Provisional Translation

資料1

Preventive and multi-layered countermeasures for Contaminated water of Fukushima Daiichi Nuclear Power Plant (Summary)

December 3rd, 2013

Cabinet Office
Contaminated Water and Decommissioning Issues Team Secretariat

Background of Contaminated Water Treatment Countermeasures

1. Assignment for the Contaminated Water Treatment Committee

(1) "Basic Policy for Contaminated Water Problem" Nuclear Emergency Response Headquarters (Sep. 3rd 2013)

To clarify potential risks and continuously review preventive measures and urgent countermeasures by utilizing professional knowledge such as the Contaminated Water Treatment Committee.

(2) "Plans and actions for Decommissioning and Contaminated Water Issue" Ministerial Meeting for Decommissioning and Contaminated Water Treatment Issue (Sep. 10th 2013)

Launch a team for gathering domestic and overseas knowledge to tackle with technical challenges.
Further potential risks should be identified and It should be done before the end of this year.

2. Progress to date

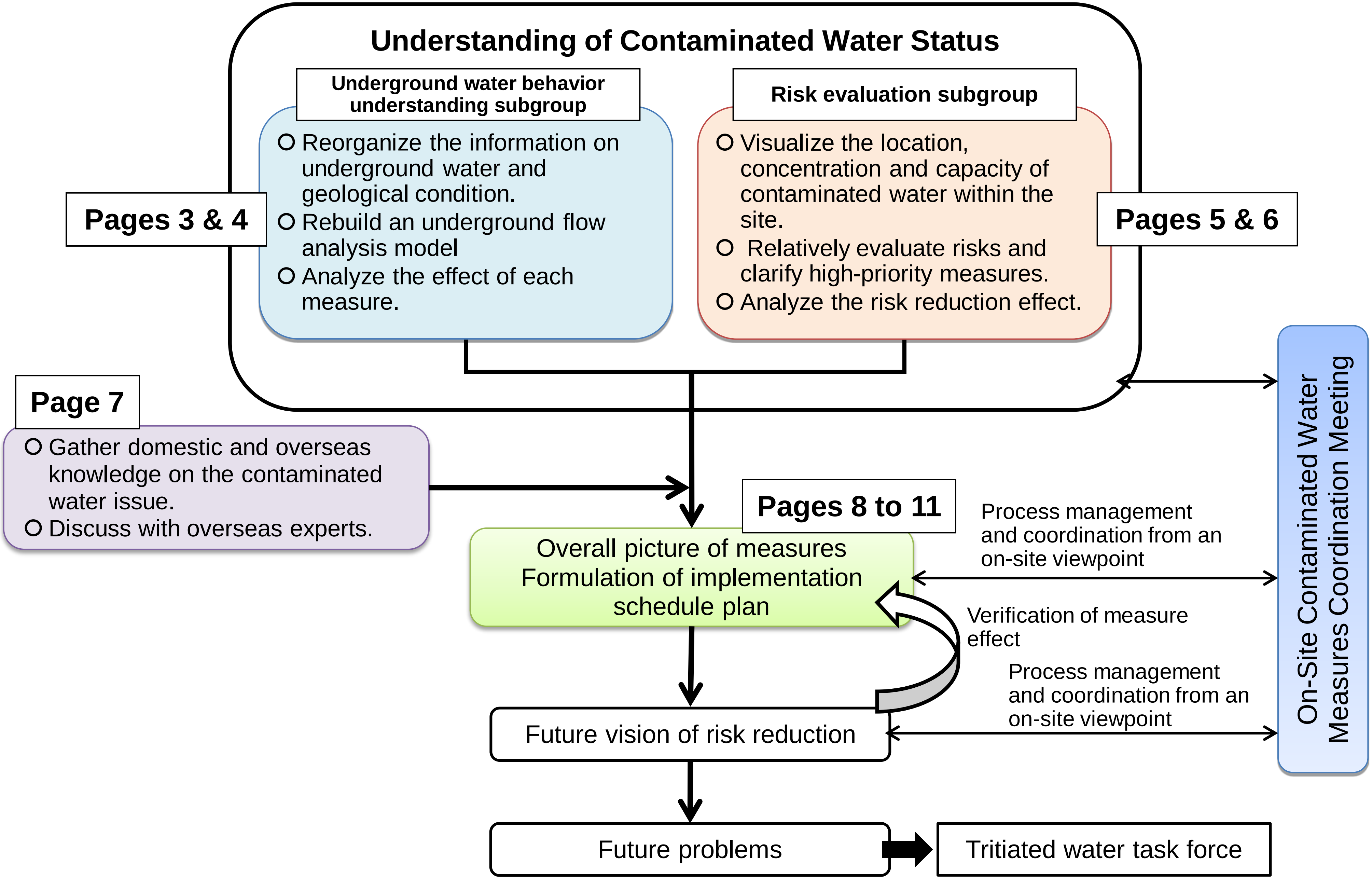
(1) Review of the Contaminated Water Treatment Committee

- Intensive discussion on Sep. 13, Sep. 27, Oct. 25, Nov. 15 and Dec. 3.
- Field survey by the *Contaminated Water Treatment Committee on Nov. 11th.*
- Discuss and cooperate from an on-site viewpoint through the Contaminated Water Treatment Field Coordination Meeting.

