FY2015 Radioactive Material Monitoring in the Water Environment in and around Fukushima Prefecture

1. Survey Overview

Surveys of the concentration of radioactive materials (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)) in Iwate, Miyagi, Fukushima, Ibaraki, Tochigi, Gunma, Saitama, and Chiba Prefectures and Tokyo Metropolis since April 2015 (surveys of the surrounding environment also included measurement of ambient dose rates).

Number of locations and number of surveys are shown in Table 1 and survey locations in Figure 1.

Table 1.Number of Survey Locations

Prefecture	Area	Number of Locations	Number of surveys	Number of Samples*		
				Water	Sediment	Surrounding environment (Soil)
Iwate	Rivers	22	80	80 (0)	80 (0)	156 (4)
	Coastal areas	2	4	8 (0)	4 (0)	—
Miyagi	Rivers	43	196	196 (0)	196 (0)	392 (0)
	Lakes and reservoirs	21	76	118 (34)	76 (0)	76 (0)
	Coastal areas	12	52	104 (0)	52 (0)	—
Fukushima	Rivers	123	822	819 (3)	845 (5)	1,665 (35)
	Lakes and reservoirs	84	552	807 (297)	541 (37)	519 (59)
	Coastal areas	15	150	300 (0)	150 (0)	—
Ibaraki	Rivers	53	212	212 (0)	212 (0)	400 (24)
	Lakes and reservoirs	19	76	149 (3)	73 (3)	68 (8)
	Coastal areas	5	20	40 (0)	20 (0)	—
Tochigi	Rivers	56	278	278 (0)	278 (0)	544 (12)
	Lakes and reservoirs	8	32	64 (0)	32 (0)	32 (0)
Gunma	Rivers	48	214	214 (0)	214 (0)	428 (0)
	Lakes and reservoirs	24	96	192 (0)	96 (0)	96 (0)
Chiba, Saitama, Tokyo	Rivers	51	216	216 (0)	216 (0)	376 (56)
	Lakes and reservoirs	8	32	37 (27)	32 (0)	16 (16)
	Coastal areas	8	41	82 (0)	41 (0)	—
Total	Rivers	396	2,018	2,015 (3)	2,041 (5)	3,961 (131)
	Lakes and reservoirs	164	864	1,367 (361)	850 (40)	807 (83)
	Coastal areas	42	267	534 (0)	267 (0)	—
	Overall total	602	3,149	3,916(364)	3,158(45)	4,768(214)
				11,842(623)		

* ( ) Number of unable to collect samples owing to ice and snow on the ground.

