General Concept for Management of the Nuclear Legacy Waste in the North-West Region of Russia

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Summary

This paper describes the main sources of radioactive waste in the North-West Region of Russia as well as the sites having large RW quantities and standing in need of environmental remediation.

Consideration is given to the current problems of RW management and remediation of the potentially hazardous sites in the region.

Information is provided on the estimated quantities of waste accumulated to date and expected in the future as well as on the RW classification made in regard to different parameters.

The final goals of RW management in the North-West Region are defined and the ways of handling this waste are determined, with the main process stages, their sequence and interrelation described and presented in diagrams.

The main RW characteristics are determined with regard to meeting the criteria of conditioned waste acceptability for storage and disposal.

Analysis of the above problem resulted in shaping of the strategic and conceptual approaches to radwaste management in the North-West of Russia, which are pivoted upon the planned construction of a regional centre for RW conditioning and long-term storage.

The key points of this approach are: centralised handling of SRW at the regional centre for waste conditioning and long-term storage, with only initial waste sorting and packaging done locally, and treatment of liquid radwaste on the sites of its generation with the use of modular facilities.

The paper discusses the principal advantages of this approach and the initial arrangements essential to the concept implementation.

1. Introduction

The North-West of Russia is known to have many potential sources of radioactive waste as well as sites in need of environmental remediation. These are naval bases, shipyards, the RW storage site “Saida”, and the temporary SNF and RW storage sites at Andreev bay and Gremikha, which were handed over by the Ministry of Defence to Rosatom for remediation.

Sited in this region are the Kola NPP and the Rodon Company which also deal with radioactive waste, but their activities proceed under other federal programmes and are currently left out of consideration in implementing the G8 Global Partnership Programme.

Location of the RW sources and storage sites in the North-West Region is shown in Fig. 1.

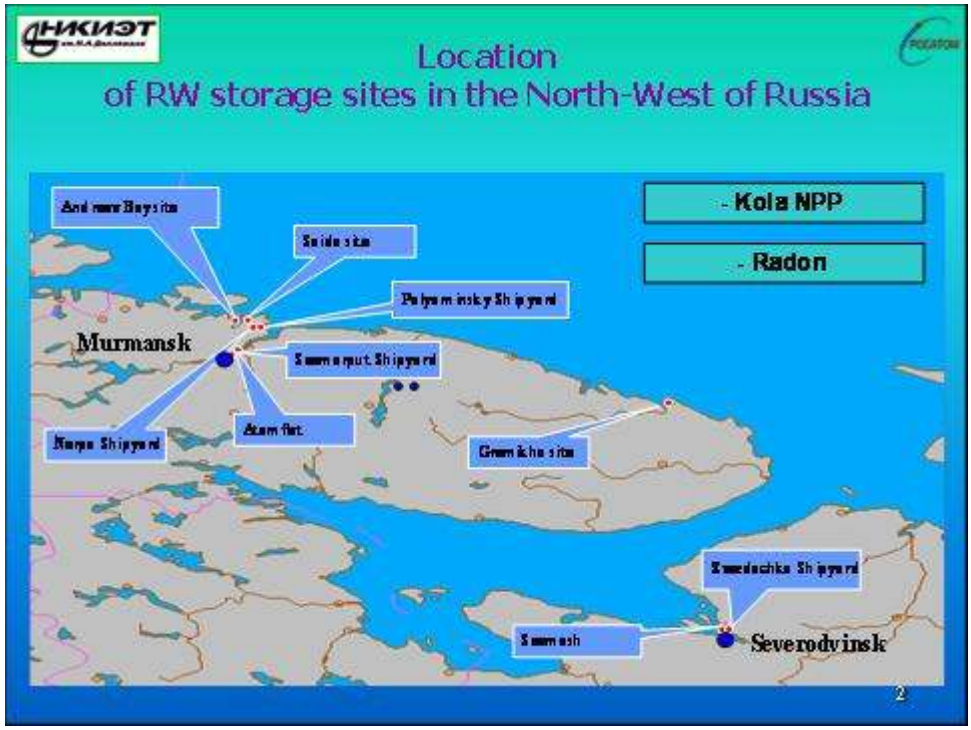

Fig. 1. Location of RW storage sites in the North-West of Russia

2. Problem description

In order to decide on the ways of resolving the RW management problem, it is necessary first to understand what we have to deal with, the whole problem as it stands today, and the final objectives of the work.

The total RW quantity to be handled in the region is determined by the waste accumulated to date, being generated in dismantling of nuclear-powered submarines and surface ships, expected to be produced in future dismantling of their reactor compartments and the nuclear service vessels, as well as in remediation of sites presenting nuclear and radiation hazards.

The volume of future waste was estimated by Rosatom and its subordinated organisations as well as in the SMP-2 development; added to the quantities already accumulated on the sites, it makes the total volume of about 100 000 m^3 to be dealt with, taking into account the planned waste compaction, changes of waste categories, and partial reuse of metal.