(2) Support of competent professionals

- Set up two sub-groups (Underground water behavior understanding SG and Risk identification SG)
- Professionals from the Ministry of Land, Infrastructure, Transport and Tourism, National Institute for Land and Infrastructure Management, Public Works Research Institute, National Institute of Advanced Industrial Science and Technology, Japan Atomic Energy Agency formulated SGs.

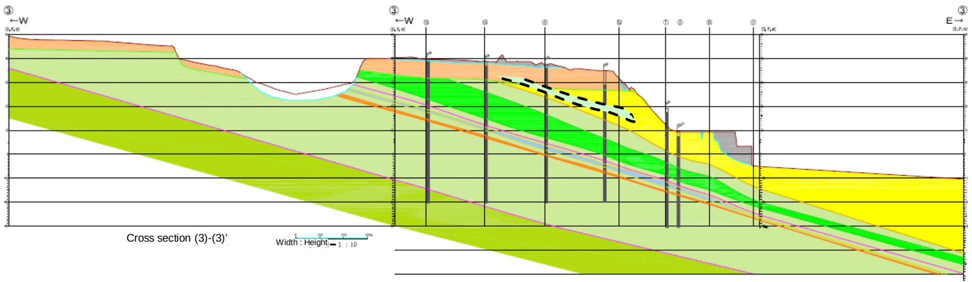
Flow of approaches at the Contaminated Water Treatment Committee



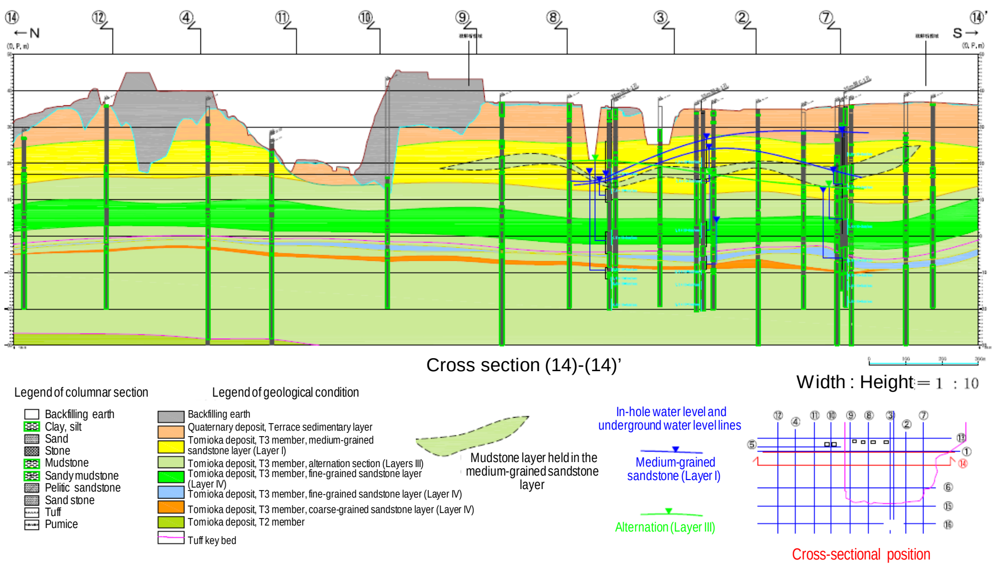
Overview of “Underground Water and Rainwater Behavior Analysis and Visualization” Subgroup (1)

- Checked the boring results and underground water level measurement results conducted by TEPCO so far, and the data on the interrelations between secular change of the underground water level and rainfall, and reorganized the underground water and geological structures within the site.

Stratum cross-sectional view of the south side of Fukushima Daiichi NPP, No. 4 reactor (East-west cross section)



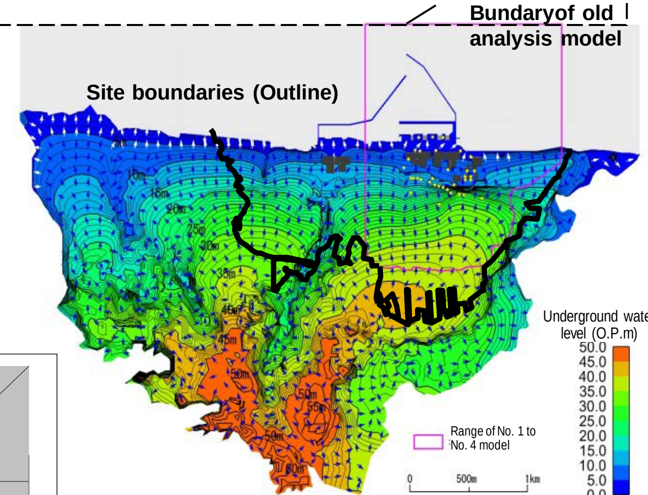
Stratus cross-sectional view of Fukushima Daiichi NPP , 35-m base (North-south cross section)



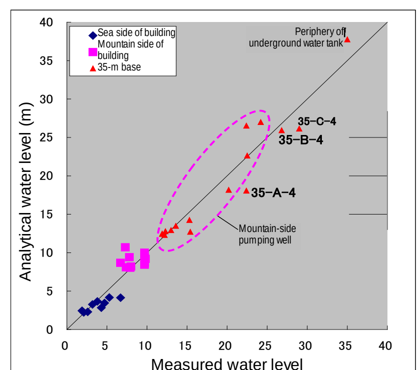
- Checked the validity of the simulation model used for deciding the existing contaminated water treatment measures.
- To study the preventive and multi-layered measures, it is necessary to understand an overall picture of underground water flow, including the periphery of the Fukushima Daiichi site. For this reason, the target area of the simulation model was expanded beyond the site boundaries.
- Compared the analysis results with the actual measurement data to check reproducibility of the new simulation model.