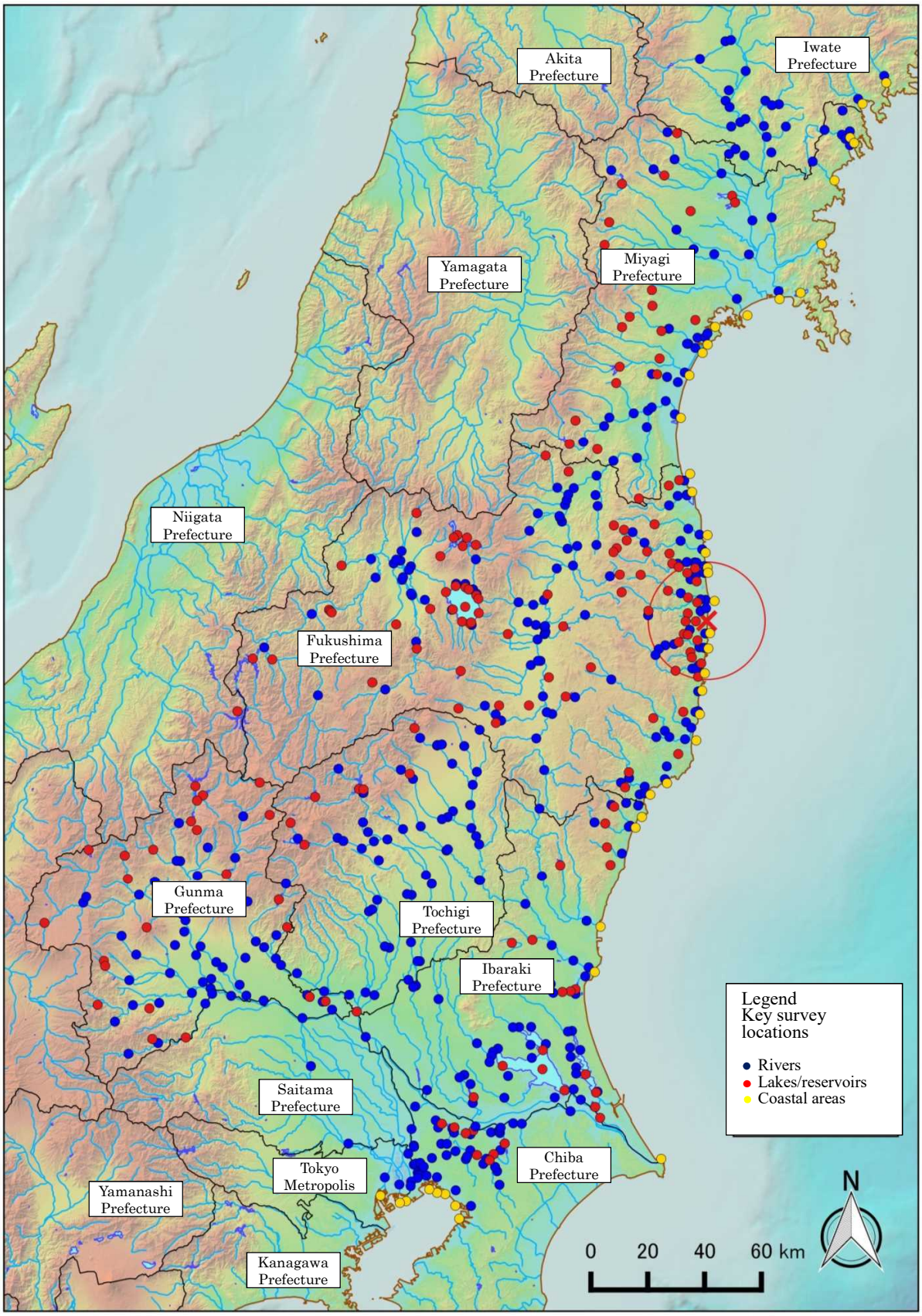

Figure 1. Survey Locations (All)

2. Outline of Results

(1) 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 52 Bq/L). This is thought to be mainly due to the effect of turbidity caused by the rise of water.

(2) Sediments

1) Rivers

High readings were seen at a limited number of locations, such as those within 20km from Fukushima Daiichi Nuclear Power Station, but at most locations, detected values were generally 300Bq/kg or lower.

Concentration levels are decreasing at most locations.

2) Lakes and Reservoirs

High readings were seen at a limited number of locations, such as those within 20km from Fukushima Daiichi Nuclear Power Station, but at most locations, detected values were generally 3,000Bq/kg or lower.

Concentration levels are mostly unchanged or decreasing with some fluctuations.

3) Coastal areas

The majority of locations, detected values were generally 300Bq/kg or lower.

Concentration levels are mostly decreasing trend.

