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Draft Safety Analysis Report for the Vrbina Krško LILW Repository

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0	Summary of Draft Safety Analysis Report	Sandi Viršek	Maruška Faganel
1	Introduction	Sandi Viršek	Matej Rupret Maruška Faganel
2	General description of the repository	Maruška Faganel Matej Rupret	Bojan Kolarič
3	Management system	Bojan Hertl	Sandi Viršek
4	Assessment of the area of the repository site	Matej Rupret	Sandi Viršek
5	Summary of Design Bases	Sandi Viršek	Leon Kegel
6	Description of systems and compliance with project	Bojan Kolarič	Sandi Viršek Matej Rupret
7	Safety analysis	Sandi Viršek	Leon Kegel
8	Trial operation	Bojan Kolarič	Sandi Viršek
9	Operation	Sandi Viršek	Bojan Kolarič Maruška Faganel
10	Physical security	Sandi Viršek	Bojan Kolarič
11	Operational limits and conditions	Sandi Viršek Bojan Hertl (section 11.2)	Leon Kegel Bojan Kolarič
12	Closure of the repository	Matej Rupret	Sandi Viršek Leon Kegel Maruška Faganel
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14	Emergency preparedness	Matej Rupret Simona Sučić	Metka Kralj Bojan Kolarič
15	Environmental aspects	Maruška Faganel	Matej Rupret
16	Decommissioning programme	Leon Kegel	Sandi Viršek Maruška Faganel

Table of contents of Draft Safety Analysis Report

Summary of Draft Safety Analysis Report

The Draft Safety Analysis Report for the low- and intermediate-level radioactive waste (LILW) repository is a document drawn up as part of the Environmental Impact Assessment. The content of the Draft Safety Analysis Report accords with the practical guideline [1] and the guidelines, whereby content is provided that in this stage of the project is already known and important for the assessment of nuclear and radiation safety, while the emphasis is on content that is important in terms of impact on the population and the environment. The remaining content, which is not covered in detail in this document, is currently being drafted and will be included in the content of the Safety Analysis Report that will be compiled in order to obtain an approval for the construction of the LILW repository.

Slovenia uses nuclear and radiation technologies that generate nuclear waste. LILW accounts for the majority of this waste in terms of quantity. The country has therefore taken the decision to seek out a site for and to construct a repository for LILW generated within its borders. The project investor is the Slovenian government and the contractor (agent) is the Agency for Radwaste Management (ARAO), a public commercial institution.

The site for the repository and the LILW disposal concept were selected through a procedure that lasted from 2004 to 2009 and in which the public was also closely involved. Appropriate design solutions were also developed during this time. The design solutions are the input data for the majority of the documentation required for an assessment of the environmental impacts and for the obtaining of a construction permit. A Conceptual Design (IDZ) [2] of the LILW repository was drawn up on the basis of the design of the project for acquisition of a construction permit (PGD), the coordination and optimisation of the design solutions and the guidelines of the architecture commission. The document is an appendix to the application for obtaining an environmental permit, and the project for acquisition of a construction permit (PGD) is also already being drafted, and is in the revision and review phase at the time of the drafting of this Draft Safety Analysis Report.

A general description of the repository is given in Chapter 2 of this document. The basic concept of LILW disposal at the Vrbina site represents the disposal of properly prepared and packaged low and intermediate level radioactive waste into the storage units located below the groundwater level at the site itself. The disposal will be performed from the surface, and therefore the repository has been recognised as a near-surface facility in accordance with the recommendations of the International Atomic Energy Agency (IAEA). During the planning process, a multi-functional or multi-barrier approach was taken, with the final barrier being the geology of the site. All LILW that meets the acceptance criteria for disposal at the planned LILW repository will be conditioned at Krško NPP. Preliminary conditioning and packaging in final packages (reinforced-concrete containers) will be conducted there. The containers will be transported to the repository, where an additional formal check of compliance with the acceptance criteria will be made. The accepted containers will then be disposed of in a disposal unit, i.e. a reinforced concrete silo. The multi-barrier system consists of the following main barriers: properly prepared waste, concrete container, concrete silo, and geology/surroundings of the repository site.