[Major analysis conditions]
1. Rainfall: Annual average rainfall 1,545 mm (1.3 mm/day)
2. Rainfall permeability: 55% (Evapotranspiration was assumed to be annually 700 mm, the maximum theoretical point evaporation value.)
3. Coefficient of permeability of structure, etc.: A coefficient of permeability was set for 23 kinds of strata and structures in total.
4. Boundary condition: The conditions on the sea- and mountain side of the analytical area were set as a hydrostatic pressure.
   (Analyzed inflow and outflow of underground water at the boundary in advance)

【Analysis results of the underground contour and flow direction diagram】



Analytical water level vs. Actual measured value



Study Overview at “Underground Water and Rainwater Behavior Understanding & Visualization” Subgroup (2)

◆ Based on the reviewed underground water simulation, the effect of inhibiting inflow of underground water into the building was analyzed when each measure is implemented individually or in combination. Over 50 cases were analyzed as to the effect of combining the measures

Typical Cases and Their Analysis Results

Case	Measures: 4-m base measure	Measures: Underground water bypass	Measures: Sea-side water impermeable wall	Measures: Mountain-side SD	Measures: Mountain in-/sea-side SD	Measures: Land-side water impermeable wall	Measures: Facing*	Measures: Mountain-side water impermeable wall	Inflow volume into building (Daily): Total amount	Inflow volume into building (Daily): Nos.1 to 4 buildings	Inflow volume into sea area (Daily)	Pumping volume (Daily)	Items of pumping volume: Underground water bypass	Items of pumping volume: SD	Items of pumping volume: Sea-side drain
No measure									400	310	290	400			
Case 1	●								410	320	220	460			50
Case 2	●	●							390 330 290	300 250 210	220 200 210	900 1220 1130	460 840 790		50
Case 3	●		●						400	320	0	750			350
Case 4	●			●					(1) 140	90	190	1000		820	40
Case 5	●				●				120	80	180	1070		920	30
Case 6	●					●			130	30	100	140			10
Case 7	●						● Entire area		(2) 130	110	90	130			0
Case 8	●						●*		300	240	170	330			30
Case 9	●							●:Inside site boundary	(3) 420	330	220	470			50
Case 10	●	●	●		●	●			(4) 70	0	0	1010	500	290	140
Case 11	●		●			●			130	30	0	270			
Case 12	●	●	●			●			130	30	0	770			
Case 13	●	●	●		●				60	20	0	1370		830	150
Case 14	●	●	●		●	●	●*	●**	(5) 30	0	0	400	140	130	90
Case 15	●		●			●	●*	●**	110	30	0	210			90
Case 16	●	●	●			●	●*	●**	100	30	0	340	150		90
Case 17	●	●	●		●		●*	●**	(6) 60	40	0	560	10	430	40

*: Denotes the 35- and 10-m base water-proof pavement

**: Denotes the combination of partial facing and peripheral water-shielding

◆ The following describes major matters clarified by comparing the analysis results of the effect of combining the measures for inhibiting inflow of underground water.

[Facts clarified by these analysis results]

(1) Implementation of mountain-/sea-side sub-drain and installation of the land-side water impermeable wall are highly effective in inhibiting inflow of underground water into the building. (Based on Cases 4, 5 and 6)

(2) Wide-range facing is highly effective in inhibiting inflow of underground water into the building, but its effect is limited if a construction area is narrowed. (Based on Cases 7 and 8

(3) Even if the mountain-side water impermeable wall is installed near the site boundary, the effect of inhibiting inflow of underground water into the building is not obtained. (Based on Case 9)

(4) The effect of inhibiting inflow of underground water into the building is obtained to a certain degree by implementing the on-going measures and those decided to be carried out. (Based on Case 10)

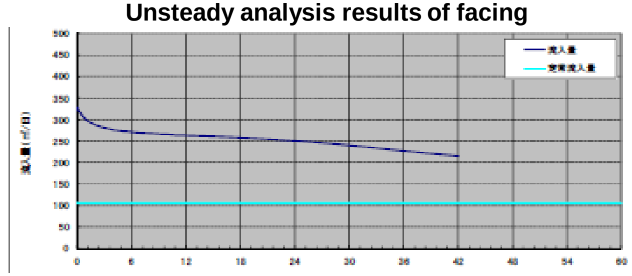
(5) The effect of the on-going measures or those decided to be carried out is increased by facing and peripheral water-shielding. However, it takes time to see the effect of facing and peripheral water-shielding. (Based on Cases 10 and 17

(6) Even if the land-side water impermeable wall fails to exhibit its full function, it can be substituted for by a combination of facing and the mountain-side water impermeable wall. (Based on Cases 10, 14 and 17)

◆ The effects of underground water bypass and sub-drain depend on operating conditions.

