

Information note n°5

Fires in Ukraine in the exclusion zone around the Chernobyl power plant: Latest measurement results and assessment of environmental and health consequences

Since the release of our previous information notes on April 7, 15, 17 and 24, 2020, fires would now be extinguished.

This note presents the latest available information, in particular the results of radioactivity measurements carried out by IRSN and by its Ukrainian and European scientific partners which attest a cesium 137 (^{137}Cs) labeling of air masses. The trajectory modeling of the fire-labeled air masses has been updated taking into account this dataset.

Both field determinations, IRSN modeling investigations, and dosimetric estimations confirm that these fires did not have any environmental and health consequences in France.

1 / Current situation as of May 5, 2020

After a significant decrease in the number of fire outbreaks observed for ten days (see information note of April 24, 2020)¹, the rains that have fallen on the area since Saturday May 2, 2020 made it possible to extinguish all the fires, according to satellite images.

The satellite image of May 4, 2020, no longer shows any fire in the exclusion zone or near the Belarusian border (see Figure 1).

According to the Ukrainian authorities², the means deployed to fight the blazes remain mobilized in order to keep under control any smoldering fires (from peat bogs, etc.).

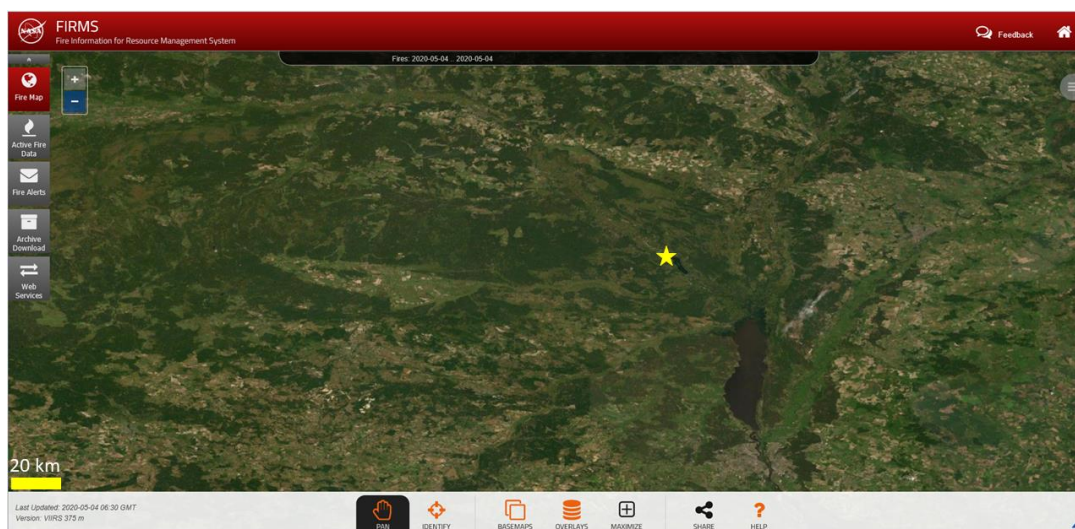


Figure 1: Satellite fire detection image (no fire) as of May 4, 2020 at 6h30 (UTC) (source: NASA / FIRMS)³. The Chernobyl nuclear power plant is marked with a star. Fire detection can be obscured by cloud cover)

¹ https://www.irsn.fr/EN/newsroom/News/Pages/20200424_Fires-in-Ukraine-in-the-Exclusion-Zone-around-chernobyl-cesium-137-results-in-france.aspx

² <http://dazv.gov.ua/novini-ta-media/vsi-novyny.html>

In order to draw up the balance sheet of this event, IRSN has taken into account the cumulative fires visible by satellite imagery since the beginning of April 2020. If, as indicated above, the situation has improved over the past period of ten days (see Figure 2), the first three weeks of April saw the development of particularly large fires, both in area and number (see Figure 3). These different periods have been taken into account in the radioactive release modeling.

The Ukrainian Hydrometeorological Institute (UHMI)⁴ reports that the area of fires on the territory of the Chernobyl Exclusion Zone (CEZ) and adjacent areas from April 2 to April 20 would have reached approximately 800 km². The burned area in the area close to the Chernobyl power plant was estimated at about 65 km².