In order to protect the repository against probable maximum flood (PMF), all of the repository structures are built on a single flood-control plateau. Waste in concrete containers (final packages) will be placed into the silo using a gantry crane. The voids between the final packages and the silo will be filled in using a suitable material (backfilling grout). A drainage system will also operate as part of the disposal system. During operation, it will collect water that could seep into the silo and then drain it in a controlled manner, thereby keeping the silo

dry during operation. When the silo reaches full capacity, it will be sealed. The silo must be sealed in such a way that it is effectively separated from the groundwater at the site, thereby preventing or retarding the spread of potential radionuclide contamination. This will be achieved using a combination of barriers (concrete and clay). The drainage system is also expected to be sealed after the silo is sealed. As far as possible, the sealed silo must constitute a monolithic structure with an adequate ratio between impermeability to water (physical barrier) and permeability to the gases that will be created at the repository (the generation of gases at the repository is presented in Chapter 7 of the Draft Safety Analysis Report), and the capacity to retain radionuclides (chemical barrier). During operation there is no expectation that a major quantity of gases could be generated, mainly because there will be no free water present and the waste will be in aerobic conditions. Minor quantities of hydrogen and carbon dioxide could be generated. Small quantities of hydrogen and methane could be generated during the period after the closure of the repository. None of the gases that will be generated will be radioactive. All of the engineered barriers at the repository (final packages, backfill, silo) are designed to carry out their safety functions as set out in the Draft Safety Analysis Report, and so that the entire disposal system is robust and provides an optimal LILW disposal solution.

Chapter 3 describes how ARAO, as the future operator of the LILW repository, has established and introduced an integrated management system that also includes a management system for the LILW repository nuclear facility. It regularly assesses this system and makes continuous improvements based on the findings of the assessments. The ARAO management system has been set up as a single integrated management system that brings together the areas of quality assurance, environmental management, health and safety at work, nuclear and radiation safety, security, human and organisational factors, social relations and economics. The management system describes how to ensure that the organisation can achieve all the set objectives safely, effectively and efficiently. It is implemented as a system of management, main, support and external processes through which ARAO realises its mission, ensures that services are of high quality, ensures human health and safety and environmental protection, satisfies interested parties and realises the planning policies and thereby the interests of the state, stakeholders and the social environment in which ARAO operates.

Chapter 4 of this report gives an assessment of the area of the repository site. The site of the low- and intermediate-level radioactive repository lies in the municipality of Krško, on Krško Polje, which is a gravel valley covered with fields and meadows, with local depressions that are artefacts of the former course of the Sava River. The closest town to the site is Krško, which is located 2.5 km from the site, while the town of Brežice is 5 km from the site. The site is located a little over 12 km from the border with neighbouring Croatia. The Krško Nuclear Power Plant is situated approximately 300 m from the western edge of the site, and the settlement of Spodnji Stari Grad lies approximately 400 m north-east of the site. The plain on the southern side of the site is bounded by the channel of the Sava, which is approximately 650 m from the repository site at its nearest point. In the north, the plain extends towards the Libna hill. In the east, the site is bounded by a local road leading from the settlement of Vrbina towards the south-east, i.e. towards the banks of the Sava. The LILW repository site lies at a height of between 151.69 m and 153.44 m above sea level. The wider area of the site used for agriculture and is designated as prime agricultural land. There are tended fields within the site itself and a commercial orchard at the site's far western edge.

The Krško Basin covers the wider area around the site, where Mesozoic sediments of unknown thickness lie below the Krško syncline of Tertiary sediments. The oldest Tertiary sediment is Ottnangian clay silicate-gravel with local concentrations of coal. Its granularity is medium to very coarse. Lying above this is erosional discordant solid Badenian limestone, covered in places with limestone Sarmatian resediments. These sediments are then covered in the Krško

Basin by a more than 1,000-metre-thick layer of Sarmatian fine-grained clastites (well-consolidated clayey carbonate sludge, silt, sandy silt and fine-grained sand) of Pannonian and Pontian age. The last and youngest unit of this area is a covering of Plio-Quaternary clastites: medium- to coarse-grained Sava gravel of varying thickness. The last Quaternary Sava layer is fairly shallow (up to 15 m).

