

# Mid-to-long Term Policy for on site Decontamination and the Performance

August 27, 2013

**TOKYO ELECTRIC POWER COMPANY**

RADIATION PROTECTION & MANAGEMENT GROUP

TORU FURUKAWA

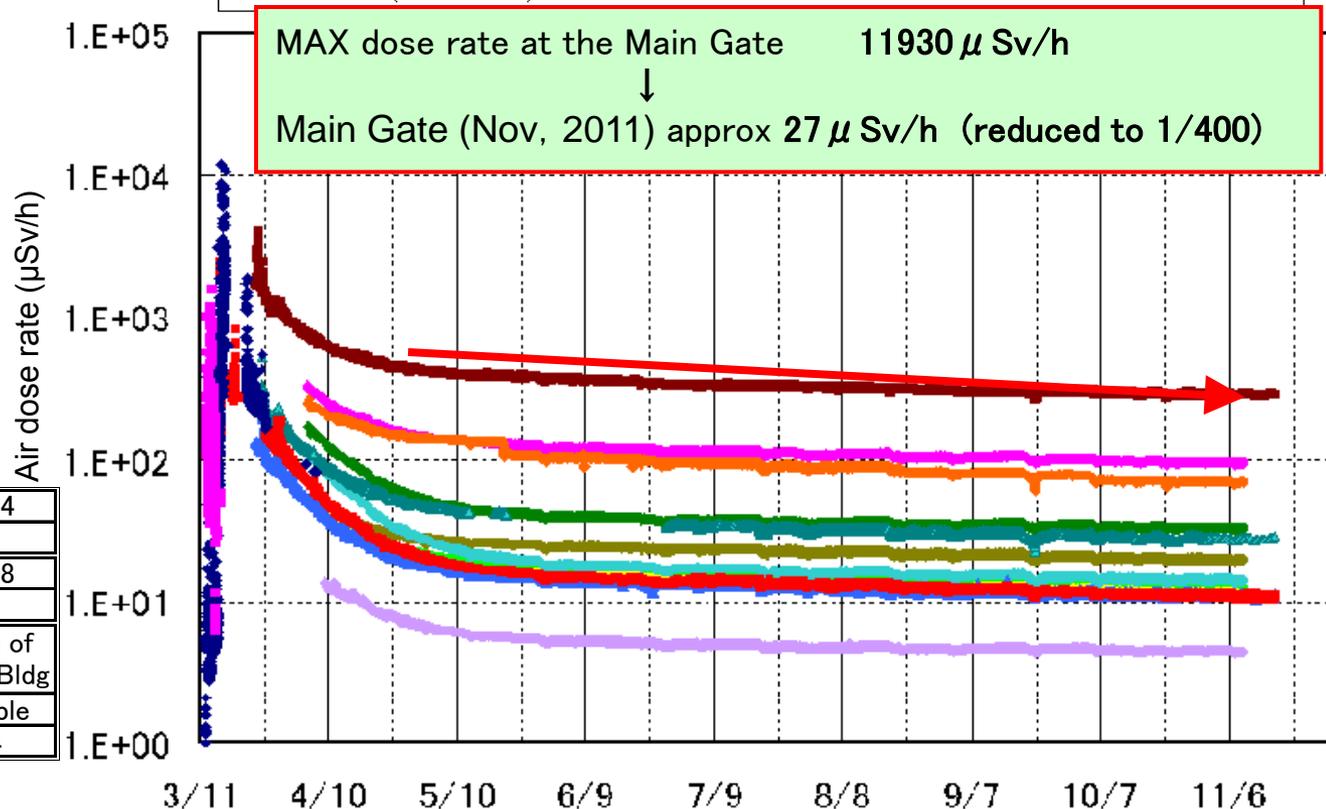
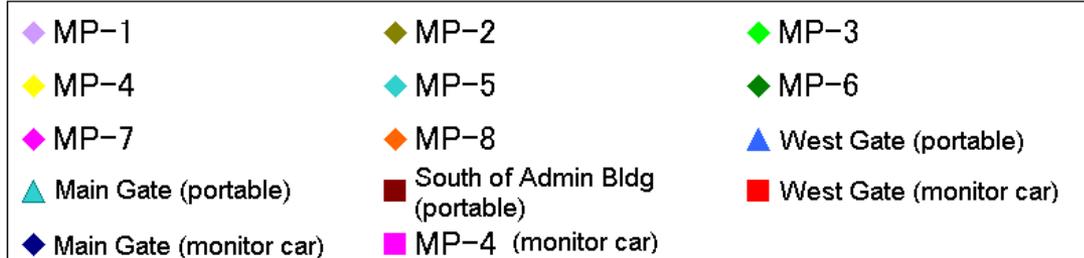


TOKYO ELECTRIC POWER COMPANY

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- *Current picture at Fukushima Daiichi NPS  
(radioactive concentration and air dose rate)*
- *Decontamination Plan (Onsite)*
- *Decontamination performance*
- *Occupational Exposure*

# Air dose rate by Monitoring Posts etc.



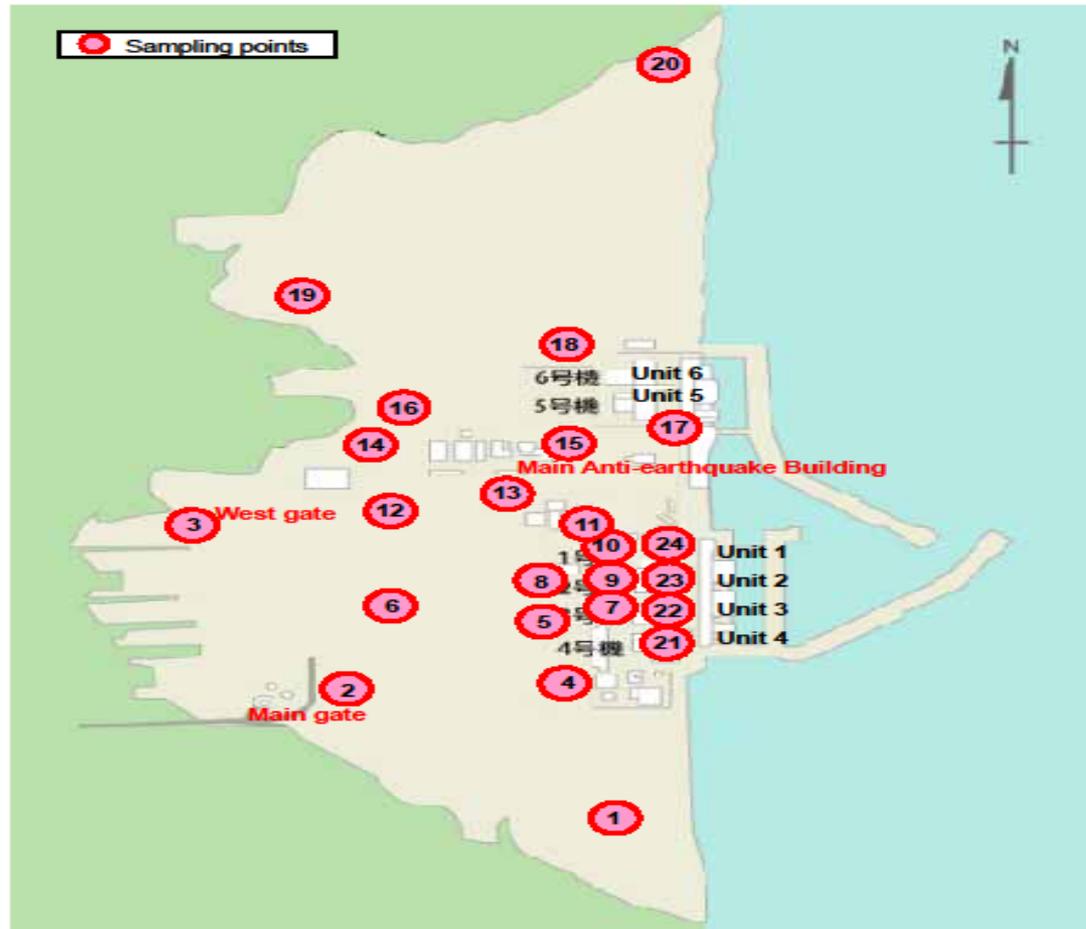
MP-1	MP-2	MP-3	MP-4
2.7	4.7	5.4	4.9
MP-5	MP-6	MP-7	MP-8
5.1	2.8	3.2	3.2
West gate		Main gate	South of Admin Bldg
monitor car	portable	portable	portable
3.5	5	15	144

Measurement date: August 7, 2013

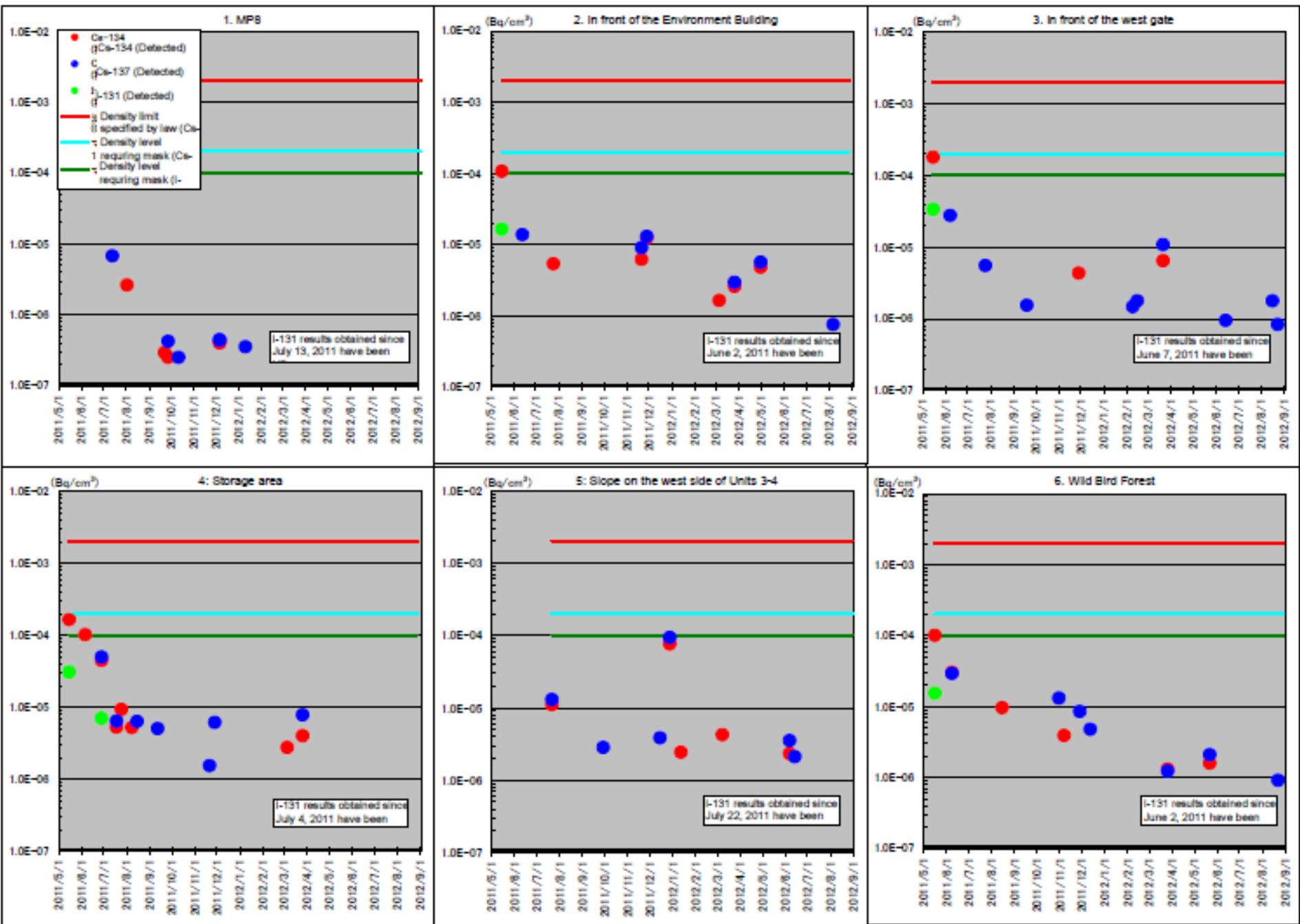
The air dose rates at each point were dramatically increased by the accident. After that, indicated steady downward trend and at this moment, at the background level at each point.

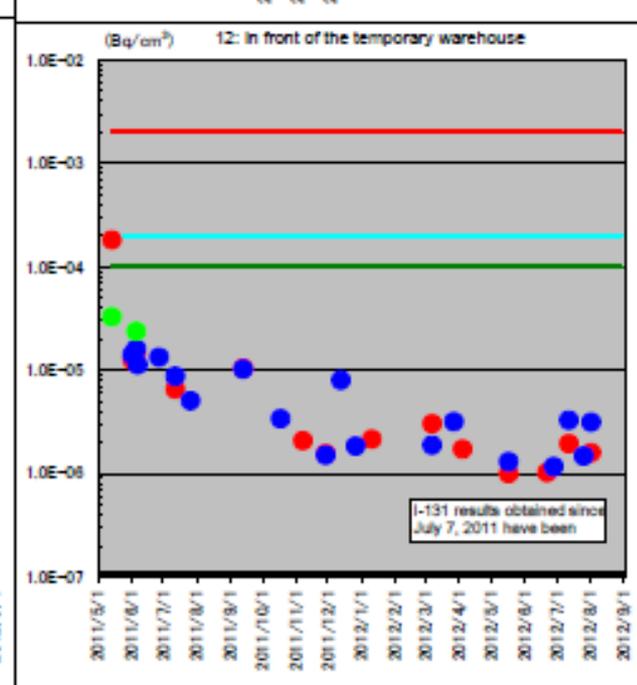
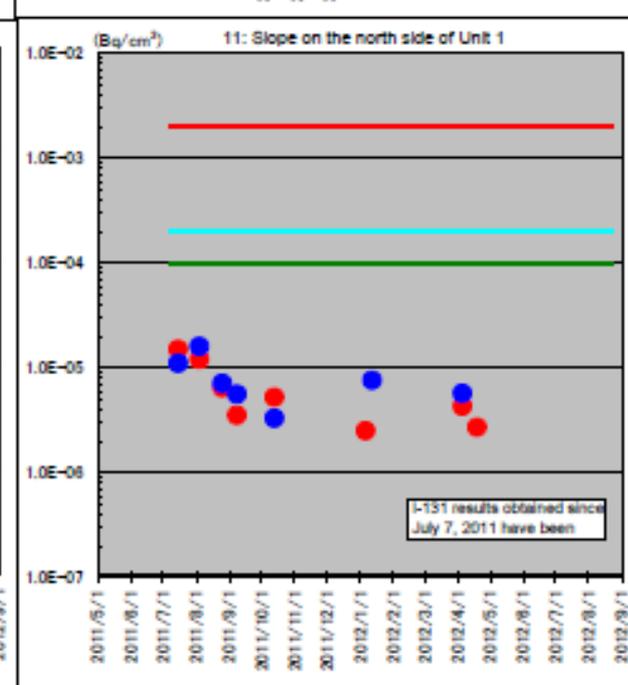
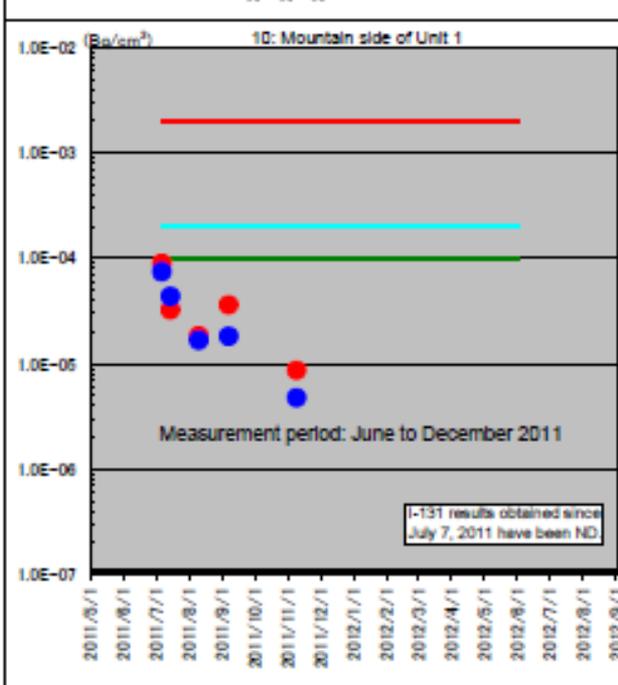
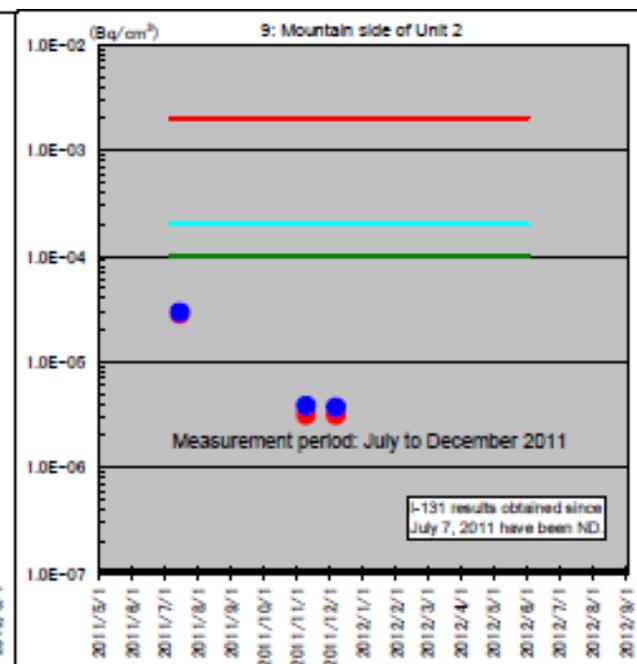
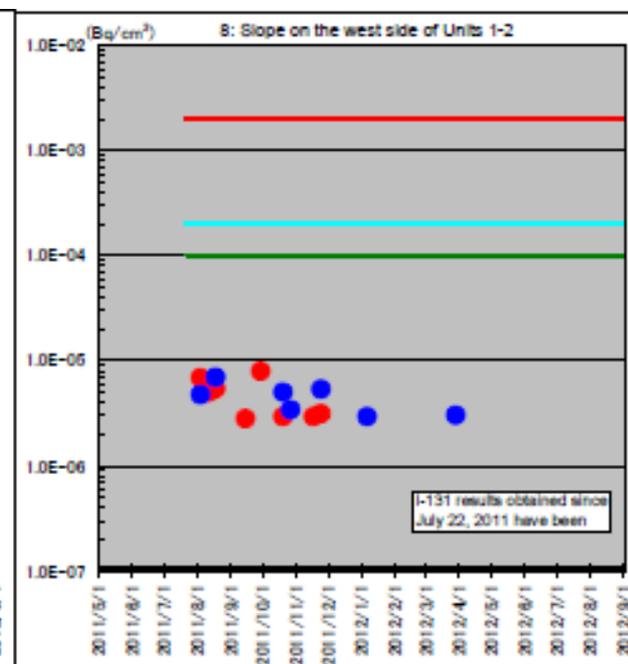
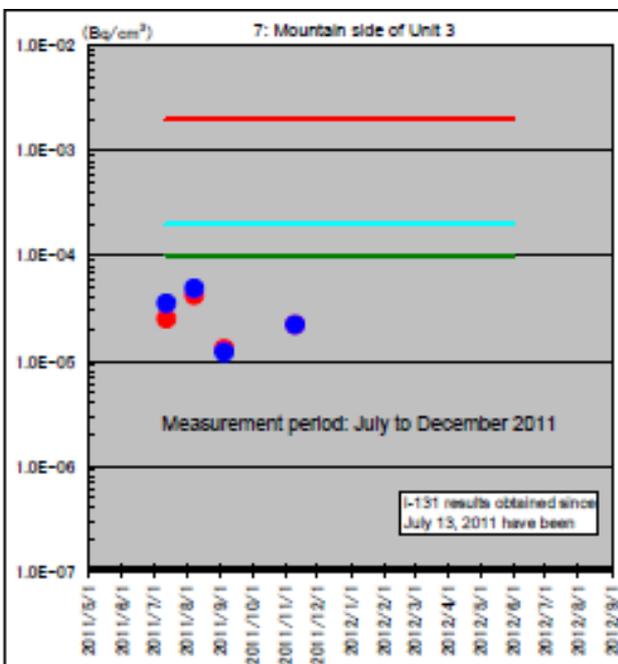
# Radioactivity density measurement results of air within the grounds

