Radioactive Waste Management
2017

National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste

Extended Methodology for the Common Presentation of Data

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NEA No. 7371

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The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;
- to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD analyses in areas such as energy and the sustainable development of low-carbon economies.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

Cover photos: Radioactive waste storage (BfS, Menkhaus); Low-level radioactive waste disposal at the Nevada National Security Site, United States (NNSS).

Foreword

The OECD Nuclear Energy Agency (NEA) Expert Group on Waste Inventorying and Reporting Methodology (EGIRM) brings together senior representatives of national organisations with a broad knowledge of radioactive waste and spent nuclear fuel management issues resulting from their work as implementers, regulators and research and development experts, or policymakers. The expert group was established by the NEA Radioactive Waste Management Committee (RWMC) in 2014 to develop a methodology that would ensure consistency of national radioactive waste inventory data presented in a common scheme and provide the best achievable comparability of data in frameworks of international programmes and initiatives. The need to develop such a methodology arose in the context of a joint initiative of three organisations – the NEA, the International Atomic Energy Agency (IAEA) and the European Commission (EC) – entitled the "Status and Trends Project on Spent Fuel and Radioactive Waste".

The EGIRM was mandated to review the radioactive waste and spent fuel management strategies of NEA member countries with the goal of developing a common presenting format for national inventory data with relevance to radioactive waste and spent fuel management strategies that have been established in member countries. The expert group was thus tasked with developing a methodology to support the Status and Trends Project, which is planning to publish a global spent fuel and radioactive waste inventory. This report provides a presenting scheme and a methodology for spent nuclear fuel and for all types of radioactive waste that could be included in inventories worldwide. The methodology and presenting scheme was extended to all types of radioactive waste and corresponding management strategies in the second phase of the EGIRM work.

Acknowledgements

The NEA wishes to express its gratitude to the members of the Expert Group on Waste Inventorying and Reporting Methodology (EGIRM) for their efforts and the successful development of the methodology. The NEA also acknowledges the joint working group of the Status and Trends Project on Spent Fuel and Radioactive Waste that recognised the value of the proposed methodology and accepted it for the project objectives.

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1. Objectives

The NEA Expert Group on Waste Inventorying and Reporting Methodology (EGIRM) was established following a decision of the Radioactive Waste Management Committee (RWMC) at the 47th meeting in March 2014. In 2013, the "Status and Trends" Project on Spent Fuel and Radioactive Waste was initiated as a joint activity of three organisations – the Nuclear Energy Agency (NEA), the International Atomic Energy Agency (IAEA) and the European Commission (EC). The first meeting of the coordination group was held in January 2014.

The Status and Trends Project set out to establish an instrument that would provide a better understanding of the global picture of spent fuel (SF) and radioactive waste (RW) management, and the main contribution of the NEA would be to create a methodology that would help provide this understanding. The primary objectives specified in the mandate for this expert group were set out as follows:

- Develop a methodology to ensure consistency of national RW inventory data when it is included in a common presenting scheme (this scheme will be used only to compare and combine RW inventory data).
- Support NEA members in preparing their national report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (IAEA, 1997), as well as the European Directive 2011/70 (EU, 2011), with the above-mentioned method being used as a tool for the comparison and compilation of data.
- Propose the method mentioned above to be used as a tool for presenting SF/RW data when preparing publications in the context of the joint "Status and Trends" Project.

The expert group successfully performed the first stage of the work and presented the results to the RWMC at the 49th plenary meeting. The RWMC approved the developed methodology, its publication and extension of the mandate for the next two-year period. For the second stage, the RWMC agreed on the following EGIRM objectives:

- expanding the methodology to cover all national radioactive waste and spent fuel inventory data with relevance to all management strategies based on the disposal routes; testing of several inventories; proposal to the joint project "Status and Trends" for presenting radioactive waste and spent fuel data in publications;

- promoting the methodology among potential implementers (EC, IAEA and others) and supporting implementation when requested;
- providing proposals on harmonising, where possible and when it has high added value, of the national data reported to the joint "Status and Trends" Project (and, where possible, to other international programmes) and presented them with the developed methodology to provide better application of the methodology as a tool for presenting data;
- investigating possible methods to provide improved quality and flexibility of data to address the requirements of potential implementers, and developing relevant recommendations;
- studying the potential web-based version of the methodology and the presenting scheme to facilitate and unify the reporting process and further data aggregation for presenting data.

2. Background

The International Atomic Energy Agency (IAEA) published a safety guide on the classification of radioactive waste in 1994 (SS 111-G-1.1) to guide member states in developing their waste classification. In 2008, the SS 111-G-1.1 was revised and a new safety guide, the GSG-1 (IAEA, 2009), was issued. The GSG-1 sets out a general waste scheme for classifying radioactive waste primarily based on considerations of long-term safety, i.e. on the minimum appropriate disposal method. To collect or disseminate radioactive waste management information, the IAEA developed a Net-Enabled Waste Management Database (NEWMDB) for member countries to report their radioactive waste management data, including inventories, on a regular basis. To input the radioactive waste data into the NEWMDB, the IAEA proposed a Waste Classification Matrix and method to translate the radioactive waste inventory data from the current national radioactive waste classes into IAEA radioactive waste classes. Translation into a common classification scheme was necessary in order to aggregate the national inventory data in the NEWMDB.

In 2011, the European Commission issued Directive 2011/70 (EU, 2011), which requires all EU member countries to have a national radioactive waste classification scheme. At the end of the first stage of the EGIRM work (in September 2016) the first round of reporting under Directive 2011/70 had been performed by EC countries, and the EGIRM has taken into consideration the relevant outcomes of this activity at the second stage of the work.

There is a wide variety of national radioactive waste classification schemes established in most countries worldwide. While many of these schemes were developed using the IAEA's waste classification (i.e. GSG-1, SS 111-G-1.1) as a reference, only a few member countries have fully adopted the actual IAEA scheme (GSG-1) in their most recent waste classifications. This is a result of a variety of factors, such as the long-standing use of a different system and the logistical difficulties which would be encountered in switching to a new system.

The classification of radioactive waste proposed in the GSG-1 "is based on the long-term safety consideration in the first, and thus, by implication, disposal of the waste" (IAEA, 2009). The provision for the long-term safety of radioactive waste may be very different among member countries as it depends on various parameters which are often unique to each country and even to each repository. These differences may lead to significant uncertainties when comparing inventories among countries based only on long-term safety considerations. It appears that a combination of two approaches – transfer to the IAEA international scheme to compare inventories from the point of view of the safety and presentation in technical terms of the management strategy and disposal routes – can provide an optimal vision and comparability of national inventories.