The disposal facilities will be built in a layer of silt at a depth of approx. 15 m to a depth of approx. 60 m below the surface. Two significant hydrogeological units have been identified at the LILW repository site: a Quaternary aquifer and a Miocene aquiclude. The Quaternary Krško Polje aquifer is an alluvial deposit of the Sava, which consists predominantly of gravel and sand with silt and occasional clay admixtures. The aquifer is classified as an extensive and high yielding (productive) hydrodynamically open aquifer. The average thickness of the Quaternary layers in the area of the site is approx. 10 m, with the thickness increasing towards the south. The velocity of groundwater flow in the Quaternary aquifer is estimated to range from approx. 23 m/day to 39 m/day and also depends on the changes in the gradient during the flooding of the Sava River. The Miocene aquiclude consists of silty-sandy, sandy-silty and silty layers. The aquiclude is classified as a geological layer without significant sources of groundwater. The measured water permeability ranges from 1.28×10^{-8} to 3.63×10^{-7} m/s. From the hydrogeological aspect, these layers can be defined as homogeneous, but with an anisotropy that is fairly variable and not dependent on either the depth or the lithological composition of the soil. The horizontal flow component of the groundwater in the Miocene aquiclude is less dependent on the level of the Sava. The prevailing direction of flow of the groundwater is towards the south. The horizontal gradient in the Miocene aquiclude is approximately 0.002. The velocity of the groundwater is roughly four orders of magnitude less than the velocity in the Quaternary aquifer.

All of the repository facilities will be built on a plateau that will reach up to 155.20 m above sea level. This will ensure the safety of the repository against probable maximum flood (PMF), which amounts to 7081 m^3/s for this area, as well as extreme flooding of the Sava Q=11130 m^3/s. For the impact of extreme hinterland water, additional analyses have shown that under the conservative assumption of zero percolation, the elevation of the hinterland water near the repository cannot exceed 154.17 m above sea level. Due to substantial uncertainty in determining the benchmark elevation of hinterland water, it has been proposed that instead of 0.5 m (ARSO proposal for Q100), the safe height should be set at 1 m; the base elevation of the plateau of the LILW repository is thus set at a height of 155.20 m above sea level.

The seismic hazard assessment for the Vrbina Krško LILW repository relies on seismic hazard assessments for the Krško NPP site, which is located in the immediate vicinity. The most recent assessments were made in 2004 and 2010. Based on this assessment and new input data from the area of the LILW repository site itself, several studies and analyses were conducted, and the design parameters for the individual facilities at the repository were determined on their basis.

Chapter 5 of this report gives summaries of the design basis, which was developed for the Draft Safety Analysis Report, and which were compiled as a separate document titled Design basis for the Vrbina Krško LILW repository – environmental impact assessment phase, [3] pursuant to Appendix 4 to the JV 5 rules. [4] Another of the basic tasks of the design basis is to identify the structures, systems and components laid down by the JV5 rules. [4] These are divided according to groups of facilities at the repository, i.e. into sets of structures, systems and components (SSC) in disposal, technological and administrative and service facilities, physical protection facilities, the external layout of infrastructural lines and connections, and monitoring facilities. As required by JV5 and the graded approach, SSC are identified on the basis of safety analyses, the determination of the safety functions and an engineering assessment made by a group of specialists in different fields, and then classified according to safety criteria. They are divided into safety-related SSC and non-safety-related SSC. The safety functions performed by the individual SSC are also laid down. The individual SSC are also presented in detail in the Draft Safety Analysis Report.

Chapter 6 gives a description of the sets of nuclear safety related structures, systems and components (SSC) at the Vrbina Krško LILW repository.

The description of SSC was drafted in the sense of the third indent of point 2 of Article 71 of the ZVISJV and the requirements set out in point 5 of the first paragraph of Article 43 of the JV5.

The provisions of point 6 of the practical guidelines PG 1.03 were taken into account when drafting the description of SSC, where the following are taken into consideration:

1. The basis for the definition of SSC, their safety functions, requirements for SSC, their designations and SSC safety classification is the Design basis for the Vrbina Krško LILW repository – environmental impact assessment phase, Revision 1, NSRAO2-POR-013-01 02-08-011-001, ARAO, August, 2016. [5]
2. The basis for the size, purpose and description of SSC is the Conceptual Design (IDZ), Rev. C for the project Vrbina Krško LILW Repository / Repository facilities, supplemented with solutions that will be shown in the project for acquisition of a construction permit (PGD).
3. SSC whose operability should be found to be radiation and nuclear safety related in probabilistic safety analyses at all times throughout the lifetime of the repository (PG 1.03, point 6.1, first paragraph), shall include SSC defined as nuclear safety related in the design basis (designated “SR”).
4. Descriptions are drafted for nuclear safety related (SR) SSC.
5. The descriptions of nuclear safety related (SR) SSC are given in accordance with the requirements set out in the fourth paragraph of section 6.1 of PG 1.03 and contain a description of the system, a technical assessment and a safety assessment.

