

STATUS OF ACTIVITIES ON REHABILITATION OF RADIOACTIVELY CONTAMINATED FACILITIES AND THE SITE OF RUSSIAN RESEARCH CENTER “KURCHATOV INSTITUTE”

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ABSTRACT

This paper describes the program, the status, and the course of activities on rehabilitation of radioactively contaminated facilities and the territory of temporary radioactive waste (radwaste) disposal at the Russian Research Center “Kurchatov Institute” (RRC KI) in Moscow as performed in 2001-2002. The accumulation of significant amounts of radwaste at RRC KI territory is shown to be the inevitable result of Institute’s activity performed in the days of former USSR nuclear weapons project and multiple initial nuclear power projects (performed from 1950ies to early 1970ies). A characterization of RRC KI temporary radwaste disposal site is given. Described is the system of radiation control and monitoring as implemented on this site. A potential hazard of adverse impacts on the environment and population of the nearby housing area is noted, which is due to possible spread of the radioactive plume by subsoil waters. A description of the concept and project of the RRC KI temporary radwaste disposal site is presented. Specific nature of the activities planned and performed stems from the nearness of housing area. This paper describes main stages of the planned activities for rehabilitation, their expected terms and sources of funding, as well as current status of the project advancement. Outlined are the problems faced in the performance and planning of works. The latter include: diagnostics of the concrete-grouted repositories, dust-suppression technologies, packaging of the fragmented ILW and HLW, soil clean-up, radioactive plume spread prevention, broad radiation monitoring of the work zone and environment in the performance of rehabilitation works. Noted is the intention of RRC KI to establish cooperation with foreign, first of all, the U.S. partners for the solution of problems mentioned above.

INTRODUCTION

Russian Research Center “Kurchatov Institute” (RRC KI) is one of the largest research centers of Russia. It hosts a complex of nuclear and other facilities, including 12 research reactors (6 of which are currently shut down or even partially dismantled), 20 various experimental facilities and hot laboratories.

RRC KI was founded in 1943. It was located near Schukino village at the North-Western outskirts of Moscow. In the current time RRC KI territory has an area of about 100 hectares and includes two sites: the main one, and the supplementary one located on the bank of Moscow river. Nowadays, 60 years since RRC KI foundation, the main site turned out to be in a highly populated area: 10 km from Kremlin and 2 km from the Strogino flood-lands. A housing area is now located just next to the outer perimeter of main RRC KI site (50-150 m).

An inevitable result of RRC KI productive activity, especially that performed at early stages, is the accumulation of substantial amounts of spent nuclear fuel (SNF) and radioactive waste (radwaste) at its

territory. SNF in the form of fuel assemblies was removed to special repositories located, as a rule, near research reactors and facilities. In the period from RRC KI foundation and up to mid 1970ies the produced solid radwastes, HLW included, was designated to temporary disposal at a special site of about 2 hectares, see Fig. 1, located in the North-Western part of the main RRC KI territory. 10 temporary repositories different in their design and structural materials were erected for this purpose at the disposal site. From 1965, these radwastes were started to be partially removed to the polygon of a newly created Moscow Scientific and Production Association "Radon" (MosNPO "Radon") located in Sergiev Posad, outside of Moscow. In 1974 the disposal of solid radwaste at RRC KI territory was stopped. Since then, all radwastes produced are removed to MosNPO "Radon" for conditioning and temporary storage.

The temporary storages of radwaste at RRC KI territory create increased gamma dose rates at particular segments of the site where they are located. Moreover, contamination of soil by ^{90}Sr , ^{137}Cs , ^{60}Co and some other nuclides is registered at these segments. Due to their long-term operation and possible waterproof failure these old repositories, as well as the contaminated soil around them, pose a potential hazard of subsoil water contamination. Radionuclides leaching from the contaminated soil and the disposed waste may penetrate to water horizon.

More than 1,200 cub. m of solid radwastes with the mass of more than 2000 metric tons and cumulative activity of more than $3.7 \cdot 10^{15}$ Bq should be removed from RRC KI territory, and nearly 8,000 cub. m of soil should be removed or cleaned in order to eliminate this potential hazard in full.

As comes to liquid radwastes, they are collected to special tanks and periodically removed from RRC KI territory through the available special sewerage system. However, this system has undergone no repairs since the moment of its construction. Radiation survey of this system has revealed partial destruction of some technological wells and rupture of several pipelines. Due to this, RRC KI special sewerage system may also be viewed as a potential source of adverse environmental impacts.

Given below is information on the activities performed for the rehabilitation of the temporary radwaste disposal site located at the main RRC KI territory. Characterization of the site is provided, program of works and major results obtained so far are outlined, problems faced in the performance of works are identified, items for international cooperation are drafted.

CHARACTERIZATION OF THE TEMPORARY RADWASTE DISPOSAL SITE

General Characterization

The area of site selected for temporary radwaste disposal is about two hectares, and the site is located not far from the external perimeter of RRC KI which, as noted above, is now located in the immediate vicinity of the city housing area, see. Fig. 1.

Inside the RRC KI territory this site is bounded by auxiliary buildings and structures of the MR nuclear research reactor that was shut down for decommissioning in 1993.