3. Survey Methods

(1) Outline

1) Sample collection

Sample		Outline
Rivers	Water	Around 3L of water samples were collected from the surface layer(at up to 50cm below the surface),using a bucket or a dipper, from the top of a bridge or from the riverbank.
	Sediments	Sediment samples were collected from the surface layer (at up to 10cm below the surface), more than three times, using an Ekman-Birge bottom sampler or a scoop, from the top of a bridge or from the riverbank , and were mixed up.
	Surrounding environment (soil)	Soil samples were collected from the surface layer (at up to 5cm below the surface) on both riverbanks near a bridge or a levee using a soil sampler or a scoop, at five points each and mix them up .
	Ambient dose rate	At the location where soil samples were collected, the ambient dose rate was measured at a height of 1 m from the ground surface using an NaI (Tl) scintillation survey meter.
Lakes and reservoirs	Water	Around 3L of water samples were collected from the surface layer(at up to 0.5m below the surface) and from the bottom layer (at 1m from the bottom),using a Van Dorn sampler or a dipper, from a boat or from the lakeside.
	Sediments	Sediment samples were collected from the surface layer (at up to 10cm below the surface), more than three times, using an Ekman-Birge bottom sampler or a scoop, from a boat or from the lakeside , and were mixed up.
	Surrounding environment (soil)	Soil samples were collected from the surface layer (at up to 5cm below the surface) on lakeside or pond edge using a soil sampler or a scoop ,five points each and mix them up .
	Ambient dose rate	At the location where soil samples were collected, the ambient dose rate was measured at a height of 1 m from the ground surface using an NaI (Tl) scintillation survey meter.
Coastal areas	Water	Around 3L of water samples were collected from a vessel from the surface layer (at up to 0.5m below the surface) and from the bottom layer (at 1m from the bottom) using a Van Dorn sampler.
	Sediments	Sediment samples were collected from the surface layer (at up to 10cm below the surface), more than three times, using an Ekman-Birge bottom sampler or a Smith-McIntyre grab sampler, from a vessel, and were mixed up.

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

Sample	Outline
Water	・Put a sample in a 2L Marinelli beaker.
Sediments	・Put a sample in a U-8 container. ・At the same time, separate approx. 10g from the sample and dry it at 105°C to obtain the sediment content.
Surrounding environment (soil)	・Put a sample in a U-8 container. ・At the same time, separate approx. 10g from the sample and dry it at 105°C to obtain the dry sediment content.

3) Analysis Methods

Analysis	Sample	Details
Cs-134 Cs-137 Other radionuclides	Water	・Measure for 1,000 seconds, in principle, using a germanium semiconductor detector.*
	Sediments	・Measure for 2,000 seconds, in principle, using a germanium semiconductor detector.*
	Soil	・Measure for 2,000 seconds, in principle, using a germanium semiconductor detector.*
Sr-90	Sediments	・Acid leaching – carbonate separation – oxalate separation – ion exchange separation- scavenging – leave for 2 weeks- milking – measurement of β-rays
Other	Water	・Suspended solids (SS), turbidity
	Sediments	・Sediment content, grain size distribution, soil particle density

* Some samples were re-measured for a long time over 1,000 or 2,000 seconds, if necessary.

(2) Details

1) Sample Collection

(i)Rivers

① Water

Around 3L of water samples were collected from the surface layer (at up to 50cm below the surface), using a bucket or a dipper, from the top of a bridge or from the riverbank at each monitoring location.

■Field observation items: Water depth, sampling depth, water temperature, color, odor, transparency, electrical conductivity

② Sediments

Sediment samples (15cm×15cm) were collected at a depth of up to 10cm below surface more than three times, using an Ekman-Birge bottom sampler (Figure 2), from the top of a bridge or from the riverbank at each monitoring location, and were mixed up.

■Field observation items: Sampling depth, properties, color, sediment temperature, odor