Previous efforts, including SMP-2 development, brought tentative site-specific quantification of the accumulated radwaste by categories. The results obtained are being updated on a regular basis as part of the routine activities of Rosatom. Figures 2 and 3 present the percentages of solid radioactive waste accumulated by this day and expected to be generated by different sources.

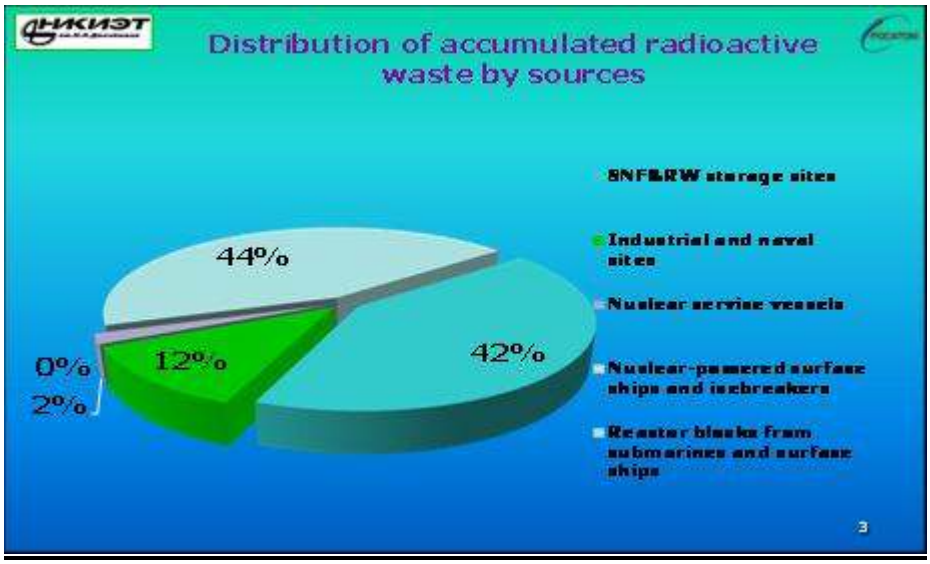

Fig. 2 Distribution of accumulated radioactive waste by sources.

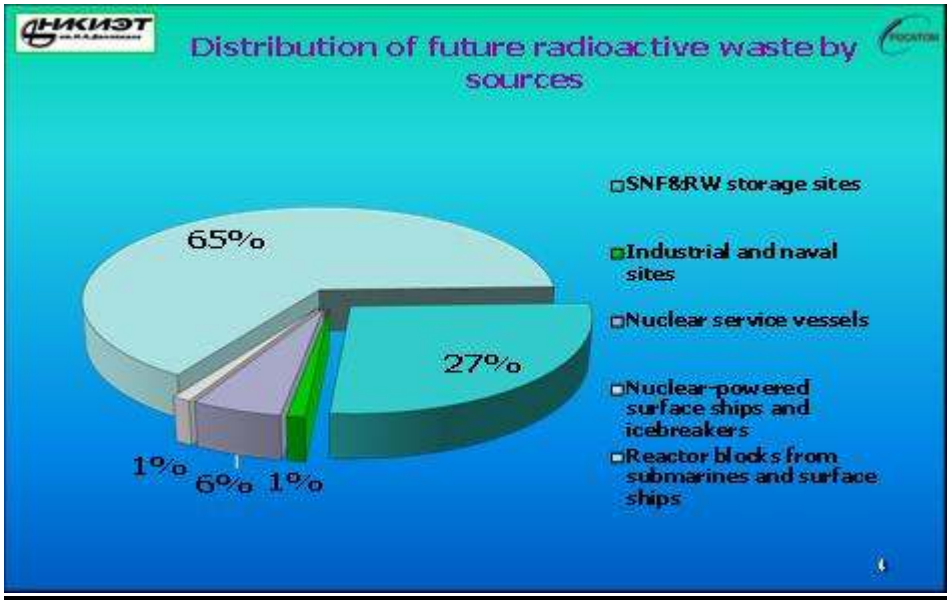

Fig. 3 Distribution of future radioactive waste by sources.

It is tentatively estimated that the total SRW volume comprises about 83 % of low-level waste (below 10^3 kBq/kg), 15.5 % of intermediate-level waste (from 10^3 to 10^7 kBq/kg) and 1.5 % of high-level waste (over 10^7 kBq/kg). In terms of composition, the solid waste kept at the coastal service bases and shipyards includes about 65 % of metal, about 35 % of compactible SRW, of which 30 % is accounted for by combustible waste. The relative quantities of radioactive waste accumulated in the region are presented in Figures 4 and 5 according the activity categories.

