# Preventive and Multi-layered Measures for Contaminated Water Issues at TEPCO's Fukushima Daiichi NPS (Summary)

December 10, 2013

Secretariat of the Team for
Decommissioning and Contaminated Water Countermeasures
Cabinet Office

# Background of Study on Contaminated Water Treatment Measures

## 1. Considerations at the Committee on Countermeasures for Contaminated Water Treatment

*(1) "Basic Policy for the Contaminated Water Issue", Sep. 3, 2013, Nuclear Emergency Response Headquarters*

- "The Government of Japan will identify all of potential risks through the processes and will constantly consider concrete preventive measures and the way of emergency response utilizing such technical expertise as the Committee on Countermeasures for Contaminated Water Treatment."

*(2) "Policies and Concrete Actions for Addressing the Contaminated Water and Decommissioning Issues", Sep. 10, 2013, Inter-Ministerial Council for Contaminated Water and Decommissioning Issues*

- "Measures to respond potential risks involving technical difficulties will widely be collected by creating a team that gathers wisdom from in and outside Japan. (Collected response measures will be closely examined mainly by the Committee on Countermeasures for Contaminated Water Treatment.)
- "The Committee on Countermeasures for Contaminated Water Treatment, based on site considerations, will identify potential risks and add countermeasures when necessary. [To be intensively carried out from the middle of this month, and provisionally summarized during this calendar year. Also in future as necessary]"
- "(Without leaving it to Tepco) the Committee on Countermeasures for Contaminated Water Treatment will conduct necessary on-site inspection."

## 2. Past study process

*(1) Study by Committee on Countermeasures for Contaminated Water Treatment*

- Intensive discussion held six times* since September 3. * September 13, September 27, October 25, November 15, December 3, December 10
- Members conducted on-site investigation on November 11.
- Study of measures and cooperation by Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue from viewpoints of site workers

*(2) Study by gathering knowledge of experts at home*

- Two sub-groups consisting of experts (Sub-group for understanding and visualization of groundwater and rainwater behavior and Sub-group for risk assessment) 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, and Japan Atomic Energy Agency were set up to understand groundwater and geological structure, create a wide-area groundwater analysis model, and assess the present situation and potential risks after measures have taken
- Each of the two sub-groups conducted deliberation eight times between October 11 and November 27.

# Overview of Contaminated Water Treatment
# (Summary of Committee on Countermeasures for Contaminated Water Treatment)

## 1. Main Points     Objective: "To compile preventive and multi-layered measures based on potential risk identified and minimize risk"

(1) Sub-group "for understanding and visualization of groundwater and rainwater behavior" expanded the groundwater flow analysis model to cover a wide area and confirmed the validity of the model, evaluated the effect of a measure by using a new analysis model, and also extracted a measure that is effective for suppressing inflow of the underground water.

(2) Sub-group "for risk assessment" assessed risk (present risk and risk after implementation of measure) based on probability of occurrence of leakage and influences in case leakage occurs, and indicated the priority and risk reduction effect of each measure.

(3) To collect wisdom from inside and outside of Japan, technical information was gathered through the International Research Institute for Nuclear Decommissioning (IRID), and 780 proposals were received.

## 2. Key additional measures of this summary

(1) Multi-layered measures that can lower risk even a trouble happens in a part of the existing measures

1) Groundwater inflow control measure [Isolating]

(Additional measure) Further groundwater control measure ("broader area pavement in the site" or "limited area pavement with an impermeable enclosure")

(Existing measures) Land-side impermeable wall, pumping up groundwater from sub-drains, pumping up groundwater for bypassing, etc.

2) Contaminated water stored in tank, etc. [Removing] [Preventing leakage]

(Additional measures) Increasing height of tank embankment, installing back-up embankment, replacing trenches to underdrains, changing route into port, collecting strontium in soil, using reliable, large-size tanks such as double-shell steel tanks, detecting small leakage from tank, etc.

(Existing measures) Cleaning up contaminated water by Advanced Liquid Processing System (ALPS), introducing ALPS with higher cleaning efficiency, accelerating replacement from bolted tanks to welded tanks, etc.

3) Measures in sea-side area [Removing] [Preventing leakage]

(Additional measures) Cleaning up seawater in port by depositing, absorbing and separating, using contamination preventing membrane that can eliminate radioactive substances, covering sediment in port, etc.

(Existing measures) Pumping up and blocking highly contaminated water in trenches, improving soil with sodium silicate, etc., installing sea-side impermeable wall, etc.

4) Increasing contaminated water storage capacity [Preventing leakage]

- General evaluation of handling of tritiated water (studied by Tritiated water Task Force)
- Study of possibility of solving issues related to tankers, underground storage, etc.

*Risk of tank capacity shortage will be assessed at as early a time as possible in 2014.

(2) Preventive measures that can cope with risks that have been unable to be handled by the existing measures

1) Large-scale countermeasures against tsunami [Preventing leakage]

(Additional measures) Improving water proofness of buildings, study of additional countermeasures such as additional seawalls