There was a general consensus on the need to develop a method to transpose as best as possible the national radioactive waste (RW) classifications to a common RW presenting format in which the inventory data of countries can be compared. The developed method would focus on the technical aspects of the disposal stages to facilitate the inventory comparison. One more intention was to try to combine into one scheme both the SF and RW inventories and the management strategies in place within countries. It was pointed out that such a method should have no influence on the countries' existing RW classification schemes or SF/RW management strategies, but should be instrumental simply in comparing and understanding the different SF/RW management practices.

It is evident that RW classification and the qualitative and quantitative criteria significantly depend on the current short-term and long-term strategy of RW management in the country concerned, and on its nuclear infrastructure and regulatory practices.

3. Review of requirements for the methodology

The general objectives of the expert group were defined in the first stage mandate of the EGIRM and updated when the mandate was extended to provide a general understanding of the kind of methodology that should be developed. However, more detailed and concrete requirements for the methodology were necessary to provide clear technical limits, for the methodology and, at the same time, to establish an optimal level of quality for the presentation of data. Some requirements were formulated based on the previous review performed by the RWMC. EGIRM experts defined other requirements after an additional specific review of national programmes and during the development of requirements and objectives for the extended mandate. At the initial stage of work, the EGIRM performed a study of the background of national RW classification schemes in NEA member countries, the definition of the most important factors influencing the methodology concept and the determination of the form and method of implementation. The expert group also analysed goals addressed by the national RW classifications, criteria used for defining RW classes, numerical values of boundaries between RW classes, national management strategies, and disposal routes accepted in member countries for each RW class.

According to the first mandate objectives, the EGIRM focused on spent fuel (SF) and radioactive waste (RW) after reprocessing. At the second stage of work, the group finalised the methodology and considered all radioactive materials that could be classified as RW. During the analysis of the current situation in NEA countries, the main requirements were specified for the development of the methodology:

- The methodology should not replace the GSG-1 (IAEA, 2009) or provide any new radioactive waste (RW) classification scheme. It should only be an instrument for presenting, comparing and compiling (if necessary) data from different countries, and should work in conjunction with the GSG-1 and national classification schemes.
- The methodology should be a technically oriented tool based on the technical aspects of final disposal routes accepted in the countries.
- Taking into account a variety of management strategies for similar SF types and RW classes in member countries, the methodology should focus on decisions and strategies accepted in the countries for each RW class. Spent fuel management should also be covered, regardless of whether the country considers it to be waste or not.

- The methodology should define SF/RW groups (with subgroups where necessary) to provide a clear and unambiguous understanding of what type of SF/RW is in each group and which disposal strategy countries specified for the group. It should not focus on numerical boundaries between the different groups.
- The number of groups should be reasonably limited.
- The methodology should be straightforward and applicable to all existing national RW classification schemes. Countries with different SF/RW management should be given the opportunity to address their needs to present all kinds of radioactive materials considered RW including "legacy waste", problematic RW (polyvinyl, graphite, sodium, asbestos), different kinds of naturally occurring radioactive material (NORM), sealed sources and others. It should not require significant efforts from country representatives for the application (e.g. complicated recalculations or assessments) and should be intuitive and user-friendly.
- The methodology should use universal units for all SF types and RW classes and consider comparable forms of RW (e.g. solid [when possible], conditioned [when applied], ready for disposal). It should operate with clear and easy-to-understand definitions.
- The methodology should cover international SF/RW management activities (reprocessing, treatment, storage, etc.) and address the requirements of international binding documents (Joint Convention, EC 2011/70 Directive) to reporting national inventories.

The EGIRM successfully addressed these requirements at the first stage of the work focusing on the SF and after reprocessing RW management. Then, at the second stage of work, the EGIRM followed these requirements, extending the methodology to other RW classes. However, being in close contact and maintaining the dialogue with potential users of the methodology (IAEA, EC, WNA, etc.), the EGIRM added points to be addressed when completing the methodology:

- The methodology should have a reserve of flexibility and capacity to meet the needs of potential users. Such flexibility could be provided with added rows/columns or footnotes.
- To better address the needs of potential users, the methodology should be able to present the summary of past practices and the prognoses of SF/RW arisings and SF/RW management during future nuclear activities.

The following definitions were therefore developed for the methodology:

- The "servicer" is the country where the SF is reprocessed or where any other service is provided as per the international agreement.
- The "user" is the country that used the nuclear fuel (i.e. generates the spent fuel) and then sent it to the "servicer" as per international agreements for reprocessing (or any other particular service).

- "Nuclear power plants' spent fuel" (NPP's SF) is the fuel that was used in a reactor built and operated for the commercial production of electricity, extracted from the reactors and included in the national inventory. RW formed after reprocessing of such SF is also included in the methodology objectives for nuclear power plants.
- "Other reactors' spent fuel" is the fuel that was used in reactors built and operated for purposes other than commercial electricity production (such as science, medicine, transport, isotope production), extracted from the reactors and included in the national inventory. RW formed after reprocessing of such SF is also included in the group "other reactors".
- "Implementer" is an organisation responsible for implementation of a nuclear programme/project including developing, building and/or operating nuclear technologies/facilities.
- "Methodology user" is the national/international organisation/initiative/ programme that uses the methodology in its activity, a professional that uses the methodology for presenting inventory data (authorised when needed) or a person who uses it to study the national/international status of RW/SF management or to get a general understanding of the status (authorisation is not obligatory).

During later discussions with representatives from the IAEA, it was noted that the terms "servicer" and "user" could be revised to be consistent with the terminology accepted in the potential customer organisations.

4. Study of existing, relevant documents

The EGIRM studied a broad range of documents relevant to its objectives implemented currently or recently in international organisations. Work focused first on the collection and analysis of information about existing approaches on how to harmonise the presentation of national spent fuel (SF) and radioactive waste (RW) inventories and relevant types of disposal facilities. It was necessary to avoid any duplication of principles and content of the methodology with other methods/approaches and to assess the applicability of existing approaches for purposes of the EGIRM.