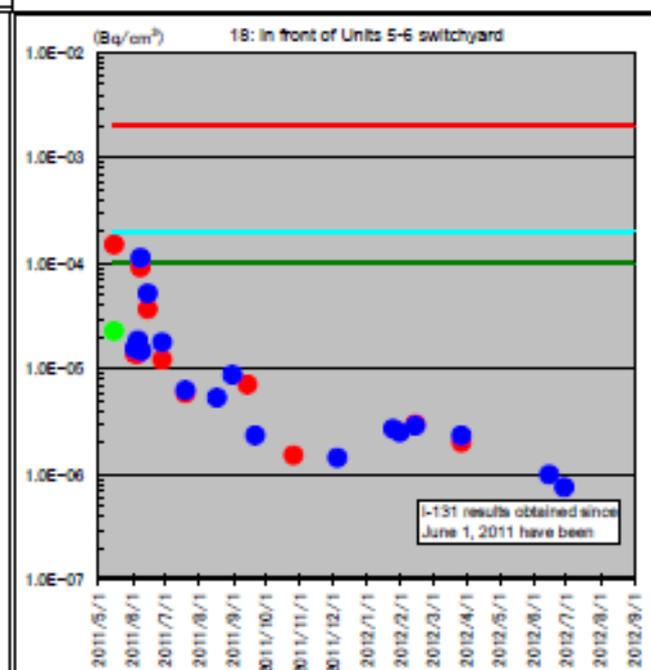
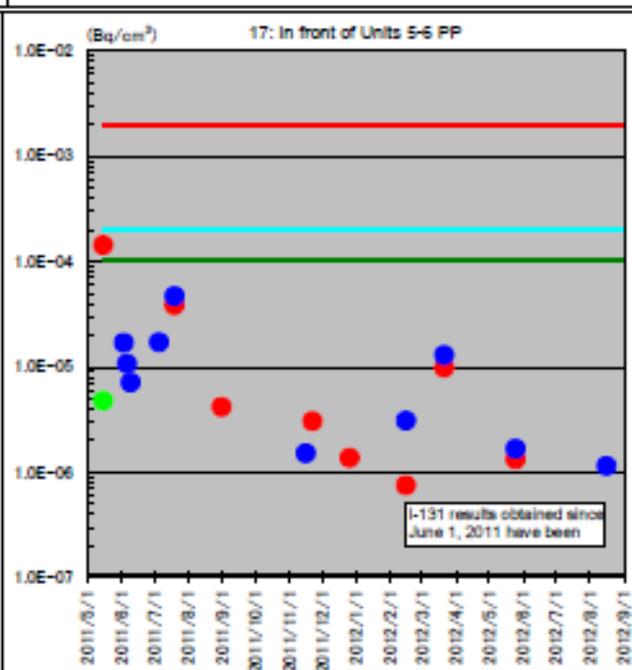
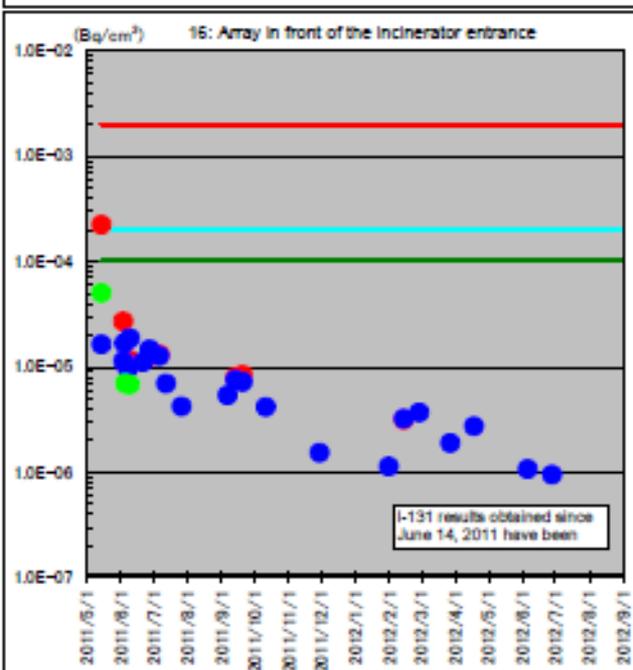
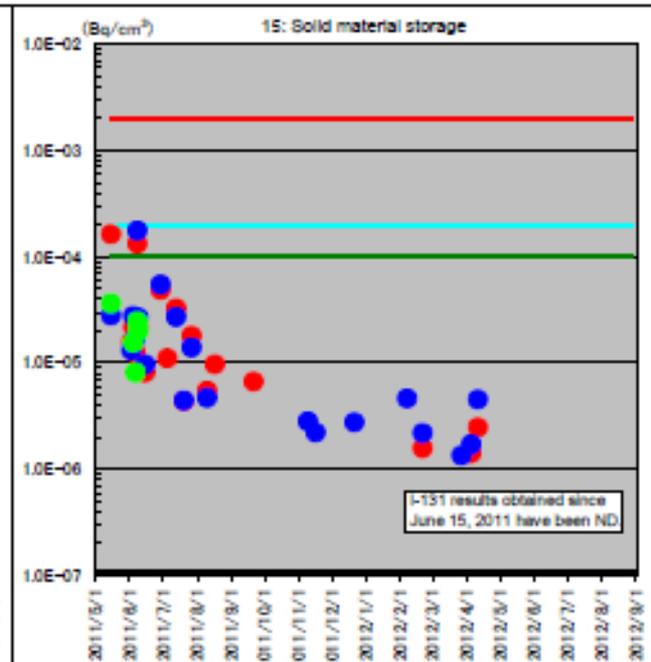
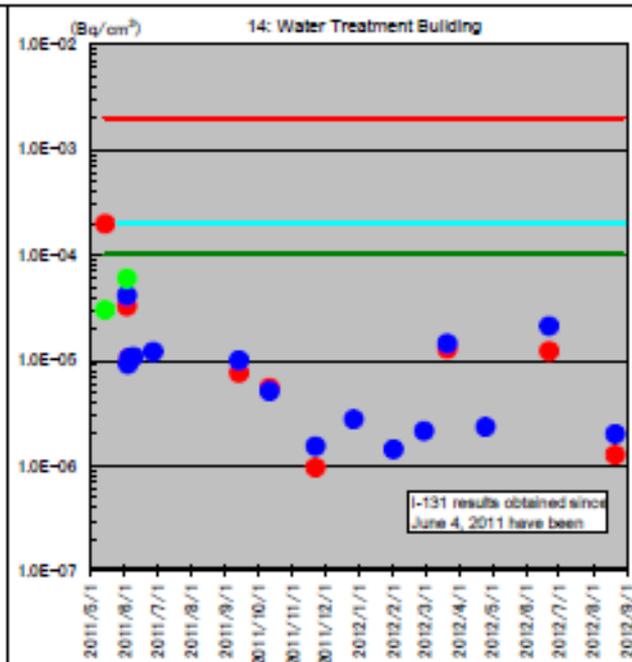
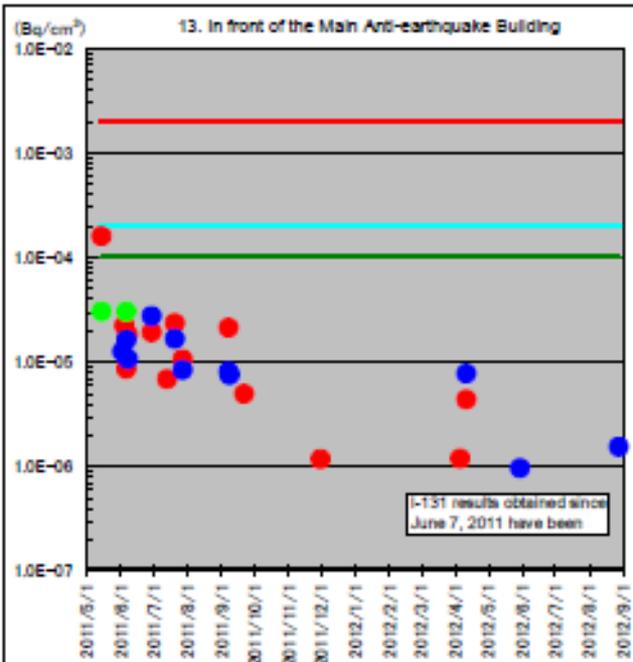
Radioactivity density measurement results of the air within the grounds of Fukushima Daiichi Nuclear Power Station

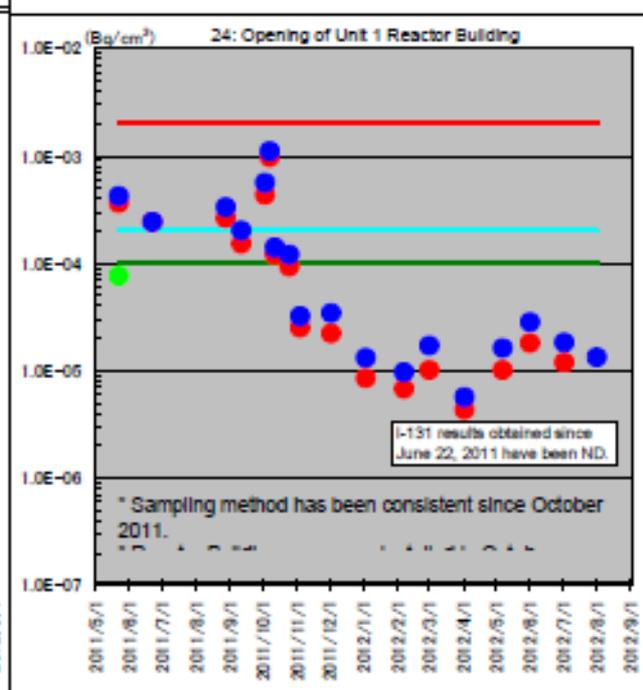
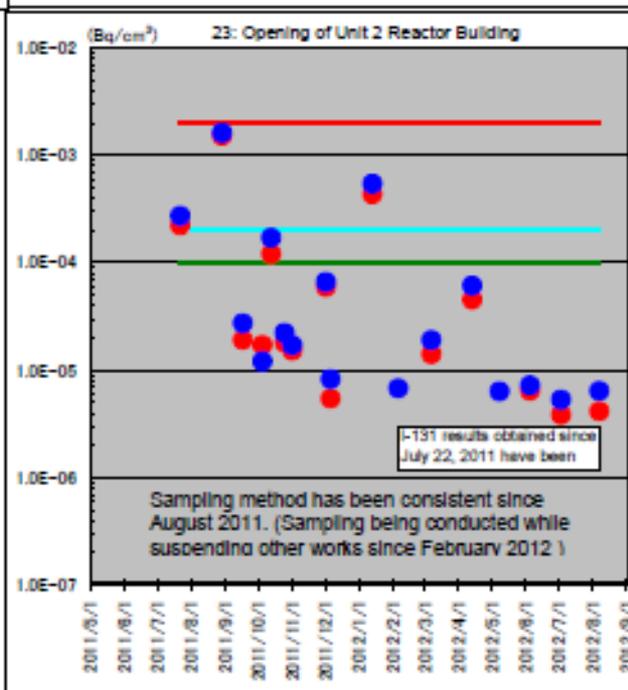
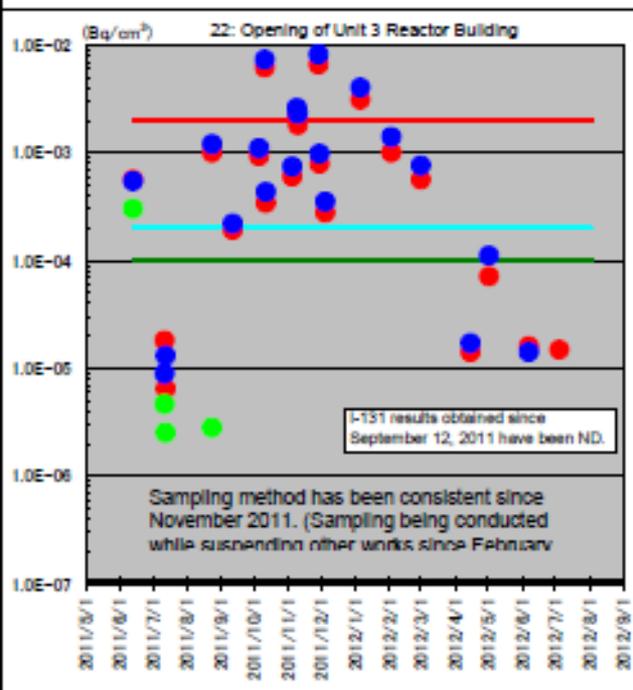
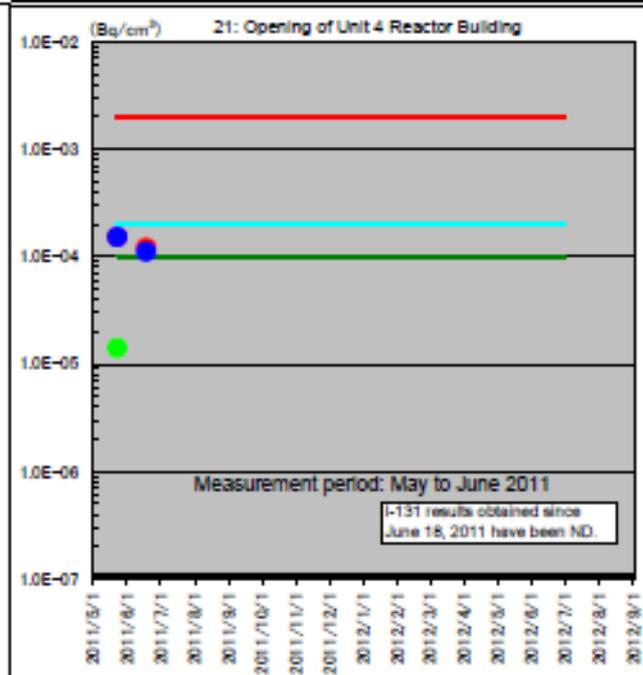
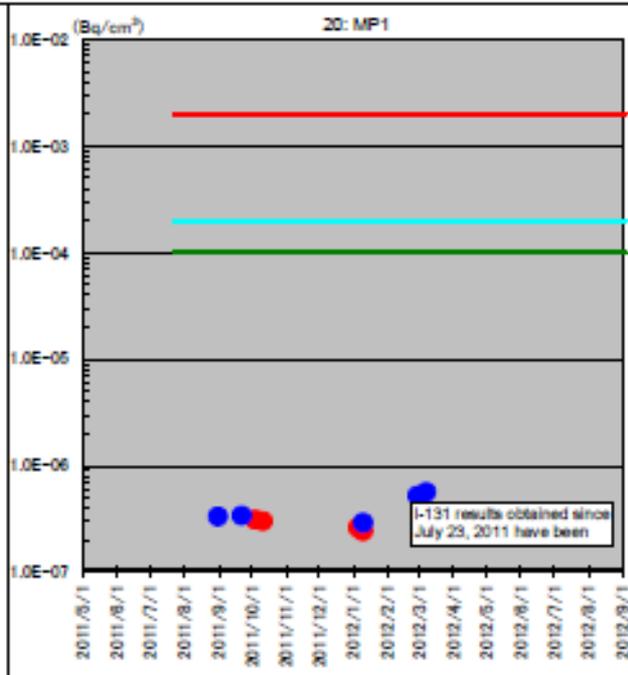
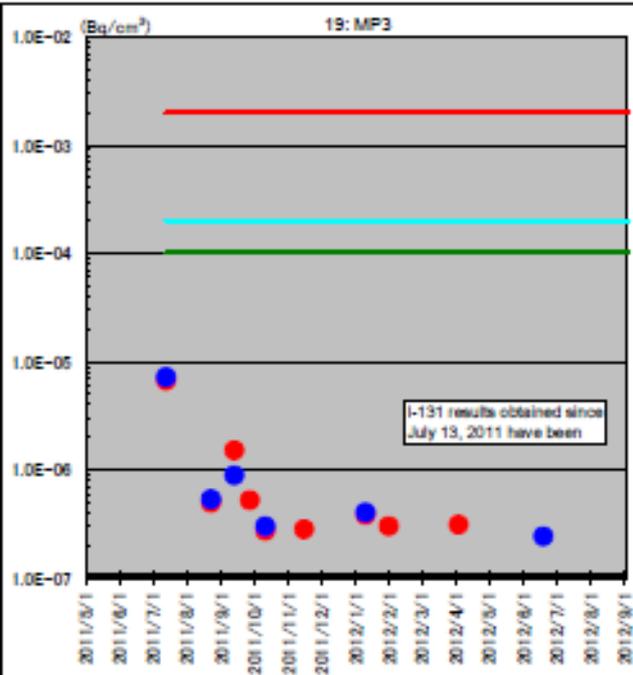