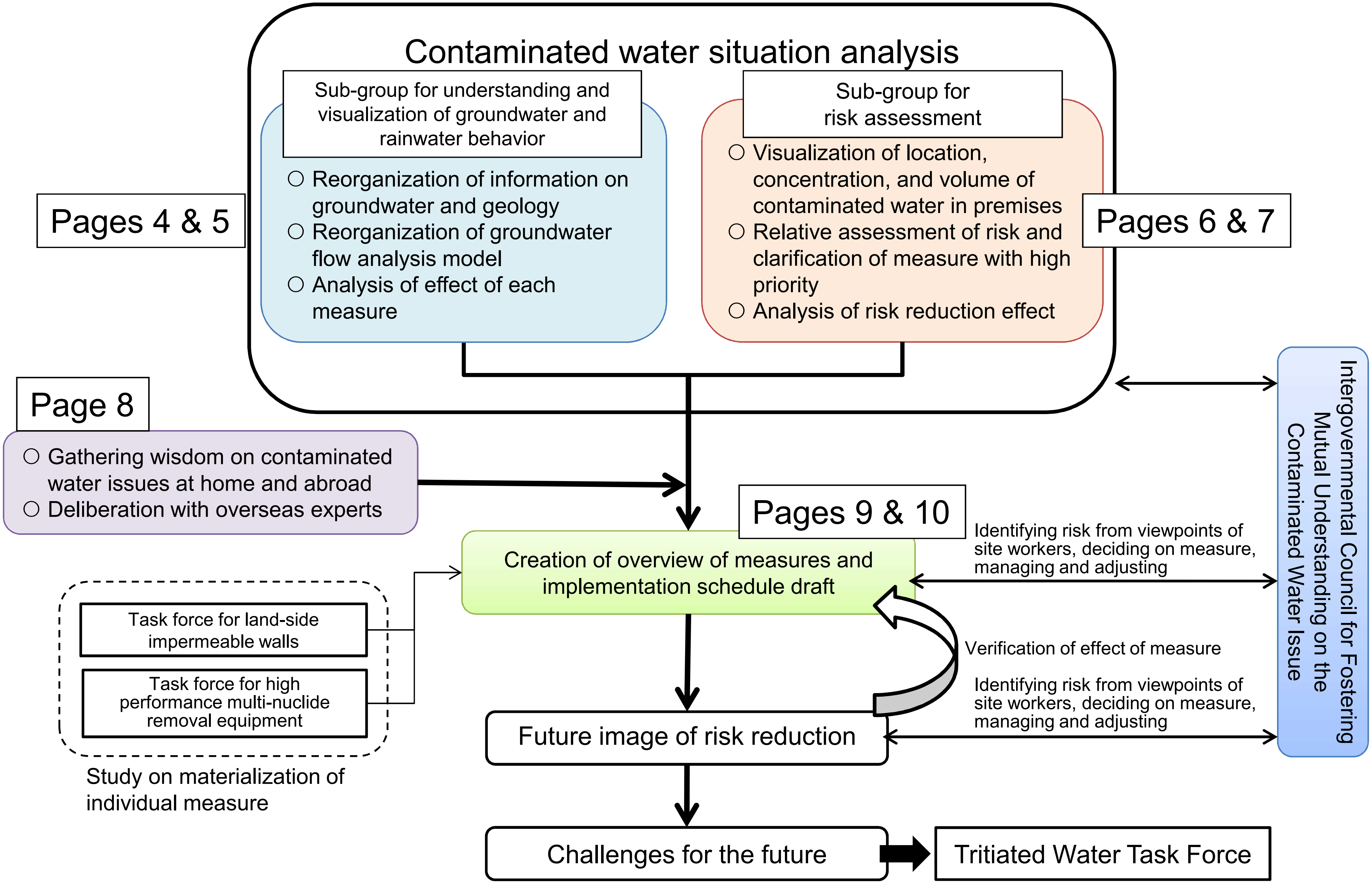
2) Preventing leakage of contaminated water from buildings [Preventing leakage]

(Additional measures) Water stopping for buildings (openings on exterior walls of buildings, gap between buildings, around building), shortening contaminated water transportation loop, etc.

## 3. Challenges for the future

(1) Handling of large amount of tritiated water, (2) Distribution of appropriate information at home and abroad, (3) Review of plan as necessary

# Flow of study at Committee on Countermeasures for Contaminated Water Treatment



# Outline of study by sub-group for understanding and visualization of groundwater and rainwater behavior (1)

◆ Reorganization of groundwater and geological structure in premises by checking results of boring and underground water measurement so far conducted by Tepco, and data on relation between change of groundwater level with time and rainfall

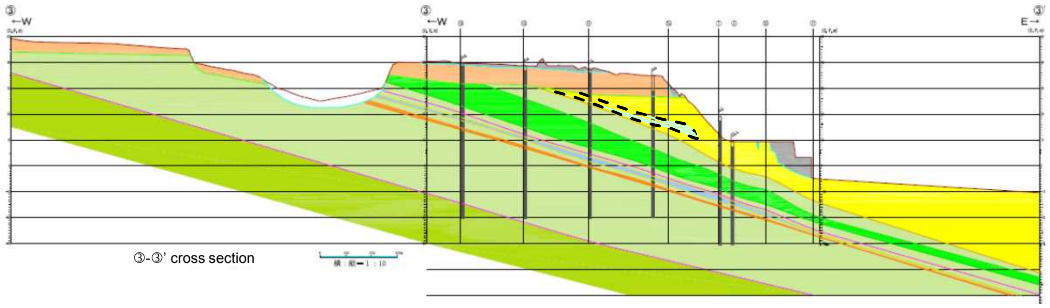
◆ Groundwater flowing through medium-grained sandstone strata is mainly rainwater seeping into soil and groundwater flowing through strata of alteration is rainfall seeping into soil in premises but some groundwater is considered mixed with water flowing in from outside premise.

◆ Checking validity of simulation model used to decide on existing contaminated water countermeasures (mainly for surrounding of buildings)

◆ Expansion of area to be analyzed with the simulation model beyond premises boundary to analyze outline of underground water flow, including around premises of Fukushima Daiichi plant, to study preventive, multi-layered measures

◆ Checking repeatability of new simulation model by comparing analysis result with actually measured data

Cross-sectional view of stratum in south of Fukushima No. 1 power plant unit 4 (east-west)




[Major analysis conditions]

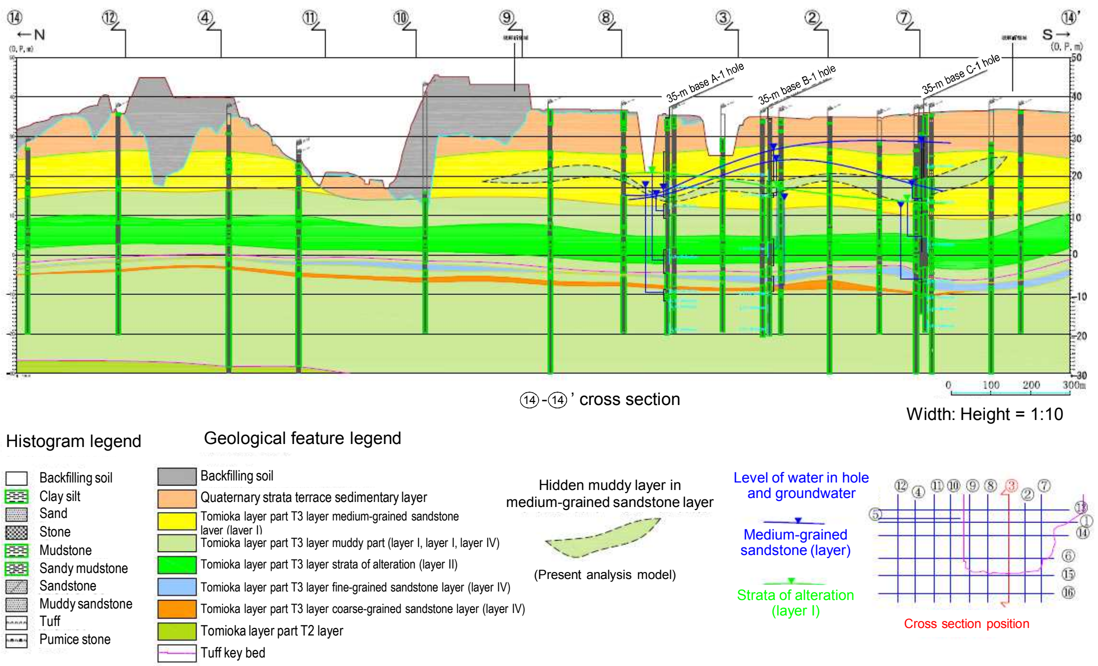
(1) Precipitation: 1,545 mm (annual average)