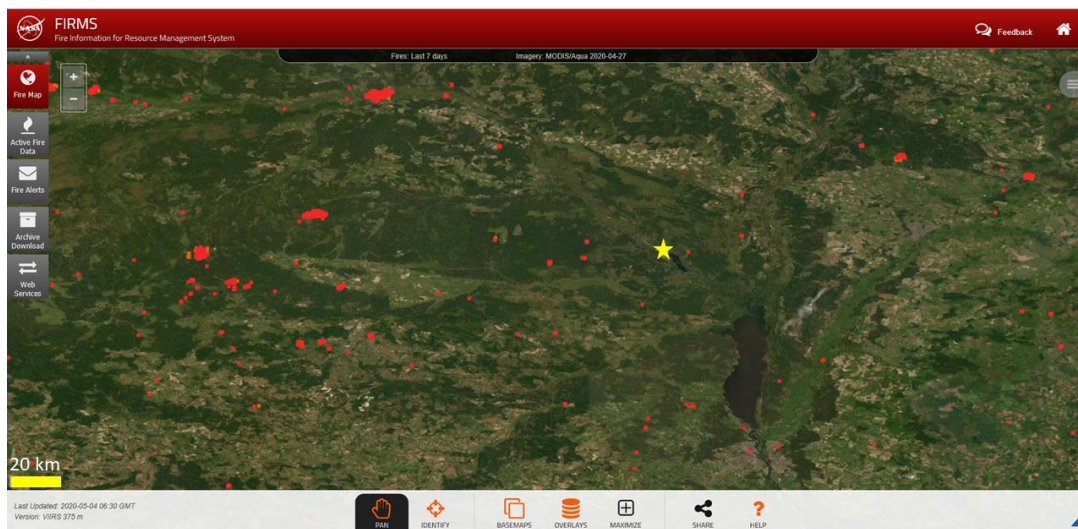


Figure 2: Cumulative map of satellite fire detections between April 27 and May 4, 2020 (source: NASA / FIRMS). The Chernobyl nuclear power plant is marked with a star.

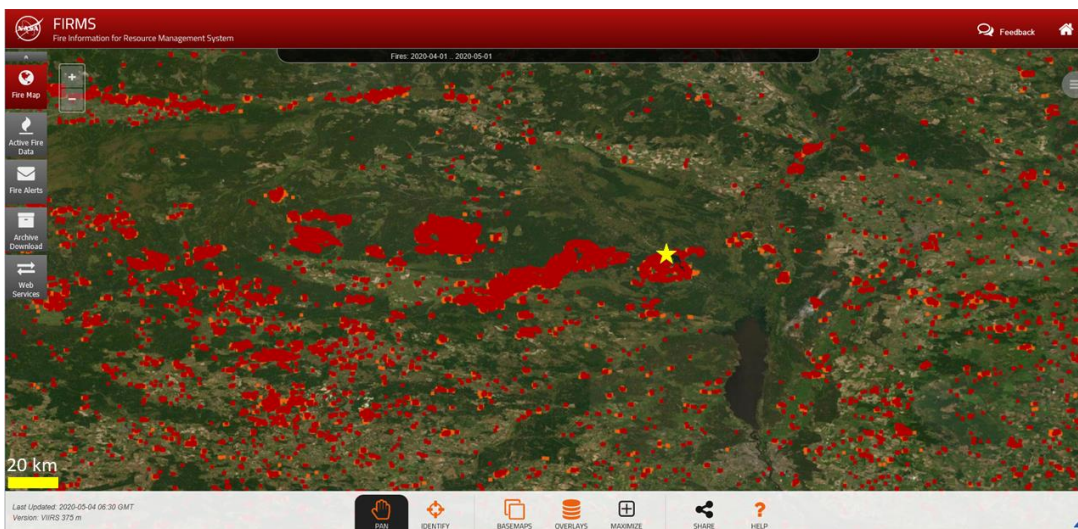


Figure 3: cumulative map of satellite fire detections between April 1 and May 1, 2020 (source: NASA / FIRMS). The Chernobyl nuclear power plant is marked with a star.

³ <https://firms.modaps.eosdis.nasa.gov/>

⁴ <https://uhmi.org.ua/msg/fire2020/analytical.pdf>

2 / IRSN's measurements in France

The IRSN publishes below all of its up-to-date available results in the air from aerosol sampling stations belonging to the IRSN's OPERA network⁵.

