The Outline of the report of the Subcommittee on handling of ALPS treated water

Agency for Natural Resources and Energy
METI

10th February, 2020

Introduction : Generation of contaminated water, purification process and tank storage

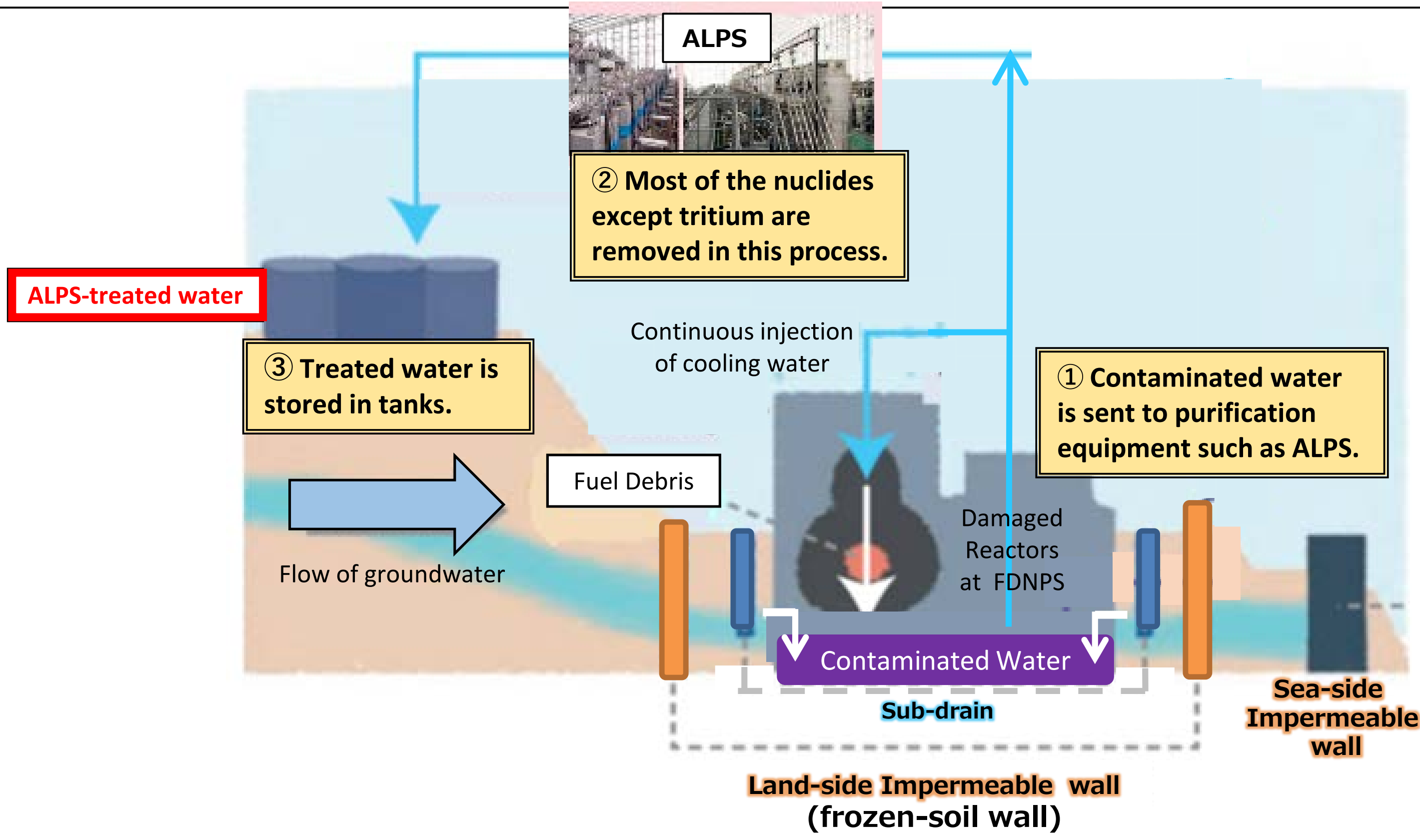
◇ **Water gets contaminated when it touches the damaged reactors and fuel debris in buildings.**

- **The level of groundwater outside is controlled to be higher** than that of contaminated water inside the buildings to prevent the water flowing out of the building.
  - ➡ **Groundwater keeps flowing into the buildings**

◇ **TEPCO has been successful in removing most of radionuclides except tritium** from contaminated water.

- **ALPS** (Multi-nuclide retrieval equipment) and the other equipment have been used. ➡ See more at P12

- **It is ALPS treated water, NOT -contaminated water, that is stored in the tanks.**
- **Radioactive materials in ALPS treated water are reduced to about 1/1,000,000 (one millionth).**



Introduction : Key figures of ALPS treated water

※ About 2 years will be needed for preparation and permission for disposal.
※There is a limited room for further tank construction

Key Figures for ALPS treated water at the site (As of Dec 12, 2019)	
Number of tanks	965
Tank Storage volume	About 1.18 million ㎥
Planned capacity (Under current plan)	About 1.37 million ㎥ (by the end of 2020)
Annual increase of ALPS treated water	About 50,000～60,000㎥/year

