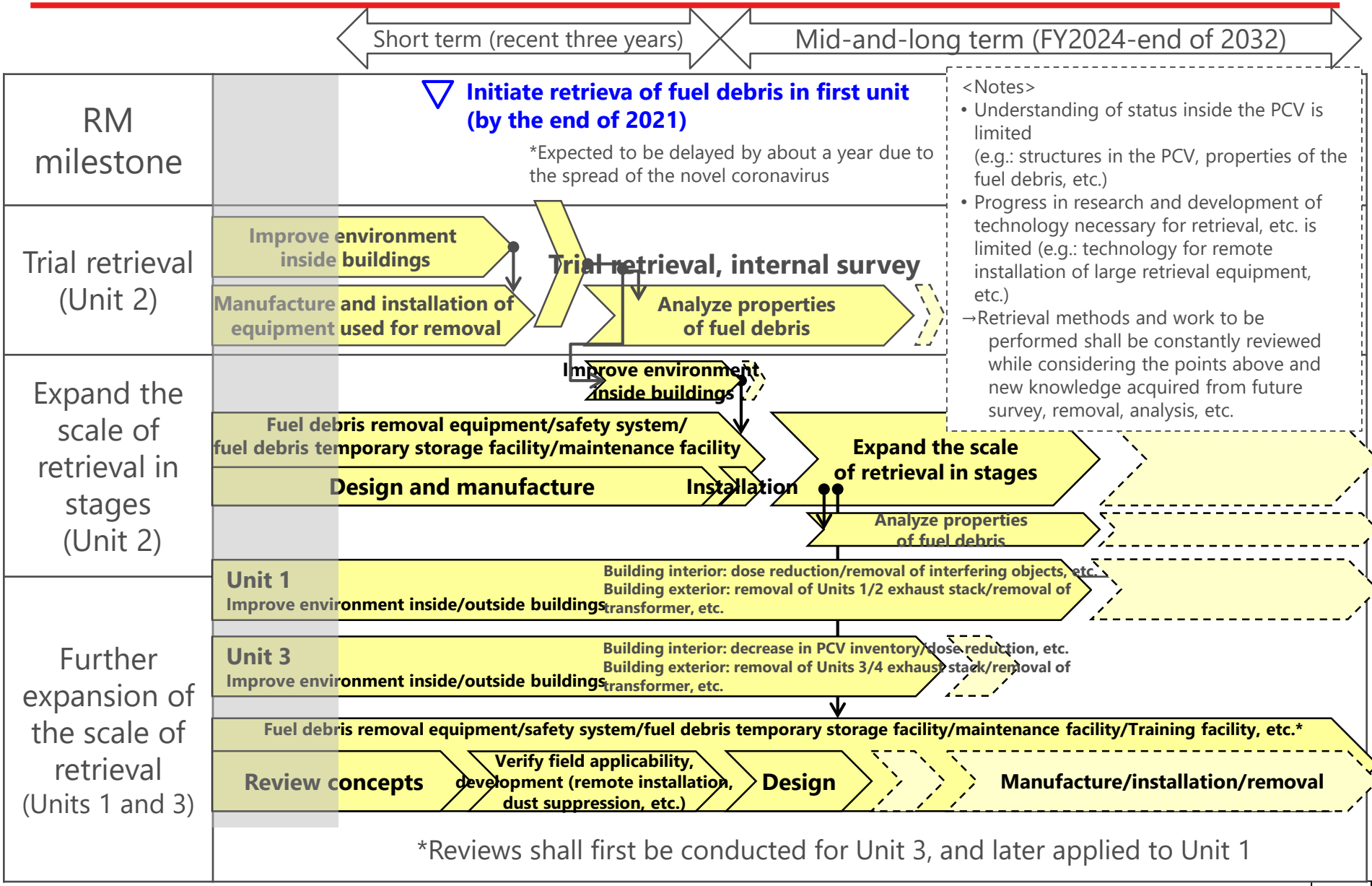
1-2. Mid-and-long-term Action Plan (example of debris retrieval)



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2. Plant Maintenance

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2-1. Plant Maintenance (long-term maintenance management plan)

Established a long-term maintenance management plan **(fully implemented from January 2021)**
: Considering the environmental changes after the earthquake, TEPCO identified significant risks to be focused on for conducting decommissioning work and contaminated water management and decided to take action against age degradation factors such as stress cracking and wear, etc., for the equipment concerned

Approx. 340,000 cases were identified in equipment and parts comprising each system and have been continuously managed with immediate temporary measures being implemented and permanent measures planned. Facilities and buildings newly installed or removed are also included in the reviews conducted every fiscal year.

① Environmental impact (including exposure of the public and workers)

(1) Loss of boundary function

Facilities containing radioactive material become damaged, and boundary function, leak detection function and shielding function of radiation are lost.

(2) Loss of monitoring function

Monitoring facilities and instruments fail, and monitoring functions are lost in facilities necessary for measures regarding decommissioning and contaminated water.

(3) Loss of function in new facilities and existing facilities currently in use

Functions are lost in facilities necessary for conducting decommissioning other than those subject to (1) and (2) above.

② Occurrence of industrial accidents (involving personnel or facilities)

(4) Collapse of buildings or architectural structures*, falling or flying of structures

Industrial accidents caused by collapse of buildings or architectural structures, or falling/flying of structures.

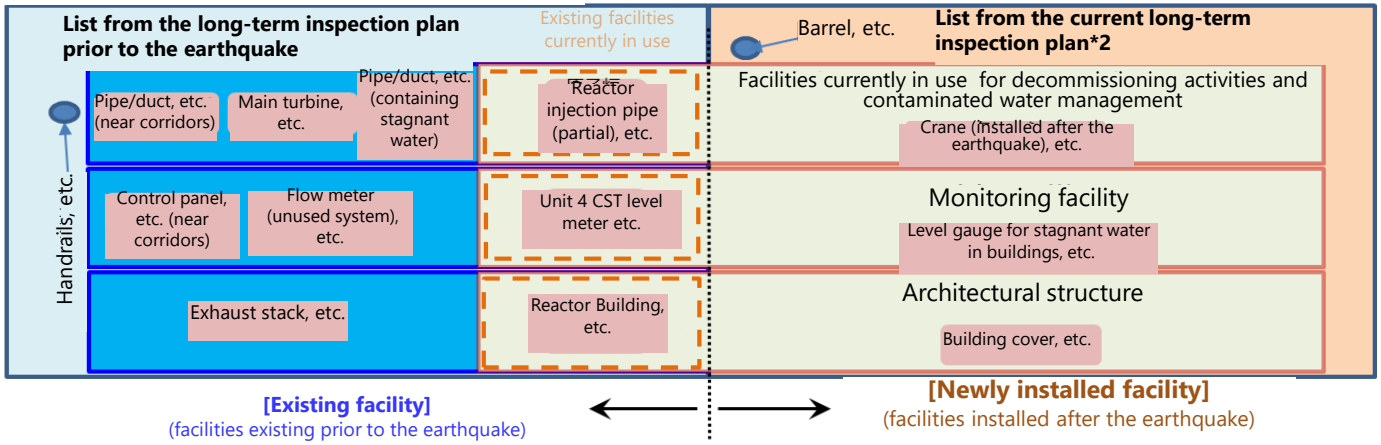
(5) Collapse of existing facilities*, falling or flying of structures

Industrial accidents caused by collapse of existing facilities, or falling/flying of structures.

*includes staircases, handrails and corridors that are part of buildings and facilities

Concept of the scope for the long-term maintenance management plan

All on-site facilities and equipment*1



Supplementary: These initiatives and concepts have been explained and disclosed at the Commission on Supervision and Evaluation of the Specified Nuclear Facilities in the past.

*1 Initiated work from approx. 340,000 cases identified subject to facility maintenance
*2 Facilities handling contaminated water and facilities monitoring radioactive dust are subject to management as temporary facilities with the exception of those used temporarily as part of construction equipment.

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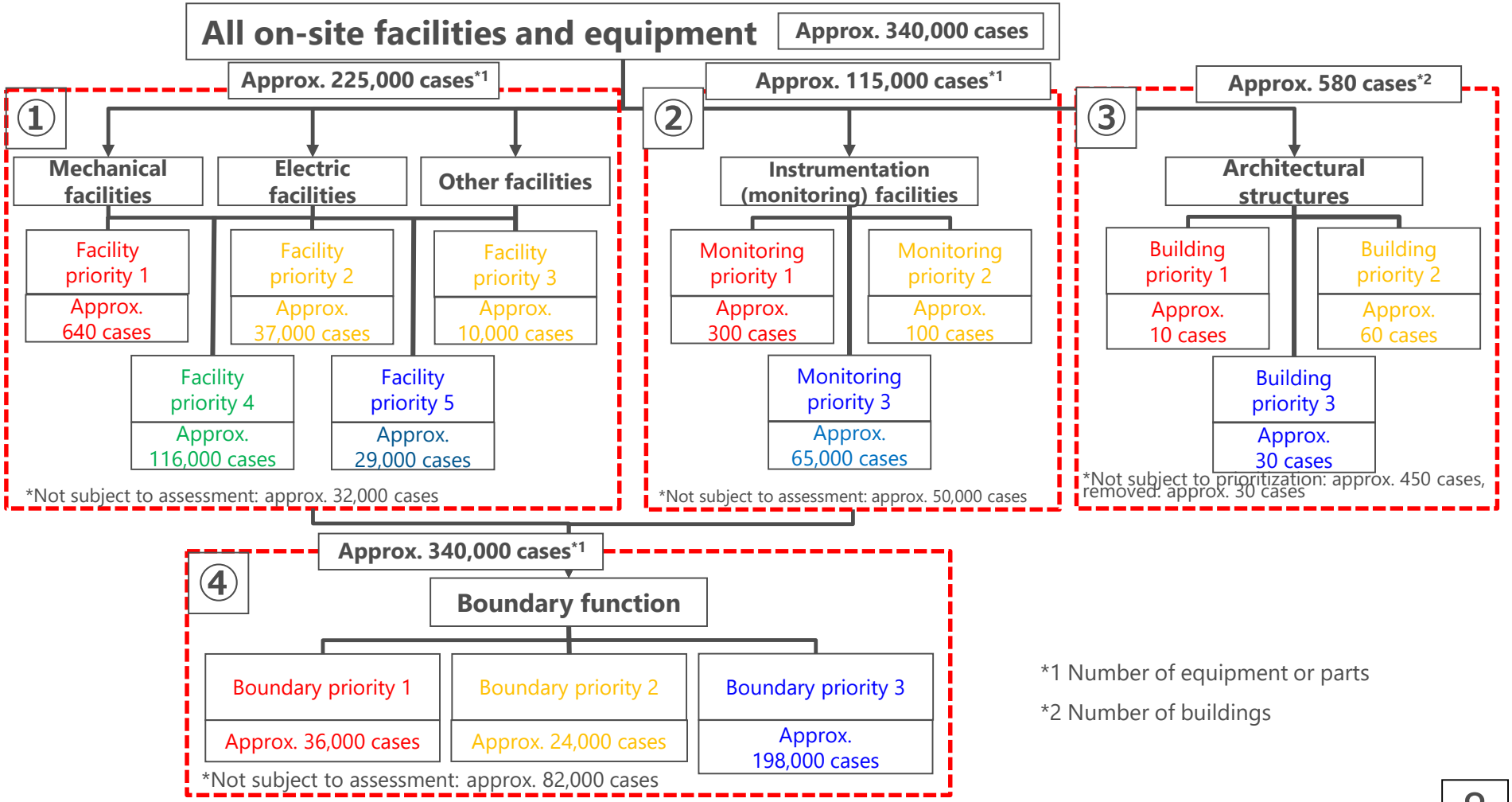
<Reference> Priority of Measures for All Facilities and Equipment

- All on-site facilities and equipment were categorized into “mechanical facilities”, “electric facilities”, “other facilities”, “instrumentation facilities” and “architectural structures”; and priorities were set based on the current management status.
- Furthermore, priorities for facilities and equipment not in the category of “architectural structures” were set based on the perspective of boundary function



*1 Number of equipment or parts

*2 Number of buildings

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<Reference> Specific Measures in the Long-term Maintenance Management Plan

(representative examples: ① mechanical facilities, electric facilities and other facilities)

【Equipment】

- Units 1-3 spent fuel pool

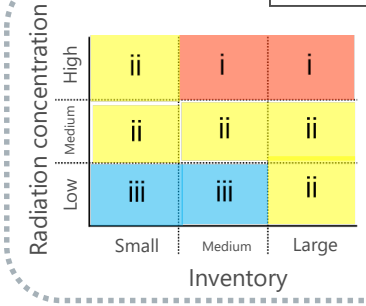
【Results of assessment for prioritization】

- Facility priority 2: review of additional measures "necessary"
- Boundary priority 3: additional measures "unnecessary

【Management status of facilities】

Management of long-term inspection plan	Yes
Material included	Liquid radioactive material
Boundary requirements	Yes
Impact on industrial safety	None
Impact on required function	Yes
Leak detector	None
Weir	Yes
Inventory grade	ii

【Inventory grade】



Grade i : High radiation concentration, inventory is above medium level, and has significant impact on the environment in the event of a leak

Grade ii : Medium radiation concentration and inventory level, and there is concern for environmental impact in the event of a leak

Grade iii : Low radiation concentration and inventory level, and environmental impact is small in the event of a leak

Unit 1 Spent Fuel Pool

Photograph taken August 2, 2019

【 Facility priority 2, details of additional measures 】

➢ Leak prevention regarding pool liner

- Installed covers on the spent fuel pool to prevent pool from being damaged by falling rubble (Unit 1).
- Monitored pool water quality (once in three months) to prevent leak caused by corrosion of pool liner, and purified pool water if necessary.