Table 1: IRSN measurements of the airborne ¹³⁷Cs volume activity

Sampling Location (Department)	Sampling period		Airborne ¹³⁷ Cs (μBq/m ³)
	from	to	
* Bouc Bel Air (13)	28/03/2020	04/04/2020	0,294 ± 0,048
* Bouc Bel Air (13)	04/04/2020	10/04/2020	1,16 ± 0,22
* Bouc Bel Air (13)	10/04/2020	17/04/2020	1,16 ± 0,13
* Bouc Bel Air (13)	17/04/2020	24/04/2020	0,288 ± 0,054
* Dijon (21)	30/03/2020	06/04/2020	0,184 ± 0,046
* Dijon (21)	06/04/2020	10/04/2020	0,59 ± 0,12
* Dijon (21)	15/04/2020	22/04/2020	0,344 ± 0,064
* Mérignac (33)	07/04/2020	14/04/2020	0,622 ± 0,11
* Orsay (91)	01/04/2020	08/04/2020	0,139 ± 0,031
* Orsay (91)	08/04/2020	15/04/2020	0,267 ± 0,064
* Orsay (91)	15/04/2020	22/04/2020	0,290 ± 0,066
* Revin (08)	01/04/2020	16/04/2020	0,183 ± 0,038
* Revin (08)	16/04/2020	28/04/2020	0,404 ± 0,070
* Romagnat (63)	03/04/2020	09/04/2020	0,269 ± 0,079
* Romagnat (63)	09/04/2020	16/04/2020	0,72 ± 0,11
** Bugey (01)	30/03/2020	06/04/2020	< 2,70
** Cadarache (13)	30/03/2020	06/04/2020	0,48 ± 0,18
** Cadarache (13)	06/04/2020	14/04/2020	1,31 ± 0,24
** Fessenheim (68)	30/03/2020	06/04/2020	< 0,70
** Fessenheim (68)	06/04/2020	13/04/2020	0,51 ± 0,20
** Fessenheim (68)	13/04/2020	20/04/2020	< 0,44
** Grenoble (38)	30/03/2020	06/04/2020	< 0,44
** Grenoble (38)	06/04/2020	14/04/2020	0,92 ± 0,25
** Grenoble (38)	14/04/2020	20/04/2020	< 0,60
** Nancy (54)	31/03/2020	07/04/2020	< 2,50
** Nancy (54)	07/04/2020	14/04/2020	< 2,60
** Nancy (54)	14/04/2020	21/04/2020	< 3,00
** Saint-Alban (38)	06/04/2020	13/04/2020	0,74 ± 0,22

The results indicated after the symbol < correspond to values below the decision threshold.

The activities are returned to the date of mid-collection (by agreement).

Localities whose names are preceded by an * are equipped with a high sampling-rate station (400 to 700 m³/h) for trace detections.

Localities whose names are preceded by ** are equipped with a lower sampling-rate station (80 m³/h).

⁵ The operating diagram of the OPERA network (from sampling to measurement of aerosol filters) is presented in the appendix of the 4th IRSN information note of April 24, 2020.

Results in bold are those that IRSN considers to be higher than the ^{137}Cs background level⁶ usually observed at each of these stations and for that season.

Given the good correlation between sampling dates and modeling expectations of the arrival of air masses on French territory, IRSN attributes this slight increase to radioactive labeling of air masses from the fire areas in Ukraine.

The highest airborne ^{137}Cs activity was measured at the Cadarache station ($1.31 \pm 0.24 \mu\text{Bq}/\text{m}^3$) from April 6 to 14, 2020. This measurement and those at the Bouc Bel Air station confirm model results which indicated that the masses would enter France through its South-Eastern corner.

IRSN publishes in an appendix the measurements carried out by Ukrainian partners⁷ and other European partners⁶ for who ^{137}Cs activity levels likely include ^{137}Cs emitted by fires. These measurements follow a decreasing east-to-west gradient over the first half of April 2020, reflecting a dilution of the airborne ^{137}Cs activity along the route of air masses.