(2) Rainfall penetration rate: 55%
(at annual evapotranspiration of 700 mm)

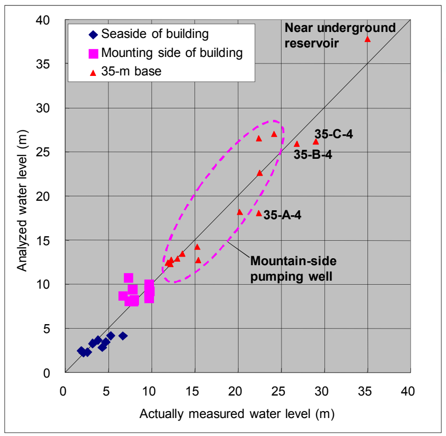
(3) Coefficient of permeability of structures, etc.: Coefficient of permeability set for total of 23 types of strata and structures

(4) Boundary condition: Each condition at sea side and mountain side of area to be analyzed set as hydrostatic pressure: (Inflow and outflow of groundwater at boundary analyzed in advance)

Cross-section al view of stratum of 35-m foundation of Fukushima Daiichi (south-north)

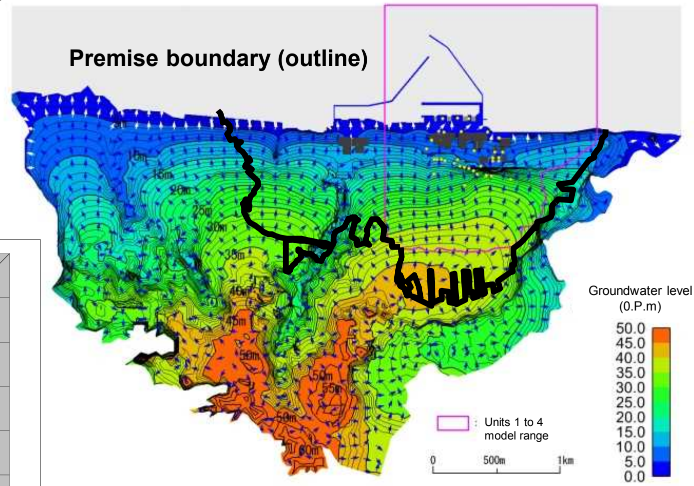



Comparison of analyzed water level and actually measured water level (unconfined ground water)




Groundwater contour, result of analysis of flow direction chart

**Range covered by existing analysis model**



# Outline of study by sub-group for understanding and visualization of groundwater and rainwater behavior (2)

◆ Analyzed the effect of holding back groundwater from flowing into buildings if an individual measure or a combination of measures is implemented, based on the new groundwater simulation model. More than 50 cases of combinations of measures were analyzed.

Representative examples of cases and their analysis results

| Case | Countermeasure construction | | | | | | | | Inflow to building (tons/day) | | Outflow to sea (tons/day) (Note 1) | Pumped up ground-water (tons/ day) | Breakup of pumped up groundwater (tons/day) (Note 2) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 m base | Ground-water bypassing | Sea-side imperme-able wall | Mountain-side SD | Mountain-/sea-side SD | Land-side imperme-able wall | Facing | Mountain-side impermeable wall | Total | Units 1 to 4 building | | | Groundwater bypassing | Sub-drain | Groundwater drain (Note 3) |
| No measure | | | | | | | | | 400 | 310 | 290 | 400 | | | |
| Case 1 | ● | | | | | | | | 410 | 320 | 220 | 460 | | | 50 |
| Case 2 | ● | ● | | | | | | | 390<br>330<br>290 | 300<br>250<br>210 | 220<br>200<br>210 | 900<br>1210<br>1130 | 460<br>840<br>790 | | 50 |
| Case 3 | ● | | ● | | | | | | 400 | 320 | 0 | 750 | | | 350 |
| Case 4 | ● | | | ● | | | | | 140 | 90 | 190 | 1000 | | 820 | 40 |
| Case 5 | ● | | | | ● | | | | 120 | 80 | 180 | 1070 | | 920 | 30 |
| Case 6 | ● | | | | | ● | | | 130 | 30 | 100 | 140 | | | 10 |
| Case 7 | ● | | | | | | ● Approx. 2.0km² | | 130 | 110 | 90 | 130 | | | |
| Case 7-2 | ● | | | | | | ● Approx. 1.7km² | | 160 | 130 | 100 | 160 | | | |
| Case 8 | ● | | | | | | ●* Approx. 1.0km² | | 300 | 240 | 170 | 330 | | | 30 |
| Case 8-2 | ● | | | | | | ●* | ●** | 170 | 130 | 140 | 190 | | | 20 |
| Case 9 | ● | | | | | | | ●:Inside premises boundary | 420 | 330 | 220 | 470 | | | 50 |
| Case 10 | ● | ● | ● | | ● | ● | | | 70 | 0 | 0 | 1020 | 500 | 310 | 140 |
| Case 11 | ● | | ● | | | ● | | | 130 | 30 | 0 | 270 | | | 140 |
| Case 12 | ● | ● | ● | | | ● | | | 130 | 30 | 0 | 770 | 500 | | 140 |
| Case 13 | ● | ● | ● | | ● | | | | 60 | 20 | 0 | 1770 | 330 | 1230 | 150 |
| Case 14 | ● | ● | ● | | ● | ● | ●* | ●** | 30 | 0 | 0 | 400 | 130 | 140 | 90 |
| Case 14-2 | ● | ● | ● | | ● | ● | ● Approx. 1.7km² | | 30 | 0 | 0 | 320 | 140 | 130 | 20 |
| Case 15 | ● | | ● | | | ● | ●* | ●** | 110 | 30 | 0 | 200 | | | 90 |
| Case 16 | ● | ● | ● | | | ● | ●* | ●** | 100 | 30 | 0 | 340 | 150 | | 90 |
| Case 17 | ● | ● | ● | | ● | | ●* | ●** | 60 | 40 | 0 | 550 | 10 | 440 | 40 |
| Case 17-2 | ● | ● | ● | | ● | | ● Approx. 1.7km² | | 60 | 40 | 0 | 590 | 20 | 490 | 20 |

*: Facing in east & west of Units 1 to 4 (35-m base, 10-m base)
**: Case where groundwater is shut off by wall around facing area (impermeable wall length: approx. 3 km)

(Note 1) "Outflow to sea" is outflow in building areas of Units 1 to 4.
(Note 2) "Pumped up groundwater" is the sum of groundwater flowing into buildings, and groundwater pumped up from underground bypass and sub-drain (SD).
(Note 3) "Groundwater drain" is a "water pumping facility near embankment".