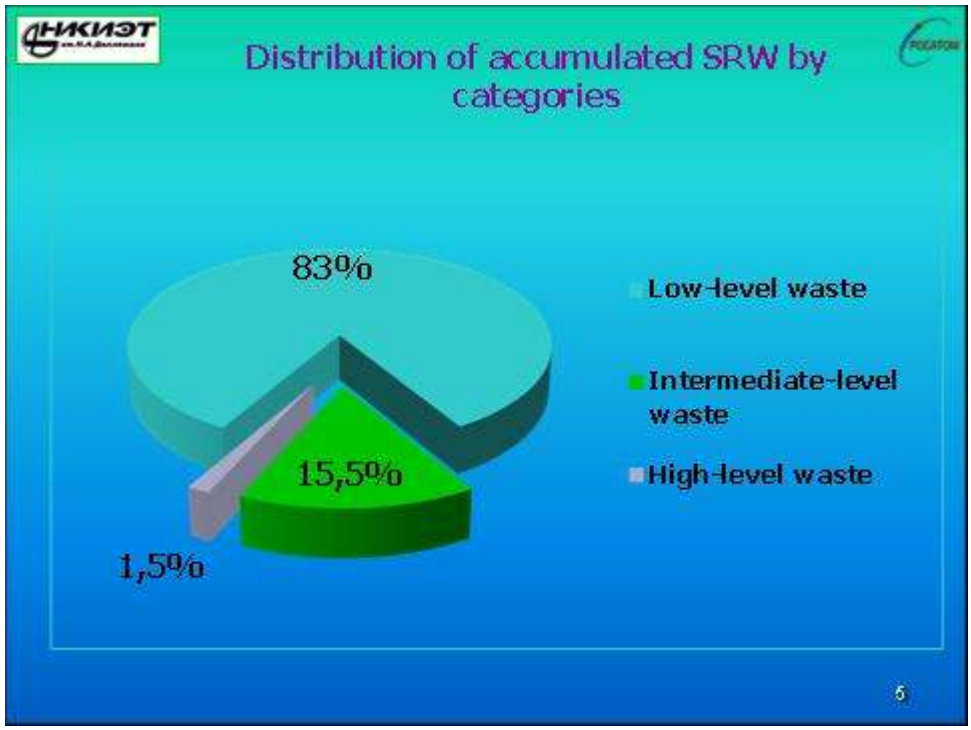

Fig. 4 Distribution of accumulated SRW by categories

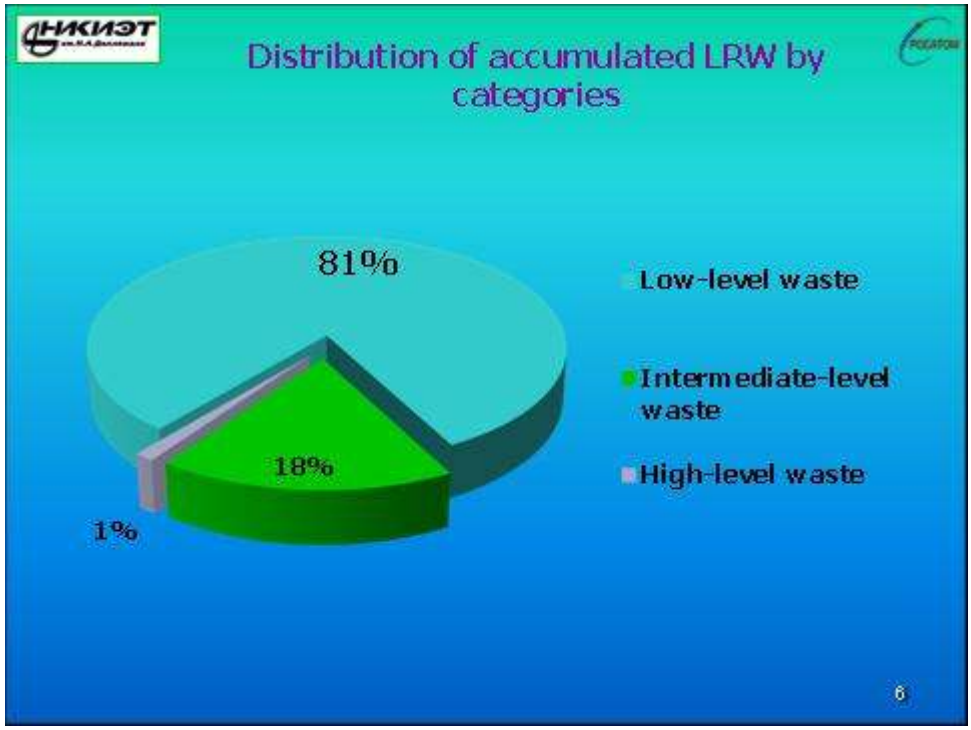

Fig. 5 Distribution of accumulated LRW by categories

The maximum specific activity does not exceed the level of 10^9 Bq/kg. The waste contains mostly radionuclides with a half-life up to 30 years, with the greatest activity coming from Cs-137 and Sr-90. The quantities of long-lived radionuclides present in the waste are such that their contribution to activity is limited to 10^4-10^5 Bq/kg, which means that there is no

need for any additional criteria in RW categorisation in accordance with the current Russian regulations.