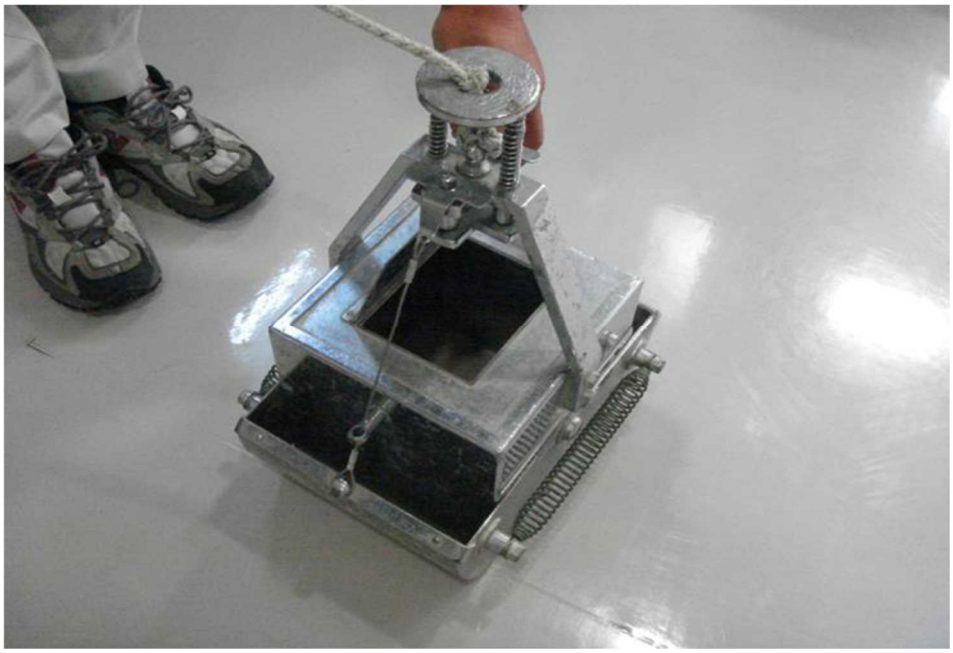

Figure 2. Ekman-Birge bottom sampler

③ Surrounding environment (soil)

In principle, on both riverbanks (at two points) outside the dike on the upstream side of each monitoring location, soil samples up to a depth of approx. 5cm below the surface were collected at five points within a 3 to 5meter square (basically four vertexes and the diagonal intersection point; see Figure 4) using a soil sampler which has a diameter of 5cm (Figure 3) or a scoop and were mixed up.

When collecting samples, sampling points were selected at flat spacious places as far as possible after measuring ambient dose rate around those points with a NaI (Tl) scintillation survey meter and confirming that there were no spots where the ambient dose rate was 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 at the site, such as selecting five points with 3 to 5m intervals along the river.

Soil samples were not collected in the following cases:

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

■ Field observation items: Properties, color, odor

Figure 3. Soil sampler kit.

