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Threat Assessment Report

Regulatory Aspects of the Remediation and Rehabilitation of Nuclear Legacy in Kazakhstan, Kyrgyzstan and Tajikistan

Statens strålevern
Norwegian Radiation Protection Authority

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Key words:
Nuclear legacy, threat assessment, radioactive waste management, remediation.

Abstract:
Based upon the completion of the threat assessments in each Central Asian country this document focuses on the existing regulatory problems at the legacy sites and projects will address the regulatory documents which should be developed within the project framework.

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Emneord:
Atomarv, trusselvurdering, håndtering av radioaktivt avfall, opprydding

Resymé:
Denne rapporten er basert på trusselvurderinger som har blitt utført i de sentralasiatiske landene, og beskriver de eksisterende regelverksproblemene i områder med atomarv og hvilke regelverk som bør utvikles innen prosjektets rammeverk.

Head of project: Malgorzata K. Sneve
Approved:

Per Strand, director, Department for Emergency Preparedness and Environmental Radioactivity.

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Threat Assessment Report

Regulatory Aspects of the Remediation and Rehabilitation of Nuclear Legacy in Kazakhstan, Kyrgyzstan and Tajikistan

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EXECUTIVE SUMMARY

During the Soviet period, the uranium mining operations in Central Asia served as one of the main uranium producers for the Soviet Union (SU) military complex. The regulatory standards for exposure and emissions control to all Soviet Republics were administered by the Ministry of Medium Machine Building and were the same across the USSR. After the collapse of the Soviet Union in 1991, the former Soviet Republics became independent, but also inherited the legacy in the form of wastes, including those from uranium ore processings and tailings and old Soviet regulatory documents, which are mostly inconsistent with the international standards and guidances and need substantial improvements.

Many radioactive waste storage facilities in Central Asia, especially in the Kyrgyz Republic and Tajikistan, are located in regions of seismic activity, in landslide- and mudflow-prone areas and areas subject to flooding and high ground water levels, and near the banks of the rivers that form the base of the large water basin of the Central Asian region. Many tailings are situated near towns, other populated areas and state borders, and they represent a long-term hazard to health and the environment.

In regard to the legal and regulatory framework, it should be noted that none of the Central Asian countries have a National Policy and Strategy for Radioactive Waste Management developed and approved by the Governments. Existing regulatory documents do not address the issues regarding safety assessments and safety cases or the implementation of long-term institutional control and monitoring of the abandoned dumps with radioactive wastes (RW) or future RW disposal sites, neither during operation nor after their closure. There is also a need to develop safety criteria (reference levels) and determine measures to be taken for existing exposure situations (past practices). In addition, there is a lack of safety requirements for different types of disposal facilities in accordance with the different categories of radioactive waste. Safety criteria and clearance levels are also not established.

The NRPA, with the support of the Norwegian Ministry of Foreign Affairs, has developed bilateral projects that aim to assist the regulatory bodies in the Central Asian countries to identify and draft relevant regulatory requirements to ensure the protection of the personnel, population and environment during the planning and execution of remedial actions for past practices and RW management in the Central Asian countries.

Based on threat assessments that have been completed in each Central Asian country during the year 2010, this document focuses on the existing regulatory problems at the legacy sites and projects will address the regulatory documents which should be developed first. It is clear that in order to remove the threat connected with radioactive wastes, both that which has already been accumulated as a result of previous activity and that which is currently being generated in significant amounts and will be produced in the future, it is necessary to at least develop and implement:

- A National Policy and Strategy for Radioactive Waste Management, including strategies for disposal of each category of the RW, allocation of responsibilities and financial assurance for these activities;
- Safety requirements on the design, siting, construction, operation, closure and establishment of the institutional control needed for disposal facilities in accordance with the approved national policy and strategy on radioactive waste management; and
- New classifications of radioactive waste according to the recently published international recommendations, including identification of corresponding categories;

In addition, it is clear that in order to remove the threats connected with extensive territories contaminated by radionuclides, the rehabilitation of these areas is required and, accordingly, it is necessary to develop regulations on:

- Quantitative criteria defining reference levels for existing exposure situations, considering its justification, optimization and the graded approach;
- Criteria and hygienic specifications on the rehabilitation of territories contaminated with radioactive materials;
- The radiation safety of the personnel and the population during the subsequent use of the territory, abuildings and constructions after rehabilitation;
- Reference levels for exposure dose constraints to prevent unreasonable irradiation of the population on the territories with radioactive contamination, and also to develop derived reference levels for the values of radiation parameters which can be directly measured when implementing radiation control; and
- Updating the exemption and clearance levels with the latest international recommendations.

Finally, it is of crucial importance to strengthen the regulatory framework and infrastructure. Only with a strong regulatory body (or well-coordinated regulatory authorities) fulfilling its main responsibilities, namely authorization, inspection and enforcement, would it be possible to implement the remedial actions in a coherent and safe way. In addition, only with a strong regulatory infrastructure in place would it be possible to avoid the repetition of such bad experiences in ongoing practices and facilities or in new coming projects. Equal attention should also be paid to other non-uranium mining and milling activities, such as the oil and gas industries.

Innhold/Contents

1. Introduction

Central Asia is located near the Asian-European border, bordering the Russian Federation to the north, China to the east, the Caspian Sea to the west, and Kyrgyzstan, Tajikistan, and Uzbekistan to the south. The territory of Central Asia is about 3.5 million km^2, with a population of more than 55 million people.

In the 1970s and 1980s, over 30% of the uranium produced in the USSR was delivered from the Central Asian republics. The uranium raw material for the first Soviet nuclear bomb was mined at "Vostokredmet" in Tajikistan. The large mines and mills were erected in the Uzbek, Kirgyz and Kazakh Soviet Socialist Republics. For instance, three of the eleven largest facilities are located on the territory of Kyrgyzstan. During 40 years (from 1949 to 1989), 456 nuclear tests were carried out by the USSR on the Semipalatinsk Testing Ground in Kazakhstan. Six nuclear research reactors and one breeder reactor were operated in the region.

The technologies, including mining and processing of uranium ores, were developed by the same research and design institutions attached to the Ministry of Medium Machine Building of the USSR. Consequently, the features of the uranium production legacy in Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan (as well in the Russian Federation, Ukraine and Eastern Europe countries) are identical.

According to the experts' assessment, about 800 million tons of radioactive waste has been accumulated in Central Asia and is awaiting safe disposal. For instance, the radioactive waste in Kazakhstan makes up 237.2 million tons with the total activity of $5.7 \cdot 10^{17}$ Bq, including 450 tons of high-level RW with the activity of $7.03 \cdot 10^{16}$ Bq; 6.5 million tons of intermediate-level RW with the activity of $4.88 \cdot 10^{17}$ Bq; and 230.7 million tons of low-level RW with the activity of $1.09 \cdot 10^{13}$ Bq. The total amount of accumulated radioactive waste in Tajikistan makes up 55 million tons and takes up an area of 170 hectares. According to the different estimates, the total activity of waste amounts to approximately 240-285 TBq.

From 1961 to 1995, the mining ceased at most of the mines; however, restoration works was performed only at a few facilities located near the important settlements.

The current situation is aggravated by the fact that many radioactive waste storage facilities are located in the regions of seismic activity, in landslide- and mudflow-prone sectors, in zones subject to flooding and high ground water levels, and also near the banks of rivers that form the base of the large water basin of the Central Asian region. Many tailings are situated near towns, populated areas and state borders.

In Central Asia, there are several radioactive waste storage facilities that could be deemed ecologically sensitive due to their negative impact on the population's health and the environment and are at risk of being destroyed by possible natural disasters and natural-anthropogenic cataclysms.

At present, there is no unified regional system that could conduct systemized monitoring of trans-boundary environmental pollution and information exchange in this field and coordinate practical activities to solve uranium legacy issues. Even though the legislative base regulating the field of radioactive waste management has been developed to some degree in all of the countries, the existing legislation is not harmonized with international norms and requirements.

Taking into account that Kazakhstan has plans to build a new nuclear power plant and that the amount of radioactive waste in the Central Asian republics continues to increase intensively, it is necessary to develop and introduce procedures and techniques that are capable of ensuring safe management into routine practice, including long-term storage of various types of radioactive waste being produced not only at nuclear power plants, but also in other spheres where radioactive material is applied, such as medicine, scientific and research centres, and different branches of industry.

The question concerning management and final disposal of the increasing amount of radioactive waste from oil production is left absolutely open. At practically all of the oil fields, the radioecological studies detected an enhanced level of natural radionuclides of radium and thorium in the stratal waters rising at drilling operations.

The problem concerning final disposal of radioactive waste requires an urgent solution. In order to have an internationally accepted level of safety, it is necessary to reduce the risks associated with the radiation contamination of the Central Asian ecosystem, which requires the establishment of a hi-tech industry for radioactive material management including final disposal.

It is necessary to note that the rehabilitation measures were implemented at very few facilities; the rehabilitation works have not been performed in many cases at all, and no special funds for the recovery of radiation safety have been established yet.

Another essential constraint for the development of national plans concerning the rehabilitation measures is the lack of a strong regulatory framework and infrastructure.

The Governments of the Central Asian Republics are eager to co-operate with all interested parties to overcome dangerous legacy. In general, project proposals from the Central Asian countries are aimed not only at addressing the urgent problems of the uranium legacy, but also to form long-term joint co-operation projects with the objective of ensuring the safety of radioactive waste tailings and the sustainable development of the countries in the region.

Norway is among a number of countries rendering assistance to the Central Asian states and promoting and contributing to the realization of safety improvement programmes concerning management, including disposal of radioactive waste in the above republics.

As part of this assistance, the Norwegian Ministry of Foreign Affairs has arranged a programme of regulatory support with its counterparts in Kazakhstan, the Kyrgyz Republic and Tajikistan. The projects are managed for Norway by the Norwegian Radiation Protection Authority (NRPA) and the beneficiaries, which are: the Kazakhstan Atomic Energy Agency, the State Agency on Protection of Ecology and Forestry of the Kyrgyz Republic, and Tajikistan Nuclear and Radiation Safety Agency, and the main contractors are: the Nuclear Technology Safety Centre, Chu Ecological Laboratory and Tajikistan Nuclear Safety Agency, respectively.

The overall objective of these projects is to identify and draft relevant regulatory requirements to ensure the protection of the personnel, population and environment during planning and conducting of works for RW management in Central Asia. The scope of the projects falls within the context of the Norwegian Plan of Action, is to ensure that activities related to RW management in both planned and existing exposure situations in Central Asia will be carried out in accordance with the international guidances and recommendations, taking into account the regulatory practice from other countries in this area.

This objective was met by carrying out the following activities:

- Development of Regulatory Threat Assessments to determine the specific priorities for development of regulatory guidance in relation to RW management in each country, with particular consideration given to storage and final disposal.
- Development of drafts of the National Policy and Strategy for RW Management for each country and proposals for RW classification, including the identification of relevant RW categories and safety criteria for the RW disposal, in accordance with the IAEA recommendations, and taking into account other national experiences.
- Development of Draft Regulatory Document on Radioactive Waste Disposal.
- Review and update of existing regulatory documents on predisposal radioactive waste management.
- Review and update existing regulatory documents on safety criteria for the intervention and remediation of contaminated sites and to address existing exposure situations.
- Development of the technical requirements for systematic radiation monitoring.

This report summarises the progress as of October 2010

2. Regulatory Framework in Each Country

1.1 Current regulatory documents

1.1.1 Kazakhstan

The potential challenge of the use of nuclear energy, as well the availability of facilities and dual-use technologies that can be used not only for peaceful purposes require legislative regulation of the above activity. The Republic of Kazakhstan (hereinafter referred to as Kazakhstan) signed a number of important international conventions, such as the "The Convention on Nuclear Safety" and "The Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management".

The current normative legal base of Kazakhstan in the field of nuclear energy use and radiation safety is presented by the documents at four levels.

The first level – The Laws of Kazakhstan and the Decrees of the President of Kazakhstan holding the force of the law.

The second level – Decrees of the Government of Kazakhstan on the issues concerning nuclear energy use and radiation safety.

The third level – Rules and Regulations regulating the issues of radiation safety in treatment of ionizing radiation sources, permissible radioactive contamination of the environment and exposure of the staff and population, approved by the central state authorities.

The forth level – standards, procedure directions, standard instructions for separate branches and enterprises of industry.

At present, the normative-technical and legal documentation for the regulation of nuclear and radiation safety in Kazakhstan is defined in the "List of the Basic Normative Legal Documents Currently in Force on the Territory of Kazakhstan in the Field of Nuclear Energy Use P-00-00-04-03", approved by the Atomic Energy Committee's Order No. 101 dated from 28.12.2002. Afterwards, the above List was supplemented by the normative-technical documents as they were developed and put into effect.

The above List comprises the normative documents at several levels, namely:

1. Laws – the normative legal Acts regulating the social relations specify the main framing principles and requirements adopted by the Parliament of Kazakhstan (by the President for the cases set by the Constitution).
2. Decrees of the Government of Kazakhstan.
3. Orders of the central state authorities of Kazakhstan.

The following documents specifying the basic provisions in ensuring nuclear and radiation safety can be defined in the List as the main framing laws:

- The Law of Kazakhstan "On the Use of Nuclear Energy";
- The Law of Kazakhstan "On the Radiation Safety of the Population";
- "Ecological Code of Kazakhstan";
- The Law of Kazakhstan "On the Ecological Expert Examination";
- The Law of Kazakhstan "On the Licensing";
- The Law of Kazakhstan "On the Sanitary-Epidemiological Well-Being of the Population".

The Law "On the Use of Nuclear Energy" was adopted on the 14th of April 1997, No. 93-1.

The Law specifies the legal basis for and principles of regulation of social relations in the field of nuclear energy use and is directed at the protection of health and life of people and the environment, ensuring of nuclear weapons non-proliferation regime and nuclear and radiation safety in use of nuclear energy.

The Law defines the following basic types of activity in the field of nuclear energy use:

1) siting, design, construction, commissioning, operation, shutdown and decommissioning of the facilities using nuclear energy;
2) performance of work and rendering of services dealing with the use of nuclear energy;
3) management of nuclear material, ionizing radiation sources and radioactive matters, prospecting and mining of mineral resources containing the above material and matters, as well as the production, use, processing, transportation and disposal of nuclear material, radioactive material and radioactive waste;
4) research studies by means of nuclear installations, ionizing radiation sources, nuclear material and radioactive material;
5) control of the use of nuclear energy;
6) all types of activity on the sites of nuclear explosions;
7) ensuring of safety in use of nuclear energy;
8) physical protection of nuclear facilities and nuclear material;
9) accountancy of and control over nuclear material, ionizing radiation sources, radioactive matters and radioactive waste;
10) export and import of nuclear material, technologies and equipment; special non-nuclear material, materials, technologies; and equipment of double-purpose, ionizing radiation sources, and radioactive matters;
11) control over the radiation status on the territory of Kazakhstan;
12) transit traffic of nuclear material and radioactive matters across the territory of Kazakhstan;
13) training and certification of specialists and personnel.

The Law specifies the basic rights of the authorized state bodies and officials in the field of nuclear energy use, establishes their independence, and specifies the rights and liabilities of citizens and public organizations in the field of nuclear energy use.

The Law "On the Radiation Safety of the Population" was adopted on the 23rd of April 1998, No. 219-1.

The Law regulates the social relations in the field of radiation safety to ensure the protection of the health of population against harmful impact of ionizing radiation.

The Law specifies that the radiation safety is provided with:

- a package of measures of legal, administrative, technical-engineering, sanitary-hygienic, preventive, pedagogical, generally educational and informative character;
- carrying out measures on the observance of regulations and rules in the field of radiation safety by the state authorities of Kazakhstan, public associations, natural persons and legal entities;
- carrying out radiation monitoring all over the territory of the republic;
- carrying out the national programmes concerning mitigation of exposure to the population from ionizing radiation sources;
- implementation of quality programmes for radiation safety at all the levels of practical activity dealing with ionizing radiation sources.

The Law specifies that the national standardization for ensuring radiation safety is implemented through the establishment of radiation safety standards, sanitary rules, hygienic standards, construction standards and regulations, labour protection rules, procedures, instructions and other documents on radiation safety.

The Law "On the Ecological Expert Examination" was adopted on the 18th of March 1997, No. 85-1.

The Law regulates the social relations in the field of ecological expert examination with the purpose of preventing a reverse impact of administrative, economic and other activities on the environment and the life and health of the population of Kazakhstan.

The Law specifies that the state ecological expert examination is mandatory for the feasibility studies (reports) and designs on siting, construction, re-design, development, re-equipment, conversion, winding-up of enterprises, facilities and complexes of buildings and structures; for the documentation substantiating ecological requirements for new machines, materials, know-how, including that which is purchased abroad; and assessments of what negative impact the operating enterprises have on the environment (under the decision of supervisory authorities and local governments).

The Law "On the Licensing" was adopted on the 11th of January 2007, No. 214.

The Law regulates the relations associated with the state licensing of activity or certain actions subject to licensing.

The Law specifies the basic principles of licensing, types and forms of licences, as well as the licensing conditions: issue procedure, terms for consideration of an application, rejection of issue, suspension and revocation of licence, etc.

The Law "On the Sanitary-Epidemiological Well-Being of the Population" was adopted on the 8th of July 1994, No. 110-XII.

The Law specifies the legal, economic and social conditions for the ensuring of sanitary-epidemiological well-being of the population in Kazakhstan and establishes the basic sanitary-epidemiological requirements for different types of economic activity.

The "Ecological Code of Kazakhstan" was adopted on the 9th of January 2007, No. 212.

The Ecological Code has been in effect in Kazakhstan since the 9th of January 2007. The document comprises the world's practice in the ensuring of ecological safety of the public and production. The statute of ecological requirements and standards of the Ecological Code has the level of a legislative Act of direct force.

Four sections of the Ecological Code of Kazakhstan are dedicated to the management of waste:

- Section 41. Ecological requirements for the definition of a property right to the waste production and usage (articles 283-285);
- Section 42. Ecological requirements for the management of waste production and usage (articles 286-297);
- Section 43. Ecological requirements to the waste's final disposal grounds and long-term storage facilities (articles 298-306);
- Section 44. Ecological requirements to the radioactive waste storage and final disposal facilities (articles 307-309).

Radioactive waste is defined as the waste containing radioactive matters in the amount and concentration exceeding the values established for radioactive matters by the legislation of Kazakhstan on the use of nuclear energy.

Classification of radioactive waste is based on its state of aggregation, origin (sources of production), radioactivity level and half-life of radionuclides, and is presented by type in the following Table (Table 1):

Table 1. Classification of Radioactive Waste (Art. 307 of the Ecological Code).

No.	Basis for classification of radioactive waste	Type of radioactive waste
1.	State of aggregation	1. Liquid radioactive waste: • solutions of inorganic matters; • slurries of materials of filters; • organic liquids. 2. Solid radioactive waste: • products; • parts of machines and mechanisms; • materials; • biological objects; • spent sources of radioactive radiation.
2.	Origin (sources of production)	1. Waste from mining industry; 2. Waste from research and power nuclear reactors; 3. Waste from nuclear explosions; 4. Disused radioactive sources and sources with expired service life.
3.	Level of radioactivity	1. Low-level waste with the specific activity (kBq/kg): • less than 1,000 for beta-emitting radionuclides; • less than 100 for alpha-emitting radionuclides (except for transuranium ones); • less than 10 for transuranium radionuclides. 2. Intermediate-level waste with the specific activity (kBq/kg): • from 1,000 up to 10 million for beta-emitting radionuclides; • from 100 up to 1 million for alpha-emitting radionuclides (except for transuranium ones); • from 10 up to 100 thousand for transuranium radionuclides. 3. High-level waste with the specific activity (kBq/kg): • more than 10 million for beta-emitting radionuclides; • more than 1 million for alpha-emitting radionuclides (except for transuranium ones); • more than 100 thousand for transuranium radionuclides.

The requirements of the Ecological Code for waste management can be divided into three parts:

1. “Before waste production” – the requirements to natural persons and legal entities producing waste during their activity, which are to be met before waste production;
2. “After waste production” – the requirements to natural persons and legal entities producing waste during their activity, which are to be met after waste production, and which also include requirements for accumulation, as well collection, processing, disposal, neutralization, transportation and storage (stockpiling) of waste;
3. “Final disposal of waste” – the requirements to natural persons and legal entities producing waste during their activity, which are to be met at final disposal of waste,

and which also include the requirements for the waste grounds, including the hazardous waste grounds and final disposal facilities for radioactive waste.

The requirements “before waste production” consist in obtaining a permit for emission to the environment, observing the ecological standards in design, construction or operation of the facilities dealing with waste management.

The requirements “after waste production” define the procedures for the management of hazardous waste. Article 42 of the Ecological Code establishes 3 levels of hazard of wastes for the purposes of their transportation, disposal, storage and final disposal in compliance with the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Diposal. Thus, each waste is ascribed to one of the following three levels of waste hazard:

1. Green - index G;
2. Amber - index A;
3. Red - index R.

The waste certificate is drawn up, and then it is registered in the authorized authority responsible for the environment protection within three months from the waste production date. As new additional information improving the completeness and adequacy of data included in the obligatory parts becomes available, the certificate on hazardous waste is subject to updates and re-registration.

Transportation of hazardous waste is permitted under the following conditions:

- availability of packaging and marking of hazardous waste appropriate for transportation;
- availability of specially equipped vehicles, as well as those with special signs;
- availability of a certificate on hazardous waste and documentation on transportation and handing-over of hazardous waste with a specification of the amount of transported hazardous waste, purpose and destination point of the transportation;
- observance of the safety requirements for transportation of hazardous waste and the requirements for handling operations.

The owner of hazardous waste must provide the marking of packages with hazardous waste with specifications of its hazardous properties.

The workers carrying out waste management and the producers of hazardous waste are obliged to keep a routine accountancy (including the type, amount, and properties) of the waste that is produced, collected, transported, utilized or disposed in the course of their activity. The owner must keep the documentation on waste accountancy for 5 years. The owners of waste submit an annual report on their activity in the field of waste management to the body authorized in the sphere of environmental protection to make an entry of it in the State Cadastre of Waste.

The requirements for “final disposal of waste”.

Final disposal of waste is made on specially established grounds. Each type of waste is permitted to be disposed on the appropriate ground, and the right on to dispose of waste is given by the ecological permit.

The ground’s owner is in charge of all the obligations to observe the ecological requirements on the ground. The owner accepts that the waste type conforms with the given ground. The owner implements the measures on environmental monitoring, closure of the facility and remediation of the ground.

In addition to the above Laws, the normative technical documents of the second and third levels in the List allow, as a whole, for providing sufficient nuclear and radiation safety at every stage of nuclear energy use in Kazakhstan, namely as follows:

- General Safety Regulations for Nuclear Power Plants (OPB-88);
- Radiation Safety Standards (NRB-99);

- Sanitary Rules for Design and Operation of Nuclear Power Plants (SP-AS-88/93);
- Sanitary Rules for Radioactive Waste Management (SPORO-97);
- Requirements Rule to the Quality Assurance Programme for Nuclear Power Plants (PNAE G-1-028-91);
- Assessment of External Impacts of Natural and Man-Induced Origin on the Nuclear- and Radiation-Hazardous Facilities (PNAE G-05-35-95);
- Safety Rules in Storage and Transportation of Nuclear Fuel at the Nuclear Industry Facilities (PNAE G-14-029-91); and etc.

During the period after 2002, in addition to the Ecological Code, several documents concerning regulation of ionizing exposure and RW management were elaborated and put into effect, namely:

- Sanitary-Hygienic Requirements Rule to the Ensuring of Radiation Safety (SGTPORB-2003);
- Requirements to the Rule on Collection, Processing and Storage of Radioactive Waste (TBSPKh-2003);

Requirements to the Rule on Safety at Processing of Radioactive Sodium (TBPRN-2004).

In order to fill all of the gaps in the regulatory basis of Kazakhstan, the following requirements are established:

- To develop the quantitative criteria defining both the levels of intervention in ecological situations and the necessity to begin rehabilitation To develop criteria and hygienic specifications on the rehabilitation of the territories polluted by radionuclides, which can provide socially comprehensive guarantees on radiation safety of the population living there.
- To develop regulating documents for maintaining the radiation safety of the personnel and the population at the subsequent use of territory, after rehabilitation of buildings and constructions.
- On the level of residual pollution of the territory by radioactive substances, criteria should be developed for several of the most probable alternatives of their use after rehabilitation: for example, territories of unlimited use; territories of limited use as the industrial target working with radioactive materials; territories of limited use as an industrial target working without application of radioactive materials.
- To develop dose constraints for the purpose of prevention of unreasonable irradiation of the population in territories with radioactive pollution, and also to develop inquiry levels in sizes of radiation parameters which can be measured when carrying out radiation control.
- To develop national policy and strategy on the radioactive waste management in which final points of management for considered categories of a radioactive waste will be defined and suitable technological alternatives of the radioactive waste management connecting a category of the radioactive waste with a final point of the reference for the given category and at last are resulted, criteria on radioactive waste burial place are defined. Here is important that the policy due to the determination of the policy on disposal facilities including their type and location is usually a governmental issue
- To develop new classifications of radioactive waste, including the identification of corresponding categories as existing classification in Kazakhstan does not allow to connect each category of the radioactive waste with a final point of its reference
- Elaborate and approve safety requirements (regulations) for the

design, siting, construction, operation, closure and establishment of institutional control needed for disposal facilities in accordance with the approved national policy and strategy on radiaocative waste management

- To develop the strategy for disposal of the radioactive waste in the Republic of Kazakhstan for each category of the radioactive waste.

A factor reinforcing this conclusion is the fact that Kazakhstan has recently signed and ratified a “Joint Convention on the Safety of Spent Fuel Management and Safe Management of Radioactive Waste”, IAEA INF / CIRC 546, (1997). This means that the management of radioactive waste in the Republic of Kazakhstan without developed national policies and strategies for radioactive waste management can be treated by the international community as failure of Kazakhstan to meet their international obligations.

1.1.2 The Kyrgyz Republic

The basic principles of radiation safety are stated in the Constitution of the Republic of Kyrgyzstan (hereinafter referred to as Kyrgyzstan), in which the citizens of the Republic have the right to an environment that is favourable to their life and health and to protection from damage to health or property as a result of actions in the sphere of nature management (Art. 35). The given constitutional proposition is further developed in the Law of Kyrgyzstan “On the Radiation Safety of the Population of Kyrgyzstan”, in which the citizens of Kyrgyzstan have the right to radiation safety. This right is ensured by the implementation of a package of measures on preventing ionizing radiation impact on the human organism.

In Kyrgyzstan the legal base that establishes the current control of the radioactive waste storage facilities and regulates legal relations in the field of radiation safety is in place.

The Laws of Kyrgyzstan “On the Tailings Impoundments and Waste-Rock Dumps”, “On the Sanitary-Epidemiological Well-Being of the Population”, and “On the Protection of the Environment” establish the principles of the legal regulation in the field of treatment of the tailings impoundments and waste-rock dumps, consolidate the state’s guarantees of the citizens’ constitutional rights to health care and a favorable environment, and stipulate requirements to the observance of the set standards and regulations in the management of radioactive and toxic materials.

Since September 2003 Kyrgyzstan has become a full member of the International Atomic Energy Agency (IAEA). Since March 2006 the State Agency for the Environmental Protection and Forest Management attached to the Kyrgyzstan Government has been assigned an executive body responsible for the technical co-operation between Kyrgyzstan and the IAEA and for the regulation of relations in the field of radiation safety, which envisages the establishment of an adequate legislative basis, seeing as most of the documents concerning remediation and rehabilitation of the RW disposal sites are still insufficiently developed.

Proclaiming the aspiration to observe the provisions of the international agreements, Kyrgyzstan has joined the “Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management”, signed in Vienna on the 5th of September 1997.

The Joint Convention is aimed at the achievement and maintenance of a high level of radiation safety by means of strengthening national measures and international co-operation, including technical co-operation in the field of waste and spent nuclear fuel safety.

In March 2006, by the Kyrgyzstan Government’s Ordinance, the Ministry of Economic Development and Trade of Kyrgyzstan was assigned a national executive body responsible for the nuclear material accountancy and control and implementation of commitments in accordance with the provisions of the mentioned Convention. In order to put into practice the above ordinance, in May 2006 the Kyrgyzstan Government directed to establish an acting working team with involvement of officials from the interested ministries and agencies on the issues concerning radiation protection and safety of the population, use of radioactive sources, and the control of radioactive material, substances and waste.

The Ministry of Health of Kyrgyzstan approved the standards on radiation safety NRB-99, as well as the sanitary regulations concerning radioactive waste management (SPORO-2002), earlier prepared for the Russian Federation. For application in practice the dose limit for workers (20 mSv/year) and for the population (1 mSv/year) were accepted. As for the former uranium facilities and their remediation, solely special regulations for "actions" and remediation processes – the "Sanitary Rules for Winding-up, Conservation and Conversion of the Facilities for Mining and Processing of Radioactive Ores" (SP LKP-91) are available in the Republic.

The draft of the general regulations "On the Radiation Safety" was prepared by the Department of the State Sanitary and Epidemiological Supervision (DSSES) in August 2009. At present, the regulations have not yet been approved by the Kyrgyzstan Government. In compliance with the Law of Kyrgyzstan "On the Principles of Technical Regulation in Kyrgyzstan", the present technical regulations establish requirements for radiation safety aimed at creating conditions for reasonable, efficient and safe use of ionizing radiation sources, protection of present and future generations against harmful impact of ionizing radiation, and defining compliance assessment forms in kind of licensing, state supervision, acknowledgement of conformity, etc.

The draft Regulations specify the requirements for restricting exposure to the population for each of the four main types of exposure: natural exposure, medical exposure of patients during diagnostics and treatment, technogenic exposure due to routine operation of technogenic sources, and emergency exposure.

The requirements of these draft regulations cover the processes of production, storage, transport and disposal of radioactive sources over the territory of Kyrgyzstan, and are obligatory for all legal and physical entities carrying out the processes of production, storage, transport and disposal of products.

The shortcomings of the present technical regulations are as follows:

- the document was developed on the tight schedule, not allowing time to work out application issues in detail,

- the document combined several by-laws that existed in Kyrgyzstan earlier and was not widely developed in those parts that required completion. Neither does the document contain references to the current standards that will challenge the legitimacy of these standards in Kyrgyzstan starting January 2010,

- the document does not comprise the current system of regulatory relations in Kyrgyzstan, as it was developed when the new regulatory system had not been defined in Kyrgyzstan yet,

- the document was developed in a different light with the current project on the improvement of legislative base in the field of radiation safety in Kyrgyzstan,

- the document was not harmonized with the international standards.

The general technical regulations "On the Ecological Safety" were approved on the 8th of May 2009, and they will be put into effect a year after the approval. Among the radiation-hazardous facilities that exist in Kyrgyzstan, the present technical regulations are mainly important for the Joint Stock Company "Kara Balta Ore Mining Combine" (JSC "KOMC"), which is an operating enterprise and must follow the ecological regulation too.

The regulations of the Ministry of Emergency Situations and other central executive authorities are also an essential part of the legal base. However, in most cases, the assessment is based on the standards of the former Soviet Union, but they do not always correspond to a current state which has changed for the last 17 years. In particular, it is necessary to fill a legal gap with regulations on commissioning, operation and decommissioning of the facilities designated for radioactive waste management, on clousure of the burial sites and performance of routine maintenance to ensure safety at the burial sites after their clousure, etc. Special attention should be given to the standards on the issues concerning existing exposure situations caused by radioactive contamination. The urban planning legislation specifying the radiation safety in the buildings of the settlements and industrial and social infrastructure is also insufficient.

Based on the information presented in the Threat Assessment Report, it seems that there are still some areas that need improvement or need to be developed, such as:

- The national legal and regulatory framework on radiation safety does not harmonize with the international recommendations.
- To assure the effective management and control of radioactive waste, the government should ensure that a national policy and strategy on radioactive waste management is established. The policy and strategy should be appropriate for the nature and amount of radioactive waste in the country, should indicate the regulatory control required, and should consider relevant societal factors. The policy and strategy should be compatible with the Fundamental Safety Principles and with international instruments, conventions and codes that have been ratified by the State. The national policy and strategy should be the basis for decision making with respect to the management of radioactive waste.
- Most acts of the legislation are general, superfluously abstract and declaratory (for instance, the mechanisms of realization of the citizens' rights to radiation safety are actually absent therein), and they lack the direct-action propositions that requires the development of the procedures and mechanisms of their execution in detail in the by-laws.
- The legislation base and methods for an estimate of harm (safety assessment) to the health of citizens and the environment caused by radioactive contamination, are absent.
- Wide powers of the local authorities on their territories are not specified in the basic Law of Kyrgyzstan "On the Local State Administration and the Local Government", i.e. the legislation is unsettled.
- Legal tools for the movement of radioactive waste within the republic's borders, and for the cases of transboundary movement settled in the established order, are absent.
- Mechanisms of implementation of requirements at privatization of facilities for operation, radioactive waste placing, and requirements to owners' ecological liability, are absent;
- Economic tools to promote owners' interest in radiation safety are absent.
- The government should establish an effective system for protective actions to reduce undue radiation risks associated with unregulated sources (of natural and artificial origin) and contamination from past activities or events, consistent with the principles of justification and optimization.
- Decommissioning of facilities and the safe management and disposal of radioactive waste should constitute essential elements of the governmental policy and the corresponding strategy over the lifetime of the facilities and radioactive sources and for the duration of activities
- Appropriate financial provision should be made for:
    - (a) Decommissioning of operating facilities or remediation of past practices;
    - (b) Management of radioactive waste, including its storage and disposal;
    - (c) Management of disused radioactive sources and radiation generators;
    - (d) Management of spent fuel.
- The government should make provision where necessary for technical services in relation to safety, such as services for personal dosimetry, environmental monitoring and the calibration of equipment. Technical services do not necessarily have to be provided by the government. However, if no suitable commercial or non-governmental provider of the necessary technical

services are available, the government may have to make provision for the availability of such services. The regulatory body should authorize technical services that may have significance for safety, as appropriate.