The map of radwaste disposal site is shown in Fig. 2. Nine temporary radwaste repositories (No. 1, 2, 3, 4, 5, 6, 8, 9 and 10) were erected at the site, and high and low activity solid wastes were removed to these repositories during the period of 1950ies to early 1970ies. Radwaste generated from the dismantling of structures or reconstruction of the RFT, Romashka and MR research reactors (see Table 1) in 1962, 1966 and 1968 were also removed to these temporary repositories. Besides, a special radwaste storage (No. 7) was constructed to meet the needs of RRC KI activities and the demand for storage of high level solid wastes produced in these activities, and to consolidate and subsequently remove these radwastes.



Fig. 1. General view of RRC KI radwaste disposal site: before (top left) and after (bottom right) preliminary accomplishment

As regards geological conditions, the site used for radwaste disposal and storage is situated on the high terrace above the floodplain of the Moscow River, on the thick layer of the Quaternary and moraine deposits overlaying the Jurassic period moraine deposits (1). It has been discovered that for the most part the geological section of the site represents sandy ground with non-mature stratum of moraine loamy soils laying at the depth of 11 to 19 meters, while the thickness of this stratum of loamy soils varies from 0.6 to 5.8 meters. Fine and middle-sized sands are water-bearing soils at the site. The upper subhorizon of underground waters is located at the depth of 5-6 meters and it's not protected against penetration of contamination from the ground surface. The filtration ratio of sandy ground is 1.8-13.8 m/day depending on the presence and size of dust particles. The lower subhorizon of ground waters is located at the depth of 11-20 meters and it's characterized by low permeability to water. In fact, this moraine stratum of loamy soils can serve as a screen protecting against possible penetration of contaminated waters from the upper subhorizon to the lower subhorizon of subsoil waters. The general direction of subsoil water stream spreading across the site is from the East-North to the West and South-West.

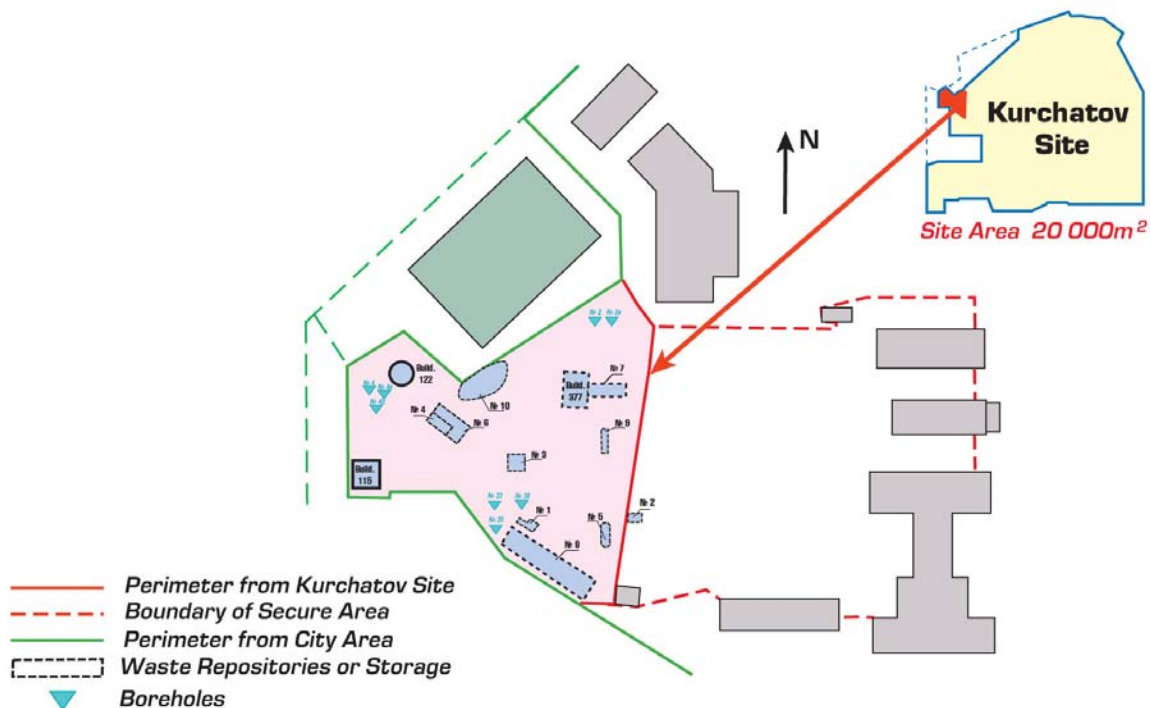


Fig. 2. RRC KI temporary radwaste disposal site

Along with the temporary radwaste repositories built on the site, over many years the site had been filled by spoils including radioactively contaminated soil, rubbish and other wastes in the form of fragments of metal structures, equipment, concrete, etc. As a result, the natural topography of the site has been changed by filling up the ravine formerly located at the site in the course of the site development, since initially the natural slopes of this ravine were used for temporary radwaste disposal. The overall layer of the piled up soil which thickness, taking into account the formerly existing ravine, runs up to 8.7 meters, contains natural and radioactively contaminated soils that were spread over the site surface by dry method and mixed with rubbish including concrete, bricks, metal pipes, wires and other industrial waste.

In addition to the above listed temporary radwaste repositories and an operating storage, there is a number of auxiliary production buildings and structures at the waste disposal site:

- Building 115 – the operating pumping station for special pumping of liquid radwaste;
- Building 122 – the old pumping station for special pumping of liquid radwaste (decommissioned in 1985);
- Building 377 – the basement of the uncompleted temporary storage for radwaste;
- gravity flow pipelines of the Institute special sewage system going to the old and operating special pumping stations;
- the underground city storm sewer crossing the city housing zone outside the Institute perimeter in the direction of the Moscow River;
- local pipelines of water supply, sewage system, central heating and electric cables.