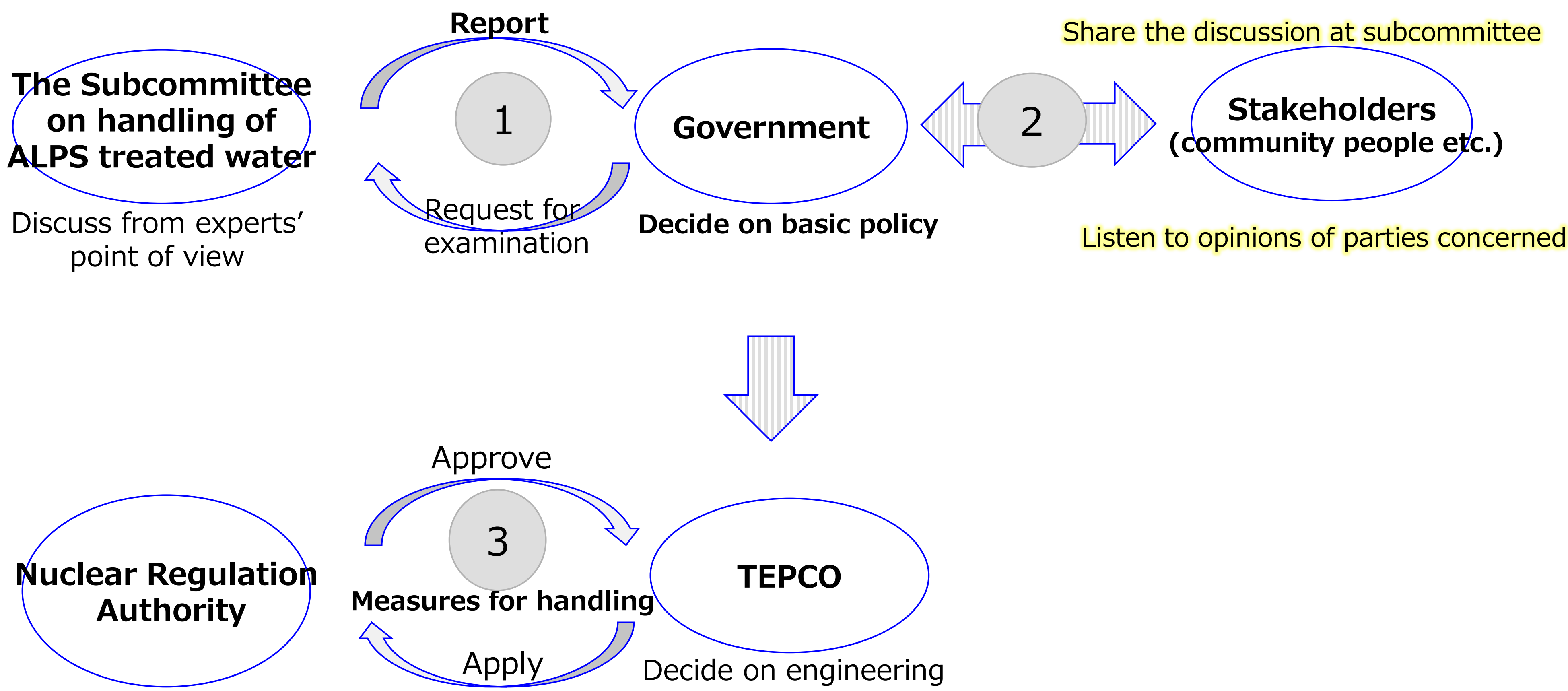
Time to reach its full capacity (forecast): around summer of 2022

Amount of Tritium (tritiated water) in tanks	Approx. 860 TBq* (16g) (*TBq = 1×10^{12} Becquerel)
Average Concentration of Tritium	0.73 MBq/L (*MBq = 1×10^{6} Becquerel)

※ As of Oct 31,2019
※Currently, several kinds of radionuclides other than tritium are found in ALPS treated water in tanks. → See page 12
※ If the treated water is discharged into the environment, it will be re-purified and diluted to meet the standards for discharge.

Introduction : Process ahead

- **Role of the subcommittee:**
  1) to examine in a comprehensive manner, such as countermeasures for reputational damage, and
  2) to compile report for the government
- **GOJ will decide its basic policy**, after receiving report of subcommittee and discussing with parties concerned.



The key points of the report (1): Basic approach

- **Reputational damage still remains and affects reconstruction of Fukushima.**

- **"Coexistence of reconstruction and decommissioning" is a basic principle:**

  - Returning of residents and reconstruction efforts in the surrounding area have been proceeding.
  - Additional reputational damage should not be caused by a hastened disposition of ALPS treated water.

- **Disposition of ALPS treated water needs to be completed until the completion of the decommissioning:**

  - with necessary storage, and
  - with due consideration to the minimization of the impact on reputation

- **In deciding the disposition of the ALPS treated water, the government must also compile a policy for countermeasures against reputational damage.**

The key points of the report (2): disposal methods

- Vapor release and Discharge into the sea have been conducted and recognized as feasible methods.
- There are precedents for discharge into the sea in Japan and it is easy to operate necessary facilities. Thus this can be conducted with certainty.
- Radiation impact of both methods is considerably small compared to natural exposure to radiation.

	Vapor release	Discharge into the sea
Technical Issues	● Precedent in case of accident at NPP overseas * Vapor is also released from reactors in normal operations at the time of ventilation. ● In Japan, there is no example of vapor release in order to dispose liquid waste. ● Difficult to predict how the released vapor is diffused into the air ● Difficult to establish proper monitoring methods	● Precedents exist world-wide ● More reliable option * precedents in Japan and easiness of operating facilities ● Relatively easy to predict how discharged water is diffused in the ocean ● Easy to examine proper monitoring method
Social issues	● Difficult to compare the social impacts of two methods * Social impact is greatly dependent on consumer psychology.	
	● May attract significant social concern	● May attract particularly large social concern if no countermeasure for reputational damage is taken

The following three options have many insurmountable issues (regulatory, technological, and timewise)

Geosphere injection : Need to seek for appropriate sites, and monitoring methods have not been established

Hydrogen release : Further technological development would be required for pretreatment and scale expansion.

Underground burial : In solidification process, water including tritium will be evaporated. New regulations may be necessary. Area for disposal yard will be needed.

Impact assessment for environmental release of ALPS treated water

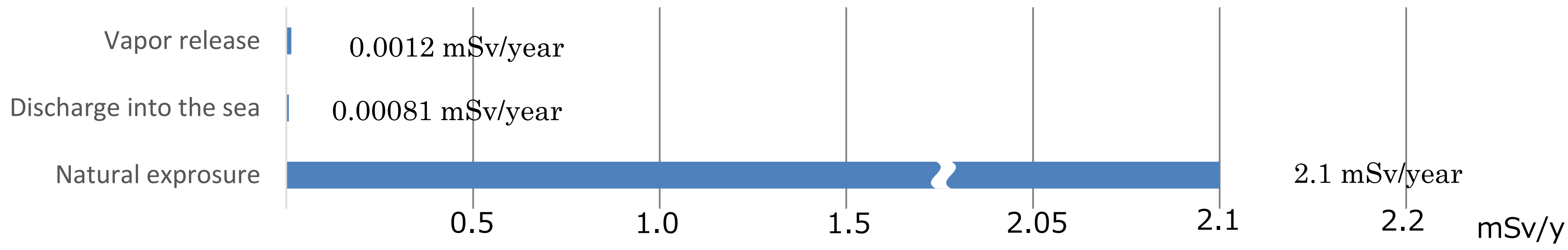
[Conditions]

- Using **UNSCEAR[*1] assessment model[*2]** and precondition that all the treated water stored in tanks (containing 860TBq of tritium) is discharged in one year.
  (*1: UNSCEAR: The United Nations Scientific Committee on the Effects of Atomic Radiation)
  (*2: re-assessed with Japanese food consumption)
  [Ref. UNSCEAR 2016 Report, Annex A "Methodology for estimating public exposures due to radioactive discharges"]
  [case 1] Vapor release ------- Approx. **0.0012 mSv/year** (1.3 µSv/year)
  [case 2] Discharge into the sea ---- Approx. **0.000071 to 0.00081 mSv/year** (0.071 to 0.81 µSv/year)
- In both discharge methods, the impact of the **radiation from the discharge is considerably small,** compared with **annual natural exposure in Japan: 2.1 mSv/year** (2,100 µSv/year).