4.1. International Atomic Energy Agency (IAEA) and European Commission (EC) documents

The expert group reviewed and analysed the following documents of both agencies:

- Classification of Radioactive Waste, GSG-1 (IAEA, 2009);
- Classification of Radioactive Waste, SS 111-G-1.1 (IAEA, 1994);
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (IAEA, 1997);
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Guidelines regarding the Form and Structure of National Reports (IAEA, 2012);
- Specific Safety Requirements SSR-5 "Disposal of radioactive waste" (IAEA, 2011);
- Guidance on Translation of Member State Waste Classes for Purposes of Reporting Waste Inventories to the Net-enabled Waste Management Data Base (IAEA, 2010);
- Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste (EC, 2011);
- Final Guidelines for MS Reports to the Waste Directive HLG_p(2014-27)_137 (ENSREG, 2014);
- Application of the Concepts of Exclusion, Exemption and Clearance, RS-G-1.7 (IAEA, 2004).

The analysis of the documents listed above is given in the previous report of the EGIRM (NEA No. 7323, 2016). The key findings made by the EGIRM are presented here to remind the reader of the experts' observations on existing methods of harmonisation.

4.2. Observations in relation to EGIRM objectives

- Most NEA member countries have established actual RW classification schemes and systems of recording, inventorying and reporting of management issues related to RW inventories based on these schemes. Most countries have actual disposal routes or have taken general decisions on disposal routes for each class of RW established in their systems. The long-term safety of RW disposed of in related facilities is appropriately approved by regulatory bodies and is the responsibility of the individual member states.
- Most member countries have established management strategies for spent fuel of different types. In general, the disposal routes are specified according to the management strategy for SF or RW resulting after reprocessing.
- Different countries have developed their RW classification schemes focusing on various issues: safe and secure management (Canada, Sweden), the final disposal path (Czech Republic, France) or specific activity and lifetime (Poland). This can lead to some uncertainties when comparing data between countries based only on safety considerations.
- It is necessary to have a method that can ensure consistency of national RW inventory when it is put into a common presenting scheme and to provide the opportunity to compare as accurately as possible SF and RW inventory data from the point of view of the management strategy and the final disposal route. The method should be a supporting tool for the existing international RW classification to provide a better and more versatile analysis of the status, past situation or future arisings (when needed) and the relevant demand in repository capacities. It should be considered as an instrument for the given objectives, not as a new or independent RW classification scheme.
- There is an existing international approach to classifying RW based on long-term safety related to the final disposal solution – the IAEA's GSG-1. Classification, as described in the GSG-1, is accepted as a tool of harmonisation of national RW inventories by the EC and the IAEA for the Net-Enabled Waste Management Database (NEWMDB) programme. However, analysis has shown that the GSG-1 does not provide a tool for visualisation of the overall inventory and management strategy in aggregation. An additional presenting tool would be useful to support the implementation of the GSG-1 scheme for presenting SF and RW inventories.
- Requirements for reporting in the framework of the Joint Convention (IAEA, 1997) do not include the necessity to apply the GSG-1 provisions, and member countries are requested to provide the RW inventory data in their national classification scheme.

- For the EURATOM Directive 2011/70, the HLG_p(2014-27)_137 recommends the provision of the national RW inventory in a unified form and the GSG-1 scheme is given as a tool for unification. At the same time, the Directive encourages countries to provide information on RW amounts in direct relation to the accepted disposal route and to demonstrate the transboundary movement of the SF and RW according to international agreements.
- To apply the GSG-1 RW classification in the NEWMDB, its operators proposed guidance on transposition (translation) of the national classification into the GSG-1 scheme. The EGIRM has found this method not fully in line with the objectives of the expert group.
- For transferring national RW inventory data into the GSG-1 scheme, countries with no defined disposal routes are referred by default to the disposal strategy (route) described in IAEA documents. However, the strategy accepted for a given RW class can be quite different from country to country. Therefore, comparing the RW inventory data from various countries, it was difficult to describe the RW management in these countries adequately. One country can dispose of low-level waste (LLW) in near-surface facilities while another country decides to do so in a deep geological repository (DGR).
- It was, therefore, necessary to adapt to individual characteristics of the national RW classifications during the development of the methodology and provide an instrument acceptable for all users.

Some additional observations were made by the EGIRM studying the documents listed above from the point of view of harmonisation of requirements (recommendations) to national reports provided under the Joint Convention and EURATOM Directive. These observations are listed below:

- The developed methodology had to provide a good reserve of flexibility to be easily adaptable to the needs of different methodology users. The presenting table had to contain the reasonable recommended minimum of data from the point of view of the EGIRM. However, when the methodology user requested it, the methodology had to allow easy inclusion of additional information.
- The developed methodology had to allow for the presentation of different statuses of SF/RW management regarding time. This means that the user had to have the opportunity to present a kind of summary of past practices or future inventory and management status. The methodology had to be flexible to address different definitions of terms such as “past practice” or “practice in the past” and “forecast” or “prognosis”.
- The methodology would be more suitable for implementation when it could be included into existing web tools for data management. The EGIRM considered the IAEA NEWMDB as the most likely used tool for data collection.

5. Consideration of radioactive waste classes in NEA countries

5.1. Spent fuel and high-level waste

The methodology was developed as a universal tool and covers SF from different kinds of reactors (nuclear power plants [NPPs], research reactors [RR], transport reactors and others) and all radioactive materials that could be categorised as radioactive waste. It is necessary to bear in mind that NEA activities do not specifically cover any military applications, including SF and RW. However, provision should be made to accommodate all kinds of SF or RW classes being categorised in a country, including that of military applications when a country chooses to do so.

The EGIRM has analysed national considerations of SF and HLW and management strategies in member countries and presented its analysis and conclusions in the previous report *National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste: Methodology for Common Presentation of Data* (NEA, 2016).

5.2. Intermediate-level waste

For the methodology objectives, the EGIRM reviewed intermediate-level waste (ILW) as radioactive waste in terms of national classifications that correlates with the GSG-1 ILW. In general, the understanding of what constitutes ILW is similar among member countries and complies with the GSG-1. Some countries use numeric values of radionuclides concentration in their RW classification systems to define the lower and upper boundaries of ILW. These limits can differ from one country to another (see Table 1).

