

NRA presentation

C3 Characterization of Source Term

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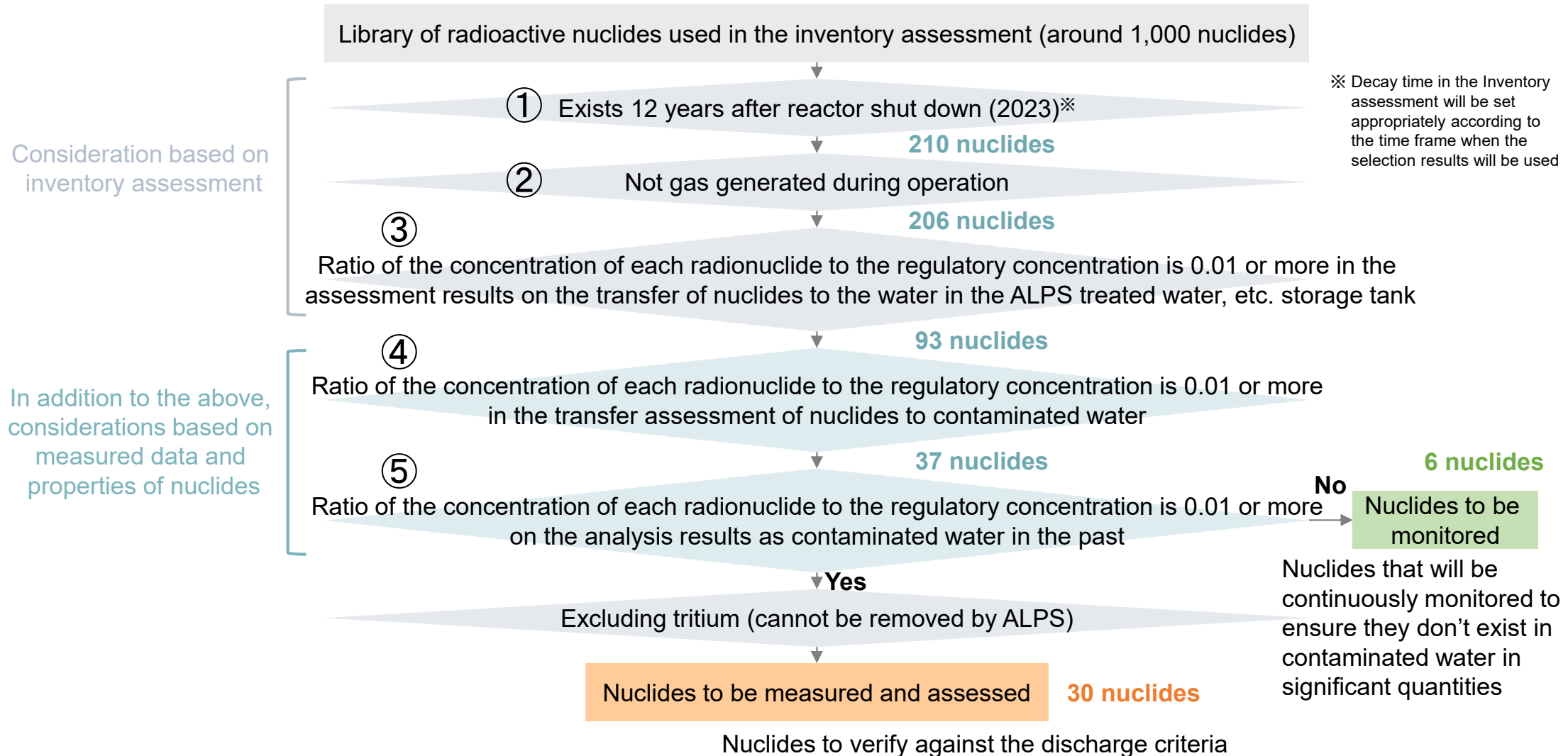
1. Overview and update from the last mission

- Before the ALPS treated water discharge, TEPCO must analyze the water and confirm that sum of the ratios of radionuclides other than tritium to each concentration limit is less than 1.
- At the 1st IAEA Review Mission, TEPCO had not submitted the detailed characterization of the source term. Therefore, NRA received the comment from TF that;
 - ✓ The Task Force noted that TEPCO needs to finalize and resubmit the characterization of the source term to allow time for review and approval by the NRA
- NRA received the “Application” about the scheme of characterization of source term in November 2022.
 - Aim of this scheme is to identify nuclides that possibly exist in contaminated water.
- NRA held 4 review meetings and had technical discussion, which has almost led to the mutual understanding.