- ◆ In the case of "No measure", about 800 tons of groundwater, including about 400 tons of water flowing out to sea every day from process buildings other than units 1 to 4 buildings and 400 tons of water flowing into buildings every day, flows per day.
- ◆ The effect of the sea-site impermeable wall is shown on the assumption that the underground drain is operating.
- ◆ The effect of the underground bypassing and sub-drain differ depending on the conditions of operation.
- ◆ The figure at the top under "Groundwater bypassing" column is the case where water flowing into buildings is controlled minimum, the middle figure is the case where the water penetrates to the strata of alternation, and the bottom is the case where the water is controlled maximum with an additional well installed in the medium-grained sandstone strata.

◆ Items that have become clear by comparing the results of analysis on combination of measures is as follows:

[Findings from this analysis]

(1) The mountain- and sea-side sub-drains and constructing the land-side impermeable wall are highly effective for controlling groundwater inflow.
<from cases 4, 5, and 6>

(2) Implementing facing over a wide area is effective for suppressing inflow of groundwater into buildings but its effect is limited if the area is narrowed down.
<from cases 7 and 8>

(3) Effect of controlling groundwater inflow to buildings cannot be obtained even if a mountain-side impermeable wall is installed around the boundary of premises.
<from case 9>

(4) Measures that have already been implemented or those that have been decided to be implemented are effective for holding back groundwater from entering buildings to some extent.
<from case 10>

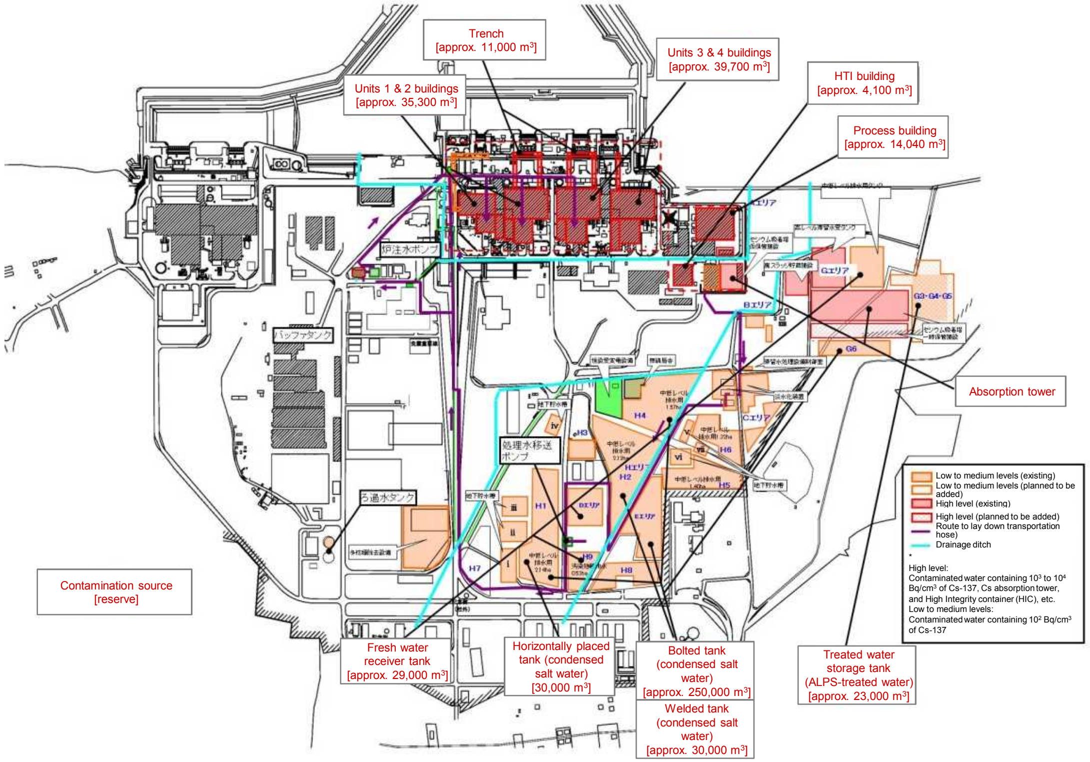
(5) Wide-area facing or additional impermeable walls and implementing facing inside the walls will enhance the effects of the measures that have already been implemented or those that have been decided to be implemented. However, it takes time until the effect of facing to block water appears.
<from cases 14 and 14-2>

(6) Even if the land-side impermeable wall is not fully effective, its effect can be substituted by wide-area facing or additional impermeable walls and facing inside these walls.
<from cases 17 and 17-2>

* The effect of facing needs close examination in the future but it was confirmed from the result of analysis of non-steady-state flow of groundwater that it would take time until the desired effect can be obtained.

# Outline of study by “sub-group for risk assessment“ (1)

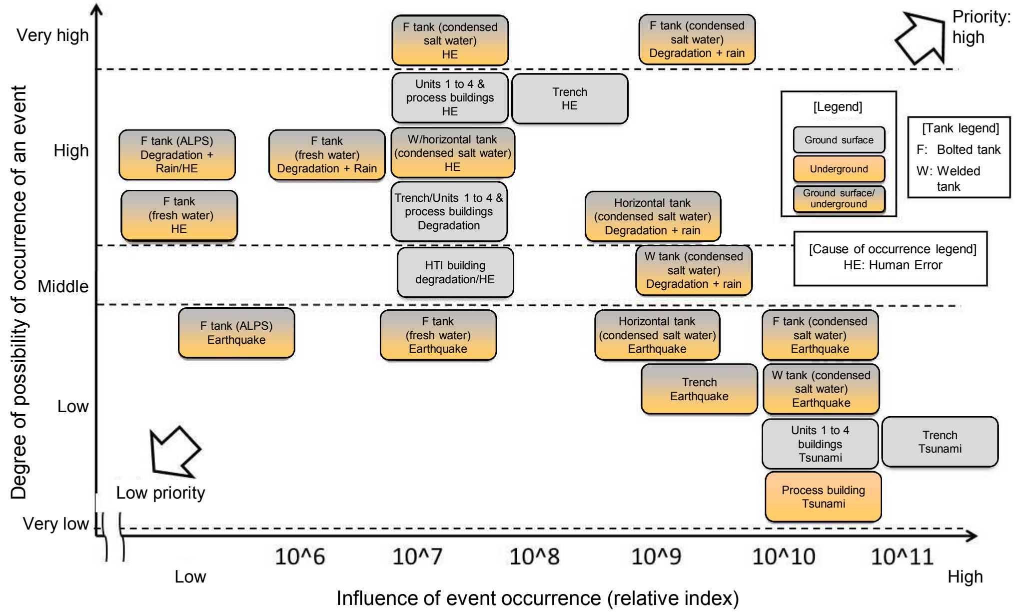
- ◆ Visualized contaminated water in premises by putting (1) location, (2) concentration, and (3) capacity in order.




