

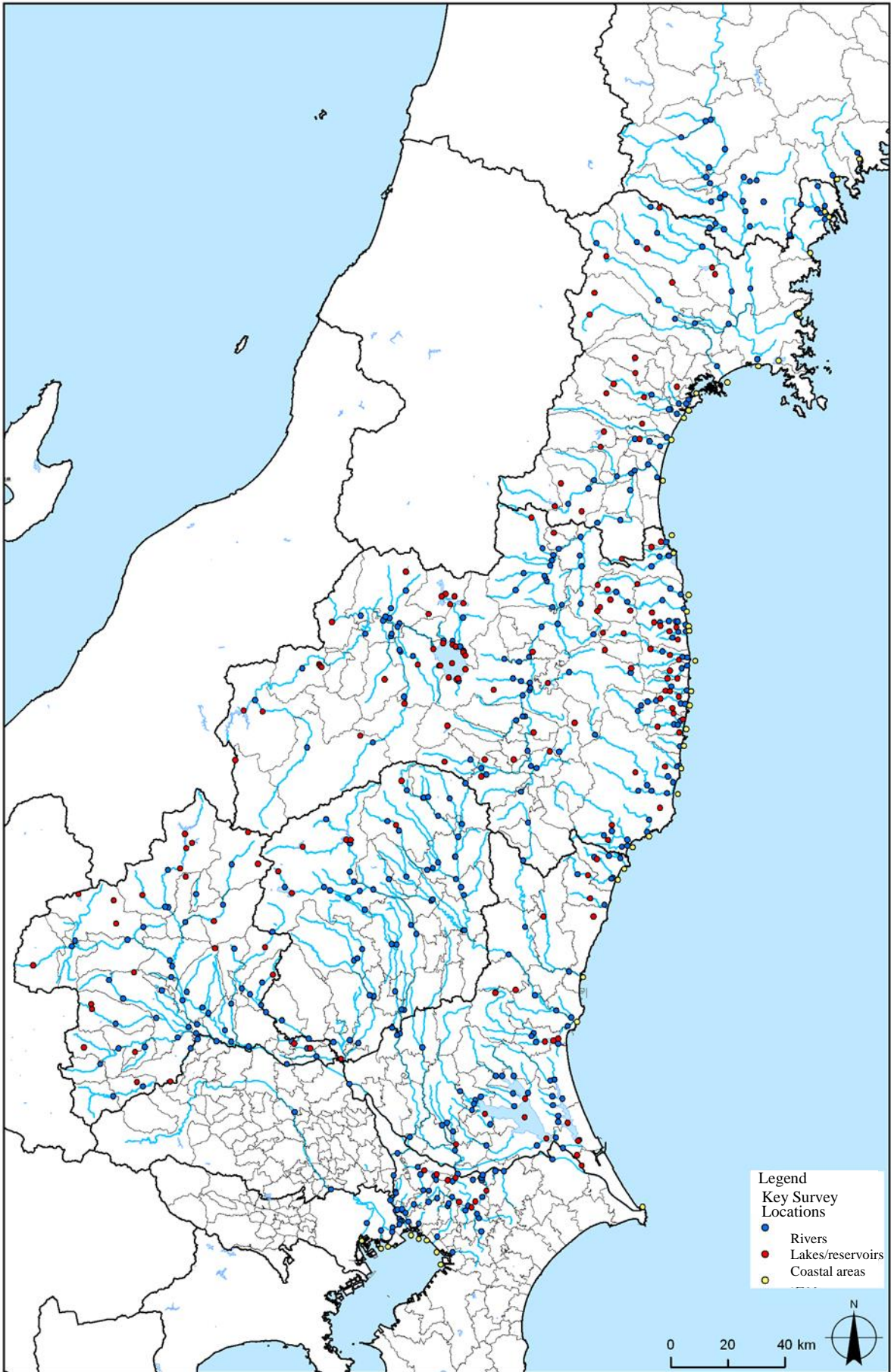
FY2013 Radioactive Material Monitoring in the Water Environment in and around Fukushima Prefecture

1. Survey Overview

Surveys of the concentration of radioactive materials (radioactive iodine, radioactive cesium, and radioactive strontium) in water, sediments and the surrounding environment (soil on river terraces and the shores of lakes) have been carried out in the water environment (public water areas (rivers, lakes and reservoirs, coastal areas, etc.)) in Iwate, Miyagi, Fukushima, Ibaraki, Tochigi, Gunma, Saitama, and Chiba Prefectures and Tokyo Metropolis since April 2013 (surveys of the surrounding environment also included measurement of ambient dose rates).