2. TEPCO's characterization of the Source Term

TEPCO's scheme to select the nuclides to be measured





2. TEPCO's characterization of the Source Term

TEPCO's scheme to select the nuclides to be measured

① Inventory Assessment

TEPCO assessed inventories of each nuclide with ORIGEN Code considering 12 years decay after 2011.

- Inventories of ***Fission Products*** are calculated based on the condition of burnup of each fuel in Units 1 to 3 reactors during the loading period
- Inventories of ***Activation Products*** are calculated considering irradiation to structures* near the reactor and corrosion products in the feedwater

(*) reactor internals, fuel assembly, pressure vessel, pedestals, etc.

② Exclusion of noble gas

TEPCO excludes noble gas (except Rn, which is continuously generated from decay chain of U and Np).



2. TEPCO's characterization of the Source Term

TEPCO's scheme to select the nuclides to be measured

- ③ Primary screening with the inventory of each nuclide
TEPCO calculated theoretical concentrations of each nuclide with a conservative assumption that all inventory assessed at ① are all dissolved to water, in order to eliminate nuclides with significantly small value.
- ④ Detailed assessment using the previous analysis results data
TEPCO calculated concentrations by assessing dissolution behavior of each nuclide to water, based on the analysis results of the stagnant water in buildings.
- ⑤ Selection of nuclides to be measured
TEPCO selected the nuclides which had been detected larger than 1/100 of regulatory concentration limits as nuclides to be measured/assessed.
Nuclides lower than 1/100 is designated as nuclides to be monitored.



2. TEPCO's characterization of the Source Term

TEPCO's scheme to select the nuclides to be measured

① Inventory assessment

Nuclides	Inventory
Nuclide-A	○ Bq
Nuclide-B	○ Bq
Nuclide-C	○ Bq
Nuclide-D	○ Bq
⋮	⋮

③ screening with conservative assumption

Nuclides	Concentration	Criteria*	Judge
Nuclide-A	25 Bq/L	20 Bq/L	○
Nuclide-B	1 Bq/L	100 Bq/L	○
Nuclide-C	20 Bq/L	10 Bq/L	○
Nuclide-D	8 Bq/L	5 Bq/L	○
⋮	⋮	⋮	⋮

(*) 1/100 of regulatory concentration limits

Concentration is calculated by the inventories assessed in ① and the volume of water

$$\frac{\text{Inventories (○Bq)}}{\text{Volume of water (133} \times 10^7 \text{ L)}}$$

④ Detailed assessment

Nuclides	Conc.	Criteria*	Judge
Nuclide-A	18 Bq/L	20 Bq/L	○
Nuclide-B	1 Bq/L	100 Bq/L	○
Nuclide-C	15 Bq/L	10 Bq/L	○
Nuclide-D	6 Bq/L	5 Bq/L	○
⋮	⋮	⋮	⋮

Calculated by the inventories of ① and previous analysis results of nuclides

⑤ selection of nuclides to be measured

Nuclides	Conc.	Criteria*	Judge
Nuclide-A	18 Bq/L	20 Bq/L	○
Nuclide-B	1 Bq/L	100 Bq/L	○
Nuclide-C	12 Bq/L	10 Bq/L	○
Nuclide-D	4 Bq/L	5 Bq/L	△
⋮	⋮	⋮	⋮

→ Nuclides to be measured

→ Nuclides to be monitored

Analysis results



2. TEPCO's characterization of the Source Term

Initial selection of source term (as of Nov. 2022)

H-3	Rb-86	Ru-106	Sn-126	Te-129m	Ce-141	Sm-151	Pu-240	Se-79	Cl-36
C-14	Sr-89	Rh-103m	Sb-124	I-129	Ce-144	Eu-152	Pu-241	U-234	Fe-55
Mn-54	Sr-90	Rh-106	Sb-125	Cs-134	Pr-144	Eu-154	Am-241	U-238	Nb-93m
Fe-59	Y-90	Ag-110m	Te-123m	Cs-135	Pr-144m	Eu-155	Am-242m	Np-237	Nb-94
Co-58	Y-91	Cd-113m	Te-125m	Cs-136	Pm-146	Gd-153	Am-243		Mo-93
Co-60	Nb-95	Cd-115m	Te-127	Cs-137	Pm-147	Tb-160	Cm-242		Ba-133
Ni-63	Tc-99	Sn-119m	Te-127m	Ba-137m	Pm-148	Pu-238	Cm-243		
Zn-65	Ru-103	Sn-123	Te-129	Ba-140	Pm-148m	Pu-239	Cm-244		