- |   |   |  |
|---|---|--|
| 1: MP6                                  | 9: Mountain side of Unit 2                        | 17: In front of Unit 5-6 PP            |
| 2: In front of the Environment Building | 10: Mountain side of Unit 1                       | 18: In front of Unit 5-6 switchyard    |
| 3: In front of the west gate            | 11: Slope on the north side of Unit 1             | 19: MP3                                |
| 4: Storage area                         | 12: In front of the temporary warehouse           | 20: MP1                                |
| 5: Slope on the west side of Unit 3-4   | 13: In front of the Main Anti-earthquake Building | 21: Opening of Unit 4 Reactor Building |
| 6: Wild Bird Forest                     | 14: Water Treatment Building                      | 22: Opening of Unit 3 Reactor Building |
| 7: Mountain side of Unit 3              | 15: Solid material storage                        | 23: Opening of Unit 2 Reactor Building |
| 8: Slope on the west side of Unit 1-2   | 16: Array in front of the Incinerator entrance    | 24: Opening of Unit 1 Reactor Building |





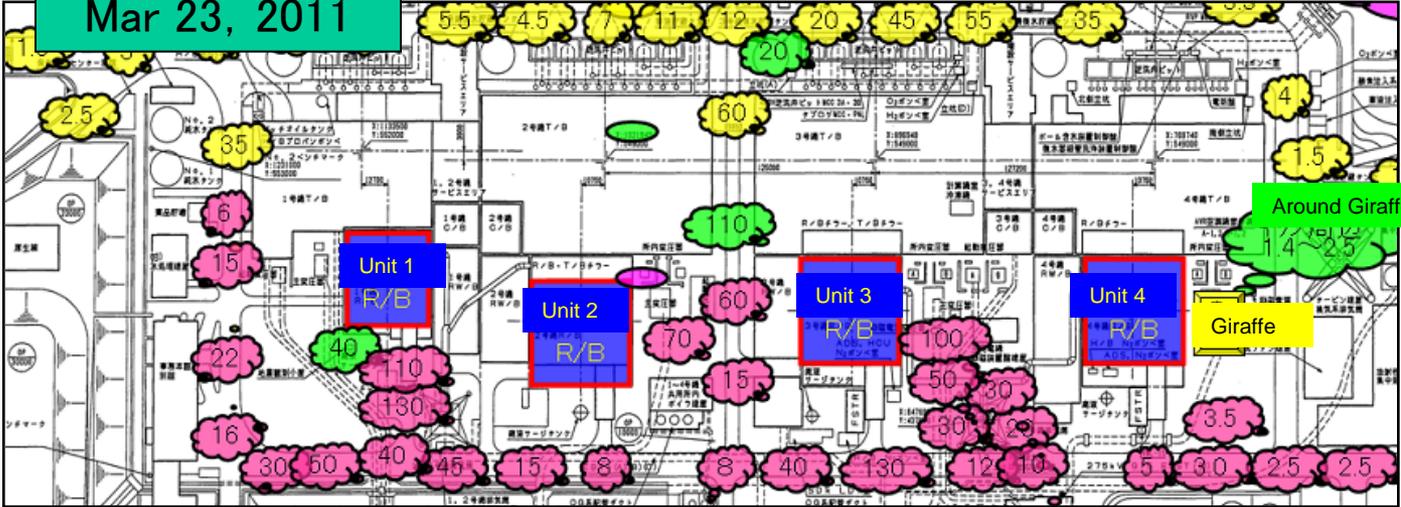




# Air dose rate in the Power Station (Immediately after an earthquake disaster)

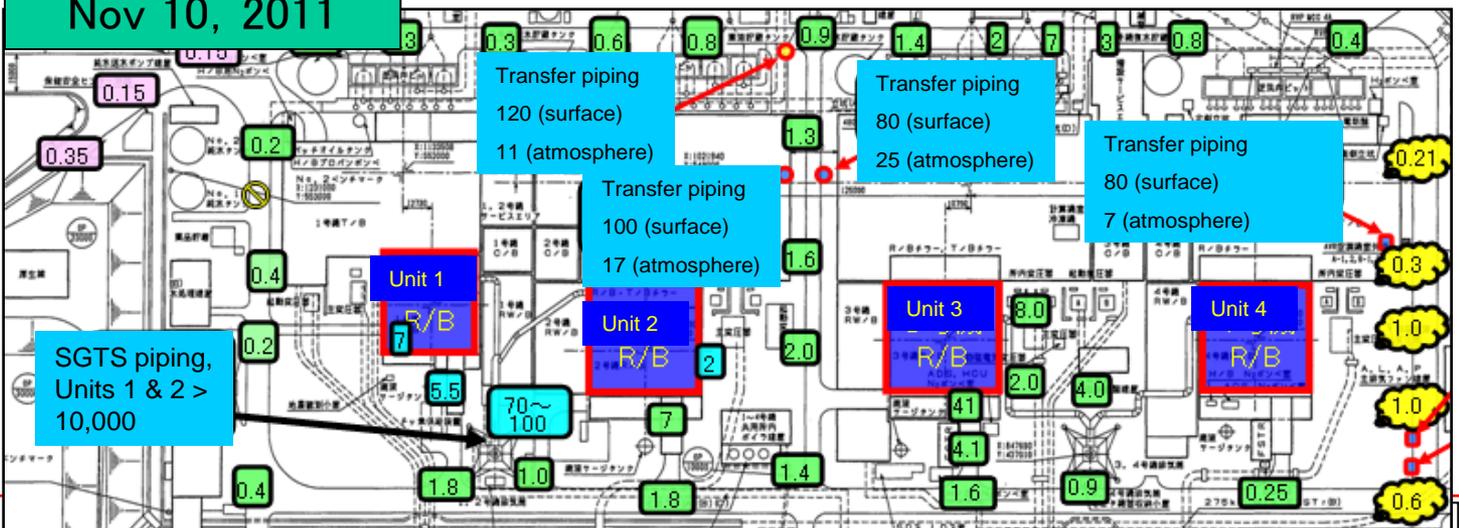
Air dose rate decreased by removal of rubbles