- Prior to the granting of an authorization, the applicant should be required to submit a safety assessment, which should be reviewed and assessed by the regulatory body in accordance with clearly specified procedures. The extent of the regulatory control applied should be commensurated with radiation risks associated with facilities and activities, in accordance with a graded approach. The safety assessment may need to be repeated or reaffirmed by the regulatory body in support of its decision.
- It is not clear from the report whether the regulatory legal framework for the safe use of radiation sources is in place.
- It is not clear from the report whether the regulatory legal framework for the mining and milling processes as well as for closure, remediation decommissioning, monitoring, etc. is in place.

1.1.3 Tajikistan

Until recently, the system of management for radioactive waste and uranium production waste on the Tajikistan Republic's territory was mainly regulated by the sanitary rules developed as long ago as from 1984 to 1991 (i.e. when Tajikistan was a republic within the USSR), as well as by a number of normative-legal documents concerning management of industrial and toxic waste. During the recent 6-7 years, a number of regulations and regulatory standards were developed in the Republic of Tajikistan (hereinafter referred to as Tajikistan), which allowed a normative-legal base for radioactive waste management to be established and the management of ionizing radiation sources to be regulated.

The legislative documents in the sphere of industrial waste management are as follows:

- The Law of Tajikistan "On the Environment Protection" dated from 27.12.1993 with the supplements in 2004;
- The Law of Tajikistan "On the Production and Use of Waste" No. 44 dated from 10.05.2002 (with the supplements of 2005);
- The Law of Tajikistan "On the Public Health Care" dated from 15.05.1997 (with the supplements of 2005);
- The Decree of the Council of Ministers of the Tajik SSR No. 167 dated from 12.06.1984 on the measures concerning implementation of the Decree of the USSR Council of Ministers dated from 03.05.1984 No. 394 "On the Disposal, Neutralization and Final Disposal of Toxic Waste".
- The Decree of the Cabinet of Ministers of Tajikistan dated from 23.12.1993 No. 619 "On the Approval of an Order of Estimates of Fare and Its Range for the Environment Pollution and Waste Disposal".
- The Decree of the Government of Tajikistan dated from 30.12.1998 No. 534 "On the Measures on Implementation of the State Ecological Programme in Tajikistan".

In 1997 Tajikistan joined the Treaty on the Non-Proliferation of Nuclear Weapons. In 1999, in compliance with the provisions of the Treaty, an agreement on the application of safeguards was signed between Tajikistan and the IAEA following the Treaty on the Non-Proliferation of Nuclear Weapons (Additional Protocol to the Safeguards Agreement was signed in November 2004).

The international co-operation of Tajikistan and the IAEA promoted the development of special standards in the field of radiation safety. With the Agency's assistance, the following laws and regulations have been developed:

- "On the Radiation Safety" (Law No. 42 dated from 01.08.2003);
- "On the Use of Nuclear Energy" (Law No. 69 dated from 09.12.2004);
- "On the Licensing of Certain Types of Activity" (Law No. 37 dated from

17.05.2004 with the supplements No. 277 of 13.06.2007);

- “Regulations on the State Regulation in the field of Radiation Safety Ensuring” approved by the Decree of the Government of Tajikistan No. 482 dated from 03.12.2004;
- Regulations “On the Features of Licensing of Certain Types of Activity” approved by the Decree of the Government of Tajikistan No. 377 dated from 01.09.2005;
- In 2005 the Government of Tajikistan by its Decree No. 471 approved the Regulations “On the Interdepartmental Council on Radiation Safety Ensuring” and the Provisions "On the Inspector in Radiation Safety in Nuclear and Radiation Safety Agency of Academy of Sciences of Tajikistan”
- “Norms of Radiation Safety” (SP-2.6.1.-001-06);
- Rules of Radiation Safety Ensuring (PORB);
- Order of organization and implementation of an inspection by the Nuclear and Radiation Safety Agency at the facilities engaged in management of radioactive material and ionizing radiation sources.

At the same time, the normative-regulatory base of Tajikistan in the field of management of waste of the former uranium production has not been fully completed yet and requires an improvement and harmonization with the basic safety standards of the IAEA. In particular, the country still lacks the norms and recommendations on how to provide safe management and rehabilitation. In some cases the enterprises can not make a decision on the expediency of secondary processing of the uranium production waste, and to provide it for a lack of practice and adequate mechanisms on how to perform such work within the current legislation.

In particular, for the most oldest uranium facilities in the country, such important characteristics of regulation and implementation of radiation protection principles as the “control levels” and “reference levels” have not been defined; there are no clear-cut requirements for the safety assessment, system of monitoring and reports; the dose constraints for personnel and the public have not been determined; there has not been set any criteria for the clearance and release of materials and uranium facilities from regulatory control, which can be used as the safety criteria in waste management; there has not been established any safety requirements for post-closure institutional control, nor any other important norms suggested in the basic standards of the IAEA on ensuring radiation safety as an effective tool in control existing exposure situations (past practices). At those facilities where such zones are formally established (Taboshar) or even where the fences are available (Degmay), there is often no possibility to organize relevant supervision of the state of the facilities and to prohibit the access of people and grazing cattle to the territories of the tailings impoundments.

In Tajikistan, as in other countries of Central Asia, the regulatory base for the management of waste of uranium ore mining and processing (just as like other mining activity) is not covered by special norms, which must differ from the norms of treatment of the usual types of radioactive waste.

In developing the threat assessment, it was identified that the following documents of high priority concerning the safety of radioactive waste management regulation for the country should be developed:

1. A law on radioactive waste, including the National Policy and Strategy for Radioactive Waste Management.
2. Funding mechanisms for the radioactive waste management and the closure and remediation of existing exposure situations.
3. Safety requirements for radioactive waste management, including disposal.
4. Routine of state accountancy and control of radioactive material and radioactive waste.
5. A procedure for issuing a licence on activity dealing with the exploitation, mining and production of uranium, as well with secondary processing of waste from the uranium industry.

6. Regulation on ensuring radiation safety during accumulation and disposal of scrap metal.
7. Treatment of mineral raw material and material with high content of naturally occurring radionuclides.
8. Regulations on the routine of expert examination of the documents substantiating the ensuring of nuclear and radiation safety of nuclear installations, radiation sources and quality of declared activity.
9. Rules of radiation safety in transportation of radioactive material and radioactive waste.

1.2 Division of Responsibilities

1.2.1 Kazakhstan

The liability distribution between the organizations working with final disposal of radioactive waste in Kazakhstan is specified in the Decree of the Government of Kazakhstan dated from the 18th of October 1996, No.1283 "Regulations on the Procedure for Final Disposal of Radioactive Waste in Kazakhstan".

The above Regulations define the procedures for final disposal of radioactive waste in the bowels of the earth, obtaining of a permit for its final disposal in the bowels of the earth from the state authorities, and set a list of required documents.

The RW management facilities in Kazakhstan are classified according to their destination, as:

- storage facilities;
- final disposal facilities;

for disposal facilities according to the depth of the location of radioactive waste from the ground surface, as:

- ground ones (on the level of or above the ground surface);
- near-surface ones (the thickness of protective coat is up to 10 metres, waste is placed below the surface);
- deep ones (waste is placed at the depth of hundreds metres from the surface).

Responsibilities of the Competent Authorities

<u>The Atomic Energy Committee of the Ministry of Power Engineering and Mineral Resources (MPEMR) of Kazakhstan carries out:</u>

- issuing of licences on the right to perform works with radioactive waste, including those on its final disposal (designing of the final disposal facilities, their construction and commissioning, operation, special treatment, processing, transportation and burial) to the legal entities and natural persons;

- issuing of decisions on a potential further use of radioactive waste from its final disposal facilities, except for the radioactive off-balance (non-commercial) ore waste in the dumps belonging to the mining and prospecting enterprises of the industrial uranium branch.

<u>The Committee for Geology and Subsurface Resources Use attached to the MPEMR of Kazakhstan carries out:</u>

- issuing of licences on the right to use subsurface resources to the legal entities and natural persons carrying out construction of the near-surface and deep disposal facilities for radioactive waste, as well as licences on the plots of bowels of the earth defined for remediation of the dumps from prospecting, mining and processing activity;
- issuing of decisions on a potential use of waste-rock dumps with the objective to extract minerals to the interested legal entities and natural persons.

<u>The Ministry of Environment Protection of Kazakhstan carries out:</u>

- state ecological expert examination of the designs of the radioactive waste storage/final disposal facilities;

- issuing of ecological decisions on the works dealing with storage/final disposal of radioactive waste with the purpose to get a licence;
- issuing of permits on the final disposal of radioactive waste;
- ecological control over the radioactive waste storage/final disposal facilities.

The Ministry of Health of Kazakhstan carries out:

- state sanitary-hygienic expert examination of the designs on construction of the radioactive waste storage/final disposal facilities;
- sanitary-hygienic control over the radioactive waste storage/final disposal facilities;
- issuing of sanitary registration certificates on the radioactive waste storage/final disposal facilities.

The Committee for the State Control over the Emergency Situations and Industrial Safety of the Ministry of Emergency Situations (MES) of Kazakhstan carries out approval for:

- the use of the closed underground workings of the natural underground cavities;
- designs of the storage/final disposal facilities where the driving of a working and the drilling of boreholes are planned;
- technologies of radioactive waste processing with the use of blasting operations and highly poisonous substances;
- at the stage of designing and operation, the supervision of engineering safety in exploitation of special-purpose process equipment (rolling-stock, pressure vessels, containers, electric equipment, and et.), as well of adequate provision of instrumentation.

The Ministry of Internal Affairs of Kazakhstan carries out:

- approval for the construction designs of radioactive waste storage/final disposal facilities;
- organization of the protection and guard of the construction of radioactive waste storage/final disposal facilities to prevent theft of products, raw materials and other radioactive matters.

The local executive authorities (in oblasts/provinces/regions) carry out:

- execution of an Act on a plot with the enclosed estimates of a plot loss for farming and forestry economy, and reports on approval with the interested parties;
- execution of a decision on withdrawal of the plot and on a concession thereof for radioactive waste storage/final disposal facilities.

The Duties of Natural Persons and Legal Entities Carrying out Activity in Radioactive Waste Management should be to:

- carry out the main responsibility for the safety of the workers, the public and the environment in all phases of a facility (design, commissioning, operation, shutdown (or closure), decommissioning and post-closure institutional control (when needed);
- inform about such an activity or a decision to start such activity in compliance with the form established by the competent authorities for obtaining the corresponding permits and, if necessary, a licence for performance of such works, and to submit the required qualification documents to the relevant authorities;
- obtain a licence for the right to use subsurface resources in case of the erection of the radioactive waste storage/final disposal facility in the bowels of the earth;
- formalize an allotment of land, taking into account the ecological and other consequences of the planned withdrawal of plots and the prospects of the given territory and its bowels;
- fulfill the design and exploration work at the construction sites of the radioactive waste storage/final disposal facilities for low-level, high-level and liquid waste (the latter is stored);

- draw up a design on making the radioactive waste storage/final disposal facility in compliance with the ecological requirements;
- take all the measures on radiation safety of the population and personnel and the environment;
- execute a sanitary registration certificate on the radioactive waste storage/final disposal facility at its commissioning, prolongation of its validity and conservation;
- submit annual data on the production and movement of radioactive waste, in compliance with the established statistical report form, to the authorized body.

Basic Documents Regulating Activity in Radioactive Waste Management

In the production of radioactive waste, one of the following documents is drawn up:

- An act on the use of radionuclide sources;
- An act on the radiometric survey;
- A balance sheet of the extraction of minerals.

For the construction or management of the radioactive waste storage/final disposal facility, the following documents are issued:

- A licence on the right to perform works with radioactive matters (waste);
- An act on a tentative selection of a plot for the radioactive waste storage/final disposal facility;
- A licence on the right to use subsurface resources (only for the near-surface and deep radioactive waste storage/final disposal facilities);
- A design on making the storage/final disposal facility;
- A decision on withdrawal of the plot and on a concession thereof for the radioactive waste storage/final disposal facility (only for the near-surface and deep radioactive waste storage/final disposal facilities);
- Rules of the safety of the population in case of accidents and emergency situations.

In authorizing of the radioactive waste storage/final disposal facility, the following is drawn up:

- A sanitary registration certificate on the facility;
- A logbook of accountancy of radioactive waste;
- A logbook of monitoring.

The management of RW in Kazakhstan is subject to a mandatory licensing in compliance with the Decree of the Government of Kazakhstan “On the Approval of the Rules of Licensing and Qualification Requirements for the Licensed Types of Activity in the Sphere of the Use of Nuclear Energy” No. 270 adopted on the 19th of March 2008. The requirements of the above Rules are obligatory for all of the legal entities and natural persons carrying out activity associated with the use of nuclear energy.

The Atomic Energy Committee (AEC) within the Ministry of Energy and Mineral Resources (Ministry of New Technologies since 2010) of Kazakhstan is the department of the above Ministry carrying out special executive, control-supervisory and implementation functions, as well as management in the field of ensuring the nuclear weapons non-proliferation regime and regulation of the safe use of nuclear energy in Kazakhstan. The primary objective of the AEC is the regulatory control of the nuclear and radiation safety in Kazakhstan.

The following types of activity are subject to licensing and supervision of the AEC:

- Siting, design, construction, commissioning, operation, conservation and decommissioning of the facilities using nuclear energy;
- Export and import of the goods and services in the field of nuclear energy, including transfer, sale or purchase in the commercial purposes or transfer of a non-commercial character;

- Performance of work and rendering services dealing with the use of nuclear energy;
- Management of nuclear material, ionizing radiation sources and radioactive matters; radiation-safe execution of workradiation safety during prospecting and mining of mineral resources containing the above material and matters; as well as the production, use, processing, transportation and disposal of nuclear material, radioactive matters and radioactive waste;
- Carrying out research studies by means of nuclear installations, ionizing radiation sources, nuclear material and radioactive matters;
- Use of nuclear energy;
- All types of activities on the nuclear explosions grounds;
- Physical protection of nuclear installations and nuclear material;
- Accountancy of and control over nuclear material, ionizing radiation sources, radioactive matters and radioactive waste;
- Control over the radiation state on the territory of Kazakhstan;
- Transit traffic of nuclear material and radioactive matters across the territory of Kazakhstan;
- Training and certification of specialists and personnel.

The procedure for issuing a licence on the right to carry out activity associated with the use of nuclear energy, comprises:

- Consideration of an application on granting a licence and preliminary check of documents submitted for obtaining a licence;
- Consideration of documents submitted for obtaining a licence, including a package of documents substantiating that nuclear and radiation safety is ensured;
- Issuing of a licence with the establishment of licence conditions.

The AEC carries out the state supervision of whether the licensee observes the licence conditions by the licensee and, in cases where conditions are not observed, applies sanctions within the scope of its competence.

Within the framework of state supervision, the AEC carries out inspections of the organizations, which includes checking the enterprise's organizational activity dealing with the design and production of the systems and installations, record-keeping, and support of the personnel's skills.

The inspections are carried out

- during licensing;
- during operation;
- by checking appeals and other official applications, except for anonymous ones, and in joint inspections with the representatives of other competent organizations or the IAEA.

- In the Kazakstan Threat Assessment Report, there was detailed information on how the regulatory activities are organized in different western countries. However, an analysis on how efficient the regulatory infrastructure in the country is, and how it could be improved according to the best practices in other countries, was not performed. It seems that the existing situation in the contry will not be improved simply by elaborating the regulatory documents. Attention should also be paid to the organization and interaction among regulatory authorities in order to avoid conflicts and efforts duplication.

1.2.2 The Kyrgyz Republic

The institutional system in Kyrgyzstan is presented by the national authorities and agencies, research institutes, private enterprises and public organizations, as follows:

<u>The Ministry of Emergency Situations of Kyrgyzstan:</u>

The Department of Monitoring, Prediction of Emergency Situations and Treatment of Tailings Impoundments. The Department is in charge of all issues concerning the safe management of radioactive and other toxic substances and carries out supervision and treatment of the decommissoned tailings impoundments and waste-rock dumps being on the Ministry's balance.

The State Inspectorate for Supervision of Industrial and Mining Safety (Gosgortechnadzor). The Inspectorate carries out supervision of how the requirements of industrial safety are observed in designing, expertise, construction, commissioning, operation, conservation or winding-up of hazardous industrial enterprises, as well as supervision of training and retraining of staff of hazardous enterprises, and the operation of tails, hydrolic-mine dump and slurry facilities.

The Central Directorate on Hydrometeorology (Kyrgyzgidromet). The Directorate monitors radiation background (exposure dose rate) and radioactive atmospheric precipitates and provides acquisition, analysis and summarization of the above information.

The State Agency for the Environmental Protection and Forest Management (SAEP&FM) is attached to the Government of Kyrgyzstan

The Agency carries out surveillance and state control over the pollution of the environment at the sites of former and currently operating uranium enterprises with the purpose of analysing and predicting the environmental and ecological status. They also fulfil the functions of state accountancy of harmful impacts of radioactive sources and RW management control, as well as issue licences on disposal, placing, neutralization and burial of radioactive waste.

Since March 2006, the State Agency for the Environmental Protection and Forest Management has been appointed an executive body on the co-operation between Kyrgyzstan and the IAEA and regulation of relations in the field of radiation safety.

The Ministry of Health of Kyrgyzstan:

The Department of the State Sanitary and Epidemiological Supervision. The Department forms the national policy, elaborates the national and regional programmes in the field of the sanitary-epidemiological well-being and radiation safety of the population. They also carry out the state sanitary-epidemiological supervision, state registration of radioactive substances potentially hazardous for people, and organize and make radiological assessments.

The State Agency for Geology and Mineral Resources attached to the Government of Kyrgyzstan

The Agency takes part, within its power, in decision-making concerning the radiation safety of the country’s population and carries out supervision of geological exploration and exploitation of deposits of radioactive ores. In 2005 the Agency worked out the State Waste Cadastre of Kyrgyzstan, which comprises 95 storage facilities of the mining industry.

The Ministry of Economic Development and Trade of Kyrgyzstan:

The Ministry carries out licensing of export, import and re-export of nuclear material, technologies, equipment and facilities, special non-nuclear material and products, equipment and double-purpose technologies related to nuclear activity, and radioactive sources of ionizing radiation, including radioactive waste and isotopic products (radioactive and artificially obtained stable isotopes). The Ministry is responsible for the realization of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

The issues concerning local assistance in the prevention and elimination of consequences of emergencies are under the jurisdiction of the local state administrations and the authorities of local government.

In addition to the executive authorities, the solution to problems concerning the prediction, prevention and assessment of the state of the tailings impoundments and waste-rock dumps is laid on a number of institutions and agencies with sufficient intellectual and technical potential.

The National Academy of Sciences of Kyrgyzstan:

The Biogeochemical Laboratory of the Institute of Biology and Mountainous Forestry of the National Academy of Sciences (NAS). The Laboratory is equipped with up-to-date instrumentation for measuring radioactivity and microelements. The Laboratory is able to measure radioactivity in different media and samples; however, the budget of the National Academy of Sciences only allows it to pay salaries to its employees, and it lacks financing for programmes and projects in the field of radiation safety and environment protection.

The Laboratory of Radiometric Measurements of the Institute of Physics of NAS. Using obsolete, but very effective equipment (ionization chambers), the specialists of the laboratory participate in the determination of uranium radionuclides in different media and in uranium exploring on the basis of the U-234 isotope recoil effect. The Laboratory also lacks financing of its activity.

The Scientific and Technical Centre "Geopribor" of the Institute of Physics and Mechanics of Rocks of NAS. The Centre specializes in applied research, engineering surveys and designs in geoecology, engineering geology and geophysics, monitoring and forecasting of natural disasters and natural and anthropogenic catastrophic processes in the regions associated with mining activity. The institution works out the geomonitoring methods and carries out risk assessment and forecasting of natural and anthropogenic hazards, engineering surveys, evaluations of the impact of mining facilities, geological analysis, assessments of synergetic risk of geological danger and analysis of facilities' vulnerability to the impact of landslides, landfalls, sills and destruction of the dams of tailings impoundments. The institution is duly equipped to implement its main and application programmes. One of the applied research programmes is the geomonitoring of landslides in Mayluu-Suu.

The "Chu Laboratory of Ecology" (CLE), town of Kara-Balta:

The Laboratory is based at a operating uranium plant (JSC "KOMC") and equipped with up-to-date instrumentation for measuring radioactivity and analysis of inorganic chemical components in objects from the environment. The Laboratory is involved in the majority of programmes/projects of radioecological monitoring of the uranium tailings impoundments in Kyrgyzstan. The Laboratory has gained wide experience in the development of regulations in the sphere of ecology.

The Central Asian Institute of Applied Researches of the Earth (CAIE):

The Institute was established in co-orperation with GTZ (Germany). The Institute carries out surveys concerning geodynamics and dangerous geoprocesses, water climate and geoecology, rational use and preservation of resources, technical infrastructure, and management of data on education, training and scientific co-operation. The Institute has capabilities to implement research on the uranium legacy problems in Kyrgyzstan and other countries of Central Asia, sharing its practice and data with other involved institutes and agencies.

The JSC "Kara-Balta Ore Mining Combine" (JSC "KOMC"):

The Combine carries out its activity in the field of uranium and non-ferrous metals processing. It is a private enterprise. A lot of experience in the sphere of radiation safety expertise has been gained during its 55 year of activity. The enterprise has accumulated big archives of data about the uranium production sites in Kyrgyzstan and Kazakhstan. The combine staff is trained in radioactive waste management, and have the opportunity to further develop their skills in Russia.

Public organizations

Ecological club "Agat",

Association "Aleyne",

Association "Biom", etc.

The Radioactive Waste Management System in Kyrgyzstan requires thorough re-structuring and a comprehensive study of all its functions. The Regulatory Body’s functions are dispersed over several institutions, some of which duplicate each other’s work, and at the same time the MES of Kyrgyzstan holds functions both of the Regulator and the Operator. In addition, the Operator’s functions are distributed among several departments and institutions, and like the departments assigned with the Regulator’s functions that coordinate, though poorly, their activity, the co-ordination between the operators is absent in practice.

A lack of funds has resulted in an improper management of the tailings impoundments and inadequate institutional potential of and control by the governmental departments.

Analysis of the institutional management basis in Kyrgyzstan allows us to draw the following conclusions:

- Several institutions at the state level and several scientific, private and joint institutions are involved in the management, and they possess certain institutional capabilities, equipment and potential. However, all of them lack financial resources, co-ordination of their activity, and the exchange of results obtained both within and beyond the republic’s borders, which undoubtedly have negative impacts on solving the problems connected to the safety of the radioactive tailings impoundments and waste-rock dumps in Kyrgyzstan;
- The government should establish and maintain an appropriate governmental, legal and regulatory framework for safety in which responsibilities are clearly allocated;
- In cases where several authorities have responsibilities for safety within the regulatory framework for safety, the government should make provisions for the effective coordination of their regulatory functions, in order to avoid any omissions or undue duplication and to avoid conflicting requirements being placed on authorized parties;
- In cases where several authorities have responsibilities for safety within the regulatory framework for safety, the responsibilities and functions of each authority should be clearly specified in the relevant legislation. The government should ensure appropriate coordination and liaison between the various authorities concerned in areas such as:
  - (1) The safety of workers and the public;
  - (2) The protection of the environment;
  - (3) Emergency preparedness and response;
  - (4) The management of radioactive waste (including the development of governmental policy making and the strategy for implementating the policy);
  - (5) Liability for nuclear damage (including international conventions and regulatory control);
  - (6) Nuclear security;
  - (7) The State system of accounting for and controlling nuclear material;
  - (8) Safety in relation to water use and the consumption of food;
  - (9) Land use, planning and construction;
  - (10) The safety of transporting dangerous goods, including nuclear and radioactive material;
  - (11) Mining and processing of radioactive ores;
  - (12) Controls on the import and export of nuclear material and radioactive material.
- This coordination and liaison can be achieved by means of memoranda of understanding, appropriate communication and regular meetings. Such coordination assists in achieving consistency and in enabling authorities to benefit from each other’s experience;

- The government, through the legal system, should establish and maintain a regulatory body, and should confer on it the legal authority and provide it with the competence and the resources necessary to fulfil its statutory obligation for the regulatory control of facilities and activities;
- The government should ensure that the regulatory body is effectively independent in its safety-related decision making and that it has functional separation from entities that have responsibilities or interests that could unduly influence its decision making. To be effectively independent, the regulatory body should have sufficient authority and sufficient staffing and access to financial resources for the proper discharge of its assigned responsibilities.
- The current state institutes pursuing their narrow departmental interests compete in receiving grants and funds. Owing to poor co-ordination, none of the institutions involved in management have comprehensive, reliable and on-line information. Information is scattered and often happens to be contradictive.
- A lack of clear-cut powers in the juridical entities and interaction mechanisms generates the need for co-ordination between the institutions, including the local authorities, but such co-ordination is absent in practice;
- The main operative agency within this system is the MES, which is responsible for co-ordinating the agencies' activities in the prevention and elimination of emergency situations, including radioactive contamination. However, in practice, its co-ordinating influence is exerted only during elimination of emergency situations that have occurred. In the process of solving departmental problems concerning the prevention of radiological threats, the influence of the MES on the agencies remains rather limited.
- The main regulatory authorities are the environmental protection authorities and the health authorities, although they do not routinely monitor the state of radioactive contamination and its impact on human health, and they are not taking enforcement actions;
- The local government authorities are only assigned participation in emergency situations, which exempts them from liability for taking precautionary measures;
- No transfer of uranium processing facilities (for instance, JSC "KOMC") to a private holding has taken place yet; the operating tailings impoundments have not been transferred to the enterprise balance yet. They have only been transferred to an operational management;
- There are no institutional methods and approaches for determining the owners' liability for the uranium production facilities and radioactive waste storage facilities;
- There are no privileges in privatization of ecological-hazardous enterprises and facilities, to which the uranium processing plants, the conserved tailings impoundments and dumps are referred;
- The country possesses the agencies and laboratories capable of carrying out radioecological monitoring of the tailings impoundments (the buildings, equipment and staff are available), but in practice, every laboratory fulfils its tasks without any interaction with each other or the interested state agencies, which makes their work unsystematic and fragmentary and does not allow for reliable results and decisions;
- Chronic financial straits, understaffing of the laboratories (including the medical and biological ones), including the lack of qualified specialists able to carry out researches in compliance with the international standards, and insufficient techniques for verification and calibration testing of the existing instrumentation, do not allow the analytical activity to be productive and of top quality.

Thus, one can draw the conclusion that for the administrative tasks concerning RW management, the contacts between the agencies pursuing the policy in this sphere are extremely insufficient, which generates weak co-ordination and duplication and reduces the liability of each of the participants of RW management process. The existing institutions do not provide the effective and co-ordinated planning, control and enforcement of the radiation-hazardous facilities or enforcement of their safety measures.

1.2.3 Tajikistan

In 2001, within the structure of the Academy of Sciences of Tajikistan, a Nuclear Energy Agency that is authorized to carry out and develop the co-operation with the IAEA was established. Then in 2003, following the Law on the Radiation Safety, the only regulatory authority responsible for the ensuring nuclear and radiation safety, the Nuclear and Radiation Safety Agency, was established. This Regulator is effectively independent. There is a separate regulation on the Regulatory Authority activities approved by the Government of Tajikistan. On 3 December 2004, No. 482 describes the function and responsibilities of the Regulatory Authority, and in this regulation, effective independence is provided to that Regulatory Authority.under subordination of the Tajik Academy of Sciences.

The Regulatory Authority cannot be influenced by the President of Academy of Sciences since the Regulatory Authority activities are separated by the legislation.

Since the establishment of the Nuclear and Radiation Safety Agency, a division on licensing and control has been formed, which develops the legislation in the field of radiation safety and carries out the state control over observance of the above legislation by the users. The given division has functioned to its full capacity and carried out inspections since 2006.

But in Tajikistan there is no well-defined distribution of functions and scope of liability between the different state administrative bodies and monitoring subjects.

2 Review of Radioactive Waste Inventories in the Republics

2.1 Radioactive waste of the uranium industry and tailings impoundments

2.1.1 Kazakhstan

The uranium industry, as well the fulfilled exploration work in the regions located on the territory of endogenous uranium ore provinces of Kazakhstan, are among the sources of natural radionuclides that are characterized by high ecological hazard and are discharged into the environment. Mostly, the above territories are located in the storage places for waste remaining after the mining and processing of the uranium ore. The uranium ore deposits (prior to prospecting and exploration activity) cannot be directly considered as the contaminants (although they actually are) and must be taken into account as a natural component of the high natural geochemical background radiation. They become more dangerous contaminants for the environment after the ore bodies are opened and the uranium ore mass is moved and stored in certain parts of the landscape sphere. In this case, the ecological damage to the environment is defined by a number of factors, namely, the following basic ones: genetic type and deposit scale, the method of opening, natural-climatic conditions, and the landscape types and features in the region where the deposit is situated. Moreover, the maximum possible damage to the environment can be caused when the mining (or exploration) is carried out at the uranium deposits of an endogenous type with low-grade ores that are located in the densely populated regions with the developed hydrography and ground waters close to the surface.

The mining (exploration) of these deposits in open pits and mines extracts huge masses of rock, but very small part of it, with the natural uranium concentrations exceeding the commercially profitable limit (normally 0.03-0.05 %), is taken out for further processing and enrichment. Huge masses of rock, mainly with a background content of natural radionuclides of the uranium and thorium series, remain there, but there are also volumes of rock assigned to low-level radioactive waste subject to be disposed. These dumps can be a hazard, since the waste rock is in a fragmentary state and intensively releases radon, which can be spread by wind in the lower levels of the atmosphere.

The next cycle of ore processing is carried out at mills, usually located near several mines. Concentrate containing the maximum amount of uranium is extracted there from the ore, and the remaining ore is accumulated in tailings impoundments. The tailings impoundments' capacities are lower than the dumps' capacities by an order of magnitude, but the average uranium contents there are higher. Dust flying off the surface of the tailings impoundments and diffusing radon can create a halo of contamination around them that exceeds the admissible values for the population. Waste of this group is the most significant one by volume (97 % of all the radioactive waste) and spreads widely over the territory of Kazakhstan, since a large number of the uranium deposits in Kazakhstan have been exploited and mined for a long time (more than 40 years). Some of them are large and unique by their resources.

Since the isotopes in the families of uranium and thorium have long half-life periods, the potential impact of the waste on the environment will last a long time and, thus, will require monitoring for a very long period of time.

Fig. 1 shows the uranium mining and processing facilities. More than 80,000 tons of uranium was mined in Kazakhstan by the military-industrial complex of the former USSR.

The currently operating enterprises possess qualified staff. Observance of all of the standards and regulations ensures a safe level of radiation, both for the population and the workers. With this in mind, it is necessary to underline that the waste accumulated at these enterprises during the previous decades of their operation now requires enormous investments to maintain its safe storage.

The shut-down or abandonment of the facilities consistute a great threat. More than one hundred such facilities have been detected on the territory of Kazakhstan. The map (Fig.1) shows their location.

The Prikaspiysk Ore Metallurgical Combine in the town of Aktau, the mines at the Kosachinskoe and Manybay deposits in the Kokchetav region, and the Botaburum and Kurday deposits in the Pribalkhash region are among the above facilities.

Only one mine at the Jidelinskoe deposit has been conserved and restored.

In the absence of conservation,

- radioactive gases are released from the dumps,

1. As weathering takes place the radionuclides are transported by dust takes, which is especially dangerous at drying of the beaches of tailings impoundments,
2. ground water, including potable water, is contaminated.

Radionuclide aerosols can be dispersed across more than 10 km distance. Thus, the natural dispersion of radioactive substances from the dumps and tailings impoundments leads to a hazardous contamination of vast territories. In addition, the local population steals the contaminated equipment and fabrics at the dumps and uses them for building. The use of red rock from the Sementaus uranium deposit as a trim stone has been registered.

The total amount of low-level radioactive waste makes up 223 million tons with the activity of over 9.3 PBq. The waste is stored at 146 sites in a 34 square km area.

The slurry storage facilities hold the main mass of radioactive waste of the uranium industry. It is necessary to note that the Koshkar-Ata tailings impoundment occupies approximately 20 square km.

The main volume of the refuse dumps and rock dumps falls upon the low-active gangue, non-commercial (off-balance) ores, tailings of radiometric enrichment and heap leaching. It is necessary to study this waste more thoroughly in order to determine its potential for use as building material (gangue) or ore raw material for deeper extraction of radioactive elements and integrated extraction of non-radioactive chemical elements. This category of waste, which is the most numerous in this industry, occupies 136 sites in 9 provinces (oblasts) of Kazakhstan.