<As of October 15, 2013>

- ◆ <u>Relatively assessed risks and mapping present risks</u> based on probability of occurrence, concentration, volume of leakage, cause of leakage, etc. of contaminated water

## Mapping present risk




* The top of [box] indicates the location of contaminated water and the bottom indicates the cause of leakage of the contaminated water.

*”Degree of influence of event occurrence” (horizontal axis) of the risk map should be partially treated for reference as quantification of the effect of measures is difficult

*On ”Degree of possibility of occurrence of event” (vertical axis), there is no difference in possibility of occurrence of risk classified into each category (high, middle, and small.

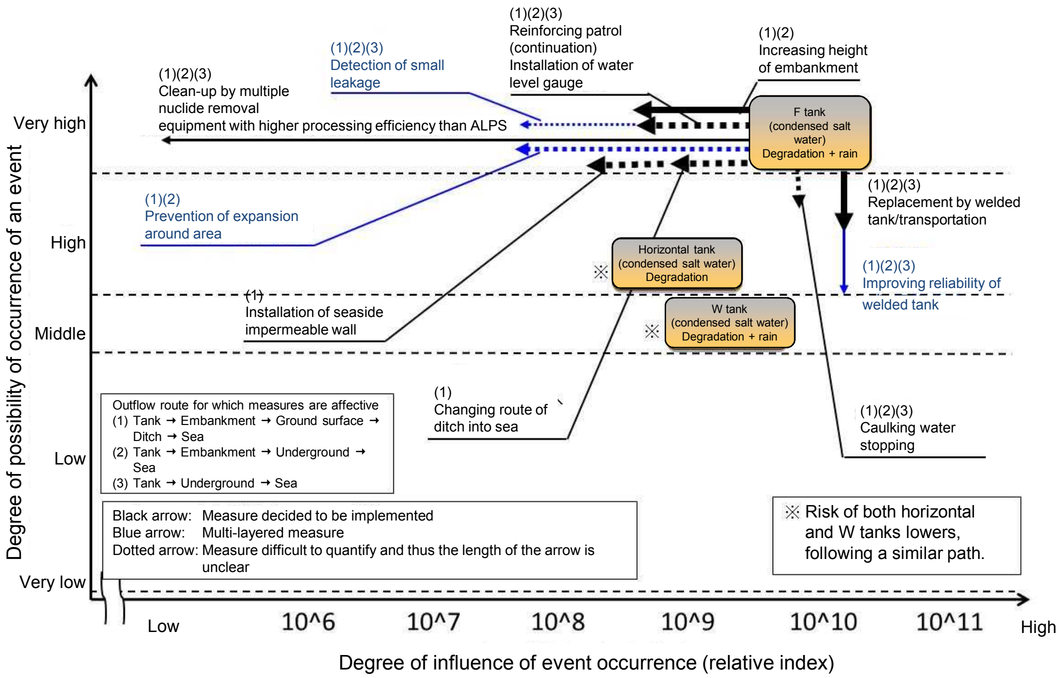
*”HE” stands for “Human Error”.

# Outline of study by “sub-group for risk assessment“ (2)

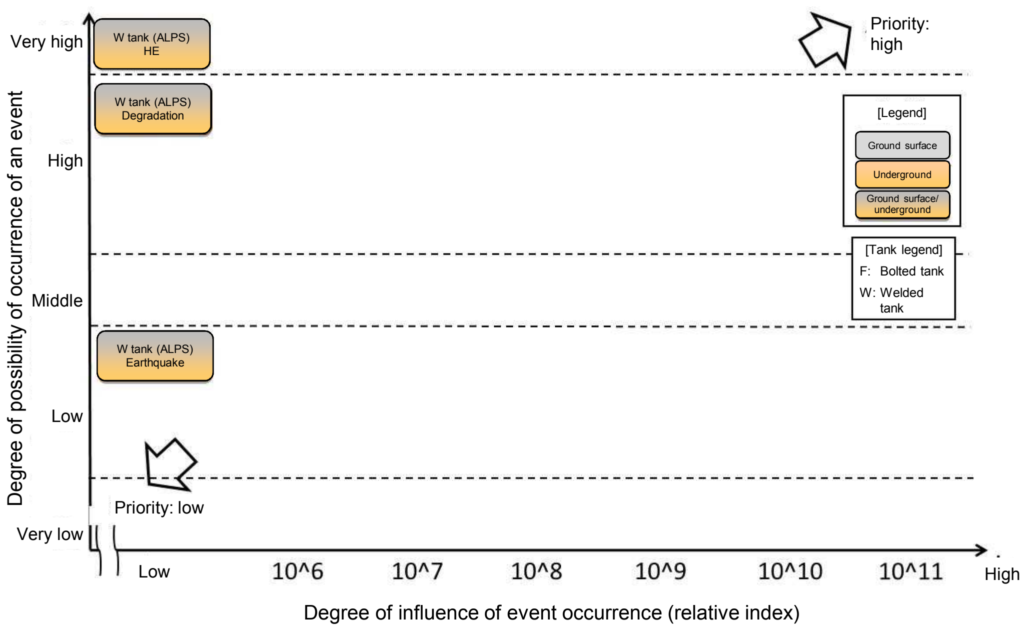
- Analyzed measures contributing to lowering each risk and their effects.
- Possibility of occurrence of leakage will be lowered if more bolted tanks and horizontally placed steel tanks are replaced by welded tanks.
- Influences in case of leakage will be reduced if clean-up is moved forward by using Advanced Liquid Processing System (ALPS).

- Made clear the effect of measures to lower risks at the facility in the future when measures with high priority, such as pumping up high-concentration contaminated water, cleaning up contaminated water with ALPS, and replacing the existing tanks with welded tanks, are sequentially implemented.
- How to handle tritiated water, which cannot be eliminated by ALPS, is the problem.