Mar 23, 2011

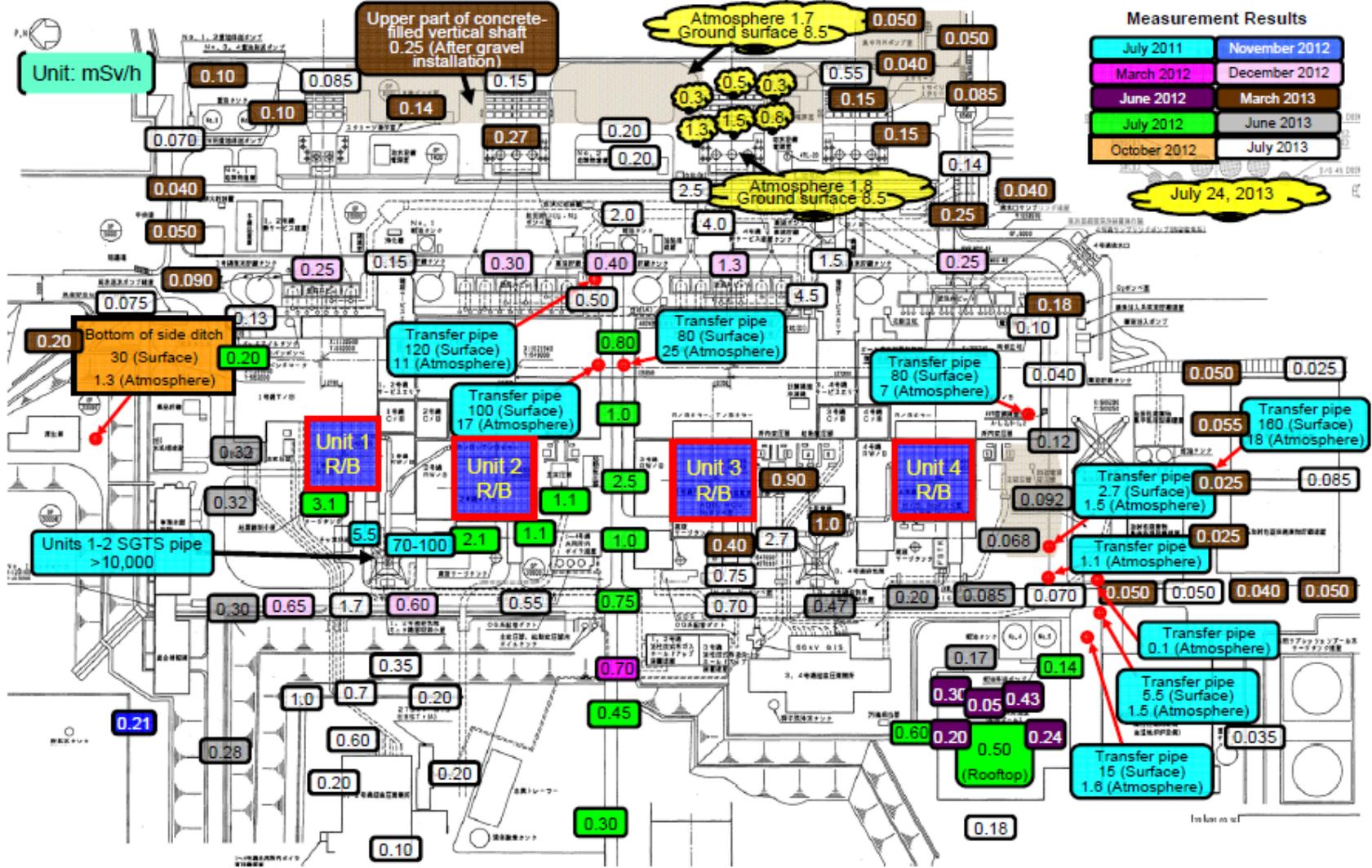


Unit: mSv/h

Nov 10, 2011

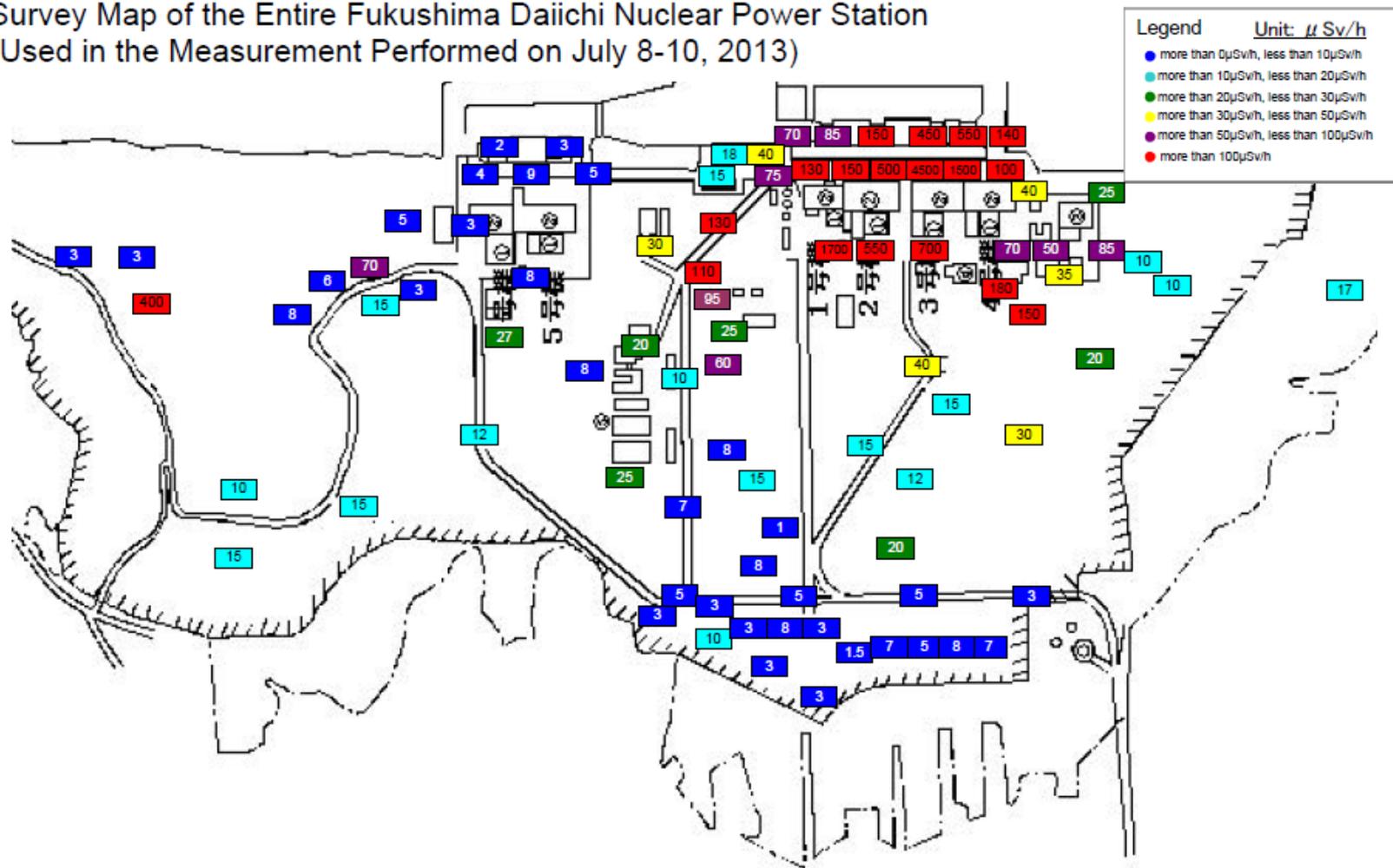


## Fukushima Daiichi NPS Survey Map (As of 12:00 PM on August 2, 2013)



# Survey Map of the Entire Fukushima Daiichi Nuclear Power Station

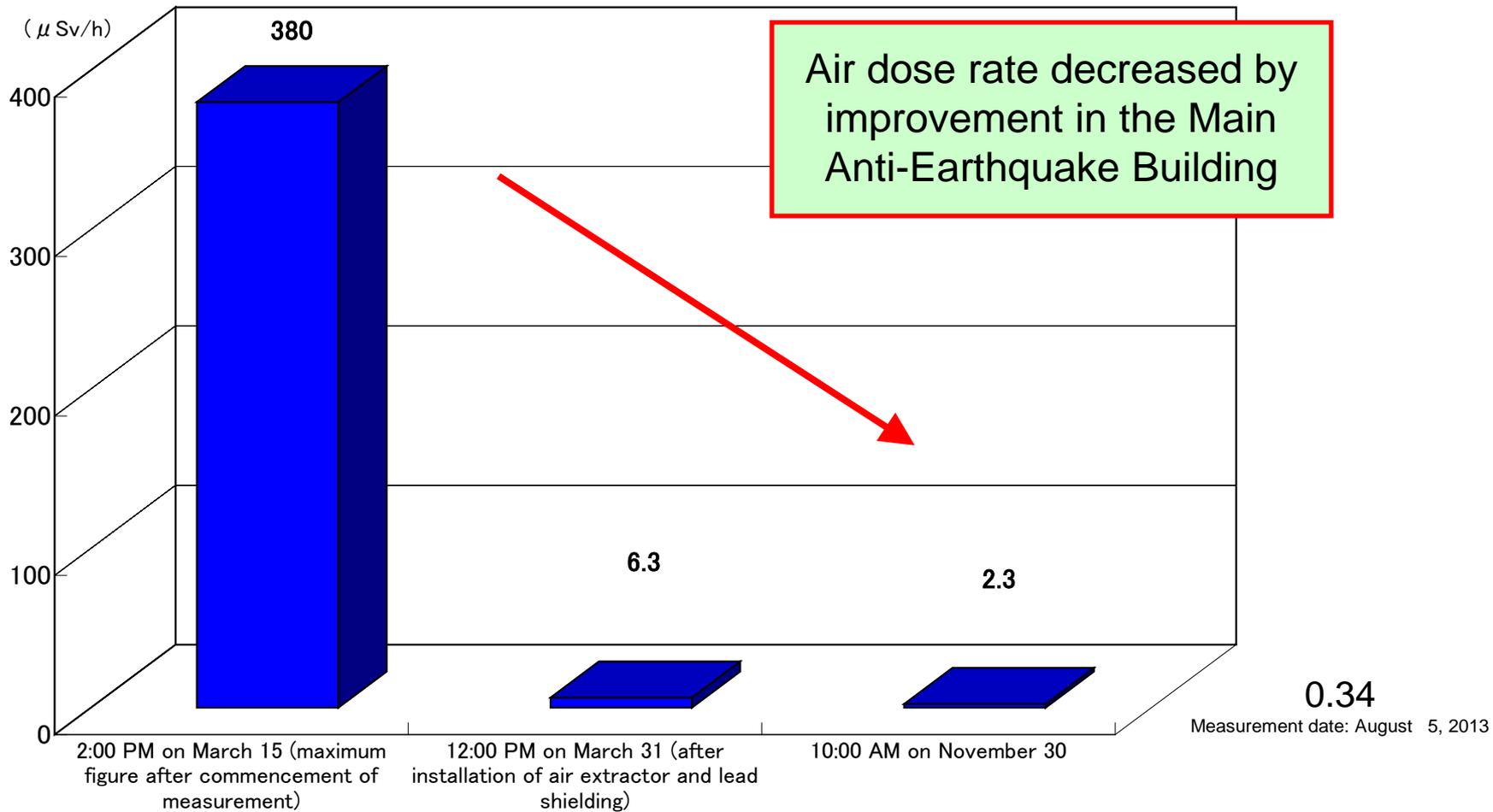
Survey Map of the Entire Fukushima Daiichi Nuclear Power Station  
(Used in the Measurement Performed on July 8-10, 2013)



Following amount in the red frames were corrected on July 26, 2013.  
450→4500, 150→1500, 170→1700

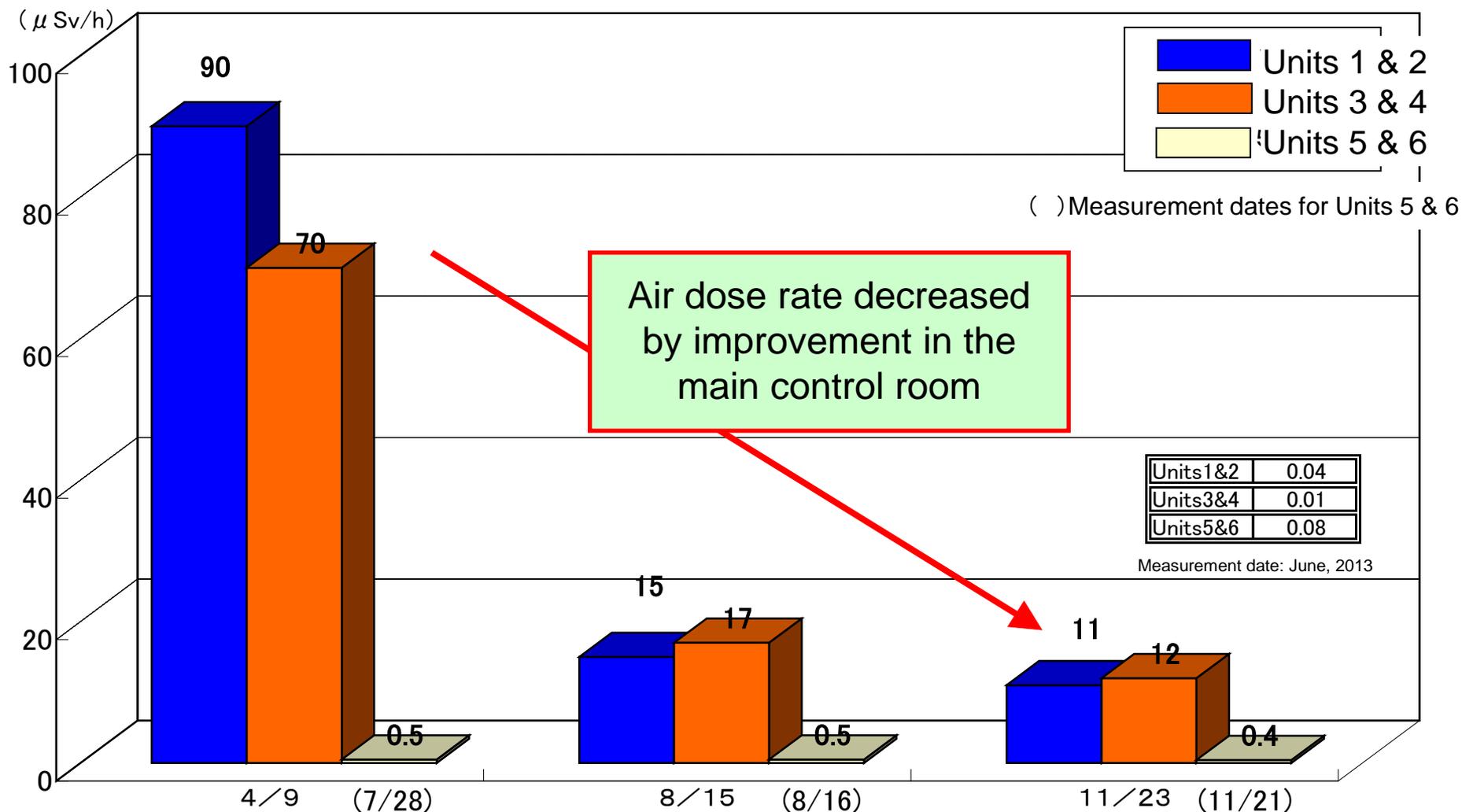
# Air dose rate on 2FL, Main Anti-Earthquake Building

Air dose rate at the emergency response room, 2FL, Main Anti-Earthquake Building (the maximum at indoor)



# Air dose rate in the main control room

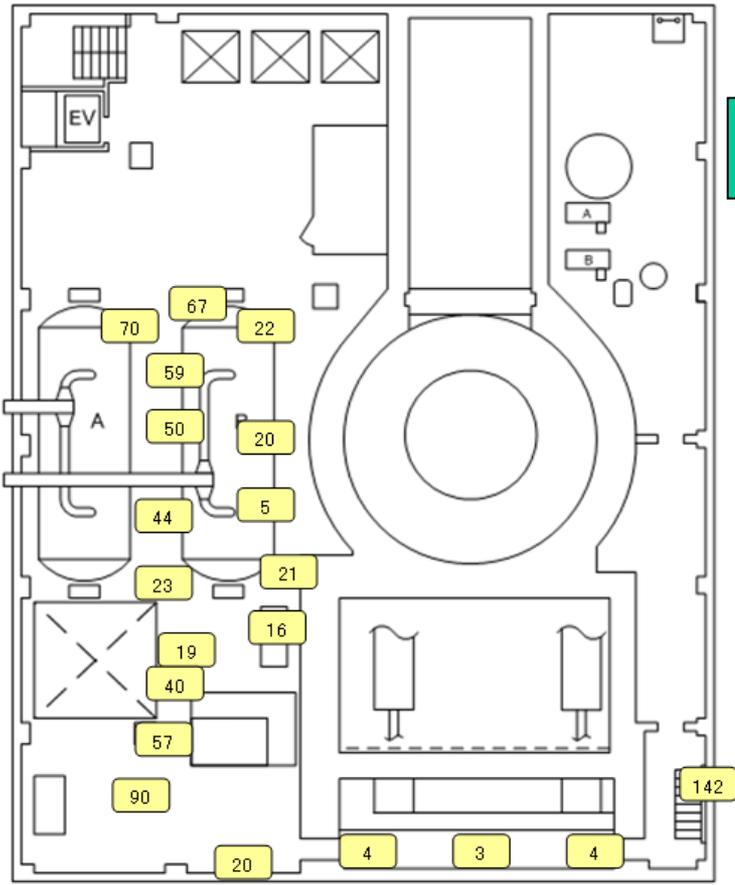
Air dose rate in the main control room for each Unit (sample point)



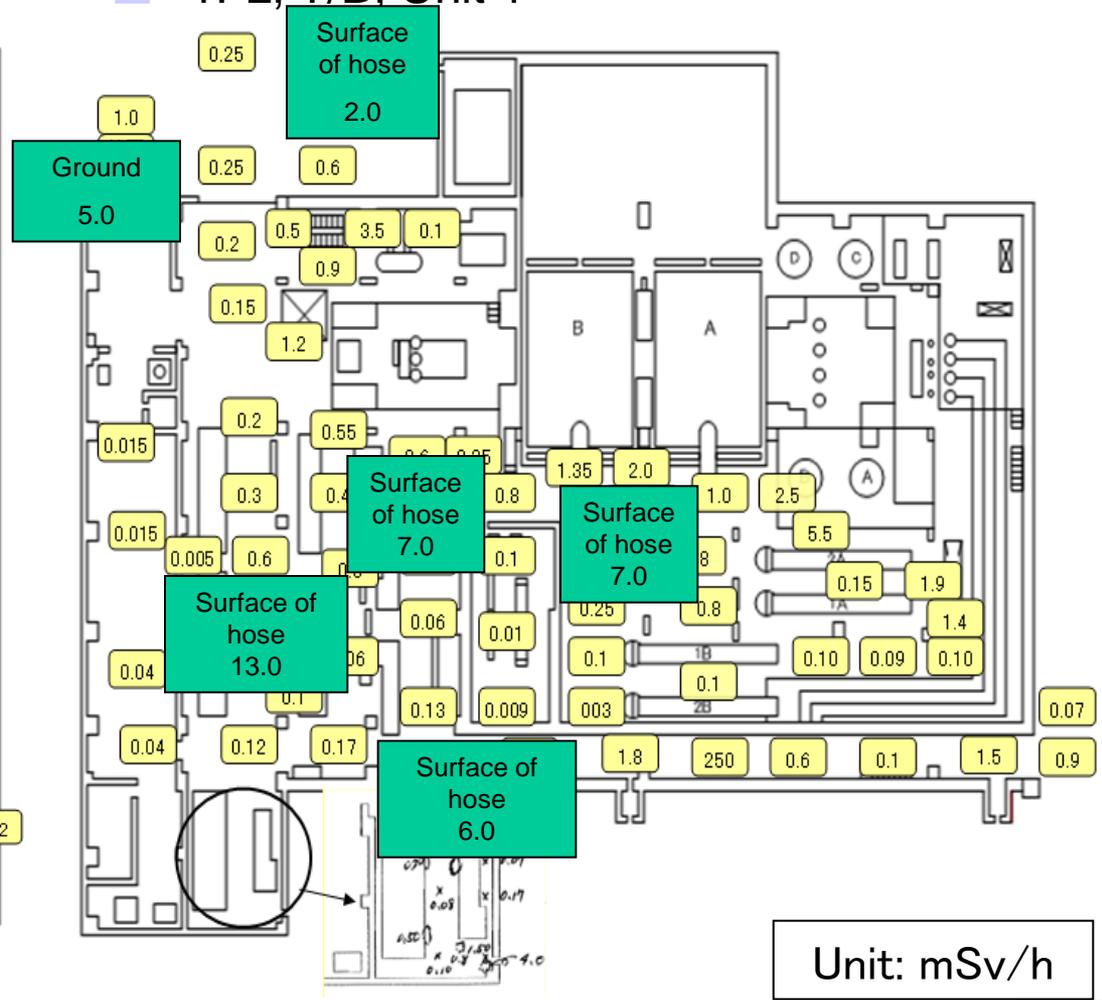
# Air dose rate in buildings

We are endeavoring to reduce radiation dose by sharing info regarding the air dose rate at the work site.

■ 4FL, R/B, Unit 1



■ 1FL, T/B, Unit 1



Unit: mSv/h

# Current Dose Rates in the Power Station Site and Implementation of Decontamination

## < Current Status >

- The dose rates within the power station site vary in the range of a few  $\mu\text{Sv/h}$  to  $1000\mu\text{Sv/h}$  and higher due to the impact of radioactive fallouts. (See the figure on the right)
- The high dose area around Units 1-4 (the area within the black dotted circle) is particularly affected by direct radiation as it is close to the Reactor Buildings. On the other hand, the area outside of the circled area is more affected by radioactive fallouts which land on the ground surface.