2. Number of Survey Locations

	Prefecture	Survey Period	Rivers	Lakes and reservoirs	Sea areas	Total
1st Quarter	Iwate	May 20 - Jun. 4, 2013	22	-	-	22
	Miyagi	Apr. 23 - Jun. 28, 2013	43	21	-	64
	Fukushima	Apr. 24 - Jun. 28, 2013	123	84	15	222
	Ibaraki	May 15 - Jun. 18, 2013	53	19	5	77
	Tochigi	May 22 - Jun. 24, 2013	56	8	-	64
	Gunma	May 22 - Jul. 1, 2013	48	24	-	72
	Chiba, Saitama, Tokyo	May 14 - Jun. 13, 2013	51	8	8	67
Total			396	164	28	588
2nd Quarter	Iwate	Jul. 19 - Aug. 29, 2013	18	-	2	20
	Miyagi	Jul. 2 - Sep. 30, 2013	43	17	12	72
	Fukushima	Jul. 2 - Sep. 25, 2013	123	84	-	207
	Ibaraki	Aug. 1 - Aug. 28, 2013	53	19	5	77
	Tochigi	Jul. 10 - Oct. 4, 2013	56	8	-	64
	Gunma	Jul. 17 - Sep. 30, 2013	44	24	-	68
	Chiba, Saitama, Tokyo	Jul. 17 - Sep. 12, 2013	51	8	8	67
Total			388	160	27	575
3rd Quarter	Iwate	Nov. 8 - Nov. 27, 2013	22	-	2	24
	Miyagi	Oct. 3 - Dec. 19, 2013	43	21	12	76
	Fukushima	Oct. 1 - Dec. 26, 2013	123	84	15	222
	Ibaraki	Nov. 1 - Nov. 28, 2013	53	19	5	77
	Tochigi	Oct. 18 - Dec. 16, 2013	56	8	-	64
	Gunma	Oct. 1 - Dec. 13, 2013	48	24	-	72
	Chiba, Saitama, Tokyo	Oct. 1 - Nov. 26, 2013	51	8	8	67
Total			396	164	42	602
4th Quarter	Iwate	Feb. 3 - Feb. 7, 2014	18	-	-	18
	Miyagi	Jan. 6 - Feb. 25, 2014	43	-	11	54
	Fukushima	Jan. 6 - Feb. 14, 2014	123	82	15	220
	Ibaraki	Feb. 3 - Feb. 24, 2014	53	19	5	77
	Tochigi	Feb. 3 - Feb. 19, 2014	56	-	-	56
	Gunma	Jan. 7 - Jan. 20, 2014	44	-	-	44
	Chiba, Saitama, Tokyo	Jan. 7 - Feb. 13, 2014	51	8	8	67
Total			388	109	39	536
Total number of FY2013 survey locations						2,301



Survey Locations (All)

3. Outline of Results

(i) Water

Radioactive materials were not detectable at most locations (detection limit: 1 Bq/L), but were detected at some locations (up to a maximum of 47 Bq/L). This is thought to be mainly due to the effect of turbidity caused by the rise of water.

(ii) Sediments

[Rivers]

High readings were seen at a limited number of locations, such as those within 20 km from Fukushima Daiichi Nuclear Power Station, but at the majority of locations, detected values were generally around 1,000 Bq/kg or lower.

Activity concentrations were generally decreasing or unchanged and showed no significant increase as a whole.

[Lakes]

High readings were seen at a limited number of locations, such as those within the 20 km zone, but at the majority of locations, detected values were generally around 3,000 Bq/kg or lower.

Activity concentrations were varying, and at some locations, such as those near TEPCO's Fukushima Daiichi NPS, significant changes were observed. However, activity concentrations as a whole showed no significant increases.

[Coastal areas (1 to 2 km)]

Overall, detected values were lower than in rivers and lakes, generally being around 150 Bq/kg or below.

Activity concentrations were generally decreasing or unchanged.