The uranium processing industry has 7 brances radioactive waste disposal facilities erected in compliance with the current requirements of radiation and ecological safety.

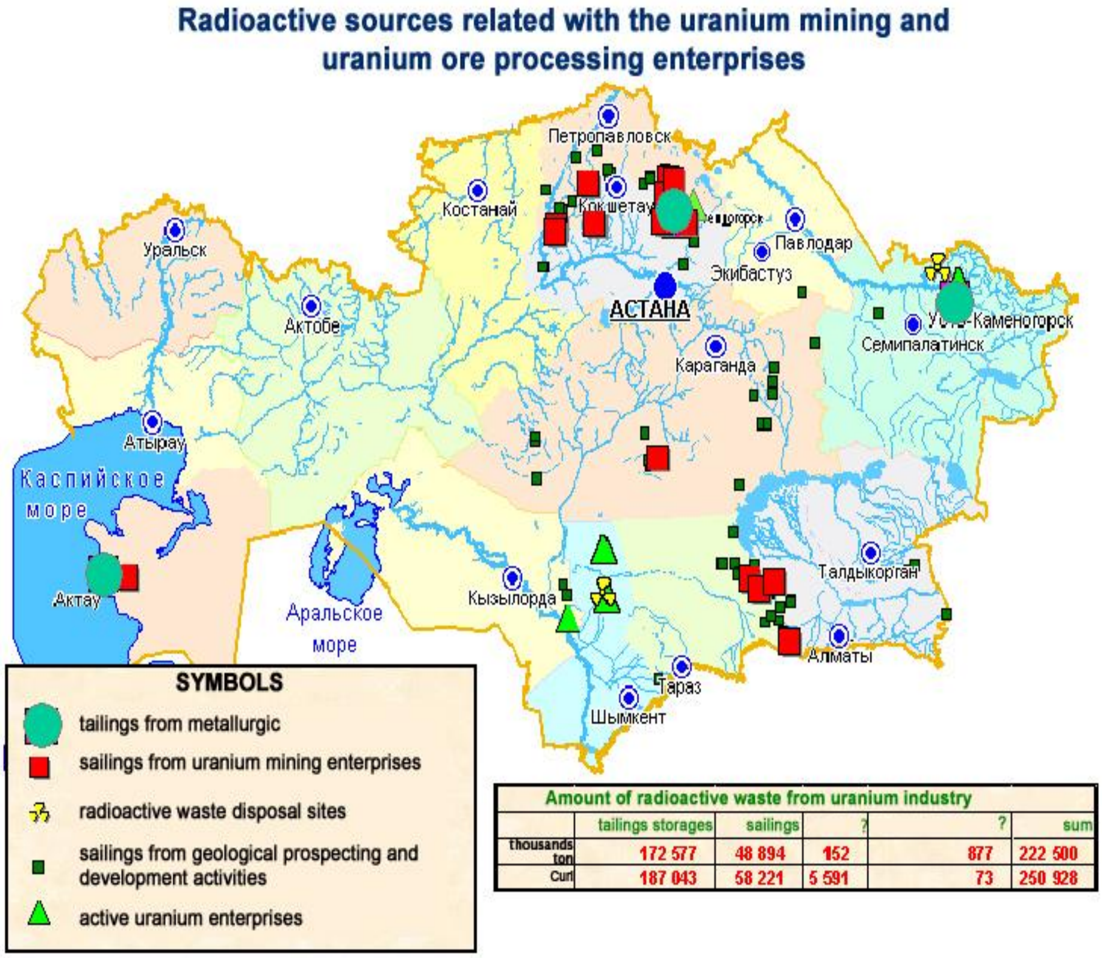


Fig. 1. Location of radioactive sources associated with the activity of the uranium mining and processing facilities.

A great bulk of radioactive waste associated with the uranium mining industry is located in the following oblasts (provinces): Mangistaus (Prikaspiysk OMC), North Kazakhstan, Akmola (Tselinniy OCC), Karaganda, Jambyl, South Kazakhstan, Kyzylorda (Mine Administration of the former Kirgiz OMC) and East Kazakhstan (Ulba MP and Irtysh CMP).

Table 2 gives the consolidated data on the location of RW associated with uranium mining and processing, geographically distributed according to the regions and provinces.

Table 2. RW associated with Uranium Mining: Location in the Administrative Oblasts (Provinces)

Region, Oblast											
Slurry				Refuse dumps, dumps				RWDP			
Number of places	Area, hectares	Mass, thousand tons	Activity, TBq	Number of places	Area, hectares	Mass, thousand tons	Activity, TBq	Number of places	Area, hectares	Mass, thousand tons	Activity, TBq
Western, Mangistaus											
1	2,000	120,000	888	19	2.6	34.8	78	1	0.2	8	148
Northern, Akmola											
1	734	46,000	5,920	30	118.2	16,870.7	217	1	0.2	6	333
North Kazakhstan											
-	-	-	-	14	7.1	3,088.1	82	-	-	-	-
Central, Karaganda											
-	-	-	-	14	34.4	774.5	8	-	-	-	-
Eastern, East Kazakhstan											
1	11	420	1	4	0.6	16.5	0.3	2	28.8	1,153	665
Southern, Almaty											
-	-	-	-	7	1.0	45.1	1.4	-	-	-	-
Jambyl											
-	-	-	-	30	364.2	27,533.6	920	-	-	-	-
South Kazakhstan											
-	-	-	-	14	28.2	118.8	24.2	2	1.8	72	2
Kyzylorda											
-	-	-	-	4	0.7	14.2	0.1	1	0.4	18	1
Total											
3	**2,745**	**166,420**	**6,809**	**136**	**620.9**	**49,178.5**	**1,331**	**7**	**31.4**	**1,257**	**1,149**

2.1.2 The Kyrgyz Republic

The operating enterprise GMP of JSC "KOMC", located in the industrial district of the town of Kara-Balta in Kyrgyzstan, carries out processing of "yellow cake" (a product of in-situ leaching) by the extraction method. The final product, uranium protoxide-oxide, is packed and transported beyond the republic's borders in compliance with the IAEA recommendations. It is a joint-stock company with the foreign capital invested in its basic share holding.

At present, the enterprise is searching for ways to mine its own uranium-containing ore. It is supposed that the radioactive waste storage facilities, both in the town of Kara-Balta and at other sites of the former uranium industry of the republic, will be the sources of this raw material.

The enterprise has trained personnel, a developed engineering infrastructure, an industrial waste treatment and neutralization system, and a departmental monitoring system. The essential disadvantage of the enterprise is the significant deterioration of its production equipment.

According to the State Waste Cadastre's data, 35 tailings impoundments and 37 rock dumps containing radioactive waste are located on the territory of Kyrgyzstan. 29 of the 35 tailings impoundments contain the uranium processing and enrichment tails, and 5 of them contain the materials containing thorium that remained after extraction of rare earth elements. Since March 1999, the 35 tailings impoundments and 25 rock dumps containing radionuclides of the uranium and thorium series have been handed over under the authority of the Department of Monitoring, Prediction of Emergency Situations and Treatment of Tailings Impoundments, which is a structural subdivision of the Ministry of Emergency Situations of Kyrgyzstan. The Department is in charge of the establishment of supervision and monitoring services at the sites of former uranium facilities, the maintaining of protective structures, and the co-ordination of all rehabilitation programmes.

The Governmental Programme for Rehabilitation of Uranium Tailings Impoundments was developed as early as 1999, but ever since, neither monitoring nor remediation at the expense of public funds has been conducted at the tailings impoundments sites. The analysis required for the defining the priorities on the realization of the rehabilitation strategy was made based only on available data about gamma radiation dose rates and some data on radon (Rn) concentrations in the tailings impoundments.

Table 3. The Main Uranium Radioactive Waste Storage Facilities on the Territory of Kyrgyzstan

No.	Name of the enterprise (combine), waste storage site	Number of facilities/volume of waste (million cubic metres)		Finished product	Period of operation
		Tailings impoundments, slurry	Waste rock dumps		
I Zapadnyi (Western) Mining and Chemical Combine (mail box 200)					
1.	Town of Mayluu-Suu: uranium mines No. 1, 2, 3, 6; hydrometallurgical plants No. 3, 7	23 / 2.0	13 / 0.845	Uranium oxide-protoxide	1946 – 1968
2.	Shekaftar settlement, uranium mine No. 5	-	8 / 0.700	Uranium ore	1946 – 1967
3.	Kyzyl-Jar settlement, uranium mine	-	2 / 0.037	Uranium ore	1946 – 1967
4.	“Tuya-Moyun” Mine; Mine Administration No.15 LGKhK	-	2 / unknown	Uranium ore for radium extraction	1904 – 1913 1923 – 1928
II Kara-Balta Ore Mining Combine					
5.	Kara-Balta Ore Mining and Metallurgical Combine	1 / 37.1	-	Uranium oxide, molybdenum	1955 – to present time
6.	Min-Kush settlement: uranium-coal mine No. 1, 2, hydrometallurgical shop	4 / 1.961	4 / unknown	Uranium ore, lignite	1955 – 1969
7.	Kadji-Say settlement: uranium-coal mine, hydrometallurgical shop No. 8	1 / 0.4000	1 / unknown	Uranium ore, coal, lignite	1949 – 1967
III Kyrgyz Mining and Metallurgical Combine					
8	Ak-Tyuz settlement – the Ak-Tyuz Mine Administration: open pits of the mill	4 / 3.35	3 / 50	Lead, rare earth elements	1942 – 1995
9	Orlovka settlement (Bourdu): open pit of the chemical-and-metallurgical plant	1 / 3.5	4 / 32	Lead, rare earth elements	1953 – 1994
IV Specialized Combine of “Kyrgyzjilkommunsoyuz”					
10	City of Bishkek: radioactive waste disposal point	1 / 300 m^2	-	Special waste, preparations	1965 – to present time
	RW IN ALL:	35 / 48.31	37 / 83.582		

Source of information: State Waste Cadastre of Kyrgyzstan.

2.1.3 Tajikistan

The earlier operating uranium deposits and a number of processing combines are located in Tajikistan. The country's own uranium ores, as well as the imported raw material, were mainly processed at the former Leninabad Ore Chemical Combine (at present – State Enterprise (SE) "Vostokredmet") and other hydrometallurgical plants, which earlier were situated in immediate proximity to the uranium ore mines (Adrasman, Taboshar). The past development of this industry resulted in an accumulation of a large amount of waste, mainly from the uranium-processing facilities containing radionuclides of high concentrations (basically, of the uranium-thorium series) and other hazardous pollutants. The above facilities are located within residential areas, as well in the upper tributaries of the main rivers of the country, such as the Syr-Darya River (Fig. 2).

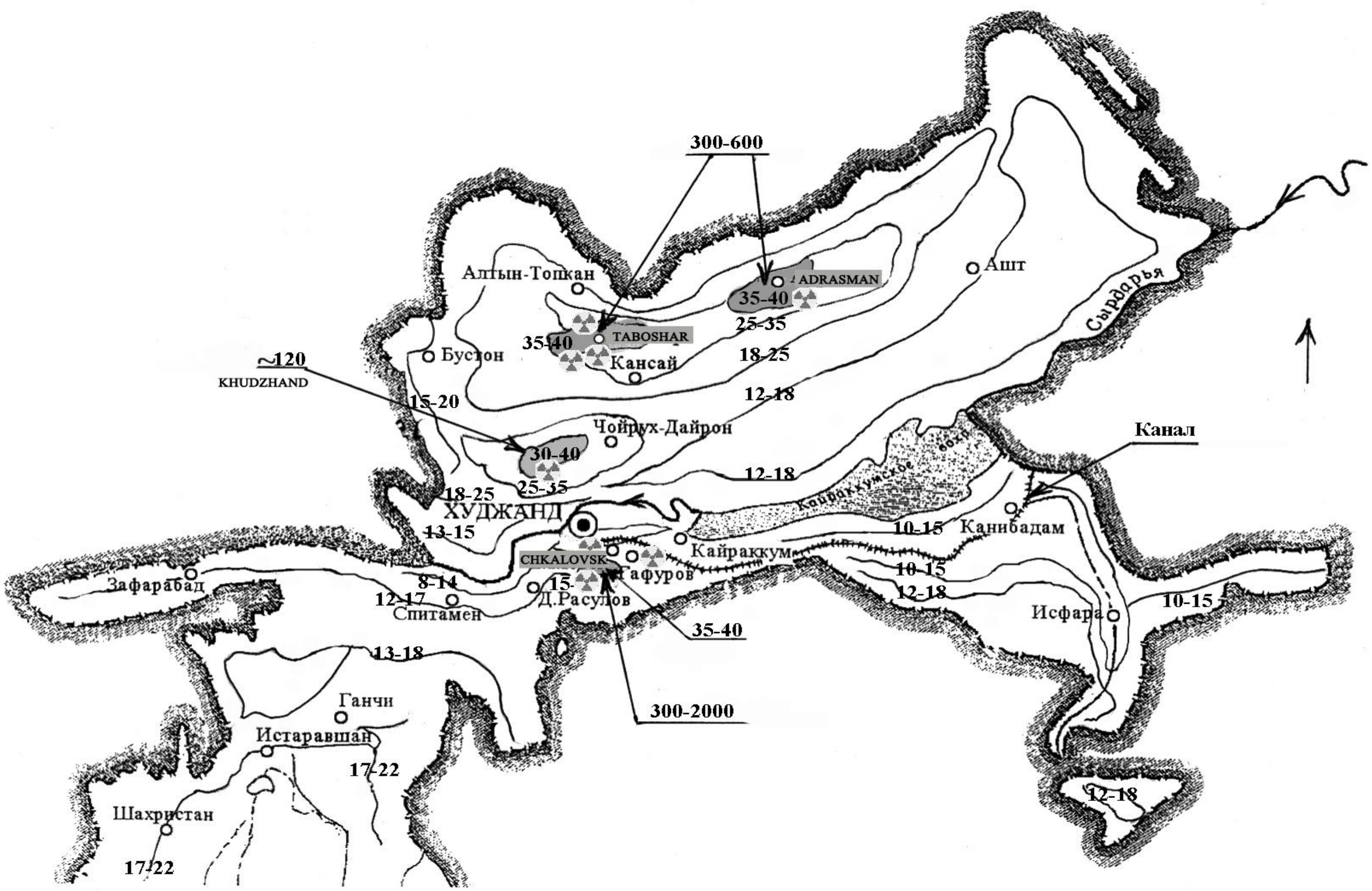


Fig. 2. *Radiological map of radioactive waste locations in Northern Tajikistan.*

At present, the only operating enterprise in Tajikistan that has kept the potential for the processing of uranium ore and acid solutions of uranium concentrates after chemical leaching is the SE “Vostokredmet”. 10 sites of uranium production waste are also on the enterprise’s balance sheet (Table 4).

Table 4. Information on the tailings impoundments of the former uranium production according to the SE "Vostokredmet" data.

No.	Name of place and tailings impoundment		Operation period	Sanitary-protective zone, m Area in hectares	Payload capacity of a storage facility, m^2	Layer of ground coat, m	Gamma exposure dose rate on the surface, μR/h	Amount of stored waste, million tons Bq
1	Tailings impoundment	Digmay cavity, 1.5 km - Gozien	from 1963	400 90.0	$194*10^5$	absent	650-2,000	20.8 $1.55 \cdot 10^{11}$
2	Tailings impoundment	town of Gafurovo, 0.5 km	1945-1950	- 4.0	$2.4*10^5$	2.5	20-60	0.4 $5.88 \cdot 10^{12}$
3	Tailings impoundment, Maps 1-9	2 km from the town of Chkalovsk	1949-1967	50.0 18.0	$26.0*10^5$	0.5	20-60	3.03 $2.88 \cdot 10^{13}$
4	Tailings impoundment (I-II phases)	town of Taboshar, 2 km	1945-1959	50.0 24.7	$9.88*10^5$	0.7-1.0	40-60	1.69 $8.07 \cdot 10^{12}$
5	Tailings impoundment (III phase)	town of Taboshar, 0.5 km	1947-1963	50.0 11.06	$1.06*10^5$	0.7-1.0	40-60	1.8 $8.58 \cdot 10^{12}$
6	Tailings impoundment (IV phase)	town of Taboshar, 1.0 km	1949-1965	50.0 18.76	$2.43*10^6$	0.7-1.0	40-60	4.13 $1.89 \cdot 10^{13}$
7	Tailings impoundment Shop No. 3	town of Taboshar, 3.0 km	1949-1965	50.0 2.86	$0.69*10^5$	0.7-1.0	40-60	1.17 $5.62 \cdot 10^{11}$
8	Storage facility of the poor ore mill (POM)	town of Taboshar, 4.0 km	1950-1965	- 3.35	$11.9*10^5$	absent	40-100	2.03 $9.36 \cdot 10^{12}$
9	Tailings impoundment 2	1 km from the settlement of Adrasman	from 1991	- 2.5	$2.4*10^5$	1.0	50-60	0.4 $5.92 \cdot 10^{12}$
10	Mine-3	2 km from the town of Khujanda	1976-1985	- 5.9	$2.07*10^5$ 100	absent, 0.5 m	60-80	3.5 $4.07 \cdot 10^{11}$

Tailings impoundments in the environs of the town of Chkalovsk

The town of Chkalovsk is a suburb of the city of Khujanda (former Leninabad - the capital of Sogdi oblast of the republic). A number of the mining enterprises, including the SE “Vostokredmet” (the former Leninabad Ore Chemical Combine), which earlier dealt with the enrichment and processing of uranium ores, is located here. During the Soviet era, the uranium ores were delivered here from Tajikistan, Kazakhstan and Uzbekistan. During the last operating years of the Combine, the raw material from Kazakhstan was delivered there in the form of acid extraction of heap or underground leaching (up to 200 g/l). Concentrates were processed in uranium protoxide-oxide and returned to Kazakhstan.

The production residues after acid extraction of uranium from the milled ore mass, which were in a coarse-grained sand fraction or a paste-type condition after neutralization, were stored in the nearby cavities of the terrain (tailings) or in the specially prepared dammed sections. A slurry pipeline was used for transfer. The tailings were stored at three sites located in the environs of Chkalovsk town (town of Gafurovo, Maps 1-9, Degmay). The tailings impoundments, so-called maps 1-9, are in the location nearest to theore mining plant of Chkalovsk town. The site is located in immediate proximity to the residential areas and gardens of the town. The tailings impoundment’s surface was flattened and covered with soil, without any apparent erosion, fractures and cracks. The site occupies 18 hectares, contains 2.9 million tons of waste, and is covered by a layer of soil from 0.5 to 1.0 m deep.

The gross activity of waste in the tailings impoundment is about 29,000 GBq. The exposure dose rates on the tailings impoundment surface are close to the natural background level and range from 0.2 to 0.6 μSv/h (20-60 μR/h). There are no warning signs or fences on the territory. The territory of the hydrometallurgical plant located about 6 km from the site is connected to the latter by several lines of the slurry pipeline that are covered with rust, but still suitable for the use. The surface of the tailings impoundment is situated 100 m higher than the industrial site.

Gafurovo tailings impoundment

The Gafurovo tailings impoundment is located 0.5 km west of the town of Gafurovo. It was operated from 1945 to 1950 – at the same time as the so-called “Pilot Hydrometallurgical Plant” functioned. The enterprise was located 10 km from the settlement of Degmay and 2 km from the mill. The territory of the tailings impoundment occupies about 5 hectares, its height is 13 m, and it contains approximately 400 thousand tons of waste, including spent ore, disabled metalwork, and technical equipment. The industrial site adjoins the highway and residential areas, which are situated at the distance of only about 50 m.

According to the local experts’ information, the waste rock dumps contain up to 800 tons of U_3O_8. According to some data from the period when the given tailings impoundment was formed, the extraction of uranium protoxide-oxide from the ore material was inefficient (only 40-60%). That is why the given tailings impoundment is considered as potential raw material for a possible secondary processing of the uranium, given the current high price of uranium. Therefore, its secondary processing would solve the problem concerning its transfer outside the residential areas of the town, and the waste would be stored in the Digmay cavity. However, the economical feasibility of such projects has not yet been considered. The coating of the tailings impoundment was formed by sediment material, including gravel, cobblestone and pebble, as well sand on a clay basis, with a total coat thickness of 1 to 2 metres. The above mass was formed on the natural surface without special preparation. The tailings impoundment is protected with a concrete fence, preventing access of people and cattle to the territory. The environmental monitoring programme at the given facility is carried out by the division of SE “Vostokredmet” and comprises only measurements of the volume concentration of radon over the surface and visual observations of the coat condition.

Due to the ground coat, the state of the tailings impoundment is considered satisfactory and has no significant effect on the local population. At the same time, since the tailings impoundment is located in immediate proximity to the town’s residential areas, it is necessary to carry out a routine observation of radon exhalation and the content of radon decay products on aerosols. Such observations can be made by an elementary air filter apparatus.

Degmay tailings impoundment

The Degmay tailings impoundment was operated from 1963 to 1993. It is located on the territory of the Gafurovo region of Sogdi oblast in the Tajikistan Republic on the Digmay Hills, which have a saddle and a bowl-shaped hollow. It is located 1.5 km from the nearest settlement (Gozien) and about 10 km from the town of Khujanda. It is the largest tailings impoundment of uranium production waste in Central Asia. It occupies an area of over 90 hectares and contains about 20 million tons of uranium ore waste, about 500 thousand tons of off-balance (non-commercial) uranium ore, as well 5.7 million tons of waste produced from the processing of vanadium-containing raw material, with the total activity of about 16,000 GBq. The embankment is considered to be 83 % full. At one side of the site, the embankment of 1,800 m length and 35 m height was erected, and thus a tailings impoundment storage space was formed on the basis of the natural saddle.

Fig. 3. *Location of the Degmay tailings impoundment in the vicinity of the towns of Khuzhand and Chkalovsk. Arrows 1 and 2 point the sampling places of Table 5.*

From the beginning of the 1990s, for the purpose of preventing dust spread, reed vegetation was artificially planted on the tailings impoundment surface. Waste slurry containing high concentrations of ion sulfate (on average, 20 g/l) was transferred into the tailings impoundment "bowl". Owing to a significant decrease of uranium ore processing in 1992-1993, the volumes of transfer of acid-containing slurry into the tailings impoundment "bowl" were reduced. In the period from 1991 to 2000, the solutions with lower concentrations, which were filtered through bedrock, partially cleaned up the filtrate water, continued to be transferred into the tailings impoundment "bowl". At the same time, full cleansing was not observed. The contaminated underground waters moved towards the Syr-Darya River. Until the mid-1990s, the tailings impoundment surface was partially covered with water. Then the water gradually dried up and, by 2000, its surface was completely dried up and covered with takyrs (cracks of up to 1–2 m depth and 30–80 cm width), increasing the intensity of radon gas release and the risk of erosion and wind dusting from the surface.

The measurement results obtained by the IAEA experts during their mission in 2006 showed high values of gamma radiation exposure dose rate, 4.5–20 μSv/h, which were significantly higher than the safe levels for non-restricted access of people.

From the opposite side of the dam, a reserve storage space of the tailings impoundment was formed. Here, the deepest part of the tailings impoundment for slurry burial is up to 20 m. In the upper terrain above the reserve storage space of the Degmay tailings impoundment, are land areas designated for the municipal scrap heap. There is free access to this site, as it is not fenced in and has no gates for vehicles and no warning signs, and sheep graze around the tailings impoundment. It is clear that the local population gathers scrap metal on the territory of the tailings impoundment.

The natural radionuclides in the tailings impoundment body that occur in concentrations that are technogenically heightened in comparison with the natural background, are the isotopes of uranium, thorium, radium and their decay products, such as ^{210}Pb and ^{210}Po. The analysis results of the tailings material composition, as well of aerosol samples taken in 2006 and analysed in the analytical laboratory of the radiation monitoring division of UkrNIGMI (the Ukrainian Hydrometeorological Research Institute), are shown for the different tailings impoundment sites in Tables 5–7 below.

Table 5*. The activity (Bq·kg^{-1}) of natural radionuclides in the soil samples taken in the Degmay tailings impoundment.*

Place of sampling*	^{238}U	^{226}Ra	^{230}Th	^{210}Pb	^{210}Po
1	980 ± 100	7620 ± 580	15600 ± 1700	14600 ± 1070	13200 ± 1320
2	820 ± 80	7220 ± 570	11165 ± 1240	10140 ± 740	12350 ± 920

* The sampling places are shown in Figure 3.

In compliance with the classification adopted in the Russian Federation and Tajikistan, the material of the tailings impoundment according to the alpha activity of technogenically strengthened concentrations of natural radionuclides, is ascribed to the low-level radioactive waste, and the tailings impoundment requires a regulatory control.

In compliance with the IAEA Safety Standards Series (Safety Guide No. RS-G-1.7), the natural radionuclides in the mentioned concentrations in mixtures significantly exceed the activity concentration values for radionuclides of natural origin, which can be exempted from the regulatory control. Thus, the region affected by the tailings impoundment must be routinely monitored in the main migration paths, atmospheric air and underground waters, and the potential effect of the uranium production waste on the health of the people must be minimized.

The tailings impoundment surface is open; the permanent and considerable discharge (exhalation) of radioactive gas radon takes place above its "bowl". The exhalation of radon-222 to the atmosphere significantly increased after the tailings impoundment surface dried up, where cracks of up to 2 m depth and 20 to 40 cm width were formed. The alpha activity concentration in the air above the tailings impoundment during the IAEA experts' mission in the summer of 2006 (during windless weather) amounted to about 1,000 $Bq \cdot m^{-3}$. The exhalation of radon-222 from the soil according to the results of direct measurements by the radon radiometer PPA-01M in June 2006, ranged from 10 to 65 $Bq \cdot m^2 \cdot s^{-1}$ at the different sites. This was 10–65 times higher than the safety level recommended for the tailings impoundments in Tajikistan (1 $Bq \cdot m^2 \cdot s^{-1}$).

Depending on the meteorological conditions and atmospheric stability, the air mass with high concentrations of radon and daughter products can spread up to several kilometers from the Degmay tailings impoundment.

The activity concentration of radon-222 in the territory of the tailings impoundment (under the condition of windy weather and significant air dilution) also considerably exceeded the regional background values (Table 6).

***Table 6**. Results of the radiation dosimetry survey of the Degmay tailings impoundment surface and adjacent sites (June 2006).*

No.	Measurement place (see the legend in Fig.1)	Gamma radiation equivalent dose rate, $\mu Sv \cdot h^{-1}$	Radon activity concentration, $Bq \cdot m^{-3}$	Radon EEAC, $Bq \cdot m^{-3}$	Radon flow density, (exhalation) $Bq \cdot m^{-2} \cdot s^{-1}$	Thoron EEAC, $Bq \cdot m^{-3}$
1	1a	3.9-4.0	102±24	5.2	9.18±2.75	-
2	1b	18.0-20.0	321±68	8.15	65.5±19.7	2.34
3	2a	6.5-7.0	187±36	15.85	50.8±16	0.54
4	2b	4.5-5.0	207±57	12.75	31.4±9.4	-
Background values		0.2-0.3	15-20			

This outcome has shown that the challenge associated with radon release can appear to be more serious than it has previous assessments have shown. Such an extremely high flow of radon into the atmospheric air must cause very high concentrations of its decay products, such as ^{210}Po and ^{210}Pb, in the composition of atmospheric precipitation and aerosols, which precipitate onto the adjacent farmlands or remain in the atmospheric air. The spread of radon decay products with the atmospheric air extends the boundaries of contamination of the soil surface on the adjacent territories. For instance, in the surface layer of soil in inspection well No. 18 outside the tailings impoundment body, the concentration of ^{210}Pb was 98 ±14 $Bq \cdot kg^{-1}$ and the concentration of ^{210}Po was 62 ±16 $Bq \cdot kg^{-1}$. That was almost twice as high as the background concentration values of the given radionuclides in the soils of the region. This fact can be used as evidence that the Degmay tailings impoundment has an effect on the adjacent territories. That is why it is important to arrange observations of the content of the mentioned radionuclides in the atmospheric air and to assess the effects of dusting on the spread of radionuclides by air from the region of the tailings impoundment location.

At present, the tailings impoundment surface is open. The territory of the tailings impoundment is protected with the reinforced concrete fence, although the population and cattle has free access up to the fence Dusting of material from the open surface of the tailings impoundment can become a serious problem.

There is no enough data available for the activity content in aerosols over the surface of the tailings impoundment. Sampling of aerosols (dust) from the atmospheric air in large volumes of up to 300 m^3 was carried out in June 2006 at two sites of the tailings impoundment. The air filter apparatus was installed 0.5 m over the land surface. Aerosols were sampled on a Petrianov filter of large diameter, and sampling was performed for 3 hours. After ashing, the filters were measured by a semiconductor gamma spectrometer. The results are given in Table 7, in together with measurement data from the towns of Chkalovsk and Taboshar.

Table 7*. Activity of radionuclides in aerosols in Tajikistan, 06-15.06.2006 and 2007.*

Sampling place	Air volume, m^3	Activity concentration of radionuclides in air, 10^{-5} Bq/m^3											
		U-238		Ra-226		Pb-210		Th-228		Be-7 *		K-40	
			+/-		+/-		+/-		+/-		+/-		+/-
Taboshar – open pit	430	1.8	0.8	1.9	0.5	47.5	3.4	1.0	04	421	11.2	10.4	0.9
Taboshar tailings impoundments I-II	400	1.9	1.0	2.1	0.5	56.1	3.6	1.0	0.4	396	24.4	17.8	1.4
Taboshar, kindergarten	520	2.8	1.4	3.1	0.5	34.6	2.7	0.8	0.4	339	19.4	15.1	1.5
Degmay No. 1	220	3.4	1.4	40.9	1.7	125	6.3	1.9	0.7	447	20.8	20.2	1.7
Degmay No. 2	250	6.0	3.0	63.6	1.3	121	5.6	1.6	0.1	390	19.5	17.7	1.0
Chkalovsk, OMP	350	15.6	2.2	4.8	0.6	129	6.3	1.2	0.3	485	19.5	12.7	1.1
Chkalovsk town**	320	2.5	2.5	4.0	1.0	134	4.6	2.6	0.6	932	31	42.0	4.0

*) ^{7}*Be and* ^{40}*K are given as a control over uniformity of the implemented measurements.*

***) Measurements within the residential area of Chkalovsk town were made in August 2007.*

This shows that dusting from the tailings impoundment surface is a problem, especially when the average windspeeds exceed 10 m/s. Earlier, experiments on a latex coat were conducted on this territory, which, on the whole, had no any long-term effect. Reed vegetation overgrowing the territory gave only a temporary effect, when the tailings impoundment surface was wet.

The ratio of the specific activity of ^{226}Ra and ^{210}Pb in the samples of the atmospheric air shows no effects of dusting from the tailings impoundment surface in the settlement, and no significant impact of radon contamination are observed in Taboshar. In the region of the Degmay tailings impoundment, a high impact on the adjacent territories owing to dusting and dispersion of radon decay products is observed. The data in Table 4 shows that ^{226}Ra activity in aerosols over the Degmay tailings impoundment surface is 20−30 times higher than in the tailings impoundments in the town of Taboshar.

In the region of the hydrometallurgical plant in the town of Chkalovsk, relatively high concentrations of uranium were detected in aerosols with a rather low content of radium-226. This can be an evidence of a relative contamination of the plant territory where uranium concentrate was produced earlier.

The nearest settlement is located about 1,500 m from the dam of the tailings impoundment. Potable water for the local population is supplied from the wells. Water from the wells is also used for irrigation. The farmlands are located as near as 200 m from the tailings impoundment dam. Cattle can be shepherded on the territories within the tailings impoundment. The river is situated about 3,500 m directly downhill from the tailings impoundment dam, from which the ground material is washed away. The length of transfer of underground waters from the tailings impoundment up to the discharge in the river is defined as about 6 km.

The studies earlier carried out by the SE “Vostokredmet” have detected a significant contamination of underground waters with ion sulfate, which allows us to assume that there is a possibility for radionuclides from the uranium production tails accumulated in the tailings impoundment to contaminate underground water. The main macro-ions of the contamination (including radionuclides) spread within the sulfate halo of underground waters with high mineralization, from which one can determine the extent and rate of the contamination of underground waters.

This feature of the contamination of underground waters was used by the SE “Vostokredmet” specialists to study the spread of contamination by means of the electro-sounding methods (Bezzubov et al., 2005). The results of observations carried out by the above method in 1994 and partially in 2003, are the only systematic observations that have allowed for making least a qualitative prognostic assessment of the propagation of the lens of contaminated underground waters in the region of the tailings impoundment location by the mathematical simulation methods.

Assessments given in the paper (Koptelov et al., 2005) have shown that a detachment of the lens of contaminated waters from the tailings impoundment surface takes place, and its front by its separate lens with high concentrations by ion sulfate and uranium, moves to the stratal waters discharge area towards the Khoja-Bakirgan and the Syr-Darya river beds. More accurate evaluations of a contamination state of the underground waters require a detailed analysis of the situation. According to the simulation assessments, the contaminated underground waters move towards the Syr-Darya River and, correspondingly, can be used by the local population for irrigation of farmlands and other needs. This circumstance is made to consider the issues concerning the evaluation and prediction of the underground water quality in the Degmay region from the point of view of potential risk for the health of the people.