64 nuclides

- Nuclides to be measured and evaluated (30)
- Nuclides to be monitored (6)
- Nuclides which is target of ALPS but not selected (38)



3. NRA's examination of the selection scheme of Source Term

NRA's examination points and result summary for each step

① Inventory Assessment

- Validity of applied analytical code
- Uncertainty of calculation, especially for activation

⇒ Confirmed that assessment has been done under conservative conditions

② Exclusion of noble gas

- This step has no review point

③ Primary screening with the inventory of each nuclide

④ Detailed assessment using the previous analysis results data

- Validity of criteria to cut off nuclides, i.e., 1/100 of regulatory limit

⇒ Confirmed that sum of the ratios of radionuclides cut off by 1/100 of regulatory limit at step ③ and ④ is respectively $6.7E-02$ compared to $2.4E+07$ of remaining nuclides and $3.6E-02$ compared to $7.7E+07$ of remaining nuclides therefore their impacts on dose assessment are significantly small



3. NRA's examination of the selection scheme of Source Term

NRA's examination points and result summary for each step

- ④ Detailed assessment using the previous analysis results data
- ⑤ Selection of nuclides to be measured
 - Calculation method of analysis result
 - TEPCO filtered samples to remove particles from liquid and analyzed the residue and the filtrate separately
 - TEPCO only reported detected values as analysis results and neglected N.D. values when the residue or the filtrate is N.D. (case 2 & 3)

⇒ NRA suggested that the detected value and the N.D. value can be summed in order to handle the analysis result carefully.

(In case of Fe-55, the summed value is 21 Bq/L, while criteria is 20 Bq/L)

	Residue	Filtrate	Analysis Result
1	Detected	Detected	Sum
2	Detected	N.D.	Value of Residue
3	N.D.	Detected	Value of Filtrate
4	N.D.	N.D.	Larger N.D.

Handling method of analysis result of this section revised to **sum of detected value and N.D.**



3. NRA's examination of the selection scheme of Source Term

NRA's examination points and result summary for each step

- ④ Detailed assessment using the previous analysis results data
- Reliability of analysis result used to set the transfer factor of nuclide into water, including sampling method
- ⇒ The NRA Confirmed that sampling point and method, analysis method, and verification method for measuring instrument are valid
- ⑤ Selection of nuclides to be measured
- Validity of criteria to decide the nuclides to be measured and evaluated and the ones to be monitored
- ⇒ The NRA suggested that the criteria to judge “Nuclides to be measured/assessed” or “Nuclides to be monitored” should be rather “whether or not 1/100 of regulatory limits are exceeded” than “whether or not detected”.

	Detected	Not Detected
More than 1/100	To be Measured and Assessed	To be Monitored
Less than 1/100	To be Monitored	To be Monitored

Scheme revised to select this category as **to be Measured and Assessed**



3. NRA's examination of the selection scheme of Source Term

NRA's examination points and result summary for each step

⑤ Selection of nuclides to be measured

- Validity of categorizing nuclides into to be measured/assessed and to be monitored

⇒ Nuclides to be monitored is not excluded by step ④, due to the conservative condition at calculation of dissolve assessment. However, these nuclides never detected at the analysis of contaminated water, and these N.D. were less than 1/100 of regulatory concentration limit, therefore the possibility of existence are significantly low both in the current contaminated water transferred to treatment and ALPS treated water.