[Survey Methods]

1. Outline

(1) Sample collection

Sample		Outline
Rivers	Water	<ul style="list-style-type: none"> • Collect around 5 L of water from the top of a bridge using a bucket. • When sampling from the top of a bridge is impossible, collect water from the river bank using a dipper.
	Sediments	<ul style="list-style-type: none"> • Throw an Ekman-Birge bottom sampler into the river from the top of a bridge and collect sediments. • When sampling from the top of a bridge is impossible, collect sediments from the river bank using a dipper (collect sediment samples three times and mix them up).
	Surrounding environment (soil)	<ul style="list-style-type: none"> • Collect soil from the surface layer (at 0 to 5 cm from the surface) on both river banks (five points each) near a bridge using a soil sampler.
	Ambient dose rate	<ul style="list-style-type: none"> • At the location where soil samples were collected, measure the ambient dose rate at a height of 1 m from the ground surface using an NAI (TI) scintillation survey meter.
Lakes and reservoirs	Water	<ul style="list-style-type: none"> • Collect water from the surface layer (at 0.5 m from the surface) and from the bottom layer (at 1 m from the bottom) from a boat, etc. using a Van Dorn sampler. • When sampling from a boat is impossible, collect water from the lakeside using a dipper.
	Sediments	<ul style="list-style-type: none"> • Collect sediments from a boat, etc. using an Ekman-Birge bottom sampler (collect sediment samples three times and mix them up). • When sampling from a boat is impossible, collect sediments from the lakeside using a dipper.
	Surrounding environment (soil)	<ul style="list-style-type: none"> • Collect soil from the surface layer (at 0 to 5 cm from the surface) on the lakeside (five points each).
	Ambient dose rate	<ul style="list-style-type: none"> • At the location where soil samples were collected, measure the ambient dose rate at a height of 1 m from the ground surface using an NAI (TI) scintillation survey meter or a GM survey meter.
Coastal areas	Water	<ul style="list-style-type: none"> • Collect water from the surface layer (at 0.5 m from the surface) and from the bottom layer (at 1 m from the sea bottom) from a vessel using a Van Dorn sampler.
	Sediments	<ul style="list-style-type: none"> • Collect sediments from a vessel using an Ekman-Birge bottom sampler (or a Smith-McIntyre grab sampler or cylindrical dredge sampler) (collect sediment samples three times and mix them up).

(2) Sample preparation (samples for gamma-ray spectrometry)

Sample	Outline
Water	<ul style="list-style-type: none"> Put a sample in a 2L Marinelli beaker.
Sediments	<ul style="list-style-type: none"> Put a sample in a U-8 container. At the same time, separate approx. 10 g from the sample and dry it at 105°C to obtain the sediment content.
Surrounding environment (soil)	<ul style="list-style-type: none"> Put a sample in a U-8 container. At the same time, separate approx. 10 g from the sample and dry it at 105°C to obtain the dry sediment content.

(3) Analysis Methods

Analysis	Sample	Details
Gamma-ray spectrometry	Water	<ul style="list-style-type: none"> Measure for 1,500 seconds, in principle, using a germanium semiconductor detector.
	Sediments and soil	<ul style="list-style-type: none"> Measure for 1,800 seconds, in principle, using a germanium semiconductor detector.
⁹⁰ Sr analysis	Sediments	<ul style="list-style-type: none"> Acid leaching – carbonate separation – oxalate separation – ion exchange separation- scavenging – leave for 2 weeks- milking – measurement of β-rays
Other	Water	<ul style="list-style-type: none"> Suspended solids (SS), turbidity
	Sediments	<ul style="list-style-type: none"> Sediment content, grain size distribution, soil particle density

2. Details

(1) Sample Collection

1) Rivers

(i) Water

Water samples were collected from the surface layer (at 0 to 50 cm from the surface), using a bucket or a dipper, from the top of a bridge or from the river bank at each monitoring location.

- Field observation items: Water depth; sampling depth; water temperature; color; odor; transparency; electrical conductivity

(ii) Sediments

Sediment samples (15cm×15cm) were collected at a depth from the bottom surface to 10 cm below three times, using an Ekman-Birge bottom sampler (Figure 1), from the top of a bridge or from the river bank at each monitoring location, and were mixed up.

- Field observation items: Sampling depth; properties; color; sediment temperature; odor



Figure 1. Ekman-Birge bottom sampler

(iii) Surrounding environment (soil)

In principle, on both river banks (two points) outside the dike on the upstream side of each monitoring location, soil samples from the surface to a depth of approx. 5 cm were collected at five points within a 3 to 5 meter square (basically four vertexes and the diagonal intersection point; see Figure 3) using a soil sampler.