A large number of measurements have been performed in Ukraine, which makes it possible to consolidate the estimation of the radiological labeling of air masses. The measurements confirm that the contamination of the air masses was of the order of a fraction of mBq/m^3 in the Kiev area and a fraction of Bq/m^3 in the CEZ.

3 / Modeling

Using meteorological data provided by Météo-France, IRSN has completed its simulation of the air mass transport which now covers the period from April, 2 to 30, 2020 (midnight).

According to this modeling, **the total amount of ^{137}Cs re-emitted into the atmosphere during this period is estimated at about 700 GBq between April, 2 and April, 30, 2020.** Most (625 GBq) of this release (established from the measurement results), occurred during the most intense fire period (from April, 2 to 24, 2020). For the following days and in view of the evolution of the situation, IRSN estimated that the releases were 20 GBq per day from April 25 to 27, then 5 GBq per day from April 28 to 30, reflecting the significant reduction in the number of fires after the rains of April 26, 2020.

The video⁸ of the air mass dispersion simulation between April, 2 and April, 30 is available on the IRSN website.

The simulation shows the arrival of a first plume with low-labeled air mass from April, 7 by the south-east of France, and which have lasted until April 14, 2020, consistent with the results in Cadarache and Bouc Bel Air.

The updated modeling also shows that a second plume of labeled air mass arrived in France from April 23, 2020 by the south-east with similar concentration levels or even lower than the previous ones, and undoubtedly close to detection limits of the best performing equipment. These air masses would have remained on a part of the French territory until April 28, 2020 before being evacuated under the effect of west winds.

⁶ Resulting from global fallout from nuclear weapon tests and Chernobyl fallout

⁷ Members of the Ring of Five (Ro5) network

⁸ https://www.irsn.fr/EN/newsroom/News/Pages/20200505_Fires-in-Ukraine-in-the-Exclusion-Zone-around-chernobyl-latest-news-and-consequences.aspx

4 / Dosimetric impact

The passage over France of a contaminated air mass marked by ^{137}Cs up to about $2 \mu\text{Bq}/\text{m}^3$ on a weekly average⁹, caused a tiny exposure of the French population. This exposure is mainly related to ^{137}Cs deposition on the ground surface. This deposition that has built up over a week is estimated to $0.006 \text{ Bq}/\text{m}^2$. As a reminder, in May 1 to 3, 1986, the average airborne activity in the East of France was around $1 \text{ Bq}/\text{m}^3$; due to rains which occurred at that time. The contamination of the air had caused deposition ranging from $2000 \text{ Bq}/\text{m}^2$ (in the absence of rain) to more than $40,000 \text{ Bq}/\text{m}^2$ in the most affected areas.

For a person who would permanently stay outside throughout the year 2020, the ^{137}Cs deposition of $0.006 \text{ Bq}/\text{m}^2$ related to the April 2020's fires, **would result in an effective external dose of 0.08 nSv** ¹⁰. This dose is in the order of 100,000 to 1 million times lower than that resulting from exposure to ^{137}Cs already present in French soil since nuclear tests and the Chernobyl accident. These range from less than $5,000 \text{ nSv}/\text{year}$ to nearly $50,000 \text{ nSv}/\text{year}$.

In addition, the doses linked to inhalation and external exposure during the passage of the labeled air masses (one week), were negligible (less than 0.002 nSv) compared to those linked to deposition.

Part of the ^{137}Cs deposited in last April was intercepted by the plant leaves, grassland, and agricultural products during cultivation. The maximum contamination that could result from it probably did not exceed $3 \text{ mBq}/\text{kg}$ fresh weight in leafy vegetables (salads, spinach ...) and meat, and $0.6 \text{ mBq}/\text{L}$ in milk. This ^{137}Cs added contamination is much lower than that usually measured in foodstuffs produced in France, which is around 10 to $50 \text{ mBq}/\text{kg}$ in vegetables, from 10 to $200 \text{ mBq}/\text{L}$ in milk and 20 to $700 \text{ mBq}/\text{kg}$ in beef meat. **Assuming continuous consumption until the end of the year, the effective dose started in 2020, would be 0.5 nSv .** For the sake of comparison, the current average effective dose in France linked to ^{137}Cs incorporation is estimated at about $200 \text{ nSv}/\text{year}$. In 1986, it had been estimated at $140,000 \text{ nSv}$ (or 0.14 milliSievert, mSv) from May to December 1986 (i.e. over the same period).