➢ Response to water leak from pool

- If water level of spent fuel pool lowers due to damage in the pool liner, maintain water level of pool by supplying water via the emergency water injection facility.

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2-2. Representative Example of Reviews

① Addition of new facilities and equipment in FY2020

Facilities related to the Units 1-4 access control points, facilities related to the subdrain iron removal unit, additionally installed facilities and piping for interior RO, facilities for the additionally installed miscellaneous solid waste treatment building, etc.

② Review of maintenance strategy

Considering the state of deterioration and records of failures, switched from breakdown maintenance (BDM) to time-based maintenance (TBM) as part of measures to avert risk in long-term use. Examples include:

-Parts of existing multi-nuclide removal facility (existing ALPS) and existing desalination system (existing RO)

-Outdoor containers storing rubble including radioactive materials, etc.

③ Equipment under trial operation and addition of temporary facilities

Unit 3 R/B seismometer, corridors near facilities, containers and small cabins for storing equipment, etc. Regarding temporary equipment in long-term use, a section responsible for the maintenance is to be clarified in the future ,considering details acquired from on-site walkdowns and information from each group, so that a system which allows continuous management can be developed.




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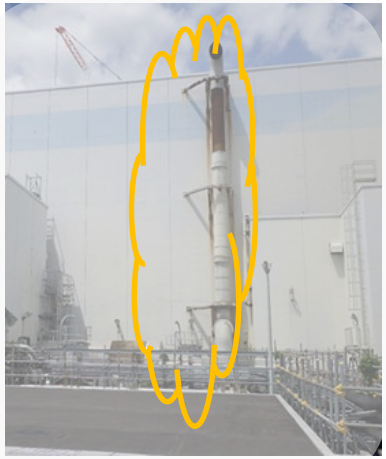
(1) Removal of the existing Units 1-4 D/G stack

Deterioration of the stack was confirmed when making the long-term maintenance management plan. A restricted area was set as an immediate temporary measure.

As a permanent measure, work to remove the stack was planned to be conducted from August 2021 to March 2022.



(2) Management of containers storing rubble, etc.

Containers located outdoors were not stored in appropriate management conditions. Therefore, for high priority containers holding radioactive material, visual inspection and checking contents are being conducted.

In the future, these outdoor containers shall be managed appropriately in the long-term maintenance management plan, and shall be subject to regular inspection.

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In addition to initiatives in the long-term maintenance management plan, consider risks to the system (with significant impact during trouble occurrence), and take initiatives for measures to improve facility reliability.

- **Multi-nuclide removal facility (existing ALPS)**
  - a. Replacing parts experiencing many defects, updating facilities with risks that have manifested
    Supply tank, pressure resistant hose (implementation of steel piping) [FY2021-FY2024]
  - b. Secure spares for main equipment and their parts (to reduce the duration of shutdowns)
    Cross-flow filter (CFF) [continuously procured from 2021 onward]
- **Multi-nuclide removal facility (additionally installed ALPS)**
  Acquire spares for CFF [continuously procured from 2021 onward]
- **Desalination unit (existing RO)**
  Newly installed supply line for treated water [planned for FY2022]
- **Cesium absorption unit (SARRY)**
  Updated valve rack [FY2021 – FY2022]
- **PCV gas control system**
  Updated motor for Units 1 and 3 [2023-2024]
- **Decontamination unit (AREVA)**
  Treatement of water retained in system (after disposing waste sludge in D pit) [around 2024]

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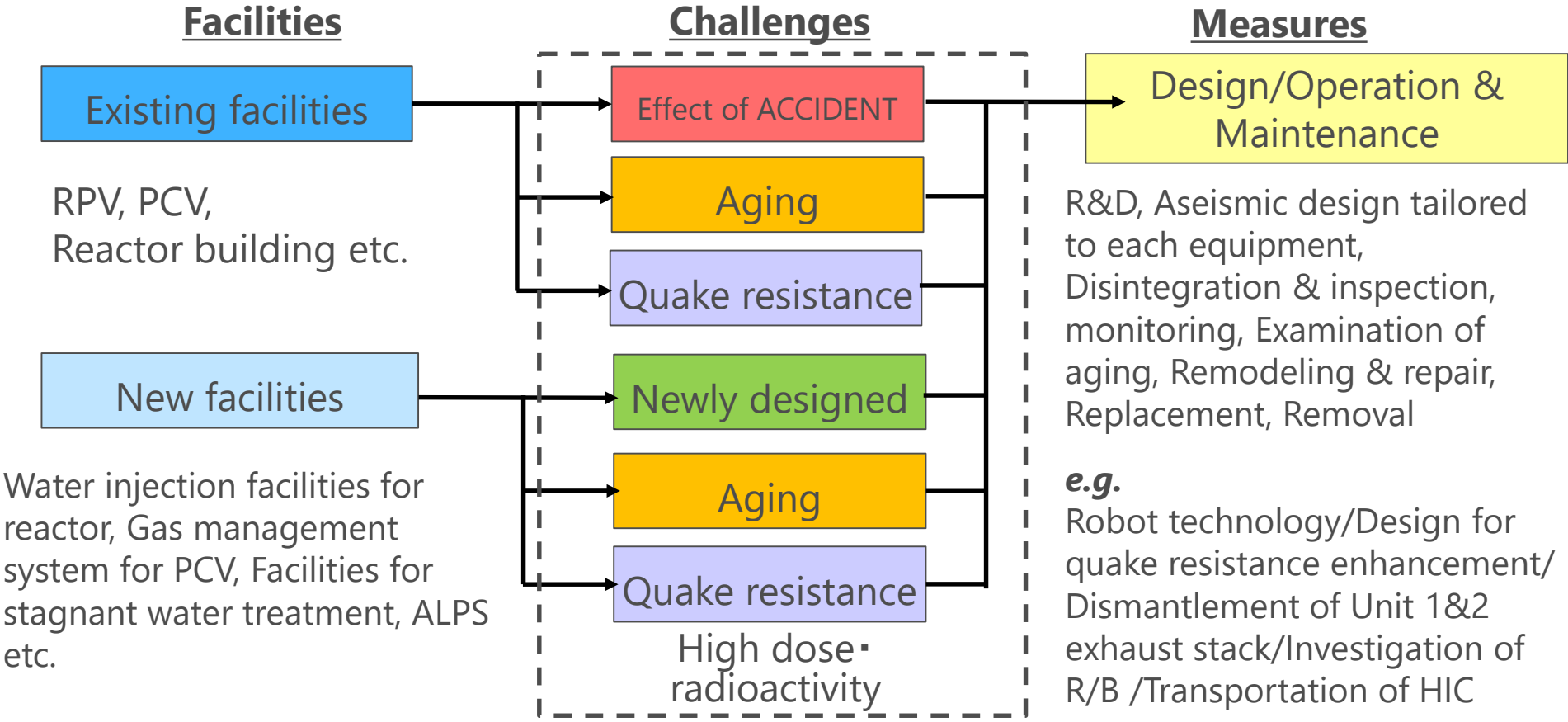
- Existing facilities: Need to address age degradation and impact by explosion at the time of the accident
- Newly installed facilities: Need to expand know-how about operation & maintenance, because they're jury-rigged or new (without any track record).
- Need to consider quake resistance to continue decommissioning work for a long time
- Need to consider high radiation dose and effect by radioactivity



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3. Radiological Control

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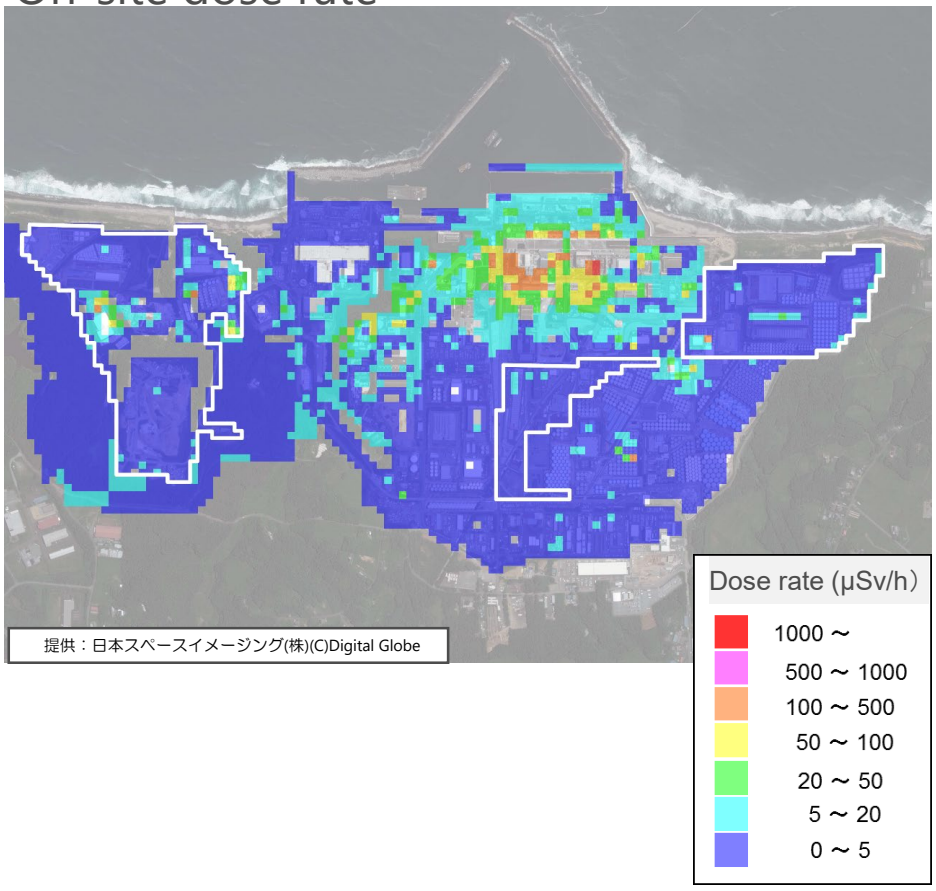
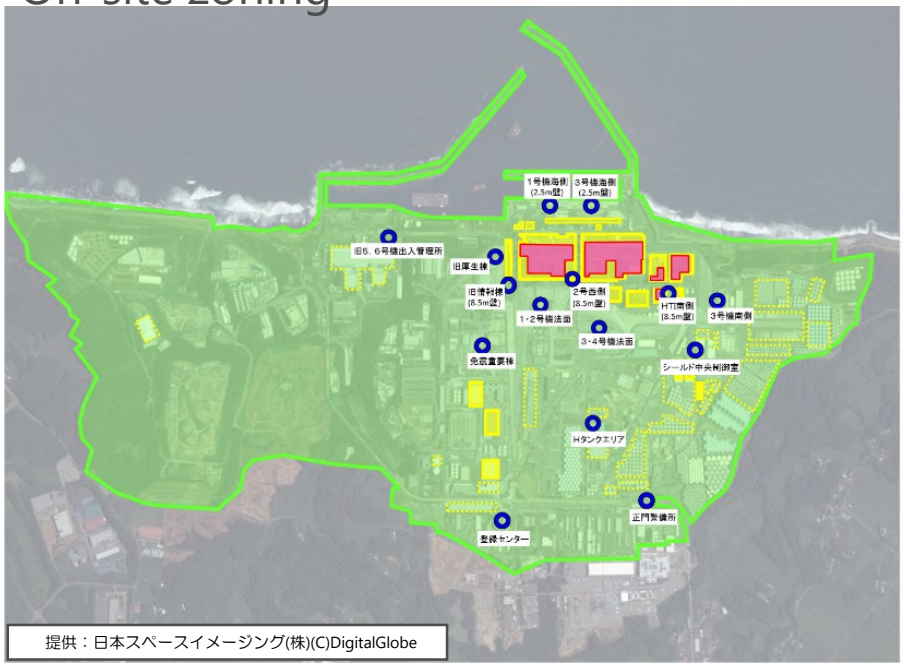
3-1. On-site Dose Reduction

- Removed top soil so that values lower to 5 μSv/ h , and conducted ground facing
- As a result, people can work in general uniforms in 96% of the premises (G zone)

On-site dose rate



On-site zoning



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3-2. Radiation Protection Gear

R zone (Anorak area)	**Y zone** (Coverall area)	**G zone** (General clothes area)
Full-face mask 	**Full-face mask or half-face mask*1**  	**Disposable dust proof mask*2** 
Anorak over coveralls 	**Coveralls** 	**General uniform** 

*1 Work performed inside buildings housing water treatment facilities or buildings near Units 1-4 (excluding the common pool and cover structure interior on the Unit 4 R/B refueling deck), as well as work involving the handling of contaminated water, and work accompanying the risk of radioactive material being dispersed requires the use of a full-face mask.