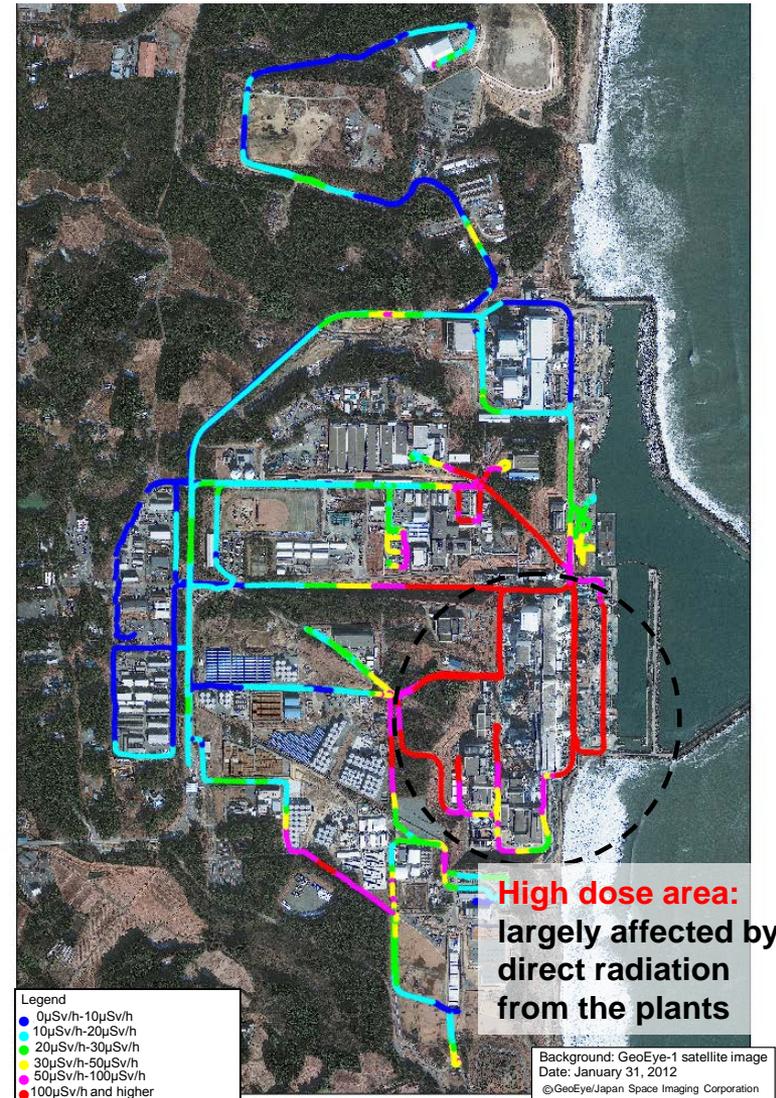
## < Decontamination measures >

- For the area within the power station site excluding the high dose area, the radioactive materials accumulated on the ground surface will be steadily removed (decontaminated) while reducing radiation exposure doses among workers [Dose reduction]. Furthermore, the area not requiring mask (breath protection tool) will be expanded while making sure that the radioactivity density of the air in the area is below the level requiring mask [Nonrequirement of mask].

\*Teams in charge of decontamination are as follows. Outdoor: environmental dose reduction team, office areas and rest areas: working environment improvement team, work area inside buildings: fuel debris removal preparation team. As for the high dose area around Units 1-4, necessary dose reduction measures such as shielding are being implemented.

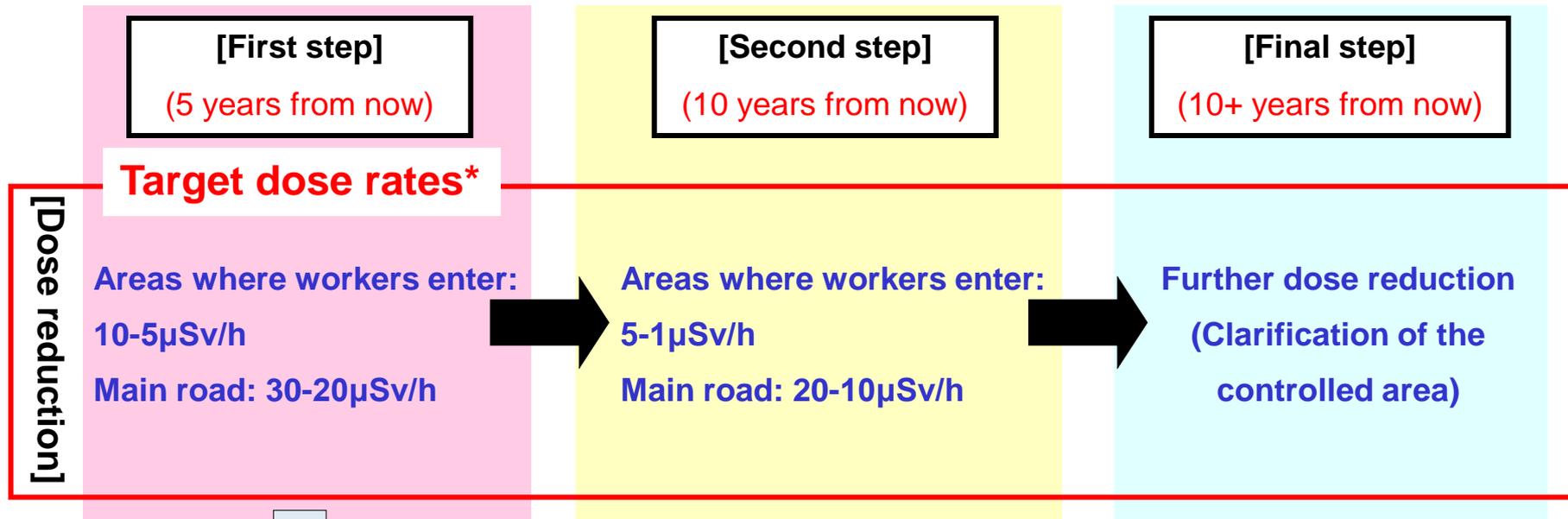
Air dose rates in the vehicle at a running survey

Measurement date: Wednesday, May 9, 2012



# Mid-to-long Term Goal of Dose Reduction

For the purpose of reducing doses in areas where many workers enter, the locations subject to decontamination are selected and target dose rates are set for each step. The target dose rates are gradually reduced for each step aiming for the levels before the accident.



[Areas where workers enter for which dose reduction measures have been implemented (See page 4)]

- Around the Main Anti-earthquake Building (Implemented in January 2012)
- Bus stop area in front of the Main Anti-earthquake Building (Implemented in September 2012)
- Around the main gate (Implemented in May 2013)
- The Entrance Control Building (Implemented in June 2013)

\*The target dose rates for the main road and the areas where workers enter are set separately since workers only pass through the main road in a vehicle.

# Areas Subject to Dose Reduction

Air dose rates in the vehicle at a running survey

Measurement date: Wednesday, May 9, 2012

Areas subject to dose reduction selected for the purpose of reducing doses in areas where many workers enter and the current dose rates

6. Around the Incinerator Building (to be constructed):

Less than 50 $\mu$ Sv/h

4. Around Units 5-6: Less than 30 $\mu$ Sv/h

5. Main road (Shiomizaka, etc. Points A-L):

Less than 220 $\mu$ Sv/h

1. Around the Main Seismic Building:

Less than 180 $\mu$ Sv/h

2. Around the Welfare Building: Less than 20 $\mu$ Sv/h

2. Around the Cooperative Company Building:

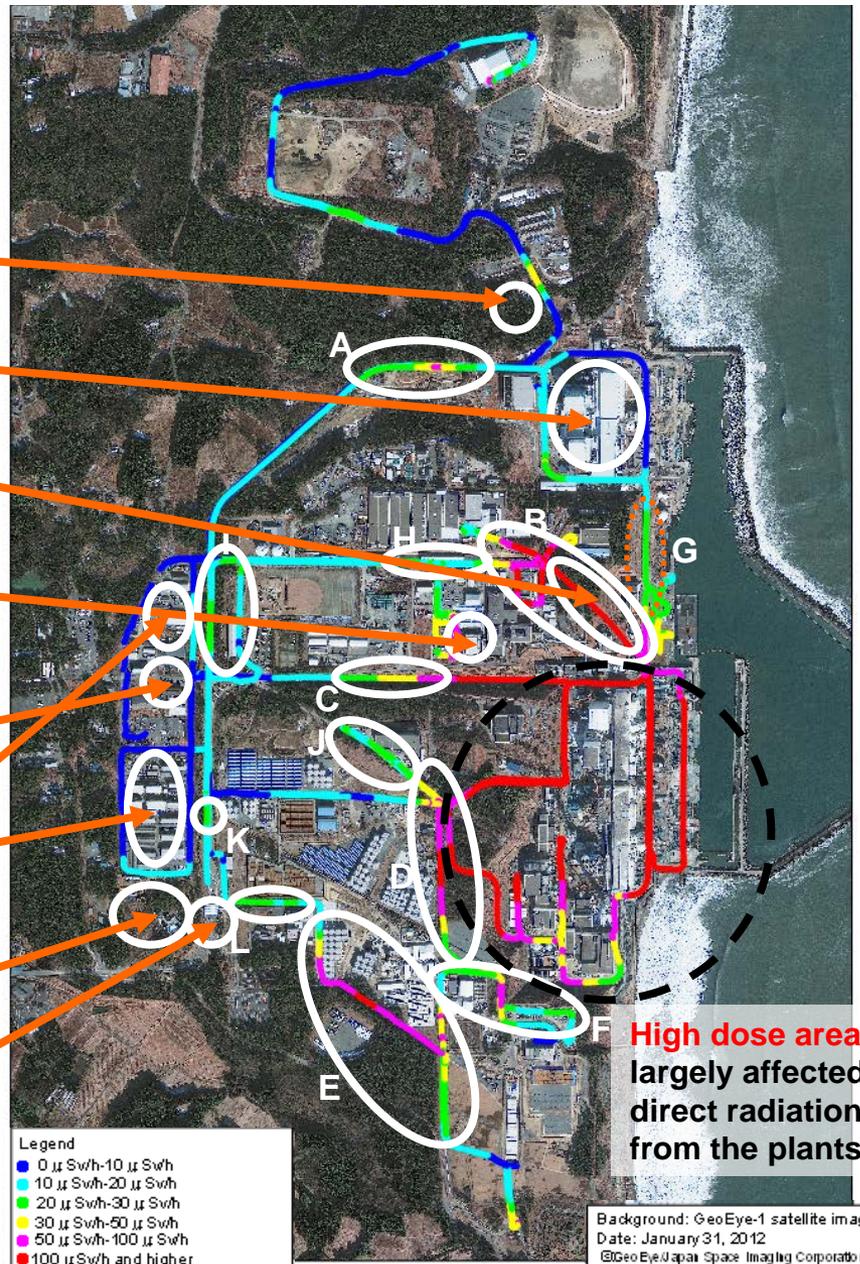
Less than 20 $\mu$ Sv/h

6. Around the Entrance Control Building

(under construction): Less than 50 $\mu$ Sv/h

3. Around the main gate: Less than 25 $\mu$ Sv/h

For the locations indicated by underlined red letters, dose reduction measures have been implemented in the past.



**High dose area:**  
largely affected by  
direct radiation  
from the plants

Legend

Blue	0 $\mu$ Sv/h-10 $\mu$ Sv/h
Cyan	10 $\mu$ Sv/h-20 $\mu$ Sv/h
Green	20 $\mu$ Sv/h-30 $\mu$ Sv/h
Yellow	30 $\mu$ Sv/h-50 $\mu$ Sv/h
Magenta	50 $\mu$ Sv/h-100 $\mu$ Sv/h
Red	100 $\mu$ Sv/h and higher

Background: GeoEye-1 satellite image  
Date: January 31, 2012  
©GeoEye/Space Imaging Corporation



# Decontamination Plan for FY 2012-2014 (in the Power Station Site)

Through decontamination, the current dose rates will be gradually reduced to the target dose rates while making sure not to exceed the workers' exposure dose limit. The concrete decontamination plan (range of decontamination area, decontamination method, etc.) will be developed separately in consideration of the geography of the site and the radiation source.

	Area subject to dose reduction	Current dose rate	Target dose rate	Decontamination tools (Planned)	Implementation timing
1	Around the Main Seismic Building (in front of the entrance, parking lot)	Less than 180 $\mu$ Sv/h	10-5 $\mu$ Sv/h	Decontamination of asphalt by high pressure water, shielding by installing steel plates, etc.	FY2012-
2	Around the Welfare Building and the Cooperative Company Building (in front of the entrance, parking lot)	Less than 20 $\mu$ Sv/h	10-5 $\mu$ Sv/h	Decontamination of asphalt by high pressure water, trimming lawn and plants, pruning, etc.	FY2013-2014
3	Around the main gate (the area security guards work)	Less than 25 $\mu$ Sv/h	10-5 $\mu$ Sv/h	Decontamination of asphalt by high pressure water, trimming lawn and plants, pruning, etc.	FY2012
4	Around Units 5-6	Less than 30 $\mu$ Sv/h	10-5 $\mu$ Sv/h	Decontamination of asphalt by high pressure water, trimming lawn and plants, pruning, etc.	FY2014
5	Main road (Shiomizaka, etc. Points A-L)	Less than 220 $\mu$ Sv/h	30-20 $\mu$ Sv/h	Removal of highly radioactive sand accumulated on road shoulders, trimming lawn and plants, pruning, etc.	FY2013-
6	Entrance Control Building, Incinerator Building, etc.	Less than 50 $\mu$ Sv/h	10-5 $\mu$ Sv/h	Land leveling for construction of buildings, etc. (deep plowing, etc.), concrete construction, etc.	FY2012- FY2014

The decontamination plan for FY2015 and on will be developed in consideration of the site conditions.

# Mid-to-long Term Goal of Expanding Area Not Requiring Mask

Current



As the radioactive material concentration in air is below the level requiring mask (Particle Cs:  $2 \times 10^{-4} \text{ Bq/cm}^3$ ), the areas indicated in blue have been designated as area not requiring mask.

[1st step] (5 years from now)



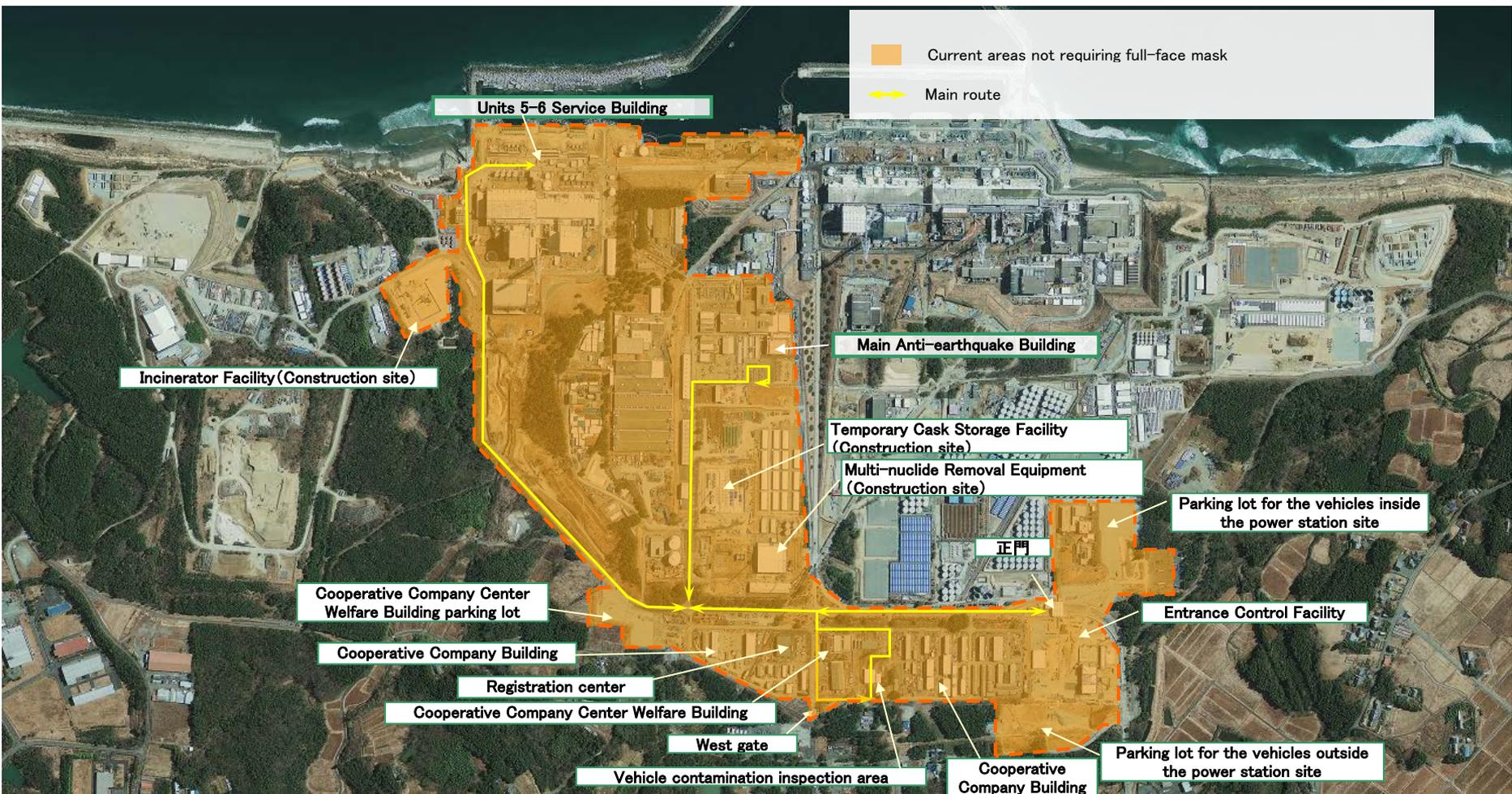
With the amount of radioactive materials flying into the air being reduced through decontamination, area not requiring mask will be expanded to other areas within the power station site excluding the high dose area around Units 1-4, tank installation areas and the forest.