The design solutions given in the Conceptual Design (IDZ) or the SSC descriptions that are drafted on the basis of the design documentation ensure the implementation of the basic disposal scenario (SA.3) set out in the approved feasibility study, [6] i.e. the Resolution on the National Programme for Managing Radioactive Waste and Spent Nuclear Fuel 2016–2025, ReNPRRO16–25, Official Gazette of the RS 31/16 (ReNPRRO). The descriptions in all of the main documents also apply to the implementation of the expanded scenario (SA.2) including Croatia’s cooperation.

The LILW repository is a nuclear facility at which all activities will be carried out that are directly linked to the disposal of radioactive waste.

The wider surroundings of the repository contain:

- the entrance to the repository,
- the core area of the repository,
- vacant surfaces of the repository, and
- areas for connection to utilities infrastructure.

The core area of the repository is intended for administration and service activities, waste takeover and disposal, and for provision of physical security of the repository. The core area of the repository is equipped with a security fence and is physically secured.

The main contents of the Draft Safety Analysis Report are the safety analyses and assessments (presented in Chapter 7), which are an integral part of the lifecycle of a nuclear facility such as the LILW repository. [7] The first iteration of the security analyses was undertaken back in 2006 [8] within the framework of the Variants Study. [9] The purpose of the analysis was to identify the optimal waste disposal concept for the Vrbina Krško site. The waste disposal concept of underground silos excavated from the surface was proposed and later confirmed in the detailed plan of national importance (DPN). [10] The concept was then developed to the phase of revision C of the conceptual design, [2] which was also the basis for the drafting of this document.

The next iteration of the safety analyses and assessments was drawn up after the adoption of the DPN for the needs of obtaining the environmental permit. At this stage the safety analyses had two main objectives:

- Assisting in the optimisation of the LILW disposal concept,
- Supporting the acquisition of the environmental permit (providing the requisite calculations and estimates for drawing up the Draft Safety Analysis Report).

The safety analyses for the phase of obtaining the environmental permit were begun back in 2011, and were based on data from the preliminary design. The optimisation and development of the project took place within the framework of safety analyses, where individual optimisations were analysed from the perspective of the impact on nuclear and radiation safety. Only optimisations that had a positive impact on nuclear and radiation safety were adopted.

When conducting the safety analyses, the recommendations of the International Atomic Energy Agency [11] were taken into account, and a conservative approach was taken, the main purpose of which was to analyse the most adverse scenarios during operation and after closure of the LILW repository. The results thus obtained represent an envelope showing the repository's maximum possible impact on humans and on the environment. In later phases of the project the safety analyses will be updated with new input data, which, given the project optimisation and the reduced unreliability and conservativeness of the safety analyses, will show more realistic results and demonstrate a smaller potential environmental impact from the repository.

The safety analyses essentially cover two time periods of the repository. These are:

- Safety analyses during operation of the LILW repository, and
- Safety analyses after closure of the LILW repository.

Within the framework of the Investment Programme for the LILW Repository, [6] it was established that the SA.3 and SA.2 scenarios are the optimal variants for disposal at the LILW repository. The key features of the scenarios are as follows:

- SA.3
  - only LILW disposal is conducted at the repository site; conditioning for disposal is conducted at Krško NPP
  - half of the waste from Krško NPP and all Slovenian institutional waste will be disposed of at the repository site (one silo is required for the disposal of this waste)
  - in the determination of the quantity of waste, it was assumed that Krško NPP would operate until 2043

- SA.2
    - The same assumptions apply as for the SA.3 scenario, except that the Croatian half of the waste will also be disposed of at the repository site (two silos are required for the disposal of all the waste).