*2 Subject mask is not required for work performed outside the Units 1-4 peripheral protection zone (with the exception of areas inside buildings of Units 5 and 6), work that does not involve the handling of contaminated facilities or equipment, as well as for light work which does not accompany the risk of radioactive material being dispersed, and also when moving via vehicle between gear exchange points or resting areas.

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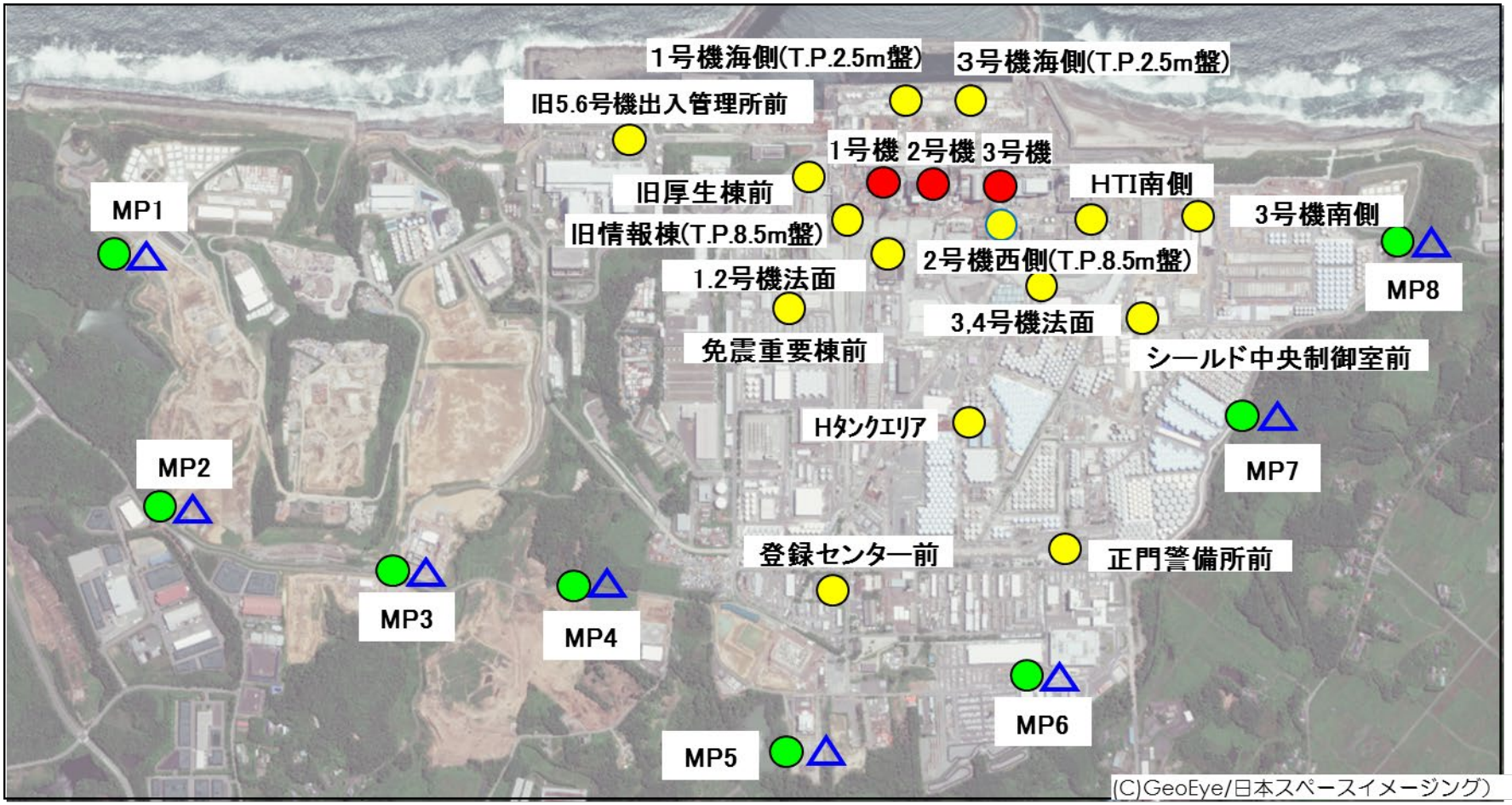
3-3. Monitoring Concentration of Radioactive Material in the Air



- Monitor via dust monitor on the refueling floor (Unit 1: 4 locations, Unit 2: 4 locations, Unit 3: 5 locations)
- Monitor via the on-site dust monitor (15 locations)
- Monitor via site boundary dust monitor (8 locations)
- Site boundary monitoring posts (8 locations)

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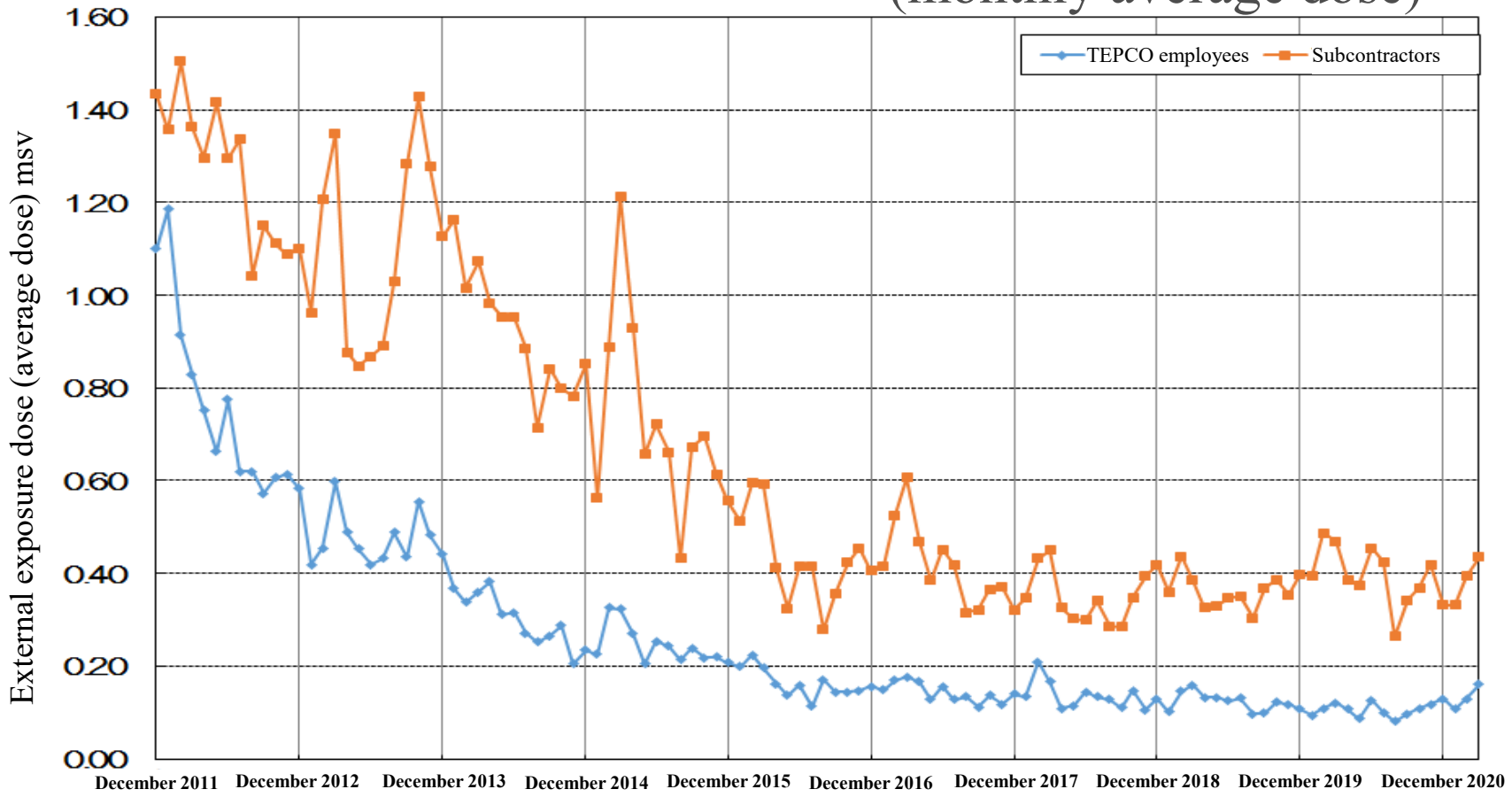
3-4. Exposure Dose

- Management conducted to observe legal limit (50mSv/y, 100mSv/5y)
- Exposure decreased by shielding, decontamination, remote control, time management and procedure adjustment

Changes in external exposure dose since December 2011 (monthly average dose)



*December 2011 (Step II) and later

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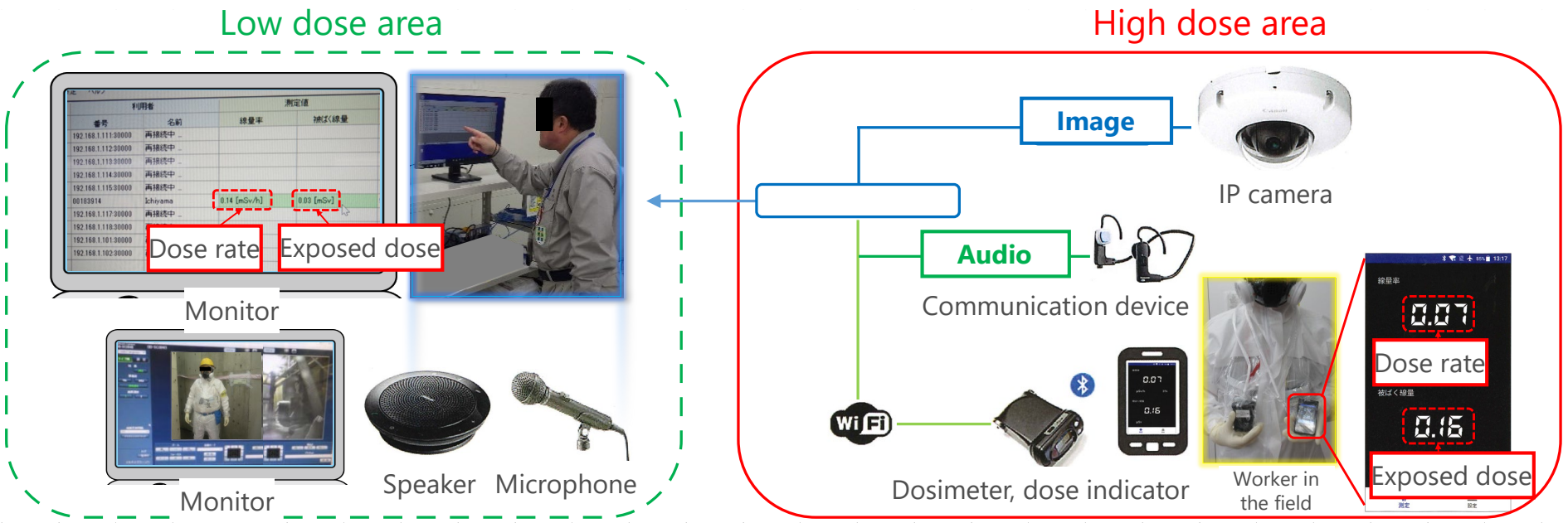
3-5. Introduction of the Remote Monitoring System (RMS)

- A remote dose monitoring system is utilized to monitor individual exposure for the purpose of reducing exposure of workers working under high dose environments such as in the reactor buildings, etc. (refer to figure below).
- Exposed dose of workers (mSv), air dose rate (mSv/h) and condition of the work area are being monitored in real-time, and instructions are given remotely via communication devices to reduce the exposure of work supervisors and radiation control personnel.