Dumps of off-balance ores and uranium tailings impoundments in the town of Taboshar

The Taboshar uranium deposit is one of the oldest on the territory of the former USSR countries. It was discovered in 1936, and the ore was actively mined here from 1949 to 1965. At present, it is a huge territory with an area of over 400 hectares occupied by a near-surface storage facility for waste from the uranium ore processing plant and mines, as well a waste storage facility of the so-called “poor ores mill” (Figures 4−5).

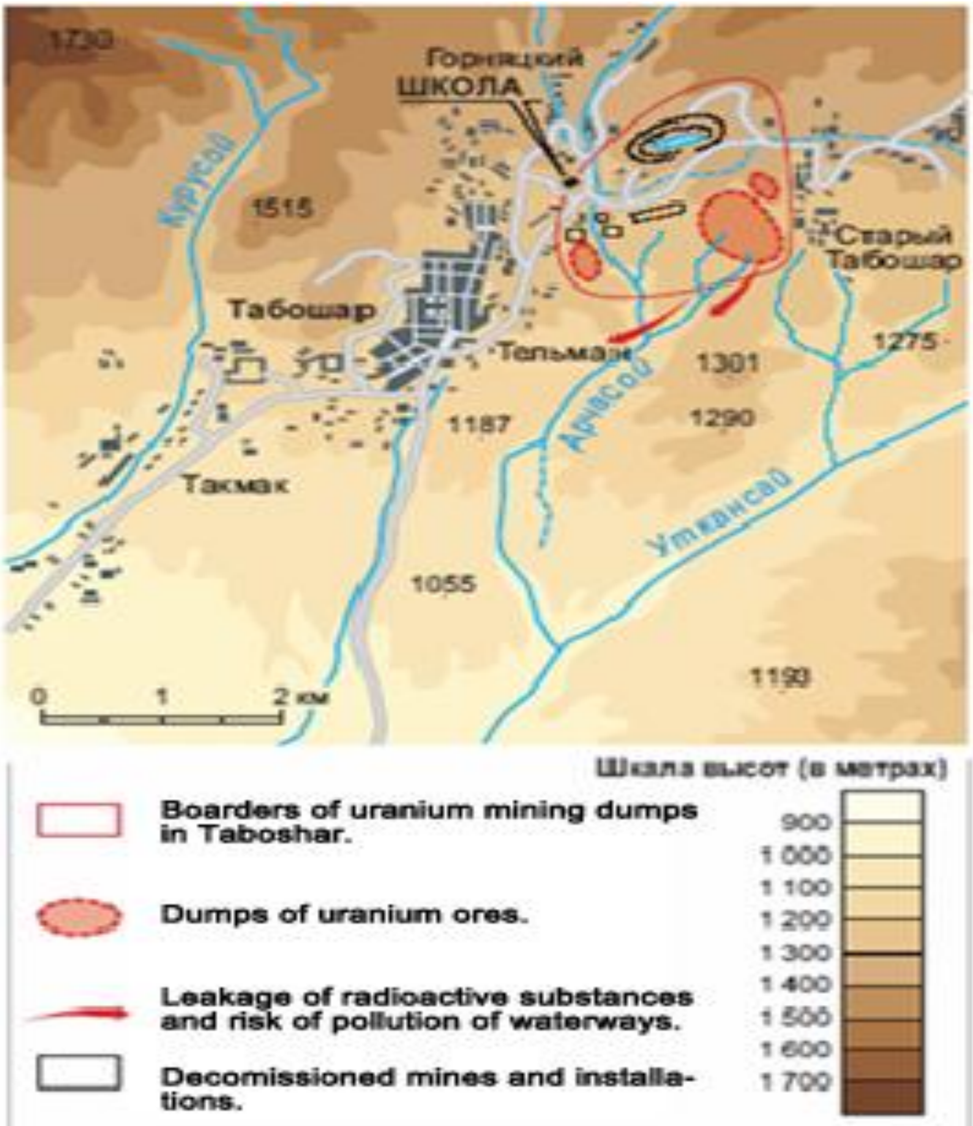


Fig. 4. The complex of dumps and uranium tailings impoundments in the town of Taboshar (UNDP, 2005).

Fig. 5. *Waste of dumps of the "poor ores mill" formed until 1965. It is one of the facilities requiring rehabilitation.*

The town of Taboshar with a population of about 12,000 is located just a few kilometers from the storage facilities. The final disposal complex consists of the non-conserved open mine, dismantled industrial buildings, and three tailings impoundments, where about 10 million tons of uranium ore waste after acid extraction are stored.

The activity of two hydrometallurgical plants resulted in the formation of tailings impoundments with a total area of about 54 hectares, and the total amount of waste of about 7.6 million tons.

The OMP tailings impoundment, where about 1.17 million tons of waste were disposed, is located 3 km upstream from the brook and 3 km from downtown Taboshar. The gangue and off-balance ores dumps are situated in the vicinity of the open pit. The gamma radiation dose rates amounted to 0.4–0.7 $\mu Sv \cdot h^{-1}$ (40–70 $\mu R \cdot h^{-1}$) around the dumps and reached 3.0–4.0 $\mu Sv \cdot h^{-1}$ (300–400 $\mu R \cdot h^{-1}$) in the places of the off-balance ore dump. Air samples were taken at the given site, and the results are given in Table 6.

In addition to the mines in the vicinity of the town of Taboshar and the open pit, which at present is water-sealed at the depth of up to 50 m, the "poor ores mill" waste is stored here too. The "poor ores mill" storage site is a hill of the milled bright-yellow material after uranium extraction (Fig. 5), which was carried out in the concrete tubs by the heap leaching method at the same site. The "poor ores mill" waste is open and has been subjected to wind and water erosion for 40 years. This waste was supposed to be reused. The level of gamma background radiation on the dump surface is not high, at 1.0–1.5 $\mu Sv \cdot h^{-1}$ (100–150 $\mu R \cdot h^{-1}$).

In the neighbourhood of the former hydrometallurgical plant shops, a number of the tailings impoundments is located upstream of the brooks of the Utken-Suu River tributaries. Mudflows that can occur in the places of tailings location aggravate this challenge. For example, from 1998 to 2000, as a result of heavy rains and formation of sills, a large part of material of the OMP tailings impoundment No. 3 was washed away to the Sarym-Sakhly-Say brook valley.

The traces of material that have spread from the tailings impoundment are observed on the banks and in the bed of the Sarym-Sakhly-Say brook. The tailings material is characterized by a relative homogenous size of fractions and reddish colour, and the places that accumulated the above material have high gamma radiation exposure dose rates. In the dry bed and redepositions of the floodplain brook, the exposure dose rate is up to 250 $\mu R \cdot h^{-1}$ (2,5 μSv·h^{-1}). The redepositions are distributed within the whole Archi-Say brook bed up to the mouth and at the confluence of the brook and the Utken-Suu River.

In 2005, the Organization for Security and Co-operation in Europe (OSCE) funded the cleanup and restoration of the sill trap in the brook upstream and the creation of a canalized bed (chute) for the controlled gathering of sill material in the brook in future. Thus, the issue concerning formation of sill flows at the given site has been temporarily settled.

The state of the coatings of other tailings impoundments is also of a certain concern. For example, in accordance with the certificate data, the tailings impoundment of former Shop No. 3, which is located only 1 km from the residential area, have a neutral ground coat of 0.7–1.0 m. In accordance with the facilities' certificates, the same values are typical for the tailings impoundments of III-IY phases too. However, the actual coat thickness recorded by the IAEA experts during their mission (2006) was not more than 0.5 m and at some sites was only 0.2–0.3 m. Such an imperfect coat of local rock does not actually hinder the penetration of oxygen and atmospheric precipitations in the tailings impoundment body, and can be destroyed by animals rooting up or pawing the ground.

The tracks of activity of animals rooting up or pawing the ground can be seen on the sides of almost all of the tailings impoundments, where the coat layer is thinner. It increases the surface permeability and the tailings material dispersion to the territories of neighbouring sites, and expands the area in which intensive radon releases from the tailings impoundment body takes place. In the places where the coat is destroyed, high flows of radon gas (from 3 to 9 Bq·m^{-2}·s^{-1}) has been detected, significantly exceeding the safety standard (1.0 Bq·m^{-2}·s^{-1}), which is set in the document "Sanitary Rules of Winding-up, Conservation and Conversion of the Facilities for Mining and Processing of Radioactive Ores" (SP LKP-91) applied for the quality assessment of a tailings impoundment coat.

The results of measurements of the radon activity concentration in the atmospheric air, radon and thoron EEACs in the regions of the tailings impoundments and open pit locations, background characteristics of the radon content in the region of measurements, and the densities of radon flows from the tailings impoundments surface (exhalation) are given in Table 8.

***Table 8**. Characteristics of the environment radiocontamination in the region of Taboshar town.*

No.	Place of measurement	Equivalent dose rate, μSv·h^{-1}	Rn activity concentration, Bq·m^{-3}	Radon EEAC, Bq·m^{-3}	Average radon exhalation, Bq·m^{-2}·s^{-1}	Thoron EEAC, Bq·m^{-3}
1	Taboshar town, open pit	0.48-0.56	20	1.92	0.09±0.03	0.23
2	POM dumps	0.76-2.8 side 0.35-0.4	17	2.0	0.86±0.25 1.06±0.28	0.17
3	Mountain area at 4 km distance from Taboshar town	0.18-0.23	12	3.3	-	0.12
4	Tailings impoundment of IV phase	0.3-0.5	25	3.0	4.8±1.6	-
5	Tailings impoundment of III phase	0.3-0.6	35	8.78	-	-
6	Tailings impoundment of I-II phases	0.4-0.5, and up to 0.9 in certain places	45	2,57	3.8±1.2 (9.97±3.0)*	0.33

* *exhalation (density of radon flow) from the fault tailings impoundment surface*

It has been detected that the drains with high uranium content in the places of thinning of drainage waters of the tailings impoundments of phases I-II in the town of Taboshar are formed as a result of uranium leaching by underground waters from the tailings material, and then in the process of water evaporation, the salt sediments are formed on the ground surface. This effect can take place both owing to a high content of residual acid in the tailings impoundment body and owing to the natural processes as a result of acid leaching of uranium in the underground waters, which level periodically rises during the rainy seasons. After each rainy season, a part of the salt enriched with uranium is washed away into the river, and during the dry season, a recovery of salt covering of the brook surface in the area of running drainage waters. The given phenomenon requires the a more detailed study and expert assessment of the development of such a process in the future.

The fact that the local population routinely uses the drainage waters with a high content of sulfates and uranium for watering cows and sheep, intensifies this challenge. The uranium content in the milk of cows were routinely watered and grazed at the given site was 0.45 $Bq \cdot l^{-1}$.

The high content of uranium and other trace elements have been detected in the mine waters and drainages used by the local population for different needs, including drinking, watering cattle and irrigation of their personal plots.

The above data have confirmed that the routine observations of the contamination of the surface and drainage waters in the region of Taboshar town must become a priority trend in the programme of environmental monitoring at former uranium facilities in the Tajikistan Republic. It is necessary to take samples at least once per season, and the sampling sites must be located at the main mine water runouts, in the Sarym-Sakhly-Say brook, the Utken-Suu River, drainages from the tailings impoundments, and in the town of Taboshar. Priority must be given to the water sources used for water supplies and subjected to contamination caused by the former uranium ore mining.

The rather low activity concentrations of radon-222 were also registered in the air in the buildings in the town of Taboshar. This can be explained by its location in the very draughty valley. High values of radon-222 EEAC were only recorded in the rooms of the former partially destroyed hydrometallurgical plant (Table 9).

The given results have confirmed the opinion that in the initial stage of rehabilitation, it is necessary to pay greater attention to the establishment of an adequate monitoring system, which must precede the stage of developing a strategic action plan on mitigating the negative impact that the mentioned facilities have on the environment and the health of the people.

***Table 9**. Results of measurements of radon-222 activity (AC and EEAC) in the air of the objects in Taboshar (dates of measurements: 07.06.2006–09.08.2006)*

No.	Installation place	Radon-222 AC, $Bq \cdot m^{-3}$	Radon-222 EEAC, $Bq \cdot m^{-3}$
1	Lenina Str., polyclinic	45	18
2	Gagarina Str., 20-3	115	46
3	Sadovaya Str., 2	48	19
4	Sadovaya Str., 2 (in the yard)	134	-
5	Pushkina Str., 29-2	85	34
6	Telmana Str., 43	171	68
7	Telmana Str., 43 (in the yard under the roof)	121	-
8	Leninabadskaya Str., 7-39 (balcony)	168	-

9	Leninabadskaya Str., 7-39 (children's room)	44	17
10	Khukumat (sports committee)	195	78
11	Town of Taboshar, school No. 5 (teachers' room)	150	60
12	Staryi /Old/ Taboshar settlement, school No. 4	144	58
13	Town of Taboshar, the former plant, semibasement	1,319	528

The results of gamma and alpha spectral analysis of the samples from the tailings impoundments and dumps are given in Table 10.

***Table 10**. Content of natural radionuclides ($Bq{\cdot}kg^{-1}$) in the rock samples from the poor ores mill (POM) dump and tailings impoundment sections 1-2 located in the region of Taboshar town.*

No.	Place of sampling	^{238}U,	^{226}Ra,	^{230}Th,	^{210}Pb,	^{210}Po,
1	POM dumps, sample 1	1,405 ± 200	6,570 ± 600	5,600 ± 1,050	5,885 ± 470	5,350 ± 580
2	POM dumps, sample 2 (of dark colour)	250 ± 60	2,090 ± 200	1,320 ± 630	2,225 ± 185	1,820 ± 250
3	POM dumps, sample 3 (material of washout from the dump)	800 ± 70	1,735 ± 130	1,025 ± 300	1,950 ± 145	1,840 ± 190
4	POM dumps, sample 4 (of yellow colour)	250 ± 80	1,030 ± 85	1,010 ± 400	1,935 ± 145	1,510 ± 245
5	Tailings impoundment, sections 1-2, sample of tailings 1	585 ± 60	3,010 ± 240	2,900 ± 530	3,895 ± 290	3,250 ± 370
6	Tailings impoundment, sections 1-2, sample of uranite salts	12,210 ± 900	55.9 ± 27	no	No	no

Dumps and drainages of mine waters in the vicinity of the town of Khujanda

The adit dumps of the former Mine No. 3 are located 4–5 km from the residential area of the town of Khujanda, situated on the Mogoltau foothill mountainside. The mines were operated from 1976 to 1985. The total area of the dumps is about 6 hectares, where about 0.35 million tons of waste rock was accumulated. The dumps are covered with a 0.5–0.7 m layer of ground. The exposure dose rate on the coat surface is 30–60 μR/h. This is evidence of an insignificant radiation effect and the reliability of the coat. Runout of mine waters with a high content of radionuclides of uranium-thorium series is observed from the adit. To purify the mine waters, a sediment trap was created, and an ion-exchange column was installed at the end of the 1990s.

The above purification system for the drainage waters with high uranium concentrations (30−36 $mg{\cdot}l^{-1}$) worked rather effectively. Nevertheless, the given system has not really functioned during the recent years, because of a lack of anion-exchange resin.

Tailings impoundments and former facilities of the town of Adrasman

Earlier, the enterprise for uranium ore processing was located in the town of Adrasman. Approximately 800 thousand tons of the uranium tailings material is stored on this territory. In 1994, the waste was gathered and placed at several sites within one restricted landscape formation in the outskirts of the settlement. The tailings were covered with a layer of ground and stone fill of approximately 40−50 cm thickness. The works to cover the tailings impoundments were performed by the enterprise "Vostokredmet". The gamma radiation dose rate on the surface of the covered tailings impoundments ranges from 0.05 to 0.10 $\mu Sv \cdot h^{-1}$ (50 $\mu R \cdot h^{-1}$). The total annual radon release was $3.07 \cdot 10^{12}$ Bq/year before conservation; it amounts to 2.41–$2.59 \cdot 10^{11}$ Bq/year after conservation.

The surface of the tailings impoundment is covered over with a layer of dump rock of the Adrasman Lead Combine. A lack of funding suspended the work on remediation and final disposal of the tailings. The ingress of storm and freshet waters and erosion are observed on the tailings impoundment surface.

The risk of washout of the tailings impoundment is high due to storm and freshet waters because of its location. The territory of the smaller fragmentary sites of the tailings impoundments, which were cleansed, and the remaining contaminated sites, require a full remediation.

2.2 Radioactive waste of nuclear explosions and military legacy

2.2.1 Kazakhstan

Nuclear explosions were carried out on the territory of Kazakhstan at the Semipalatinsk Testing Site (STS), at the testing grounds of Azgir, Lira and others, from 1949 to 1989.

The Semipalatinsk Testing Site is the largest one, with an area of 18.5 thousand km^2. Both the surface explosions a nd the underground ones were carried out at the Semipalatinsk Test Site. During STS functioning, 466 nuclear tests, including 30 surface, 88 air and 348 underground nuclear explosions, were carried out on its territory. According to the various experts' assessments, about 1.2 million people were exposed to radiation.

The first industrial thermonuclear explosion, which formed a reservoir known as an atomic lake at the "Balapan" site, and surface explosions produced low-level radioactive waste at the "Opytnoe pole" site and some other sites.

Basic radioactivity at the testing sites is deposited in the cavities of underground nuclear explosions. However, a part of the activity is discharged in the underground water tables, leading to contamination of the environment.

At present, the greatest hazard for the environment comes from the places of nuclear explosions, with the release of nuclear reaction products in the atmosphere; the places for treatment of nuclear and radioactive materials; and the places for testing of military radioactive substances. First of all, this hazard comes from the transport of radionuclides in the atmosphere over the territory, the penetration of radionuclides in the near-surface waters, and the direct exposure to people not taking any special precautionary measures.

The exposure dose rate in the air at the "Opytnoe Pole" site caused by the presence of the gamma emitting radionuclides Cs-137, Eu-152 and Co-60 is very high, and it reaches, in the extreme cases, 8,000–10,000 μR/h or more (the natural background activity is 10–25 μR/h). At the Balapan site, the exposure dose rate is up to 500–1,000 μR/h. In the places of surface nuclear explosions, the concentrations of plutonium isotopes reach values of 28,000 Bq/kg, and at the sites of excavation explosions, 3,222,000 Bq/kg. Concentrations beyond the admissible values are also recorded in the settlements outside the testing grounds. (In the draft concerning the criteria for the return of land for agricultural needs, the admissible concentration in soils is less than 3,7 Bq/kg).

The area in which the annual exposure dose is over 1 mSv can be as large as 1,800 km^2.

The radiation hazard of STS, the largest nuclear ground in Kazakhstan, mainly originates from from the possibility of unauthorized access to its contaminated sites, despite of the special measures that are taken to restrict access to the ground territory. Unauthorized economic activity is regularly revealed on the ground territory. In 2008, about 80 winter quarters used for grazing cattle was detected there, without any control.

The tests that are less known were carried out at the “Azgir” (or “Galit”) ground, as well as at other sites of Kazakhstan, such as “Lira“, “Say-Utes” (3 explosions), and 6 explosions within the framework of such programmes as “Meridian”, “Region”, “Batolit”, concerning the study of the geological structure of the earth’s crust. At the “Azgir” ground, 17 explosions were carried out in the mass of rock salt. At present, its surface has been remediated as a whole, although the challenges concerning the ground waters are similar to those of the Semipalatinsk Testing Ground. At the “Lira” site, at 700–900 m depths, 6 bags with the capacity of about 50,000 m^3 designated were formed for the storage of gas condensate from the Karachaganak deposit. The capacity of four of them is still filled with the condensate at 10–75 %.

The total amount of intermediate-level radioactive waste from the nuclear testing grounds is estimated to 6.5 million tons of $4.77 \cdot 10^{17}$ Bq radioactivity, and low-level waste is estimated to 5.8 million tons of $4.29 \cdot 10^{14}$ Bq of radioactivity.

Figure 6 shows the places where the nuclear explosions were carried out. The numbers represent the number of underground explosions. The Figure also shows the traces of the main radioactive clouds outside the Semipalatinsk Testing Ground and other cesium contaminations of the surface.

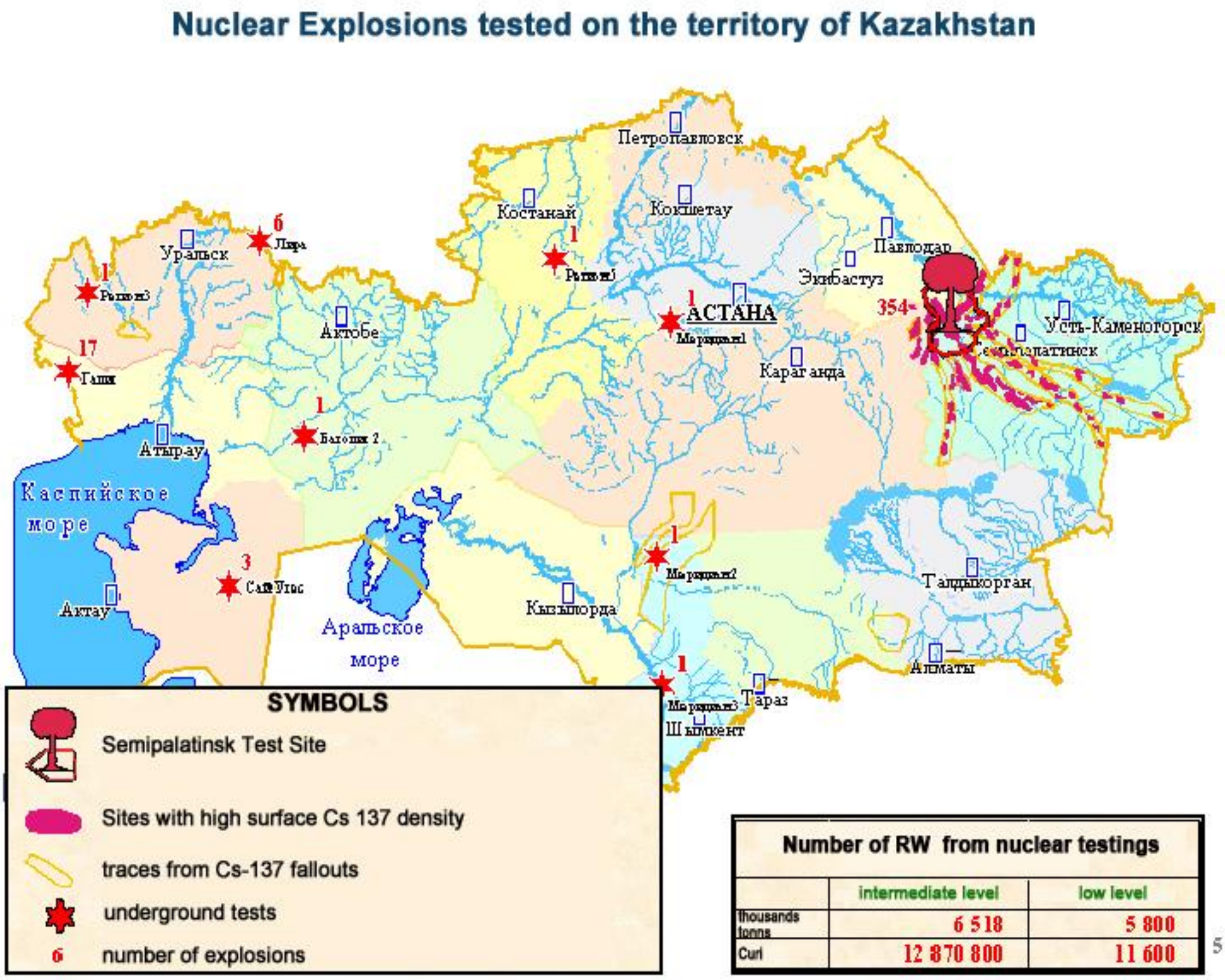


Fig. 6. *Nuclear explosions tested on the territory of Kazakhstan.*

2.3 Radioactive waste of nuclear power engineering

2.3.1 Kazakhstan

There are five reactors on the territory of Kazakhstan. One power reactor is located in the town of Aktau, three research reactors at the Semipalatinsk Testing Ground, and one research reactor in the city of Almaty.

At present, the power reactor BN-350 in Aktau is shut down; however, 11,000 tons of solid and liquid intermediate- and low-level radioactive waste (spent nuclear fuel is not included) has been accumulated, with the activity of $1.53 \cdot 10^{16}$ Bq, of which 6,000 tons have been disposed at the near-the-reactor radioactive waste disposal point and 5,000 tons are to be reprocessed and disposed. The spent nuclear fuel (SNF) of 450 tons and an activity of about $7.03 \cdot 10^{16}$ Bq has been stored in the near-the-reactor water cooling pond. At present, the decision to place the SNF for long-term dry storage has been made. For that purpose, the operation to unload the SNF from the cooling pond have been started, and the fuel has been loaded in the dual-use metal-concrete containers designated for SNF transportation and storage. As for the further management of the SNF, a special decision must be made.

All five reactors produced 14,500 tons of low- and intermediate-level radioactive waste with the activity of $1.56 \cdot 10^{16}$ Bq and 450 tons of high-level radioactive waste with the activity of $7.03 \cdot 10^{16}$ Bq.

By present time, the National Nuclear Center has disposed 3,500 tons of intermediate- and low-level radioactive waste produced as a result of the operation of 4 research reactors, though the further accumulation of the SNF is going on.

It is necessary to note that a large amount of waste will be produced during the dismantling work associated with the reactor BN-350 decommissioning. According to the project, which has not been approved yet, and the technological and organizational principles of final disposal of the nuclear power plant units, the total volume of waste reprocessed and packed in the containers after the decommissioning of reactor BN-350 will make up 62,300 m^3.

2.4 Radioactive waste of non-uranium mining and ore processing

2.4.1 Kazakhstan

A number of Kazakhstan's deposits of polymetals, rare-earth metals and phosphorites contains the uranium mineralization, which is extracted together in ore mining. A part of the radioactive mineralization goes in dumps and tailings, and a part remains in the basic products (especially in phosphoric fertilizes). At some coal deposits, the upper oxidized coal beds are also accompanied by uranium mineralization. The above coal is not sold as coal, it must be stored as RW. The examinations of the oil and gas fields territories detect the radioactively contaminated soils, oil slurries, equipment and pipes (mainly with Ra-226 and Th-232) that are connected with the long effect of oil waters enriched with naturally occurring radionuclides. A significant part of this waste (98 %) is produced at the oil and gas fields. At present, the RW of the mentioned group is taking of special significance because of active exploitation of the Mangyshlak-Prikaspiy oil fields and mining of the small deposits of lignite of the Jurassic period, characterized by a high content of naturally occurring radionuclides.

As a rule, the places for storage of the bulk of radioactive waste have not been designed at the non-uranium mining and processing enterprises until now. At present, the designs for coal mining with the oxidized coal beds designate the storage and further final disposal of radioactive waste. The 57 of the 76 registered storage places are associated with the contaminated equipment and soils at the oil and gas fields. By now, the sites for decontamination of equipment and pipes have been created at the Kalamkas and Jetybay deposits in Mangistaus oblast. In Jetybay and Novyj Uzen, the radioactive waste disposal points for 100 thousand tons (Novyj Uzen) and 70 thousand tons (Jetybay) respecitvely, were commissioned.

Fig. 3 shows the location of the mining enterprises of the non-uranium industry possessing radioactive waste. The oil-producing and coal-mining companies are in the most radiation-hazardous enterprises of the non-uranium industry on the territory of Kazakhstan. The stratal waters of the oil deposits contain the largest amount of radionuclides in comparison to all known stratal waters, except for the uranium-deposits waters. For instance, the analysis of the samples from the wells of the Uzen and Jetybay deposits showed a radium concentration 100 times higher than the allowable limit, and a thorium concentration 20−30 times higher than the limit. The implemented examinations of only the territories of Mangistaus and Atyraus oblasts have detected 1.3 million m^3 of radioactive waste and a contaminated area of 650 hectares in which the surface radiation exceeded 1 μSv/h.

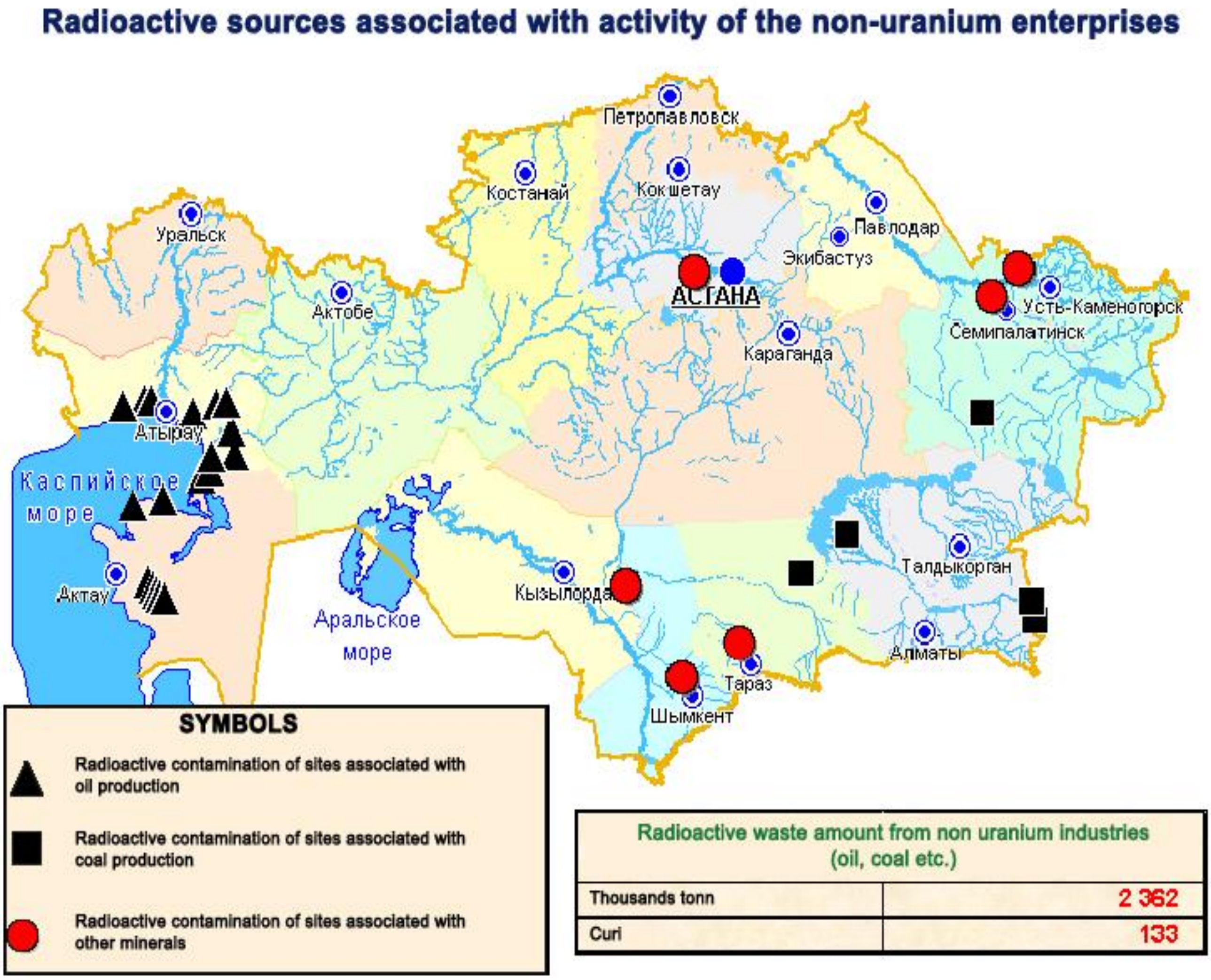


Fig.7. *Location of radioactive waste associated with activity of the non-uranium enterprises.*

The designs for the mining of the new deposits specify the measures on radiation safety, but no work is performed to improve the situation at the old enterprises and facilities that are no longer in use.

The mining of the Kulan deposit of bituminous coal by NAK "KATEP",and JSC "Western Mine Administration" produces gangue containing complex coal with a uranium content from 0.0046 to 0.0078 %. Of the toxic components, the coal contains: $10–100·10^{-4}$ % of As, 0.085 g/t of Hg, and 0.04 % of F. The total specific radioactivity of the coal is 867 Bq/kg. The danger class is I. Such coal is not subject to be sold and must be disposed of as radioactive waste. It is necessary to underline that at burning, the radioactivity of ash increases by 5–6 times.

In addition to the oil fields and open pit coal mine the radioactive contamination takes place when mining some deposits of phosphorites and ferrous, non-ferrous and noble metals. The aero-gamma-spectrometric survey has registered the radioactive waste of the metallurgical, chemical and ore mining enterprises within the established sanitary-protective zones in the cities of Semipalatinsk, Taraz and Shymkent and in Akmola oblast.

During the mining of polymetalic ores, thorium is also extracted. Now, its concentrate is stored at the Irtysh Chemical and Metallurgical Plant and must be disposed.

For the non-uranium enterprises an involuntary extraction of uranium to the surface is especially dangerous, seeing as the places for storage of radioactive waste at the non-uranium mining and processing facilities were not designed until the 1990s. Moreover, the examination of the radiation state has been implemented for only 40 % of the republic's deposits.

According to some estimates, the amount of radioactive waste of the non-uranium industry makes up 2.3 million tons with the activity of $4.92·10^{12}$ Bq.