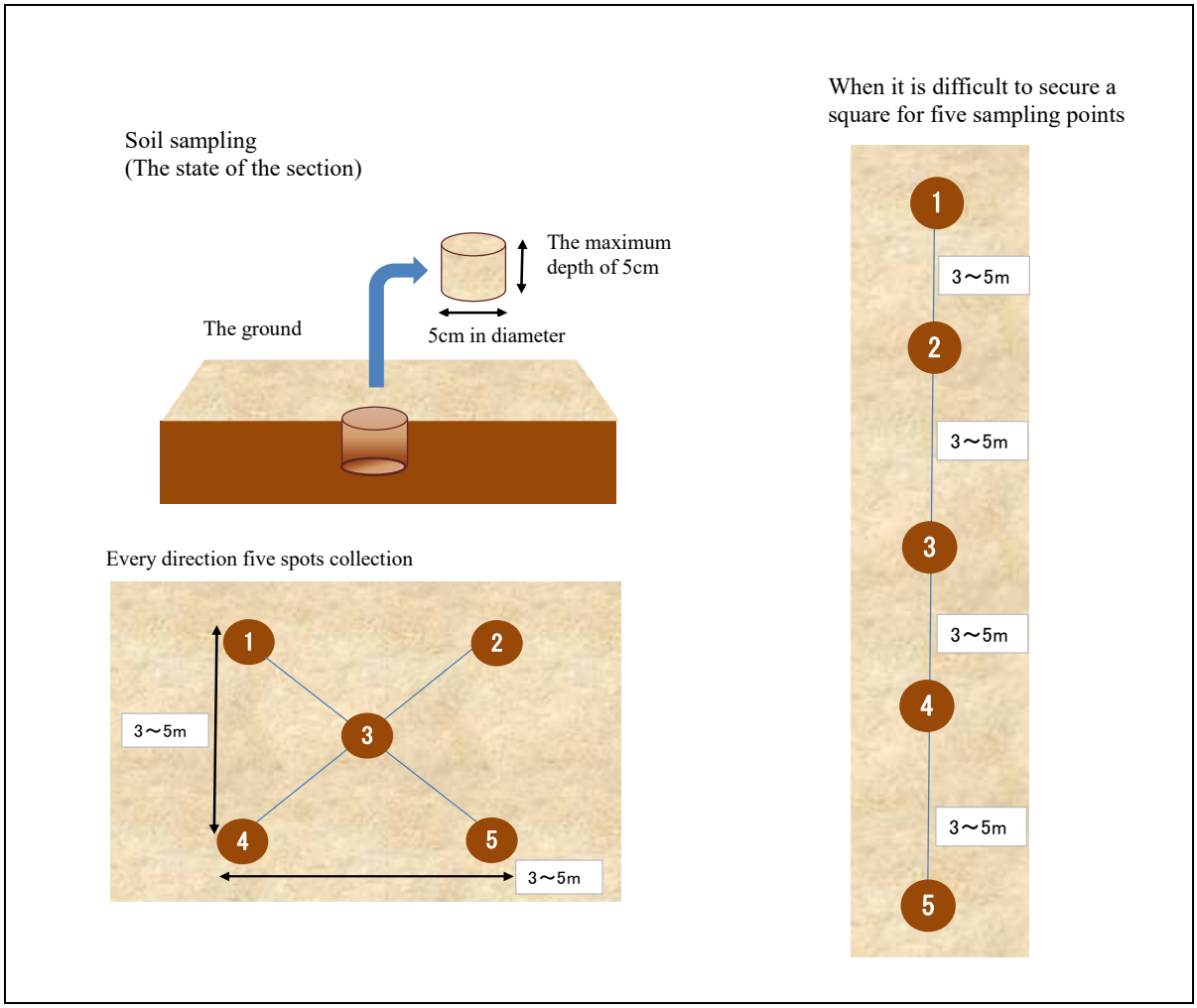

Figure 4. Examples of soil sampling

④ Measurement of ambient dose rates

At each location where soil samples were collected (at the center within a 3 to 5m-sided square), ambient dose rate was measured using a NaI (Tl) scintillation survey meter(Table 2 and Figure 5) (Figure 6).

Measurement was conducted at a height of 1m from the ground surface, while keeping the sensing station of the NaI (Tl) scintillation survey meter horizontal. The time constant was set at 30 seconds (10 seconds when the detected value was 0.1 μSv/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. The ambient dose rate was obtained by multiplying the average of the readings by the calibration constant.