Overview of the remote monitoring system for individual exposure (remote monitoring system)

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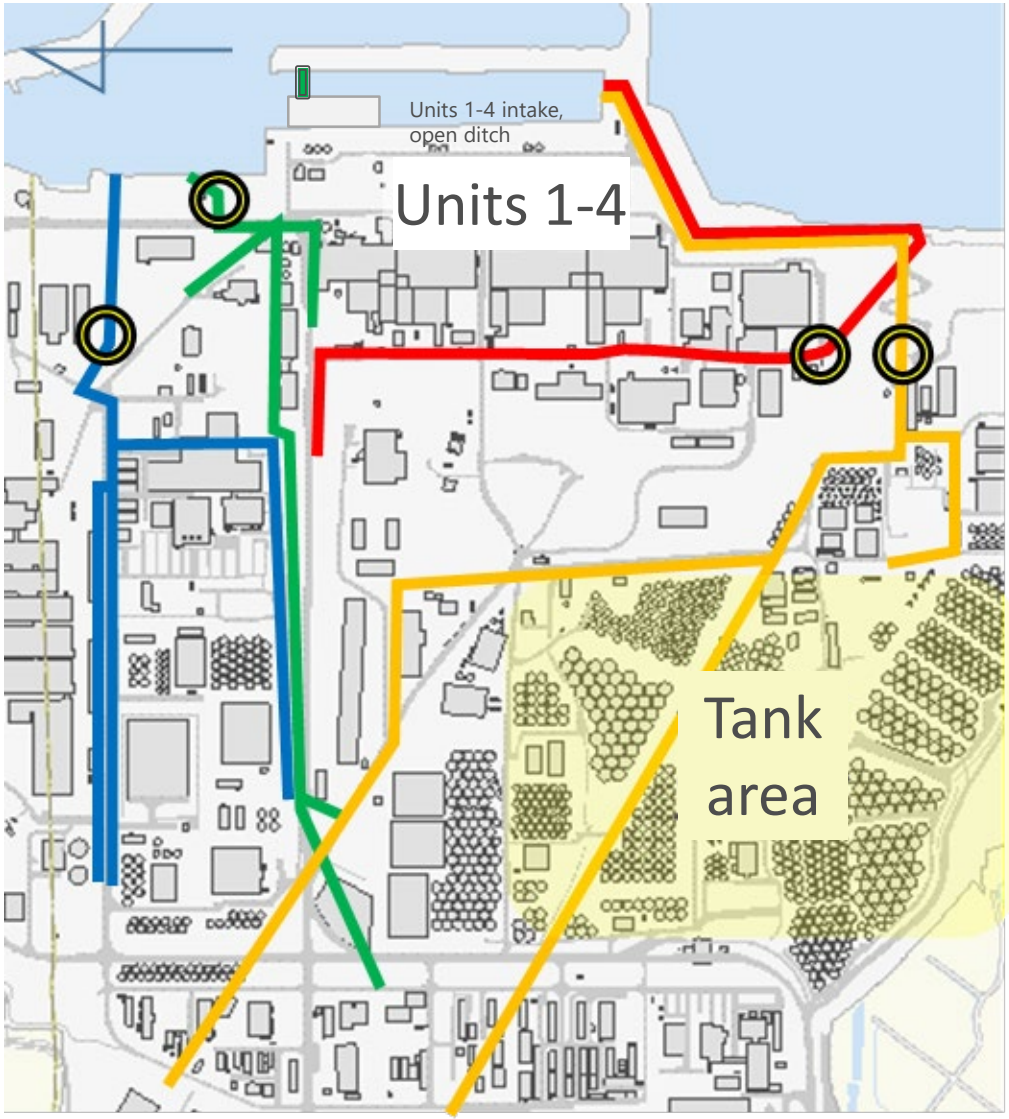
3-6. Monitoring Using Monitor for Drainage Channel



- Monitor leakage of contaminated water using the drainage channel monitor
- In stages, install monitors capable of monitoring β rays (from Sr-90) without being affected by fallout caused by precipitation (γ ray from radiation Cs)
  (currently installed in drainage channel K and drainage channel of the unloading area)

: Drainage channel A

: Drainage channel of the unloading area

: Drainage channel K

: Drainage channel BC

: Continuous monitoring unit

: Bridge

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3-7. Sampling Inside and Outside the Harbor

Monitor radiation concentration in seawater both inside and outside the harbor

【Sampling points for seawater】

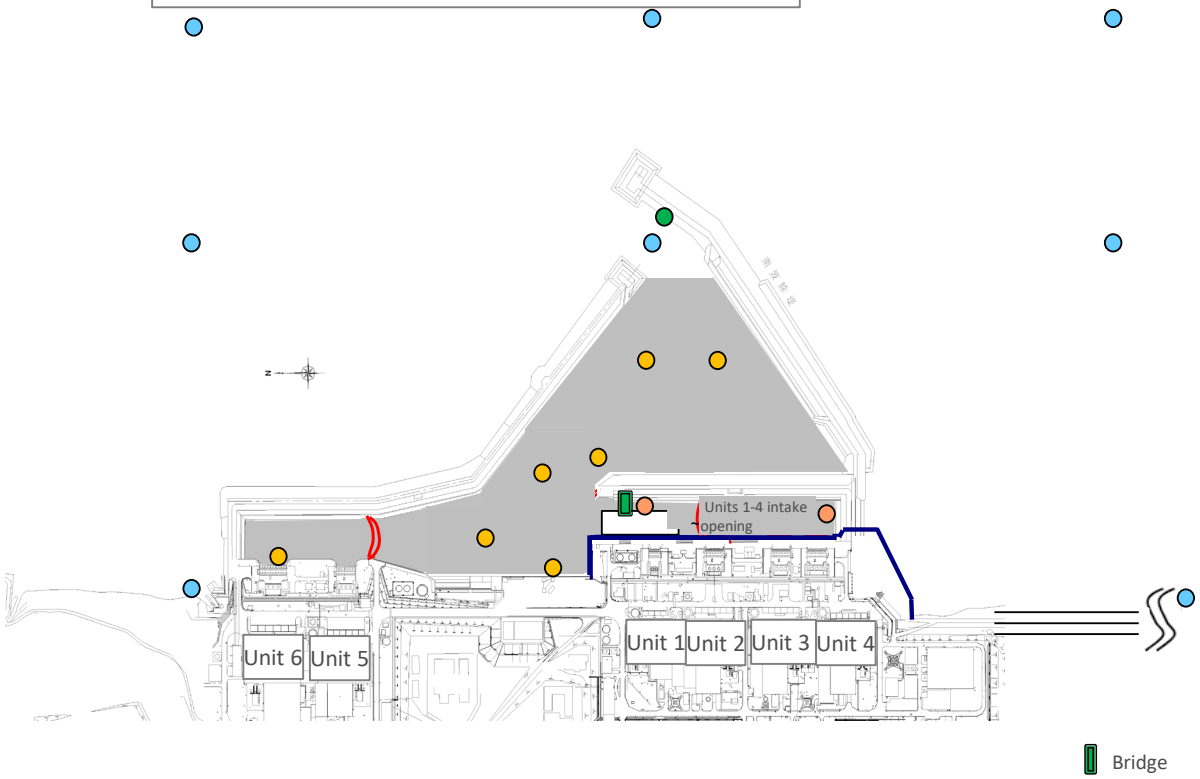
- Monitor impact on the ocean (8 locations)
- Seawater radiation monitor (1 location)
- Monitor distribution of radiation concentration in the harbor (7 locations)
- Monitor impact on the inside of the harbor (2 locations)

Other (31 locations along the coast [7 in Miyagi Prefecture, 28 in Fukushima Prefecture, 6 in Ibaraki Prefecture])

【Measures to reduce radioactive material in the harbor】

- Silt fence
- Sea-side impermeable wall
- Seabed covered with soil

(Measures such as decontamination, enhancement of ground foundation, installation of impermeable wall conducted on land)



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3-8. Sample Analysis

- Approx. 80,000 samples are analyzed annually.
  (approx. 16 times larger than the number prior to the accident.)
- On-site laboratories are used primarily, and smart glasses are used to improve the reliability of analysis.
- The chemical analysis building (capable of handling samples with low radiation concentration) has acquired ISO/IEC 17025 qualification regarding the analysis of cesium 134,137 and tritium.

Chemical manipulation prior to tritium analysis(chemical analysis building)

Image displayed on the inner side of the glass

Smart glass enables staff to conduct analysis, while confirming analysis procedures and data trend from graphs

＜Video demonstrating the use of smart glass＞
https://www.tepco.co.jp/library/movie/detail-j.html?catid=107299&video_uuid=cmr78g35

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4. Waste Management

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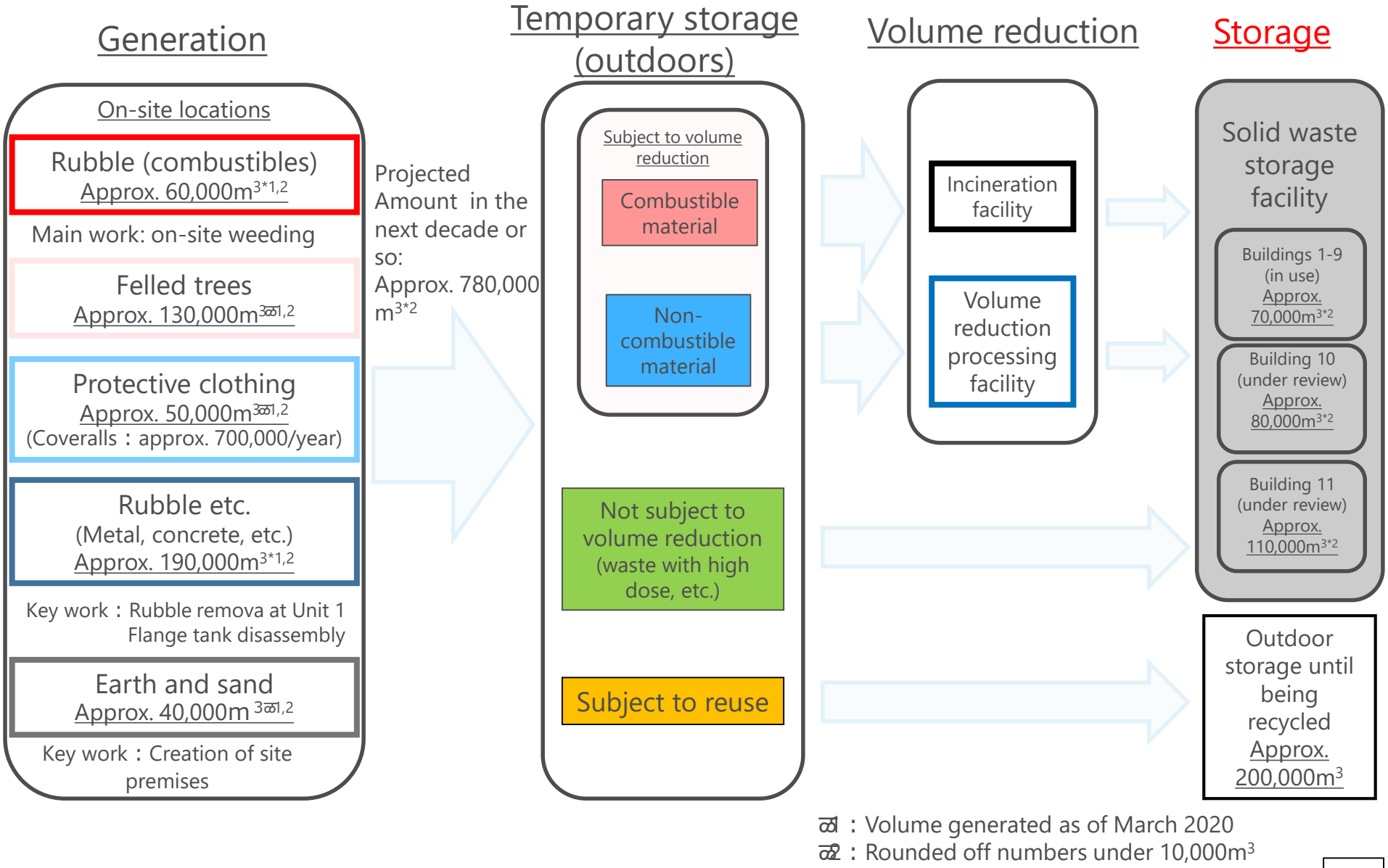
4-1.Waste storage management (1)