The first strontium 90 (^{90}Sr) analyses in the air carried out in Ukraine show that its airborne activity would be approximately 4 times weaker than those of ^{137}Cs . We can suppose that the ^{90}Sr airborne contamination in France was also 4 times lower than for ^{137}Cs , i.e. a ^{90}Sr activity of the order of $0.5 \mu\text{Bq}/\text{m}^3$ on average during the week concerned¹¹. Although more radiotoxic than ^{137}Cs , **the total dose due to ^{90}Sr fallout in France following fires in Ukraine would be around 10 times lower than that due to ^{137}Cs fallout.** This low contribution is mainly explained by the fact that the external exposure to the deposition is much lower for ^{90}Sr (no gamma radiation)¹² and that the transfer of ^{90}Sr to meat is about 100 times lower than that of ^{137}Cs .

⁹ Each measurement result represents an average value over a usual 7-day sampling period which does not necessarily corresponds to the period during where the ^{137}Cs -labeled air mass resulting from fires in Ukraine was present at the sampling station. Therefore it can lead to a lower value compared with what would have been measured if the sampling had started exactly at the time of the air mass arrival. In order to take this into account, the IRSN, based on its weekly routine airborne ^{137}Cs measurements at the closest OPERA station to Bouc Bel Air (i.e. the one located at La Seyne sur Mer in the Var department) estimated the usual average background value measured in the same period (March to May) over the past 5 years, in the region. This average ^{137}Cs background level is $0.15 \mu\text{Bq}/\text{m}^3$. By subtracting this background level and most precise estimated dates of the ^{137}Cs -labeled air mass resulting from fires (data from modeling performed by IRSN), IRSN estimated that the average ^{137}Cs level added by fires in Ukraine during the presence of the air mass is about $2 \mu\text{Bq}/\text{m}^3$.

¹⁰ 1 nanoSievert (nSv) = 10^{-9} Sievert

¹¹ Filters from the IRSN's OPERA stations with the most significant ^{137}Cs added activities will be analyzed for ^{90}Sr .

¹² As a pure beta emitter ^{90}Sr does not emit gamma radiation

Regarding the dose estimates that may have been received by the general public in the Kiev region or near the exclusion zone, the measurements transmitted by the Ukrainian partners¹³ of the Institute confirm the order of magnitude of the dosimetric evaluations presented in the April 15, 2020 information note, i.e. a maximum of a few tens of μSv for the consumption of foodstuffs contaminated by radioactive ash deposits near the exclusion zone.

Regarding the possible impact of plutonium in Ukraine, IRSN does not currently have measurements of its airborne activity. Furthermore, in France, it is very likely that the isotopes of this radioelement are too low to be measured, even with the most efficient techniques. Qualitatively, it can be emphasized that, unlike ^{137}Cs and ^{90}Sr , the transfer of plutonium to plants is extremely low; this element is therefore very little present in forest organic matter and remains fixed in the mineral fraction of soil contaminated in 1986. Its resuspension during fire events therefore had to be very low. **Furthermore, plutonium is not much transferred in the food chain. Despite its high radiotoxicity, it is therefore likely that its contribution to the population exposure by inhalation or ingestion has been negligible. It also does not cause any external exposure.**

5 / Risk for storage facilities

Regarding the safety of the facilities on the Chernobyl plant site and in the CEZ there are no new elements, compared to those appearing in the previous note (April 15 and April 17, 2020). Regarding the waste storages in this area, the measurements transmitted by our Ukrainian scientific partners have not revealed any release of activity from former deposition, which could have been caused by the fires.

IRSN will continue to measure aerosol filters from its OPERA stations, especially to check for activity levels due to the passage of the second plume. These measurement results will be published on the website of the National Network for Radioactivity in the Environment¹⁴.

¹³ Ukrainian Government Agency for the Exclusion Zone Management (DAZV), Ukrainian Hydrometeorological Institute, Kiev (UHMI), Central Geophysical Observatory, Kiev (CGO), SSE "Ecocentre", Kiev.