◆ As a result of the unsteady analysis of facing, it was found out that it took a longer period to exhibit the effects of measures, compared with a frozen soil wall implemented near the building (it takes approx. 42 months or longer to exhibit about half of expected effects).

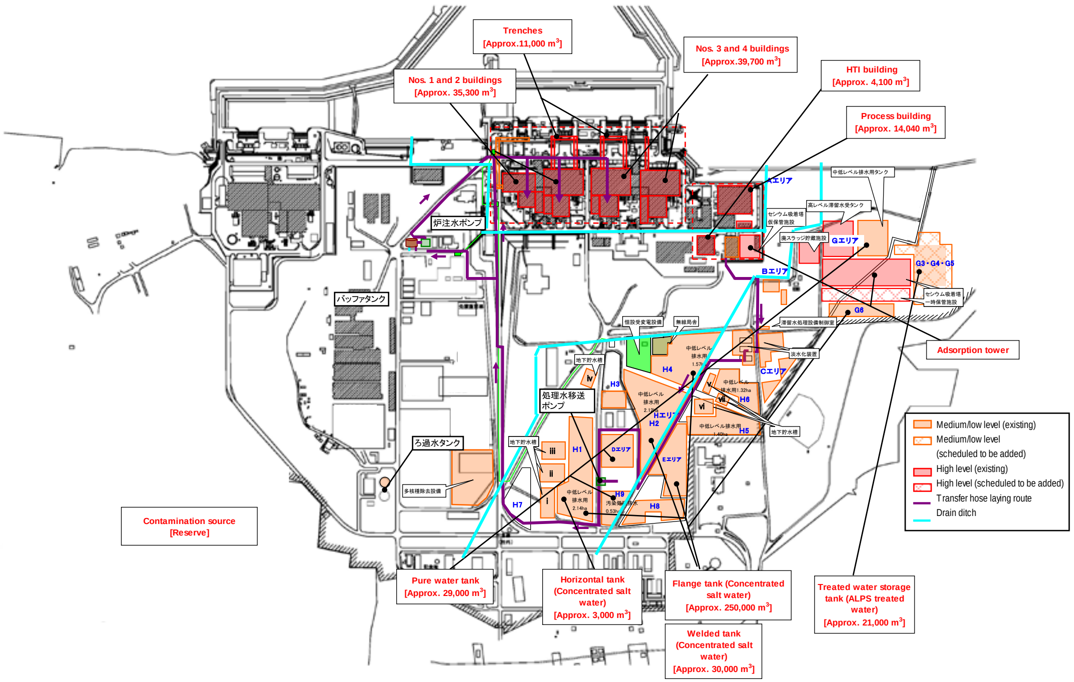
Unsteady analysis results of facing



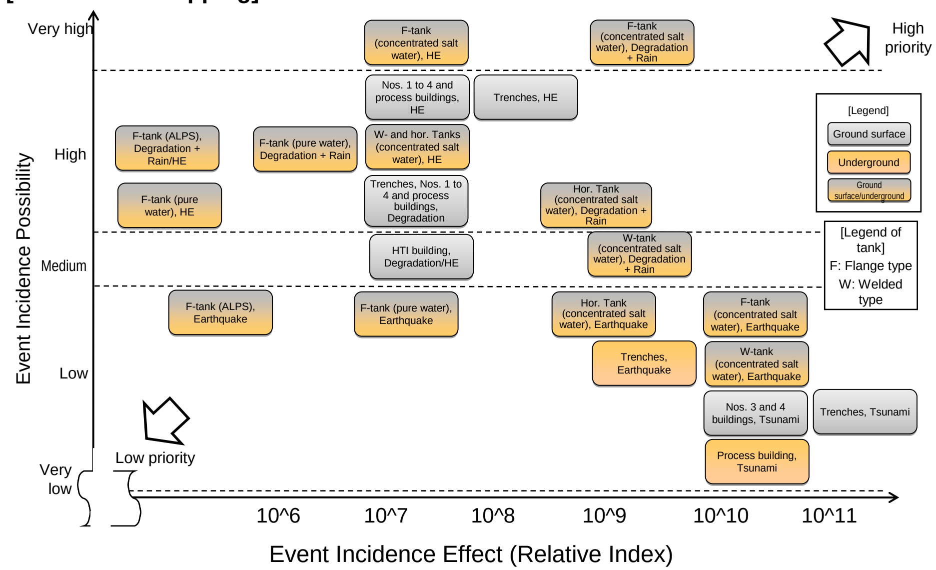
Study Overview at “Risk Evaluation” Subgroup

◆ Organized and visualized (1) location, (2) concentration and (3) capacity as to contaminated water within the site.

◆ Made relative evaluation of the expected risks to map the current risks based on the leakage probability of contaminated water, concentration of contaminated water, leakage volume, leakage incidence factors, and so on.