*1：Volume generated as of March 2020
*2：Rounded off numbers under 10,000m3

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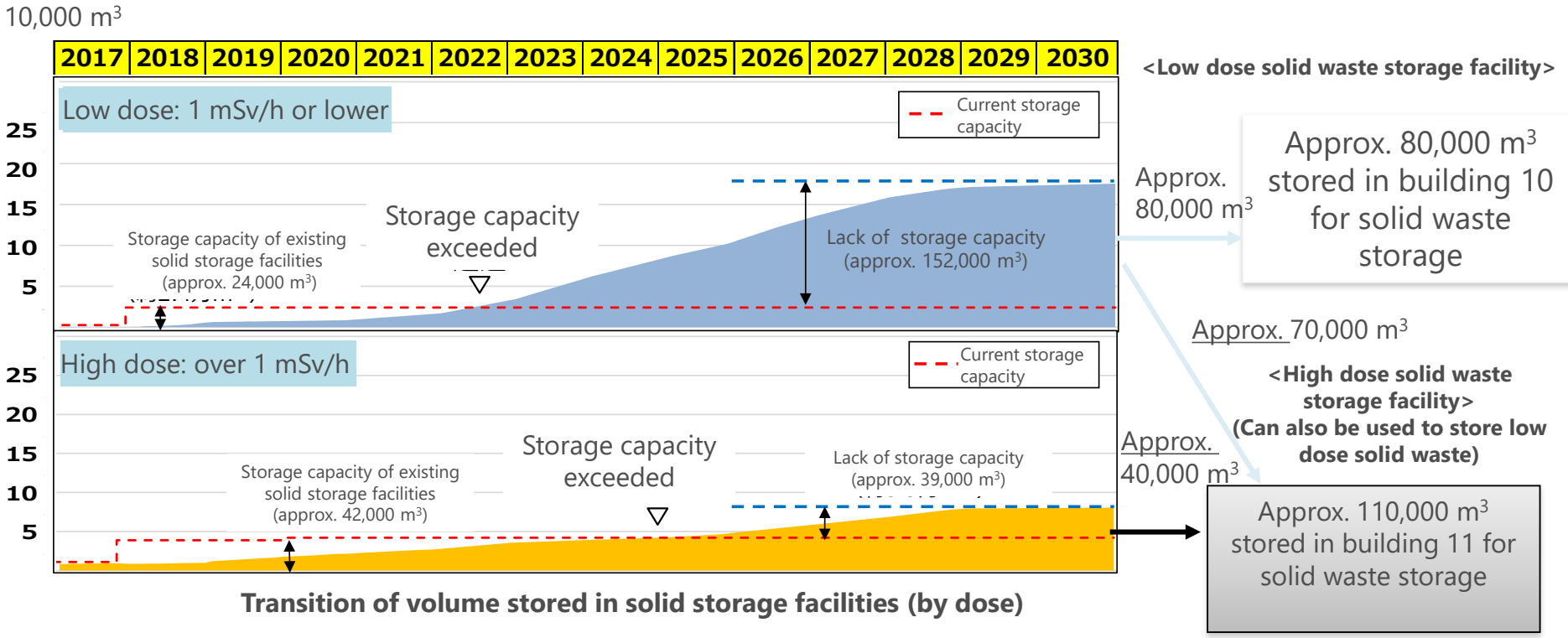
4-1.Waste storage management (2)

- The volume of waste planned to be stored inside buildings by the end of FY2030 is approx. 260,000 m^3.
- The storage capacity of existing solid storage facilities is approx. 70,000 m^3, so expanding the capacity by 190,000 m^3 is being considered.
- Volume of solid waste stored in the solid waste storage facility buildings 10 and 11 shall be distributed in accordance with the dose level of the subject waste.



Transition of volume stored in solid storage facilities (by dose)

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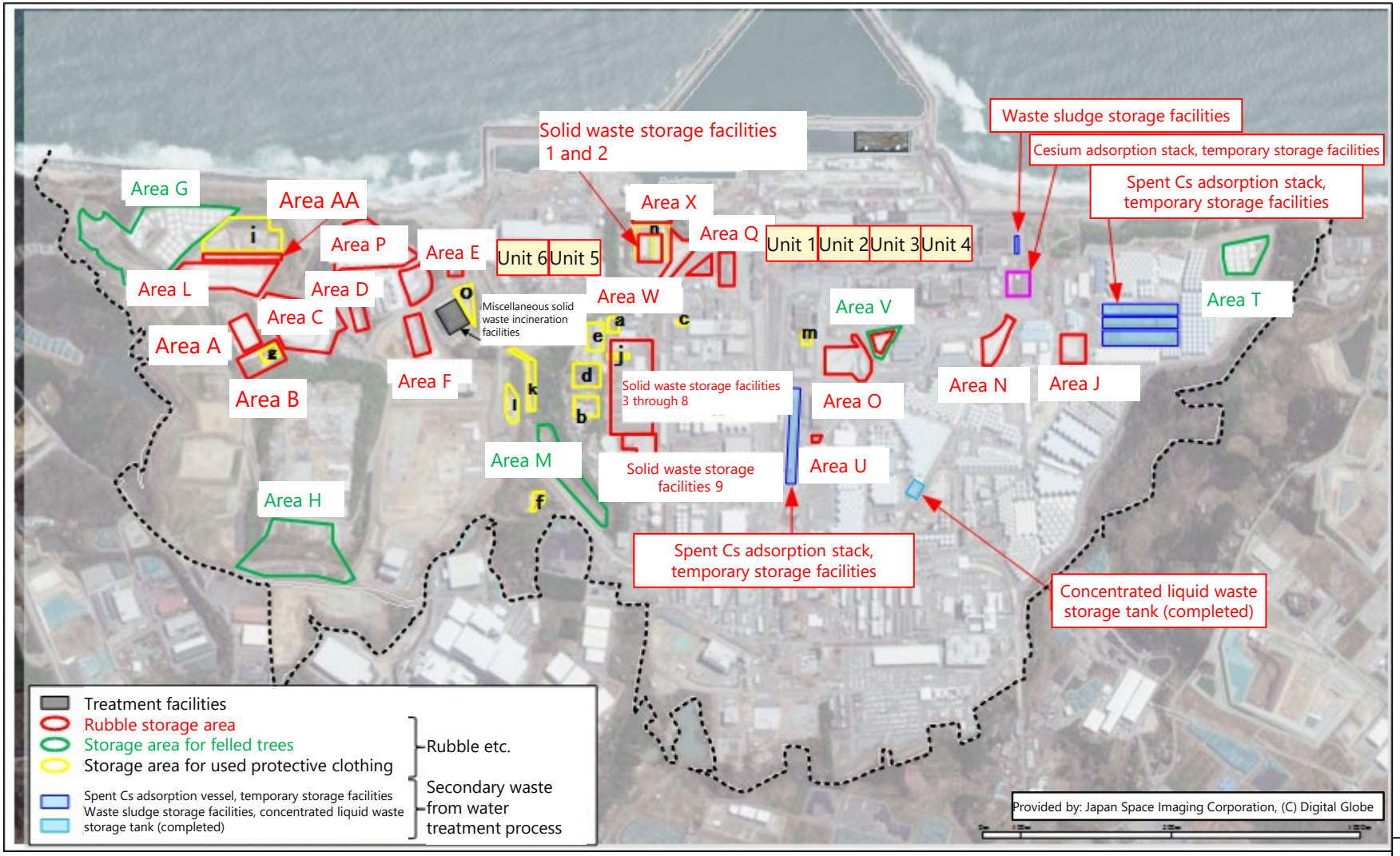
4-2. Storage of Rubble etc. (current status)

- There are various outdoor temporary storage areas for rubble etc. littered on the site premises of 1F (approx. 50 locations)

⇒The outdoor temporary storage area shall be eliminated in FY2028※, and waste material shall be stored indoors (at the solid waste storage facility).

※Excludes area for materials to be reused



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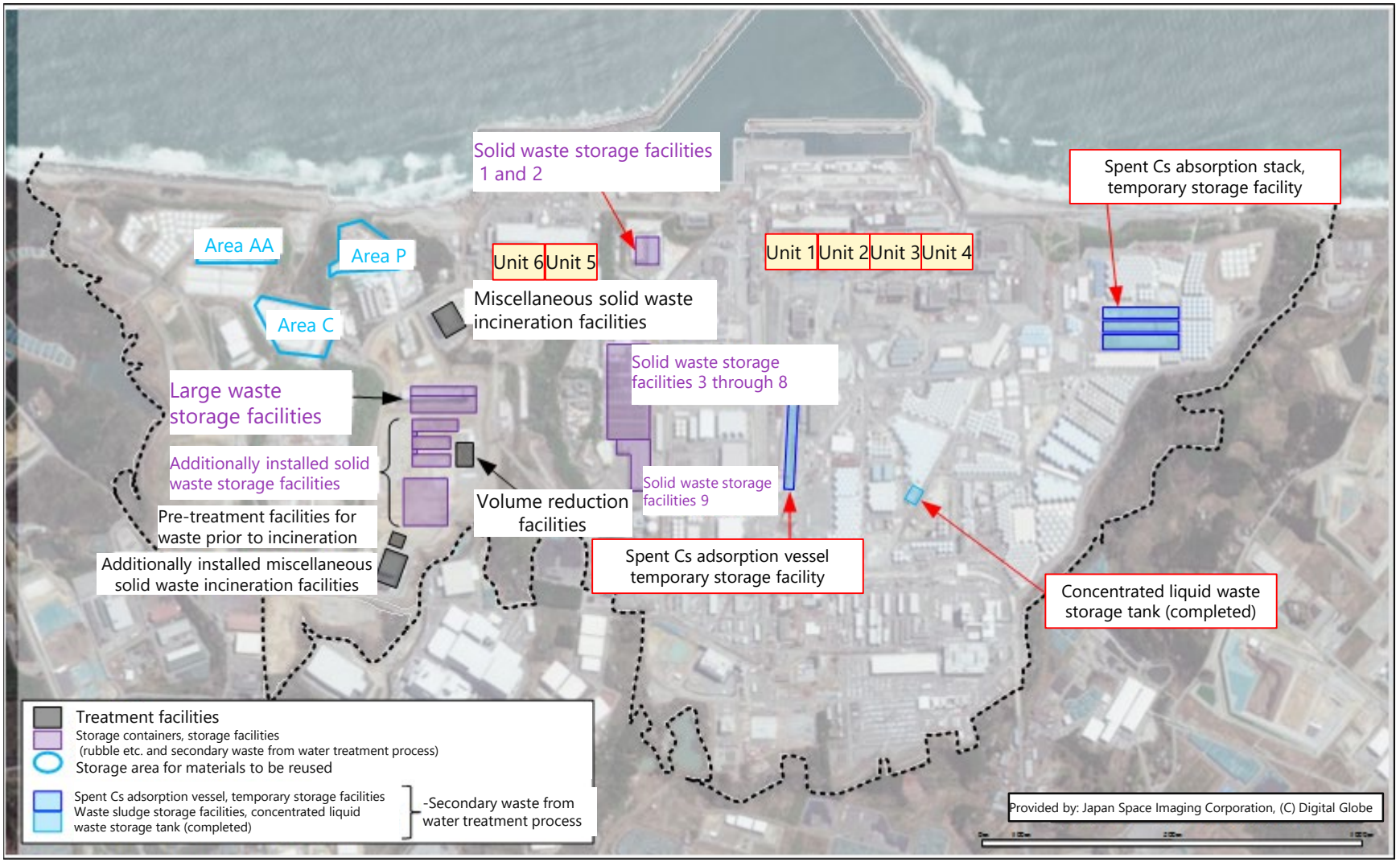
4-2. Storage of Rubble etc. (in the future)

- Layout of premises in FY2028 when the outdoor temporary storage areas for rubble etc. is eliminated