The final goals of RW management in the North-West of Russia may be defined as follows:

1. To establish an efficient system of RW management in the region;
2. To phase out the environmentally hazardous temporary RW storage facilities in the region and to restore the contaminated sites to their normal condition;
3. To set up a regional centre for long-term radwaste storage.

The Russian regulatory framework as it stands today is adequate to the purpose of ensuring radiation safety during operations and is consistent with the international standards.

The current regulatory documents defining the procedures for setting up storage facilities and sites for disposal of various radioactive wastes, point out that all the engineering solutions should be developed and justified with regard to the RW characteristics and natural conditions on the site under consideration.

Russian and foreign approaches to RW management and disposal are rather similar, including the recommended characteristics of radionuclides in the waste proposed for disposal in subsurface storage facilities.

The Russian regulatory framework for RW management is undergoing improvements aimed, among other things, at further convergence with the international approaches. Consideration is being given to the possibility of step-by-step introduction of the VLLW (very low-level waste) category, with some spadework already in progress.

3. The ways and key stages of implementing the RW management concept

In this context, it is necessary to identify the ways and the basic process stages in general management of radioactive waste, such as collection-sorting-compacting (for solid waste), collection-treatment-cementation (for liquid waste), and packaging-storage-disposal. The sequence and interrelation of process stages are presented in Figure 6.

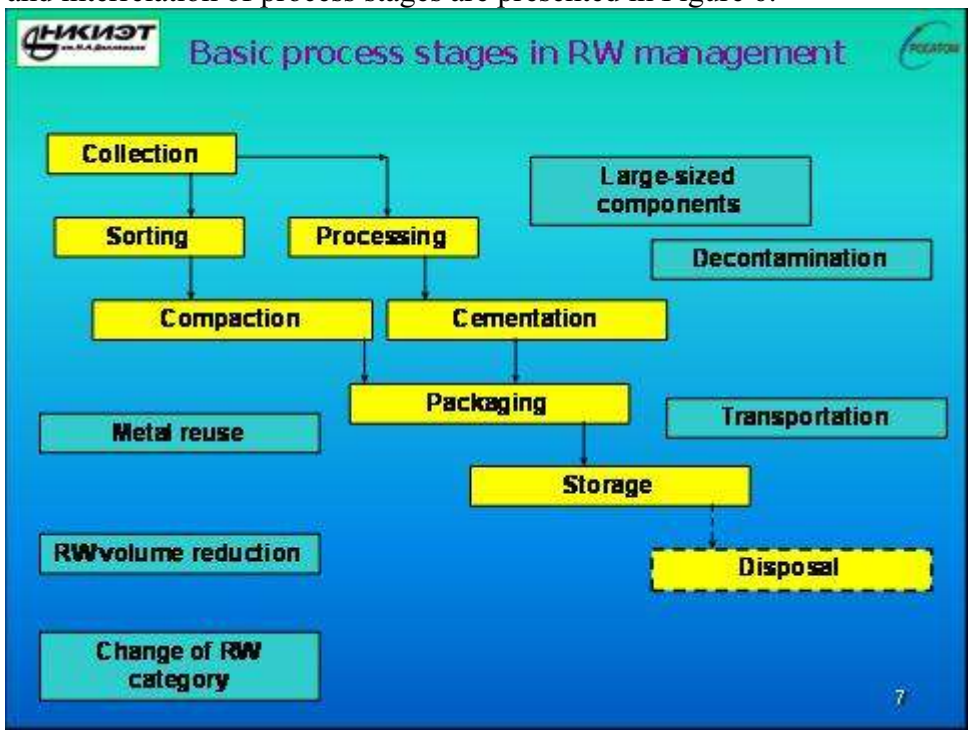

Fig. 6 Basic process stages in RW management

These operations will undoubtedly involve waste transport and handling of large non-separable pieces of equipment. Upon decontamination, some materials will be reused, others will be classed under a different category – that is, generally speaking, decontamination, compacting and processing will result in reduction of the initial RW volumes.

The next stage of determining the initial parameters lies in specifying operations for the main RW categories in accordance with the handling methods adopted for them.
For SRW, such categories are:

- High-level waste;
- Intermediate- and low-level waste;
- Very low-level waste (when this category is introduced).

The LRW categories include:

- High-level waste;
- Intermediate- and low-level waste;
- LRW of complicated chemistry.

With the methods of LRW handling determined, the above list may be reduced to the main initial RW categories, which should be considered in the general concept of RW management in the region. Such categories are:

- High-level SRW;
- Intermediate- and low-level SRW;
- Very low-level SRW (upon introduction of this category);
- Liquid RW.

An important step and final point in the process of RW management is the waste confinement and burial in specially built repositories, primarily in geological formations, with no intent of its subsequent retrieval. Such disposal necessitates a multibarrier system of underground RW isolation, including natural (geological) and man-made (engineered) barriers. To this end, extensive work has been done by the leading scientific organisations, with a contribution of special importance made by the Design and Survey Institute of Industrial Technology, the Kola Research Centre and the Institute of Mining.