[Current risk mapping]

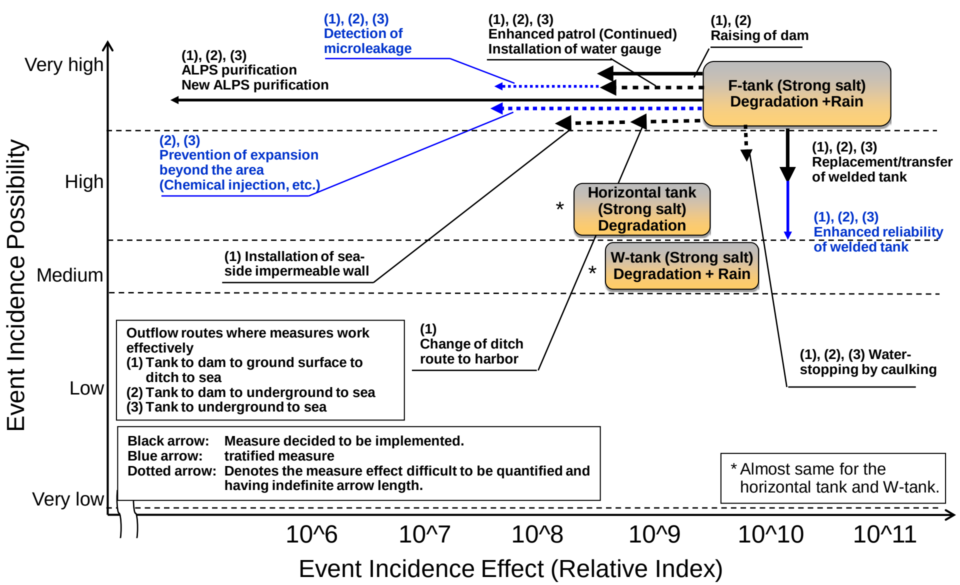


Study Overview at "Risk Evaluation" Subgroup

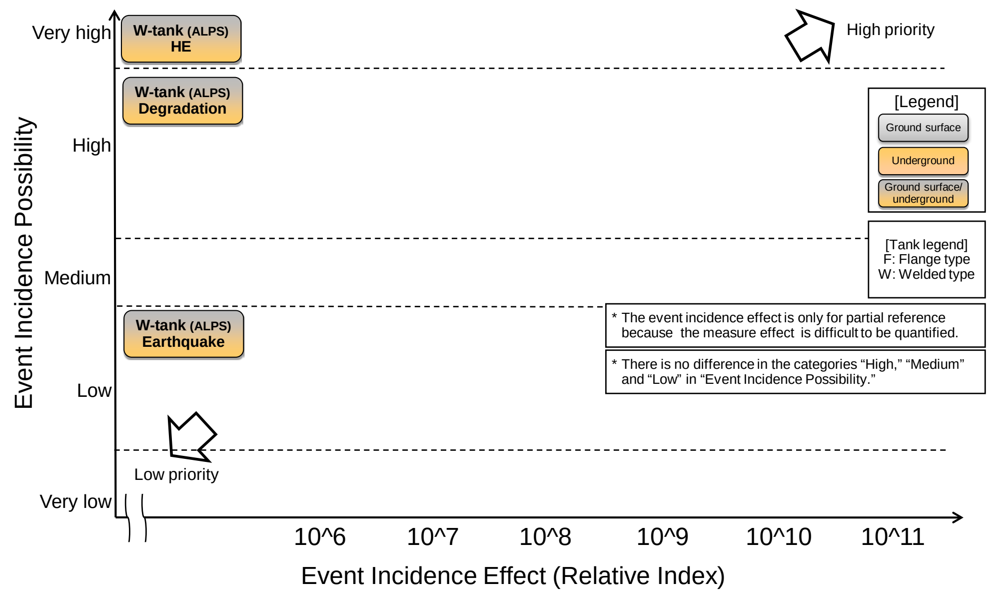
◆The measures contributing to risk reduction and their effects were analyzed as to individual risks.

◆The risk reduction effect of the measures over years to come was clarified when each measure is implemented according to their priority.

Contaminated Water Event Occurrence Risk Map
[Flange Tank/Aging Degradation]



[Verification of Risk Reduction Effect] (End of 2020)



Gathering of Domestic and Overseas Knowledge on Contaminated Water Problem

■ Invitation of technical proposals

◇ A team of professionals was launched to gather domestic and overseas knowledge to receive technical proposals, centering around the International Research Institute for Nuclear Decommissioning (IRID). (Invitation period: Sep. 25 to Oct. 23)

◇ The invited proposals were mainly scrutinized by the "Contaminated Water Treatment Committee" consisting of professionals

◇ They are reflected on the overall picture of the preventive and stratified contaminated water treatment measures to be coordinated by the end of the year

■ State of application

◇ There were 780 proposals. The following describes the details.