※Excludes area for materials to be reused



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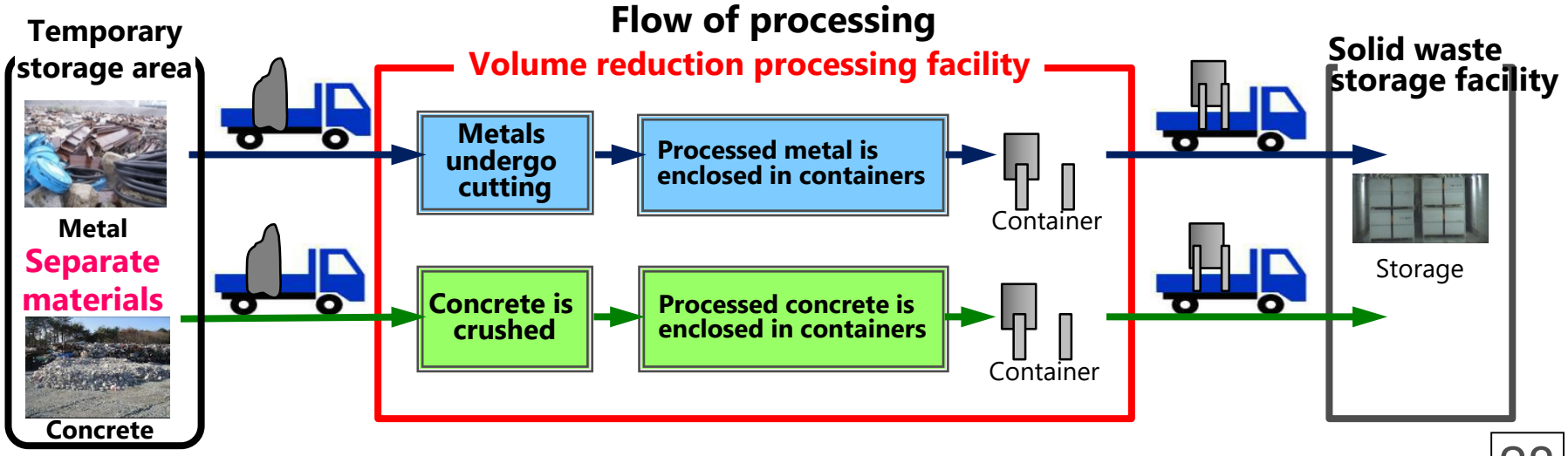
Overview of facilities and aseismic performance

Overview of facility	Facility for cutting metal rubble and crushing concrete rubble. Target volume reduction rate is approx. 50%.
Processing capacity	Metal：Approx. 60 m^3/day Concrete：Approx. 40 m^3/day
Building structure	Steel frame construction (areas with shielding function: reinforced concrete), built with adequate shielding capabilities and structural strength
Aseismic class	Class C
Initiation of operation	FY2022 (currently under review)



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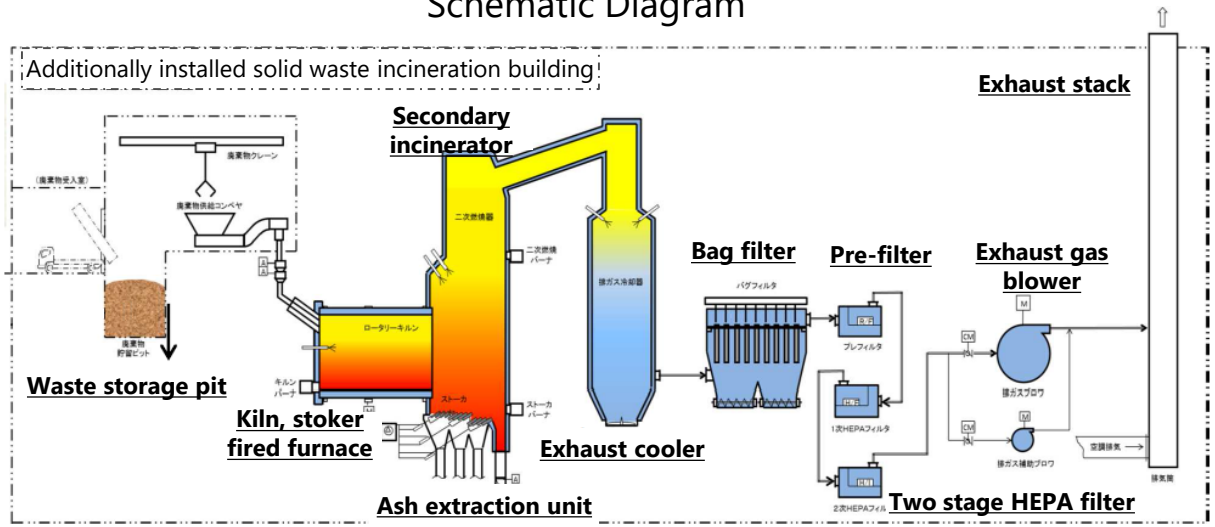
Overview of facilities and aseismic performance

Overview of facilities	Facilities mainly for incinerating felled trees and combustible rubble (kiln stoker type incinerator). Target volume reduction rate is below 10%.
Processing capacity	95 t/day (operated 24 hours a day)
Building structure	Reinforced concrete, built with adequate shielding function and structural strength
Aseismic class	Class B (main equipment such as incinerators, building)/ Class C (components other than above)
Initiation of operation	FY2021

Exterior view of building

Additionally Installed Miscellaneous Solid Waste Incineration Facilities
Schematic Diagram



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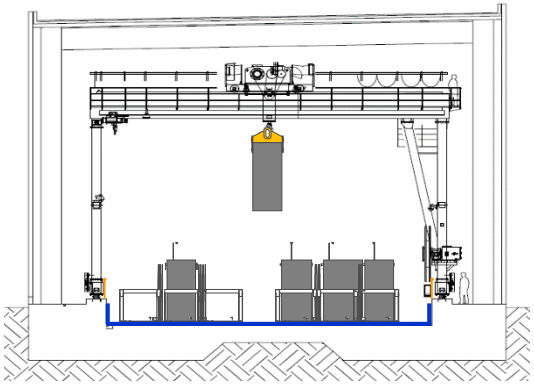
Overview of facilities and aseismic performance

Overview of facilities	Facilities for storing large and heavy waste such as secondary waste generated from water treatment during the operation of contaminated water treatment facilities.
Processing capacity	Building 1： Approx. 4,000 m^2 (adsorption vessel 744 units：SARRY 360 units, KURION 384 units) Building 2：approx. 8,000 m^2 (Equivalent to approx. 1,200 adsorption vessels) (to be reviewed in the future)
Building structure	Steel frame construction, precast slab built with adequate shielding function and structural strength
Aseismic class	Class B
Initiation of operation	FY2021 (currently under review)



Storage at the large waste storage facilities

Secondary waste from water treatment currently temporarily stored

Adsorption vessel of No. 2 cesium adsorption unit (SARRY)

Adsorption vessel of cesium adsorption unit (KURION)

High performance container for multi-nuclide removal facility (ALPS)

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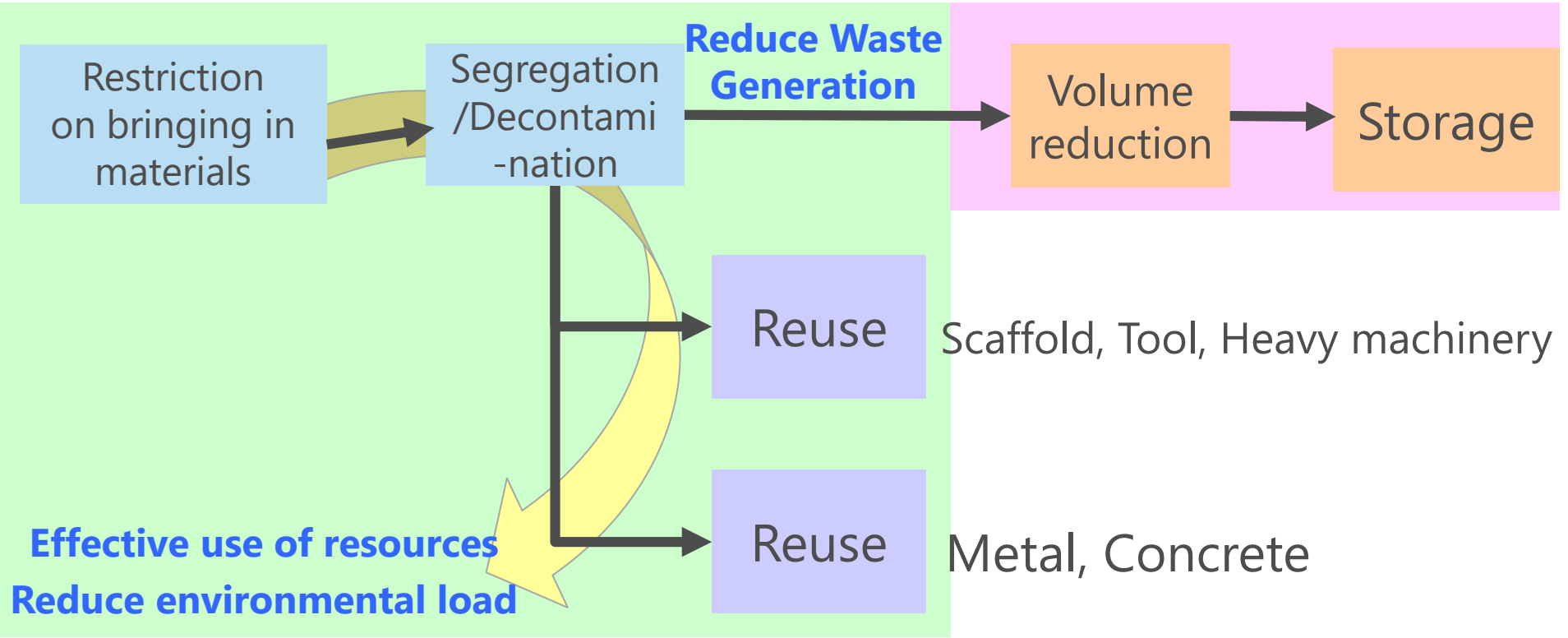
4-6. Waste Management: Effort to Reduce Waste Generation

- The volume of generated waste will be reduced to the extent possible and transition to indoor storage will be conducted.
- In parallel, restriction on bringing in unnecessary materials, appropriate segregation and decontamination to be conducted to reduce waste generation
- Reduce environmental load through reuse of supply and metals etc.



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5. Measures Against Natural Disasters

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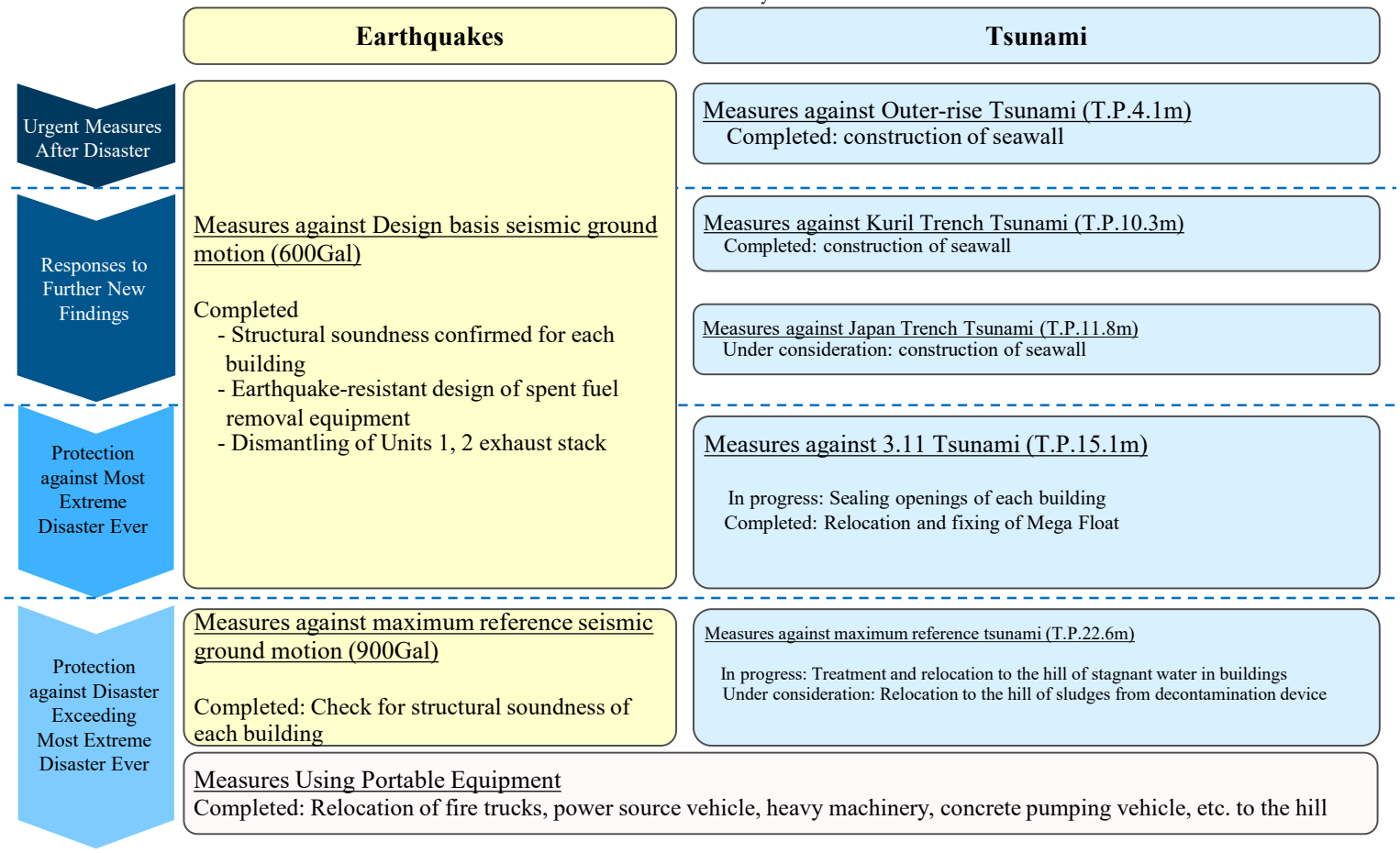
5-1. Policy for Measures against Earthquakes and Tsunami

- Measures and assessments critical for ensuring safety are being implemented in stages in view of their feasibility, etc.