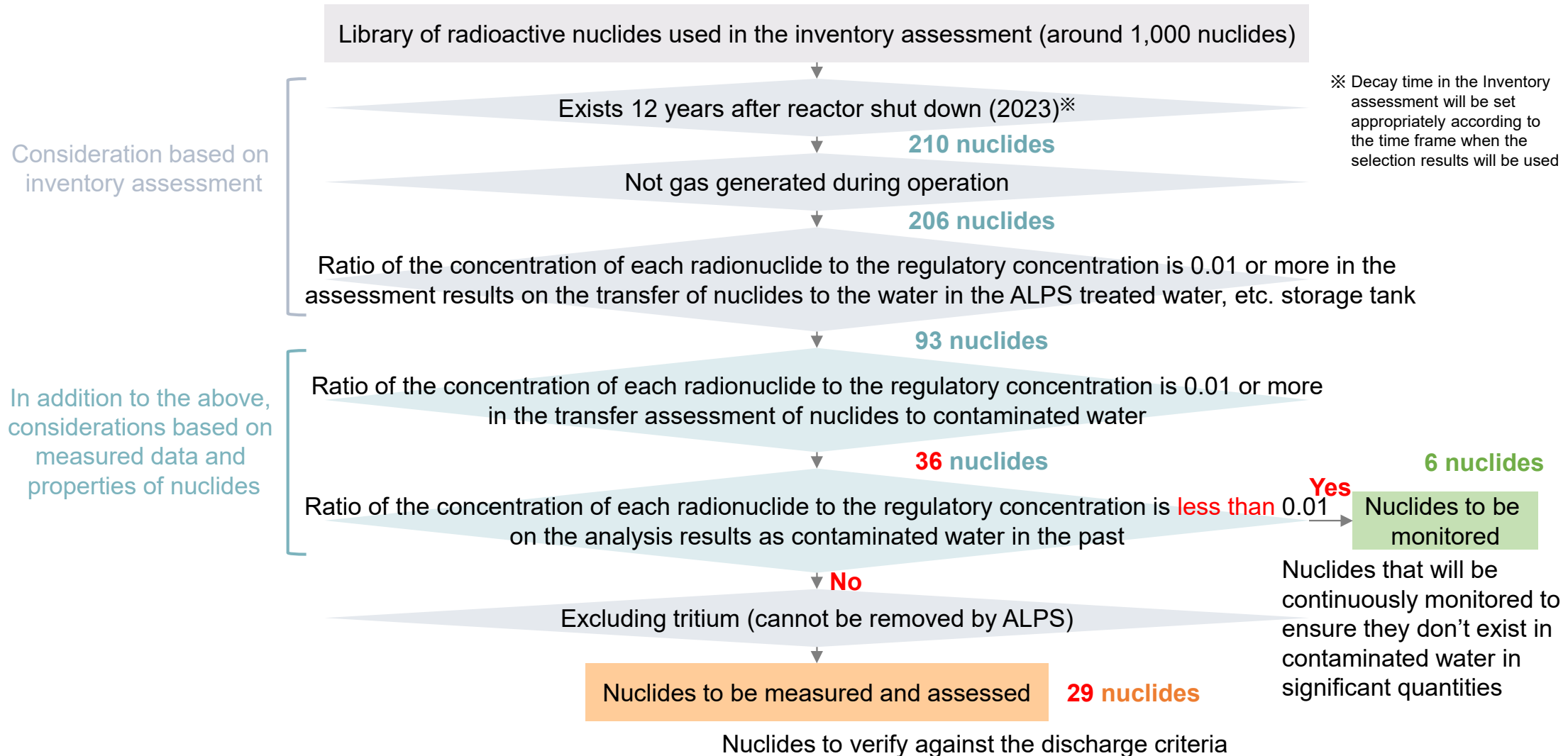
On the other hand, inventory of these nuclides are relatively large, and its half-life is long. Therefore, TEPCO will analyze Nuclides to be monitored once a year to ensure they don't exist in contaminated water in significant quantities, since these nuclides might be transferred into contaminated water due to the progress of decommissioning.

The NRA confirmed that categorizing nuclides at ⑤ is valid, and examined the validity of its criteria



3. NRA's examination of the selection scheme of Source Term

TEPCO's revised scheme to select the nuclides to be measured






3. NRA's examination of the selection scheme of Source Term

Result of TEPCO's scheme

(after discussions with the NRA at the review meetings)

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C-14	Sr-89	Rh-103m	Sb-124	I-129	Ce-144	Eu-152	Pu-241	U-234	Fe-55
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Ni-63	Tc-99	Sn-119m	Te-127m	Ba-137m	Pm-148	Pu-238	Cm-243		
Zn-65	Ru-103	Sn-123	Te-129	Ba-140	Pm-148m	Pu-239	Cm-244		

 Nuclides to be measured and evaluated (including H3)

 Nuclides to be monitored

 Nuclides which is target of ALPS but not selected

 Nuclides which category changed from the submission of "Application"