Exposure dose [mSv/y]	Vapor release※1	discharge into the sea※2
All radionuclides※3	0.0012※4	0.000071～0.00081
- tritium	0.0012	0.0000068

※1 Sum of external dose from the atmosphere and soils, and internal dose from inhaling the air and ingesting terrestrial life (at 5km points from the FDNPS)
※2 Sum of external dose from beaches and internal dose from ingesting marine life.
※3 Estimation was conducted on the two assumptions that "ND (Not Detected)" nuclides are 1) their ND value and 2) zero.
※4 For exposure dose for [case 1 (vapor release)], there is no difference between the results from two assumptions

Comparison of radiation impact between natural exposure and discharging treated water containing 860 TBq of tritium



The key points of the report(3): Countermeasures against reputational damage

1) Well planned disposition process
2) Expansion and enhancement of countermeasures building on best practices
3) Continuous and flexible response

<1. Well planned disposition processes >

- **Re-purify** radionuclides other than tritium
- **Stop the disposition process in case of emergency**

  e.g. environmental situation, malfunction of facilities
- **Determine the details (starting time, volume, and period of disposition),** while listening to opinions of stakeholders
- **Disseminate information** in a considerate and an easy-to-understand manner
  - ✓ Concentration of pre-disposition ALPS treated water
  - ✓ Monitoring results of surrounding environment
- **Explain safety of surrounding environment by** utilizing diffusion simulation

<2. Expansion and enhancement of countermeasures building on best practices>

< Risk communication>
- to convey relevant information

- **Disseminating information** on the disposal method and scientific knowledge in advance
- **Providing information** via:
  - ✓ Social media, mass media
  - ✓ On-site lectures
- **Strengthening information dissemination abroad**
  - ✓ Basic information on decommissioning
  - ✓ **Disposition methods in the world** as well as precedents outside of Japan

< Economic measures>
- for reputational damage

- **Constructing analytical framework** for:
  - ✓ Environmental monitoring, and
  - ✓ Food sampling measurement
- Utilizing **third-party certification** to secure consumer trust, such as
  - ✓ GAP (Good Agricultural Practice)
  - ✓ MEL (Marine Eco-label)
- **Developing new market channels** by
  - ✓ **Promotion events** for Fukushima products
  - ✓ **Allocation of special sales staff** in stores
  - ✓ Opening of **on-line stores** etc.

The key points of the report(4):Possibility of storage continuation

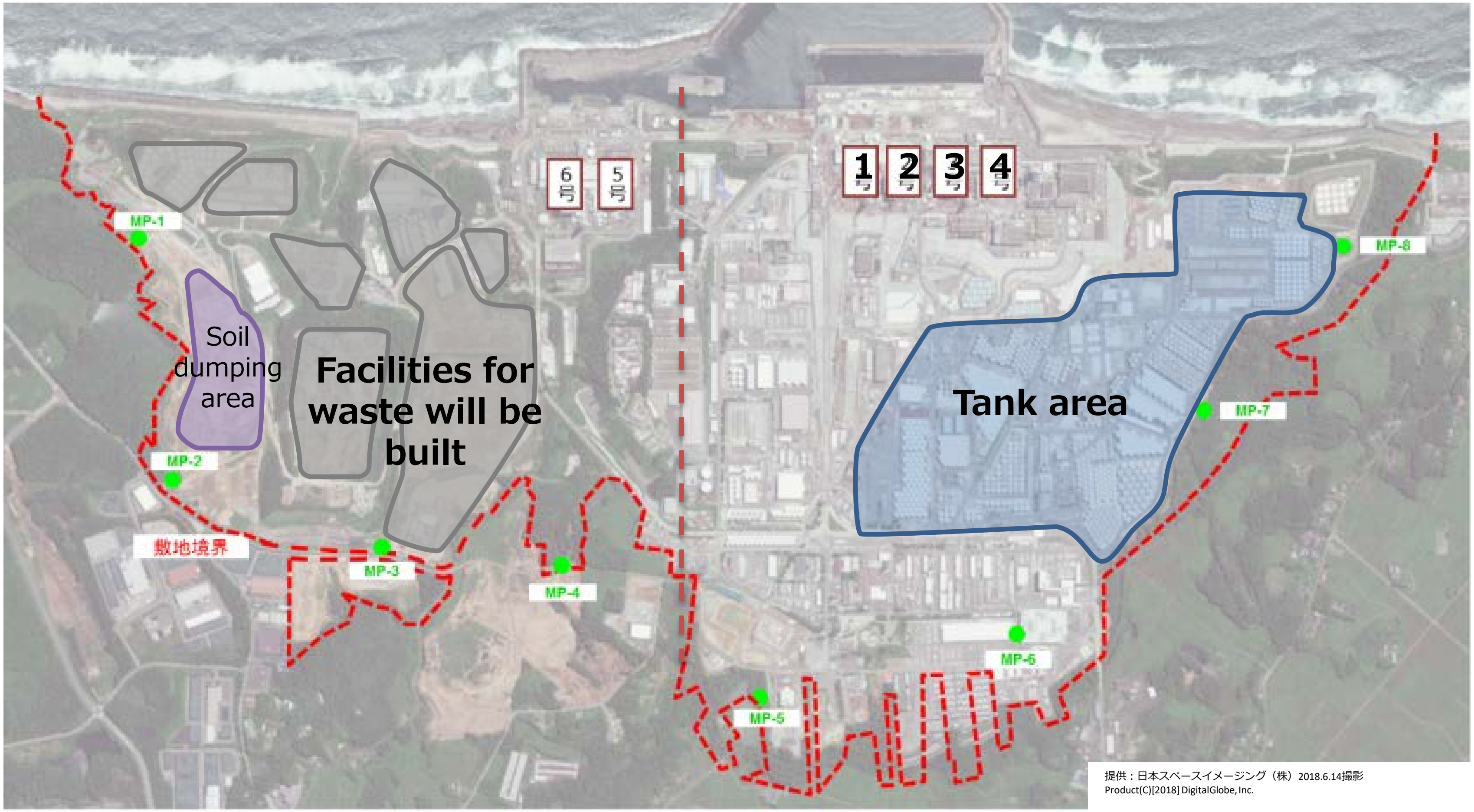
- **There is a limited room for construction of additional tanks.**

  (Tank capacity under the current plan: approx. 1.37 million m^3)

  ✓ **Areas where flanged tanks used to be built may become available.**

  ✓ For further decommissioning work, **various facilities will be needed** (such as storage tanks for ALPS treated water temporary storage facilities for spent fuel and fuel debris).