In those activities, the basic principles of secure RW isolation in geological formations were identified as the answerability to the future generations and the radiation safety, which are consistent with the safety principles and technical criteria developed by the IAEA. To this day, waste burial in geological formations is universally recognized as the safest and most reliable disposal method. The rock mass in this case appears to be the key safety barrier.

At the same time, generation of radioactive waste to be disposed of should be kept as low as reasonably achievable, with its characteristics adjusted to conform to the current Russian regulations and rules related to nuclear energy uses and radwaste management.

Much importance is attached in this process to development of the RW acceptance criteria and their application, i.e., the quality criteria to be met after waste collection, processing, storage, and conditioning for long-term storage and disposal. Development of the above criteria is provided for in the Russian regulatory documents and is currently in progress as applied to RW management in the North-West Region.

During transportation and storage, it is essential to ensure the structural stability of the RW form, which is determined by a combination of its main physical and chemical characteristics. The waste form should be strong enough to withstand the loads arising at various stages of RW handling, and should retain its geometry. It should be resistant to any reasonably conceivable chemical, biological, radiation and thermal impacts.

The acceptance criteria for storage and disposal of conditioned radwaste should be adopted with regard to the following waste characteristics:

- total activity of the RW package, specific activity of the waste, and its radionuclide composition;
- equivalent dose rate;
- surface contamination;
- structural stability of the waste form;
- radiation resistance;

as well as to other properties specified in the current regulations.

RW packages containing explosive and (or) spontaneously igniting substances are not acceptable for storage and disposal. The content of poisonous, chemically toxic, pathogenic and infectious materials in a package should be known with a sufficient degree of accuracy and has to be limited. RW packages containing chemicals with toxic characteristics corresponding to Class I (extremely dangerous) and Class II (highly dangerous) will not be accepted for storage and disposal.

We shall now consider the general strategic approaches to SRW and LRW management in the North-West Region (Fig. 7). Such approaches were to some extent presented to our foreign partners at previous meetings and workshops, as well as in the SMP-2 documents.

Fig. 7 Strategic approaches to SRW and LRW management in the North-West Region

The key points of this approach are: centralised handling of SRW at the regional centre for waste conditioning and long-term storage, with only initial waste sorting and packaging done locally, and treatment of liquid radwaste on the sites of its generation with the use of modular facilities.

One of the main stages of waste preparation for storage and disposal is conditioning, which may involve a number of methods, such as:

- placement and cementation of SRW in a cask;
- placement of processed SRW (LRW) in a cask;
- placement of solidified LRW in a cask;
- placement and cementing of SRW in a cask;
- placement of an RW package in an additional cask.

In choosing the waste conditioning method it is appropriate:

- to assess different conditioning methods with regard to the requirements for safety in RW storage and disposal as well as to the technical and economic factors;
- to analyse the expected RW characteristics after its collection and processing, the existing RW processing technologies, and the safety problems associated with waste processing;
- to check the RW characteristics against the acceptance criteria for storage and disposal.

Considering the complicated situation on the SNF and RW storage site at Andreev Bay as well as the fact that a large part of the regional radwaste will come from this site, an optimised decision was taken in consultation with the foreign donors to build an infrastructure on the site to the extent required for handling the solid and liquid waste.

In the cases unprovided for in the general handling and transport scheme, or necessitating special-purpose technologies, the radioactive waste will be handled under separate projects.

The management scheme presented in Fig. 8 is recommended for handling intermediate- and low-level SRW which constitutes the bulk of the solid radwaste in the region. Waste collection, sorting, primary treatment and packaging for transportation will be arranged in situ.

On completion of these operations, some materials will be reclassified as very low-level waste and will be transferred to the appropriate management system. Part of the waste will be diverted for reuse, and the rest will be packaged in casks and placed on the site buffer pads to be subsequently shipped as required to the regional centre for conditioning and long-term storage.

After decontamination, large-sized non-separable components should not be necessarily packaged in casks but may be prepared with the use of special technologies and thus delivered in one piece to the regional centre. Casks should be shipped primarily by a special carrier vessel, which is to be built under a contract with Italy.