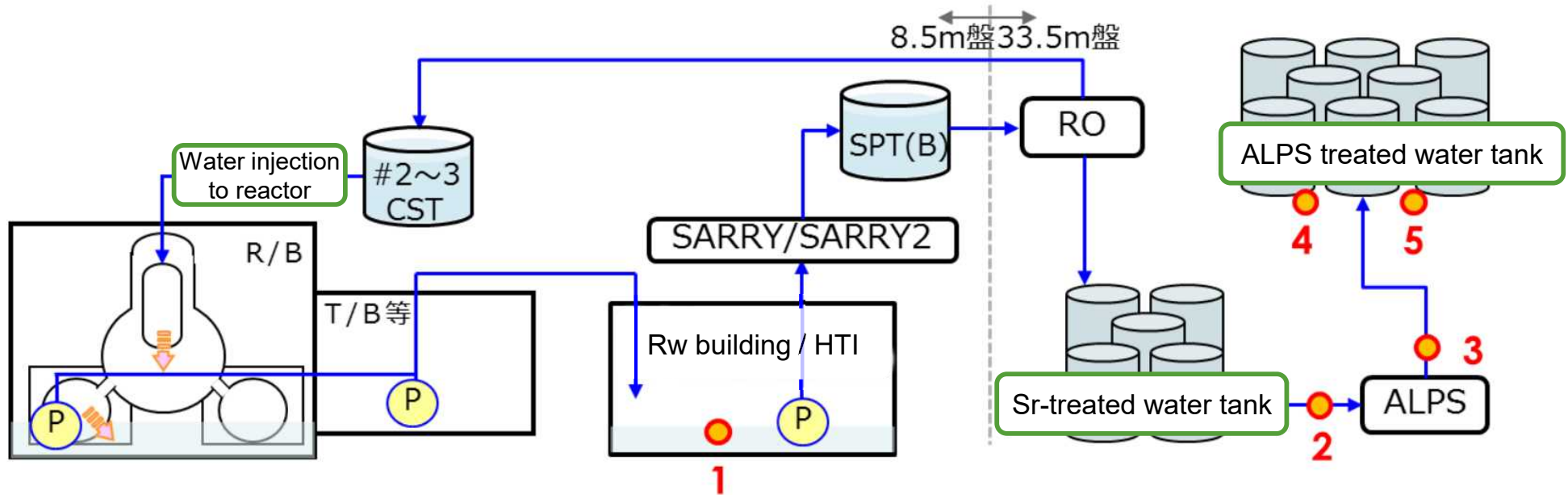
3. NRA's examination of the selection scheme of Source Term

NRA's examination points for the other part of the "Application"

- Periodical review on nuclides to be measured and evaluated.
- Nuclides to be monitored will be analyzed periodically, i.e., once a year, and its result is reflected to the characterization as necessary.
- In addition, depending on the progress of decommissioning, or the changes in trend of periodical analysis (see next slide), detailed analysis would be conducted to check the concentration trend of nuclides in contaminated water.
- Even if other radionuclides are added to the selection in the future, those impacts would be very small compared to the dominant nuclides in ALPS treated water (main 7 nuclides, C-14, Tc-99) taking into account the past measurement data of ALPS treated water.



ref. Sampling points and Objective Nuclides



Explained in 3rd Review Meeting; https://www.nra.go.jp/disclosure/committee/yuushikisya/1F_gijyutsu/index.html
(only in Japanese)

Point	Objective Nuclides	Frequency
1	Cs-134, Cs-137, Sr-90, total α , total β , H-3	More than once a month
2	Major 7 nuclides (Co-60, Sr-90, Ru-106, Sb-125, I-129, Cs-134, Cs-137), Tc-99, total α , total β , H-3	More than once a month
2	Nuclides to be monitored	More than once a year
4, 5	Nuclides to be measured/assessed, total α , total β , γ spectrum	Every batch before discharge



(Reference) Consideration regarding the Source Term

(D) Characterization of Source Term before discharge

- NRA understand that the potential existence of other nuclides than 64 nuclides which may have large radiological impact is inconsiderable so that the fully purified ALPS treated water is satisfies the regulatory requirements of discharge.
- Nevertheless, in ALPS treated water, there may be activated nuclides originated from reactor internal structure or low energy β nuclides which have not been measured and evaluated.
- From this perspective, NRA requires TEPCO to conduct realistic evaluation again considering the decay after the Accidents until the starting point of discharge, and to select measurement target nuclides after analyzing nuclides which can possibly exist in the ALPS treated water.
- NRA will confirm the TEPCO's evaluation and analysis results of nuclides by the beginning of discharge.