*Data for tsunami protection measures have been revised in view of highest water levels observed in vicinity of former tide station.



* Design basis seismic ground motion: seismic ground motion used as reference for an earthquake-resistant design taking into consideration knowledge and data before the Great East Japan Earthquake and the Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities (seismic ground motion of the same magnitude as that observed on the site during the Great East Japan Earthquake)
* Maximum reference seismic ground motion: seismic ground motion assumed under the most extreme conditions for a power station taking into consideration knowledge and data after the Great East Japan Earthquake and the new regulatory standards
* Maximum reference tsunami: tsunami assumed under the most extreme conditions for a power station taking into consideration knowledge and data after the Great East Japan Earthquake and the new regulatory standards
* Outer-rise tsunami: tsunami likely to be caused by a normal fault earthquake occurring at the outer-rise part (uplift area at the outer side of an ocean trench) after an interplate earthquake
* Kuril Trench Tsunami: tsunami to be caused by an earthquake occurring along the Kuril Trench
* Japan Trench Tsunami: tsunami assumed reflecting the report of the "Cabinet Office's Committee for Modeling a Megaquake along Japan Trench and Kuril Trench"

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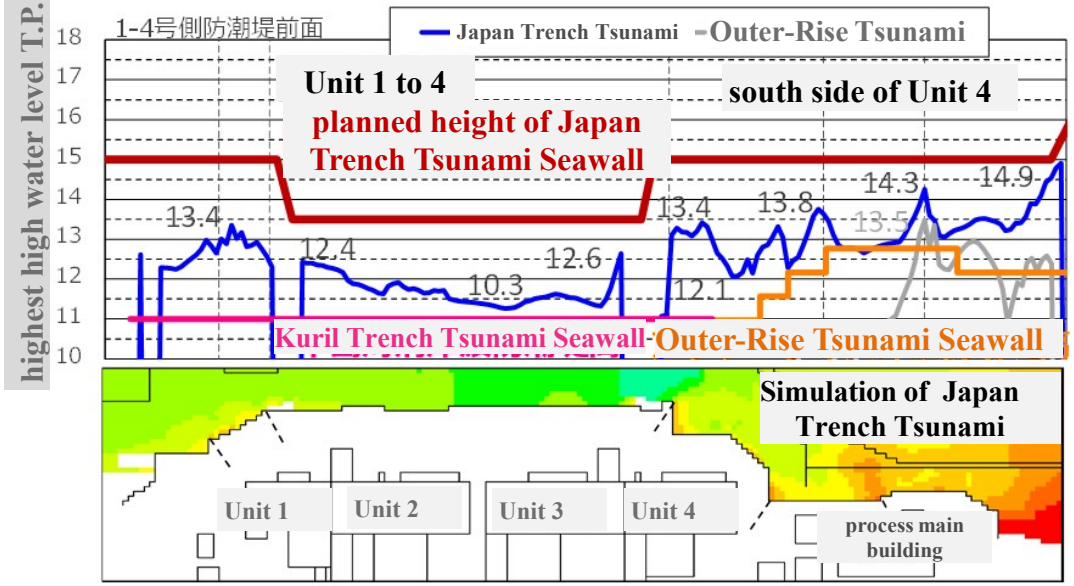
5-2. Seawall Against Tsunamis from the Japan Trench (1)

- Height of the seawall has been set by "tsunami data analysis" reflecting the latest horizontal alignment of seawall which takes into account the workers' traffic line of ongoing and planned decommissioning project



- Required height of seawall derived from tsunami analysis (highest water level) - by assuming vertical infinite wall at planned location for seawall,

※ height and other details may change during the future construction work

unit: m		Unit 1 to 4	South side of Unit 4
Outer-Rise Tsunami	Analysis results	–	T.P.9.7 to 12.7 (plan) T.P.8.6 to 13.5 (present assessment)
	wall height	–	T.P.11.0 to 12.8 (plan)
Kuril Trench Tsunami	Analysis results	T.P.10.3	–
	wall height	T.P.11.0	–
Japan Trench Tsunami	Analysis results (present assessment)	T.P.10.3 to 13.4	T.P.12.1 to 14.9
	Planned wall height*	T.P. about 13.t to 15	T.P. about 15 to 16

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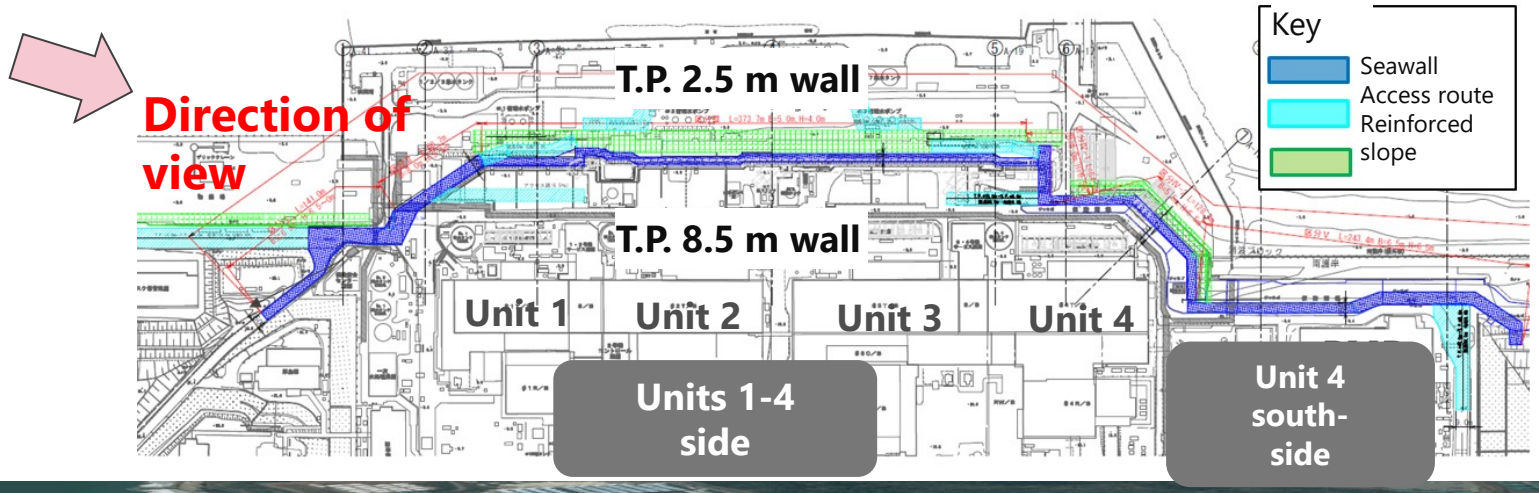
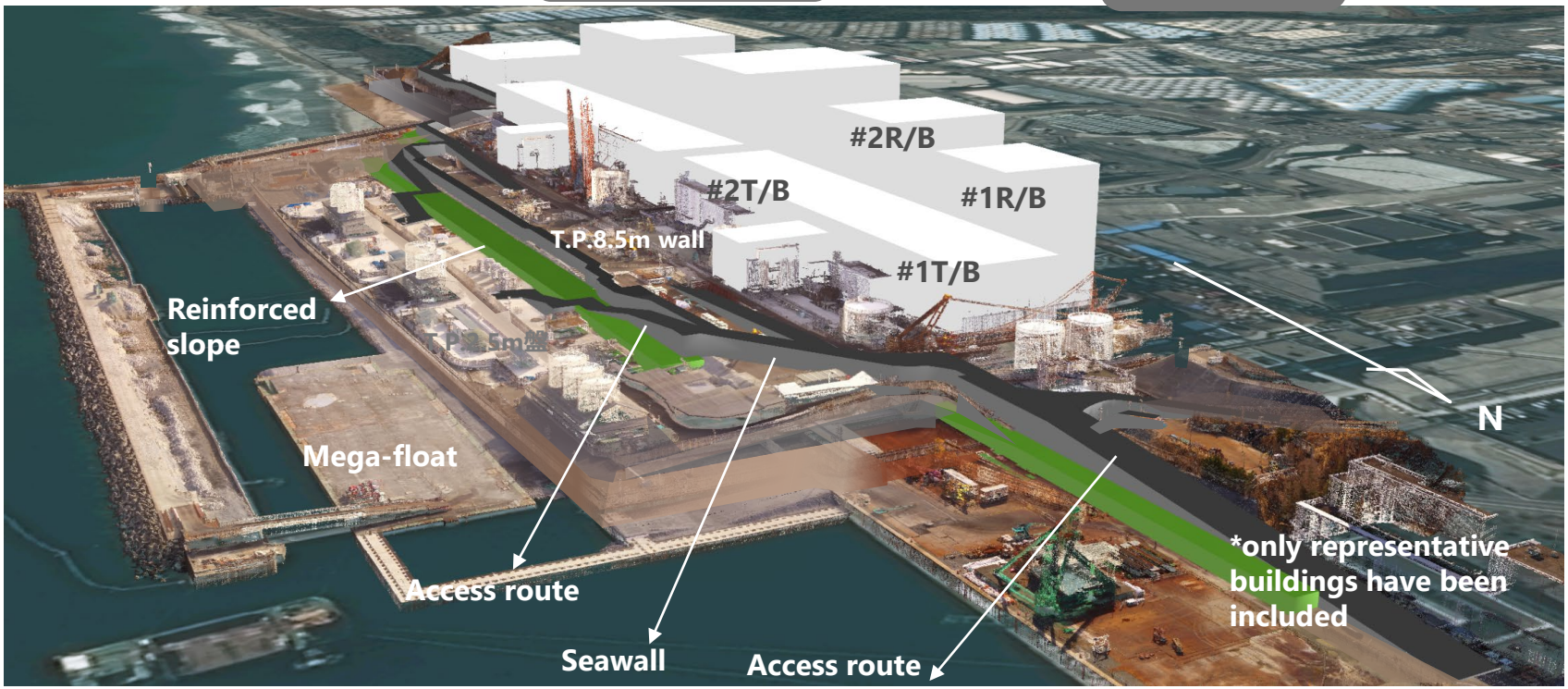
5-2. Seawall Against Tsunamis from the Japan Trench (2)