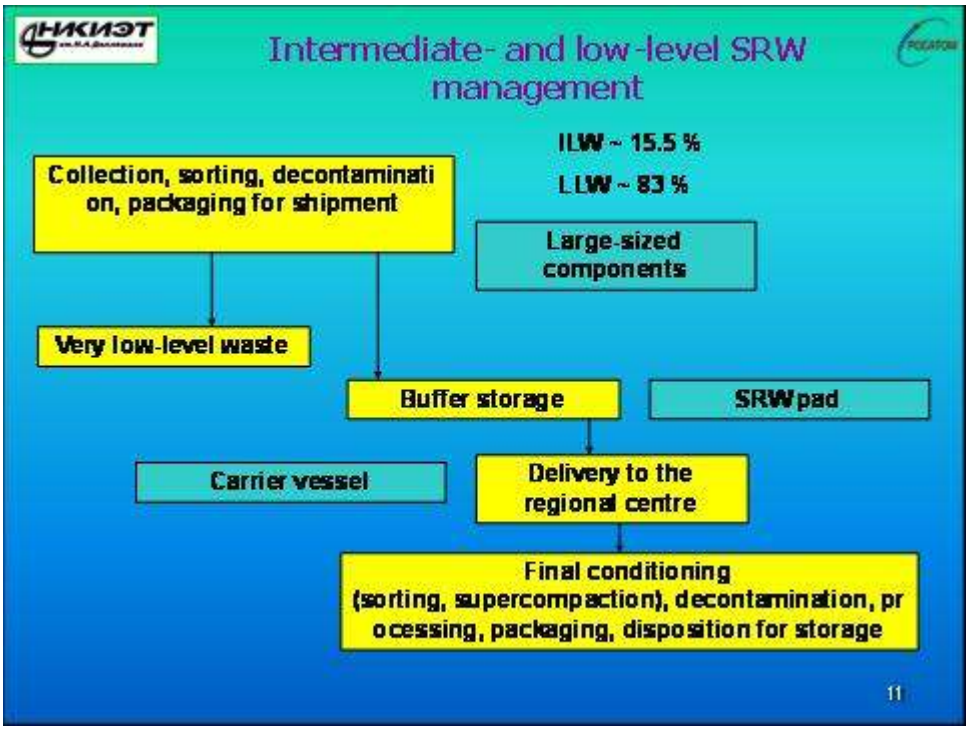

Fig. 8 Intermediate- and low-level solid waste management

A point of importance to this scheme is unification of the casks for SRW packaging on the sites. In order to reduce the operations in places of SRW generation, it is expedient to have this waste packaged in situ using returnable shipping casks of the same model, which will be delivered from the regional centre when cleared of the previous waste.

On delivery to the regional center, the waste will be unpackaged and transferred to the appropriate facilities to be finally prepared for long-term storage, including final sorting and high compaction. Having undergone the whole process at the center, waste is to be packed in casks qualified for long-term storage; the casks, whose type is yet to be determined, will be manufactured and supplied to the regional centre.

A possible exception to this rule is the SNF and RW storage site at Andreev Bay, which, as mentioned earlier, is the main source of radioactive waste in the region, and where it is planned to provide special facilities for RW handling. On this site, waste will undergo all the essential operations, including placement of compacted waste in the casks to be stored at the regional centre, provided they meet the acceptance criteria for long-term storage at the centre. These casks will be delivered to the centre and placed in storage without any additional treatment.

Once the category of very low-level waste (VLLW) is introduced, it will be possible to reduce considerably the volumes of containerised waste storage and, consequently, the structural volumes of the regional centre. Such waste will consist mostly of soil, combustible waste, secondary waste from remediation work (building units), and individual components of auxiliary equipment (Fig. 9).

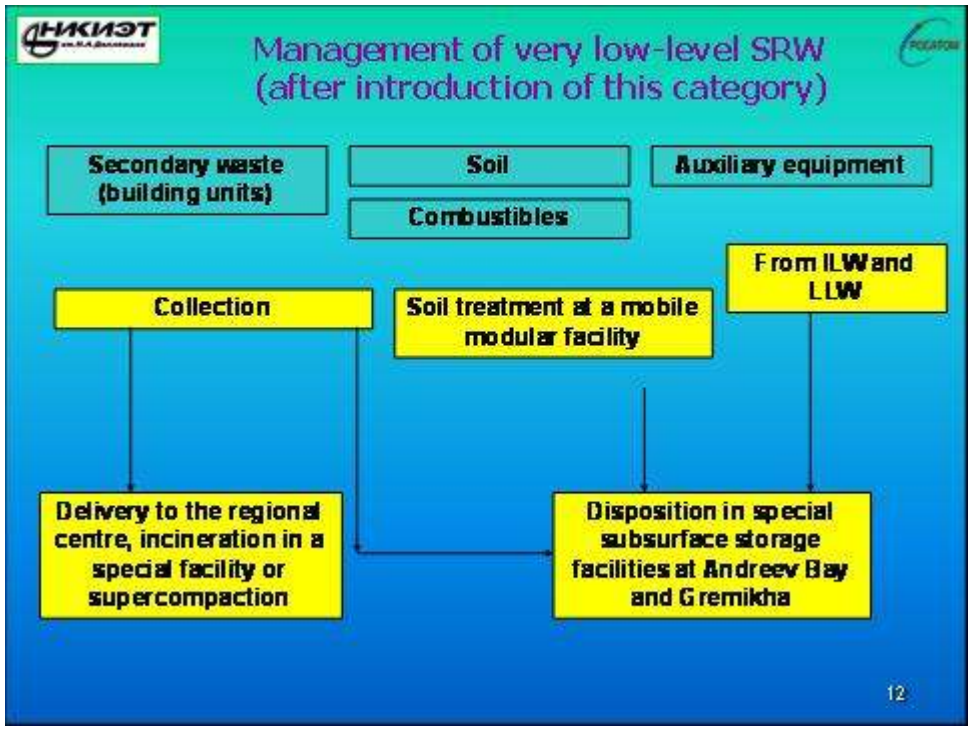

Fig. 9 Management of very low-level solid waste (after introduction of this category)