[2nd step] (10+ years from now)



Area not requiring mask will be further expanded according to the reduction in tank installation area, etc. as a result of making the reactor cooling loop smaller and installation of waste storage facilities (excluding the high dose area around Units 1-4 and the forest).

# Expansion of the Areas not Requiring Full-face Mask in Fukushima Daiichi NPS



< Areas not requiring full-face mask in Fukushima Daiichi NPS >

**Areas within the dotted line excluding the surrounding area of Unit 1-4, the tank area and the debris storage area are designated as areas not requiring full-face mask. (at the date of August, 2013)**

# Classification of the required mask in the site of Fukushima Daiichi NPS

<Classification of the required mask in the site of Fukushima Daiichi NPS>

	<b>Inside Unit 1-4 Buildings and the surrounding buildings, <math>\beta</math>-ray area</b>	<b>Areas other than areas not requiring full-face mask</b> (Surrounding area of Unit 1-4, debris storage area, etc.)	<b>Areas not requiring full-face mask</b> (Outdoor areas such as surrounding area of Unit 5 and 6, around the Main Anti-earthquake Building, around the Cooperative Company Center Welfare Building and the Cooperative Company Building, around the Main gate)
Works handling highly radioactive dust	Full-face mask	Full-face mask or half-face mask + goggle	Full-face mask or half-face mask + goggle 
Other works	Full-face mask	Half-face mask	Disposal dust mask 

\* Full-face mask and half-face mask with particle filtration efficiency of more than "99.9%" and disposal dust mask with particle filtration efficiency of more than "95%" is required. The workers who work in areas where the radioactivity density in the air is confirmed to be less than  $1 \times 10^4 \text{Bq/kg}$  (currently, areas around the main gate and the Entrance Control Facility) can use surgical mask.  
 The use of mask in the areas not requiring full-face mask is classified into two. Full-face (half-face) mask is required during the work handling highly radioactive dust, and disposal dust mask is required during the other work in order to ensure safety and appropriate operation control of the areas in accordance with the regulation related to ionizing radiation during decontamination.

# **Dose Reduction in Front of Seismic Isolation Building at Fukushima Daiichi Nuclear Power Station**

## **Measures to Reduce the Environmental Dose**

**Purpose: To reduce the dose workers incur when moving around at Fukushima Daiichi Nuclear Power Station.**

**Collection of small debris: January 7 - January 30, 2012 (Announced)**  
**Laying of steel plates: August 20 – September 26, 2012**

# 1<sup>st</sup> Measure - Collection of Small Debris

Implementation period: January 7 – January 30, 2012

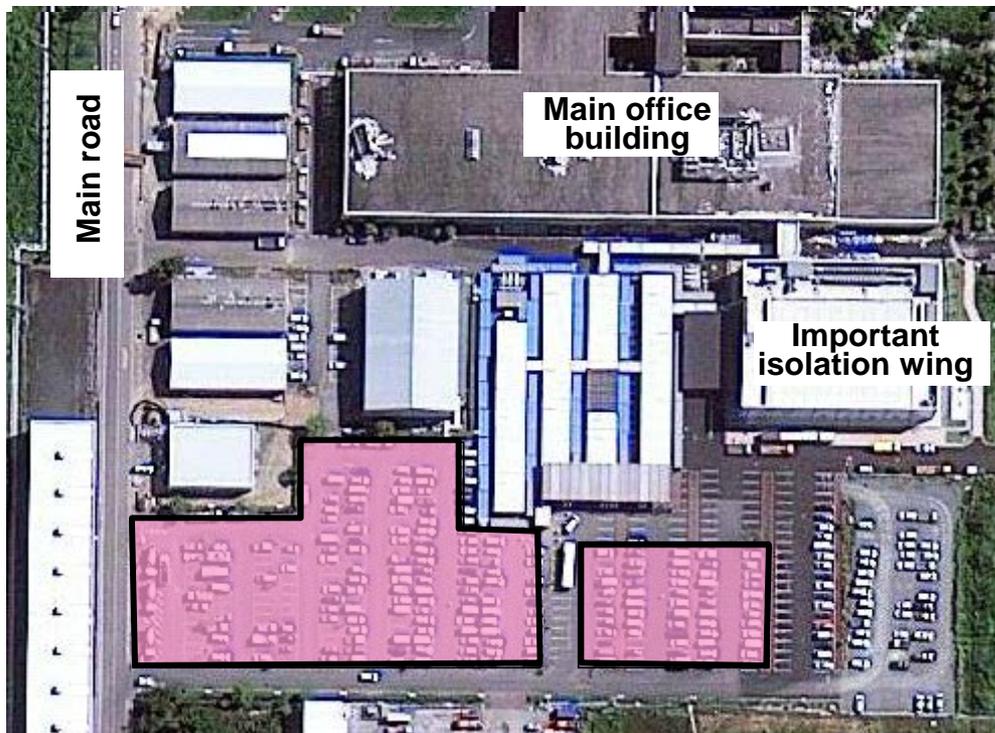
Area: Front parking area of the seismic isolation building

(Excluding the bus route, shown within the  area below.)

Method: Mainly the collection of small debris on the road.

Result: Confirmed approximate reduction of 34% in the average dose rate from before

(Before) 82 [ $\mu$  Sv/h]  (After) 54 [Sv/h]



(C)GeoEye / Japan Space Imaging



<Dust collector used>

# 2<sup>nd</sup> Measure - Laying of steel plates

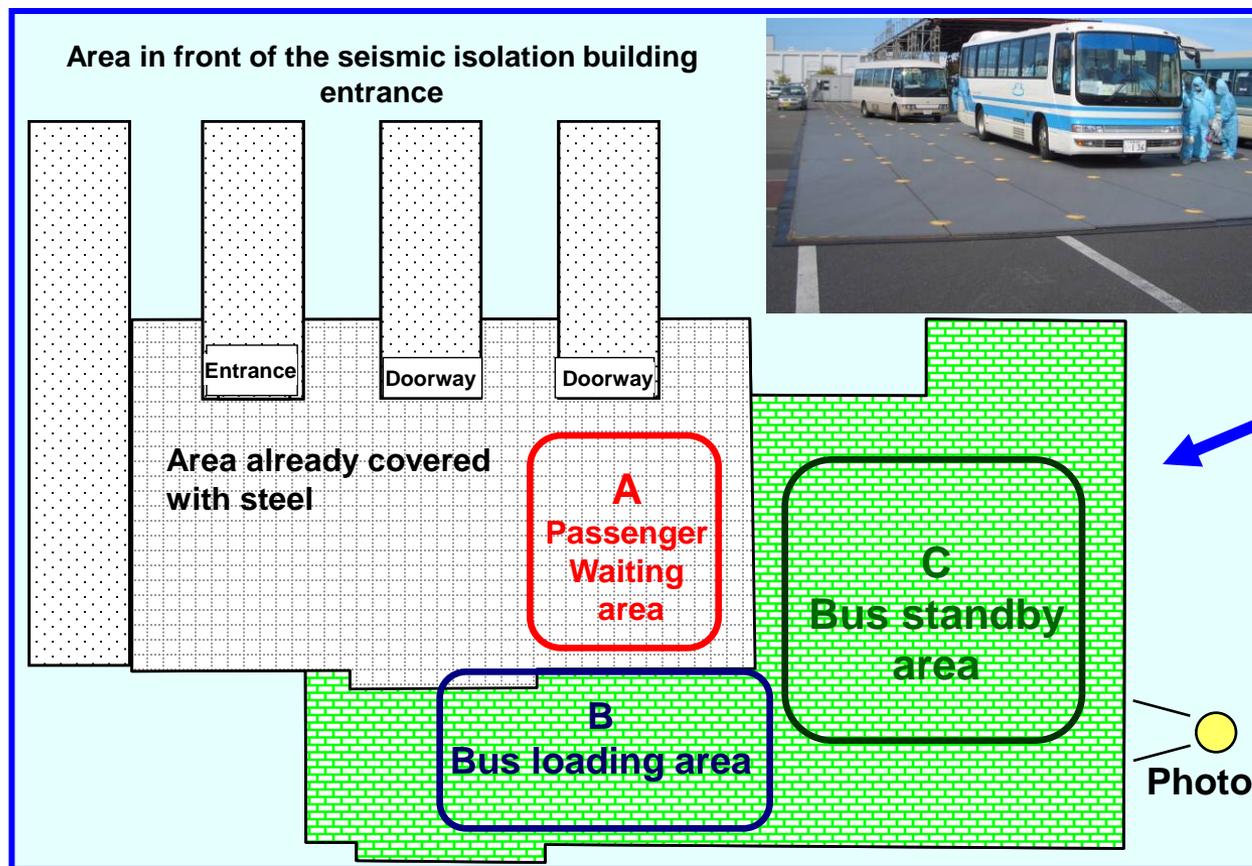
Implementation period: August 20 – September 26, 2012

Area: Area in front of the seismic isolation building entrance

Area for loading and waiting passengers shown below (  )

Method: Rubber mats (10mm thickness) + laying of steel plates (22mm thickness)

Result: Confirmed reduction of approx. 58% in the average dose rate in the lower chest area



	Average dose rate (Previously measured values)	
<b>A</b>	<b>30 (48)</b>	<b>↓ 37%</b>
<b>B</b>	<b>37 (87)</b>	<b>↓ 58%</b>
<b>C</b>	<b>42 (100)</b>	<b>↓ 58%</b>
<b>Inside the bus</b>	<b>15 (60)</b>	<b>↓ 75%</b>

Unit:  $\mu\text{Sv/h}$

Measures were taken to reduce the dose in the area in front of the seismic isolation building to reduce the dose workers incur when moving around at Fukushima Daiichi Nuclear Power Station.

## 1<sup>st</sup> Measure – Collection of small debris

The dose rate (chest area) was reduced by 34% in the overall parking area in front of the seismic isolation building to an average of around 54 [ $\mu$  Sv/h]. [As of January 2012]

Goal: Dose rate of 30 [ $\mu$  Sv/h ] or less for workers waiting for the bus or inside the bus.

## 2<sup>nd</sup> Measure – Laying of steel plates

The dose rate (chest area) for the bus loading and standby area in front of the seismic isolation building entrance was reduced by around 58% to 37 – 42 [ $\mu$  Sv/h]. In addition, the rate within the bus dropped around 75% to 15 [ $\mu$  Sv/h]. [As of September 2012]

We will continue to work on maintaining the environment in front of the seismic isolation building and reducing the dose rate.

# Dose reduction measure implementation situation

①



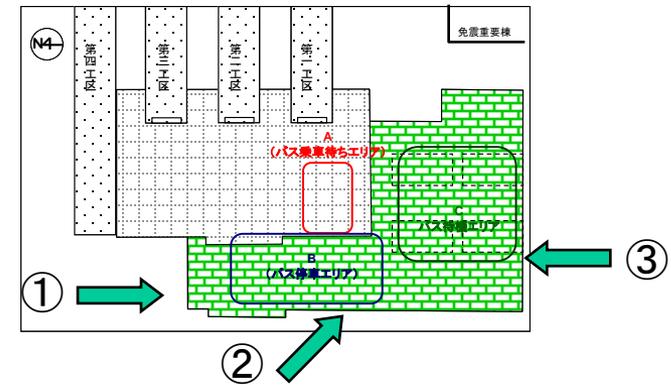
②



③



Implementation period:  
August 20 – September 26, 2012



# **Dose Reduction Around Front Gate Security Guard at Fukushima Daiichi Nuclear Power Station**

## **Measures to Reduce the Environmental Dose**

**Purpose : Main gate circumference area is decontaminated for the purpose of gate security guard's contamination reduction.**

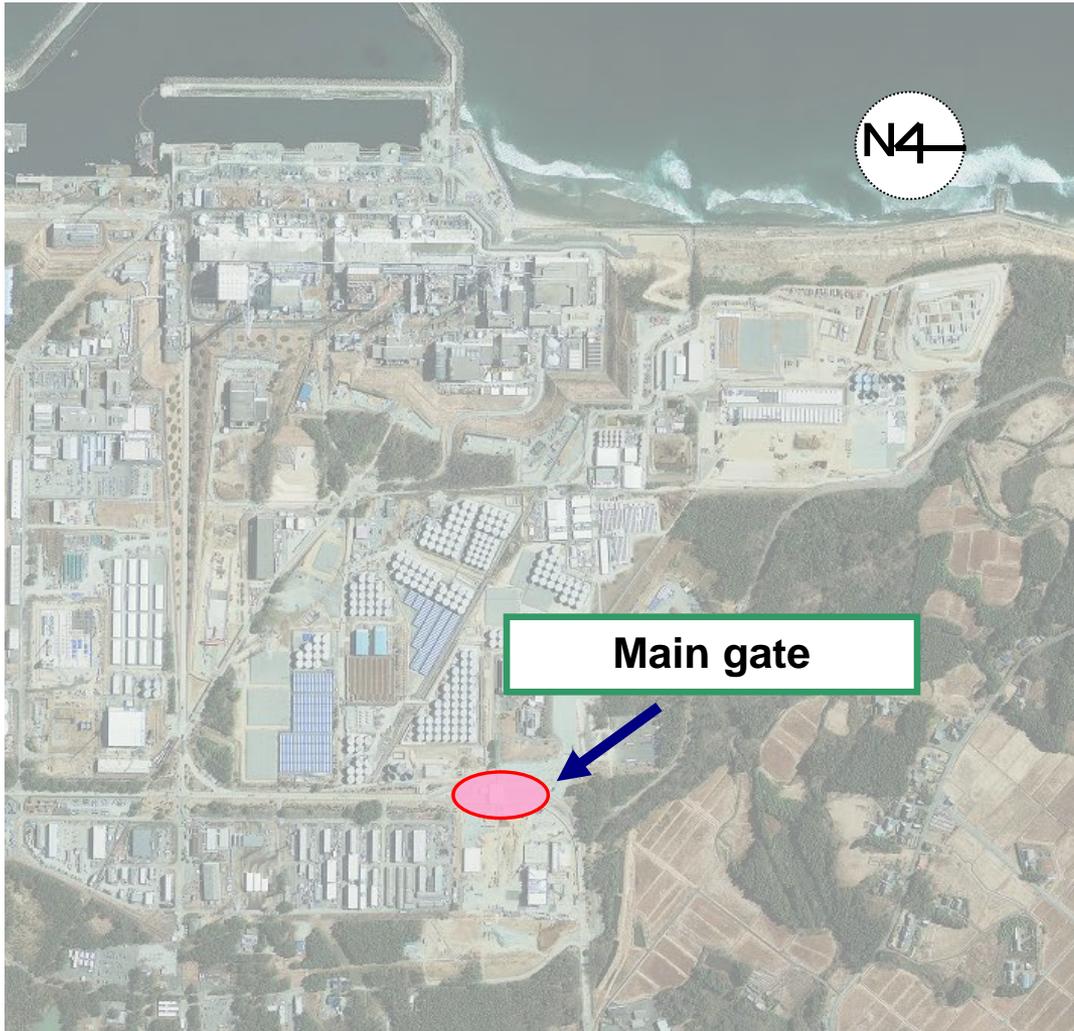
**Work period : December 10,2012-April 30 2013**



# Decontamination Area and Method

Decontamination shall be carried out by plowing to replace surface soil with subsoil for the green (soil) area and by washing with super high pressure water for the paved area.