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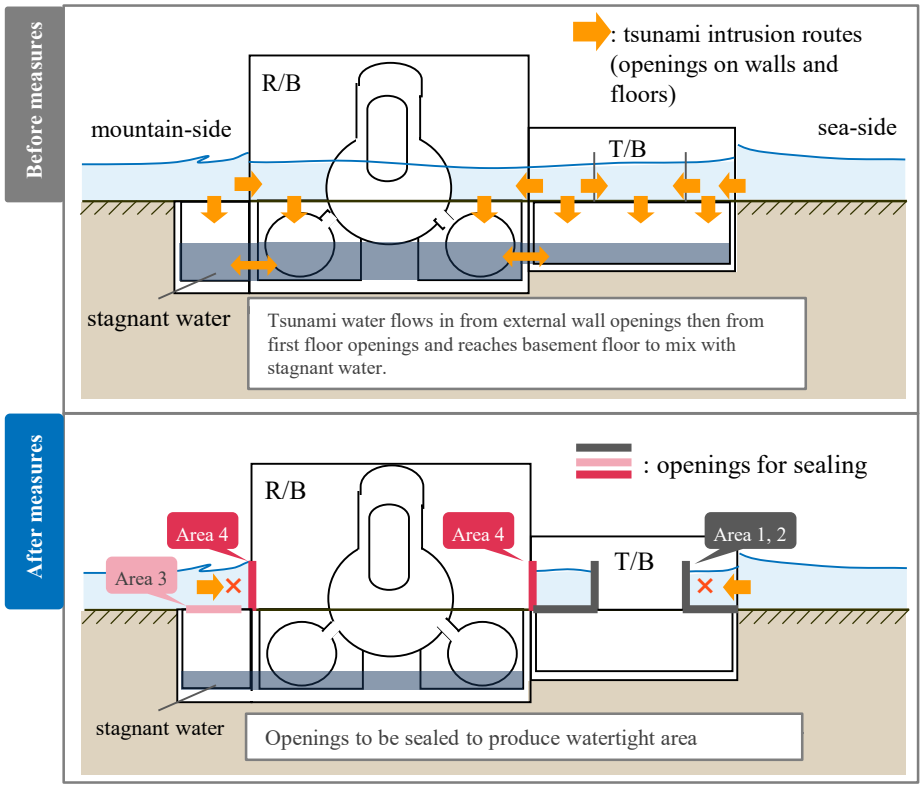
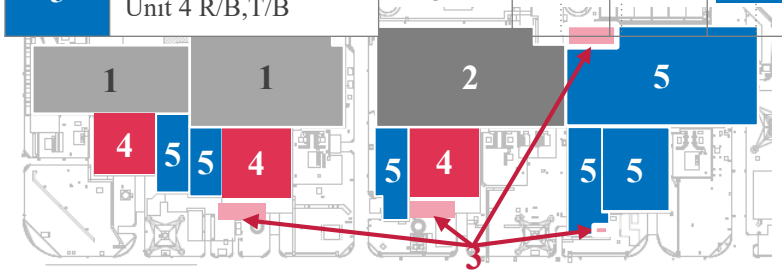
5-3 Sealing of Building Openings

- **Purpose**: As measures against 3.11 Tsunami for main buildings in Unit 1 to 4, sealing of building openings is under way. It aims to prevent leakage of stagnant water in buildings into sea due to backwash. It also aims to avoid tsunami waves inflow to the extent possible so that the increase in stagnant water in the buildings can be curbed.
- **Progress**: "Sealing" or "inflow prevention" for openings of main buildings in Unit 1 to 4 are under way
  As of end of May, 2021, 116 out of 127 completed as scheduled
  - Areas 1, 2 ⇒ end of FY2018 (completed)
  - Area 3, 2·3R/B (external floor) ⇒ end of FY2019 (completed)
  - Area 4, 1~3R/B (door) ⇒ Nov. , 2020 (completed) :buildings with stagnant water
  - Area 5, 1~4Rw/B, etc. ⇒ To be completed by the end of FY2021(in progress): buildings without stagnant water



(FY)

Area	Building	Completed/ Planned No.	2018	2019	2020	2021
1	Unit 1, 2 T/B, HTI, PMB, common pool	40/40				Current
2	Unit 3 T/B	27/27				
3	Unit 2, 3 R/B (external floor, etc.)	20/20				
4	Unit 1 to 3 R/B (doors)	16/16				
5	Unit 1 to 4 Rw/B Unit 4 R/B,T/B	13/24				to be completed at end of FY2021



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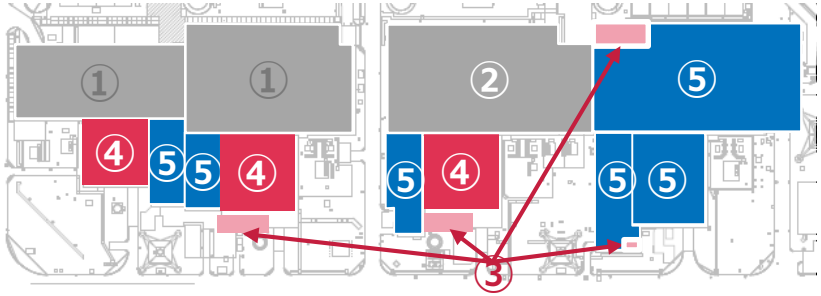
5-3. Progress in Sealing of Building Openings

- Increase in the number of areas where measures have been completed

  (compared to the previous count as of January 25, 2021)

Category	Building	Planned number of areas	Number of completed areas		Increase in the number of completed areas
			Previous	Current	
①	1・2T/B, HTI, PMB, common pool	40	40		0
②	3T/B	27	27		0
③	2・3R/B (External floor, etc.)	20	20		0
④	1-3R/B (door)	16	16		0
⑤	1-4Rw/B 4R/B,4T/B	24	10	13	**+3**
	Total	**127**	113	**116**	**+3**



- Status of measures
  - Category ③ 2R/B external floor

2R-8 Completed 2020.1

Before measures are taken	After measures are taken
	

Method: Closure using concrete

  - Category ③ 4T/B external floor

4T-10 Completed 2020.3

Before measures are taken	After measures are taken
	

Method : Closure using water proof panel

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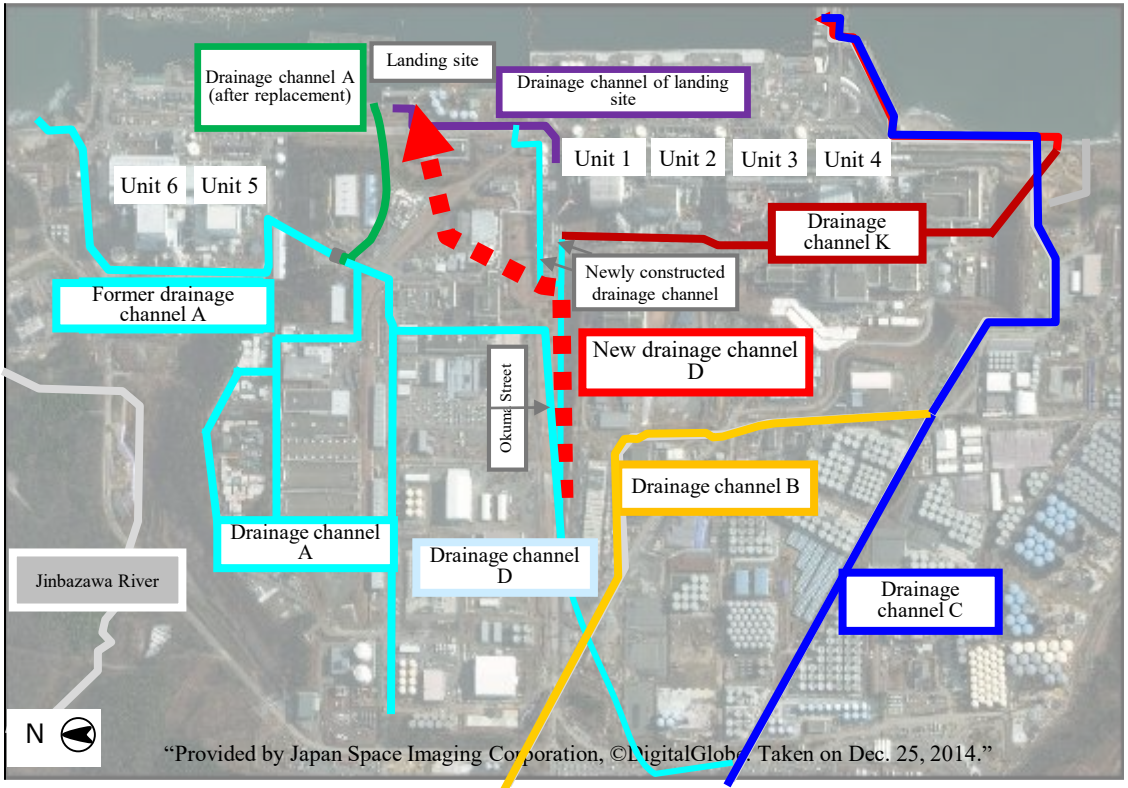
5-4. Construction work of new drainage channel D

[Construction Outline]

- The drainage channel D, which can be the most effective against rainstorm risk, will be developed to resolve rainstorm risk before the typhoon season in 2022.
- As shown in the figure below, the total length (red line) is about 800 m (propulsion tunnel Φ2200), and the water is drained into the port in the sea area in front of the landing site.
- Based on the results of the internal water inundation analysis, connection space have been added to the area where rainwater flows into the northeastern part of Unit 1.
  (Internal water inundation analysis will be conducted in the future with the final drainage channel shape)



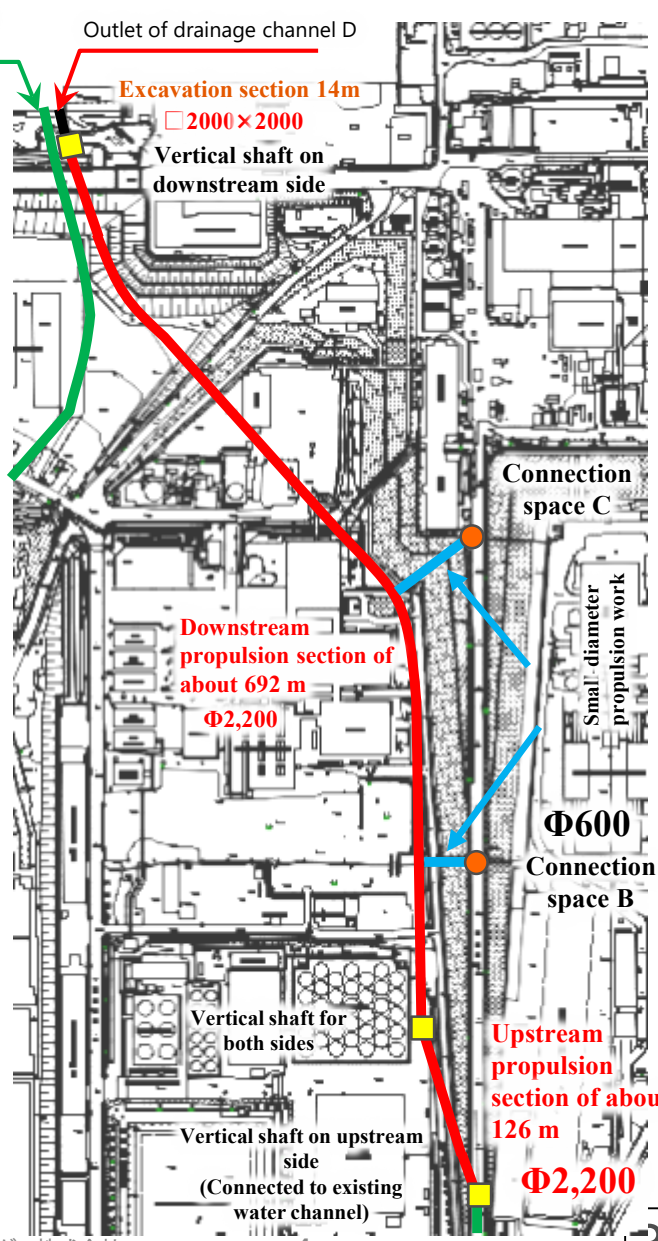


Fig. 1 Overview of on-site drainage channels

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6. Summary

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6. Summary

Reduce risk in the Fukushima Daiichi Nuclear Power Station by procceding with the decommissioning project, and conduct management in accordance with the progress of work and environmental changes.

- **Risk management**
  - Systematically reduce risk unique to the Fukushima Daiichi Nuclear Power Station in accordance with RM and LTP.

- **Plant maintenance**
  - Identify age degradation and maintaining integrity of newly installed facilities (with little or no prior operating experience)
  - Confirm and secure integrity of existing facilities (affected by the accident)

- **Radiological control**
  - Exposure reduction through decontamination, shielding and use of remote operation technologies.
  - Environmental impact assessment through monitoring of area within and outside of site premises, and applying results to the decommissioning project

- **Waste management**
  - Stable storage (secondary waste from water treatment, etc.), storage after volume reduction (concrete, metals, combustibles)
  - Controlling waste generation (controlling reception of off-site materials, recycling, etc.)

- **Measures against natural disasters**
  - Clarifying aseismic requirements for new facilities (currently under review)
  - Measures for facilities against tsunami and heavy rain (seawall, drainage channel, etc.)

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