The works on partial cleaning of scrap, fragments of metal structures, equipment, trees, wood and other process waste from the site have been performed by now.

Classification of Temporary Radwaste Repositories and Radwaste Storage Located at the Site

According to the available records, till 1955 the disposal of solid radwaste at a dedicated site within RRC KI was carried out by dumping the waste into the natural ravine existing at this site, and covering the waste by soil and various rubbish (repository No. 10). In subsequent years (1955 to 1973), temporary concrete structures of different sizes and designs were built for these purposes at the site. During this period 8 temporary radwaste repositories (No. 1, 2, 3, 4, 5, 6, 8 and 9) were additionally built at the site, see Fig. 2.

There are almost no archive records on the design of the above listed temporary radwaste repositories and their filling up with waste. According to the available data, the disposed wastes are solid radwastes of, mainly, low and medium specific activity. They were transferred for unorganized disposal in the form of samples of structural materials, fuel channels, parts of structures, equipment and instruments, filters used when operating nuclear research reactors and facilities, laboratory equipment, glass and ceramic articles and other contaminated rubbish.

From the archive records it follows that activity of disposed solid radwaste is to be defined by gamma- and beta-active nuclides only. Wastes of SNF, transuranium nuclides and other alpha-active nuclides were not transferred for disposal. However, it should be noted that the presence of insignificant amount of nuclear fuel products in the waste must not be completely ruled out since the waste includes dismantled structures, equipment, instruments and other components of nuclear research reactors. Basing on the archive data and results of the preliminary survey of the site within RRC KI used for radwaste disposal, suggested may be the following classification of contaminated objects located at this site:

- radwaste repositories easily accessible for withdrawal of radwaste;
- radwaste repositories not easily accessible for withdrawal of radwaste;
- contaminated soil and radwaste it contains.

Characterization of Accessible Temporary Radwaste Repositories and Radwaste Storages

The list of accessible temporary radwaste repositories identified in accordance with the above classification, including their estimated volume and level of filling up with waste, as well as the characteristics of radwaste they contain and the waste activity as obtained from available data and expert evaluations are presented in Table 1.

The accessible for easy waste removal are repositories No. 1, 2, 3, 5, 8, 9, 10 located at the site of temporary radwaste disposal. In this, the accessibility of repositories No. 2 and 5 requires further examination with respect to the selection of a particular technology of radwaste removal to be applied to them. Cumulative volume of wastes located in accessible repositories is estimated to be about 500 cub. m, mass of these wastes – around 750 metric tons, cumulative activity – around $5 \cdot 10^{14}$ Bq (10,000-12,000 Ci).

Additional information characterizing design and other features of temporary radwaste repositories listed in this table is presented below.

Repository No.1

Represents a concrete encased reservoir deepened in the ground.

Repository No. 2

In its design represents a reinforced concrete well filled with structural material waste. At present this well is covered with soil and construction rubbish.

Repository No. 3

In its design represents a reinforced concrete repository of ground type with the area of 6.0x6.0 square meters and height of 3 meters. It has a reinforced concrete lid atop, equipped with metal hatches.

Repository No. 5

Represents an underground structure made in the form of 6 reinforced concrete wells 1.2 meters in diameter and 6 meters deep.

Repository No. 8

In its design represents a concrete underground repository with the area of 40.0x10.0 square meters and depths of 1.8 meters. On the top this repository is covered by concrete plates.

Repository No. 9

The repository is made in the form of a concrete well.

Repository No. 10

This is a trench type radwaste repository for which a natural ravine formerly existing at the radwaste disposal site was used. It was filled up with radwaste mixed with construction and other rubbish.

Characterization of Temporary Radwaste Repositories that are not Easily Accessible

The list of not easily accessible temporary radwaste repositories identified in accordance with the classification suggested above, including their estimated capacity and level of filling up with waste, as well as the characteristics of waste they contain and activity of the waste obtained from the available data and expert evaluations are presented in Table 2.

Cumulative volume of wastes located in accessible repositories is estimated to be about 1200 cub. m, mass of these wastes – around 1800 metric tons, cumulative activity – around $4 \cdot 10^{15}$ Bq.

Table 1. List and Description of Temporary Radwaste Repositories at RRC KI Accessible for Radwaste Extraction

Repository number	Capacity of radwaste repository (level of filling up)	Radwaste characterization	Estimated radwaste activity		Note
			Specific activity, 10^7 Bq/kg	Total activity, 10^{12} Bq	
1	50 m ³	Medium and low activity	25	20	Information on the level of filling up is not available
2	30 m ³ (100 %)	Medium activity	40	20	
3	100 m ³ (70 %)	High activity	80	80	
5	30 m ³ (70 %)	Medium and low activity	60	20	
8	100 m ³ (15 %)	High and medium activity	80	20	
9	10 m ³	High activity	250	40	Information on the level of filling up is not available
10	2,000 m ³ (100 %)	Medium and low specific activity	1	40	Natural topography of the site was used for the radwaste repository

Additional information characterizing design and other features of temporary repositories and radwaste storage listed in this table is presented below.