Field particularly asking for technical proposal/advice	Proposal
1. Contaminated water storage (Storage tank, microleakage detection technique, etc.)	206
2. Contaminated water treatment (Tritium separation technique, long-term stable tritium storage method, etc.)	182
3. Purification of sea water in the harbor (Technique to eliminate radioactive Cs and Sr in sea water, etc.)	151
4. Contaminated water control in the building **(Building internal water stop technique, ground improvement technique, etc.)**	107
5. Site management for inhibiting inflow of underground water (Water-shielding wall construction technique, facing technique, etc.)	174
6. Understanding of behavior of underground water, etc. (Geological condition and underground water data measuring system, water quality analytical technique, etc.)	115
Others (Those not falling under 1 to 6 above)	34

(Note 1) The invitation fields are based on the applications of proposers.
(Note 2) Some single proposals are found out related to multiple fields.

■ Responses

Technique recommended to use immediately	➢ Reliability improvement and scaling up of tank(Double steel shell tank, etc.) ➢ Light-weight shielding sheet free from lead ➢ Pollution preventive membrane (silt fence, etc.) ➢ Water stop technique (building internal water stop, building peripheral water stop) ➢ Survey of geological condition and underground water, improvement observation network…
Technique recommended to use after selection of suitable method	➢ Technique of water-shielding (Facing of the site , peripheral water-shielding measure)
Technique to check/verify	➢ Microleakage detection technique (dye included) ➢ Decontamination technique free from water. ➢ Technique of tritium storage and separation ➢ Purification of sea water in the harbor ➢ Underground filter (technique to collect strontium in the soil) ➢ Unmanned boring technique
Evaluation /Study	➢ Overall evaluation of handling of tritiated water ➢ Study on the possibility of responses to the problems such as a floating tanker, underground storage

Clarification of Expected Risks and Required Preventive and multi-layered Measures

Risk/Problem			Measure taken by Sep. 3 or decided to be taken	Preventive and stratified measure expected to be required in addition to the left-mentioned
Risks/Problems decided to be responded to	Risk of contaminated underground water flowing out into the sea	Contaminated water in sea-side trench	○ Pump and purify high-concentration contaminated water in the sea-side trench. [Removal]	○ Improve the north-area soil of the No. 1 reactor's intake. [No leakage] ○ <u>Remove the radioactive materials by installing the pollution preventive membranes. [No leakage][Removal]</u> ○ <u>Remove the radioactive materials in sea water. [No leakage][Removal] *</u> ○ <u>Covering of marine soil.</u>
		Sea-side contaminated soil of the turbine building	○ Install sea-glass walls on the revetment of the sea-side contaminated area of the building. Pump contaminated water from the contaminated area. [No leakage] ○ Pave the ground surface of the sea-side contaminated area of the building with asphalt, etc. [No leakage] ○ Install the sea-side water-shielding walls in the harbor. [No leakage]	
		Contaminated water stored in the tanks	○ Enhance a patrol for the tanks and their piping. [No leakage] ○ Install water gauges, leak detectors, etc. [No leakage] ○ Replace the horizontal steel tanks. [No leakage] ○ Accelerate replacement of bolted tanks by welded ones. [No leakage] ○ Purify contaminated water by the ALPS (Advanced Liquid Processing System) [Removal] ○ Purify contaminated water by the higher-processing efficiency purification equipment. [Removal] ○ Collect the contaminated from the periphery of the tanks. [Removal]	○ Increasing the height of the embankment, installing the back-up embankment. [No leakage] ○ Underdrain the ditches to prevent inflow of contaminated water. In addition, reroute the ditches to the harbor. [No leakage] ○ Further accelerate installation of welded tanks and improve reliability. (double steel shell tanks, etc.) [No leakage] ○ Install a rain gutter onto the tank top plate to inhibit rainwater stored in the dam. [No leakage] ○ Stop a water leak by caulking the bottom of the bolted tanks, and so on. [No leakage] ○ <u>Decontaminate the used tanks consequent upon their replacement. [No leakage]*</u> ○ Prevent underground water contaminated by leak water from the tank from flowing out into the sea (prevent expansion of contamination by chemical injection, and so on). [No leakage] ○ <u>Collect strontium in the soil. [No leakage]*</u> ○ Accelerate purification of contaminated water by expanding the multi-nuclide removal equipment [Removal] ○ <u>Detect microleakage from the tank. [No leakage]*</u>
	Risk of contaminating underground water by leaked waste and allowing its outflow into the sea (Leakage from the high-performance container (HIC), etc. storing high-concentration waste after treated by the ALPS)		○ Reduce a waste volume by the higher-processing efficiency purification equipment. [No leakage]	○ Take measures to prevent a waste leak from the high-performance container (HIC) [No leakage] ○ Reduce high concentration waste further and formulate a stable storage measure. [No leakage]
	Risk of increasing a contaminated water volume and failing to store it due to shortage of storage tanks, and so on		○ Pump underground water on the mountain side of the building (underground water bypass). [No access]	
			○ Pump underground water from the well near the building. (Sub-drain) [No access]	
			○ Install the land-side frozen soil based water-shielding walls which surround the buildings. [No access]	○ Install new water-shielding walls outside the frozen soil walls, implement facing within the site, or implement a combination of them. [No access]
			○ Install required additional tanks so as to surely store increasing contaminated water [No leakage]	○ <u>Appropriate treatment of tritiated water is to be studied by the tritiated water task force in a comprehensive manner.</u>