2.4.2 The Kyrgyz Republic

Several sites with high radiation background are also known in Kyrgyzstan. Some of them are located near the sites of the former uranium industry, like the town of Mayluu-Suu, Kadji-Say and Min-Kush settlements. To a greater degree, the high radiation background in these settlements is caused by the illegal use of the contaminated materials (in particular by building with the use of radioactive waste).

The screening inspection of several settlements of the republic detected the places with natural high content of radon in the air of rooms, such as the Kadji-Say settlement and three resorts where radon water is used for medical treatment purposes. Two local sites with natural high radiation background are also known on Lake Issyk-Kul.

According to data collected by geological groups of Kyrgyzstan in each oblast of the Republic, there are several local areas with high background radiation, due to magmatic rocks formations. The average annual effective dose of radiation in these places can be 2–5 mSv/year. Compared to worldwide average annual dose of 2.4 mSv/year.

In Kyrgyzstan, there are coal deposits with natural background radiation between 0.25 and 4.5 μSv/hour (deposits «Agulak», «Yuzhny», «Dzhergalan», «Central»). All of these deposits are located near former uranium mining areas (Minkush, Kadjisai), at some cuts where the background radiation does not exceed 0.25 μSv/hour.

The areas with higher background radiation in places are not marked at all, only specialists who get involved in the subjects of radiation safety or ecology know about the characteristics of those places.

An interesting situation concerning radiation safety developed around a major water body of Kyrgyzstan, Lake Issyk-Kul. The bank of Lake Issyk-Kul is known for its sources of thermal radon waters. At the exit of the deepest source of thermal radon water, medical resorts were constructed in the Soviet period. The procedures of taking radon baths were strictly regulated, and the dose received by the patients did not exceed maximum 1 mSv/year. In visiting these resorts (NATO SfP Project 981742 (RESCA) project), breaches of the safety rules were detected: rooms where patients take baths were closed. In these conditions, the established procedures for room ventilation were not followed. The measurements of bulk concentrations considerably exceeding the maximal values (up to 15,000 Bq/m^3) were discovered. Inspection of the residential houses at the bank of the lake showed that there were areas with higher indoor values for radon. There is no constant monitoring for the purpose of assessing the radiation doses to the public in these areas. At present time, the available data is only received with the technical support of the IAEA and NATO.

2.5 Waste from isotope production and use

2.5.1 Kazakhstan

The waste of the enterprises using isotope products is separately taken into account. In Kazakhsan, the sealed radiation sources of the "Izotop" company are mainly ascribed to the above waste. Annually, some 100,000 items of the sources with an activity of up to 25,000 Ci are in use. For their long-term storage, a repository based on the "Baikal-1" complex under the jurisdiction of the National Nuclear Center. Currently, the repository contains more than 40,000 sealed sources with a total activity of about $3 \cdot 10^{15}$ Bq.

The radionuclide content of the sources ranges from tritium to americium-241. Radionuclides are divided by their half-life period into the short-lived (up to 5 years), medium-lived (from 5 up to 96 years) and long-lived (more than 96 years) ones, and this should be taken into account when selecting a method and a place for final disposal.

The decision on clearance or release from regulatory control should be performed on a case-by-case basis, considering the initial activity of the source. The total waste activity of isotope products amounts to $1.2 \cdot 10^{15}$ Bq.

2.5.2 The Kyrgyz Republic

Data from the inventory taken during 2007–2009, numbers 378 ionizing radiation sources being in operation in Kyrgyzstan. The inventory data on the sources is included in the RASOD database developed on the basis of the Regulatory Information System (RIS).

Regulator in the field of accountancy of sources	SAEP&FM
Authority issuing licences on the use of sources	DSSES
Institution which took the inventory and which is the RASOD Database Administrator	CLE

In Kyrgyzstan, only two sources operated in the National Oncological Centre are ascribed to the first category. Other ionizing radiation sources are ascribed to the third, fourth and fifth categories.

Most of the sources (230 items) are stored and used in Chu oblast (province) of Kyrgyzstan. The inventory revealed the loss of two sources in Kyrgyzstan; and, currently, the investigation concerning the location of two more sources or their probable loss is under way. A part of the sources registered by DSSES lacks passports, which were lost by their owners.

In 2008, two incidents with unidentified ionizing radiation sources took place. The detected sources were handed over for storage to the Radioactive Waste Disposal Facility in the city of Bishkek.

2.5.3 Tajikistan

A new joint project with the USA has started, which is financed by the Nuclear Regulatory Commission (NRC). The objective of this project is to make an inventory of all available ionizing radiation sources (sealed, unsealed, generators and associated equipment) and put them into a database. This is the RASOD database. The uniqueness of RASOD is that the programme automatically determines the current activity and categorization of the source (categorization is made in accordance with IAEA Safety Guide No RS-G-1.9, – Recommended categories for sources used in common practices).

In accordance with the inventory carried out in the north and west of Tajikistan, there are 936 sealed sources, 35 unsealed sources and 569 generators of ionizing radiation. Most of them are not in use, and will in the near future be transported for long-term storage to the Republican Waste Disposal Facility in a joint project with IAEA disused sources from North and West will be.

3 Status of Legacy Site, Radioactive Waste Management, and Rehabilitation Issues

3.1 Management of different categories of waste in Kazakhstan

3.1.1 Management of Low- and Intermediate-Level Waste of the Former Uranium Mines

The cardinal measures in the field of RW management have started to be taken recently due to the elaboration and realization of the "State Programme of Conservation of the Uranium Mines and Elimination of Consequences of Uranium Deposits Mining for 2001-2010". The targets of the Programme are as follows: the protection of the population against the radiation impact of waste from the former uranium mines; inventory of the radiation-hazardous enterprises and their ranking according to their degree of danger; systematization of accountancy and storage of the sealed radiation sources that are in use and final disposal of the spent ones; and definition of scope and types of urgent rehabilitation works and required financial means.

One of the basic legislative documents for the Programme development was the Presidential Decree of Kazakhstan "On the State Programme "Health of the People"" (No. 4153 dated from 16.11.98), in which Article 1.2 stated: "No works on the restoration of the dumps, non-commercial ores and tailings impoundments, radioactive ore mining and processing enterprises are performed".

The Customer of this Programme is the MPEMR. The Principal Executor is the Republican State Enterprise "Uranlikvidrudnik".

The terms for the implementation of this Programme are divided into two stages: the first phase during 2000–2005 and the second phase during 2006–2010.

In order to attain the objectives on rehabilitation of the territories of the former uranium mining enterprises, the Programme stipulates for:

- final disposal of radioactive waste;
- decontamination of the radio-contaminated objects;
- remediation of disturbed land.

Proceeding from the principle of a balance between the expected expenses and the anticipated benefits, it was in the period of 2001–2005 planned to rehabilitate the most radiation-hazardous enterprises that are generally concentrated in the densely populated regions and assigned first priority based on risk factors.

The objects which need to be rehabilitated are:

- dumps of commercial and non-commercial ores and dumps of heap leaching;
- contaminated territories of the industrial sites;
- non-closed (non-conserved) openings (mine shafts, open pits, caves on the surface, etc.).

The rehabilitation of the facilities of the second phase and the completion of the minor works at the facilities of the first phase were planned for 2006–2010, as the data on environmental monitoring is acquired in order to carry out a more thorough selection of the objects being rehabilitated and to assess the ecological consequences of a long-term radiation impact on the environment.

Ten of the 34 existing deposits of the North Kazakhstan are declared the priority deposits**.** In South Kazakhstan, two deposits are of phase I (Bota-Burum and Korday) and 8 deposits are of phases I–II (Kyzylsay) (of 48 deposits and mines). Their characteristics are given in Table 11.

Table 11. *Facilities of Phase I (2001-2005)*

No.	Facilities	Type of work	Period for implementation
1	North Kazakhstan. Mine No. 12, Mine Administration No. 5 (the Grachevskoe deposit)	conservation	2001-2002
2	Mine No. 3, Mine Administration No. 4 (the Shokpak and Kamyshovoe deposits)	conservation	2001-2003
3	Mines No.1 and No. 2, Mine Administration No. 4 (the Ishimskoe deposit)	winding-up	2001-2003
4	The Kosachinoe deposit	conservation	2002-2003
5	South Kazakhstan. Eastern Mine (the Bota-Burum and Djusandalinskoe deposits)	winding-up	2002-2005
6	Mine No. 8, Mine Administration No. 3 (the Zaosernoe deposit)	conservation	2003-2004
7	Mine No. 9, Mine Administration No. 3 (the Tastykol deposit)	winding-up	2003-2004
8	Mine Korday (the Korday deposit)	winding-up	2004-2005

Advice on the rehabilitation of the non-industrial facilities of South Kazakhstan can be defined only after their comprehensive examination, similar to those carried out for the deposits of North Kazakhstan and Jambyl oblast.

The characteristics of the facilities of phase II are given in Table 12.

Table 12. Facilities of Phase II (2006-2010)

No.	Region, facility	Type of work	RW volume, thousand cubic metres
1	North Kazakhstan. The Koksor, Shatskoe, Glubinnoe, Agashskoe deposits	conservation and winding-up	510.8
2	The Balkashinskoe, Vostok deposits		1,316.6
3	Tailings impoundment, OMP JSC "KazSabton"	restoration	27,400.0
4	Central Kazakhstan. The Bezymyannoe, Ulken-Akjal, Kyzyl, Ulutauskoe deposits	winding-up	87.0
5	South Kazakhstan. The Kyzylsay deposit (8 sites)	winding-up	1,791.8
6	West Kazakhstan. Tailings impoundment "Koshkar-Ata"	restoration	120,000.0
7	**Total** Completion of work of the previous years		**151,106.2**

The main financial source for all of the work on conservation of the non-operating uranium mines and elimination of the consequences of mining uranium deposits is the republic's budget, since these enterprises generally are state enterprises. However, this fact does not exclude the need to attract off-budget means, and in particular the target funds of the uranium mining and processing joint-stock companies.

The approximate cost of the restoration measures for the facilities of phases I and II were estimated to 3,120 million Kazakhstani tenge in total (23.98 million U.S. dollars).

On the whole, the given Programme is considered as a part of the long-term national programme for rehabilitating the territories that are polluted not only by the uranium mines, but also in the course of oil field activity and as a result of test explosions in the past.

The following outcomes were anticipated as a result of implementing all of the rehabilitation measures stipulated by the Programme:

- decreasing the level of radioactive contamination down to the standard values in the uranium mine industrial sites and the adjacent sites in most parts of the republic's territory;
- terminating radioactive dust discharge and restricting radon release to the environment;
- preventing the uncontrolled use of materials from the radioactive dumps;
- terminating the further contamination of the State National Park "Kokshetau", the Ishim and Imanburluk Rivers by radionuclides; and rehabilitating Lakes Shokpak, Salkynkol and Koksor;
- ordering the management of the encapsulated ionizing radiation sources (EIRS) and, as a result of that, preventing radiation accidents associated with EIRS theft, loss and unintended use;
- acquire data on environmental monitoring and assessments of the late consequences.

As a whole, the procedure for conservation of the closed-down uranium enterprises is as follows: At first, the General Customer (RSE "Uranlikvidrudnik"), with the involvement of the representatives of the Akimat (the authorities), experts of the local sanitary supervisory, and the environmental protection authorities and design organization, implements a preliminary sanitary-dosimetric examination of the corresponding facility. Then, the specialists of RSE "Uranlikvidrudnik" order the designs and find contractors to execute them. There are only a few licensed enterprises dealing with such special challenges in Kazakhstan.

A commission makes a decision on the restoration and signs an act. A radiometric survey of the territory, including gamma and radon measurements, is made. The natural background radiation not exceeding 30 μR/h was considered standard.

Thus, in 2002, one of the contractors of the given programme, JSC "KATEP", started the winding-up and conservation of the Vostochny uranium mine in the Moyynkum region of Jambyl oblast (Aksuek settlement). Three mines were closed down, the filtration fields were covered with clean ground, a number of the "dirty" industrial objects were liquidated, the non-commercial ore dumps were flattened, and the territory of Aksuek settlement was cleansed of radioactivity.

The technology of the given design specifies the cleansing of the contaminated territories and objects by collecting and removing radioactive material that has a contamination level significantly exceeding the admissible values. The collected contaminated materials are delivered to the places for their conservation and final disposal and covered with clean ground and layers of organic soil. As for the flattened non-commercial ore dumps, they are covered with inert materials and vegetable layer of soil.

As a result, the sources of radioactive dust from the open pits, whose damage earlier might have represented an important hazard and caused contamination of the clean territories, appeared to be safely covered.

All of the restoration operations are performed by machines, the buildings and constructions are demolished by the drilling-and-blasting method, and debris is transported to its conservation and disposal places. At first, the mines are filled up with radioactive waste and then with clean rock. This diminishes the release of radon gas into the atmosphere. The enterprise dealing with the disposal and conservation of radioactive waste must meet a number of requirements, such as having a licence on the right to perform the given type of work, a sanitary-welfare building equipped with a shower and a sanitary inspection room, dining room, and a station for washing and decontaminating vehicles and earth movers.

In addition, they use up-to-date mining machinery with cabins that are safely protected against radioactive dust. Every worker is provided with a personal radioactivity counter. Operations on dust suppression are regularly performed by means of water sprinkling at the industrial sites.

The JSC "KATEP" covered the open pits 5-8 and surfaces of some of the dumps of the Korday mine with clean loam and then sowed grass on them. Here, 1,737,000 m^3 of radioactive waste has been disposed for a little more than a year.

The results of a study on one of the above most ecologically hazardous facilities, namely, the Koshkar-Ata tailings impoundment, allowed the specialists of the Nuclear Physics Institute of the National Nuclear Center (NPI NNC) to choose two reference sites to improve the restoration technology on the uncovered surface of the tailings impoundment in its southern part.

The soil fill method is used for restoration. The comparative analysis of the available documents has shown the advantages of using sandy-clay soil because of its accessibility and relative cheapness. Clay contained in this soil prevents dusting and presents a supplementary barrier for radon emanation. The sandy-clay soil cover encourages growth, which serves as an additional protection against wind erosion.

Before the restoration work, the gamma field within the site had a mosaic-type character and was characterized by the high values of exposure dose rate, which exceeded the background values by 2–3 times. After covering the site territory with soil, the gamma field became practically homogenous, and it is now characterized by exposure dose rates corresponding with the background values typical for the given region.

The preliminary results of the efficiency assessment of the applied restoration method shows a significant improvement of the radiation characteristics of the investigated site.

In addition, for the purpose of ensuring maximum efficiency of the restoration work, the NPI NNC developed the technology of a radiation survey in the highlands at the closed-down uranium mine located 15 km from the settlement of Koktal in the Borokhudzir River canyon, and in immediate proximity to the active sanatorium "Jarkent-Arasan". Because it was not allowed to place such a facility on the territory of the health centre, it was decided that it should be liquidated. A variety of methods, including radiometric survey and determination of the radon release, as well as an examination of radiation characteristics of soils, allowed for the estimation of the area of contamination and the volume of contaminated soil.

Currently, 67 sites of the former uranium and geological exploration industry have been restored, making up more than 99 % of the amount of the waste from mining and geological exploration The standard restoration programme is implemented in compliance with the approved designs only on the surface of the former uranium mines and at the industrial sites of the former territories of the mines, dumps and tailings impoundments, and comprises:

- restoration of mine workings
- layer-by-layer removal of contaminated soil in order to achieve the safety criteria set by the regulations and design documents on restoration;
- collection of scrap metal at the remediated territories and its disposal if it is contaminated and not subject to decontamination or recycling;
- decontamination of building structures, as well their dismantling;
- disposal of radioactively contaminated building material and construction waste in the dumps (at winding-up of the facility);
- flattening and grading of surfaces of the poor ore dumps and combined dumps;
- covering the dump surfaces with clean soil, which provides an exceeding of the gamma-radiation dose rate less than 20 μR/h of the natural radiation background at 1.0 m height from the remediated surface, and, besides, in formation of the near-surface disposal points for radioactive waste at the facilities - an exceeding of the radon exhalation less than 1.0 Bq/m^2*s in compliance with the requirements of the Sanitary Rules LKP-98;
- fencing in the restored facilities that are located less than 5.0 km from the nearest settlement.

It is necessary to note that in the country, significant practice has been gained in rehabilitating former uranium deposits and processing enterprises with the purpose of minimizing their effect on the environment. The relatively unsophisticated technologies and methods of restoration were applied in the arid zones of the country, where, as the basic strategy, these methods were chosen: mechanical cleansing of contaminated ground surfaces, decontamination of buildings and dismantling of constructions and their subsequent disposal, and formation of different soil covers on surfaces of the rock and poor ore dumps. A typical example is the shutdown and restoration of the old mines at the Vostochny Mine.

A more sophisticated undertaking is to restore the old uranium mining facilities under the conditions of a temperate continental climate, with a large amount of precipitation, high level of underground waters, and relatively high infiltration of underground waters (for instance, in the region of the Stepnogorsk OCC). Here, in addition to the traditional actions to prevent a secondary aerosol contamination of the territories in droughty and windy seasons, special attention should be given to the monitoring and radiological control of water consumption, due to the high risks of contamination of the underground waters and the possibility that the population uses the drainages of mine water. Accordingly, the regulations of the environmental monitoring must be developed further here, too.

A sophisticated undertaking, from the technological point of view, is to also rehabilitate the former uranium facilities located in the highlands (for instance, the Kurday and Panfilofskoe facilities). Here, the main ways for spread of radionuclides is by water flows, because of the high modules of surface water flow in the highlands and the high risks of contamination of the mountain lakes and old water-sealed ore open pits, which take in the contaminated water flows and drains and are used by the local population for fishing and local water consumption. In the highlands in the regions of the poor ore dumps, landslides and sills occur. That is why the people who live nearby these sites often need to erect constructions protecting against landslides and to even place concrete on the sides of the uranium ore dumps.

There is no doubt that the waste of uranium industry leads to irreversible contamination of the environment, and it is necessary to take measures to restrict its impact on the environment. But taking into consideration that the waste can contain minerals, which stocks can become of standard condition in time, the task on its re-valuation and transfer in technogenic mineral formations is put. This task will become more and more vital as the mineral resources in the depths become exhausted.

In recent years, the uranium mining in Kazakhstan has been carried out by the method of underground leaching. Various objects that are in close contact with the productive solutions are sources of radioactivity at the enterprises that use underground leaching to get uranium. These are the so-called external sources of radiation.

In the process of operating the deposits in accordance with the above method, relatively cheap uranium is extracted from poor ores of the sandstone-type deposits, and sometimes technological solutions leak during pumping-in or pumping-out, or failure and leakage of the pipes for pump-down and productive solutions at the pipeline take place.

So, at in-situ studies of the ground within the mines of the Kanjugan, Northern (Severny) Karamurun, Uvanas and Mynkuduk deposits, sites of radiation contamination of the soil were detected.

Below, Table 13 shows the types, average content of radionuclides in samples (in mg/kg of dry soil) and their activity concentration (Bq/kg).

Table 13. Data on the sites of radiation contamination at the deposits Kanjugan, Northern Karamurun, Uvanas and Mynkuduk according to the in-situ studies, and calculated values of dust blown-off of these sites

No. of model	**No. of site**	**Conta-minated area, m^2**	**Weighted average activity of radionuclides in the soil, Bq/kg**						**Amount of blown-off dust, g/s**
			U^{238}	**Th^{232}**	**Th^{230}**	**Ac^{227}**	**Ra^{226}**	**Pb^{210}**	
Deposit Kanjugan									
1	1. 2	50,000	104.36	65.0	-	-	1,630.0	-	0.255
2	3.4	1,540,000	124.0	71.3	24.8	1.5	-	-	7.854
Deposit Northern Karamurun									

3	1.2	1,226,000	237.5	107.4	321.6	13.5	25.4	59.8	6.2526
Deposit Uvanas									
4	1.2	1,596,000	193.0	88.0	913.0	174.0	275.0	1,798.0	8.1396
Deposit Mynkuduk									
5	1.2	210,650	278	101.0	1,494.0	60.0	1,132.0	2,037.0	1.0743

For the Zarechnoe deposit mined by the underground leaching method, the specialists of the NPI NNC also conducted in-situ and laboratory studies for the purpose of determining the character of the spread of natural radionuclides and toxic elements in the environment. Special attention was paid to the location of the self-pouring-out wells.

It has been detected that at most of the examined sites of the given deposit, the exposure dose rate is within the range of natural background radiation (0.12–0.18 μSv/h). At the same time, at some key points, the concentration levels of the natural radionuclides of the ^{238}U family several times significantly exceeded the value of minimum significant activity (MSA – 10,000 Bq/kg).

The results of the radionuclide analysis of the water samples have shown that the concentrations of some natural radionuclides of the ^{238}U and ^{235}U families in the water of wells Z-23, Z-24, Z-25 and, especially Z-02, considerably exceed the sanitary standard “Intervention Level”. For example, in the filtered water of well Z-02, the concentration of ^{226}Ra (5.9 Bq/l) exceeds the intervention level (0.5 Bq/l) by a factor of 10. According to the element analysis, it has been determined that the content of Se in the water of well Z-25 (123 μg/l) is more than 12 times higher than the sanitary standard maximum concentration limit for potable water (10 μg/l). The highest concentrations of many elements (Ca, Sc, Fe, Co, Ni, As, Rb, Sr, Zr, Mo, Cs, Ba, Ce, Re, etc.) have been detected in the Z-02 well water. On the one hand, this particular feature confirms the role of this well as a source of contamination. On the other hand, the availability of high concentrations of many important elements (in particular, Re and Se) shows an additional practical value of the mined deposit.

3.1.2 Management of Low- and Intermediate-Level Waste Produced as a Result of Activity of the Semipalatinsk Testing Ground

The Semipalatinsk Testing Site (STS) is situated at the intersection of three oblasts: East Kazakhstan, Pavlodar and Karaganda, and was closed down by the Decree of the President of Kazakhstan on 29th of August, 1991.

The operations to eliminate the consequences of the nuclear tests that started after the closing of the STS comprise the shutdown of the infrastructure of nuclear weapon tests, conversion of the military-industrial complex facilities, unbiased assessment of scope and degree of environmental contamination, measures shielding the health of the population from effects of the nuclear tests, and remediation (restoration) of the radiocontaminated territories.

The inhabited locations within the following settlements have been ascribed to a zone of extreme radiation hazard from the former STG.: Sarjal, Abay, Dolon and Bodeneli of the Beskaragay region and Sarapan and Isa of the former Janasemey region of the former Semipalatinsk oblast. The inhabited settlement of Abay of the Beskaragay region, as well the settlements within the boundaries of the former Abralin and Janasemey regions of the former Semipalatinsk oblast, the settlements of Akjar and Maldar of the May region of Pavlodar oblast, have been ascribed to the zone of maximum radiation hazard.

An important problem of the STS is the possible contamination of soils with radionuclides that in turn are likely to contaminate water sources. In the period after the shutdown of the STS, some studies of contaminated land were conducted. At present, the mapping of the safe places of the STS are under way. After completion of the cartography, it will be necessary to define the status of the land and the boundaries of the areas where any residence or activity is not to be permitted for tens or hundreds of years. The consequences of nuclear tests will be experienced by 5–6 future generations.

The results of radioecological studies recently conducted on the STS territory have detected sites of significant radioactive contamination, including contamination with nuclear materials. This contamination is mainly associated with the testing platforms and traces of the clouds of nuclear explosions.

The STS sites are mostly contaminated with transuranium elements. In the “Opytnoe Pole” sites, 4 surface and atmospheric nuclear explosions have resulted in $7.96 \cdot 10^{12}$ Bq of plutonium. By the beginning of 2001, the total activity of radionuclides (products of all the explosions) made up: $3.13 \cdot 10^{13}$ Bq of Pu, $3.29 \cdot 10^{13}$ Bq of ^{137}Cs, and $1.33 \cdot 10^{13}$ Bq of ^{90}Sr. The ratio of Pu and ^{137}Cs activities as a result of these four explosions is approximately 1. Therefore, the significant content of plutonium and, correspondingly, ^{241}Am, is the most hazardous contaminant of Site 2 of the “Opytnoe Pole” vicinities. On the territories earlier considered relatively safe from radiation point of view (the northern and western parts of the STS), the sites identified as the places of military radioactive charges tests have been detected. These are the places polluted by the propellant components. Some rather small and restricted sites with significant radioactive contamination have also been detected, which, in the experts’ opinion, are caused by unauthorized activity, generally by searching for scrap of ferrous and non-ferrous metals.

3.1.3 Management of RW Produced by the Enterprises and Plants of Petroleum Refining, Non-Ferrous and Ferrous Metals and Chemical Industry

The challenge concerning radiation safety in connection with the accumulation of natural radionuclides in the environment due to the mining of hydrocarbon raw material is also very important for Kazakhstan. The huge territories are contaminated and continue to be contaminated in the process of oil field activity.

According to the radioecological studies, the regions of oil and gas fields in West Kazakhstan are in a critical ecological situation due to technogenic radiation. For instance, in 1992–1997, the radioecological studies at the sites of oil production in Mangistau’s and Atyrau’s oblasts revealed 50 oil fields of 3,370 km^2 with 275 sites of radioactive contamination. It has been determined that in the process of oil production, the contamination of the environment with the natural radionuclides uranium, radium and thorium, in concentrations exceeding the background radiation tens or hundreds of times, is associated with the stratal waters extracted from the depths together with oil.

The scope of the challenge may be also assessed proceeding, for example, from the fact that at present, only at the Jetybay oil field in Mangistaus oblast, 6 million pump and compressor pipes with a total weight of 600,000 tons have been accumulated, each of which, in compliance with the radiation safety standards, falls under the definition of an ionizing radiation source. Quite often, the solution that is chosen for this problem is the unsystematic final disposal or storing of contaminated materials (equipment) at spontaneous dump heaps, creating a source of uncontrolled radioactive contamination of the area.

Having this in mind, the NPI NNC and the Kazakh-Czeck Company “Asia-Clean” jointly developed a method for an effective and ecologically safe know-how for cleaning the radiation-hazardous sediments off the oil field equipment of and disposing of the produced waste.

The basis for the given know-how is the application of several types of working solutions, by which the cleansing and decontamination of contaminated and radioactive surfaces are carried out.

As a result of the implemented treatment, the pump and compressor pipes have been cleared from superfluous radioactivity. The operational characteristics of a greater part of the decontaminated pipes meet the criteria for working pump and compressor pipes, allowing them to be reused. Taking into account that the cleansing has been made for the pipes before stored during 15–25 years on the open sites, there is every reason to believe that at timely cleansing the quantity of recycled pipes can reach 80−90 % of their total number.

As a result of laboratory experiments, it has been concluded that the given know-how enables the elimination of radioactive contamination by technological sediments from the surface reliably and by practically 100 %.

The Irtysh Chemical and Metallurgical Plant (ICMP) in the settlement of Pervomaysky of East Kazakhstan oblast, which had its first phase commissioned in 1959, specialized in the production of rare-earth metals like loparite and then thorium and uranium raw material. In 1999, the “Irtysh Rare-Earth Company” was established on the base of the ICMP rare-earth production. After that, a considerable part of the production cycles was partially or completely shut down. As a result, the control over the radioactive waste that had been stored in the technological tanks by the time of production shutdown, was lost. To present day, 69 tanks contain a total volume of about 100 m^3, of which 56.5 m^3 are ascribed to LRW, are stored in shops 22 and 22A of the former ICMP. In 2006, within the framework of the republican budget programme “Ensuring of Radiation Safety”, the NPI NNC performed the works on the development and experimental approbation of a pilot know-how of the disposal of LRW stored in shops 22 and 22A of the former Irtysh Chemical and Metallurgical Plant.

The classification of dividing the LRW into several groups differing in phase composition and physicochemical properties was made on a basis of laboratory analyses of the samples selected from the technological tanks. It has been proposed to store the inorganic LRW by means of grouting in special tanks or containers to be placed in long-term storage.

The given method of disposal comprises a preliminary preparation of LRW for grouting, taking into consideration the following features:

- as a rule, low values of pH (1−3) corresponding to the highly acidic medium;
- high values of mineralization (sediments after evaporation) of a part of the LRW, exceeding 200 g/l;
- presence of sediments of organic substances in suspension or odoemalsion of up to 10 % by volume.

These are reasons why the preliminary preparation includes the operations on LRW neutralization, oxidation and decomposition of organic substances and precipitation of a greater part of dissolved mineral salts and sediments of organic substances in kind of insoluble compounds. The remaining weakly mineralized supernatant is delivered to the inlet of the grouting installation.

3.1.4 Management of the RW of Reactor BN-350

The decommissioning of the fast neutron reactor BN-350 is a special case for radioactive waste management in Kazakhstan. The given reactor, with sodium coolant, had operated since 1972 and was the main electric power and heat supply source in the city of Aktay.

In 1999, the decision was made to shut down the reactor and to bring it in a safe storage mode (SAFESTOR) for 50 years, and then to perform the work on final decontamination and dismantling (partial or full).

A preliminary assessment has been made of the state of the representative series of core assemblies and the shield after irradiation and storage in water during 5–10 years. The research methods included visual inspection, photography, gamma scanning, profilometry of the fuel assemblies and casings, determination of the accumulation of gaseous decay products in the fuel rod claddings, and the determination of short-term mechanical properties of the samples. Measurements were made of the density and optoelectronic microscopy was performed on the samples of casings and guide wire of fuel assemblies. The assemblies were chosen to cover the whole range of the state of the fuel stored in the cooling pond, and also included Ts-19 fuel assemblies with faulty fuel rods. In addition, the implemented analysis took into consideration international practice in storage of spent nuclear fuel in water and the results of the examination of the first and second fuel assembly types of reactor BN-350. The analysis and assessment were aimed at determining what measures should to be taken to ensure the safe package, transport and dry storage of the spent fuel of reactor BN-350.

About 5,000 m^3 of liquid and 6,000 tons of solid high-level radioactive waste was accumulated at the reactor facility. The evaporation of LRW, grouting of residual slurries and their further final disposal are assumed. The project of solid RW treatment is at the stage of co-ordination.

For reprocessing of the liquid metal coolant of the reactor BN-350, the building of a plant is planned on the territory of JSC "MAEK-Kazatomprom" for processing the given coolant (liquid sodium) into a concentrated alkaline solution, and another plant for processing of alkali into a geocement stone for long-term safe storage. The two plants will be connected by pipelines for the alkali transportation.

The above production is experimental and has no analogues in Kazakhstan, but its main technological processes have already passed successful laboratory research.

The U.S. Idaho National Laboratory and the UK RWE NUKEM Ltd. are the partners of the project. According to the foreign experts' estimate, the total cost of the BN-350 conservation is about $85 million.

3.1.5 Management of Disused Sealed Radiation Sources (DSRS)

The "State Programme of Conservation of the Uranium Mines and Elimination of Consequences of Uranium Deposits Mining for 2001–2010" also envisages a number of actions on the ordering of treatment of spent ionizing radiation sources in the quantity of more than 39,000 by the end of 2000, appeared to be needless and subject to final disposal after winding-up of a number of enterprises. The service life of most sources has expired and their further storage becomes very hazardous. After the shutdown of a number of the uranium mines and geological organizations that specialized in the prospecting and exploration of radioactive raw materials and used DSRS in their activity, as well significant reduction of the enterprises (because of their economic bankruptcy), a large quantity of such sources happened to be needless.

Many of the operating enterprises, and especially those subject to a bankruptcy procedure, lack the funds for a final solution of the disused sealed sources. Conditions for the management of DSRS, many of which have the expired term of life and often lack a certificate, are of great concern.

The DSRS must be considered radioactive waste, written-off and handed over for final disposal.

At present, the main licensed enterprise of republican importance for interim storage of DSRS is the "Baykal-1" Facility in the town of Kurchatov. The first phase of the EIRS storage facility at the "Baykal-1" Stand Complex was commissioned in 1995.

The given Complex is equipped with the following: 2 special vehicles, temporary storage facility, special washer, radiation-protective chamber, interim storage facility, hoisting crane with a set of special grippers and spreaders, shielding container, cases, magazines, and a permanent storage facility.

Proceeding from the number of DSRS being stored at users, terms of renewal of the sources and financial opportunities of the enterprises, the annual amount of final disposal is estimated to be some 450−500 items.

On the whole, the operations on accepting, transporting and storing DSRS have improved the radiological situation considerably in many regions of Kazakhstan, to renew work of the oncological centres. Annually over 40 contracts with different enterprises and institutions of Kazakhstan are implemented.

At the present time, the storage facility contains more than 20,000 DSRS from all over the territory of Kazakhstan.

In addition, the EIRS storage facilities in the country operate in the following organizations: JSC "MAEK Kazatomprom" (city of Aktay), Ulba Metallurgical Plant (city of Ust-Kamenogorsk), and the storage facility for low- and intermediate-level DSRS in the NPI NNC (city of Almaty).

The organizational structure of control and supervision of nuclear and radiation safety in Kazakhstan, as a whole, ensures the safe work with EIRS and has recently enabled the significant reduction of the risks associated with their unregulated use.