Table 2. Type of NaI (Tl) scintillation survey meter

Manufacturer	Model, etc.
Hitachi-Aloka Medical, Ltd.	TCS-172B、TCS-161

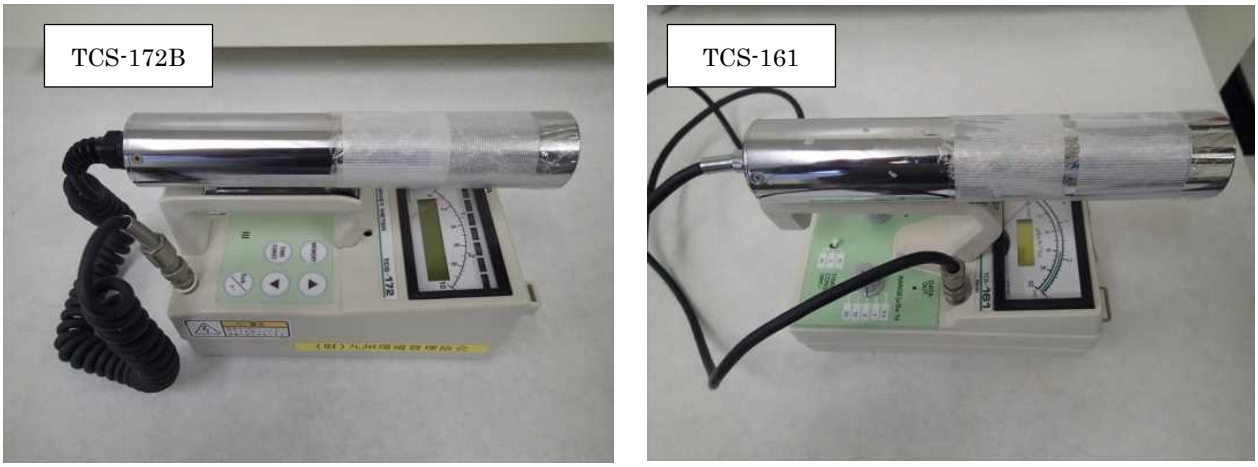

Figure 5. NaI (Tl) scintillation survey meter

Figure 6. Measurement of ambient dose rates(example)

At locations where soil samples could not be collected by a reason except the snow, measurement of ambient dose rates was conducted at points near the locations where water or sediment samples were collected. On the other hand, at the point that could not arrive at the investigation point due to the snow, the air dose rates were not measured.

The requirements to be noted when selecting the point of ambient dose rates 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

(ii)Lakes and Reservoirs

① Water

Around 3L of water samples were collected at each monitoring location, from a boat, etc., from the surface layer (at up to 0.5m from the surface) and from the bottom layer (at 1m from the bottom) using a Van Dorn sampler(Figure 7).

No bottom layer water sample was taken when the use of a boat was not possible.

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

■Field observation items: Water depth, sampling depth, water temperature, color, odor, Secchi disk depth, electrical conductivity

Figure 7. Van Dorn sampler

② Sediments

Sediment samples (15cm×15cm) were collected at each monitoring location, from a shipboard or from the lakeside, from the surface layer (at up to 10cm below the surface) using an Ekman-Birge bottom sampler(Figure 2). 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

③ Surrounding environment (soil)

At lakes, dams and reservoirs, soil samples were collected only at one location on the lakeside or reservoir edge 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 "(2) Details 1) Sample Collection (i)Rivers ③Surrounding environment (soil)".

④ Measurement of ambient dose rates

At each location(center) where soil samples were collected, ambient dose rate was measured using a NaI (Tl) scintillation survey meter(Figure 5).

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

The survey method was the same as that employed for "(2) Details 1) Sample Collection (i)Rivers ④Measurement of ambient dose rates".

(iii)Coastal areas

① Water

Water samples were collected at each monitoring location, from a vessel, from the surface layer (at up to 0.5m below the surface) and from the bottom layer (at 1m from the sea bottom) using a Van Dorn sampler(Figure 7).

■Field observation items: Water depth, sampling depth, water temperature, color, odor, secchi disk depth, salinity

② Sediments

Sediment samples (15cm×15cm or 20cm×20cm) were collected at a depth of up to 10cm below the surface layer more than three times, using an Ekman-Birge bottom sampler (Figure 2) or a Smith-McIntyre grab sampler, from a vessel at monitoring location, and were mixed up.

■Field observation items: Sampling depth, properties, color, sediment temperature, odor

2) Field Survey

Table 3 to Table 6 show the field survey methods used.