(1) Additional preventive & multi-layered measures

(2) Further risk identification

Risk				Preventive measures expected to be required in addition to the above-mentioned
Risks requiring future responses	Contaminated water leak from the circulative cooling system	Risk of contaminated water leaking from the building	Contaminated water leak from the building	○ Configure a circulation loop using the SPT as a buffer tank, exclude the HTI and process buildings gradually from the loop, thus reducing the loop by direct transfer of contaminated water of each reactor to the contaminated water treatment facility, and so on. [No leakage] ○ Shorten loops to remove contaminated water(Circulation contaminated water in the building). [Removal] ○ Purify highly concentrated contaminated water in the building. ○ <u>Water stop of the building penetrating sections and the gaps between the buildings and so on. [No leakage]*</u> ○ Control the underground water level and contaminated water level by installation of drainage pumps in the deep sections of the reactor buildings, and so on. [No leakage]
			Outflow of building internal contaminated water into the sea by outer-rise tsunami	○ Improve waterproofness of the openings, etc. and considering additional countermeasures such as construction of sea walls [No leakage]
		Leak from the transfer piping		○ Take measures such as replacement by high-radiation resistance piping and multiplexing of piping. [No leakage]
		Leak from the SARRY		○ Take measures to prevent a contaminated water leak from the SARRY (install a leak receiver). [No leakage]
	High-concentration waste after cesium removal			○ Take measures to prevent waste leak from the cesium absorption tower [No leakage] ○ Take measures for volume reduction and stable storage of waste from the cesium absorption tower. [No leakage]
	Breakage of the tanks, etc. by large-scale natural disaster, etc.			○ Build a system to prevent external discharge by swift transfer of a large amount of contaminated water to the building, etc., and so on. [No leakage]

- *: Denotes a measure to be verified about feasibility
- An underlined measure is introduced as a result of public invitation of techniques.

(Note 1) In addition to the risks listed here, keep in mind that there may be other ones which cannot be accurately understood due to information shortage, etc. at this moment.

→ <u>From now on, in the process of improving an observation network to enhance observation, make appropriate use of technique considered effective, according to its purpose of investigation.</u>

1. Results;

(1) Checked the validity of underground water flow analysis model. About 800 m^3/day of underground water was supplied from the west side of the building, out of them 400 m^3/day intruded into the building and the rest flowing into the port.

(2) Evaluated the potential risks and the remaining risks after taking each measures, based on the probability of leakage and radiological impacts from them. The impact of each risk reduction were clarified and prioritalised.

2. Additional counter measures

(1) Multi-layered counter measures capable of responding to the risks if the existing measures are obstructed

[1] Measures for preventing underground water inflow [Isolation]

(Additional measures) "Extensive facing" or "Combination of partial facing and peripheral water-shielding"

(Existing measures) Land-side impermeable walls, pumping of underground water from the sub-drain, pumping by the underground bypass, and so on.

[2] Measures for contaminated water stored in the tanks, etc. [Removal] [No leakage]

(Additional measures) Increasing the height of the embankment, Installing the back-up embankment, Covering of ditches, capturing strontium in the soil, Reliable and larger tank(double steel shell tank, etc.), Microleakage detection device.

(Existing measures) Clean-up of contaminated water by ALPS, introduction of high-performance clean-up system, acceleration of replacement by welded tanks, and so on.

[3] Measures for the sea-side areas [Removal] [No leakage]

(Additional measures) Purification of sea water in the harbor such as precipitation, adsorption and separation, Elimination of radioactive materials by membrane, covering of marine soil

(Existing measures) Pumping of contaminated water in trenches, installation of water glass and sea-side impermeable walls, and so on.

[4] Measures against the risk of failing to store contamination water [No leakage]

- Overall evaluation of handling of tritiated water
- Study on the possibility of responses to the problems about a tanker, underground storage, and so on.

2. Additional counter measures

(2) Preventive measures capable of responding to the risks beyond the capacities of the existing measures

[1] Measures against outer-rise tsunami [No leakage]

(Additional measures) Improvement of waterproofness of the openings, etc., Considering additional countermeasures such as construction of sea walls.

[2] Measures against leakage of contaminated water from the building [No leakage]

(Additional measures) Water stop of the building penetrating sections and the gaps between the buildings, Shorten loops to remove contaminated water.