¹⁴ <https://www.mesure-radioactivite.fr>

Appendix

Measurements performed by IRSN foreign counterparts for which the detection of ¹³⁷Cs is clearly linked to the fire emissions (Ukrainian partners) or likely to be (other European partners)

Location	Country	Start of sampling	End of sampling	Radionuclide	Airborne activity (μBq/m³)
Brno	Czech Republic	06/04/2020	14/04/2020	Cs-137	2,51
České Budějovice	Czech Republic	30/03/2020	07/04/2020	Cs-137	1,42
České Budějovice	Czech Republic	07/04/2020	14/04/2020	Cs-137	1,84
Holešov	Czech Republic	06/04/2020	13/04/2020	Cs-137	3,75
Hradec Králové	Czech Republic	06/04/2020	14/04/2020	Cs-137	3,22
Cheb	Czech Republic	31/03/2020	07/04/2020	Cs-137	1,53
Kamenná	Czech Republic	06/04/2020	14/04/2020	Cs-137	1,83
Ostrava	Czech Republic	06/04/2020	13/04/2020	Cs-137	2,85
Praha	Czech Republic	07/04/2020	14/04/2020	Cs-137	1,61
Ústí nad Labem	Czech Republic	01/04/2020	07/04/2020	Cs-137	1,81
Thessaloniki	Greece	11/04/2020	13/04/2020	Cs-137	20
Thessaloniki	Greece	14/04/2020	16/04/2020	Cs-137	8
Thessaloniki	Greece	20/04/2020	22/04/2020	Cs-137	6
Thessaloniki	Greece	23/04/2020	24/04/2020	Cs-137	8
Svanhovd	Norway	14/04/2020	20/04/2020	Cs-137	0,4
Viksjo fjell	Norway	12/04/2020	19/04/2020	Cs-137	0,5
Ahronomiya	Ukraine	08/04/2020	15/04/2020	Cs-137	75
Arbuzinka	Ukraine	31/03/2020	07/04/2020	Cs-137	8,22
Arbuzinka	Ukraine	07/04/2020	14/04/2020	Cs-137	53
Arbuzinka	Ukraine	14/04/2020	21/04/2020	Cs-137	18,4
Baryshivka	Ukraine	11/04/2020	14/04/2020	Cs-137	45
Baryshivka	Ukraine	14/04/2020	17/04/2020	Cs-137	190
Baryshivka	Ukraine	17/04/2020	20/04/2020	Cs-137	170
Buhs'ke	Ukraine	01/04/2020	08/04/2020	Cs-137	10,3
Buhs'ke	Ukraine	08/04/2020	15/04/2020	Cs-137	49
Buryakivka	Ukraine	30/03/2020	04/04/2020	Cs-137	210
Buryakivka	Ukraine	30/03/2020	04/04/2020	Sr-90	63