With the purpose of further improvement of DSRS treatment, the “State Programme of Conservation of the Uranium Mines and Elimination of Consequences of Uranium Deposits Mining for 2001–2010” directs to:

establish a centralized centre carrying out accountancy and transfer of sealed ionizing radiation sources, collection upon request for their management and final disposal, and organization of leasing the sources unused by enterprises;

take an inventory of all ionizing radiation sources in the country and develop a database containing systematized (unified) data on sealed sources;

establish regional centres for the collection, temporary storage, and transport of sources for final disposal, on the base of the enterprises engaged with or having intentions to deal with rendering services on interim storage of DSRS;

include the cost of final disposal of sources (without transport expenses) in the price of ionizing radiation sources purchased by enterprises; in doing so, it is advisable to accumulate the cost of final disposal (or long-term storage) on a special account (in a special fund) and use it for final disposal at the shutdown and bankruptcy of an enterprise or change of an enterprise’s ownership form and other circumstances;

define a fixed cost of final disposal (or long-term storage) of a radionuclide activity unit or an ionizing radiation source type, and agree it upon with the Antimonopoly Committee.

3.2 Characteristics of the Uranium Industry Facilities in the Kyrgyz Republic

Descriptions are given below for the following main facilities:

- Mayluu-Suu site
- Min-Kush site
- Kadji-Say site
- Kara-Balta site
- Shekaftar site
- Ak-Tyuz site
- Orlovka site

Mayluu-Suu Site

The Mayluu-Suu site is located on the territory of the Suzaks region in Jalal-Abad oblast (province). The uranium ore was processed at Mayluu-Suu from 1946 to 1968. For more than twenty years of operation, the Mayluu-Suu Zapadnyi (Western) Mining and Chemical Combine produced 10,000 tons of uranium oxide (U_3O_8).

At present, at the place of the former facility, a part of which was located inside the town boundaries, 23 tailings impoundments and 13 waste rock dumps with approximately 2.5 million m^3 of waste remain. All available tailings impoundments were conserved from 1966 to 1973. Until now, the territories of the sites, and in particular those located on the banks of the rivers, have not been fully rehabilitated.

The location of the tailings impoundments and waste rock dumps at the Mayluu-Suu site is shown in Photo 1 and Figure 8.

Mayluu-Suu is situated in a seismic hazard area. Strong earthquakes can cause landslides, which in turn might destroy the tailings impoundments or dam the river bed. During a long period of time (from 1973 to 1999) , the remedial and rehabilitation work at the tailings impoundments were not executed routinely. None of the dams protecting the tailings impoundments can by the characteristics of their engineering design stand against an earthquake. Among the landslides in that region, the "Tektonik" and "Koy-Tash" are considered the most dangerous ones that are likely to destroy the tailings impoundments. According to an estimate, these landslides might push 2–3 million m^3 of land.

The Mayluu-Suu River is a tributary of the Syr-Darya River in the top part of the Ferghana Valley, and it flows on the territory of the neighbouring states, Uzbekistan and Tajikistan. Hazards that might be caused by landslides, which might result in radioactive spills in the Mayluu-Suu River and contamination all over the Ferghana Valley, generate the rise of social tensions in the Central Asian region.

Photo 1: The Mayluu-Suu tailings impoundments No. 5, 6 and 7

Source: MES Project "Prevention of ES"

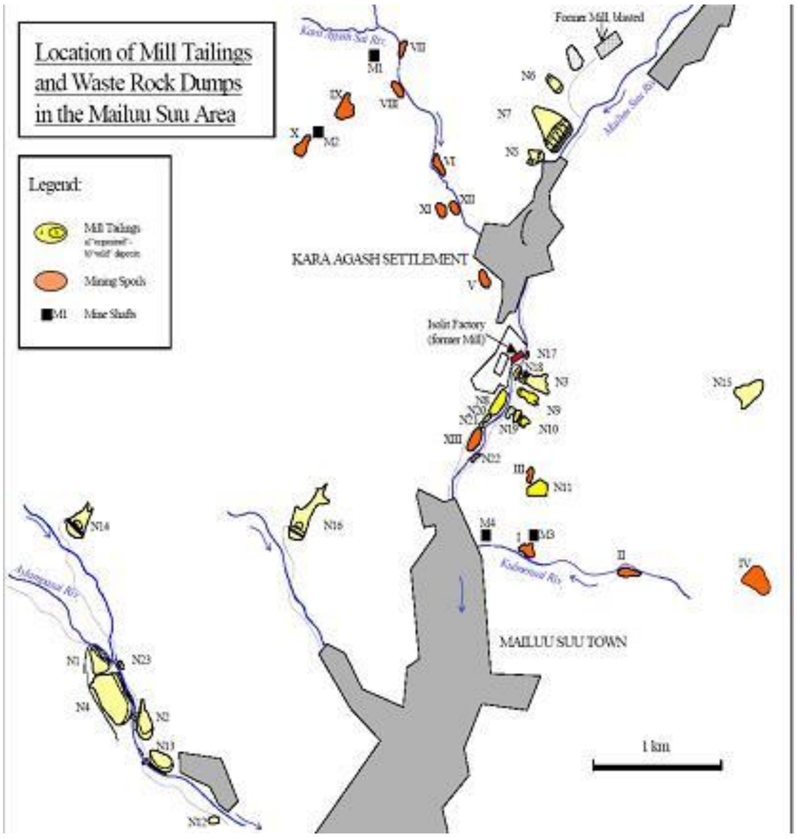


Figure 8: Location of the tailings impoundments and waste rock dumps sites in Mayluu-Suu
Source: TACIS Project 2001-2003.

In 1992–1993, the European Bank for Reconstruction and Development (EBRD) conducted several missions to estimate the potential exogenous hazard (landslides in the river valley) and threat to the Ferghana Valley population. Experts have come to the conclusion that among the Kyrgyzstan tailings impoundments, the most potentially dangerous ones are the Mayluu-Suu tailings sites. The above sites are divided into two groups according to their vulnerability to landslides. The first group comprises 5 tailings impoundments requiring the utmost urgent measures to be taken to provide their safety. The second one includes the remaining 18 tailings impoundments, which are rather stable with respect to landslides and do not demand any maintenance yet.

Min-Kush site

The settlement of Min-Kush is located on the territory of the Jumgal region in Naryn oblast. There are 4 tailings impoundments and 4 rock dumps with the waste produced at the uranium mining and processing enterprises in this region. The total volume of waste amounts to 1.961 million m^3. The mines were worked from 1955 to 1969. When the uranium mines were shut down, the tailings impoundments were conserved. The register of Kyrgyzstan Ministry of Emergency Situations highlights the Tuyuk-Suu and Taldy-Bulak tailings impoundments as the potentially hazardous ones (Photo 2, Figure 9).

Photo 2. A part of the settlement of Min-Kush and view to the Tuyuk-Suu tailings impoundments above the settlement
Source: NATO Project Sfr 2005–2008

The Tuyuk-Suu tailings impoundment is located in the river bed that bears the same name, and covers a territory of 3.2 hectares. The total volume of uranium tailings therein amounts to 450,000 m^3. Previously, in order to take the Tuyuk-Suu River's waters away from the body of tailings, a reinforced concrete canal was built. A part of the concrete structures of the drainage canal was destroyed by strong streams of water/freshets. The resulting partial damming impedes the free flow of surface water, and the tailings impoundment top surface settles down differently. At some places, the protective cover, fences and warning signs were destroyed. The further destruction of the tailings impoundment and, in particular, the system of canals, can lead to the sliding of tails into the Kokomeren River and the Naryn River, and then into the Toktogul Reservoir and further down the Ferghana Valley.

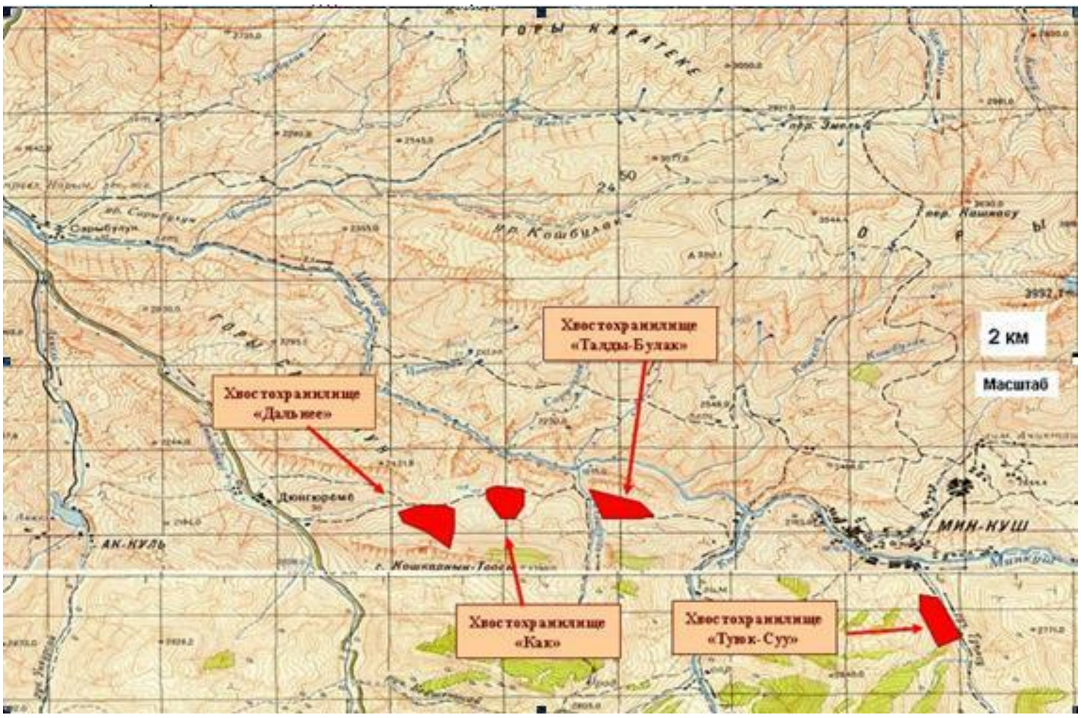


Figure 9: Location of four tailings impoundments near Min-Kush settlement
Source: Project "Carrying out of Prospecting Work",
Association "Alpproekt", Association "TcAGK", 2007.

The Taldy-Bulak tailings impoundment is located 12 km away from Min-Kush settlement, and the territory of the tailings impoundment is 3.35 hectares. The volume of waste in the dump makes up about 395,000 m^3. The drainage canal of the local brook starts from Taldy-Bulak sai and ends with the water-carrying system beneath the tailings impoundment bed. The main water canal located upstream is periodically blocked with sill drift. Because of the grooves on the tailings impoundment surface, some protective covers are destroyed. Fences and warning signs are broken. The drainage system is in a critical state and must be restored to prevent the destruction of the tailings impoundment body and ingress of tails into the Kokomeren River and further down the Ferghana Valley.

The Dalnee and Kak tailings impoundments are located side by side at 11 km distance from Min-Kush settlement and cover a territory of 13.1 hectares. The total volume of drift tails makes up 306,000 m^3. At present, freshet water is accumulated in several cavities on the surfaces of the tailings impoundments. The surface of the Kak tailings impoundment is partially overgrown with grass. The local population uses this site for grazing cattle. The gamma radiation dose rate on the surface of the tailings impoundments averages 0.30–0.60 μSv/h, although in some places it reaches 5.0 μSv/h. In some places of the Dalnee tailings impoundment, the gamma radiation dose rate reaches 12.0 μSv/h. In order to provide for the safety of these tailings impoundments, it is necessary to build a drainage canal system and to restore the protective cover.

The ore storage and the gangue burial are also located in this region. The total contaminated territory makes up about 61,000 m^2. The average gamma radiation dose rate is in the range of 0.30–1.0 μSv/h, but in some places it is 1.0–5.0 μSv/h, and therefore, the tailings impoundments and waste rock dumps in this region require an urgent rehabilitation.

Kadji-Say Site

The Kadji-Say site is located on the territory of the Ton region in Issyk-Kul oblast. This site on the southern shore of Lake Issyk-Kul gives rise to a special concern for the public and the Government of Kyrgyzstan. The site is located 3 km east of Kadji-Say settlement and 1.5 km away from of Lake Issyk-Kul. The facility worked from 1949 to 1967 and used the procedure of acid leaching to extract uranium from lignite (brown coal) ash of the local deposit. Earlier, the coal had been burnt at the local thermal power plant. The volume of accumulated tails of the uranium facility, as well of other solid industrial waste, amounts to approximately 150,000 m^3. The tailings impoundment is located on the mountainside terraces.

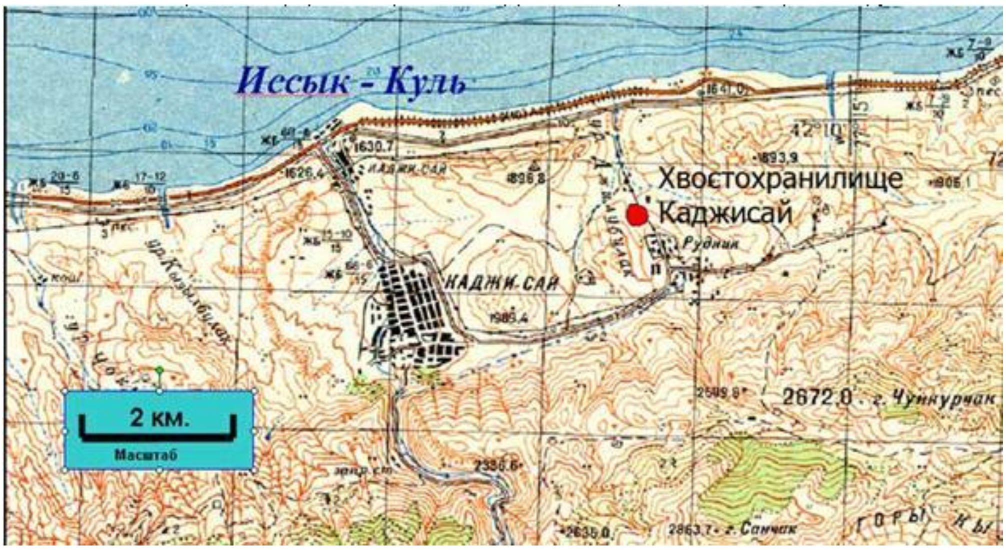


Figure 10: Location of the Kadji-Say uranium tailings impoundment

Mainly, the tailings impoundment contains a mixture of mill waste, coal ash from the former thermal power plant, rock gangue, and residue of coal ash processed for uranium extraction. In the waste dumps and some other places, metal scrap was disposed. Attempts made in the past to protect the site by covering it were obviously inefficient, because the local population destroyed it by digging out the dumps to get metal scrap as a source of income. In 1966, the tailings impoundment was taken under the state’s control, but as of now, its problems have not yet been solved.

The gamma radiation dose rate on the surface of the tailings impoundment averages 0.30–0.60 μSv/h, although according to the data from the Ministry of Emergency Situations of Kyrgyzstan, there are several places with the abnormally high radiation levels at 6.0–15.0 μSv/h. In general, these are the places with faulty cover that has been broken by human activity or water erosion. The places with high gamma radiation level were detected in the industrial area used for lignite storage, as well as at the uranium mining and processing site where, for instance, the dose rate reached 1.2–2.0 μSv/h.

Right up until the present time, the tailings impoundment was in bad condition. Water erosion contributed to wash-out of the tailings impoundment sides, and the drainage system built near the sides to prevent wash-out of the tailings impoundment body was destroyed.

The remediation works were financed (400,000 U.S. dollars) through ISTC (the International Science and Technology Centre, Moscow) and were co-ordinated through the U.S. Department of Energy (DoE) and the U.S. Lawrence Livermore National Laboratory (LLNL). The rehabilitation plan focused on the consolidation of waste at a minimum number of places (until 2006), the installation of a protective shield on the tailings impoundment surface to minimize radon emanation and gamma radiation dose, and to protect it against erosion and contamination.

At present, the works on the rehabilitation are still under way. In particular, the works directed at stabilizing the tailings impoundment sides that protect them against erosion have not been finished yet, and the fence system around the tailings impoundment has not been restored either. The local population therefore has free access to the tailings impoundment and continues to dig it out and sell the dug metal.

Kara-Balta Site

The Kara-Balta site is located in the Jaiyl region in Chu oblast. The tailings impoundment in the town of Kara-Balta has been operated since 1955. It is located 1.5 km south of the town of Kara-Balta, which has a population of more than 50,000 inhabitants. Since 2008, the combine has been privately owned ("Uran-Platina Holding", Russia). The total volume of stored radioactive waste makes up about 37 million m^3, whereas the design capacity of the tailings impoundment is nearly two times greater, at 63.5 million m^3. A part of the tailings impoundment is in a continuous rehabilitation process. A constrained economic state of JSC "KOMC" leads to a deterioration of the control over the tailings impoundment, which poses a threat to the densely populated town. The Kara-Balta tailings impoundment is one of the most potentially hazardous sites and the most radionuclide-contaminated site in the Kyrgyz Republic.

At present, the underground waters beneath the tailings impoundment and the town of Kara-Balta are under surveillance. The contamination halo radius reaches 10 km, and an assessment of the underground waters in this region is likely to be worse. The insufficient funds reduced the monitoring of the underground waters.

The local population builds new houses directly on the boundary to the tailings impoundment territory. The tailings impoundment territory itself is used freely by the local population for grazing cattle. Calculations of the dose burden for the urban population have not been made.

In the tailings impoundment, the system for high-mineralized waters interception was destroyed. At present, it is completely necessary to take a number of new measures to decrease the ecological and radiological damage from the plant's discharges entering the tailings impoundment.

The volume of discharges from the operating uranium enterprise can reach 50,000 m^3/year. The discharges from the plants specializing in production of molybdenum and gold from the foundry, a car-repairing plant, and two large analytical laboratories are also delivered to the tailings impoundment. There is a storage facility for liquid discharges containing cyanides on the territory of the tailings impoundment.

Shekaftar Site

The Shekaftar site is located in the Ala-Bukin region of Jalal-Abad oblast. The Shekaftar uranium mining was worked from 1946 to 1967. There are 8 sites with dumps here, and the surface of one of them was so destroyed that it became practically level with the natural terrain. About 700,000 m^3 of rocks (of low-level radiation) and non-commercial ores are accumulated in these dumps. Houses with personal plots and gardens are located nearby. None of the sites have been rehabilitated yet.

The average gamma radiation exposure dose on the tailings impoundments surface is equal to 0.6–1.5 μSv/h (60–150 μR/h). The dumps located on the bank of the Sumsar River are actively washed out by the river water during flood periods. A lack of vegetation on the surface promotes wind erosion and wash-out of material from the surface and further transport of the material away to Shekaftar settlement and to the adjoining territory of the Ferghana Valley.

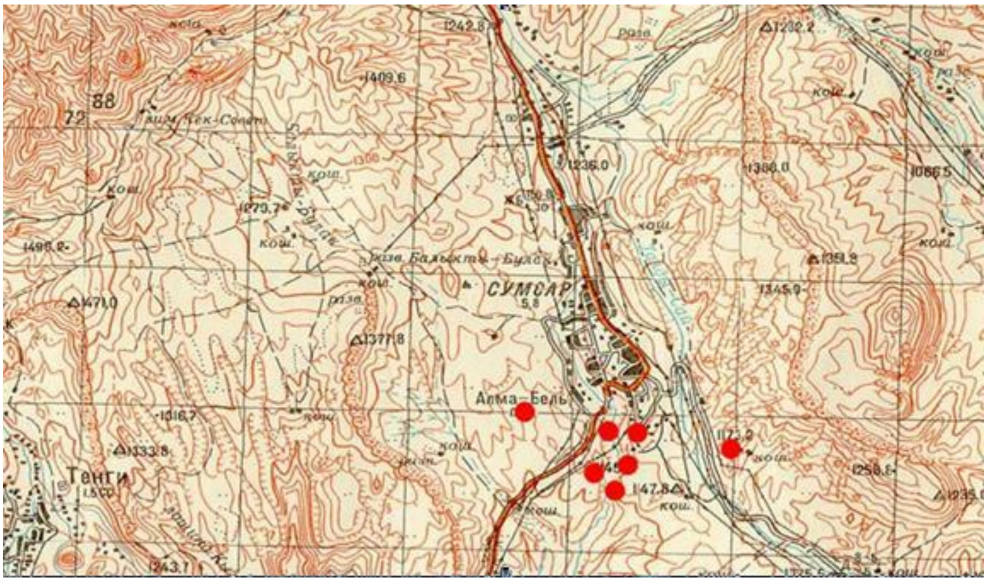


Figure 11: Location of the gangue dumps at the Shekaftar site

The Ak-Tyuz site is located in the Kemin region of Chu oblast. Nearby the settlement of Ak-Tyuz, situated 150 km east of the city of Bishkek, the mining and processing of ores containing lead, zinc and rare earth elements was carried out since 1942. The processed ores are characterized by high radioactivity caused by thorium minerals (monazite, thorite, zircon, and etc).

In the neighbourhood of Ak-Tyuz settlement on both sides of the Kichi-Kemin River valley, there are 4 tailings impoundments with about 3.4 million m^3 total volume of radioactive waste and 3 waste rock dumps, with a capacity exceeding 50 million m^3.

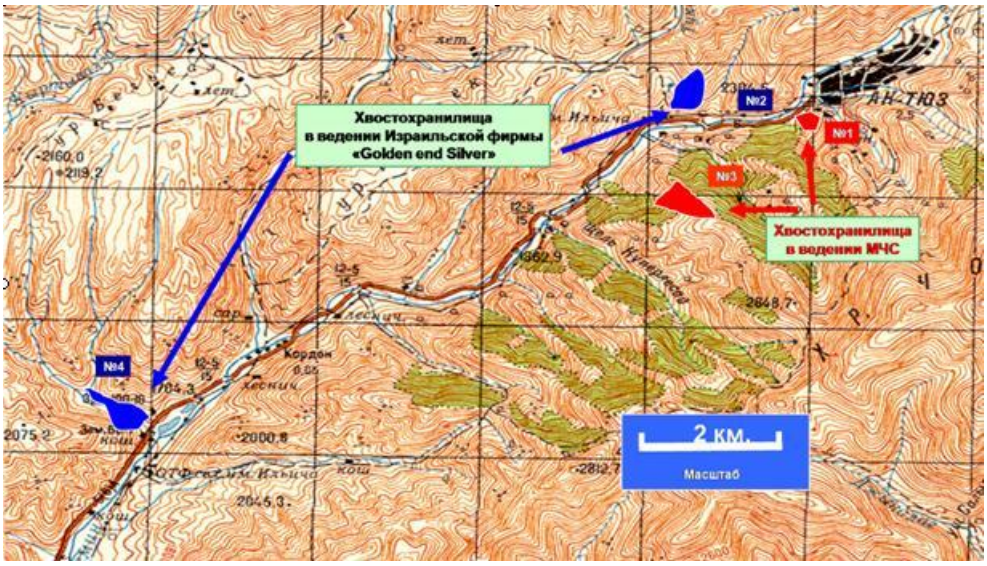


Figure 12. Location of the tailings impoundments at the Ak-Tyuz site

Tailings impoundment No. 1 was conserved in 1956, and No. 4 in 1995.

Due to water and wind erosion of the surface, the tailings impoundments and dumps are sources of systematic contamination of the environment by radionuclides (thorium) and heavy metals in the valleys of the Kichi-Kemin and the Chu Rivers.

Radioactive sands containing thorium and heavy metals are open at most places. The gamma radiation dose rate on the surface amounts to 0.1–1.0 μSv/h. The risk of contamination is increasing, because the above facilities are likely to be destroyed by earthquakes, landslides and sills, causing a transboundary challenge.

Orlovka Site

The Orlovka site is located on the territory of the Kemin region in Chu oblast. Nearby the Orlovka settlement, situated 92 km east of the city of Bishkek, the Bourdu lead mine has been worked since 1954 and the chemical and metallurgical plant since 1969.

This plant processed ore concentrate of the Ak-Tyuz mill to get rare earth metals.

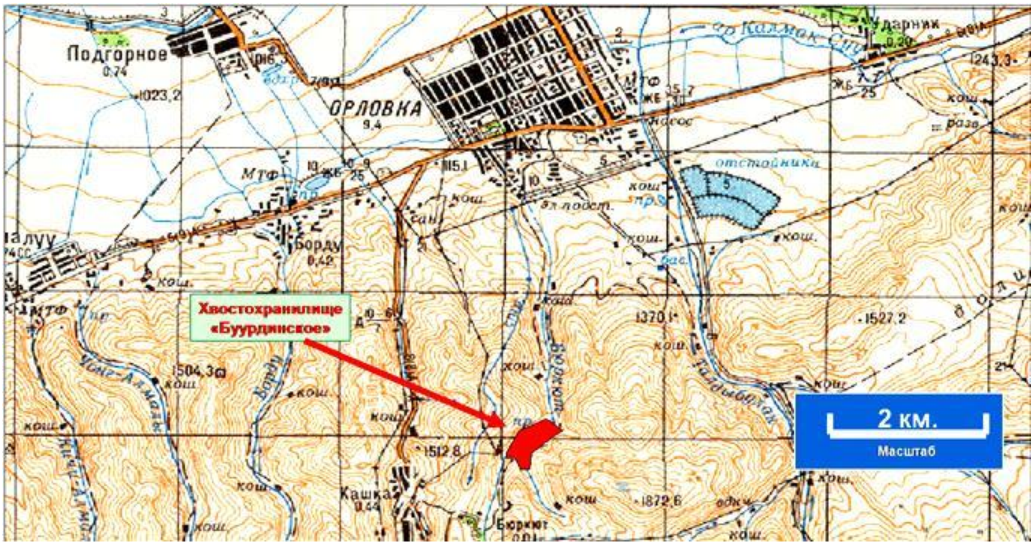


Figure 13. Location of the tailings impoundment at the Orlovka site

The waste that remained as a result of the Bourdu mine's activity is stored in the rock dumps (above 32 million m^3) and in the Bourdu tailings impoundment with a volume of over 3.5 million m^3. The dumps have not been restored yet, and the tailings impoundment was conserved in 1967. The waste contains lead, zinc, cadmium and rare earth elements. If the integrity of the tailings impoundment is destroyed by the sills, landslides, or earthquakes, it can contaminate the Berkut River, a tributary of the transboundary Chu River. The state of the tailings impoundment is unsatisfactory since its surface is not restored and its screen is broken. It is therefore necessary to take urgent measures to restore the dam of the industrial sewage pond containing 1.8 million m^3 of liquid (1.2 million m^3) and solid waste.

3.3 Evaluation of the status of former uranium facilities in Tajikistan

Tajikistan has a number of uranium ore deposits and mining and milling facilities that operated in the past. This country's own ores and imported raw materials were processed mainly at the former Leninabad Geochemical Combine facility (currently State Enterprise (SE) “Vostokredmet”) and also at other hydro-metallurgical plants located in the vicinity of uranium ore extraction sites (Adrasman, Taboshar, Isphara etc.). Presently, the only operating enterprise in Tajikistan that still has the potential to process uranium ores, using an acid leach extraction process, is the SE “Vostokredmet”.

It is interesting to note that the mine wastes at the Adrasman site were recently successfully reprocessed to produce lead concentrate. Otherwise, all underground and open pit mines and old radium and uranium facilities have been decommissioned, but most of them are still not remediated. Due to the recent significant increase in the price of uranium, the uranium mining residues have become a focus of interest for various different investors and commercial companies who are considering processing the waste rock piles and mill tailings of Northern Tajikistan.

Based on estimates from SE “Vostokredmet”, the total amount of residual uranium in the tailings and waste rock piles in Tajikistan is about 55 million tons. The total activity of these wastes is estimated to be approximately 240–285 · 10^{12} Bq (see Table 4 above in subsection 3.1.3). The total volume of waste rock piles and tailings in the vicinity of former hydrometallurgical plants and chemical leaching sites is more than 170 million tons.

The waste rock piles and tailings at Taboshar, Adrasman and Degmay (which is near the outskirts of Chkalovsk) are not well contained. In particular, the surfaces of the tailings usually have no protective cover, and the surface is eroded or damaged by burrowing animals. Significant amounts of contaminants are exposed, which are subject to dusting and wind. The cover of these tailings and waste rock piles has usually been washed away by water, mudslides and wind, thus becoming a source of highly contaminated drainage water, which is migrating into surface and ground water bodies. The same sources of water are commonly used by the local population.

In many areas where water is in short supply, it is common to graze and water the livestock using such contaminated waters. Local horticulture also uses these drainage waters for irrigation and even for rice paddies and orchards located near the sites of uranium waste piles.

Illegal excavation and collection of non-ferrous metals from areas of the tailings and waste rock piles and mines has become more frequent. This creates serious concerns over the transfer of contamination, as well as the exposure of the individual diggers. There is concern that these metals are sold at local, illegal markets in Tajikistan or even transported abroad.

3.4 Development of remedial plans and their implementation

With regard to the post-closure phase, there are two issues to be considered in the region:

- the remediation of the legacy sites, and
- the preventive post-closure planning for the currently operating and future mines and mills.

In the case of the remediation of the old legacy sites, this is best approached as an intervention measure to deal with a pre-existing situation. The first step should be to prepare a comprehensive national policy and strategy for radioactive waste management, decommissioning and remediation, which would consider all abandoned tailings deposits, waste rock dumps, and contaminated areas and structures to be decommissioned and demolished. This will allow for the prioritization of the individual sites. Specific remedial plans should then be developed for each site, while the selection of the most suitable remediation solution should be done by weighing the risk potential of the abandoned objects against the economic factors and stakeholder issues.

The remedial actions that are selected must be justifiable, optimized and effective under the local conditions, i.e. they should consider all local events that can jeopardize the containment of the wastes (including human and animal intrusion, earthquakes, and extreme weather, etc). However, the selected remedial solution must be in balance with the potential consequences of the waste release.

The best way to ensure the long-term sustainability of the remediation measures is to follow the strategy of putting the reclaimed land and remediated objects to productive use, whenever feasible. A post-remedial stewardship plan must accompany the transfer of the objects/sites for post-remediation use, in order to ensure that the safety requirements are met in the long term. Some form of institutional control is always going to be required.

Apart from the environmental reasons, remediation of the legacy sites is also desirable for socio-economic reasons. Experience from various parts of the world shows that the successful development of a closed mine in a former mine district is greatly assisted by successful environmental rehabilitation. An example from a remote area is found at Elliot Lake, Canada, where an attractive retirement community developed after the rehabilitation of the uranium mines. An example from a densely populated area is provided by the town of Schlema in the Ore Mountains in Germany, where after remediation, the Wismut legacy was successfully re-developed into a popular health spa.

In this sense, it must be remembered that returning mining and milling legacy sites and objects to productive use is an essential pre-requisite for regional re-vitalization. However, it is essential that in all cases, the “remediated” status and an inventory of the content of the remediated sites be carefully preserved in the long term.

Because of the considerable expansion of uranium mining and development of new mines in Kazakhstan and Uzbekistan, a proactive environmental approach is recommended for the currently producing mines and any future mines. This should be of particular interest to the producers because the new mines are likely to be of lower ore grade, and both economic and environmental issues will become even more challenging than in the past.

The recommended strategy under these conditions is the proactive minimization of mining and milling waste and the prevention of future damage at the stages of design, development and operation. This should include mining process modifications, improvements of processing and waste management practices, as well as considered decisions on the disposal sites.

4 Examples of the Radiological Impact on the Environment and Population in Kazakhstan

4.1 Consequences of surface and air nuclear tests

Significant contamination of a surface by the gamma-emitting radionuclides Cs-137, Eu-152, and Co-60 defines the dose of external irradiation.

The high concentration of these radionuclides at the site “Experimental ground” in Kazakhstan can produce the average radiation exposure dose rate of 26 µSv/h. In Kazakhstan, the natural background radiation is about 0.11–0.20 µSv/h. Civil engineering is not allowed at the sites with excess of this value by more than on 0.2 µSv/h. The exposure dose rate at the site "Balapan" can reach 6–10 µSv/h in some places.

Within the next 100 years, the gamma background will decrease by at least by a factor of 10 due to the decay of radionuclides, their downwards movement in the soil, and washout from the surface. Taking this into account, the surface of “Experimental ground” and other sites are closed for any activities.

Possibly, plutonium is a radionuclide that spread as a result of nuclear explosions and that was not investigated well enough. Without being a gamma emitter, it is getting into an organism by various ways, and is the most dangerous of all fission products.

When Pu-238 and Am-241 are captured by organism as a result of inhalation together with airborne dust, these elements are considered to be the most radiotoxic ones, except for the less widespread Ac-227 (from the U-235 decay chain). Taking into account the high ability of soils to form dust, the distribution of plutonium and americium over the testing ground surfaces should be given close attention, including the use of special sampling probes for soils. Although the maximum concentrations of these elements are related to the areas of surface explosions and to the wells of an emergency source of fission products ("Balapan"), significant concentrations of the isotopes have been revealed on practically all areas of the testing ground. Even outside of the testing ground, there are contaminated sites on which the individual annual exposure doses reach 0.36 mSv. When inspecting similar sites for radioactive effects, a study of radionuclides is conducted. Scientists from the Institute of Radiation Safety at the National Nuclear Center of Kazakhstan have given the characteristics of the formation and atmospheric transport of radioactive products from the wind-eroded soils on the contaminated territories, and have offered a simplified model of calculating the radiation risks for the Semipalatinsk Test Site.