Repository No. 4

Represents an underground reinforced concrete repository with the area of 18x7.5 square meters and depths of 4.5 meters. The repository is divided into 3 separate compartments with the area of 5x5 square meters, covered by the common concrete layer with 3 hatches measuring 1.0x1.0 meters for each compartment. Once placed in the repository, the waste was turned into a monolith by grouting.

Repository No. 6

Represents a trench type underground repository with side slopes 2:1 made of reinforced concrete and brick. The repository was filled up with diverse waste of different specific activity, after which the entire volume of the repository was turned into a monolith by grouting.

Table 2. List and Description of Kurchatov Institute Temporary Radwaste Repositories not Easily Accessible for Radwaste Extraction

Radwaste repository number		4	6
Capacity of radwaste repository (level of filling up)		625 m ³ (100 %)	600 m ³ (100 %)
Characterization of radwaste activity		High and medium activity	Medium activity
Estimated level of radwaste activity	Specific activity, 10 ⁷ Bq/kg	400	20
	Total activity, 10 ¹² Bq	4,000	200
Note		Radwaste is converted into a monolith by cement grout	Radwaste is converted into a monolith by cement grout

Characterization of Soil at the Radwaste Disposal Site

Contaminated soil is present at the territory of temporary radwaste disposal site and in repository No. 10 that appears as former ravine to which auxiliary equipment and lab apparatuses have been dumped, and which was later on filled with debris. Preliminary survey has shown the depth of radioactive soil contamination to be within the range from 0.5 to 3.5 m. Main isotopes present in the soil are ¹³⁷Cs, ⁹⁰Sr и ⁶⁰Co.

SURVEYING AND RADIATION CONTROL AT THE TEMPORARY RADWASTE DISPOSAL SITE

Radiation monitoring is conducted at the RRC KI temporary radwaste disposal site, which includes:

- monitoring of exposure gamma radiation dose using stationary dosimeters, and monitoring of gamma dose rate using portable dosimeters;
- monitoring of activity and radionuclide composition of environmental objects around the site: subsoil waters, soil and vegetation.

In the summer of 2002 performed were new measurements of radiation field at the territory of radwaste disposal site. Used was the mesh that included 20,000 measurement points. Results of these measurements are illustrated by Fig. 3.

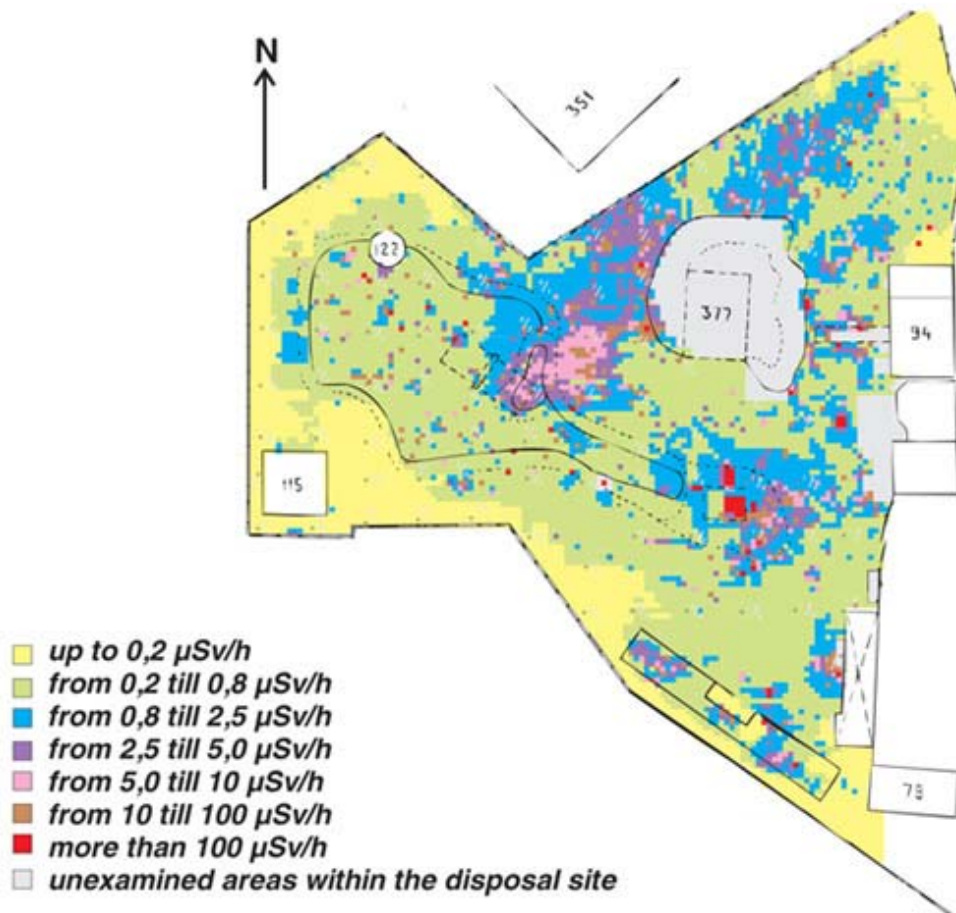


Fig. 3. Map of the gamma dose rate ($\mu\text{Sv/h}$) within 0.05 m from the soil surface at the radwaste disposal site

This figure shows that there are zones and spots at the disposal site where the dose rate exceeds the control level of 2.5 $\mu\text{Sv/h}$ established for strict security areas – a category under which this radwaste

disposal site falls. Small local zones with the dose rate exceeding 10 $\mu\text{Sv/h}$, as well as individual spots with the dose rate higher than 30 $\mu\text{Sv/h}$ were noted at the site.