It was therefore decided that it would be reasonable to conduct an environmental impact assessment that addresses the total quantity of disposed waste, i.e. two silos. Revision C of the conceptual design [2] sets out the basic project design for the SA.3 scenario, which in the Development potentials of the repository to be taken into account in elaboration of the EIA, which is part of the conceptual design, addresses the execution of the SA.2 scenario, i.e. the disposal of all operating and decommissioning waste from Krško NPP and all other Slovenian LILW. In this case two disposal silos will be constructed at the repository site.

In conducting the safety analyses, the total inventory of radioactive waste that will be generated in Slovenia was taken into account, including waste generated from the decommissioning of Krško NPP. It was also assumed (from the aspect of the spreading of concentrations of radionuclides) that all of the waste could be disposed of in one single silo. This constitutes a conservative approach to estimating the impact of the repository on the natural environment and humans, and represents the upper limit of the potential impact.

The following scenarios were addressed:

Operation of the repository:

- normal operation, with anticipated operational events
- Accidents / abnormal operation:
    - Fire (fire in the technological facility or airplane crash into the silo)
    - Container drop
    - Explosion (terrorist attack or airplane crash)
    - Earthquake[1]
    - Flooding[2]

By phases: trial operation, operation, suspension of operations, standby phase, decommissioning phase and closure.

After closure of the repository:

Normal evolution scenario with sub-scenarios:

- Nominal scenario:
    - an alternative model of degradation of the engineered barriers, where the barriers fail in succession,
    - a biosphere without a well (all water required is taken from the river),
    - a biosphere in which water from the well is used to irrigate crops,
    - a biosphere in which water from the well is used to supply water for livestock.

Alternative development scenarios:

- early failure of engineered barriers,
- river meandering and surface erosion,
- inadvertent human intrusion,
- change to hydrological conditions.

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[1] considered as a design-basis earthquake
[2] flood-control measures (plateau)

All of the scenarios were analysed using appropriate models, through which the repository's impact on the environment and humans was assessed. The impact on employees and the population was analysed. In the case of construction of a second silo, construction will take place after the first silo is closed, so there will be no impact on workers during construction of the second silo from waste deposited in the first silo.

As part of the safety analyses and calculations an assessment was also made of the impact on other organisms (non-human biota). The results indicate that the impact of the repository on the organisms in question will be negligible, since the calculated doses are far below the recommended reference levels.

An assessment was also made of the impact of toxic metals mixed into the LILW and deposited together with it. It was determined that the expected, conservatively estimated releases of toxic metals from the repository are below the prescribed limits for drinking water.

The assessment from the safety analysis is that the planned LILW repository at the Vrbina location can be operated safely, and its impact after closure on the environment and humans will be below the prescribed limits.

The Draft Safety Analysis Report covers the LILW repository's lifecycle phases, which are in line with the Conceptual Design. [2] These are as follows:

- repository trial operation
- operation with operational limits and conditions (including standby phase)
- decommissioning of the repository
- closure of the repository and long-term monitoring

Trial operation of the repository is presented in Chapter 8 of this document. The purpose of the trial operation is to carry out tests of the operation of the constructed repository in order to verify and define the conformity of constructed facilities with approved design solutions and the required design conditions and at the same time the relevance of design solutions and operating procedures which address the use of these solutions, depending on the desired functions. It will be possible to remove, from the silo and from the repository, containers with waste placed in the disposal silo in the course of trial operation. Voids between the waste containers placed in the silos in the course of trial operation will not be filled with filler grout. Two years of trial operation are planned, during which 15 containers will be disposed of.

Operation of the LILW repository (Chapter 9 of this document) will be in compliance with the operational limits and conditions, which are divided into two sections:

- operational limits and conditions for safe operation, and
- acceptance criteria for disposal of radioactive waste

All waste will be conditioned for disposal at Krško NPP. The operation of the repository will be coordinated with the conditioning of LILW and with the plan of transport of LILW to the repository, which, in turn, will be coordinated with the LILW acceptance programme. The maximum annual capacity of the repository is 200 containers.

Disposal dynamics:

- construction (3 years)
- trial operation (2 years)
- from 2022 to the end of 2024 (operation at full capacity)
- transition to standby phase in 2025
- restarting of operation in 2050
- termination of operation and decommissioning in 2061
- closure of the repository in 2062

One of the repository operating states is the standby phase, [4] i.e. a repository phase in which acceptance and disposal of LILW is suspended for a period of time and only activities necessary to ensure safety, security and monitoring are carried out to an optimised extent.