## Contaminated water event occurrence risk map [bolted tank/aging]




## Verification of risk reduction effect (end of 2020)



# Gathering domestic and overseas wisdom on solution to contaminated water issues

■ Inviting technical proposals

◇ A team consisting experts, such as members of the International Research Institute for Nuclear Decommissioning (IRID), was set up to collect wisdom from both at home and abroad and accepted technical proposals (period: September 25 to October 23).

◇ The gathered proposals were closely examined by the "Committee on countermeasures for contaminated water treatment" to reflect on the overall image of the preventive and multi-layered contaminated water measures.

■ State of collection

◇ A total of 780 proposals were submitted. The details are as follows:

| Field of information gathered | Number of proposals submitted |
|---|---|
| **(1) Contaminated water storage** (Storage tank, small leakage detection technology, etc.) | 206 |
| **(2) Contaminated water treatment** (Tritium separation technology, long-term, stable tritium storage method, etc.) | 182 |
| **(3) Clean-up of seawater in port** (Technology to eliminate radioactive Cs and Sr in seawater, etc.) | 151 |
| **(4) Controlling contaminated water in buildings** (Technologies to stop water in buildings and for soil improvement work, etc.) | 107 |
| **(5) Management of premises to suppress groundwater inflow** (Technologies to construct impermeable walls and conduct facing, etc.) | 174 |
| **(6) Understanding behavior of groundwater** (Geological/groundwater data measurement system, water quality analysis technology, etc.) | 115 |
| **Others** (Those that do not fall under (1) to (6)) | 34 |

(Note 1) A field was filed by the proposer.
(Note 2) Some proposals were related to two or more fields.

◇ Technical proposals presented from both inside and outside of Japan are precious data that provide the complete picture of technologies for contaminated water treatment.

◇ Taking into consideration the maturity of technologies, emergency of response, and adaptability of technologies to the site, the following technologies were selected:

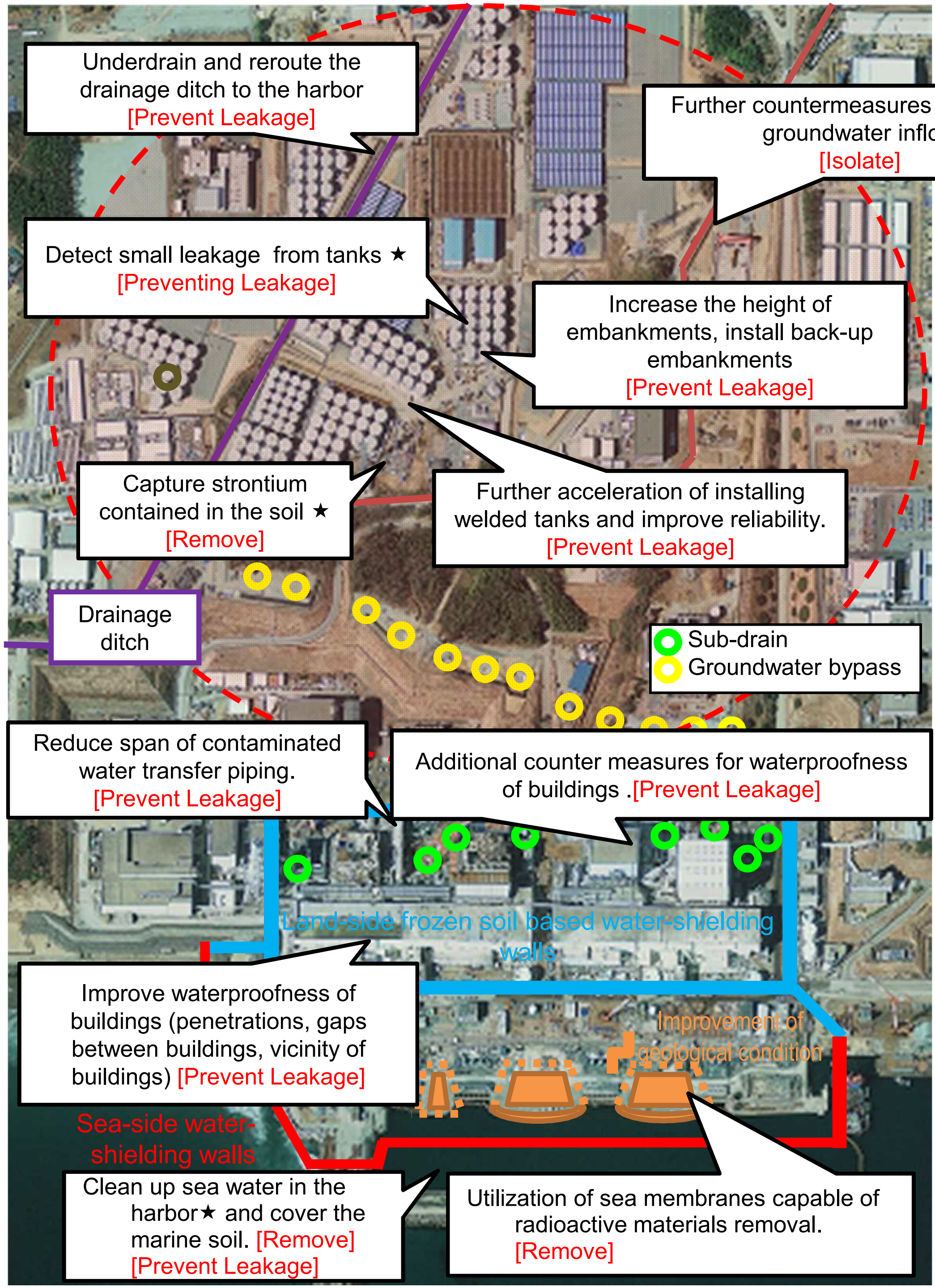
(1) Technologies that should be adopted after confirming their adaptability to the side:
- ➢ High-reliability, large-size tanks such as double-shell steel tanks
- ➢ Lightweight shielding sheet that does not use lead
- ➢ Contamination prevention membrane (silt fence, etc.)
- ➢ Water stopping technology (stopping water in and around buildings)
- ➢ Geological/groundwater survey, preparing observation network etc.

(2) Technologies to be used by selecting an execution method based on workability and cost effectiveness
- ➢ Water shut-off technologies (facing, water shut-off, etc.)

(3) Technologies that are expected to be effective but need to be checked and verified before being used
- ➢ Small leakage detection technology (including dyes)
- ➢ Tank decontaminating technology without using water
- ➢ Tritiated water storage and separation technologies
- ➢ Technology for cleaning up seawater in port
- ➢ Technology for capturing strontium in soil
- ➢ Automated boring technology etc.