It is obvious that by visiting these territories unauthorized or using the contaminated waters and soil, it is highly possible to get radiation exposure dose of more than 1 mSv/year. Therefore, it is necessary to continue the threat assessment of the surface contamination of the territory as a result of the ground and atmospheric tests, excavation explosions, the releases of the contaminated waters from the wells of “Degelen”, and massive and emergency emissions from the wells of "Balapan" site. The threat assessment should consist of:

1. an investigation of the plutonium and americium-241 distribution in soil and water flows;
2. an investigation of the migration processes of artificial radionuclides in surface water and, on this basis, draw up the forecast for the next 100 years;
3. an investigation of the territories allocated for economic activities; and
4. a radiological environmental impact assessment and an evaluation of the doses received by the population with access to these areas.

4.2 Testing grounds for nuclear explosions

In accordance with existing understanding, the migration of radionuclides from the underground explosion chambers to the environment can occur through natural water movement, without the direct influence of human activities. The drilling of wells, career, and industrial explosions should be absolutely avoided.

The speed and direction of mass transfer in a studied top layer of the earth crust basically depends on the following major factors:

- the presence of underground water (soil, crack, sheeted);
- the chemical composition of the water;
- the condition and type of bearing strata (cracking, porosity, sorption properties, etc.);
- rain in the fractured soil;
- grouping (or density of underground explosions on volume unit).

The period of time in which radionuclides may be released through water in the cracks, soil and surface and into the environment that is accessible to the population depends on the parameters mentioned above and the quantities and specific activities of radionuclides in the explosion chambers. The process of radioactive contamination of underground and surface water continues on the STS test areas, and according to the monitoring, it has a rather stable character. While now outside of the STS sites, the level of concentration of technogenic radionuclides in water reservoirs does not on average exceed the admissible values for potable water. The radiological investigation results of the samples taken from the environment in the areas adjoining the STS in 2005–2009 are presented in Table 14. The data on the disease incidence rates for first-time diagnosed malignant neoplasms in these areas for the same years is presented in Table 15 (the data is presented by the Sanitary Epidemiologic Station of Kazakhstan).

Table 14: The Results of Radiological Researches of the External Environment Tests (2005–2009)

##	Territory of Test Selection	Title of the Tests	Test Quantity	Research Results																					
				Ra-226 Bq/kg		Cs-137 Bq/kg		Sr-90 Bq/kg		Pb-210 Bq/kg		U-238 Bq/l		Th-232 Bq/l		Sum α active Bk/l		Sum β active Bq/l		K-40 Bq/kg		Rn-222 Bq/l		Aeff. Bq/kg	
				min	Max	Min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
2005																									
1	Abay District	Bread	3			0.33	0.35	0.52	1.18	0.09	0.13														
		Milk	1			0.54		0.81		0.1															
		Grain	1			3.3		2.1																	
		Vegetables	2			1.6		1.1																	
		Hay	1			0.5		2.9																	
		Soil	1	15.6										22.08						466.2					
		Water	2													0.018	0.22	0.007	0.03						
2	Beskargai District	Bread	4	0.07	0.09	0.54	1.6	0.42	0.8	0.16	0.19														
		Meat	2	0.05	0.07	0.25	0.3	0.052	0.26	0.12	0.14														
		Milk	3	0.07	0.09	0.28	3	0.14	0.28	0.1	0.12														
		Grain	1			0.77		0.34		0.26															
		Vegetables	5			2.9	3.1	1.2	1.6																
		Water	10													0.02	0.08	0.2	0.4						
		Soil	1	12.2										15.1						581					
		Hay	1			3		2.94																	
3	Borodulikhinskiy District	Bread	3	0.03	0.06	0.16	0.41	0.074	0.08	0.04	0.13														
		Meat	2	0.056	0.09	0.19	2.6	0.15	0.7	0.15	0.18														
		Milk	6	0.01	0.08	0.26	1.9	0.07	1.14	0.07	0.1														
		Grain	1			0.27		0.06																	
		Soil	4	11.1	23.1	4	4.5							27	120					588.5	695				
		Hay	1			3.3		2.5																	
		Water	7	0.1	0.15							0.05	0.24	0.08	0.15	0.06	0.09	0.11	0.17						

4	Kurchatov town	Bread	3			1.1	1.8	0.07	0.09																
		Meat	1			1.9		0.16																	
		Milk	2			0.06	0.22	0.09	0.2																
		Fish	1			0.11		0.2																	
		Grain	1			0.12		0.04																	
		Vegetables	5			0.9	3.1	1.6	1.9																
		Water	3													0.02	0.09	0.11	0.26						
		Building Materials	1	20.4										19.7						368.8				79	
5	Semey city	Bread	6			0.13	1.6	0.057	0.35	0.05	0.07														
		Meat	5			0.1	2.7	0.56	2.2	0.08	0.12														
		Milk	3			0.083	3.3	0.06	0.07	0.09	0.11														
		Non--alcoholic drinks	1			0.5		0.7																	
		Water	1	0.03								0.06		0.02		0.1									
2006																									
1	Abay District	Vegetables	5			2.2	3.6	0.7	3.2																
		Soil	1	11.2		3.8								21.7						497					
		Water	5													0.014	0.06	0.007	0.07						
2	Beskargai District	Bread	6			0.25	0.37	0.02	0.45	0.08	0.11														
		Meat	1			0.05		0.06		0.14															
		Grain	1			0.11		0.22																	
		Vegetables	5			0.06	2.2	0.012	3.1																
		Water	8													0.013	0.08	0.01	0.25						
		Soil	1	6.01		3.6								0.08						477.8					
		Hay	1			0.9		3.1																	
3	Borodulikhinskiy District	Bread	8			0.23	0.5	0.07	0.15	0.06	0.15														
		Meat	2			0.3	0.45	0.045	0.2	0.14	0.16														
		Milk	3			0.035	0.16	0.14	0.24	0.1	0.11														
		Vegetables	5			1.9	3.6	0.7	3.5																
		Soil	1	12.3		4.3								19.67						689					

		Water	3													0.007	0.02	0.016	0.03						
4	Kurchatov town	Bread	5			0.12	0.21	0.09	0.13	0.11	0.16														
		Vegetables	5			0.06	2.9	0.04	3.2																
		Water	3													0.007	0.02	0.03	0.06						
		Building Materials	1	11.7		3.2								0.06						394.3				45	
5	Semey city	Bread	16			0.04	0.3	0.08	0.25	0.07	0.1														
		Meat	1			0.15		0.04		0.085															
		Milk	8			0.05	0.1	0.067	0.12	0.11	0.14														
		Fish	1			0.15		0.01		0.1															
		Grain	1			0.2		0.18		0.1															
		Soil	1	10.6		3.6								0.05						540					
		Hay	1			6.3		4.8																	
		Water	6													0.006	0.02	0.02	0.06						
		Building Materials	4	5.5	6									0.9	1.3					315.9	606			48	95
	2007																								
1	Abay District	Bread	5			0.01	0.04	0.03	0.11	0.092	0.11														
		Meat	1			0.3		0.09		0.16															
		Vegetables	7			0.52	2.6	0.01	0.08	0.14	0.16														
		Soil	2	10.6	20.4	2.2	2.6							0.8	1.2					377	422				
2	Beskargai District	Bread	8			0.2	0.45	0.45	0.5	0.12	0.13														
		Meat	2			0.34	0.35	0.16	0.23	0.19	0.33														
		Milk	2			0.06	0.35	0.03	0.09	0.28	0.3														
		Grain	2			3.2	3.8	15.2	19.6																
		Vegetables	5			0.1	2.1	0.16	3.2																
		Water	31			0.01	0.07	0.017	0.07							0.02	0.09	0.1	0.34						
		Soil	3	8.3	8.7	3.2	4.5							6.2	7.5					528.3	625				
		Hay	2			9	31.2	2.6	2.9																
3	Borodulikhinskiy	Bread	10			0.08	0.5	0.3	0.45	0.08	0.12														

	District	Meat	1			0.2		0.04		0.06															
		Milk	2			0.26	0.29	0.04	0.09	0.09	0.1														
		Grain	1			3.1		2.6																	
		Vegetables	3			0.06	0.16	0.05	0.1	0.09	0.11														
		Soil	2	3.6	4.5	9.4	11.4							8.5	12.3					463.2	567				
		Vegetable oil	13			1.5	3																		
		Hay	1			3		1.6																	
		Water	21			1.2	1.8	0.22	0.35							0.008	0.02	0.06	0.1			12.4	24.1		
4	Kurchatov town	Bread	1			0.06		0.012																	
		Vegetables	5			0.03	0.12	0.06	0.13																
		Soil	1	10.7		3.6								10.4						699.9					
		Hay	2			10	14.4	1.5	3.5																
		Water	3			0.6	1.2									0.017	0.02	0.014	0.05						
		Building Materials	2	6.8	11.8									16.7	18					296.5	312			59	62
5	Semey city	Bread	16			0.25	0.27	0.03	0.14	0.08	0.09														
		Meat	5			0.15	0.3	0.04	0.11	0.11	0.15														
		Milk	5			0.14	0.23	0.08	0.12	0.1	0.14														
		Fish	1			0.14		0.3		0.16															
		Soil	2	6.25	13.6	3.6	4.5							1.6	20.9					461.5	621				
		Hay	2			19.8	21.2	2.9	3.2																
		Water	22	1.4	3.2											0.005	0.2	0.036	0.07						
		Building Materials	7	2.6	19.1									0.06	7.56					154.4	343			3	47
2008																									
1	Abay District	Bread	1			2.3		1.6																	
		Meat	2			0.18	1.6	0.21	4.4	0.12															
		Milk	1			1.7		1.3																	
		Vegetables	6			2.5	3.2	4.6	5.6																
		Soil	1	15.1		9.8								7						425					
		Coal	1	2.3										0.26						44.13				41.3	

		Water	7	7.5	16.4	1.5	2.3	0.015	0.09							0.013	0.06	0.027	0.1			6.6	19.8		
2	Beskargai District	Bread	4			0.11	0.5	0.07	0.14	0.08	0.11														
		Meat	1			0.3		0.17		0.15															
		Milk	1			0.14		0.15		0.19															
		Grain	1			0.43		0.18		0.15															
		Vegetables	5			1.9	2.4	2.3	3.3																
		Water	19			1.8	2.9	0.01	0.06							0.01	0.1	0.02	0.09			3.3	6.76		
		Soil	2	3.3	14.8	2.83	5.2							14.8	15.2					415.4	544				
		Vegetable oil	2																						
		Coal	1	1.2		3.8								3.1						6.5				51	62
		Sawdust	2			6.9	13.7	14.4	15.6																
		Hay	2			1.1	4.9	3.2	6.1																
		Building Materials	5	1.48	6.3	2.2	3.3							0.06	0.1					10.5	562			1	16
3	Borodulikhinskiy District	Bread	2			0.34	0.55	0.08	0.09	0.09	0.11														
		Meat	1			0.16		0.06		0.11															
		Milk	7			0.14	0.21	0.06	0.16	0.11	0.12														
		Grain	2			0.42	0.5	0.12	0.3	0.15	0.18														
		Vegetables	5			0.3	2.9	0.2	2.7	0.14	0.16														
		Soil	2	5.4	23.2	3	3.6							26.6	35.2					404	547				
		Hay	2			3.6	3.9	3.2	6.5																
		Water	13			1.8	4.2									0.01	0.05	0.013	0.12						
4	Kurchatov town	Bread	2			2.3	3.2	0.7	3.6																
		Vegetables	5			1.4	1.8	1.6	2																
		Soil	2	10.7	11	4.1	4.3							0.8	1.4					536.2	552				
		Coal	2	3.41	5.07	0.9	3.5							2.07	2.8					61.85	68			5	67.2
		Hay	3			2.5	3.8	3.3	3.8																
		Water	7			1.9	2.9	0.014	0.1							0.03	0.06	0.07	0.25			3.8	29		
		Building Materials	3	5.06	11.1	1.2	4.01							0.4	1.2					204.2	588			22	55
5	Semey city	Bread	6			3.82	4.7	2.6	3.3	0.09	0.12														

		Meat	4			2.2	5.6	1.8	3.2	0.08	0.12														
		Milk	22			0.16	0.33	0.11	0.13	0.11	0.13														
		Fish	2			0.32	4.9	0.09	0.15	0.08	0.11														
		Grain	1			0.44		0.22		0.09															
		Sawdust	2			5.8	6.7	8.8	9																
		Soil	2	4	10.5	6.4	6.6							0.2	0.6					373.1	392				
		Hay	1			4.9		6.1																	
		Vegetables	5			0.19	0.25	0.14	0.24	0.13	0.18														
		Water	14	5	14.9									0.4	1.6	0.02	0.08	0.012	0.02			11.8	48.4		
		Building Materials	11	13.3	29.6	0.05	3.05							3.7	14.5					12.66	509			26	65
2009																									
1	Abay District	Bread	3			0.3	3.2	0.5	0.7	0.13	0.15														
		Coal	1	3.8		1.4								0.8						39.2				47.2	
		Soil	1	20.2		4.5								17.3						441					
		Water	12	7.2	21.6	1.57	3.1	2.6								0.01	0.22	0.03	0.1			7.7	15.4		
		Building Materials	3	12.4	19.7	0.06	3.2							7.12	14.8					375.2	600			66	76
2	Beskargai District	Bread	4			0.21	0.28	0.15	0.41	0.11	0.13														
		Meat	1			0.19		0.11		0.14															
		Milk	2			1.6	3.2	0.7	2.3	0.12	0.14														
		Grain	1			0.2		0.16		0.17															
		Vegetable oil	2																						
		Vegetables	5			3.6	3.9	2.2	2.8																
		Coal	1	10.51		2.85								0.45						0.2				64.9	
		Sawdust	2			5.6	12.4	7.7	11.6																
		Hay	2			2.4	3.6	2.9	6.5																
		Soil	2	10.6	11.2	4.2	4.6							11.13	12.6					500.2	522				
		Water	20	5.2	11.3	2.9	4.9									0.01	0.09	0.01	0.14			2.4	26		
		Building Materials	4	1.1	5.21	1.06	1.49							25.4	29.2					435.2	680			64	98

3	Borodulikhinskiy District	Bread	8			0.27	3.2	0.4	0.7	0.13	0.14														
		Meat	3			3.2	3.9	0.7	3.2																
		Milk	2			0.35	0.38	0.3	0.8	0.14	0.15														
		Vegetable oil	7																						
		Grain	2			0.26	2.4	0.22	4.3	0.14	0.16														
		Vegetables	4			0.13	2.1	0.09	1.6	0.094	0.12														
		Coal	1	3.2		0.015								0.08						33.07				35.4	
		Hay	2			2.8	3	3.35	5.4																
		Soil	1	25.5		5.94								35						479.3					
		Water	7			1.89	2.02									0.01	0.1	0.03	0.09						
		Building Materials	6	3.2	40.5	0.015	2.1							0.05	36.4					317.5	506			7	112
4	Kurchatov town	Bread	1			0.16		0.3																	
		Milk	2			0.26	0.35	0.12	0.15																
		Vegetables	10			2.8	3.1	2.1	2.7																
		Soil	3	11.5	23.8	6.7	12.6							30.25	40.2					498	535				
		Coal	3	6.7	8.3	1.3								2.35						4.06	25.3			53.1	70.8
		Hay	3			3.4	13.4	3.8	9.5																
		Water	4													0.005	0.06	0.2	0.4						
		Building Materials	4	10.4	12.8									11.14	15.2					617.7	756			80	98.4
5	Semey city	Bread	5			0.29	1.8	0.23	0.9	0.09	0.11														
		Meat	3			0.21	0.27	0.13	0.14	0.13	0.15														
		Milk	7			0.19	1.66	0.16	0.18	0.1	0.12														
		Fish	2			0.17	0.43	0.18	0.27	0.11	0.17														
		Grain	3			0.24	0.76	0.22	2.5	0.11	0.13														
		Soil	2	16.7	18.9									16.5	25.4					520.5	672				
		Vegetable oil	3			3	4.2																		
		Coal	5	3.6	4.6	1.6	1.8							1.43	1.52					12	24			23.6	36.8
		Sawdust	1			19.1		22																	
		Hay	1			3.6		3.8																	

		Vegetables	10	1.7	4.42	0.43	0.55	0.23	0.33	0.1	0.12														
		Water	17	3.34	5.6	0.98	6.5	2.6	3.1							0.009	0.1	0.015	0.14						
		Building Materials	21	28.8	49.3	0.3	6.5							9.91	53.7					39.7	1200			41	211

Table 15: Incidence rates of newly diagnosed malignant neoplasms

Title of Populated Area	**2005**		**2006**		**2007**		**2008**		**2009**	
	Absolute Indicator	**Per 100,000 persons**	**Abso-lute Indica-tor**	**Per 100 thousand persons**	**Absolute Indicator**	**Per 100,000 persons**	**Absolute Indicator**	**Per 100,000 persons**	**Absolute Indicator**	**Per 100,000 persons**
Semey	756	249.8	815	265.2	812	263.6	732	235.7	841	267.5
Kurchatov	24	241.2	21	203.9	15	144.2	24	226.4	20	184.3
Abay district	29	177.4	20	125.0	32	200.6	39	246.1	27	171.4
Beskaragayskiy district	58	230.6	62	253.1	55	226.8	49	206.3	49	209.9
Borodulikhinskiy district	121	281.1	86	206.2	107	258.5	90	221.1	91	227.8
Eastern Kazakhstan oblast	**3976**	**275.9**	**3921**	**274.9**	**3792**	**266.5**	**3709**	**261.4**	**3751**	**264.3**

In accordance with the radiation safety standard NRB 99, the preliminary assessment of acceptability of the drinking water may be given based on the specific activity values of total alpha (A_α) and beta (A_β), emitters, which should not exceed 0.1 and 1.0 Bq/kg, respectively. As can be seen from Table 14, the concentration of alpha emitters in some of the water samples taken in the Borodulikhinsliy district reaches the level of intervention 0.1. Bq/kg, while in some samples from Abay district it exceeds the level of intervention. The levels of intervention for other radionuclides in drinking water are:

- Rn^{222}: 60 Bq/kg
- Ra^{226}: 0.5 Bq/kg
- Cs^{137}: 11.0 Bq/kg
- Sr^{90}: 5.0 Bq/kg
- Pb^{210}: 0.2 Bq/kg.

The data presented in Table 15 show that the disease incidence rate for malignant neoplasms among the population living in the neighborhood of the Semipalatinsk Test Site does not exceed the disease rate for the whole Eastern Kazakhstan oblast; neither does it reveal any tendency for an increased rate for the period of 2005–2009.

4.3 Radioactive wastes of uranium mining and processing

The wastes generated during this activity can be subdivided into two subcategories based on their conditions, volumes and influence on the environment:

- Wastes generated during explorations works, mining and processing of ores of endogenous uranium deposits;
- Wastes produced as a result of exploration works on a deposits layer of infiltration type within artesian basins.

4.3.1 Exploration, Mining and Processing of Uranium Ores

Wastes of primary cycles in the uranium mining industry (exploration of areas and mining by means of excavation) produce the main volume of the rocks lifted on a surface, including those relevant to the category of low-level radioactive wastes. During further enrichment of ores on the factories, tailing dumps are created, the mass and volumes of which are lower than that of primary cycles wastes. However, based on the level of their average activity, they are considered low-level wastes. Their total amount on the territory of Kazakhstan makes up about 217 million tons with the total activity of $9.29 \cdot 10^{15}$ Bq.

The most active wastes are concentrated in the tailings of mining and melting enterprises (Ulba Metallurgical Plant and Irtysh Chemical Factory).

The impact of these massive wastes on the environment and population was studied adequately and represents a threat in the case of radioactive contamination of soil and surface water used by the population.

Considering the very high half-life periods of the natural radionuclide's decay, this waste represents a threat to the population, especially in densely populated districts, within any foreseeable period of time, and the application of the most economically effective techniques of rehabilitation are required. Some measures to decrease the radiological risks are taken at practically all tailing storages of Kazakhstan, within the limits of the national budgetary programme No. 008 "Temporary Shutdown and Winding-up of the Former Uranium Mines, and Storage of Industrial Waste" and programme No. 011 "Management of Radiation Safety" confirmed by the Government of Kazakhstan.

As was already mentioned, by present time, the wastes from uranium mining and exploration, mainly heaps and dumps, have been rehabilitated under these programmes. The main radiological risks associated with these objects are related to using radioactive rocks for construction of industrial and inhabited buildings.

The settlement Akshatau in the Karaganda region can be used as an example of the rock materials being used in this way. When inspecting the settlement Akshatau, it was revealed that the majority of an old settlement, which had not been relocated to a safe area, was located in a territory with a rather high radiation exposure dose caused by the tungsten-molybdenum ore deposit, accompanied by uranium and thorium auras. The radiation exposure dose rate levels were within the range 0.3–0.8 µSv/h and up to 8 µSv/h in the water pipe trenches. The specific activity of radium reached 6,500 Bq/kg. The volume of the radioactive waste is 1,000 m^3 with a total alpha activity of 35 GBq. The radium activity exceeded the limit (200 Bq/m^3) in 9 of 13 surveyed buildings made from ore waste and achieved levels up to 23,000 Bq/m^3. A radon threat was revealed using track detectors in these buildings. The annual exposure dose in one of the contaminated dwellings was 220 mSv. People were removed from these buildings.

The radiological risks associated with the objects from uranium mining and processing were decreased by a factor of 10 as a result of nature conservation measures. However, the risks associated with excavations that have not been secured still remain due to the insufficient financing of the designated programmes. Excavations are caved in and craters appear on the surface (Figure 6), which become traps for animals and the population.

Rehabilitation measures undertaken in the highlands have not excluded a drainage of contaminated ground waters in surface waterways (for example, objects of Kurday and Panfilovsky).

It is evident that the wastes of uranium mining lead to irreversible environmental contamination, and measures should be taken to restrict their influence on the environment, while keeping in mind that these wastes can contain useful elements, amount of which could become conditioned one in the future their revaluation and conversion in anthropogenic mineral formations is possible.

Figure 14

4.3.2 Exploration and uranium mining by means of in-situ leaching technique

This type of radioactive waste has been formed in Kazakhstan since 1970 during exploration and operation works in the Chu-Sarysuyskaya and Syr-Darya uranium ore provinces. Considerable spots of soil contamination are formed during spontaneous water releases from artesian wells, which releases ground water with a high content of natural radionuclides.

These contamination spots are mainly caused by Ra-226 absorption in soils, up to 0.5 m in depth and sometimes deeper, and with a radium specific activity from several thousand Bq/kg up to hundreds of thousands of Bq/kg (the background concentration of Ra-226 in soils is within 20–50 Bq/kg).

In the Chu-Sarysujskiy province about 55 such spots were revealed within the contours associated with the ore bodies (at the depths from 100 to 600 m). Usually, they occupy a territory from hundreds to tens of thousands km^2, with an average radiation exposure dose rate of 1–4 µSv/h. The Ra-226 specific activity in the soils is from 10^3 Bq/kg to $1{\cdot}10^6$ Bq/kg. Figure 15 shows the contaminated sites within uranium ore province.

Table 16 shows the data on the average content of radionuclides, their types and the specific activities (Bq/kg) in the samples (in mg/kg of dry soil) based on the results of field work carried out on the highland territories of the deposits Kanzhugan, Northern Karamurun, Uvanas and Mynkuduk.

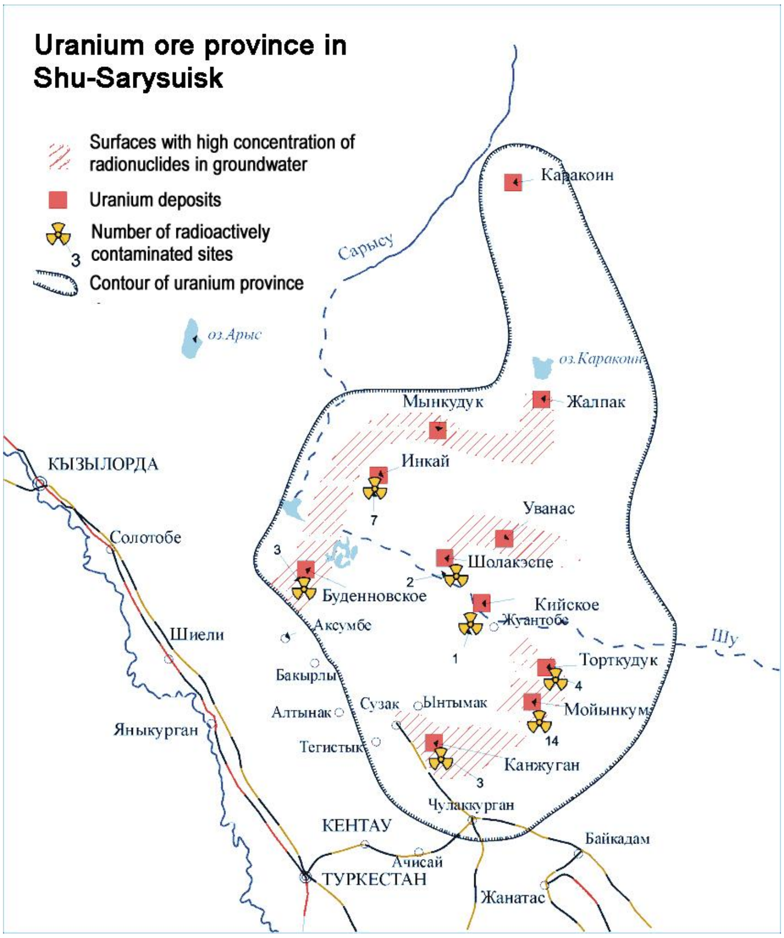
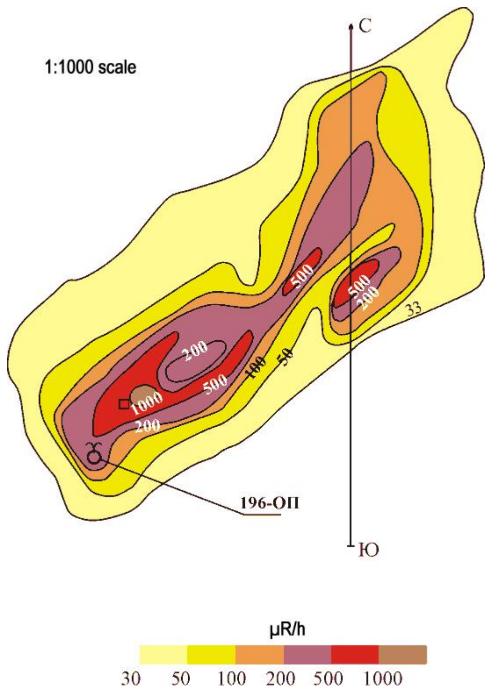


***Figure 15**. The map of the contaminated spots on the surface as a result of spontaneous release of ground water.*

Table 16. Data on the spots of radiation contamination in the deposits of Kanzhugan, Northern Karamurun, Uvanas and Mynkuduk in accordance with the results of field work and estimated values of the quantity of dust blown away from the surface of these spots

Model Number	**Plot Num ber**	**Area polluted, m²**	**weight ed average activity of radionuclides in the soil, Bq/kg**						**Quantity**
			U^{238}	**Th^{232}**	**Th^{230}**	**Ac^{227}**	**Ra^{226}**	**Pb^{210}**	**Dust blown away, g/s**
Kanzhugan Deposit									
1	1, 2	50000	104,36	65,0	-	-	1630,0	-	0,255
2	3,4	1540000	124,0	71,3	24,8	1,5	-	-	7,854
Northern Karamurun deposit									
3	1,2	1226000	237,5	107,4	321,6	13,5	25,4	59,8	6,2526
Uvanas deposit									
4	1,2	1596000	193,0	88,0	913,0	174,0	275,0	1798,0	8,1396
Mynkuduk deposit									
5	1,2	210650	278	101,0	1494,0	60,0	1132,0	2037,0	1,0743

A map of exposure doses and results of soil and ground water sampling on one of the spots of the Kanzhugan deposit are represented in Figure 16.



Radionuclide content in the water, Bq/l			
Ra-226	Rn-222	Pb-210	Po-210
8.0	1260	1.7	< 0.3

Concentration of radionuclides in the point of maximum activity:

Depths Interval, cm	U, mg/kg	Ra-226, Bq/kg
0–10	4	12,700
10–20	5	10,800
20–30	4	2680
30–40	4	52

Figure 16. A radioactive halo near artesian well 196-ОП (Kanzhugan Deposit).

For another deposit called "Zarechnoe" developed by a method of "in situ leaching", the experts of the Institute of Nuclear Physics of Kazakhstan carried out field and laboratory investigations for the purpose of determining the character of the distribution of natural radionuclides and toxic elements in objects of environment. Special attention has been given to the locations of self-releasing wells.

It was established that the exposure dose rate level is within the limits of natural background (0.12–0.18) μSv/h on the majority of the surveyed sites of the given deposit. At the same time, the concentration levels of natural radionuclides of the ^{238}U family in the samples taken from several control points significantly (in several times) exceeded the value of minimum significant activity (MSA – 10,000 Bq/kg).

The results of the radionuclide analysis of the water samples showed that the concentrations of natural radionuclides, in particular of the ^{238}U and ^{235}U families, in water wells Z-23, Z-24, Z-25 and especially Z-02 significantly exceeded the sanitary standard of "Level of Intervention" . The concentration of ^{226}Ra (5.9 Bq/l) in the filtered water taken from the well Z-02 exceeded the "Level of Intervention" (0.5 Bq/l) by more than 10 times. Based on the results of the element composition analysis, the content of Se (123 μg/l) in the water of the well Z-25 was more than 12 times higher than the sanitary normat for the maximum concentration limit for drinking water (10 μg/l). The highest concentrations of many elements (Ca, Sc, Fe, Co, Ni, As, Rb, Sr, Zr, Mo, Cs, Ba, Ce, Re, etc.) were found in water of well Z-02. On one hand, this feature confirms the role of this well as a contaminator. On other hand, the presence of high concentrations of many valuable elements (especially Re and Se) confirms the additional practical importance of a developed deposit.

Self-releases of water on all of these sites cause a threat to the population due to external irradiation, radon emanation from the surface, water consumption and cattle living on the territories near the artesian wells. The average annual individual exposure dose can reach 10 mSv/year. During 1997−2007, 122 artesian wells were liquidated under the programme "Liquidation and preservation of oil and self-releasing hydro-geological wells". As a result, the radiological risks have been considerably decreased due to the minimization of radioactive waters from the wells, and only 5 of the 55 sites of radioactive contamination represent a threat due to consumption of the cattle that has been feeding on these contaminated sites. Subsequently, it is necessary to rehabilitate the given sites and to organize radiation monitoring for the use of water resources in the given region.

4.4 Wastes of non-uranium ore mining and processing

Among the wastes of non-uranium ore mining and processing the greatest sources of contamination are oil field production sites, where natural radionuclides are extracted together with strata water and contaminate the territory.

In 1992−1996, radioecological research was carried out in the regions of oil field production sites on a total area of 2,870 km^2 in Western Kazakhstan, which revealed that on the territory of 22 major oil fields where oil production is now under way, there were 267 spots of radioactive surface contamination with the radiation dose rate varying from 100−17,000 μR/h. A map of these contaminated sites located within the oil field region of Kazakhstan is shown in Figure 17.

Figure 17. Map of radioactively contaminated spots in Kazakhstan's oil fields region.

By 1997, the radioecological situation is surveyed on only 49 of the 138 oil fields in areas of Western Kazakhstan, which is 35 % of the total number of deposits in the Republic. According to estimations, no less than 2,920,000 m^3 of radioactive soil and industrial wastes were accumulated on this contaminated area of 584.7 hectares.

The results of the survey research performed on the spots of oil production sites located near the 12 largest settlements are presented in Table 17 below.

Table 17. Results of the survey research performed on the spots of oil production sites located near the 12 largest settlements

N	Location	Area, m^2	Number of Radioactive Contamination Spots	Radiation exposure dose rate, μR/h		Contaminated Area, hectare / Soil volume, thousand m^3
				Natural background	maximum	
	JC«Mangystau Munay Gas»	1628	192	8-14	10300	110,2/220,5
1	Noviy Uzen town	348	54	8-14	3000	56,2/112,4
2	Zhetybay town	204	33	8-12	3420	34,8/69,6
3	Kalamkas settlement	200	101	8-10	10300	18,7/37,4
	JC «Embamunaygas»	880	39	8-11	17000	407,4/814,8
1	Makat town	50	2	8-12	250	9,2/18,4
2	Dossor town	40	2	11-13	2650	9,0/18,0
3	Komssomolskiy settlement	20	2	9-11	6700	18/36
4	Kokshar settlement	100	8	8-11	3000	89/178
5	Baychusan settlement	305	9	8-10	1200	135/270
	JC «Tengismunaygas»	362,1	36	8-10	950-6700	132,6/365,2
1	Kulsary town	46	6	8-10	5400	1/2
2	Koschagyp settlement	24	16	8-9	6700	3/6
3	Karaton settlement	42	6	8-10	400	60/120
4	Sarakamys settlement	78	2	8-9	950	4,8/9,6

The main bulk of radioactive contamination is associated with the discharges of water-oil emulsion on the evaporation fields in the lower parts of the landscape. The given type of contamination is represented by sites with oiled soil, oil slime and radioactive solutions of formation waters, produced as a result of their discharge when drilling wells, implementation of scheduled preventive maintenance of the equipment, and emergency situations related to the systems of technological pipelines, including oil pipelines and water pump collectors.

Taking into account the permeability of the soil presented by sand fractions, its impregnation by water-oil emulsion is observed up to depth of 0.5−1 m, where the radiation exposure dose rate was found to reach values of up to 200−300 μR/h.