Chapter 10 presents physical security at the Vrbina Krško LILW repository, which will be provided in order to prevent criminal offences that could constitute a threat to nuclear safety or enable the circulation of nuclear weapons or the unlawful use of nuclear materials, for which reason the operator of the nuclear facility must provide physical security for the facility.

The ZVISJV stipulates that an investor in a nuclear or radiation facility must enclose to the Safety Analysis Report a security plan as referred to in Article 119 of that act as a separate and confidential document in accordance with the regulations governing data confidentiality. It is logical that all of the design documentation containing details on physical and technical security be treated as confidential documents.

The repository operator (ARAO) is obliged to provide a security service. Security shall not be provided only for the nuclear facility, but also the general safety of persons and property (private security) in connection with facilities whose security is not provided by the state.

Physical security activities shall be carried out by security service staff – security officers. Security officers must undergo security screening, must be mentally and physically capable of carrying out their duties, and must be qualified to carry out general physical security and fire safety tasks as well as radiological practices in controlled radiation areas or with radiation emitters.

Chapter 11 presents the operational limits and conditions, and is divided into two sections. The first section presents and describes operational limits and conditions for safe operation and the definition of the applicability of operational limits and conditions, measures in case of non-compliance with operational limits and conditions and monitoring of parameters that are regulated by operational limits and conditions. These are summarised from the reference document Operational limits and conditions. [12]

The second section presents acceptance criteria for waste disposal, summarised from the reference document Acceptance criteria. [13]

The closure and decommissioning programme for the LILW repository are presented in chapters 12 and 16. After the termination of repository operations, the decommissioning, closure and long-term monitoring of the repository are planned. The chapter on decommissioning addresses the decommissioning of the repository only in the part that is not intended for disposal (technological facilities within the controlled radiation area) and covers in particular the decontamination and dismantling of equipment. The decommissioning activities relating directly to the disposal unit (silo) and construction elements, the associated mechanical and electrical systems, and decommissioning activities relating to non-radioactive waste at the repository, are addressed in Chapter 12 on the closure of the repository. Considering the planned procedures and activities for conditioning RW for disposal at Krško NPP, in accordance with the applicable acceptance criteria, monitoring of packages upon acceptance at and during RW transport to the repository, the planned operational activities at the LILW repository, the fact that only solid LILW will be brought to the repository, and in particular the fact that the area to be decommissioned in the non-disposal part of the repository is relatively small and contains little technological equipment, one can expect no emergency events to occur during the period of operation of the LILW repository that might result in major contamination of the technological part of the repository and its immediate surroundings. The decommissioning of the Vrbina Krško LILW repository will be conducted as a sequence of activities, firstly procedures for obtaining permits, including the drafting of documents, followed by decommissioning, including the emptying of the technological facility, continuous monitoring and measurement of contamination, and finally the dismantling of contaminated systems. Various additional final activities and the completion of decommissioning are envisaged after the decommissioning phase. The chapter on decommissioning also contains a description of the method for handling waste, the expected environmental impact, safety during decommissioning, decommissioning dynamics, and the documentation required for decommissioning, including the planning of preliminary works.

During the closure of the repository, all measures that must be carried out to ensure the long-term safety of the repository will be carried out. Following closure, the repository will acquire the status of a closed repository, for which long-term monitoring and maintenance must be provided. In the basic scenario, the decommissioning of the non-disposal facilities is planned to be carried out in 2061, and closure in 2062, when the disposal silo and the repository will be closed in accordance with the Repository Closure Programme. The sealing of voids in the silo will also be carried out during the closure of the repository. Waste generated from the decommissioning of the repository facilities will be conditioned for disposal in the hall. After the removal/disposal of all LILW, the hall, which will be decontaminated after the conditioning of the LILW from decommissioning, will also be dismantled, and any waste from the decontamination process will be disposed of as the final LILW.

Preparatory activities for the transition of the repository to long-term monitoring and maintenance will be carried out from 2063–2065, followed by active long-term monitoring and maintenance. The active long-term monitoring and maintenance phase is planned to last for 50 years, after which the repository will pass into the phase of passive long-term monitoring. The above-ground facilities of the repository will be removed or transferred to unrestricted use. The passive monitoring phase is planned to last a maximum of 250 years after the end of active long-term monitoring of the repository.