Exploratory and observation boreholes were drilled at the waste disposal site to enable monitoring of ground water contamination: 91 boreholes with the depth from 10 to 39.5 meters were drilled at the site in 1975 - 1992 for this purpose. Unfortunately, only 7 of them can be used for measurements nowadays. In 2002, 10 new boreholes for monitoring were drilled beyond the limits of radwaste disposal site in the territory located outside RRC KI perimeter along the direction of subsoil water flow.

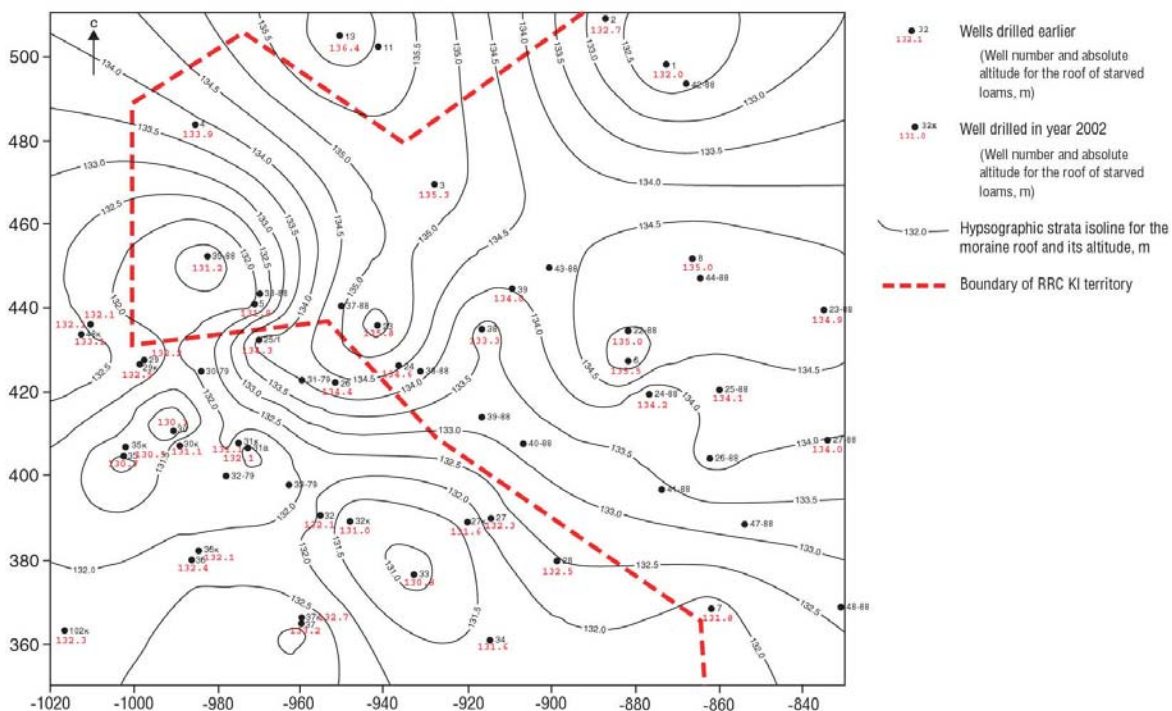


Fig. 4. Map showing the location of boreholes and the hypsographic strata isolines for the roof of starved loams

At the present time the radiation monitoring of subsoil water contamination at the waste disposal site is being conducted by means of the observation boreholes covering the upper and lower subhorizons of ground water spreading. These are boreholes No. 2, 4, 4a, 4b, 23, 38 and 7 located at the radwaste disposal site and at nearby territory within RRC KI perimeter, and 10 new boreholes drilled beyond the limits of RRC KI temporary radwaste disposal site but still within the limits of RRC KI territory, namely, boreholes No. 27k, 29k, 30k, 31k, 32k, 35k, 36k, 37k, 42k, and 102k, see Fig. 4. In the current time, drilling of new boreholes at the territory of temporary radwaste disposal site is restricted because there are data that such drilling results in an increase of the levels of subsoil water contamination, in particular, beyond the limits of RRC KI temporary radwaste disposal site.

Regular surveys of the radwaste disposal site have been conducted since 1991 in order to evaluate conditions of the “soil – water” ecosystem. In the process of these surveys, about 500 samples of soil and water were taken and analyzed to determine the radionuclide content, and detailed gamma-mapping of the entire area of the site was performed. The measured gamma dose rate varies throughout the site over a rather wide range. At the major part of the site, the gamma dose rates exceed the reference levels.

Stationary equipment widely used in the radioecology field was applied to determine the qualitative and quantitative composition of soil and water samples taken at the radwaste disposal site. Measurements of spectral composition of soil and water samples are made using a spectrometer included into NOKIA LP-4900B pulse analyzer with a GEM-30195 semiconductor detecting unit. Measurements of the total activity of beta emitting radionuclides are made using a low background radiometric system. ^{90}Sr radionuclide is extracted from soil and water samples using a radiochemical method, and the samples are further measured with the radiometric system. Measurements for the presence of alpha activity are not done for the samples, therefore, the presence of ^{241}Am in soil samples is noted by its gamma spectrum.