(4) Technologies to be moved ahead based on study by the Committee on countermeasures for contaminated water treatment
- ➢ General assessment of handling of tritiated water
- ➢ Study on issues related to tankers and underground storages, etc.

# Overview of preventive & multi-layered contaminated water treatment




**Three principles**

1. Remove sources of contamination
2. Isolate water from contamination
3. Prevent leakage of contaminated water

**Immediate measures**

1. Remove highly-contaminated water in the trenches【Remove】
2. Soil improvement with sodium silicate (liquid glass) , rainproof pavement, and pumping out【Isolate】【Prevent leakage】
3. Pump up groundwater for by-passing【Isolate】

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**Fundamental measures**

1. Pump up groundwater from sub-drains near buildings【Isolate】
2. Install sea-side impermeable walls【Prevent leakage】
3. Install land-side frozen soil impermeable walls【Isolate】
4. Install more efficient water treatment equipment【Remove】

etc.

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**Preventive and Multi-layered Measures**

(★:measure to be studied on its feasibility)

1. Further countermeasures for prevent groundwater inflow【Isolate】
2. Increase height of embankments, install back-up embankments【Prevent leakage】
3. Further acceleration of installing welded tanks and improve reliability【Prevent leakage】
4. Underdrain and reroute the drainage ditch to the plant port【Prevent leakage】
5. Detect small leakage from tanks.★【Prevent leakage】
6. Capture strontium in contained water in soil.★[Remove]
7. Reduce span of contaminated water transfer piping. [Prevent Leakage]
8. Improve waterproofness of buildings(penetrations, gaps between buildings, vicinity of buildings), etc. [Prevent Leakage]
9. Counter measures for great tsunami (consideration on additional counter measures for waterproofness of buildings, wave breakers, etc.)[Prevent Leakage]
10. Clean up sea water in the harbor★ and cover the marine soil. [Remove] [Prevent Leakage]
11. Utilization of sea membranes capable of radioactive materials removal. [Remove]

Main measures taken or to be taken after decision of basic policy on Sep. 3

# Identifying potential risks and necessary preventive & multi-layered countermeasures

| Risk | | | Countermeasures taken or decided to be taken by September 3 |
|---|---|---|---|
| Risks already being responded | Leakage of contaminated ground water into the sea | Contaminated water in the seaside trenches | ○Pumping, blockading, and cleaning up high-concentration C/W in seaside trenches of building [Removing] |
| | | Contaminated soil in the seaside turbine building | ○Improving soil of embankment in eastern area of seaside of buildings by injecting sodium silicate and pumping up C/W from contaminated area [Preventing leakage]<br>○Paving with asphalt the ground surface of contaminated area at seaside of buildings [Isolating]<br>○Install sea-side impermeable walls in the port [Preventing leakage] |
| | | C/W in the storage tanks | ○Enhancing survey of leakage and patrols of tanks and pipe [Preventing leakage]<br>○Installing water gauge [Preventing leakage]<br>○Replacing horizontal steel tanks [Preventing leakage]<br>○Accelerating replacement from bolted tanks to welded ones [Preventing leakage]<br>○Cleaning up C/W by ALPS [Removing]<br>○Accelerating clean-up of C/W with ALPS having higher processing efficiency [Removing]<br>○Collecting contaminated soil around tank from which C/W leaked and pumping up C/W [Removing] |
| | Contamination of ground water by leakage of secondary waste and its leakage into the sea (e.g., leakage of secondary waste stored in HIC) | | ○Reducing volume of waste by using ALPS with higher processing efficiency [Preventing leakage] |
| | Shortage of tanks due to contaminated water increase | | ○Pumping up ground water on mountain side well (groundwater by-passing [Isolating]<br>○Pump up water from building side well (sub-drain) [Isolating]<br>○Installing frozen soil walls enclosing the reactor and turbine buildings [Isolating]<br>○Increasing contaminated water storage tanks [Preventing leakage] |