- **Entire premises should be used effectively, considering its limitation.**



提供：日本スペースイメージング（株）2018.6.14撮影
Product(C)[2018] DigitalGlobe, Inc.

The key points of the report(5): Storage at off-site

- If ALPS treated water would be stored at off-site,
  - **Legally compliant transfer facilities** would be required.
  - **Consensus** would be needed from the municipalities where a possible transfer route would be located.
  - **At a storage site, operation license** and **approval of local municipalities** would be needed.

→ **The transfer of ALPS treated water to off-site would <u>require significant preparation a wide range of coordination in advance and considerable period of time</u>.**

[Issues on transfer to off-site]

- **Transfer facilities** in accordance with the laws and regulations would be needed.
  - ex. **Pipeline**: physical protection facilities (fence, etc.) surrounding the pipelines would be needed.
  - ex. **Vehicles or ships**: need to carry type L transport casks (maximum volume of 4 m^3) procedure for transport outside the nuclear site would be needed.
- **Consensus would be needed from local municipalities** where a possible transfer route would be located.
- **Leakage risk** during transfer cannot be ruled out.

[Issues on off-site storage]

- **Operation license** for a storage site in accordance with the laws and regulations.
- **Consensus from local municipalities** at the storage site would be needed.

The key points of the report(6): Tritium separation technology

Tritium separation → **removing highly concentrated tritiated water (HCTW) from lowly concentrated tritiated water (LCTW).**

- If the tritium separation technology would be applied to ALPS treated water, **large amount of LCTW, which needs to be disposed of after dilution to meet the regulatory standards, would have to be generated**.
- **HCTW** needs to **be stored continually**.

- Preceding cases of tritium separation technologies show that the application of the technologies to ALPS treated water is NOT practical because:
  - ✓ **The tritium concentration of ALPS treated water is too low to be applied to.** **(See red boxes below)**
  - ✓ **The throughput of existing separation technologies are too small to deal with ALPS treated water.** **(See green boxes below)**
- Demonstration project for tritium separation technology (2014-2016) revealed that **there was no technology close to practical use** for ALPS treated water.
- Technological trends should be monitored carefully and continuously.

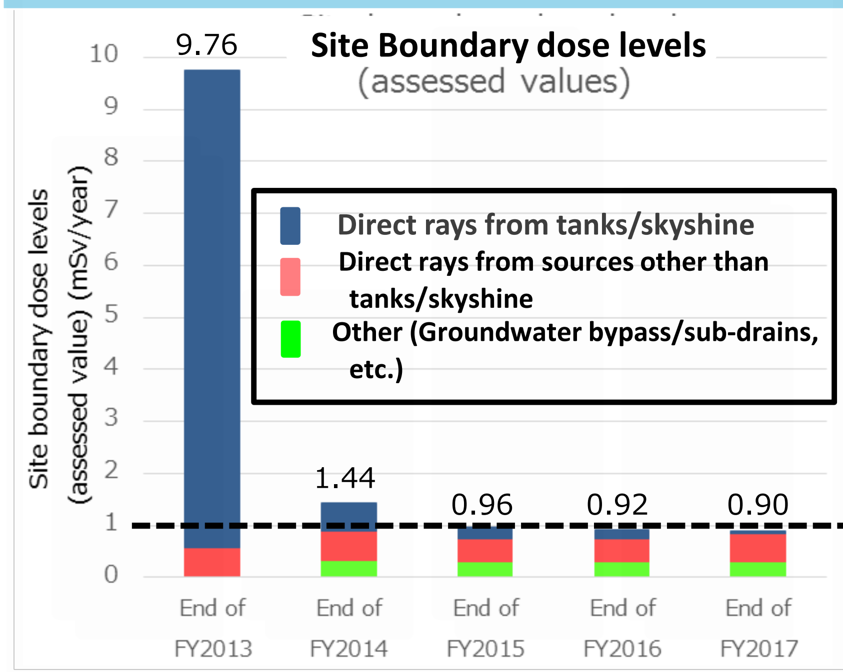
Table: Existing tritium separation technologies: the change of concentration and throughput

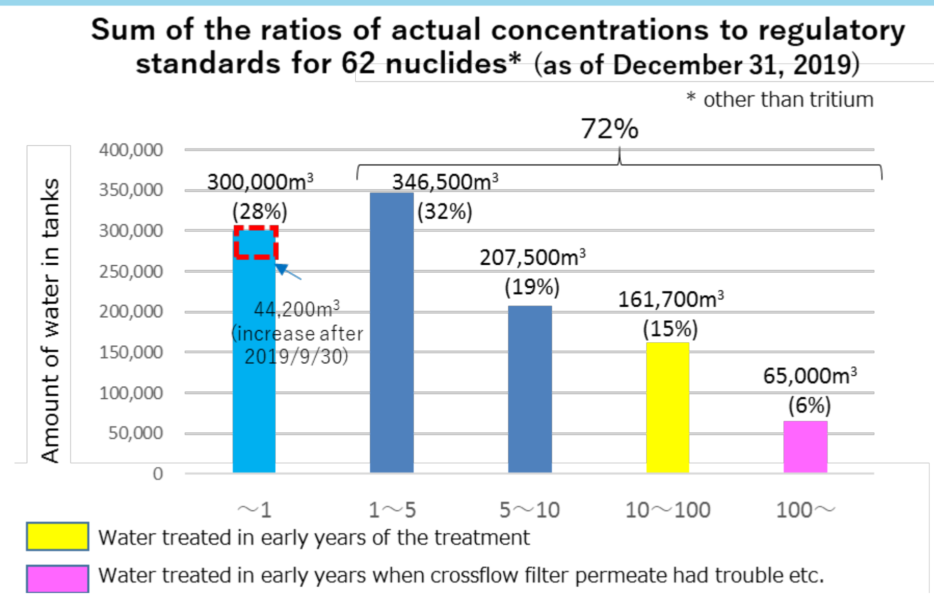
Preceding cases	Applied separation technologies	Concentration before separation/ raw water	Concentration after separation [LCTW]**	Throughput (m^3/day)
Darlington Tritium Removal Facility (Canada)	Isotope exchange + Hydrogen distillation	0.4～1.3 TBq/L	0.01-0.035 TBq/L	8.6
Wolsong Tritium Removal Facility (Korea)	Isotope exchange + Hydrogen distillation	0.04～2 TBq/L	0.001-0.07 TBq/L	2.1
Fugen Heavy Water Upgrader (Ⅱ) (Japan)	Isotope exchange	0.1 TBq/L	0.000004 TBq/L (4 MBq/L)	0.03
ITER Tritiated Water Treatment Equipment (Design stage) (EU)	Isotope exchange+ Hydrogen distillation	0.4 TBq/L*	0.000004 TBq/L (4MBq/L)	0.48*
(Ref.) ALPS treated water at FDNPS	-	0.00000073 TBq/L (0.73 MBq)	-	At least, several hundreds m^3/day

*The data is only from isotope exchange. **The above figures of tritium concentration are the ones before dilution for discharge.