VLLW will result primarily from soil collection and treatment by a mobile modular facility, as well as from decontamination of intermediate- and low-level waste. The options under consideration for such waste are to store it in special subsurface facilities at Andreev bay and Gremikha or to ship it to the regional centre where it will be supercompacted and put in storage as required for waste of this category.

The current plan for handling liquid radioactive waste looks as follows (Fig. 10). LRW is to be treated in situ by modular facilities, with the resulting waste solidified and packaged in standard drums for transportation to their storage place at the regional centre.

Technologies for processing LRW of high activity or complicated chemistry should be chosen on a case-by-case basis depending on the physical and chemical properties, the conditions and location of the waste in question.

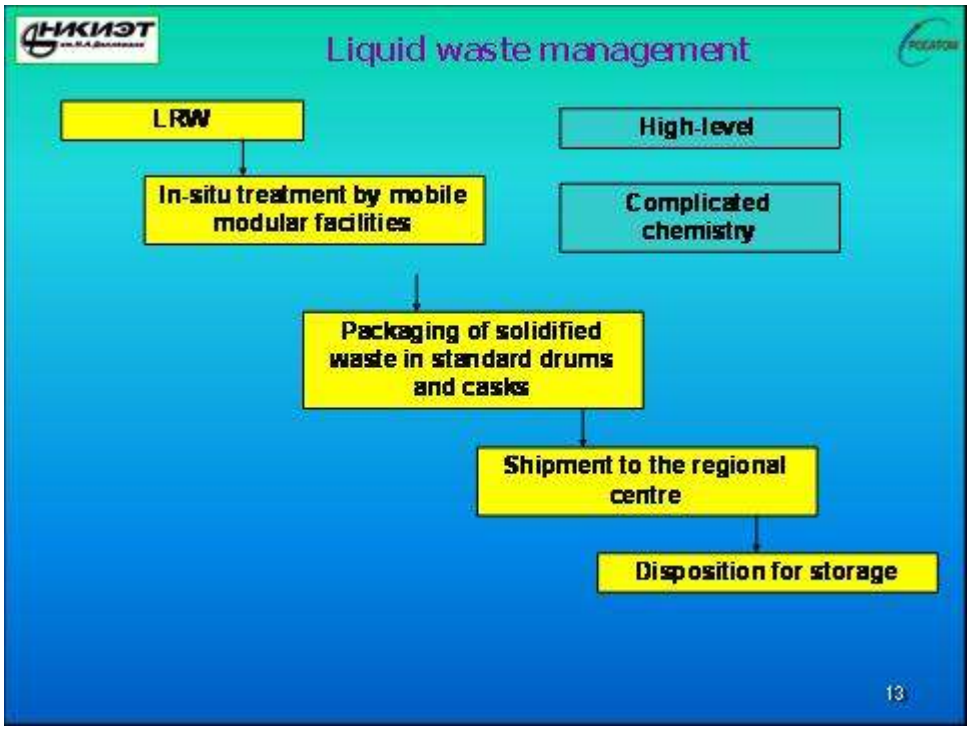

Fig. 10 Liquid radioactive waste management

4. High-level solid waste management

High-level solid waste, which accounts for no more than 1.5 % in the total RW volume, is particularly difficult for management. The main types of such waste are rods of control and protection systems and activity traps with sorption filters, found mostly on the temporary SNF and RW storage sites and on the territory of shipyards (Fig. 11).

The activity traps are to be packed in special casks and transported to the regional centre for long-term storage.

The CPS rods will be treated depending on their condition. Rods showing no external damage or bending may be accommodated inside the reactor vessels of decommissioned submarines during formation of one-reactor compartment block at the Nerpa Shipyard.

If such disposition in reactor vessels proves impossible, the rods will be loaded in special casks and put in a special storage facility of the regional centre. The total number of CPS rods found in the temporary SNF and RW storage facilities and on nuclear service vessels is currently estimated to be as many as 1800, but this figure has to be updated, which will be done during examination of the storage facilities and operations on the Andreev Bay and Gremikha sites.

Disposition of CPS rods in reactor vessels is a technically complicated task which necessitates arrangement of a special working area, presumably on building ways at Nerpa, making it as close as possible to the site of formation of one- reactor compartment blocks and providing access to the reactor vessels; it involves retrieval of CPS rods from their storage places, their delivery to the working area and accommodation in reactor vessels, with the safety of all operations properly assured. The HLW handling and transport scheme is being elaborated by NIKIET.