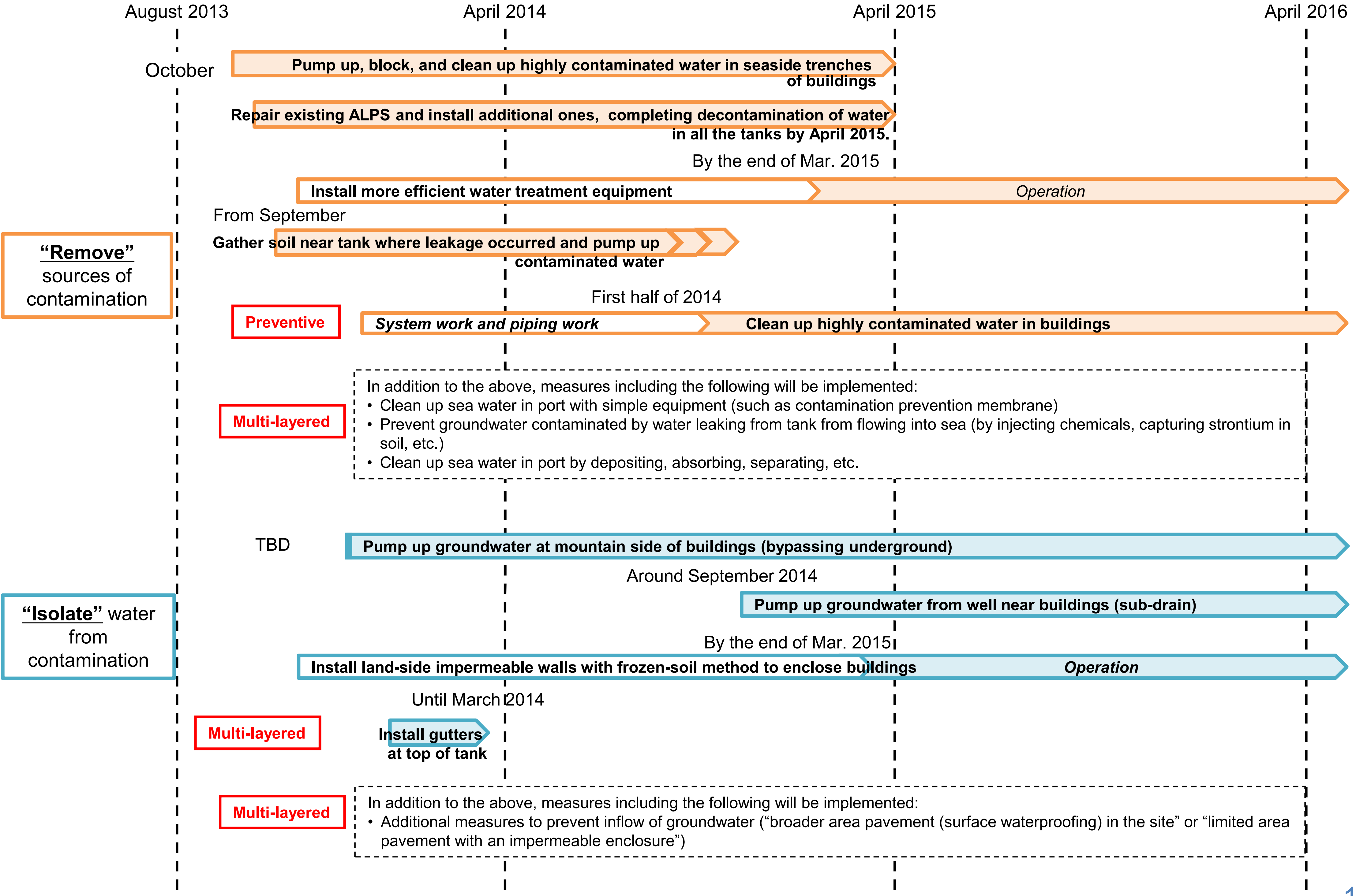
| Multi-layered measures necessary in addition to the measures in the left table |
|---|
| ○Improving soil of north-side area of Unit 1 cooling water intake [Preventing leakage]<br>○Cleaning up seawater in port with simple equipment (such as contamination prevention membrane) [Removing]<br>○Cleaning up seawater by depositing, absorbing, separating, etc. [Preventing leakage]*<br>○Covering marine sediment in port [Removing] |
| ○Increasing height of and doubling tank embankment [Preventing leakage]<br>○Using underdrain for drainage ditch and changing route of drainage ditch into port [Preventing leakage]<br>○Accelerating installation of welded tanks and employing of highly reliable tanks such as double-shell steel tanks [Preventing leakage]<br>○Installing rain gutter on tank top plate [Isolating]<br>○Countermeasures against leakage on bottom surface of bolted tanks [Preventing leakage]<br>○Decontamination of used tanks that was replaced [Preventing leakage]*<br>○Preventing groundwater contaminated by water leaking from tank from flowing into sea (such as by injecting chemicals and collecting strontium in soil) [Removing]*<br>○Accelerating clean-up of C/W by increasing ALPS [Removing]<br>○Detection of small leak from tanks [Preventing leakage]* |
| ○Preventing waste from leaking from High Integrity Container (HIC), and reducing volume of and stable high-concentration waste and its stable storage [Preventing leakage] |
| ○Additional measures to prevent groundwater inflow ("wide-area facing (surface water shut-off)" or "additional impermeable wall and facing inside of it") [Isolating] |
| ○Comprehensive study on appropriate treatment of tritiated water will be conducted by the tritiated water task force.<br>*To secure C/W storage capacity, risk of tank capacity shortage will be assessed by as early a time as possible in 2014. |

| Risks | | | | Preventive measures necessary in addition to the measures in the above table |
|---|---|---|---|---|
| Risks in need of assessment | Leakage from cooling system | Leakage of C/W in buildings | Leakage of C/W in buildings | ○Reduction of quantity of C/W staying in HT and process buildings [Preventing leakage]<br>○Shortening loop for transporting C/W (circulating inside buildings) [Preventing leakage]<br>○Cleaning up high-concentration C/W in buildings [Removing]<br>○Water stopping in and around buildings (through holes on exterior walls of buildings, gaps between buildings, and around buildings) [Preventing leakage]*<br>○Controlling water level in buildings in preparation for falling of groundwater level (installation of drainage pump deep inside reactor building) [Preventing leakage] |
| | | | Leakage of C/W in the buildings to the sea by an outer-rise tsunami | ○Countermeasures against tsunami (improving water proofness of buildings, study of additional measures such as seawall) [Preventing leakage] |
| | | Leakage C/W from pipes | | ○Changing piping route to safer one and replacing existing pipes with ones with high resistance to radiation [Preventing leakage] |
| | | Leakage C/W from cesium removal equipment | | ○Prevention of C/W from cesium removing equipment by stopping water in and around buildings [Preventing leakage] |
| | Radioactive waste generated after cesium removal | | | ○Prevention of leakage of waste from cesium absorption tower, reduction of volume of waste, and its stable storage [Preventing leakage] |
| | Natural disaster or other incidents ( e.g. damage of tanks) | | | ○Creating system to prevent C/W from flowing into sea in case large amount of C/W leaks [Preventing leakage] |

- Measures marked * should be implemented after technologies for them have been checked and verified.
- Underlined are measures to be taken based on the result of publicly inviting technical proposals.

(Note 1) Further risk studies are expected due to the shortage of sufficient information at present on risk assessment.
→ In the future, technologies deemed effective in the course of enriching observation by preparing and improving an observation network will be appropriately used depending on the purpose of its survey.

# Three countermeasures against contaminated water issues – Key schedules (1) (including preventive and multi-layered measures)



# Three countermeasures against contaminated water issues – Key schedules (2) (including preventive and multi-layered measures)

August 2013 | April 2014 | April 2015 | April 2016

From August 9 — **Soil improvement by sodium silicate**

From August 9 — **Pump up contaminated water from contaminated area**

From August 22 — **Enhance survey of leakage and patrols of tanks and pipe**

**Preparation for installing sea-side impermeable wall** — September 2014 — **Operation**

**Mount water level gauge to bolted tanks** — Until end of November — *Operation of water level gauge*

**“Prevent leakage” of contaminated water**

**Mount water level gauge to welded tanks** — February 2014 — *Operation of water level gauge*

Multi-layered — **Use underdrain for drainage ditch** — Until December — *Operation*

Multi-layered — **Increase height of embankment and install back-ups** — *Operation*

Multi-layered — **Change route of drainage ditch into port** — *Operation*

Multi-layered — **Change piping route to safer one** — *Replacement of pressure-resistant hose with polyethylene tube*

Preventive — **Reduce length of contaminated water transfer piping (circulation in buildings)** — *Operation*

Preventive — From October — **Countermeasures for tsunami (improve waterproofness of buildings)** — Second half of 2014 — **Consider installing wave breakers.**

Preventive — *Design and lay down line for circulating water* — First half of 2014 — **Reducing quantity of contaminated water in HTI building, etc.**

Multi-layered

Preventive

In addition to the above, measures including the following will be implemented:
- Acceleration of installing welded tanks and installing highly reliable, large-size tanks such as double-sell steel tanks
- Detect small leakage from tanks
- Decontaminating used tanks that were replaced
- Water stopping in and around buildings (through holes on exterior walls of buildings, gaps between buildings, and around buildings)