## Fukushima Daiichi Nuclear Power Station



Cutting by super high pressure water



Plowing

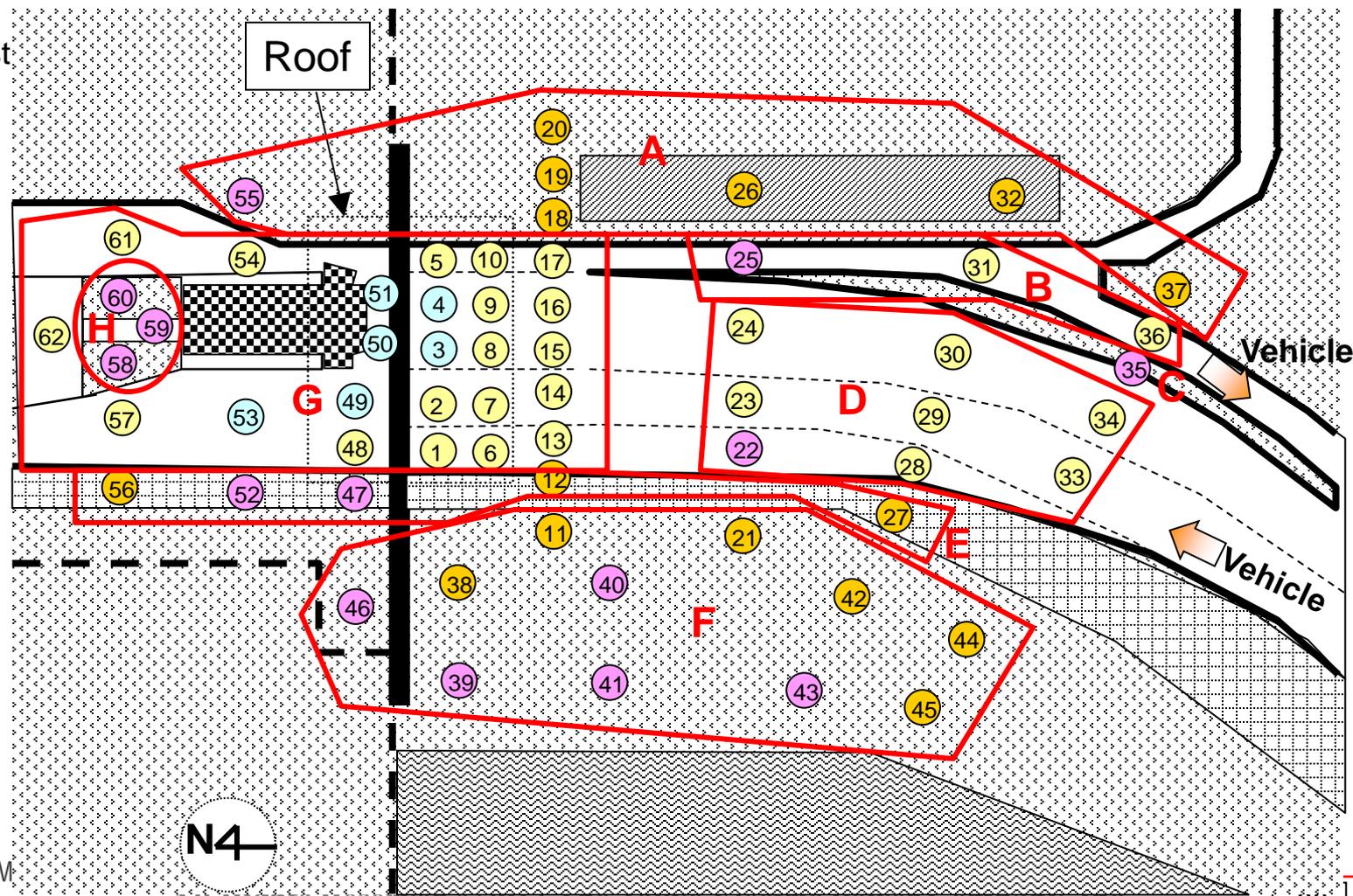
# Result of Measurement of Radiation Dose before Weeding

■ Mean dose rate at the work area of the front gate security guards is 13.6 [ $\mu$ Sv/h].

Dose rate at the chest

- ~ 5 [ $\mu$ Sv/h]
- ~ 10 [ $\mu$ Sv/h]
- ~ 20 [ $\mu$ Sv/h]
- ~ 30 [ $\mu$ Sv/h]
- 30~ [ $\mu$ Sv/h]

- Asphalt
- Lawn or sand
- Grove of trees
- Sidewalk (cushioning properties)
- Control room
- Soil depot



- Before decontamination, since the dose rates of gate security guard work area is  $13.6\mu\text{Sv/h}$ , a gate security guard's annual dose is set to  $27.6\text{mSv}^{*1}$ .
- Under this environment, since  $100\text{mSv} / 5$  years of the dose limit of a statute are exceeded, gate security guard resident area is decontaminated so that the dose limit of a statute may be filled.
- The target dose rates after decontamination is set to  **$5\mu\text{Sv/h}$** (annual dose  $9\text{mSv}$ ) <sup>\*2</sup>.

※1 Annual office hours is made into a maximum of 2000 hours from the track record.

※2 In order to fulfill a statute limit,  $10\mu\text{Sv/h}$  may be sufficient, but a dose is reduced as much as possible, and in order to carry out generous dose management, the dose rates after decontamination is made into  $5\mu\text{Sv/h}$ .

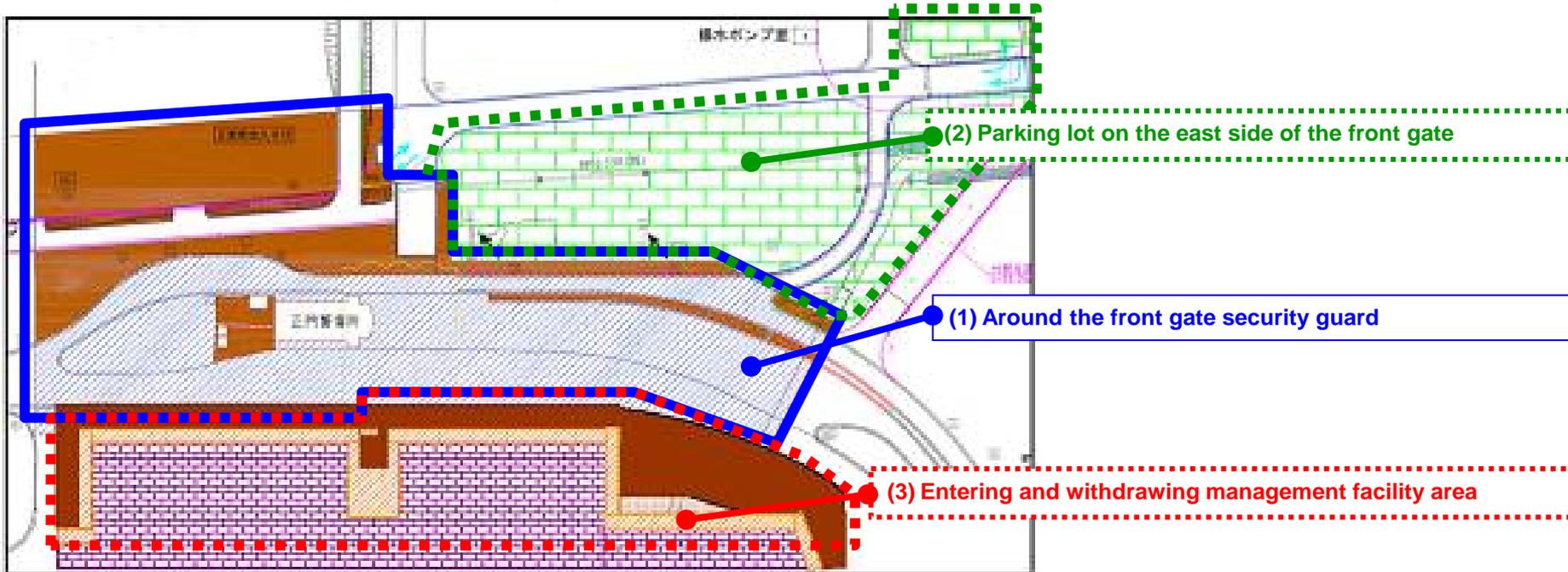
# Decrease of Radiation Dose Around Front Gate Security Guard

## ■ Objective

Decontamination of the surrounding area shall be carried out based on “Mid-and-long Term Enforcement Policy of Decontamination on the Premises” to decrease the exposure dose of the security guards.

## ■ Decontamination Area and Method

Decontamination shall be carried out by plowing to replace surface soil with subsoil for the green (soil) area and by washing with super high pressure water for the paved area.



Legend	Details
	<ul style="list-style-type: none"> <li>◆ Removal of deposits</li> <li>◆ Cutting by super high pressure water</li> </ul>
	<ul style="list-style-type: none"> <li>◆ Weeding</li> <li>◆ Trimming or pruning</li> <li>◆ Plowing (replacing 10 cm of surface soil with 20 cm of subsoil) or stripping</li> </ul>
	<ul style="list-style-type: none"> <li>◆ Stripping</li> <li>◆ Aggregate (Crusher run RC-40) 30 cm</li> <li>◆ Dense-graded asphalt paving 5 cm</li> </ul>

Legend	Details
	<ul style="list-style-type: none"> <li>◆ Plowing (replacing 20 cm of surface soil with 20 cm of subsoil) or stripping</li> <li>◆ Aggregate (Crusher run RC-40) 10 cm</li> <li>◆ Dense-graded asphalt paving 3 cm</li> </ul>
	<ul style="list-style-type: none"> <li>◆ Plowing (replacing 20 cm of surface soil with 20 cm of subsoil) or stripping</li> <li>◆ Aggregate (Crusher run RC-40) 30 cm</li> <li>◆ Coarse-graded asphalt paving 5 cm</li> <li>◆ Dense-graded asphalt paving 5 cm</li> </ul>
	<ul style="list-style-type: none"> <li>◆ Weeding</li> <li>◆ Plowing (replacing 20 cm of surface soil with 20 cm of subsoil) or stripping</li> </ul>

# Result of Decreasing Radiation Dose

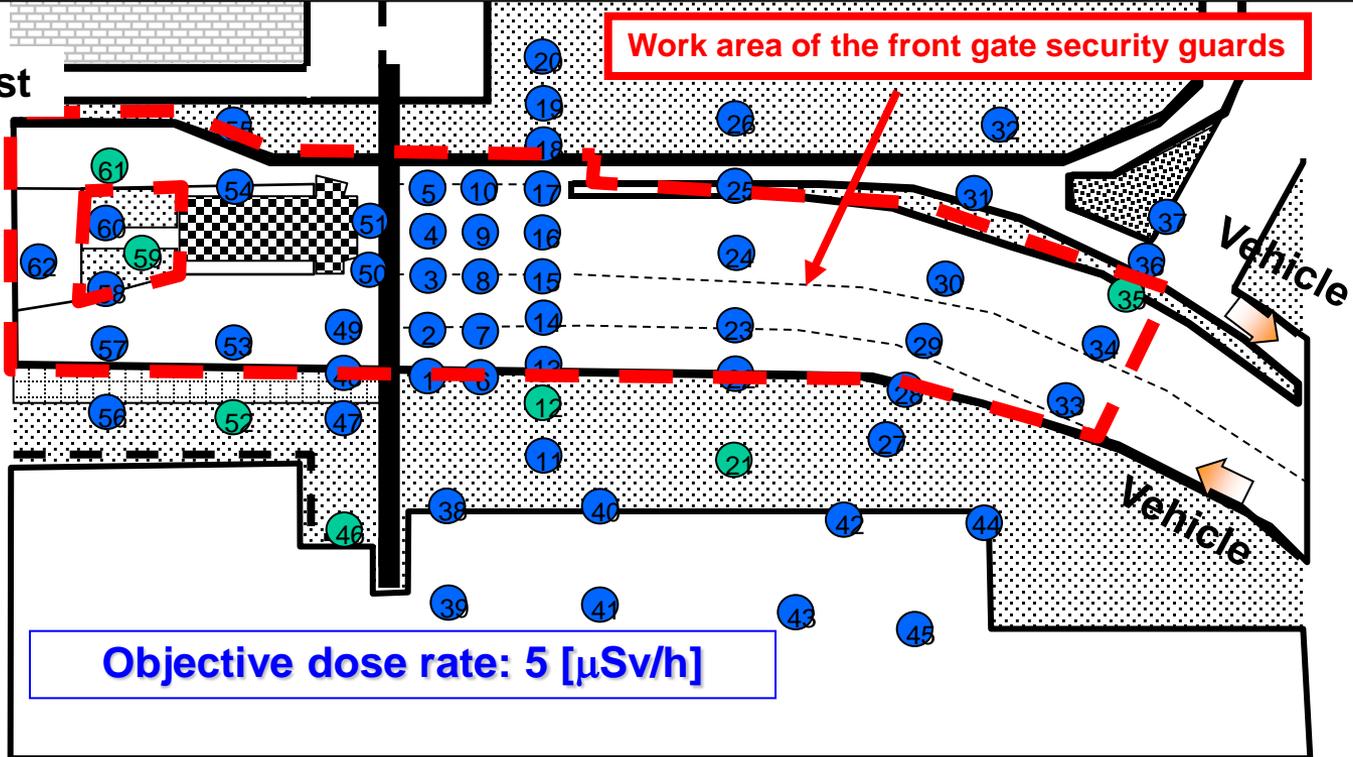
Measurement date: May 13, 2013

The mean dose rate at the work area of the front gate security guards is decreased to **3.8[μSv/h]** (before decontamination; 13.6[μSv/h]). With this, the yearly dose of the workers is well below 20[mSv/year].

## Dose rate at the chest

- ~ 5[μSv/h]
- ~ 10[μSv/h]
- ~ 20[μSv/h]
- ~ 30[μSv/h]
- 30~[μSv/h]

- Asphalt
- Soil
- steel sheet
- sidewalk
- Control room



**Before decontamination**  
 Dose rate : 13.6[μSv/h]  
 Annual dose : 27.6[mSv/y]\*  
 \*Yearly 2000 hours

Decreasing rate **72%**

**After decontamination**  
 Dose rate : 3.8[μSv/h]  
 Annual dose : 7.6[mSv/y]\*  
 \*Annually [Yearly] 2000 hours

**Goal Achievement!**



# **Dose Reduction at Entrance Control Facilities and Off-premise Vehicle Parking**

**July 25, 2013**

**Environmental Dose Reduction Team**

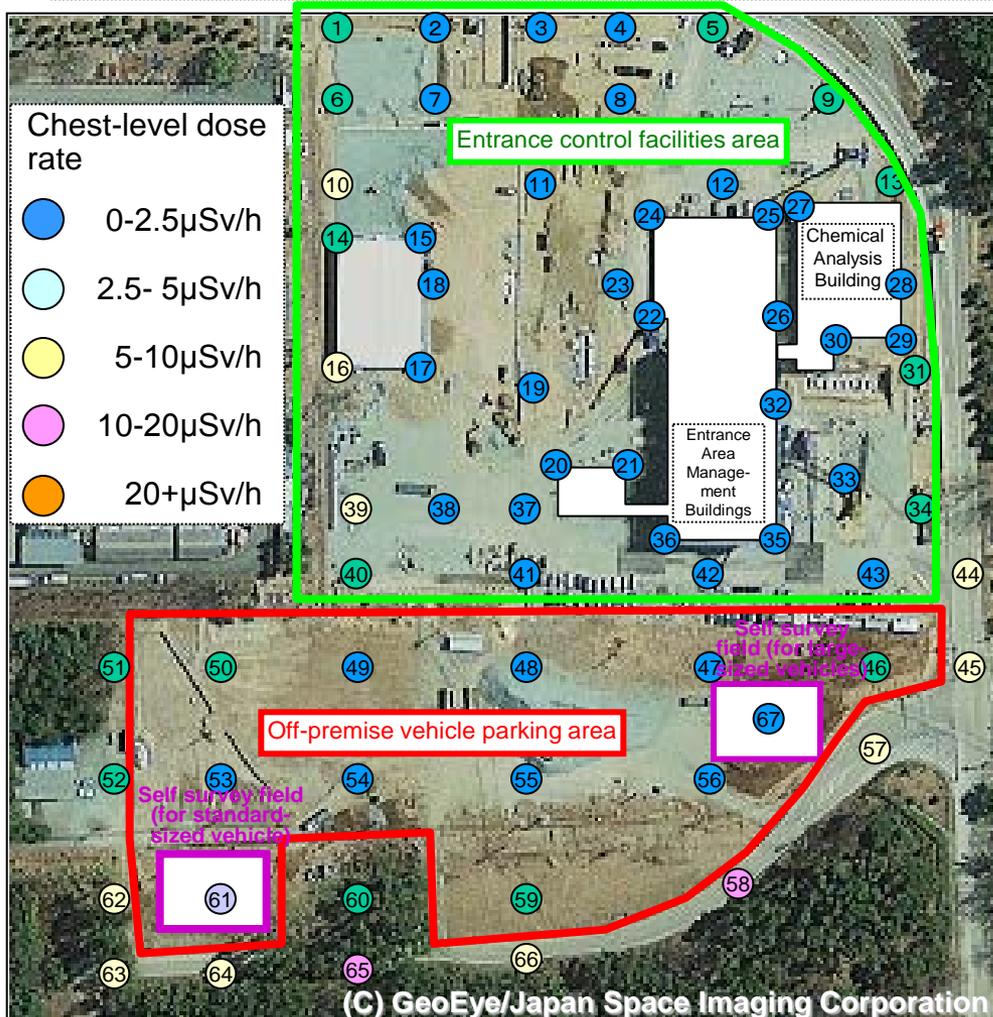
**Object: To implement dose reduction at the entrance control facilities and off-premise vehicle parking, which are accessed by a large number of workers, in Fukushima Daiichi Nuclear Power Station.**

**Construction period: July 31, 2012 to June 30, 2013**

**Construction scheme: Tree cutting and surface soil removal before construction, stone crushing and asphalt paving, etc.**

# Dose Reduction Status at Entrance Control Facilities and Off-premise Vehicle Parking (Outdoor)

The average dose rate of the entrance control facilities, the off-premise vehicle parking, and the self-survey fields was reduced to  $2\mu\text{Sv/h}$  (lower than the target dose rate). As we have done so far, we will continue the effort to maintain the environment in order to reduce radiation exposure of workers entering into and leaving from the entrance control facilities and workers working in these areas.