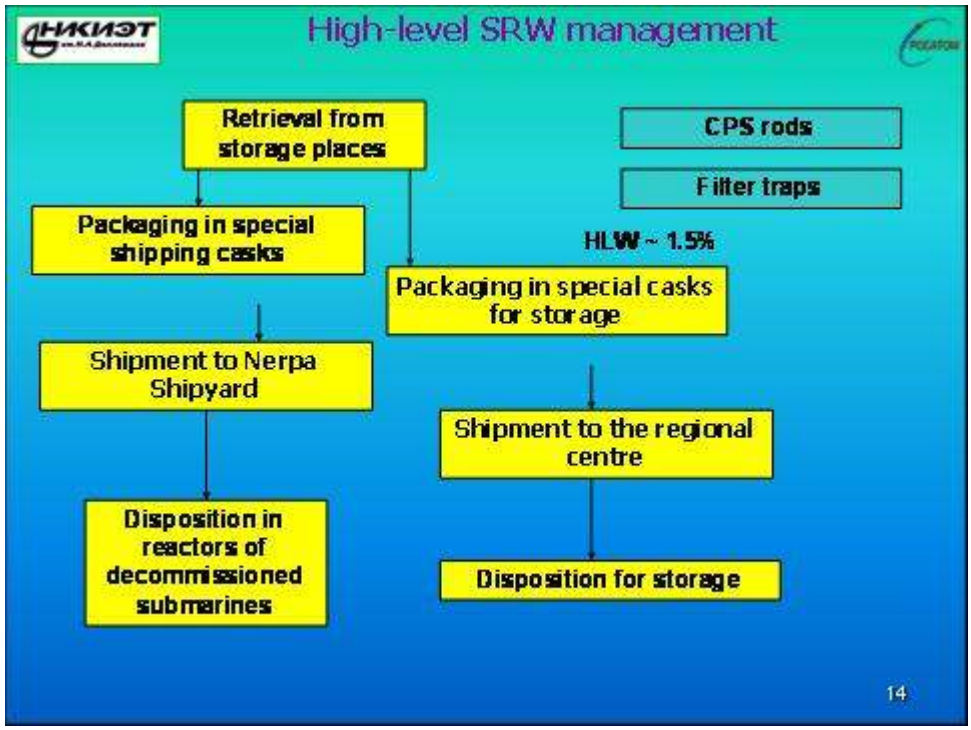

Fig. 11 Management of high-level solid waste

An advantage of the proposed way of handling the highly active CPS rods lies in the fact that, once they are placed in the reactor vessels of decommissioned submarines, the question will be settled in a conclusive way as there is no intention to dismantle such vessels later – they will be disposed of in one piece. In our opinion, it is hard to find a better container for high-level waste.

Even if CPS rods are loaded in the best casks available, their long-term storage at the regional centre will entail expenses, and so will their subsequent disposal with possible repackaging in new casks.

The described methods of handling various types of radioactive waste dictate basic requirements for the system of RW management in the region, for the technical characteristics and functions of the regional centre.

The regional centre for conditioning and long-term storage of radioactive waste should be designed to take in and process waste at a rate of 5-7.5 thousand m^3/year, with the RW volume to be accommodated tentatively estimated at 100 000 m^3. The waste includes roughly 65 % of metal, 25 % of compactible non-combustible materials, and 10 % of combustible waste. Capabilities should be provided for dismantling, decontamination, conditioning, temporary storage and radiation monitoring of radioactive materials and waste.

No provisions are made for handling spent nuclear fuel at the regional centre. The centre should be capable of taking in and processing the special objects to be kept in the regional storage facility of the 2nd construction stage (compartments of nuclear service vessels, reactor compartments of icebreakers and other surface ships), whose dimensions are larger than those of submarine reactor compartments. Reactor compartments are to be taken apart in the dismantling shop, which will be additionally equipped if required. Capabilities should be provided for handling the LRW from the internal processes taking place at the centre.

5. Conclusions

This approach allows optimal use of the infrastructure available already or yet to be built.

Local operation of transportable modular facilities alone will minimize the number of facilities to be built on the sites, which will have to be subsequently dismantled or subjected to remediation.

In the cases unprovoked for in the general handling and transport scheme, the radioactive waste will be handled under separate projects.

The technical assignment on building the regional centre for RW conditioning and long-term storage should describe as much as possible the equipment and facilities to be provided.

It is necessary to assess in technical and economic terms and to optimise the handling and transport options for radioactive waste delivery to the regional centre.

The casks to be used in the handling and transport process should be clearly identified and unified, with the number of their types reduced to a minimum.

Such work is already in progress and is planned to be completed next year.

All the basic engineering solutions for the RW management system should be adopted in consultation with NIKIET as the scientific leader of the programme and the organisation in charge of nuclear and radiation safety in decommissioning of nuclear submarines and environmental remediation of nuclear sites. Such decisions should also be approved by Rosatom in order to prevent uncoordinated actions and to have a common radioactive waste management policy pursued in the North-West Region.