The key points of the report(7): Characteristics of ALPS treated water

- Two regulatory standards:
  1) **Applicable to storage**: to keep site boundary dose levels less than 1mSv/year — Goal currently achieved through ALPS
  2) **Applicable to release to the environment**: to keep radionuclides concentrations of treated water less than the regulatory limit.
- There are various concentration of ALPS treated water in the tanks, because:
  - ✓ Concentration of ALPS treated water depends on the attributes of water to be treated and operation management of ALPS such as frequency of absorbent exchange; and
  - ✓ Especially in the first few years after the accident, which was before improvement of ALPS performance, concentrations of tritium in ALPS treated water was relatively high.
- **In case of releasing ALPS treated water to the environment, the water needs to satisfy standard 2).**
  - ✓ TEPCO announced to re-purify ALPS treated water, to meet standard 2) for radionuclides other than tritium.
  - ✓ After the re-purification, the water will be diluted to meet the standard 2) for tritium.

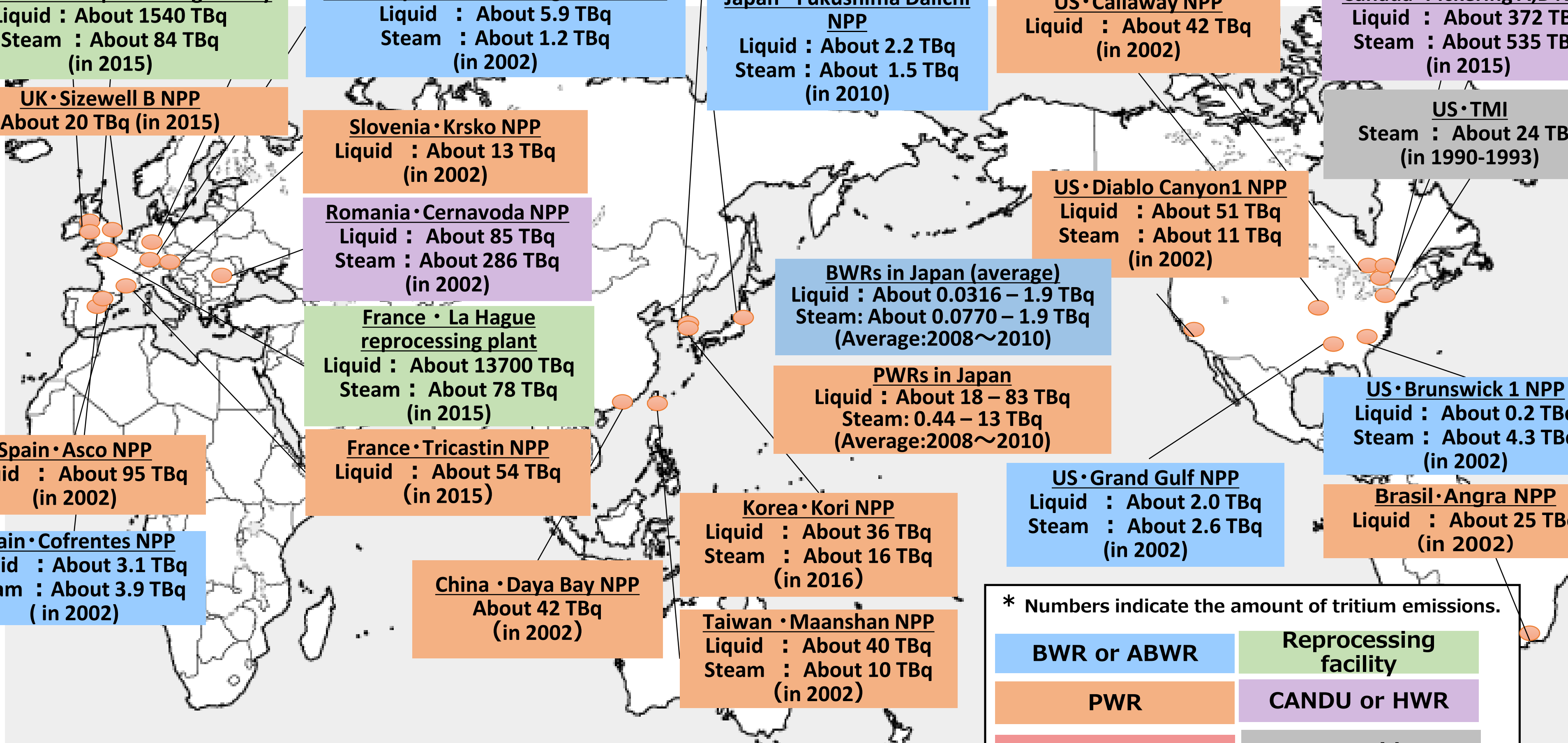




*These drawings are quoted from "Treated water `portal site (TEPCO HP)"

The key of the report(8): Examples of tritium emission

[Ref.]Annual Tritium emissions from nuclear facilities around the world



UK・Haysham B NPP
Liquid ：About 390 TBq
(in 2015)

UK・Sellafield reprocessing facility
Liquid：About 1540 TBq
Steam ：About 84 TBq
(in 2015)

UK・Sizewell B NPP
About 20 TBq (in 2015)

Germany・Gräfen Rheinfeld NPP
Liquid ： About 21 TBq（in 2002, not in operation)

Germany・Gundremmingen B-C NPP
Liquid ：About 5.9 TBq
Steam ：About 1.2 TBq
(in 2002)

Slovenia・Krsko NPP
Liquid ：About 13 TBq
(in 2002)

Romania・Cernavoda NPP
Liquid：About 85 TBq
Steam：About 286 TBq
(in 2002)

France ・ La Hague reprocessing plant
Liquid： About 13700 TBq
Steam： About 78 TBq
(in 2015)

France・Tricastin NPP
Liquid ： About 54 TBq
（in 2015）

Spain・Asco NPP
Liquid ： About 95 TBq
(in 2002)

Spain・Cofrentes NPP
Liquid ：About 3.1 TBq
Steam ：About 3.9 TBq
(in 2002)