Buryakivka	Ukraine	04/04/2020	09/04/2020	Cs-137	77
Buryakivka	Ukraine	09/04/2020	15/04/2020	Cs-137	500
Buryakivka	Ukraine	09/04/2020	15/04/2020	Sr-90	140
Buryakivka	Ukraine	15/04/2020	21/04/2020	Cs-137	940
Buryakivka	Ukraine	18/04/2020	18/04/2020	Cs-137	190
Buryakivka	Ukraine	21/04/2020	21/04/2020	Cs-137	3300
Chornobyl	Ukraine	29/03/2020	03/04/2020	Cs-137	14
Chornobyl	Ukraine	29/03/2020	03/04/2020	Sr-90	8,6
Chornobyl	Ukraine	03/04/2020	08/04/2020	Cs-137	36
Chornobyl	Ukraine	08/04/2020	13/04/2020	Cs-137	370
Chornobyl	Ukraine	13/04/2020	20/04/2020	Cs-137	400
Chornobyl	Ukraine	10/04/2020	10/04/2020	Cs-137	2600
Chornobyl	Ukraine	12/04/2020	12/04/2020	Cs-137	290
Chornobyl	Ukraine	04/04/2020	07/04/2020	Cs-137	33
Chornobyl	Ukraine	07/04/2020	10/04/2020	Cs-137	380
Chornobyl	Ukraine	10/04/2020	13/04/2020	Cs-137	290
Chornobyl	Ukraine	13/04/2020	16/04/2020	Cs-137	66
Chornobyl	Ukraine	17/04/2020	17/04/2020	Cs-137	2400
ChNPP area	Ukraine	13/04/2020	13/04/2020	Cs-137	180000
ASKRS Chernobyl	Ukraine	13/04/2020	13/04/2020	Cs-137	370
Denisovetske forestry	Ukraine	07/04/2020	07/04/2020	Cs-137	9400
Dytyatky	Ukraine	29/03/2020	03/04/2020	Cs-137	7,3
Dytyatky	Ukraine	29/03/2020	03/04/2020	Sr-90	1,6
Dytyatky	Ukraine	03/04/2020	08/04/2020	Cs-137	54
Dytyatky	Ukraine	08/04/2020	13/04/2020	Cs-137	89
Dytyatky	Ukraine	08/04/2020	13/04/2020	Sr-90	63
Dytyatky	Ukraine	13/04/2020	20/04/2020	Cs-137	200
ASKRS Dytyatky	Ukraine	13/04/2020	13/04/2020	Cs-137	89
Energodar	Ukraine	06/04/2020	13/04/2020	Cs-137	8,5
Energodar	Ukraine	13/04/2020	21/04/2020	Cs-137	33
Energodar	Ukraine	14/04/2020	21/04/2020	Cs-137	21
Energodar	Ukraine	15/04/2020	22/04/2020	Cs-137	29
Korogodske forestry, sq.11	Ukraine	12/04/2020	12/04/2020	Cs-137	43000
Korogodske forestry sq. 41	Ukraine	12/04/2020	12/04/2020	Cs-137	1600
Kyiv	Ukraine	27/03/2020	06/04/2020	Cs-137	25,2
Kyiv	Ukraine	08/04/2020	09/04/2020	Cs-137	290
Kyiv	Ukraine	10/04/2020	11/04/2020	Cs-137	567
Kyiv	Ukraine	11/04/2020	12/04/2020	Cs-137	185
Kyiv	Ukraine	12/04/2020	13/04/2020	Cs-137	57
Kyiv	Ukraine	16/04/2020	17/04/2020	Cs-137	236
Kyiv	Ukraine	06/04/2020	08/04/2020	Cs-137	48,4
Kyiv	Ukraine	08/04/2020	09/04/2020	Cs-137	126
Kyiv	Ukraine	09/04/2020	11/04/2020	Cs-137	477