Investigations of activity of the soil samples taken at the radwaste disposal site show that the main dose-producing radionuclides are ^{137}Cs and ^{90}Sr , with concentrations of ^{137}Cs in all of the samples and of ^{90}Sr in some points exceeding the prescribed allowable specific radioactivity of soil. Concentrations of these radionuclides vary over the following ranges: ^{137}Cs – from 0.2 to 60,000 Bq/kg, ^{90}Sr – from 0.4 to 20,000 Bq/kg. However, along with contamination with ^{137}Cs and ^{90}Sr , local contamination with other radionuclides, in particular, ^{60}Co , ^{134}Cs , and ^{152}Eu , was noted in the soil of the disposal site. Moreover, the presence of ^{241}Am in small quantities was detected in several soil samples taken from two boreholes.

The presence of the above radionuclides in the soil at the radwaste disposal site may result in contamination of the subsoil waters, because their upper subhorizon is located at the depth of 5-6 meters and is not protected against penetration the contamination from soil surface. Moreover, the contamination leached from radwaste repositories, which are sunken virtually to the level of subsoil waters, also may penetrate to this subsoil water subhorizon. Analyses of water samples taken from the boreholes show that subsoil water activity is defined by the presence of ^{90}Sr . The presence of ^{90}Sr was also found in samples of the lower subhorizon, but its maximum concentrations are by an order of magnitude lower than in the upper subhorizon.

The current status of the upper subsoil water subhorizon contamination due to the presence of ^{90}Sr radionuclide was analyzed on the basis of the obtained results, and a preliminary evaluation of the possible further spreading of this radionuclide in the upper subhorizon waters was carried out. Results of the analysis of the currently existing mentioned above distribution suggest that there could be a local center of contamination with ^{90}Sr in the upper water subhorizon. Thus, a plume of contamination is formed following the subsoil water stream, with the concentration of ^{90}Sr within this plume decreasing from the initial to background level. The size and shape of this radioactive plume may depend on the duration of the contamination center existence, as well as on the initial concentration of ^{90}Sr , subsoil water velocity, dispersion parameters, sorption properties of the soil and other factors. In the current time this plume is not being spread beyond the limits of RRC KI territory.

Long-term operation of the temporary radwaste repositories might result in degradation of their moisture penetration barriers, migration of radionuclides into subsoil waters, as a result of which one cannot rule out the possibility that radioactivity being leached from these radwastes may in time be carried outside the RRC KI site.

Finally, it should be mentioned that radiation monitoring of the atmospheric air is exercised for the entire RRC KI site. A filter ventilation unit is used for this purpose, which is faced towards the direction of prevailing winds (according to long-standing observations, the prevailing wind in the North-Western Moscow Administrative District, where RRC KI is located, blows from South-West to the North-East). Parameters that characterize radiation conditions of the atmospheric air within the RRC KI site and the city area from 1997 to 2000 are presented in Table 3. It follows from this data that annual-average concentrations of beta-radionuclide aerosols in the atmospheric air at the RRC KI site exceed the corresponding level characteristic of the North-Western Moscow Administrative District. In this, maximum and minimum concentrations of beta-radionuclides at the RRC KI site are higher than similar values for the city area, but are always below the permissible value established by the current sanitary regulations for population.

Table 3. Concentration of Aerosols in the Surface Air Within the Kurchatov Institute Site and City Area

Years		1997	1998	1999	2000		
Kurchatov Institute	Beta-active nuclides, $\mu\text{Bq}/\text{m}^3$	Aver.	127	212	237	157	
		Max.	319	518	379	344	
		Min.	42	70	137	86	
	^{137}Cs , $\mu\text{Bq}/\text{m}^3$	Aver.	2.0	1.8	2.7	3.3	
		Max.	2.9	2.9	5.2	4.0	
		Min.	1.2	1.0	1.6	1.5	
	Atmospheric aerosols (dust), $\text{n} \times 10^{-2} \text{ mg}/\text{m}^3$	Aver.	5.05	5.73	8.22	5.41	
	North-Western Administrative District of Moscow	Beta-active nuclides, $\mu\text{Bq}/\text{m}^3$	Aver.	75	107	94	92
			Max.	138	246	148	146
Min.			37	31	59	57	
^{137}Cs , $\mu\text{Bq}/\text{m}^3$		Aver.	-	2.0	1.8	1.7	
		Max.	-	3.0	2.7	2.6	
		Min.	-	1.2	1.2	1.2	

CONCEPT AND PROGRAM OF RRC KI SITE REHABILITATION

The presence in RRC KI of radiation heritage related to former USSR nuclear programs creates a potential radiological hazard. RRC KI has developed proposals and made multiple applications to the federal and municipal authorities with a request to provide financial support for moving SNF and radwaste away from the site and for site remediation.

On August 25, 1998 the Government of Moscow has adopted Resolution No. 642 "On Speeded-up D&D of Radiation Hazardous Facilities of RRC KI" which put a priority on the removal of SNF and radwaste repositories from RRC KI territory. However, practical implementation of this resolution was interrupted by the financial crisis faced by Russia in August, 1998. The situation improved only in 2001, when under an approval and financial support from the Minatom RF, RRC KI President academician E.P. Velikhov has issued an ordinance on the organization of an integrated project called "Rehabilitation" that has a goal to consolidate all activities performed for rehabilitation of radioactively contaminated facilities and the site of RRC KI.