China ・Daya Bay NPP
About 42 TBq
（in 2002）

Korea ・Wolseong NPP
Liquid：About 17 TBq
Steam：About 119 TBq
(in 2016)

Japan ・Fukushima Daiichi NPP
Liquid：About 2.2 TBq
Steam：About 1.5 TBq
(in 2010)

BWRs in Japan (average)
Liquid：About 0.0316 – 1.9 TBq
Steam: About 0.0770 – 1.9 TBq
(Average:2008～2010)

PWRs in Japan
Liquid：About 18 – 83 TBq
Steam: 0.44 – 13 TBq
(Average:2008～2010)

Korea・Kori NPP
Liquid ： About 36 TBq
Steam ： About 16 TBq
（in 2016）

Taiwan ・Maanshan NPP
Liquid ： About 40 TBq
Steam ： About 10 TBq
（in 2002）

Canada・Bruce A,B NPP
Liquid ：About 892 TBq
Steam：About 1079 TBq
(in 2015)

US・Callaway NPP
Liquid ： About 42 TBq
(in 2002)

US・Diablo Canyon1 NPP
Liquid ：About 51 TBq
Steam ：About 11 TBq
(in 2002)

US・Grand Gulf NPP
Liquid ： About 2.0 TBq
Steam ： About 2.6 TBq
(in 2002)

Canada・Darlington NPP
Liquid ：About 241 TBq
Steam：About 254 TBq
(in 2015)

Canada・Pickering A,B NPP
Liquid ： About 372 TBq
Steam ：About 535 TBq
(in 2015)

US・TMI
Steam ： About 24 TBq
(in 1990-1993)

US・Brunswick 1 NPP
Liquid： About 0.2 TBq
Steam： About 4.3 TBq
(in 2002)

Brasil・Angra NPP
Liquid ： About 25 TBq
(in 2002)

＊ Numbers indicate the amount of tritium emissions.

BWR or ABWR	Reprocessing facility
PWR	CANDU or HWR
AGR	NPP Accident

<Ref.> 1×10^{12}Bq≒ about0.019g（Tritiated water)

Source：UK：Radioactivity in Food and the Environment, 2015
Canada：Canadian National Report for the Convention on Nuclear Safety, Seventh Report
France：Tritium White paper 2016
Korea： FY2016 Survey on environmental radioactivity around the nuclear power plant and evaluation report, KHNP
Other countries ：UNSCEAR「2008 Annual report」 Japan： Fukushima Pref. and TEPCO report 2010 (data period from April 1, 2010 to March 11, 2011)

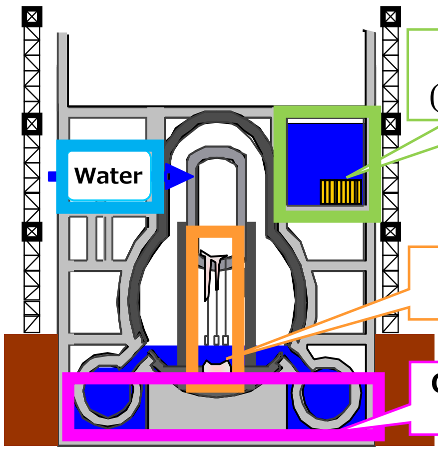
References

[Ref.1] Decommissioning of TEPCO Fukushima Daiichi NPS (FDNPS)

◇ **<u>Fukushima Daiichi Decommissioning is a continuous risk reduction activity</u>** to protect the people and the environment from the risks associated with radioactive substances by:

- ✓ Removing <u>spent fuel</u> and <u>fuel debris</u> from the Reactor Building
- ✓ Reducing the risks associated with <u>contaminated water</u> and <u>radioactive waste</u>

◇ **<u>Safe and steady decommissioning is a prerequisite for reconstruction of Fukushima</u>**



Spent fuel
(Spent fuel pool)

Fuel that remains after its usage for power generation.
Continuous cooling is needed to suppress the heat

Fuel Debris

Fuel that has melted and solidified by the accident.
Continuous cooling is needed to suppress the heat

Contaminated Water Management

Radioactive Solid Waste Management

Removing fuel from the Spent Fuel Pool: Rubble removal (▼ Units 1 and 2) → Installation of fuel removal equipment → Fuel removal (▼ Unit 3) → Storage/Transportation (▼ Unit 4)

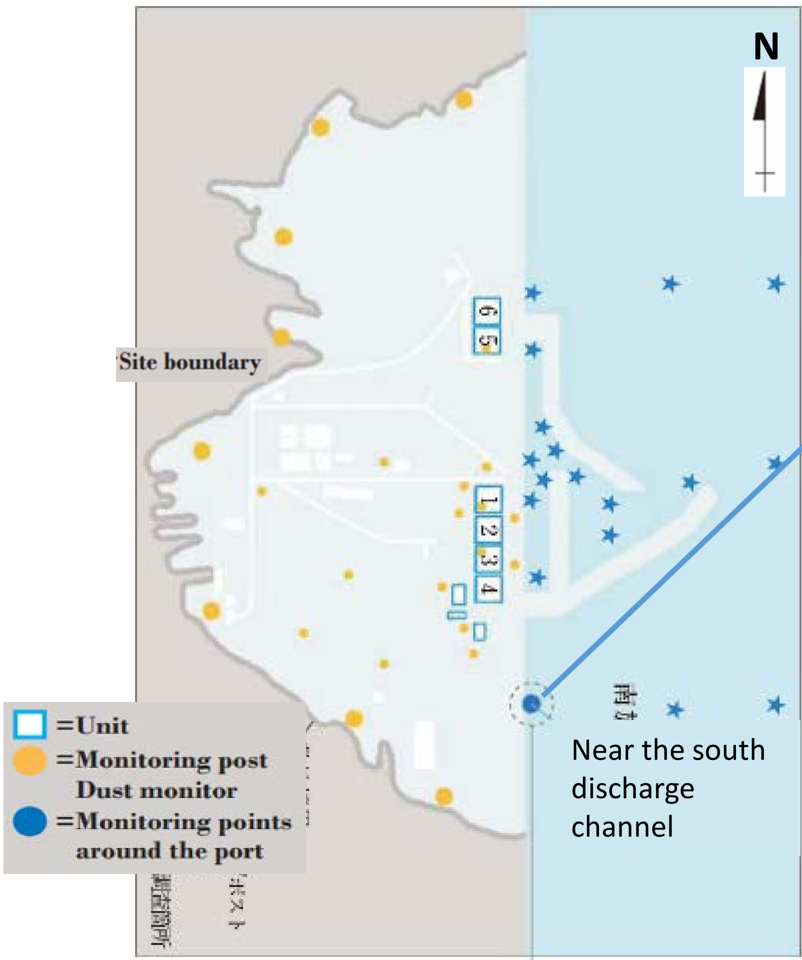
Fuel debris retrieval: Ascertaining of the situation inside the PCV/ consideration of fuel debris retrieval etc (▼ Units 1-3) → Fuel debris retrieval → Storage/ Transportation