As can be seen from the table, member countries mostly use such criteria as heat emission, activity concentration (especially long-lived alpha radionuclides) and origin of RW. Sometimes the period of danger (i.e. half-life) was used as a criterion. Regarding disposal routes for this RW class, it is mostly the disposal of in underground facilities that is used. However, in some specific cases, the disposal of limited amounts of ILW in near-surface facilities can be considered possible as well in some countries, depending on the safety case for the disposal facility. There is a method of ILW disposal implemented only in Russia and in the United States (in the past) – the deep injection of liquid ILW into confined aquifers. Facilities of this type will be discussed further in this report. Sea dumping of ILW is discussed in Annex 1 as a past practice, which is now banned.

Table 1: ILW definition in NEA member countries

Country	Lower boundary LB	Upper boundary UB	Criteria
Australia	GSG-1	GSG-1	GSG-1
Austria	GSG-1	-	
Belgium	GSG-1	GSG-1	GSG-1
Canada	"significant" LL RN (α+β), $T_{1/2}$>30 years	HE= 2 kW/m^3	HE
Czech Republic	GSG-1	HE	HE
Denmark	-	-	-
Finland	100 MBq/kg (package) or 10 MBq/kg (room) after 500 years	(SF) high AC	AC
France	$1*10^6$ Bq/g	10^9 Bq/g (α+β)	AC
Germany	not separated from NHG RW	high AC; HE=200 W/m^3	AC+HE
Greece	not specified	-	-
Hungary	> 10^3 exemption activity concentration (EAC)	HE = 2 kW/m^3	HE
Iceland	-	-	-
Ireland	-	-	-
Italy	SL RN >5 Mb/g Ni^{59}-Ni^{63} >40 kBk/g LL RN >400 Bk/g	high AC (LL RN) HE	HE + AC (LL RN)
Japan	type of repository	type of repository	disposal route, origin
Korea	close to GSG-1	4 000 Bq/g (α), $T_{1/2}$=20 years, HE=2 kW/m^3	AC (α)+HE
Luxembourg	-	-	-
Mexico	danger after 300 years	danger after 500 years	time (origin)
Netherlands	$T_{1/2}$ >15 years	origin (after SF reprocessing + SF) + NHE	$T_{1/2}$ origin
Norway	(2 classifications combined – GSG-1 and old national)	(2 classifications combined – GSG-1 and old national)	-
Poland	10^4 x value < AC < 10^7 x value (EL)	AC > 10^7 x value (EL) for individual isotopes	AC
Portugal	-	-	-
Russia	Solid RW: AC 10^8 Bq/g (T^3); 10^4 Bq/g(β); 10^3 Bq/g(α); 10 Bq/g (TU); Liquid RW: 10^4 Bq/g (T^3); 10^3 Bq/g(β); 10^2 Bq/g(α); 10 Bq/g (TU)	Solid RW: 10^{11} Bq/g (T^3); 10^7 Bq/g(β); 10^6 Bq/g(α); 10^5 Bq/g (TU); Liquid RW: 10^8 Bq/g (T^3); 10^7 Bq/g(β); 10^6 Bq/g(α); 10^5 Bq/g (TU)	AC

Country	Lower boundary LB	Upper boundary UB	Criteria
Slovak Republic	AC>400 Bq/g LL RN (α)	HE	AC+HE
Slovenia	close to the GSG-1	close to the GSG-1	~ GSG-1
Spain	AC LL RN (α); $T_{1/2}$>30 years;	AC LL RN (α); $T_{1/2}$>30 years; HE	AC (α) +HE
Sweden	origin	SF	origin
Switzerland	not separated from LILW; AC 20 kBk/g (α)	origin	origin + AC
Turkey	not separated LILW	high AC; HE	Mix
United Kingdom	AC>4 GBq/te (α) or >12 GBq/te (β/γ)	Significant HE	HE
United States	AC>100 nCi/g (3 700 Bq/g) (α); "Greater than Class C" (GTCC); disposal route	not HLW (defined by origin of waste)	Mix

AC – activity concentration; HE – heat emitting; EL – exemption level; LILW – low and intermediate level waste; LL RN – long-lived radionuclide; NHE – no heat emitting; SL RN – short-lived radionuclide; TU – trans-Uranium.

The lower boundary for ILW defined in the GSG-1 as AC of 400 Bq/g on average (and up to 4 000 Bq/g for individual packages) for long-lived alpha emitting radionuclides.

The upper boundary is defined in the GSG-1 as the lower boundary for HLW-based on heat emission 2-20 kW/m^3 (total activity – 10^4-10^6 TBq/m^3 – 10^9-10^{11} Bq/g approx.)

5.3. Low-level waste and very low-level waste

For the methodology objectives, the EGIRM reviewed very low-level waste (VLLW) and low-level waste (LLW) as radioactive waste classes in terms of national classifications that correlate with the GSG-1 LLW and VLLW accordingly. LLW is not specified in this chapter because it falls between VLLW (when VLLW is a separate class in the national classification) and ILW or is the lowest class (when no VLLW is in the national classification). The upper boundary of VLLW coincides with the lower boundary for LLW in the first case or the lower boundary of VLLW is the same as for LLW in the second case. In both cases, the upper boundary for LLW coincides with the lower boundary for ILW, which is specified in the previous chapter. In general, the understanding of LLW and VLLW (when established as a separate class) in member countries corresponds to the GSG-1. However, there are some differences in the definition of boundaries of these RW categories in RW classification systems. The results of the review of LLW and VLLW definitions in national RW classifications are shown in Table 2.

Table 2: EW, VLLW and LLW definitions in NEA member countries

	EW		VLLW		Criteria for VLLW
Country	LB	UB	LB	UB	
Australia	-	RS-G-1.7	GSG-1	GSG-1	GSG-1
Austria	-	RS-G-1.7	*(LILW)	*(LILW)	SS 111-G-1.1
Belgium	-	RS-G-1.7	-	-	-
Canada	-	RS-G-1.7	*(LLW)	*(LLW)	-
Czech Republic	-	RS-G-1.7	*(LLW)	*(LLW)	NORM included
Denmark	-	RS-G-1.7	(LILW)	(LILW)	-
Finland	-	RS-G-1.7	*(LILW)	*(LILW)	may be released or recycled
France	-	- (mbc)	-	<100 Bq/g	AC
Germany	-	RS-G-1.7	*(NHG=LLW)	*(NHG=LLW)	-
Greece	-	RS-G-1.7			-
Hungary	-	RS-G-1.7	*(LLW)	*(LLW)	-
Iceland	-	-	-	-	-
Ireland	-	1 mSv/year	-	-	-
Italy	-	AC=1 Bq/g; $T_{1/2}$=75d	AC=1 Bq/g; $T_{1/2}$=75d	<10 years to reach clearance level; 100 Bq/g total; 10 Bq/g LL RN (α)	$T_{1/2}$
Japan	-	RS-G-1.7	RS-G-1.7	+	disposal route
Luxembourg	-		-	-	-
Mexico	-	-	-	+ ****	time <100 years
Netherlands	-	RS-G-1.7 **	-	-	-
Norway	-	RS-G-1.7	-	-	-
Poland	-	+ (national AC table)	-	-	-
Portugal	-	-	-	-	-
Korea	-	RS-G-1.7	-	-	-
Russia	+***	+***	+ ***	+ ***	AC