Chapter 13 presents the protection of workers at the LILW repository from radiation, which is addressed in the Radiation protection study for the compiling of the design documentation for the LILW repository at the Vrbina site. [2] Additional analysis and estimates of exposure during normal operation and during the potential operational events and accidents are provided in the document Safety Analysis and Waste Acceptance Criteria. [14]

A summary of the safety analyses, which includes exposure during operational events and accidents, is given in Chapter 7 of this Draft Safety Analysis Report.

According to the ZVISJV, [15] radiation protection is also addressed separately and additionally by the radiation protection assessment enclosed in the application for authorisation to pursue radiation practices. The radiation protection assessment will also be reviewed by a certified radiation protection expert. The assessment will be drawn up in accordance with the Rules on the conditions and methodology for assessing doses in the ionising radiation protection of workers and the public (SV5) [16] and will take account of all the key characteristics of the LILW repository. The radiation protection assessment will be drawn up in the next phase of preparation of the documents for the Safety Analysis Report for the LILW repository.

Chapter 14 of this report deals with emergency preparedness. The basic objectives of emergency preparedness are to prevent the further development of emergencies into radiological accidents, to limit risk and to protect the environment, the population and repository employees against any harmful consequences. LILW repository emergencies are events in which radiation safety is reduced and events that require action. Owing to the danger of an increased level of radiation or contamination of the working environment and of various surfaces at the repository with radioactive material and the spreading of the repository's radiological impact into the surrounding environment as a result of an emergency, remedial measures will be required. Emergencies are covered during the phase of operation of the LILW repository. The safety analyses for that period indicate that due to emergencies, radiation safety could be reduced to such extent as to require protective measures. In the safety analyses, which are summarised in Chapter 7 of this document, fire, container drops and explosions are recognised as repository emergencies. The scenario analyses have indicated that in the event of an emergency, the design of the disposal unit (silo) is sufficient to reduce the radiological impact on workers, the population and the environment below the legally defined limits. In addition to the aforementioned events, other emergencies are covered that could directly or indirectly impact radiation safety at the LILW repository (work accident, accident during transport, intrusion, sabotage, diversion, attack and similar events). At the time of the drafting of this document, the estimated level of threat to humans, animals, property, cultural heritage and the environment during natural and other disasters has not yet been determined for the repository, however, in view of the results of the safety analyses, we assume that the impacts outside the area will remain below the legally permissible levels.

The environmental aspects are presented in Chapter 15. The repository has been planned and laid out for the long-term storage of LILW.

Long-term safety of the repository will be ensured by means of a disposal system comprising:

- the repository site with the appropriate (chiefly hydrogeological) characteristics (siting of disposal facilities in a geological area with low water permeability);
- waste suitably conditioned for disposal (disposal of waste in a form that retards the discharge of radionuclides);
- disposal facilities (design solutions, materials);
- monitoring and surveillance of the repository.

Radiation practices shall be performed in such a way that discharges of liquid or gaseous radioactive waste into the environment do not exceed the limit values.

During the period of operations at the repository site, water will be collected from the silo in the collection tank in the lower part of the silo, water from the control point to be constructed in Phase 1 of the technological facility shall be collected in the control tank, and water from the reserve storage capacities (to be constructed in Phase 2 of the TF) in the floor drain sump (and surplus water from these two sources in the control pool). During normal operation, industrial waste water will appear only in the silo.

The likelihood of radioactive substances being contained in airborne discharges during operation is low and could only occur in the event of damage to a container and the radioactive waste management operations that would follow at the repository.

The (operational) radioactivity monitoring programme shall determine:

1. the discharge types (liquid, atmospheric),
2. the main pathways,
3. the radionuclides most responsible for exposure,
4. the monitoring of other required data, such as meteorological and hydrological data, land use data, or data on the dietary and other habits of the population.

An outer perimeter fence is proposed for the border of the restricted use area of the repository.

The restricted use area resulting from an LILW repository after closure is the broader area of controlled use, which is defined as a circle with a radius from the centre of the silo and clearance of 50 m from the silo, or a circle with a radius of 65 m from the centre of the silo.