When collecting samples, sampling points were selected at flat and spacious places as far as possible after measuring activity concentrations around those points with a survey meter and confirming that there were no spots where activity concentrations are extraordinarily high. If there was too much vegetation, surface grass was cut and removed with a sickle, etc.

When it was difficult to secure a 3 to 5m square, adjustments were made depending on the circumstances on the site, such as selecting five points with 3 to 5 meter intervals along the river.

- Field observation items: Properties; color; odor



Figure 2. Soil sampler, etc.

Soil samples were not collected in the following cases:

- When the sampling location was on private property (house, farmland, facility site, etc.) or on a road
- When the sampling point was concrete-covered and soil was not exposed
- When soil was not exposed due to snow coverage

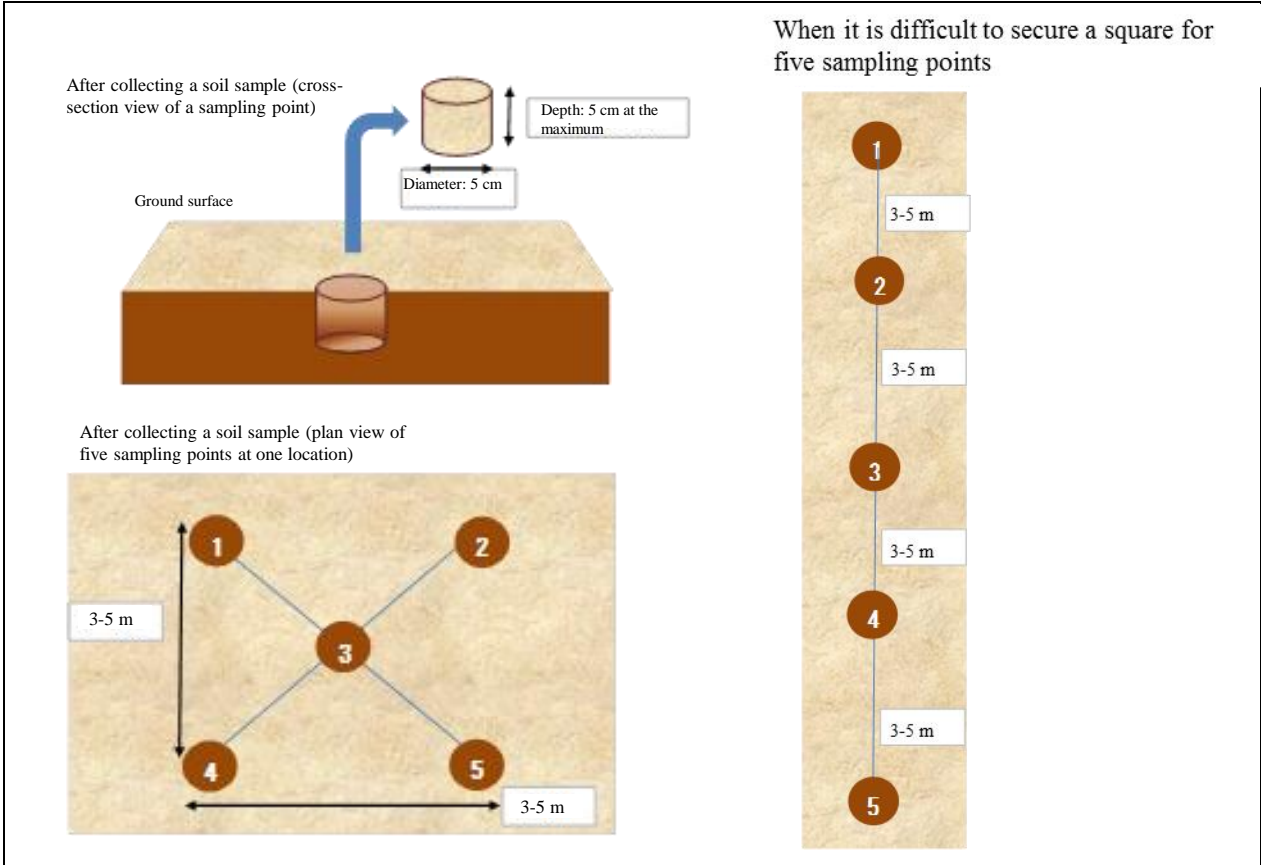


Figure 3. Examples of soil sampling

(iv) Measurement of ambient dose rates

At each location where soil samples were collected (at the center, in principle), ambient dose rate was measured using a survey meter (such as an NAI (TI) scintillation survey meter) (Figure 4).