The goal of rehabilitation activities to be performed is to eliminate all potentially hazardous sources of radiation that may produce adverse environmental effects, and to transform RRC KI into a secure and safe nuclear research center within Moscow city limits. The activities within the project of rehabilitation of contaminated facilities and the site of RRC KI will be carried out in the following sequence:

- preparation for the performance of works on rehabilitation;
- recovery of radwaste from temporary repositories and storages;
- soil clean-up at the contaminated segments of the territory;
- separation, packaging and removal of the recovered or produced in the clean-up of soil radwaste to the polygon of specialized MosNPO "Radon" enterprise;
- delivery-acceptance procedure after the works on rehabilitation are completed.

At first stage the following activities are to be carried out at RRC KI radwaste disposal site:

- waste removal from the accessible temporary repositories No. 1, 2, 3, 5, 8, 9, 10, see Fig. 2 and Table 1;
- examination of structural elements of the decontaminated temporary repositories and making a decision on their dismantling and elimination or on their accommodation and further use for RRC KI needs;
- examination of not easily accessible temporary repositories No. 4 and 6 (see Fig. 2 and Table 2), analysis of their possible impact upon the environment, and making a decision on their further management;
- technology development and management planning for activities on the clean-up or removal of contaminated soil from the temporary radwaste disposal site;
- dismantling of the equipment and technological systems and dismantling of the structural elements of building 122 that belongs to an old pumping plant of special sewerage system, now decommissioned;
- reconstruction or dismantling of the industrial wells, dismantling or conservation of underground pipelines of the defunct branches of special sewerage system.

The second stage would include the following activities at RRC KI temporary disposal site:

- elimination of not easily accessible temporary storages No. 4 and 6, or creation of additional protection barriers around them;
- verification of the technology and performance of works on the clean-up of contaminated soil;
- implementation of particular measures that will be found necessary to prevent the spread of radioactive contamination beyond the limits of temporary radwaste disposal site.

In 2001-2002, the funding of rehabilitation activities at RRC KI site was provided by Minatom RF within the framework of a special budgetary fund "Nuclear and Radiation Safety of Russia". Partially, current works on rehabilitation are being funded by RRC KI on its own.

The project of works on rehabilitation of radioactively contaminated objects and the site of RRC KI is currently being worked out and, partially, undergoes the required coordinations and approvals. The funding of works by Moscow Government has been opened late in 2002.

RRC KI ACTIVITIES ON REHABILITATION OVER THE PAST YEAR

Principle outcome of the activities on rehabilitation of RRC KI temporary radwaste disposal site as performed in late 2001 through 2002 is summarized below:

(1). The concept of works on rehabilitation of RRC KI contaminated facilities and segments of territory has been developed. This document has been coordinated with the supervising authorities of the Minzdrav RF (RF Ministry of Health Protection) and Gosatomnadzor of Russia (Federal Survey of Russia on Nuclear and Radiation Safety). Contents of this document are outlined in the previous section.

(2). A set of necessary documents has been prepared, an application has been made, and a license of Gosatomnadzor of Russia for the management of radwaste from research reactors at the facilities and structures of RRC KI has been obtained.

This license provides a legal basis for practical performance of rehabilitation works on the removal of waste and site remediation at RRC KI territory by RRC KI co-jointly with its subcontractors. A plan of personnel training and certification has been compiled and is being implemented. According to it, particular categories of RRC KI staff involved in works on rehabilitation will obtain the certificates of Gosatomnadzor granting them a legal right to carry out relevant works at the objects of atomic energy use in Russia.

(3). To expand the base for radiation control over the migration of radionuclides beyond the limits of RRC KI temporary radwaste disposal site, 10 new boreholes have been drilled at the segment of outside territory adjacent to the territory of the site in the direction of subsoil water flow.

Gamma-ray logging of these new boreholes has been carried out, samples of water and soil have been taken from them, and radiometric analysis of these samples has been performed. Results of this analyses show that contamination of subsoil water and soil by artificial radionuclides is present at this segment of RRC KI territory located beyond the limits of the temporary radwaste disposal site. The cumulative activity registered of water samples collected is essentially below the regulatory level prescribed for drinking water.

The character of ^{137}Cs distribution in soil samples taken from the boreholes makes it possible to presume that radioactive contamination of soil by this nuclide may be due to the displacements of soil at this territory resulting from the planning and construction works performed earlier. Comparison with the results of similar examinations performed in 1992-1993 for the needs of exploration and survey shows that currently registered levels of activity are essentially lower.

To verify the results obtained so far and to expand the base for control over radionuclides' possible migration beyond the limits of radwaste disposal site it is planned to perform the following further works:

- to go on with periodical examinations of subsoil water activity in the available borehole net;
- to drill new additional boreholes at the segment of outside territory adjacent to the territory of RRC KI site in the direction of subsoil water flow.

(4). The technology of machine soil clean-up as developed by the Bochvar Institute (VNIINM) has been selected as a candidate one for soil remediation at RRC KI temporary radwaste disposal site. This technology implements a machine-based hydroclassification of soil and is said to be capable of reducing contamination level in the bulk of soil by a factor of 10-40 (at least, as comes to ^{137}Cs). The verification of this technology for RRC KI conditions is being performed currently. Samples of soil from RRC KI radwaste disposal site with the overall weight of 5 metric tons have been delivered to VNIINM, radiometric analysis of these samples and facility commissioning have been performed.