Table 3. Field survey methods (common)

Item	Survey Method	Survey Subject *		
		Rivers	Lakes and Reservoirs	Coastal Areas
Survey・Sampling Date	(Recording to an survey field book)	○	○	○
Survey・Sampling Time	(Recording to an survey field book)	○	○	○
Weather	Visual evaluation	○	○	○
Air temperature	Electronic thermometer (resolution 0.1°C)	○	○	○

*○:Survey subject

Table 4. Field survey methods (water)

Item	Survey Method	Survey Subject *		
		Rivers	Lakes and Reservoirs	Coastal Areas
Water depth	Hydro barometer	○	○	○
Sampling depth	Hydro barometer	○	○	○
Water temperature	Electronic thermometer (resolution 0.1°C)	○	○	○
Color	Evaluation using JIS names of colours	○	○	○
Odor	Olfactory evaluation	○	○	○
Transparency	Transparency meter	○	-	-
Secchi disk depth	30cm white Secchi disk	-	○	○
Electrical conductivity	Electrical conductivity meter	○	○	-
Salinity	Electrical conductivity meter	-	-	○

*○:Survey subject -:Outside the scope of the survey

Table 5. 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 standard soil color charts	○	○	○
Sediment temperature	Electronic thermometer (resolution 0.1°C)	○	○	○
Odor	Olfactory evaluation	○	○	○

*○:Survey subject

Table 6. Field survey methods (surrounding environment(soil))

Item	Survey Method	Survey Subject *		
		Rivers	Lakes and Reservoirs	Coastal Areas
Properties	Visual evaluation	○	○	-
Color	Evaluation using standard soil color charts	○	○	-
Odor	Olfactory evaluation	○	○	-

*○:Survey subject -:The subject of survey outside

4. 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.

1) Measurement

Activity concentrations were calculated based on measurement conducted using a germanium semiconductor detector for around 1,000 seconds (water samples) and 2,000 seconds (soil and sediment samples). For sediment samples in which Cs-137 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.

Errors in measured values were calculated from the square root of the number of peakcounts detected by the germanium semiconductor detector upon measurement (counting errors).

2) Measuring equipment

Germanium semiconductor detectors

GMX 30P (1 units) (SEIKO EG&G, Co., Ltd.)

GX4018 7915-30ULB (3 units) (CANBERRA, 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 2003). The outline of the procedures is as follows.

1) Chemical separation

A strontium carrier was added to a sample, then hydrochloric acid was added and thermal extraction was carried out. Y-90 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 Y-90 was precipitated along with iron hydroxide (III) precipitation (milking). The remaining substance was used for the measurement.

2) Measurement

Concentrations of Sr-90 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).

3) Measuring equipment

Low background beta counter

LBC-4311 (Hitachi-Aloka Medical, Ltd.)

LBC-4301 (Hitachi-Aloka Medical, Ltd.)

LBC-4200 (CANBERRA, Ltd.)

(4) Other items analyzed

Table 7 shows the methods used to analyze other items.

Table 7. 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 December1971 (Environmental Quality Standards for Water Pollution)	mg/L	1
	Turbidity	Japanese Industrial Standard K 0101 9.4	FNU	0.1
Sediments	Sediment content	2 of Remarks 5 of Environment Agency Notice No.3 of 1976	%	0.1
	Grain size distribution	Japanese Industrial Standard A 1204	%	0.1
	Soil particle density	Japanese Industrial Standard A 1202	g/cm^3	-

5. Survey Result

View of the results

(1) In principle, sampling locations are listed from north to south, and for different points along the river, from upstream to downstream.

(2) Analysis of gamma-ray spectrometry was displayed in two significant figure by rounding off. For the result of non-detection, was denoted by the "<" to the value that the two significant figures by rounding up the detection limit.

(3) Analysis of gamma-ray spectrometry have been corrected for decay to represent the value as of the time when the sample was taken.

(4) Analysis results of Sr-90 was displayed in two significant digits by when the sample was taken rounding off the value obtained by correcting the sampling date. For the result of non-detection, was denoted by the "<" to the value that the two significant figures by rounding up the detection limit.