Disassembly of reactor facility, etc: Consideration of scenario and technologies (▼) → Design and construction of equipment → Dismantling and other tasks

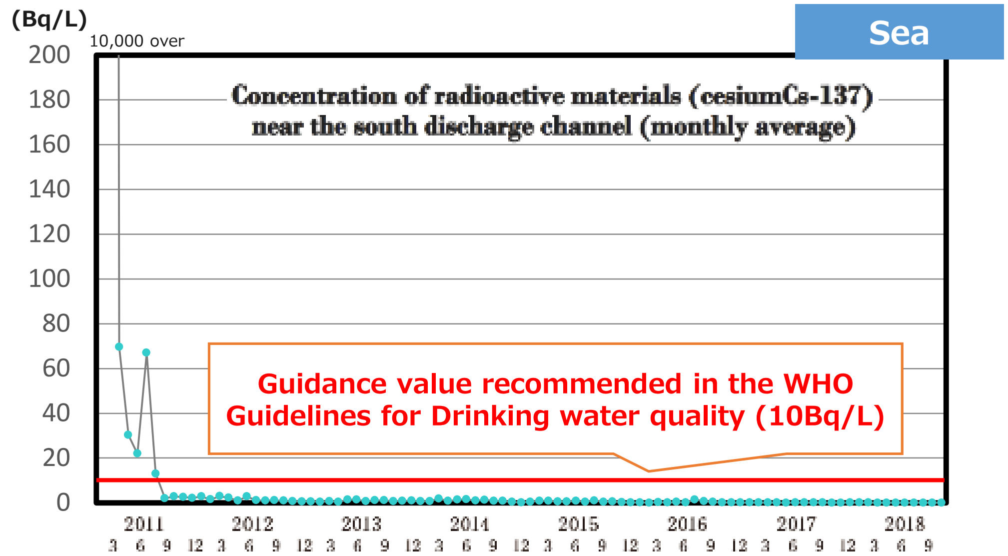
▼ Current progress

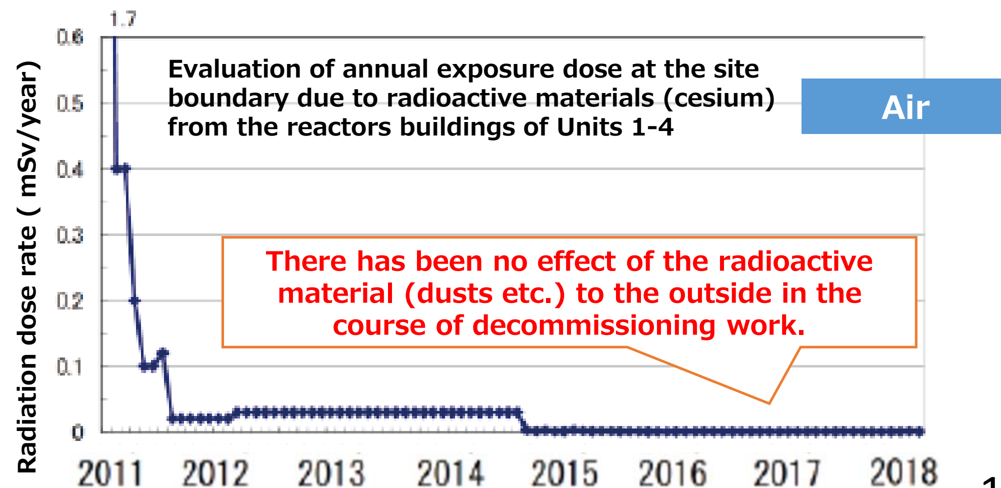
Extended to 30-40 years

- The environmental impact on the site and surrounding area have been significantly reduced.



Whole map of Fukushima Daiichi Nuclear plant





[Ref.3] What is Tritium?

◇ **Tritium is a relative of hydrogen that emits weak radiation**.

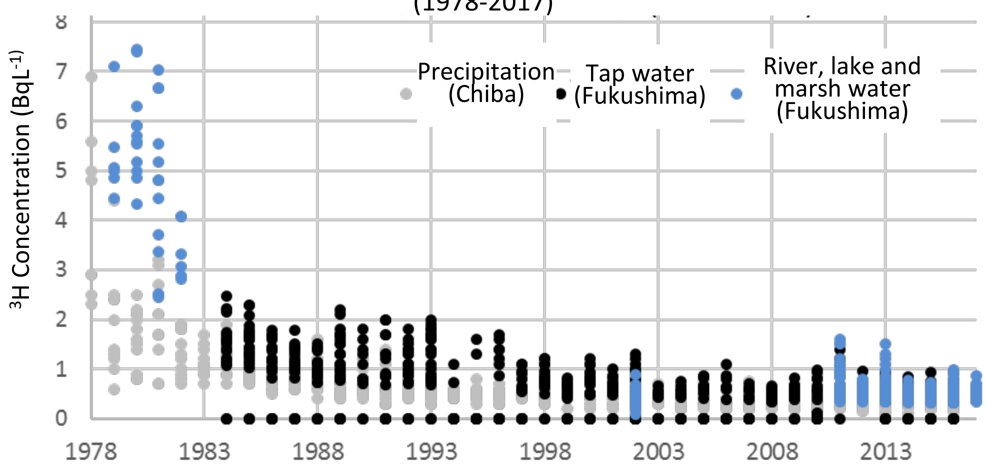
◇ **Tritium exists naturally** and is found in water such as water vapor in the atmosphere, rain, sea water, and tap-water, as tritiated water has similar properties as those of water.