Abnormal sites of oiled ground cover an area of up to tens of thousands of square meters, having a radiation exposure dose rate ranging from 30−100 μR/h, with natural background radiation of 8−11 μR/h. The soil of brown color is often covered by a film of dry oil.

On the sites where large volumes or repeated discharges took place, the average level of radioactive contamination was 250−600 μR/h of gamma irradiation, on areas of tens and hundreds of square meters, with local maximum values up to 1,000−2,800 μR/h.

Radioactive contamination of the given type, with a considerable area of soil contamination, were mainly revealed on the oil fields of the final and middle stages of development where repeated discharges of formation waters took place. The most hazardous industrial wastes are the accumulated volumes of oil slime, rusts, salts and their sediments on internal surfaces of the industrial equipment. This type of waste is represented in 31 radioactively contaminated sites, which make up 11 % of all registered ones.

During the investigation of formation waters (the oil field Zhetybay, 1991), it was shown that when heating formation water up to 40−60 degrees, a kind of oil slime of dark brown colour precipitates, which is absorbing the natural radioactive elements.

Oil slime is precipitated on the internal surfaces of pump compressor pipes, the bottoms and walls of discharge tanks, reservoirs, measuring installations, oil pipelines, water pressure head collectors, furnaces for heating oil and other equipment. Salts, rust, and cinder are precipitated in the same places. Salts constitute a mixture of sulphates of calcium, barium, radium, thorium, and potassium.

Spots contaminated with oil slime and salts on the ground surface often represent local areas from 1 to 100 m^2, where the dose rate varies from 300 to 5,000–6,000 μR/h.

Accumulations of radioactive oil slime and other sorbents – salts, rust, and cinder – are formed in the process of cleaning, repairing and dismantling the industrial equipment. Accumulations of spent filters for back-pumping formation waters represent sand fractions immobilized in oil slime with dose rate of 5,000 μR/h are localized on the places of drilling and have the rough sizes of 10×20 m.

Parameters of environmental contamination by radionuclides are presented in Table 18.

Table 18. Parameters of Environmental Contamination by Radionuclides

No.	Material content and depth of sampling	Sample activity in Bq/kg		
		Alpha emission	Ra-226	Th-232
1	**JC «Mangystaumunaygas»** Noviy Uzen, industrial waste dump			
	Oil slime	Not defined	1807	57
	Metal wastes (slime, cinder, salts)	Not defined	7265	61
2	**JC «Embamunaygas»** Dossor oil and gas region Black oiled soil on the fields of evaporation of cavities, Including on the depth of:			
	0-25 cm	31,820-161,320	1665-139,601	420-10,388
	25-50 cm	1406-4490	18.5-925	112
	Oil slime, salts, dross	235,925	10130	9199
	Spent filters for reverse pumping of formation waters	338,873	41,679	3017

3	**JC «Tengizmunaygas»** Kulsarinskiy oil and gas region Black oiled soil on the fields of evaporation of cavities, Including on the depth of: 0-10 cm 10-25 cm 25-50 cm Oil slime, salts, dross Spent filters Metal waste (slime)	 37,000-53,280 Not defined Not defined 87000 672,000 758,000	 6105-52,910 11,700 6140 13,800 131,000 138,000	 392-2464 120 35 1980 9900 113,000
	Oil and gas region Seaside rise «Prorva» fields of evaporation of cavities, Including on the depth of: 0-10 cm 10-25 cm 25-50 cm	 22,500-62,400 Not defined Not defined	 2540-14,700 105 450	 670-4800 34 70

Several settlements located in the Mangistauskiy and Atyrauskiy regions that have radioactive contamination caused by oil and gas fields are shown in Figures 18−23.

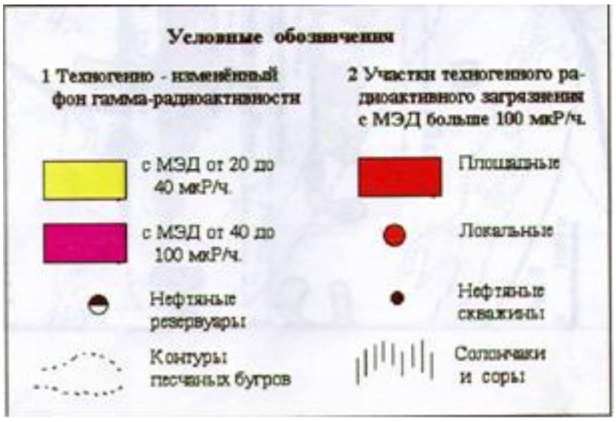


Figure 18*. Symbols to the figures ##11-15 where settlements located in the Mangistauskiy and Atyrauskiy regions and having radioactive contamination caused by oil and gas fields*

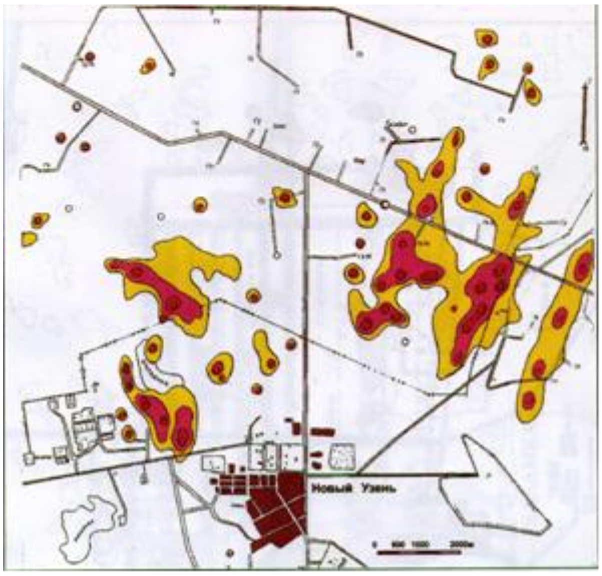


Figure 19*. Spots of radioactive contamination at the Noviy Uzen settlement*

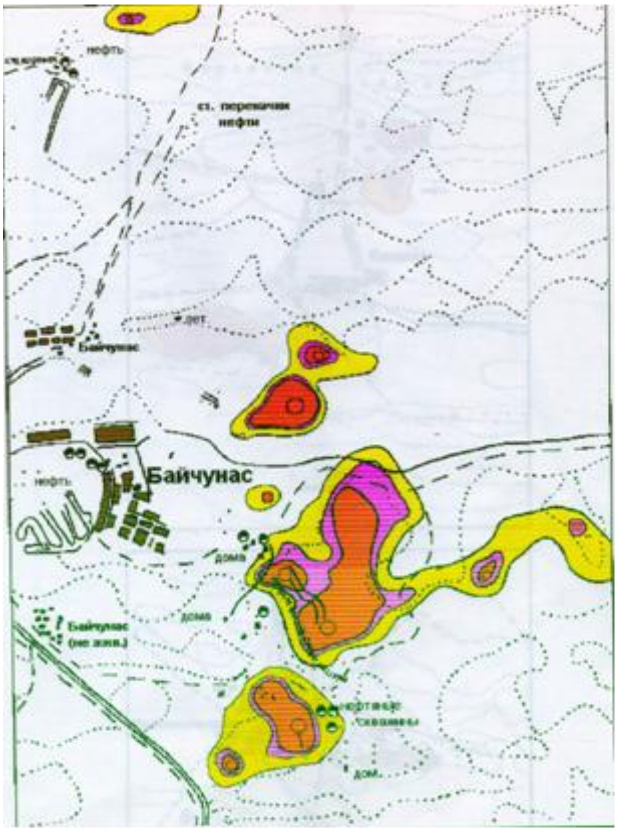


Figure 20. *Spots of radioactive contamination at the Baychunes settlement*

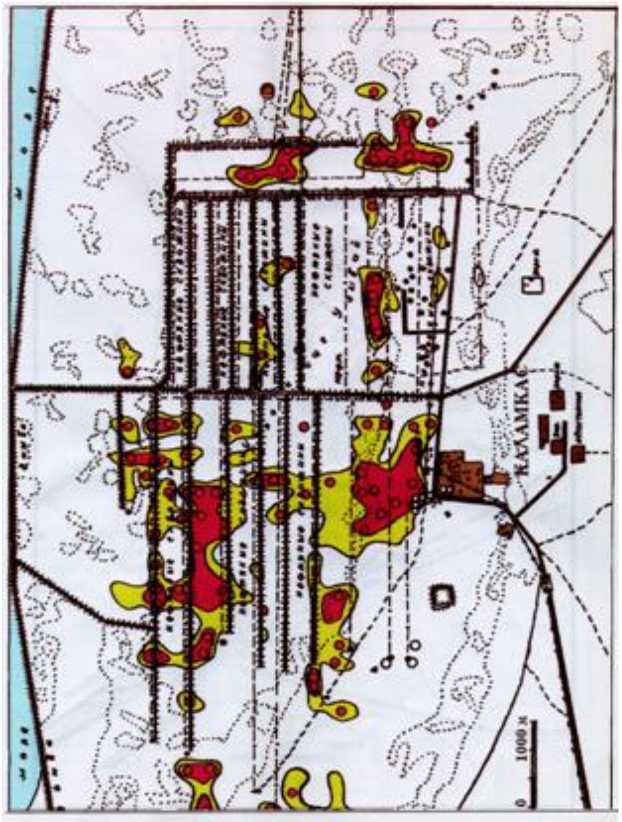


Figure 21. *Spots of radioactive contamination at the Kalamkas settlement*

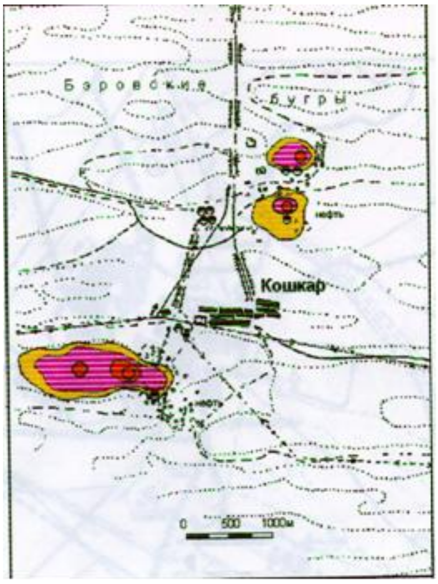


Figure 22. *Spots of radioactive contamination at the Koskar settlement*

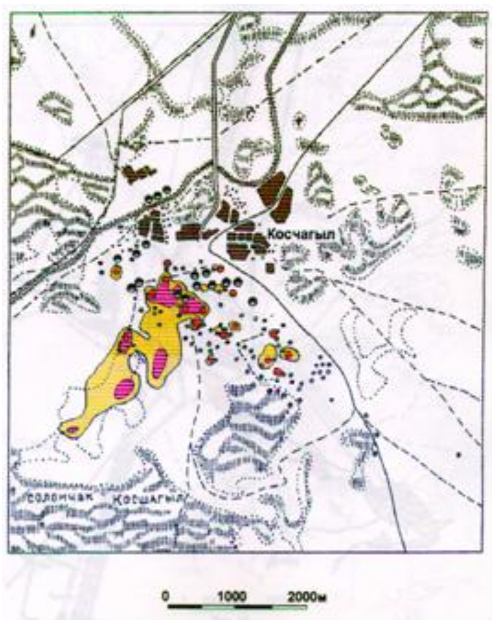


Figure 23. *Spots of radioactive contamination at settlement Koschagyl*

It is necessary to note that the data presented in this section were obtained 10−15 years ago because research has not been performed afterwards. However, taking into account the fact that any serious actions for rehabilitation of the contaminated territories has not been conducted, it is likely to assume that the ecological situation on these territories has not been significantly improved, and that on the contrary, it could have been aggravated as a result of the intensive continuation of works on oil and gas production.

Caused by these sites' radiological risks for the population are connected basically with a possibility of using stored contaminated pipes and the equipment. The contaminated soils are often salted and black-oiled, there is a poor vegetation on them that reduces radiation risks for the local population, related to the cattle

In addition to the issues related to oil production, the mining and processing of rare metals and coal create dumps with the radioactive elements that reach the level of low-activity waste. At the present time, much attention is given to such objects. But radiation control is required to be performed by regulatory authorities to control implementation of license conditions for these enterprises.

Regulatory actions and measures should be taken to avoid the repetition of this situation after the design and operational phases.

4.5 Waste from isotope production

The potential overexposure of the population to sources of ionizing radiation used in the industry, medicine, scientific research, and also in education (both technical laboratories and offices in schools, and technical schools of higher education) arises only in the case of their loss or uncontrolled use. In order to prevent such incidents, constant state regulatory control and radiation monitoring are necessary.

5 The Analysis of Threats from a Regulatory Perspective

5.1 Existing problems

The legacy problems left behind by uranium mining and milling in Central Asia are not very different. The most important constraints to the development and implementation of efficient regulatory control, monitoring systems, and the planning and implementation of remediation plans, can be summarized as follows:

1. **Inadequate regulatory and legislative framework for the safe management of radioactive waste.**

   It is clear that in order to eliminate the existing threats, it is necessary to manage (including the disposal of) radioactive wastes accumulated/generated in Central Asia, taking into account international safety recommendations. However, it seems rather problematic to achieve this task in the near future as only some basic elements of the National Policy and Strategy for Radioactive Waste Management are in place in the republics. The national strategies for RW management need to be developed in accordance with the IAEA recommendations and based on the experience of other western countries. In addition, the mechanisms for the long-term financial and human resources support of the works and the safe management of radioactive wastes are not established yet. Existing regulatory documents do not address the issues regarding implementation of long-term institutional control and monitoring of the abandoned dumps with radioactive wastes, as well as the future RW disposal facilities both during operation and after their closure. There is also a lack of safety requirements for different types of disposal facilities in accordance with the different categories of radioactive waste. Safety criteria and clearance levels are not established or need to be reviewed.

2. **Costs of remediation and limited availability of national funding.**

No funds been set aside for mine closure and remediation in any of the Central Asian countries. Except for Kazakhstan, none of these countries have a systematic national programme for remediation of the legacy sites. Considering that the Gross National Products in Kyrgyzstan and Tajikistan are considerably lower than in Kazakhstan, it is considerably more difficult for these governments to dedicate adequate funds for this purpose without an incentive. A combined national/international financing programme would be a feasible approach in these cases. At the same time, there is no funding mechanism at the governmental level nor any requirements for the licensee or the operator to create such a funding mechanism after the beginning of the operational phase.

3. **Regulatory Development Issues**

On the question of which regulatory documents are insufficient for performing the planning and remedial activities according to the international recommendations in the nearest future, it is possible to consider three basic aspects:

First, it is not clear which territories it is necessary to rehabilitate and which territories it is necessary to start this work in. This is connected with the fact that no accurate quantitative criteria defining reference levels to begin territory rehabilitation have been established. So, for example, in cases when the individual annual dose that can be received on a territory is less than 10mSv, there is no basis for intervention, while if an individual annual dose is more than 100 mSv, intervention is always justified. The IAEA recommends in the WS-R-3, paragragh 3.2, an existing annual effective dose limit of 10 mSv from all sources, including natural background radiation. This will normally be assessed as the mean dose for an appropriately defined critical group. Remedial measures would often be justified below the generic reference level, and national authorities may define a lower reference level for identifying areas that might need remediation. The new draft Basic Safety Standards, paragraphs 5.7−5.9, establishes that

> "The government and the regulatory body or other relevant authority shall ensure that the strategy for the control of existing exposure situations established is commensurate with the risks associated with the existing exposure situation and that remedial or protective actions yield sufficient benefit to outweigh the detriments associated with taking them, including detriments in the form of radiation risks. The implementation of remedial actions (remediation) does not imply the elimination of all radioactivity or all traces of radioactive material. The optimization process may lead to an extensive remediation but not necessarily to the restoration of pre-existing conditions. The regulatory body or other relevant authority and other parties responsible for remedial or protective actions shall ensure that the form, scale and duration of such actions are optimized. While this optimization process is aimed at providing optimized protection of all exposed individuals, priority shall be given to those groups of individuals whose residual dose exceeds the reference level and all reasonable steps shall be taken to avoid doses remaining above the reference levels. Reference levels shall typically be expressed as an annual effective dose to the representative person in the range 1–20 mSv or other equivalent quantity, the actual value depending on the feasibility of controlling the situation and past experience in managing similar situations. The regulatory body or other relevant authority shall periodically review the reference levels to ensure that they remain appropriate in the light of prevailing circumstances".

In Kazakhstan, the territories with a rather safe ecological situation are the territories where the annual values of individual effective radiation exposure doses due to man-caused sources do not exceed 1 mSv, while individual dozes caused by natural sources do not exceed 30 mSv.

Second, it is not quite clear how to rehabilitate the territories that are contaminated by radionuclides because the regulatory requirements for rehabilitation and clearance of such territories are absent. The radiation-hygienic criteria and norms for a territory on which there was radioactive waste for the period after its rehabilitation, are not defined in a quantitative expression. Requirements for monitoring in the phase of institutional control are not established. There are no criteria for clearance or release of the territory from regulatory control. In the western countries, regulatory documents define radiation-hygienic criteria and norms in a quantitative expression for the rehabilitated territory, depending on the special-purpose designation of its use.

Third, it is not quite clear how to convert the radioactive wastes that have already accumulated, that are currently being generated, and those that will be produced in the future, seeing as they have various chemical and physical states as well as radionuclide composition in a condition suitable for their disposal. On the basis of which criteria should RW disposal sites be excluded from the institutional control? What is the scope of the long-term institutional control and monitoring for the future disposal sites, both during their operation and after their closure? These questions could only be answered by performing a safety assessment, but the requirements for performing such an assessment and its use for affecting remedial and postclosure solutions is still not present in the regulatory framework in these countries.

4. **Inadequate knowledge of the inventory of the legacy components and the risks associated with them.**

Except for in some obvious cases, such as Mailuu Suu and similar sites, sufficiently reliable data for assessment of the "realistic" risks presented by the legacy sites presently does not exist. A reliable database is paramount for the justification and prioritization of the remediation, especially in the case of some less obvious sites. The preparation of effective and efficient remedial plans requires additional data to that which is available for most of the legacy sites today.

5. **Very varied public and social attitudes toward the legacy sites.**

The health and environmental risks presented by the legacy sites are perceived very differently by the various stakeholders.

- The local populations near the legacy sites are often too careless regarding health hazards.
- Concerned groups working on the site are too narrowly focused on the subtle details of the impact of the legacy sites, which are incomprehensible to the local population.
- Examples from Taboshar, Tajikistan: Complacency of the local people used to the uranium mining and milling objects. Below a large tailings pile at the top of a valley, directly on the stream that carries the periodic seepages from the pile, a small farm is operating. A local shepherd sees no problems in grazing his animals directly on the tailings and waste rock piles overgrown with grass. Materials from the tailings ponds are used for construction purposes by the local population.
- Non-pragmatic activities of concerned groups at the site.
- At the same site, concerned environmentalist groups are carrying out studies of genetic changes in the fauna and flora at the site.

To deal with situations like these requires considerable work with all stakeholders and an extensive information campaign targeting the local population.

6. **Inadequate legislative and regulatory framework for the operation, closure and environmental remediation of mines.**

Since the Central Asian countries became independent, there has not been an adequate technological and regulatory framework and infrastructure in place. The regulatory requirements to assess, authorize, inspect (monitor) and, if justified, remediate the legacy sites, must come from a consistent set of legal health and environmental protection requirements and from the mining law. A set of legal acts, decrees and regulations that govern the remediation are in place and are being applied in Kazakhstan. An understanding of the complexity of the remediation issues, prompted by the case of Mailuu-Suu, is developing in Kyrgyzstan.

In the present situation, the regulatory procedure does not request safety assessments and radiological environmental impact assessments in a sense as practiced in the classical uranium mining countries, not even for situations of considerable potential hazard. A consistent set of practical regulations based on an environmental and risk and safety assessment approach is highly recommended for adoption in the Central Asian countries. This should include the use of the relevant international standards and guidelines. This could, ultimately, also facilitate the availability of international funding.

It is also necessary to mention that, as was recognized in the Threat Assessments, the regulatory control and enforcement is in place for ongoing practices (uranium and non-uranium mining and milling) is weak, giving rise to large uncontrolled contaminated areas. The introduction of good regulatory procedures and constructive interaction with the remediation proponent (operator) could be facilitated by the involvement of experienced external experts.

7. **Lack of personnel with uranium mining and milling experience or knowledge of remedial works.**

This problem concerns all levels, including the government administration that provides the funding, the regulators checking and approving the permit requests, and the operators implementing the remedial works. The personnel responsible for raising international funds and co-operating with the funding agencies, steering the national remediation programme, organizing the projects and controlling the implementation, would need training on the job, supported by experienced international experts.

8. **Shortage of state-of-the-art equipment and machines.**

In addition to the tools needed for data collection, evaluation and interpretation, which will be dealt with in the section on monitoring, there is a lack of state-of-the-art machinery used in mining and remediation. There is little suitable computer software, no GIS or plotters available for preparing remediation plans, no laser scanning surveying instruments to support remediation work, and no proper drilling rigs and sampling devices for investigation of the sites. A particular problem is going to be the lack of machines (e.g. bulldozers and scrapers) capable of working on steep slopes, e.g. for building of covers. No large size (100+ ton) haulage trucks are available for relocating waste rock or tailings. The available machinery is old and small in size (often dating back to the 1980s), which does not allow for efficient implementation according to international standards. Unless large-scale investments in machinery can be made, the remediation plans must consider the slower working pace and the international funding agencies must be made aware, and take account, of this.

Beyond facilitating the use of internationally relevant and acceptable considerations, the sharing of experience, knowledge, information and good practice between countries will help the newly independent Central Asian countries deal with the legacy left from uranium mining and milling. The overall aim of a further stage of co-operation is also to facilitate co-operation among the participating project partners and help them in developing sound environmental and social legislation and regulations, thus clearing the way for the sustainable development of the uranium mining regions in the future.

9. **Cross-border regional problems related to the former uranium facilities in Central Asian Countries**

The cross-border issues of monitoring and remediation of the former uranium facilities in the region are rather sensitive because the most of the former uranium facilities are located near the borders of the adjacent states. The water pathways are the main factor of the cross-border aspects of the problem.

The Syr-Daria River is the main artery of potential contaminant transfer, as the watershed spreads from Kyrgyzstan and flows through the Fergana Valley, where a significant number of uranium residue and tailings piles are situated. Consequently, the integrated monitoring of water contamination with radionuclides and chemical elements is an issue of international significance due to the possible impact of the former uranium facilities.

6 Conclusions and Recommendations

From the perspective of the current knowledge of the state of affairs, it appears necessary to first obtain a consistent and reliable assessment of the legacy sites and components, which should include:

- The characterization of the inventory of both radioactive and non-radioactive contaminants.
- The effluent and influent streams from the disposal sites and the emissions to the air.
- Information on the geotechnical stability of the sites, erosion, stability of the current containment barriers, if any, and the design details of the containment barriers.
- A safety assessment and an environmental impact assessment.
- To develop the understanding of a site, an appropriate monitoring and surveillance plan must be set up, including specifications of where to sample, how to sample, and how many samples must be taken, etc. The use of the recently acquired instruments and equipment should be incorporated into these plans.

The decisions regarding in-situ stabilization or relocation of residues such as tailings should be based on the results obtained on the basis of the new data.

As for filling all of the gaps in the regulatory and legislative framework in the Central Asian countries, the following safety requirements or actions need to be developed and implemented:

- To elaborate the draft national policy and strategy for radioactive waste management to be approved and implemented by the Government.
- Review, update and elaborate the needed legal and regulatory framework for the safe management of existing exposure situations and radioactive waste. This includes the regulatory basis for the licensing of future disposal facilities, including the elaboration of safety assessments, safety cases and environmental impact assessments.
- Review, update and elaborate the needed legal and regulatory framework (including authorization, inspection and enforcement) for the safe management of radioactive waste and radioactive waste management facilities, including those linked with the production of NORM waste.
- Clearly define how the responsible organizations will realize the national policy for radioactive waste management with use of the available technical measures and financial resources.
- To define how and when the identified objectives and tasks will be achieved.
- To define what level of competence is necessary in order to achieve these tasks, and how it will be provided.
- To develop the management pathways for each type of radioactive waste, through all stages of the RW life cycle (from the moment of generation to disposal), as part of the national strategy for radioactive waste;
- To strengthen trust of the public concerning radioactive waste management and remedial action.
- The establishment of mechanisms for providing resources and funding for the safe decommissioning, remedial actions and long-term RW management.

- The availability of sufficient and qualified human resources to perform the rehabilitation activities and safe management of radioactive wastes, including resources for training and R&D, where needed.
- Implementation of monitoring of the radioactive waste storage facilities and disposal sites both during their operation and after their closure (including institutional control where needed).
- To perform the safety assessment and radiological impact assessment for the contaminated territories and to take the needed measures to diminish the risks in accordance with the results of this assessment.
- To carry out long-term monitoring and control over the abandoned objects of the uranium industry, and to take the necessary security measures to prevent unauthorized access on the contaminated territories.
- To carry out long-term monitoring and control over nuclear test sites and to take security measures where it is necessary to prevent unauthorized access on the contaminated territories.
- To carry out long-term monitoring and regulatory control over the sites of gas and oil production that have contaminated soils and storage places for the contaminated pipes and the equipment, and also to take the security measures where necessary to prevent unauthorized access on the contaminated areas.
- To implement an effective authorization and inspection process for new mining and milling industries, as well as for other industries (e.g. gas and oil) that produce radioactive materials with NORM, in order to avoid creating exposure situations similar to those existing today.
- To develop safety requirements for the design and implementation of radiation monitoring of the territories contaminated with natural and artificial radionuclides.
- Development and implementation of projects concerning final disposal or secondary processing radioactive materials.
- Development and implementation of the needed projects concerning restoration.
- To establish the quantitative criteria defining the "reference levels" and to consider that the rehabilitation of the sites will be strongly dependent on the established safety criteria (reference levels) and the existing exposure situation.
- To develop criteria and hygienic specifications on the rehabilitation of territories contaminated by radionuclides. This could provide socially comprehensible guarantees of radiation safety for the population being on the territories with radioactive contamination.
- To develop regulatory documents for maintaining the radiation safety of the personnel and the population during the subsequent use of the territory, buildings and constructions after rehabilitation. A guidance should be developed for the derived levels of residual contamination of territory with radioactive substances for several most probable options of their use after rehabilitation, for example, territories of unlimited use; territories of limited use for the industrial needs with using radioactive materials; territories of limited use for industrial needs without using radioactive materials.
- To develop derived reference levels for the radiation parameters that can be directly measured when implementing radiation control.
- To develop classification of radioactive waste in accordance with the recently approved IAEA international recommendations in this regards.
- To develop and approve safety requirements (regulations) for the design, siting, construction, operation, closure and establishment of institutional control needed for disposal facilities in accordance with the approved national policy and

strategy on radioactive waste management.

- To authorize projects concerning secondary processing of the uranium tailings impoundments with the purpose to extract uranium.

In case of secondary processing of the uranium tailings impoundments and extraction of uranium or other minerals from mine waters, it is necessary to implement and enforce an authorization process that will require the potential investors to be responsible for the implementation of the projects concerning restoration at every tailings impoundment involved. This process should include:

- Performance of a safety assessment and Radiological Impact Assessment;
- Rehabilitation and secondary processing of the uranium tailings impoundments.
- Final disposal and rehabilitation of the off-balance ores and extraction of uranium from mine waters.
- Final disposal and rehabilitation or secondary processing of the uranium tailings impoundments.
- Final disposal and rehabilitation or dislocation of secondary processing of the uranium tailings impoundments.
- Organization of permanent radiation monitoring at existing tailings impoundments.

The present project will try to prioritize these regulatory documents, which should be developed to eliminate existing gaps in the regulatory basis, based on an assessment of what possible future influence the absence of these documents might have on the population.

It is also clear that in order to remove the threats associated with the presence of radioactive wastes, both that which has already been accumulated as a result of previous activity and that which is currently being generated in significant amounts and which could be produced in the future, it is necessary to develop at least the following documents:

1. a national policy and strategy for radioactive waste management;

2. a new classification of radioactive waste, including identification of the corresponding categories;

3. safety requirements on the design, siting, construction, operation, closure and establishment of institutional control needed for disposal facilities in accordance with the approved national policy and strategy on radioactive waste management;

4. safety requirements for the management of radioactive waste.

It is clear that in order to remove the threats associated with the presence of extensive territories contaminated by radionuclides, their rehabilitation is required and, accordingly, it is necessary to develop a legal and regulatory framework defining:

1. Responsibilities of the Government, the licensees (operators) and other interested parties in existing exposure situations;
2. Justification and optimization of protective actions in existing exposure situations, including safety-related criteria such as “reference levels” and derived quatities to be directly measured;
3. Institutions or organizations to be responsible for the remedial actions in areas with residual radioactive materials;
4. Criteria and hygienic specifications on the rehabilitation of contaminated territories with radioactive materials; and
5. Regulatory framework preventing the occurrence of similar situations in the future.

Taking into account further:

First, that the level of the threats associated with the presence of extensive territories that have already been contaminated with radionuclides could be considerably reduced and remain at acceptable level within a reasonable period of time if the following actions would be taken:

- Establishing a strong and effective legal and regulatory framework, including the proper enforcement actions to guarantee the safe management of remedial actions and radioactive waste management, and at the same time providing the assurance that similar situations will not repeated.
- Carrying out the safety assessment and radiological impact assessment for the contaminated territories and, in accordance with the results of these assessments, to take the needed measures to diminish the risks.
- Carrying out institutional control, including the long-term monitoring and control over the abandoned objects of the uranium industry where it is necessary to prevent unjustified exposure of the public.
- Carrying out institutional control, including the long-term monitoring and control over nuclear test sites (in Kazakhstan) where it is necessary to prevent unjustified exposure of the public.
- Carrying out monitoring and regulatory control over the places of gas and oil production that have contaminated soils and storage places for the contaminated pipes and the equipment, and also taking the proper security measures where it is necessary to prevent unauthorized access to the contaminated areas.

Second, the elaboration and implementation of a national policy and strategy for radioactive waste management is of high priority considering:

a) the level of the threats connected with the presence of radioactive wastes increases continuously, due to their increased volume in view of the incessant operation of uranium mining, oil and gas production and other industries

b) the increased amount of radioactive waste that will be produced in the future if existing plans to build new nuclear power plants (e.g. in Kazakhstan) are realized, and keeping in mind the operation of nuclear installations that already exist

c) there are no defined end points for the management of the radioactive wastes that already exist, nor those which could be produced in the future

The factor strengthening this conclusion is that the republics have signed and recently ratified "The Joint Convention on the Safe Management of Spent Nuclear Fuel and the Safe Management of Radioactive Waste", IAEA INF/CIRC 546, (1997). This means that the radioactive waste management in the republics without a developed national policy and strategy can be considered by the international community as non-fulfillment of the international obligations that the republics have adopted.

The conclusions made above are extensive to all of the Central Asian countries (Kazakhstan, Kyrgyzstan and Tajikistan). The regulatory framework of these countries reviewed in the above section has shown that the normative-regulatory base in the field of waste management for former uranium production has not been fully completed yet, and it requires improvement and harmonization with the IAEA Safety Standards. In particular, the countries still lack the norms and recommendations on how to provide safe management and rehabilitation. In some cases, the enterprises cannot make a decision on the expediency of secondary processing of the uranium production waste and to provide it for a lack of practice and adequate mechanisms for how to perform such work within the current legislation.

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8 List of Abbreviations and Acronyms

AEC	Atomic Energy Committee (Kazakhstan)
CAIE	Central Asian Institute of Applied Researches of the Earth (Kyrgyzstan)
CLE	Chu Laboratory of Ecology (Kyrgyzstan)
DoE	Department of Energy (U.S.)
DSRS	Disused sealed radiation sources
DSSES	Department of the State Sanitary and Epidemiological Supervision (Kyrgyzstan)
EIRS	Encapsulated ionizing radiation source
IAEA	International Atomic Energy Agency
ICMP	Irtysh Chemical and Metallurgical Plant (Kazakhstan)
ICRP	International Commission on Radiological Protection
ISTC	International Science and Technology Centre, Moscow
JSC “KOMC”	Joint Stock Company “Kara Balta Ore Mining Combine” (Kyrgyzstan)
LLNL	Lawrence Livermore National Laboratory (U.S.)
LRW	Liquid radioactive waste
MES	Ministry of Emergency Situations
MPEMR	Ministry of Power Engineering and Mineral Resources (Kazakhstan)
NORM	Naturally occurring radioactive material
NPI NNC	Nuclear Physics Institute of National Nuclear Center (Kazakhstan)
OSCE	Organization for Security and Co-operation in Europe
POM	Poor ores mill
RW	Radioactive waste
SAEP&FM	State Agency for the Environmental Protection and Forest Management (Kyrgyzstan)
SE	State Enterprise
SNF	Spent nuclear fuel
SSR	Soviet Socialistic Republic
STG	Semipalatinsk Testing Ground (Kazakhstan)
USSR	Union of the Soviet Socialistic Republics

Statens strålevern
Norwegian Radiation Protection Authority

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Virksomhetsplan 2011

StrålevernRapport 2011:2
Måling av naturlig ultrafiolett stråling i Norge

StrålevernRapport 2011:3
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