Measurement was conducted at a height of 1 m from the ground surface, while keeping the sensing station of the survey meter horizontal. The time constant was set at 30 seconds (10 seconds when the detected value was 0.1 $\mu\text{Sv/h}$ or above). After holding the survey meter for a duration 5 times the time constant, readings were taken 5 times with intervals equivalent to the time constant. Ambient dose rate was obtained by multiplying the average of the readings by the calibration constant.



Figure 4. Measurement of ambient dose rates (example)

At locations where soil samples could not be collected, measurement of ambient dose rates was conducted at points near the locations where water or sediment samples were collected. The requirements for such points were as follows:

- A flat, open area without any major obstacles in the vicinity
- A site with as little vegetation as possible
- A site on soil, wherever possible, not on asphalt or concrete

Ambient dose rates were not measured at points where soil was not exposed due to snow coverage.

Table 1 and Figure 5 show the survey meters used for the measurement of ambient dose rates.

Table 1. Type of survey meter

Manufacturer	Model, etc.
Hitachi-Aloka Medical, Ltd.	TCS-172B



Figure 5. Survey meter

2) Lakes and reservoirs

(i) Water

Water samples were collected at each monitoring location, from a boat, etc., from the surface layer (at 0.5 m from the surface) and from the bottom layer (at 1 m from the bottom) using a Van Dorn sampler.

The survey was not conducted when the water surface was frozen.

- Field observation items: Water depth; sampling depth; water temperature; color; odor; transparency; electrical conductivity



Figure 6. Van Dorn sampler

(ii) Sediments

Sediment samples were collected at each monitoring location, from a boat or from the lakeside, from the surface layer (at around 0 to 15 cm from the surface) using an Ekman-Birge bottom sampler. Sampling was conducted three times and the samples were mixed up.

The survey was not conducted when the water surface was frozen.

- Field observation items: Sampling depth; properties; color; sediment temperature; odor

(iii) Surrounding environment (soil)

At lakes, dams and reservoirs, soil samples were collected only at one location on the lake side or reservoir side where soil was exposed. Sampling was not conducted when the whole circumference was concrete-covered.

The survey method was the same as that employed for the surrounding environment in the case of rivers.

(iv) Measurement of ambient dose rates

At each location where soil samples were collected, ambient dose rate was measured using a survey meter.

The survey method was the same as that employed for the measurement of ambient dose rates in the case of rivers.

3) Coastal areas

(i) Water

Water samples were collected at each monitoring location, from a vessel, from the surface layer (at 0.5 m from the surface) and from the bottom layer (at 1 m from the sea bottom) using a Van Dorn sampler.

- Field observation items: Water depth; sampling depth; water temperature; color; odor; transparency; salinity

(ii) Sediments

Sediment samples were collected at each monitoring location, from a vessel, from the surface layer (at around 0 to 15 cm from the surface) using a an Ekman-Birge bottom sampler (or a Smith-McIntyre grab sampler or KS sampler)

- Field observation items: Sampling depth; properties; color; sediment temperature; odor

(2) Field Survey

Table 2 to Table 4 show the field survey methods used.

Table 2. Field survey methods (water)

Item	Survey Method	Survey Subject		
		Rivers	Lakes and Reservoirs	Coastal Areas
Weather	Visual evaluation	○	○	○
Air temperature	Electronic thermometer (resolution 0.1°C)	○	○	○
Water depth	Measuring rope, hydrobarometer, etc.	○	○	○
Sampling depth	Measuring rope, hydrobarometer, etc.	○	○	○
Water temperature	ES-51 (Horiba, Ltd.)	○	○	○
Color	Evaluation using JIS Names of Colours	○	○	○
Odor	Olfactory evaluation	○	○	○
Transparency	Transparency meter	○	—	—
Secchi disk depth	30cm white Secchi disk	—	○	○
Conductivity	Measured using a conductivity meter (Ltd. ES-51 (Horiba))	○	○	—
Salinity	Measured using a conductivity meter (ES-51 (Horiba, Ltd.); used in salinity measurement mode)	—	—	○