	EW		VLLW		Criteria for VLLW
Country	LB	UB	LB	UB	
Slovak Republic	-	RS-G-1.7	-	-	-
Slovenia	-	RS-G-1.7	*(LILW)	*(LILW)	-
Spain	-	-	-	+*	disposal route
Sweden	-	RS-G-1.7	RS-G-1.7	+	origin + disposal route
Switzerland	-	RS-G-1.7	-	-	-
Turkey	-	RS-G-1.7	RS-G-1.7	GSG-1	AC
United Kingdom	-	RS-G-1.7	RS-G-1.7	+*	complex criteria
United States	-	-* (mbc)	-	-	-

EW – exempt waste. AC – activity concentration; EL – exemption level; LILW – low and intermediate level waste; LL RN – long-lived radionuclide; SL RN – short-lived radionuclide; NHG LLW – no heat generating LLW (in German RW classification); NORM – naturally occurring radioactive material.

Lower boundary (LB) – none for EW;
Upper boundary (UB) for the Exemption Waste EW can be based on activity concentration values given in the RS-G-1.7 (IAEA)] is the lower boundary of VLLW (LLW). When EW or VLLW is not applied in the national inventory "-" is put in relevant cells, and "+" when there are specific criteria of definition, the relevant parameters are noted. UB for EW in the GSG-1 defined as AC given for radionuclides in the RS-G-1.7 (bulk RW amount).

Upper boundary (UB) for VLLW, when this class is established in the country, can be specified in accordance with recommendations given in the GSG-1 (IAEA) or with specific criteria. UB for VLLW in the GSG-1 defined as one or two orders of magnitude above the EL (for SL RN and limited total activity) – 10*EL-100*EL.

* – VLLW considered as subclass of LLW or LILW without the definition in the classification;

** – Exceptions are Ra-226, Ra-228 and Co-60. The clearance levels of these radionuclides that are applied in the Netherlands (1 Bq/g);

*** – specific values of activity concentrations (AC) (individual nuclides (in)/total, TU);

**** – subclass of LLW (class A);

- (mbc) – lower boundary is not specified, but may be considered in the future.

Member countries mostly use criteria such as activity concentration and origin of RW to specify VLLW and therefore LLW. Also, other criteria can be used to define LLW (see Table 1). Sometimes the period of radiological risk is used as a criterion. The disposal in near-surface facilities is mostly used for LLW and VLLW. VLLW is considered suitable for disposal in the NSF-2 while for LLW the NSF-1 (NSF-1 and NSF-2 are defined in Section 6.1) is more acceptable. However, in some countries, the disposal in underground facilities is the currently accepted practice. The method of deep injection of liquid RW into confined aquifers has also been implemented for LLW but only in Russia up to now and briefly in the United States in the past.

6. Disposal facilities

The methodology should provide a presentation of the national spent fuel (SF) and radioactive waste (RW) inventories with relevance to disposal strategies, and thus it was necessary to devise a survey on existing variants of the disposal facilities and the types of facilities used or planned for SF/RW disposal. Initially, the arrangement given in the IAEA documents was studied.

The EGIRM reviewed the description of disposal routes given in IAEA documents the GSG-1, (IAEA, 2009) and the SSR-5, (IAEA, 2011) during the first stage of the work and presented its observations in the first report (NEA, 2016).

Aggregation of disposal facilities according to their depth was recognised not suitable for purposes of the Expert Group on Waste Inventorying and Reporting Methodology (EGIRM). There is a lack of clearance for distinguishing the different types of repositories and terminology used in countries (e.g. an “intermediate depth” facility in one country could be deeper than a “deep” facility in another country).

Experts reviewed the variety of disposal routes being implemented currently or in the past in NEA countries as well.

During the second stage of methodology development, the EGIRM performed an additional study of this subject and reviewed other disposal routes including rare, specific and discontinued. The experts paid attention to specific disposal practices such as the following: disposal in boreholes, in situ disposal (entombment), conversion of storage facilities with non-removable RW into disposal facilities and others. More details are given below, and recommendations for aggregation of all specific disposal routes are provided.

The EGIRM addressed the requirement formulated for this aggregation that the number of proposed disposal facility categories should be as minimal as possible.

Following this requirement, the EGIRM specified four basic disposal routes that, in general, closely correspond to those described in IAEA documents. For specific disposal routes, three additional categories were proposed. Relevant cells can be added to the presenting table when a country deems it necessary.

6.1. Arrangement of disposal facilities (routes) for methodology objectives

A definition of the types of facilities (disposal routes) was developed and implemented in the first part of the methodology. The expert group formulated clear definitions for each disposal route to help the user to complete the table.

For SF to be reprocessed, the expert group provided a possibility to present the resulting RW. Taking into account the possibility that other categories apart from heat-emitting HLW might be formed, two subgroups were envisaged for RW after the reprocessing. As different values of heat emission are used in member countries, the EGIRM decided not to use any numeric values, but only indicate whether the heat emission is significant enough for consideration in the facility design in a given country. This decision permitted separation of underground facilities for the SF/HLW from underground facilities for other RW in this methodology. Thus, heat emission was as one of the criteria used for the definition of types of underground facilities.

The EGIRM developed the simplified and widely used definitions or features given below:

- facility position relative to the ground surface: underground, near surface, etc.;
- connection with the surface at the repository construction and operation stages and the technical solution used for such a connection (open air construction or connected with the surface through boreholes, shafts, ramps, etc.);
- application of the artificial engineered barriers on the side of the natural ones;
- limiting factors accounted in the repository design: heat emission due to radioactivity, package, physical state, etc.