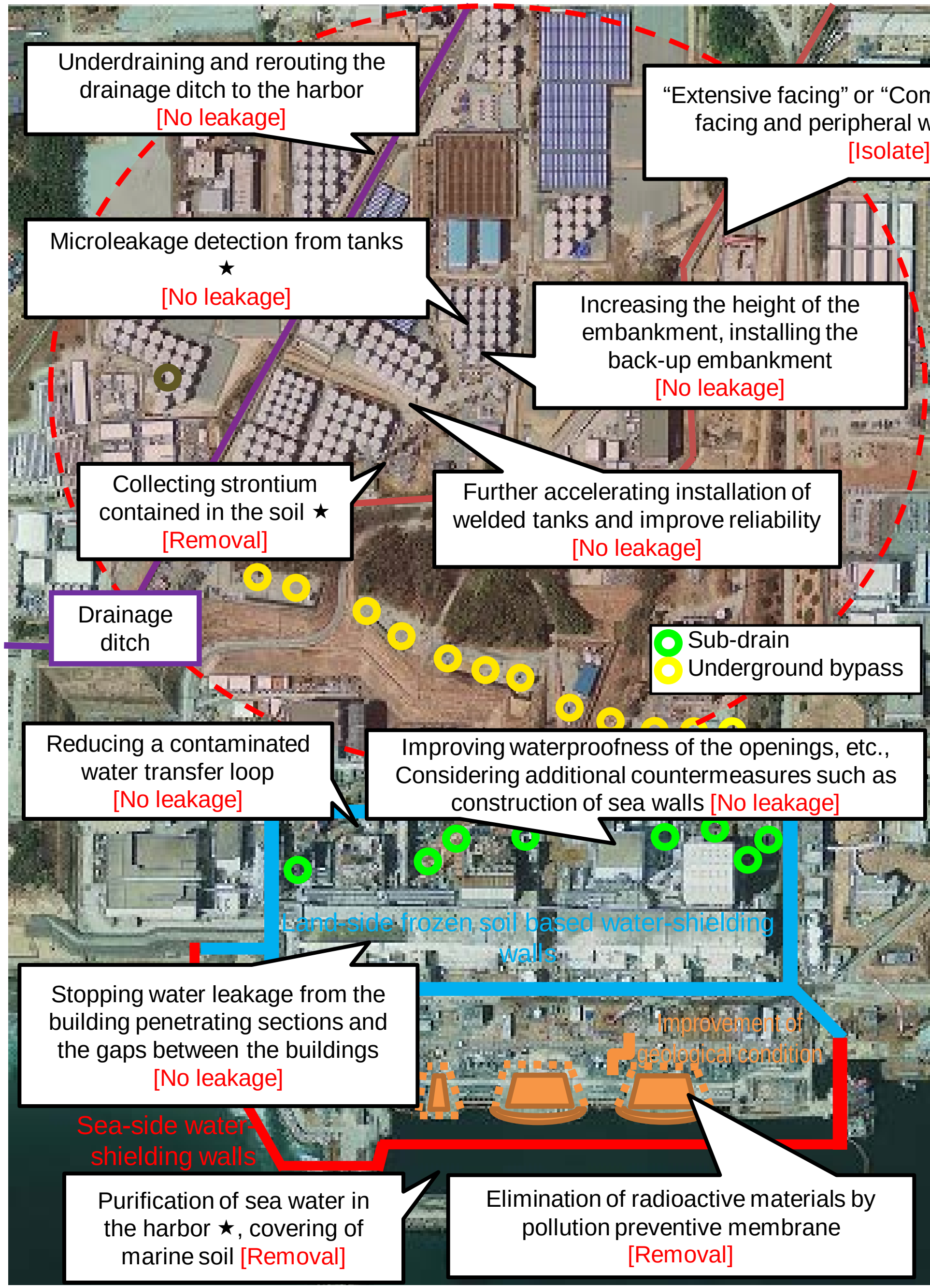
3. Future Actions;

(1)Handling of tritiated water stored in tanks (→ Formulate the tritiated water Task Force)

(2) Information shearing with inside and outside of Japan,

(3) Review of the plan as required

Overview of preventive and multi-layered counter measures



3 basic principles for contaminated water treatment measures
1. Isolate a contamination source.
2. Remove water close to the contamination source.
3. Prevent leak contaminated water.

Urgent measures

1. Eliminate high-concentration contaminated water in the trenches. [Removal]
2. Improve the soil of the contaminated area by water glasses, pave the ground surface with asphalt, etc. and pump underground water. [Isolate] [No leakage]
3. Pump underground water from the mountain side (underground water bypass) [Isolate]

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Fundamental measures

1. Pump underground water by sub-drain. [Isolate]
2. Install the sea-side water-shielding walls. [No leakage]
3. Install the land-side water-shielding walls by the frozen soil method. [No access]
4. Prepare higher-processing efficiency contaminated water purification equipment. [Removal]

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Preventive and multi-layered countermeasures

1. "Extensive facing" or "Combination of partial facing and peripheral water-shielding".[Isolate]
2. Increase the height of the embankment, install the back-up embankment. [No leakage
3. Underdrain and reroute the drainage ditch to the harbor. [No leakage]
4. Further accelerate installation of welded tanks and improve reliability. [No leakage]
5. Detect microleakage from them ★. [No leakage]
6. Collect strontium contained in the soil. [Removal]
7. Reduce a contaminated water transfer loop. [No leakage]
8. Purify sea water in the harbor ★ and cover the. marine soil. [Removal] [No leakage]
9. Remove the radioactive materials by the pollution preventive membranes. [Removal] [No leakage]
10. Improve waterproofness of the openings, etc., Considering additional countermeasures such as construction of sea walls. [No leakage]
11. Stop water leakage from the building penetrating sections and the gaps between the buildings. [No leakage]

(callout box): Main measure taken after decision of basic policies on Sep. 3 or decided to be taken.

★ Measure to be studied on its feasibility.