Kyiv	Ukraine	11/04/2020	13/04/2020	Cs-137	94,3
Kyiv	Ukraine	13/04/2020	14/04/2020	Cs-137	39,2
Kyiv	Ukraine	14/04/2020	16/04/2020	Cs-137	32,5
Kyiv	Ukraine	15/04/2020	16/04/2020	Cs-137	76
Kyiv	Ukraine	16/04/2020	17/04/2020	Cs-137	114
Kyiv	Ukraine	17/04/2020	18/04/2020	Cs-137	124
Kyiv	Ukraine	18/04/2020	19/04/2020	Cs-137	78
Kyiv	Ukraine	17/04/2020	21/04/2020	Cs-137	135
Kyiv	Ukraine	21/04/2020	24/04/2020	Cs-137	40,4
Kyiv	Ukraine	24/04/2020	27/04/2020	Cs-137	18,8
Maryanivka	Ukraine	05/04/2020	05/04/2020	Cs-137	310
Naftobaza	Ukraine	29/03/2020	03/04/2020	Cs-137	190
Naftobaza	Ukraine	03/04/2020	08/04/2020	Cs-137	410
Naftobaza	Ukraine	08/04/2020	13/04/2020	Cs-137	8300
Naftobaza	Ukraine	13/04/2020	21/04/2020	Cs-137	3800
Netishyn	Ukraine	05/04/2020	06/04/2020	Cs-137	14,5
Netishyn	Ukraine	06/04/2020	07/04/2020	Cs-137	42,5
Netishyn	Ukraine	06/04/2020	07/04/2020	Sr-90	8,66
Netishyn	Ukraine	11/04/2020	12/04/2020	Cs-137	13,5
Netishyn	Ukraine	12/04/2020	13/04/2020	Cs-137	14,7
Odessa	Ukraine	09/04/2020	12/04/2020	Cs-137	48
Odessa	Ukraine	12/04/2020	15/04/2020	Cs-137	77
Ovruch Control Checkpoint	Ukraine	07/04/2020	07/04/2020	Cs-137	960
Ryabokoneve	Ukraine	31/03/2020	07/04/2020	Cs-137	5,11
Ryabokoneve	Ukraine	07/04/2020	14/04/2020	Cs-137	53
Ryabokoneve	Ukraine	14/04/2020	21/04/2020	Cs-137	17
Ragivka	Ukraine	04/04/2020	04/04/2020	Cs-137	910
Richtza	Ukraine	21/04/2020	21/04/2020	Cs-137	1200
Snovsk	Ukraine	09/04/2020	12/04/2020	Cs-137	52
Snovsk	Ukraine	12/04/2020	15/04/2020	Cs-137	41
Stara Krasnitza	Ukraine	21/04/2020	21/04/2020	Cs-137	8200
Varash	Ukraine	30/03/2020	05/04/2020	Cs-137	4,45
Varash	Ukraine	05/04/2020	06/04/2020	Cs-137	13,5
Varash	Ukraine	06/04/2020	07/04/2020	Cs-137	61,1
Varash	Ukraine	06/04/2020	07/04/2020	Sr-90	11,1
Varash	Ukraine	07/04/2020	08/04/2020	Cs-137	15,8
Varash	Ukraine	08/04/2020	09/04/2020	Cs-137	12,7
Varash	Ukraine	09/04/2020	10/04/2020	Cs-137	4,73
Varash	Ukraine	10/04/2020	11/04/2020	Cs-137	8,86
Varash	Ukraine	11/04/2020	12/04/2020	Cs-137	14,5
Varash	Ukraine	12/04/2020	13/04/2020	Cs-137	19,4
Varash	Ukraine	13/04/2020	14/04/2020	Cs-137	2,88
Varash	Ukraine	14/04/2020	21/04/2020	Cs-137	6,73
Volya	Ukraine	02/04/2020	09/04/2020	Cs-137	1,53

Volya	Ukraine	09/04/2020	16/04/2020	Cs-137	81,2
VRP-750	Ukraine	29/03/2020	03/04/2020	Cs-137	390
VRP-750	Ukraine	29/03/2020	03/04/2020	Sr-90	71
VRP-750	Ukraine	03/04/2020	08/04/2020	Cs-137	630
VRP-750	Ukraine	08/04/2020	13/04/2020	Cs-137	1400
VRP-750	Ukraine	08/04/2020	13/04/2020	Sr-90	240
VRP-750	Ukraine	13/04/2020	20/04/2020	Cs-137	10000
Yasen	Ukraine	05/04/2020	05/04/2020	Cs-137	1300
Yuzhnoukrainsk	Ukraine	31/03/2020	07/04/2020	Cs-137	8,27
Yuzhnoukrainsk	Ukraine	02/04/2020	09/04/2020	Cs-137	17,5
Yuzhnoukrainsk	Ukraine	06/04/2020	10/04/2020	Cs-137	14,5
Yuzhnoukrainsk	Ukraine	07/04/2020	13/04/2020	Cs-137	49,5
Yuzhnoukrainsk	Ukraine	08/04/2020	15/04/2020	Cs-137	75
Yuzhnoukrainsk	Ukraine	09/04/2020	16/04/2020	Cs-137	92,4
Yuzhnoukrainsk	Ukraine	10/04/2020	17/04/2020	Cs-137	89,6
Yuzhnoukrainsk	Ukraine	14/04/2020	21/04/2020	Cs-137	18,4
Yuzhnoukrainsk	Ukraine	15/04/2020	22/04/2020	Cs-137	24,7
Yuzhnoukrainsk	Ukraine	16/04/2020	23/04/2020	Cs-137	27,6
Yuzhnoukrainsk	Ukraine	17/04/2020	24/04/2020	Cs-137	30
Yuzhnoukrainsk	Ukraine	21/04/2020	27/04/2020	Cs-137	11,5
Yuzhnoukrainsk	Ukraine	21/04/2020	28/04/2020	Cs-137	15,9
Yuzhnoukrainsk	Ukraine	14/04/2020	21/04/2020	Cs-137	24
Zhovtneve	Ukraine	04/04/2020	04/04/2020	Cs-137	3600