All types of underground facilities for the disposal of SF and RW have several common features:

- position relative to the ground surface – underground;
- connection with the ground surface (stage of the repository lifetime and the technical solution) – connected to the ground surface through tunnels, shafts, boreholes or ramps, during construction and operation.

Also, the EGIRM used the following individual features:

- application of artificial engineered barriers on the side of the natural ones:
  - underground facility of the 1st type (UF-1) – multi-barrier principle of the highest engineering level (intensive application of artificial barriers), accounting for a high concentration of radionuclides including long-lived;
  - underground facility of the 2nd type (UF-2) – multi-barrier principle of engineering level (rather wide application of the artificial barriers) sufficient for the radionuclide concentration appropriate to ILW, including long-lived.
- limiting aspects accounted in the repository design include heat emission, package, physical state:

- UF-1 – for disposal of the SF/HLW + all others, solid, packaged (for SF/HLW/ILW), heat emission is considered in the design;
- UF-2 – for disposal of all RW classes except for SF/HLW, solid, and some RW can be without a package, and heat emission is not considered in the design.

Similarly, the near-surface facilities were defined.

Near-surface facilities (NSF):

- position relative to surface – near surface below or on the ground surface level;
- connection with the ground surface (stage of the repository lifetime and technical solution) – open air during construction and sometimes during operation (can be covered with weather shelter);
- application of artificial engineered barriers in addition to the natural ones:
  - near-surface facility of the 1st type (NSF-1) – multi-barrier principle with considerable engineering level (rather wide application of artificial barriers);
  - near-surface facility of the 2nd type (NSF-2) – multi-barrier principle with minimally reasonable engineering level (limited application of the artificial barriers).
- limiting aspects accounted in repository design include: heat emission, package, physical state:
  - NSF-1 – for disposal of solid, packaged (when necessary) RW, heat emission is not considered in the design;
  - NSF-2 – for disposal of solid RW, only simple packaging required (or none), heat emission is not considered in the design.

Thus, the EGIRM reviewed disposal options that are all widely accepted and recommended by the IAEA (SSR-5), arranged them into four types and gave clear and easy-to-understand descriptions for each of them.

Other disposal routes not widely implemented worldwide are discussed in Annex 1 where a group of such routes is introduced. The EGIRM also discussed some specific ways of RW disposal and suggested how to qualify them in the table.

Table 3: Arrangement of the disposal facilities for the objectives of the EGIRM

Type of facility	Features	RW classes (in terms of GSG-1) that can be disposed of	SSR-5 equivalent (1.14)
UF			
UF-1	- no direct, open connection with the surface during construction or operation stage (i.e. ramp, shaft or borehole access); - intensive application of artificial barriers; - heat emission is considered in design; - package for SF/HLW/ILW – yes.	SF; HLW; ILW; LLW; VLLW; (NORM; TENORM) – solid	Geological disposal
UF-2	- no direct, open connection with the surface during construction or operation stage (i.e. ramp, shaft or borehole access); - rather extensive application of artificial barriers; - heat emission is not considered in design; - package for ILW – yes.	ILW; LLW; VLLW; (NORM; TENORM)	Disposal on intermediate depth + geological disposal
NSF			
NSF-1	- open air at construction stage; sometimes also during operation; operation from the earth surface; - rather extensive application of artificial barriers; - heat emission is not considered in design; - package for ILW – yes.	ILW; LLW; VLLW; (NORM; TENORM)	Near-surface disposal + disposal on intermediate depth (particularly, when operated from the surface)
NSF-2	- open air at construction stage; sometimes also during operation; operation from the earth surface - minimally reasonable application of artificial barriers; - heat emission is not considered in design; - package for LLW – yes.	LLW; VLW; (NORM; TENORM)	Near-surface disposal; Landfilling
OTHER DISPOSAL ROUTES			
Other disposal routes are not included in the group of recommended and widely accepted types of disposal facilities. They are discussed in Annex 1.			

NORM – naturally occurring radioactive material for which no further use is foreseen.

TENORM – technologically enhanced naturally occurring radioactive material.

7. Methodology

7.1. The presenting scheme

The Expert Group on Waste Inventorying and Reporting Methodology (EGIRM) developed the presenting scheme as a format for presenting national spent fuel/radioactive waste (SF/RW) inventories in conjunction with the national strategy of each country for SF/RW management.

This scheme is a means to present the combined SF and RW inventory, as well as strategies for waste management related to disposal solutions, as established by the country. In other words, once completed by the country, this scheme presents the real picture of SF/RW management in the country during the period of reporting.

This scheme is also suitable for presenting forecasted future inventories and country strategies if needed.

The presenting scheme extended to all radioactive waste classes and all disposal routes is shown in Table 4.

Table 4: The presenting scheme

Spent fuel and radioactive waste inventory presentation

Country:____________________

Date of inventorying:____________

SF/RW types (in national terms)		No strategy	SF reprocessing/ service		Disposal in:								
			home	abroad	UF-1		UF-2		NSF-1		NSF-2		Others
(A)		(B)	(C1)	(C2)	(D1)	(D2)	(E1)	(E2)	(F1)	(F2)	(G1)	(G2)	→
1. SF + reprocessing RW													
1.1. NPP													
1.1.1. SF, [tHM]													
1.1.2 HLW (HG), [m³]													
1.1.3. RW (NHG), [m³]													
1.2. Other reactors													
1.2.1. SF, [tHM]													
1.2.2. HLW (HG), [m³]													
1.2.3. RW (NHG), [m³]													
2. Other HLW, [m³]													
3. ... class, [m3]													
4. ... class, [m3]													
Equivalence with IAEA GSG-1 classification	1.1.2	HLW	HLW	HLW	HLW								
	1.1.3												
	1.2.2	HLW	HLW	HLW	HLW								
	1.2.3												
	2.												
	3.												
	4.												
	5.												

The presented scheme size can be minimised when there is no need to separately present management of RW after SF reprocessing. The minimal format is given in Table 5.

Table 5: The presenting scheme (minimised)

Spent fuel and radioactive waste inventory presentation Country:____________ Date of inventorying:____________													
SF/RW types (in national terms)		No strategy	SF reprocessing/ service		Disposal in:								
			home	abroad	UF-1		UF-2		NSF-1		NSF-2		Others
(A)		(B)	(C1)	(C2)	(D1)	(D2)	(E1)	(E2)	(F1)	(F2)	(G1)	(G2)	→
1. SF													
1.1. NPP													
1.2. Other reactors													
2. HLW, [m³]													
3. … class, [m3]													
4. … class, [m3]													
Equivalence with IAEA GSG-1	2.	HLW	HLW	HLW	HLW								
	3.												
	4.												