The envisaged period of long-term monitoring is 300 years (after closure and preparation for long-term monitoring). During this period, access to the repository shall be controlled and the site will have to be maintained and monitored.

The Draft Safety Analysis Report is a part of the Environmental Impact Assessment, [17] in which the assessment of impacts on the environment relates to the phases of construction, operation and termination of activity, and the period following clearance. Due regard is given to the existing state, including the cumulative impacts. The description and assessment of the possible impacts include: the quality of the air, groundwater, surface waters, soil and agricultural land, nature, landscape, waste, noise, ionising radiation, electromagnetic radiation and light pollution.

A report titled Evaluation of Potential Doses at the Slovenia–Croatia Border [18] was produced to examine the impacts during the post-closure period of the repository as part of the safety analyses and waste acceptance criteria. The report addresses the spread of radionuclides through water, taking account of the surface waters (Sava river) under conditions of low sorption or the absence of sorption (radionuclide retention capacity) in the sediments. The environmental impact assessment concludes that these impacts are negligible, i.e. that there will be no cross-border impacts. Estimated doses of the population are max 0.1 μSv per year and are hundreds of times smaller than the natural background level.

The Draft Safety Analysis Report and the environmental impact assessment also propose environmental monitoring with an emphasis on radioactivity monitoring. Monitoring will be conducted in all time periods of the repository, including pre-operational, operational and post-operational monitoring. The limit values for potential discharges of solid, liquid and gaseous substances are also proposed.

The Draft Safety Analysis Report also defines the restricted use area due to the LILW repository and proposes a smaller restricted use area than that set out in point 5 of Article 3 of the UV3. [19] It follows from the Draft Safety Analysis Report (Chapter 7) that the doses received by persons present at the perimeter of the LILW repository would be considerably lower than those set out in Article 3 of the Decree on areas of restricted use due to nuclear facilities and on the conditions of construction (UV3), i.e. considerably lower than 250 mSv or a thyroid dose of 3 Sv. It is therefore proposed in the Draft Safety Analysis Report that the boundary of the restricted use area be the outer perimeter of the LILW repository.

All reference literature used in the drafting of the individual chapters of this Draft Safety Analysis Report is listed at the end of the individual chapters. Therefore no Chapter 17 of the Draft Safety Analysis Report, as proposed in the Practical Guidelines, was drafted.

The safety analyses under the report were conducted taking a graded and conservative approach. Data and methods were used in this phase that generate the maximally conservative estimate of the repository’s impact on humans and the environment. In subsequent phases or revisions of the Safety Analysis Report, more realistic estimates of the individual parameters will be used, which are expected to lead to an impact assessment that is even lower than the current one. Thus in the subsequent phases we are planning to use a more realistic definition of the parameters relating to the construction of the repository and the materials used therein, as well as the parameters regarding the characteristics of the individual waste streams. The site of the LILW repository is defined very precisely, and the unreliability of the associated parameters is therefore exceptionally low.

The Draft Safety Analysis Report with all of the accompanying documentation therefore demonstrates that the impact of the planned LILW repository on humans and the environment is negligible.

Recommendations, unresolved issues and major uncertainties that will have to be reduced in future revisions of the Safety Analysis Report

The following recommendations, unresolved issues and major uncertainties were identified during the drafting of the Draft Safety Analysis Report:

- In order to gain confidence in the meeting of the regulatory requirements in all of the subsequent phases it will be necessary to reduce uncertainties in the assumptions used in the models in the following areas:
    - disposed inventory
    - degradation of engineered barriers
    - categorisation of deposited waste
    - categorisation of site
- Throughout all phases verify alternative solutions in the areas of packaging of waste, repository design and operational practices that could improve safety at the repository.
- Increase awareness of the various forms of C-14 in the inventory, which will allow for less conservatism in modelling.
- Further characterisations are required in relation to Ca-41, which the analyses indicate as a significant radionuclide, particularly from the perspective of its chemical properties. It is highly likely that owing to the large quantities of stable calcium in the vicinity of the repository (due to the use of concrete) the impact (dosage) due to Ca-41 will be reduced.
- An additional phase of development and determination of acceptance criteria for disposal and the drafting of specifications for the disposal packages for the individual waste streams is required.

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