■ Measured dose rates ( $\mu\text{Sv/h}$ ) ■

	Entrance control facilities	Off-premise vehicle parking	Self-survey fields
	Target dose rate: 5.0	Target dose rate: 5.0	Target dose rate: 3.0
Before surface soil removal	<b>34</b> (Jun. 27, 2012)	/	/
↓			
After surface soil removal	<b>8.5</b> (Sep. 26, 2012)	<b>13</b> (Feb. 14, 2013)	<b>16</b> (Feb. 14, 2013)
↓			
After asphalt paving	<b>2.1</b> (Jun. 6, 2013)	<b>2.2</b> (Jun. 27, 2013)	<b>1.9</b> (Jun. 27, 2013)
	Target achieved	Target achieved	Target achieved

# Dose Environment inside the Entrance Area Management Buildings

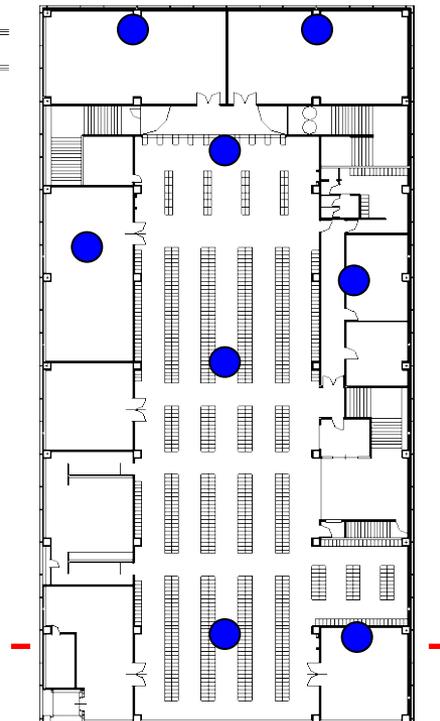
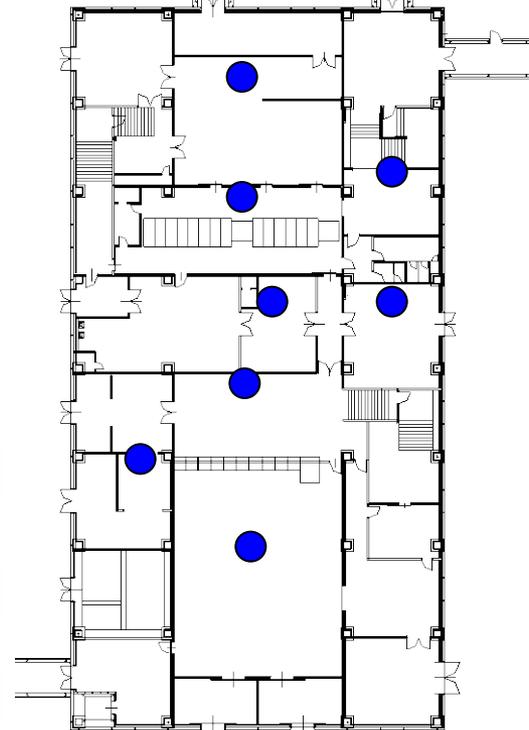
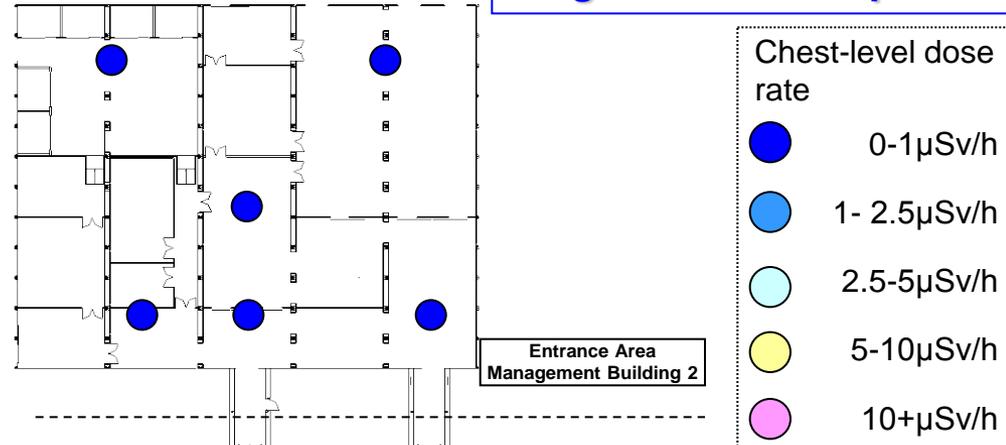
The average dose rates in Entrance Area Management Building 1 and Entrance Area Management Building 2 were reduced to **0.07 $\mu$ Sv/h** and **0.6 $\mu$ Sv/h**, respectively (the target dose rate of 1 $\mu$ Sv/h was achieved).

As we have done so far, we will continue the effort to maintain the environment in order to reduce radiation exposure of workers entering into and leaving from the Entrance Area Management Buildings and workers working in these buildings.

■ Measured dose rates ( $\mu$ Sv/h) ■ (Jun. 27, 2013)

Area	Dose rate [ $\mu$ Sv/h]	
1st Floor of Entrance Area Management Building 1	0.07	Target achieved
2nd Floor of Entrance Area Management Building 1	0.06	Target achieved
Entrance Area Management Building 2	0.57	Target achieved

Target dose rate: 1 $\mu$ Sv/h

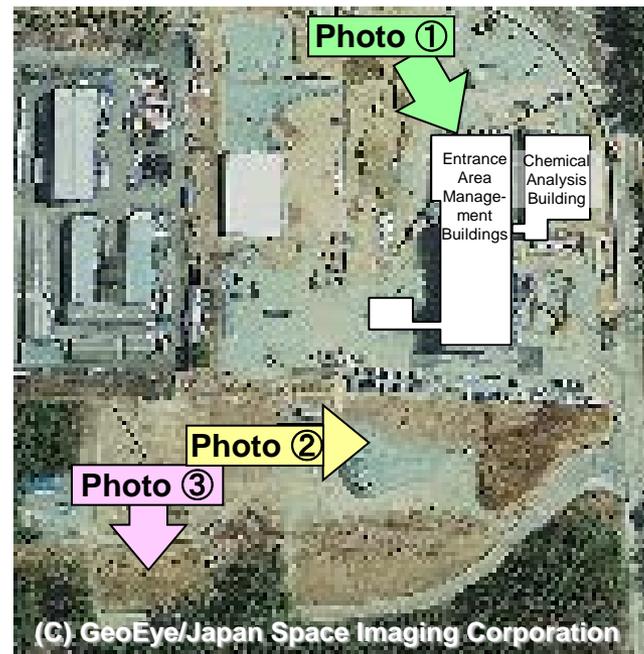


# Reference: Conditions of Entrance Control Facilities and Off-premise Vehicle Parking

[Before construction]



As of Apr. 16, 2012



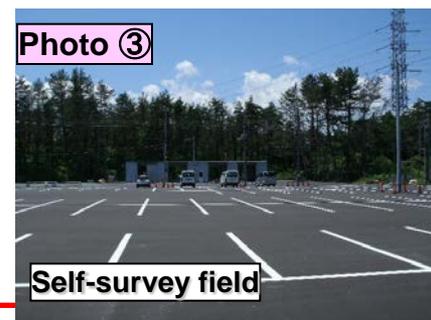
[After construction]



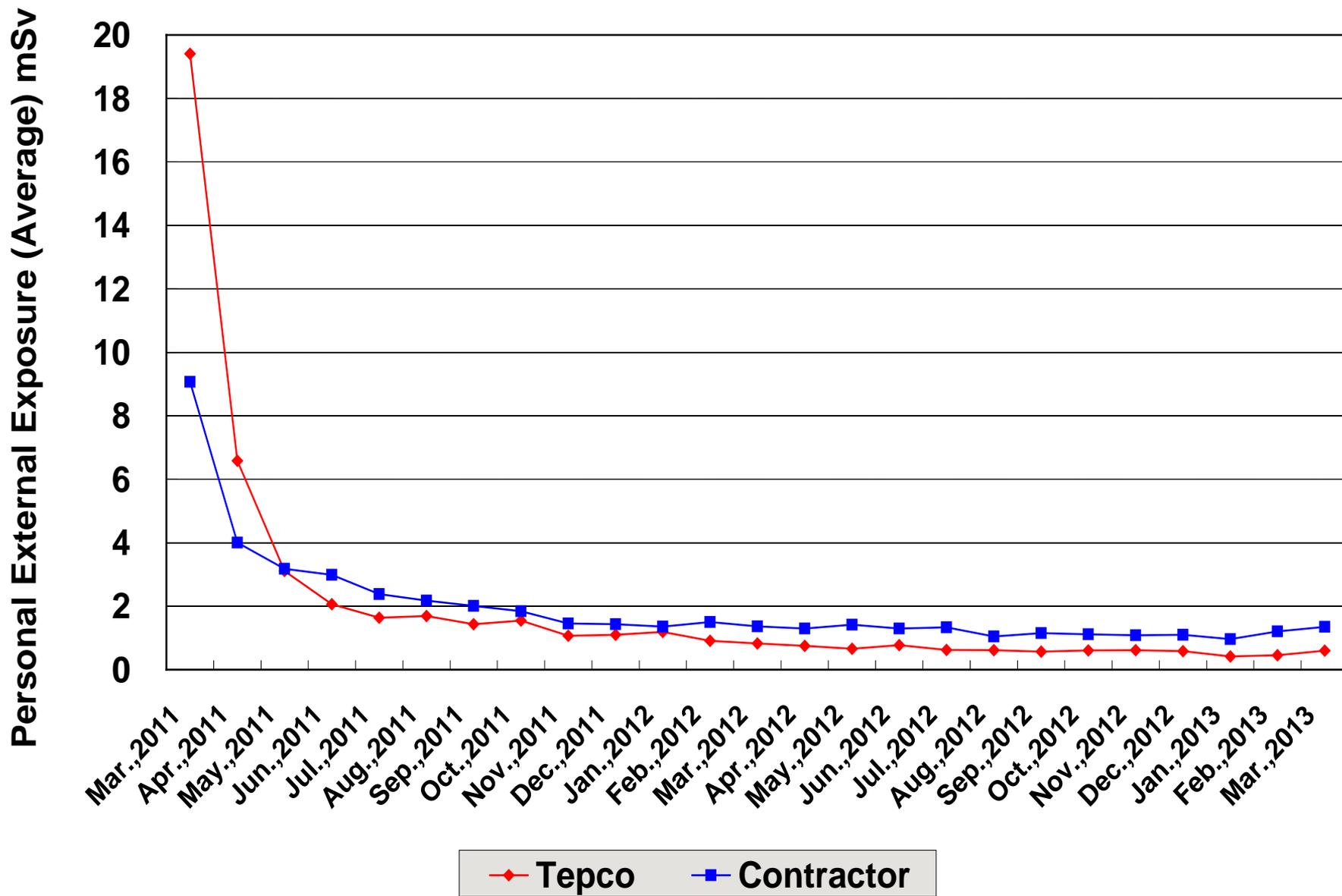
As of May 13, 2013



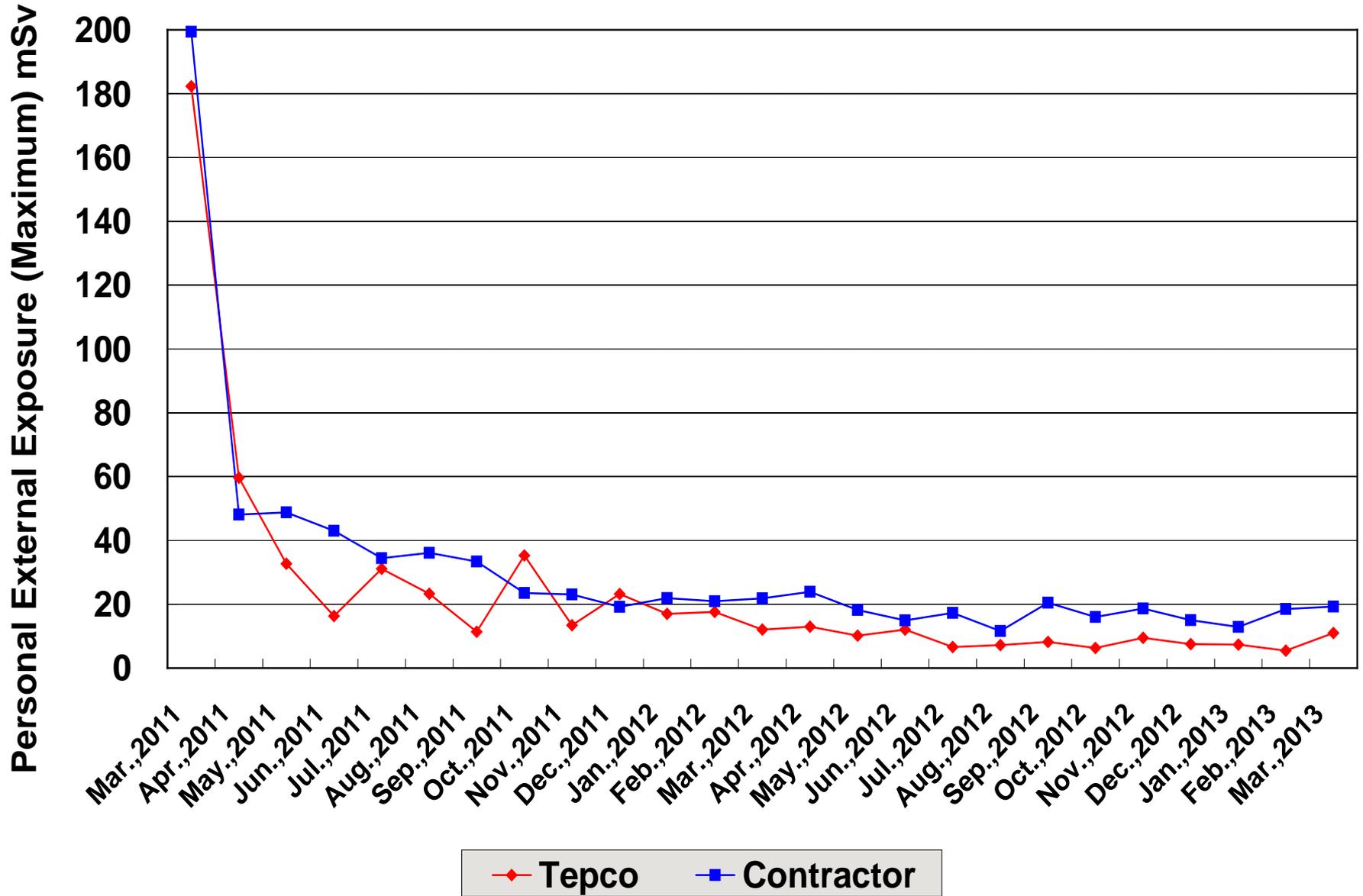
As of Jun. 27, 2013



# Worker's external exposure (Average)



# Worker's external exposure (Maximum)



# Distribution of total (internal&external) exposure

*March 2011 to March 2013*

Dose (mSv)	Tepco	Contractor	Total
Over 250	6	0	6
200~250	1	2	3
150~200	24	2	26
100~150	118	20	138
75~100	234	84	318
50~75	300	566	866
20~50	613	3620	4233
10~20	497	3499	3996
5~10	413	3236	3649
1~5	611	6067	6678
1or less	893	6545	7438
<b>Total</b>	<b>3710</b>	<b>23641</b>	<b>27351</b>
<b>Max.(mSv)</b>	<b>679</b>	<b>238</b>	<b>679</b>
<b>Ave.(mSv)</b>	<b>25</b>	<b>11</b>	<b>12</b>