7.2. Format of data presented

The recommendations on the presentation of data regarding units are:

- National SF (NPPs and other reactors) inventory data, presented in tHM.
- National RW inventory, as in the national classification, presented in cubic metres. When completing the table, a user should consider different parameters of RW in the inventory (m^3, "as is", "as disposed", physical status, stored and disposed of).
- National disused sealed radioactive sources (DSRS) inventory data, presented in pieces (when DSRSs are included in the inventory as separate kind of RW).

The user should make the final decision on the units for presenting the inventories according to objectives of the international programme. The EGIRM proposed the above-listed units as the most universal and comparable. Other parameters can be implemented by the international programme (e.g. specific activity, total activity). For addressing of such specific requirements, additional columns and rows can be inserted into the presenting scheme. However, new cells added to the table hinder its readability.

The EGIRM then developed the following recommendations needed for a better presentation of national inventories and management strategies:

- The matrix for transfer of national RW classification into GSG-1 terms (most countries applied it for the NEWMDB objectives) is a useful tool to present the correlation of national RW classes with the classification proposed by the GSG-1.

- National strategy on SF management should be an officially stated decision of a level as high as required in the country (law, governmental decree, state programme and other kinds of decisions).
- For the objectives of the methodology, the national strategy on RW management related to the final stage – disposal (disposal routes for the RW classes) – is the one that is officially established in the country. An absence of a strategy for some kinds of RW in the context of reporting should also be noted and presented in the Column B of the table.
- International agreements signed by the country regarding reprocessing or other kinds of services for SF (or treatment of RW) abroad/from abroad are also to be considered. Amounts of SF or RW being the subject of such agreements should be presented in the table. International programmes usually establish the level of details for presenting such SF and RW. The EGIRM further gives recommendations on how to present international SF/RW management activities; however, the methodology is rather flexible to address each level of detail required by the potential user.

To provide adequate comparability of data, the EGIRM has recommended that countries present volumes of the conditioned, (ready for disposal) RW in the corresponding table cells. When countries have RW in non-conditioned forms, the recalculation from “as is” into “as disposed” volume is recommended. The packaging factor should be accounted for during recalculation of volumes. From the point of view of the repository features, the real volume to be disposed of has a value for the assessment of capacity.

When the presenting of “as disposed” volume is onerous or impossible for different reasons, a given part of RW in the “as is” form can be presented. Such “as is” volume should be included in a total volume in the relevant cell of the table. A proper explanation of “as is” and “as disposed” portions in this cell can be given in the footnote.

The same approach could be used when RW exists, for example, in liquid form, since currently recalculation of volumes is impossible or leads to significant uncertainties, or the packaging factor cannot be adequately accounted for.

When SF from nuclear power plants (NPPs) and other reactors, and in turn RW after reprocessing, are included in the inventory mixed, a country should make the relevant decision on where to put the SF/RW amount – in the lines under “1” or “2”. An explanatory footnote should accompany this amount.

7.3. International service on spent fuel or radioactive waste management

Four options for SF management in another country are possible:

- send SF for the reprocessing, and resulting RW to be left in the country of ”servicer”;
- send SF for direct disposal of in the country of the fuel’s origin (service);

- send SF for reprocessing, and the resulting RW to be sent back to the country of SF origin (“user”);
- send SF for the long-term storage awaiting a strategy (repository) and then send back to the country of origin.

When SF is reprocessed, the resulting RW can be left in the country of the “servicer”, sent back to the country of the “user” or, theoretically, sent to a third country.

The presentation of SF being reprocessed or getting another service in another country is explained in detail, and relevant cells in the table are noted below, in the methodology of the scheme’s application.

The Joint Convention (IAEA, 1997) and the EC 2011/70 Directive (EU, 2011) require member countries to report SF/RW that is the subject of international agreements on the provision of service (reprocessing). To provide a traceability of the international SF/RW management per requirements, both parties of the agreement can present on the table the amount of SF stored abroad awaiting reprocessing, as well as RW to be sent back to the country of origin. The format of data presenting is recommended to be put in accordance with reporting requirements of the programme.

When it is necessary to provide information about the initial amount of SF sent abroad or RW to be sent back to the country of origin, it is recommended that countries give a brief explanation in the footnote.

When countries need to provide information about RW/SF management in the past, they can present it in the separate table of the same format according to reporting requirements of international programmes.

When countries are asked to provide a future prognosis, they can present SF waiting reprocessing abroad and RW to be sent back at a future date specified in the separate table.

For other kinds of international service, the same method of reporting is recommended. Countries that are parties to an agreement should include SF/RW in the cells of the table dedicated to the service.

For direct SF/RW disposal abroad (when the relevant agreement exists), countries should use the cells in column D for “servicer” and cells in column C2 for “user” until SF/RW is included in the inventory in “user”. Both parties should mark this SF/RW with a relevant explanation in a footnote.

For long-term storage of SF/RW abroad, countries should use cells in column B for “servicer” and cells in column C2 for “user” until SF/RW is included in the inventory in “user”. Both parties should include an explanatory footnote for this SF/RW.

7.4. Completing the table

All quantities of SF/RW should be reported according to the actual situation in the country’s inventory on the reference date of reporting.

Before completing the table, it makes sense to compare the national types of disposal facilities with the arrangement proposed for this methodology and assign the national facilities to the types established for this methodology. This should not require lots of effort as the facility arrangement in the methodology is based on straightforward criteria.

The purpose and recommendations for completion of the table are given for each line and row in the table. Following this methodology, the table can be completed, and then it can be used each time when needed to show the current national status in SF/RW management for the period until the next national inventorying.

An example of the table populated for a hypothetical national RW/SF inventory (Country X) is given in Annex 2 and followed with explanations on how to read it.

Column (A)

In column (A), a country should list all classes of RW existing in the country (starting from the line [3.] and below) as in the national classification.