- **It has not been found that tritium concentrates in human beings and particular living organisms**
- **Impact on health** is very low, **around 1/300 of that of Potassium-40.**

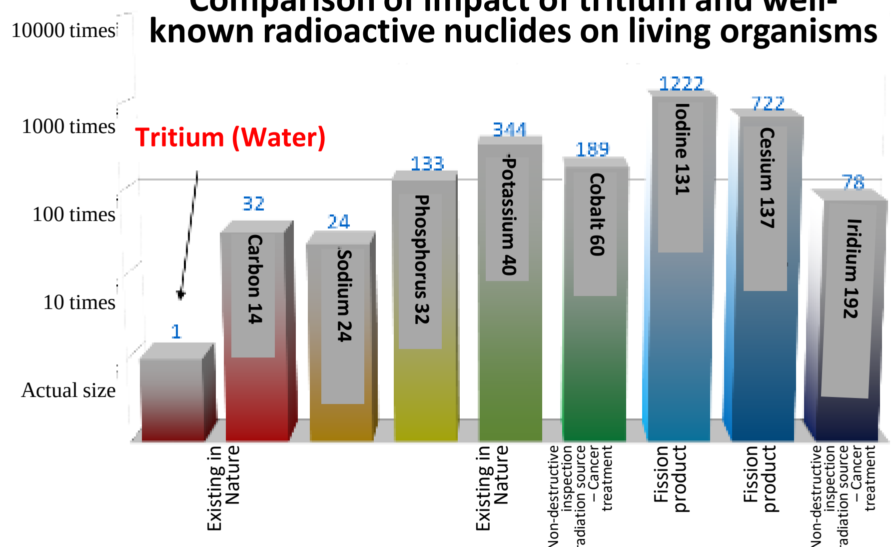
  (* Potassium-40 is abundant in foods such as vegetables and fruits.)

- **NPPs in Japan and overseas have been discharging water containing tritium for more than 40 years in compliance with** the standard limits based on the laws and regulations.
  - ✓ Concentration of tritium in sea water near NPPs are significantly lower than that of drinking water standards in the world.
  - ✓ **It has not been found that tritium from NPPs have an impact on health.**
  - ✓ The amount of tritium, which is generated at domestic nuclear power plants (NPPs) and released into the sea annually*, is around 1.7 times as much as that of tritium found in annual precipitation in Japan. (* 5 year average before 2011)

^{3}H concentration in river water and tap water in Fukushima pref. and ^{3}H concentration in precipitation at Chiba pref.
(1978-2017)



Comparison of impact of tritium and well-known radioactive nuclides on living organisms



[Ref.4] Impact assessment –UNSCEAR Model* -

UNSCEAR Model*

- Made for public exposure assessment in the case of radionuclides discharge, both to the air and into the sea, on the assumption that there has been constant discharge**.

  * Re-assessment was made using national health and nutrition examination survey in Japan.

  ** assess the public exposure in the 100th year, on the assumption that there will be a continuous and constant discharge for 100 years

[Case 1] Vapor release

- Public exposure is calculated as the sum of external dose from the atmosphere and soil, and internal dose from inhaling the air and ingesting terrestrial life (at 5km points off the leeward side of the FDNPS).
  - Rate of the time staying outside: 0.2
  - Rate of the local terrestrial food: 0.25
  - Amount of Food consumption per person (kg/year): Japan (Ref: Asia+Pacific) (Grains 155 (141.5), Plants/Fruits 188 (240.8), Mild/Dairy products 41.8 (44.5), Meat/Internal organs 35.4(29.5))

[Case 2] Discharge into the sea

- Public exposure is calculated as the sum of external dose from beaches and internal dose from ingesting marine life.
- For the assessment, sea area is divided into local sea areas (area with 1 billion m^3 of sea water) and regional sea area (with 1000 trillion m^3)
  - Rate of marine food from local sea area: Fish 0.25, Crustacea 1.0, Mollusk 1.0
  - Rate of marine food from regional sea area: Fish 0.75, Crustacea 0, Mollusk 0
  - Amount of Food consumption per person (kg/year): Japan (Ref: Asia + Pacific) (Fish 21.7 (6.9), Crustacea 1.42(1.4), Mollusk 1.97 (2.4))

Other parameters for the assessment

- Assumption of concentration of tritium before dilution : 1 M Bq/L
  (concentration rate will be set to meet the standard before discharge)
- Concentration of radionuclides other than tritium before dilution: Data of the treated water stored in K4 tank area**
  (** Radionuclides that are not detected (ND) is assumed to be 1) their ND value and 2) zero, ^{14}C = 10Bq/L)

[Ref. 5] Information Portal site （1） ： Fukushima Daiichi NPS

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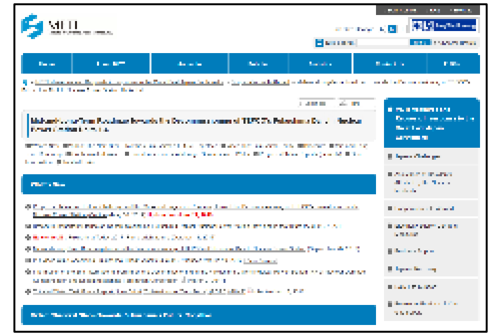


- **Decommissioning and Contaminated Water Management at TEPCO's Fukushima Daiichi NPS**
  https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/index.html

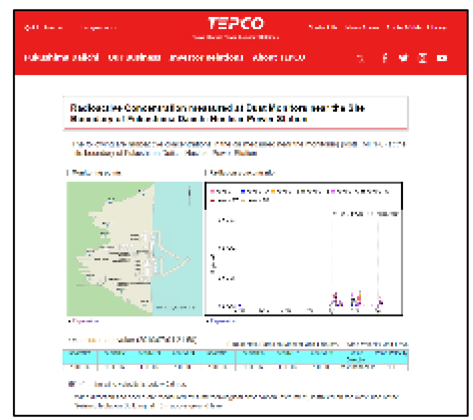
- **Film, Fukushima Today 2019**
  - Efforts to Decommission and Reconstruction
  https://www.youtube.com/watch?v=v_PeSp--Wuk

- **Film, Fukushima Today**
  - 8 years after the earthquake -
  https://www.youtube.com/watch?v=pKjsSAz5Kws

TEPCO
Tokyo Electric Power Company Holdings

- **Treated Water Portal Site**
  http://www.tepco.co.jp/en/decommission/progress/watertreatment/index-e.html

- **Observation Data, Fukushima Daiichi NPS**
  https://www7.tepco.co.jp/responsibility/decommissioning/1f_newsroom/data/index-e.html



IAEA
International Atomic Energy Agency

◆ Fukushima Daiichi Status Updates

https://www.iaea.org/newscenter/focus/fukushima/status-update

◆ IAEA Review mission reports (Press release)

IAEA Team Completes Fourth Review of Japan’s Plants to Decommission Fukushima Daiichi (November 13, 2018)
https://www.iaea.org/newscenter/pressreleases/iaea-team-completes-fourth-review-of-japans-plans-to-decommission-fukushima-daiichi

IAEA Issues Final Report on Fourth Review of Fukushima Decommissioning (January 31, 2019)
https://www.iaea.org/newscenter/pressreleases/iaea-issues-final-report-on-fourth-review-of-fukushima-decommissioning

United Nations Scientific Committee on the Effects of Atomic Radiation

◆ UNSCEAR 2016 REPORT
-Sources, effects and risks of ionizing radiation

hhttps://www.unscear.org/unscear/en/publications/2016.html