Table 3. Field survey methods (sediments)

Item	Survey Method	Survey Subject		
		Rivers	Lakes and Reservoirs	Coastal Areas
Sampling depth	Visual evaluation	○	○	○
Properties	Visual evaluation	○	○	○
Color	Evaluation using JIS Names of Colours	○	○	○
Sediment temperature	Electronic thermometer (resolution 0.1°C)	○	○	○
Odor	Olfactory evaluation	○	○	○

Table 4. Field survey methods (surrounding environment)

Item	Survey Method	Survey		
		Rivers	Lakes and Reservoirs	Coastal Areas
Properties	Visual evaluation	○	○	○
Color	Evaluation using JIS Names of Colours	○	○	○
Odor	Olfactory evaluation	○	○	○

(3) Analysis Methods

1) Sample preparation

Sample preparation was carried out in accordance with MEXT's Radioactivity Measurement Method Series No. 24 "Sample Pretreatment for Gamma-ray Spectrometry in a Radiological Emergency" (August 1992) and No. 29 "Gamma-ray Spectrum Analysis in a Radiological Emergency" (February 2004). The outline of the procedures is as follows.

Water samples were put in 2L Marinelli beakers and soil and sediment samples were put in U-8 containers for gamma-ray spectrometry.

2) Gamma-ray spectrometry

Gamma-ray spectrometry was carried out in accordance with MEXT's Radioactivity Measurement Method Series No. 7 "Gamma-ray Spectrometry using Germanium Semiconductor Detectors" (revised in August 1992) and No. 29 "Gamma-ray Spectrum Analysis in a Radiological Emergency" (February 2004). The outline of the procedures is as follows.

(i) Measurement

Activity concentrations were calculated based on measurement conducted using a germanium semiconductor detector for around 1,500 seconds (water samples) and 1,800 seconds (soil and sediment samples). For sediment samples in which Cs137 was detected at a level below 10 Bq/kg (dry), measurement was conducted under conditions to ensure the detection limit of 1 Bq/kg (dry). The nuclear data used were taken from the Atomic Data and Nuclear Data Tables (1983), in principle.

(ii) Measuring equipment

Germanium semiconductor detectors

GEM 25P4-70 (2 units) (SEIKO EG&G, Co., Ltd.)

GEM 30-70 (4 units) (SEIKO EG&G, Co., Ltd.)

3) Analysis of radioactive strontium

The analysis of radioactive strontium was carried out in accordance with MEXT's Radioactivity Measurement Method Series No. 2 "Radioactive Strontium Analysis" (revised in July 2013). The outline of the procedures is as follows.

(i) Chemical separation

A strontium carrier was added to a sample, then hydrochloric acid was added and thermal extraction was carried out. ⁹⁰Y was removed (scavenging) from the strontium separated and refined via the iron exchange method, then the sample was left for two weeks and the newly-formed ⁹⁰Y was precipitated along with iron hydroxide (III) precipitation (milking). The remaining substance was used for the measurement.

(ii) Measurement

Concentrations of Sr⁹⁰ were calculated based on measurement conducted using a low background beta counter for 3,600 seconds, in principle. Errors in measured values were calculated from the square root of the number of counts detected by the beta counter upon measurement (counting errors).

(ii) Measuring equipment

Low background beta counter

LBC-4201B (1 unit) (Hitachi-Aloka Medical, Ltd.)

LBC-4202B (1 unit) (Hitachi-Aloka Medical, Ltd.)

4) Other items analyzed

Table 5 shows the methods used to analyze other items.

Table 5. Methods of analyzing other items

Item		Analysis methods	Unit	Lower detection limit
Water	Suspended solids (SS)	Method indicated in Annex Table 9 of Environment Agency Notice No. 59 of December 1971 (Environmental Quality Standards for Water Pollution)	mg/L	1
	Turbidity	Japan Industrial Standard K 0101 9.4	FNU	0.1
Sediments	Sediment content	2 of Remarks 5 of Environment Agency Notice No. 3 of 1973	%	0.1
	Grain size distribution	Japan Industrial Standard A 1204	%	0.1
	Soil particle density	Japan Industrial Standard A 1202	g/cm ³	-