(5). Works on localization and decontamination of the enclosed areas of surface contamination were carried out at the segment of temporary radwaste disposal site located in the middle of its North part and adjacent to Building 351 (see Fig. 3).

The radiation and radiological survey performed before the works have revealed the area of the localized territory segment for decontamination to be around 200 sq. m. In the course of works, the soil at this decontaminated segment has undergone a uniform hand-driven (with the use of a spade) separation

performed to the depth of 1 m on average. The performed sorting was followed by radiometric analysis which made it possible to separate about 170 cub. m of soil on the total. Of these, 10.8 cub. m of contaminated soil were removed to the polygon of MosNPO "Radon". After the completion of works, gamma dose rate along the whole decontaminated segment was below the levels prescribed by radiation safety regulations.

(6). Performed were the works on the recovery of waste and elimination of structures for radwaste repository No. 9 (see Fig. 2) that initially appeared as a ground concrete structure covered by reinforced concrete slabs.

After building blocks of repository No. 9 were eliminated, a separation of soil at the place of their former location was performed. The contaminated soil was sent for disposal to MosNPO "Radon".

An important role of MosNPO "Radon" – principal RRC KI subcontractor for the works on rehabilitation of radioactively contaminated facilities and the site – should be noted. In the course of 2002 MosNPO "Radon" was involved in exploration and engineering works at RRC KI temporary radwaste disposal site targeted at a more precise definition of the contents and parameters of temporary radwaste repositories. MosNPO "Radon" has also organized a transportation chain for daily removal of radwaste from RRC KI to the disposal polygon.

CONCLUSION

Planning and performance of works for rehabilitation of the RRC KI temporary radwaste disposal site has made it possible to define several important technological problems for which there is no final solution at the moment. Noted among them should be:

(1) Recovery of ILW and, probably, HLW from not easily accessible repositories No. 4 and 6 makes a demand for the remote technologies of grouted waste withdrawal and fragmentation. As there is no exact data on the contents and activity level in these repositories, performance of their preliminary diagnostics would be required also. As the housing area is located just next to the site, practical works on diagnostics and waste withdrawal would, probably, make a demand for the use of dust depressing technologies.

(2) After the withdrawal is completed, packaging of the fragments of radwaste from the not easily accessible repositories No. 4 and 6 should be performed for further transportation of these fragments to the MosNPO "Radon" polygon in Sergiev Posad.

(3) As it was already mentioned, the temporary radwaste disposal site of RRC KI is characterized by an uneven, spotty contamination of soil. Notwithstanding the fact that local or point-type contamination with intermediate or even high level of activity are present, the overall average contamination of soil at the site is estimated to be below 10,000 Bq/kg. According to the regulations in force, such soil can not be categorized even as a low level waste. At the same time, the cumulative volume of soil to be cleaned or removed is quite significant, about 8,000 cub. m. The volume of corresponding works and their costs may be minimized if a machine technology of soil clean-up is implemented, namely the one which makes it possible to concentrate contamination up to the level of ~100,000 Bq/kg in relevantly small soil volumes. Then, such relatively small volumes of contaminated soil should be removed from the RRC KI territory as LLW components. In the current time, the machine technology of VNIINM is being considered as a candidate one. However, final selection of the technology has not been made so far.

(4) The preliminary separation of soil is currently performed manually, with the use of a spade. Search for and application of machine methods of the preliminary separation are of permanent interest to RRC KI.

(5) The available data on depth profile of soil contamination are insufficient for a representative calculation modeling of radionuclides migration in soil and transport by subsoil water. At the same time,

due to the reasons mentioned above, drilling of new boreholes at the territory of RRC KI temporary radwaste disposal site is currently restricted. Correspondingly, RRC KI is pursuing a search for the advanced technologies of physical and chemical exploration of soil's depth profile, namely those that would make it possible to continue the surveying without posing additional risks to the nearby housing area.

(6) Useful for RRC KI might be learning from an advanced world experience in carrying out of a broad radiation monitoring when performing the works on rehabilitation of radioactively contaminated facilities and territories.

Several foreign countries and, first of all, U.S.A., have made a big progress in development and implementation of the advanced technologies for rehabilitation of radioactively contaminated facilities and soils, as well as in planning and management of the practical works in relevant fields. RRC KI is ready to negotiate with its potential foreign partners several mutually beneficial cooperation options, including those that would provide for a further more broad advancement to the evolving Russian market.

Early in 2001 RRC KI Vice-president N.N. Ponomarev-Stepnoi visited U.S.A. and had a meeting with the U.S. DOE Under Secretary Mr. Robert Card. In the course of this visit discussed was an option of the U.S.-Russian cooperation in the field of rehabilitation and environmental management. Mr. R. Card expressed his support to the initiation and development of such cooperation. The delegation of the U.S. DOE headed by Mr. Robert Card and Mr. Linton Brooks was among the first foreigners to visit RRC KI temporary radwaste disposal site and get acquainted with the actual course of works on rehabilitation. In July 2002, an official invitation for RRC KI specialists to visit the DOE sites involved in rehabilitation programs was handed over to the Russian party. This visit was planned to establish scientific and technical contacts with the U.S. companies involved in remediation programs and, if possible, to initiate particular commercial partnerships. However, this visit has not been accomplished because of the insoluble visa problems. Visit of the U.S. DOE specialists on rehabilitation to RRC KI site is now being planned to initiate the cooperation (scheduled for early April, 2003).

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