Row (1.) "SF + reprocessing RW" including rows (1.1 and 1.2) and sub-rows is fixed for this table and should not be changed. When a country does not have any NPP (or other) SF, then the country should input 0 ("zero") in the relevant lines. The sub-rows (1.1.1; 1.1.2; 1.1.3 and 1.2.1; 1.2.2; 1.2.3) are also included in the table to provide presenting of management of RW after SF reprocessing (especially international SF/RW management). However, when presenting of such RW is not required (needed), these sub-rows could be excluded (see Table 5) and volumes of RW after SF reprocessing added to RW in relevant cells of rows "2" and lower. Explanations can be given in a footnote when necessary.

Row (2.) "Other HLW" is for other (not related to the SF reprocessing) HLW that could be categorised in the country. When such HLW has another title, it should be specified instead of "other HLW". When HLW after SF reprocessing is entered in this line, it should be titled "HLW" (another national title of HLW). When there is no RW class considered HLW in a country, the next lower RW class should be put into this row.

Other rows (3, 4, 5, 6, etc.) are for all RW classes established in a national classification and for all types of DSRS when they are categorised as a separate waste class.

The last row of the table "Equivalence with the IAEA's GSG-1 classification (type)" shows where the respective waste classes (as in GSG-1) fall within the presentation scheme matrix. When several RW classes are to be disposed of in a facility of one type (i.e. put in one column of the table), one should put all equivalent GSG-1 classes on the relevant cell in the lines given in sub-rows in order of appearance from top to bottom. Equivalent classes as those in the GSG-1 can be defined based on the national NEWMDB transfer matrix.

Column (B)

Column (B) is provided to input SF or RW for which there is no currently defined strategy. It could be SF/RW placed into a long-term storage facility and awaiting a decision. It could also include the SF/RW collected because of past activities (for example, former reprocessing of research reactor fuel) and currently stored in the storage facilities or the places of origin without a long-term management strategy. Since much of such RW may not be conditioned yet, it is acceptable to input this RW in the form of "as is" (raw or stored volume) with the relevant footnotes.

Important: SF or RW currently stored awaiting reprocessing/disposal should not be put into Column (B), since it has a defined strategy.

Column (C)

Column (C) is provided to input all SF to be reprocessed, and the resulting RW from SF that has been reprocessed, including SF, sent abroad (for reprocessing or another service) following the provisions of an international agreement. Column (C) is divided into the two sub-columns (C1) and (C2).

Column (C1) is provided to input all SF to be reprocessed. This should also include the SF "imported" from the "user" countries and included into the national inventory of the "servicer" country. In the case where the "servicer" provides another service to the "user", the amount of SF is to be put in other relevant columns.

It is important to note that any RW obtained because of the SF reprocessing, stored and included into inventory currently at the "servicer" country with the intention to be sent back to the "user" country (later) should be put into the cells of this sub-column by the "servicer" country.

For better understanding of the information in this sub-column, it is proposed that the "servicer" country presents the amount of SF as a sum where components are their own SF and imported from the "user" countries. A breakdown of this sum by countries is recommended to be put into a footnote with countries' codes top-level domain (ccTLD), for example, Fr for France. The same is proposed for RW intended to be sent back to the "user" countries.

The "user" country inputs its own SF to be reprocessed abroad (in the future), while being stored and included in the inventory in their (i.e. "user") country, within this sub-column.

A relevant reference on agreement and the role of the reporting country ("servicer" or "user") can be provided in the footnotes.

Column (C2) is provided to input SF currently sent for reprocessing or other service, and RW sent for the service abroad and reflects what is currently stored and included in the inventory in the "servicer" country. This quantity of SF is to be input by the "user" country and each kind of RW sent abroad for the service into the relevant cells. SF/RW sent for different kinds of service should be marked (superscript markers), and an explanation of the service type should be given in the footnotes.

Also, the "user" country should include in the relevant cells of this sub-column RW obtained after SF reprocessing, included into inventory to the date of reporting and to be returned to the "user". RW sent for any service (treatment, storage, etc.) should be presented separately from RW after SF reprocessing, marked relatively and explanations should be given in footnotes.

When the “user” country has sent its SF or country has sent RW to several “servicer” countries, SF/RW should be presented as a sum (see above). The same should be done for the RW obtained and to be returned by the “servicer” countries.

Hence, the sub-column (C2) is only valid for countries that have an international agreement on reprocessing (or another service) of SF as a “user” country or any service on RW and have sent the SF/RW abroad. A relevant reference on agreement and the role of the reporting country (“user”) can be provided in the footnotes.

Column (D)

Column (D) is provided to input SF that is to be directly disposed of, HLW and other RW decided to be disposed of in a UF-1 facility. Column (D) is divided into the two sub-columns (D1) and (D2).

Column (D1) is provided to input SF from NPPs (row – 1.1.1.) and other reactors (row – 1.2.1.) to be directly disposed of according to the decided strategy. Since the UF-1 is the only acceptable path to dispose of SF and HLW, the HLW amount is anticipated to be also put into relevant cells of this sub-column.

Important: the SF/RW currently being stored awaiting a disposal facility UF-1 should be put into (D1).

When a country decides to dispose of other types of RW (from HLW to VLLW) in the UF-1, they should all be put into the relevant cells of (D1). It is preferred that all RW amounts should be input in the form of “as disposed”.

Column (D2) is provided to input SF/HLW amounts or other waste that are already disposed of in the UF-1 facilities. Since there are no operating UF-1 facilities (for SF or HLW), this sub-column is highlighted and should not be completed until the UF-1 is implemented.

Column (E)

Column (E) is provided to input all RW to be disposed of and already disposed of in a UF-2.

Column (E1) is provided to input RW to be disposed of in a UF-2 facility. Each RW class, except HLW (HE) and SF, can be put into the relevant cell of (E) if, according to the decided strategy, if it is to be disposed of in a UF-2. It is preferred that all the RW amounts should be input in the form of “as disposed”.

Column (E2) is provided to input the RW amounts that have already been disposed of in a UF-2 facility. As an example of a UF-2, the WIPP facility in the United States, the Batapaati facility in Hungary or the SFR facility in Sweden could be mentioned.

Column (F)

Column (F) is provided to input RW to be disposed of and already disposed of in a NSF-1 facility.

Column (F1) is a specific column provided to input the RW amount to be disposed of in an NSF-1 facility. Typically, this type of facility is used to dispose of LLW and lower classes. However, when a country decides to dispose of ILW (normally only LLW) in the NSF-1, it should be put in this sub-column.

The RW amount is preferred to be presented in “as disposed” form.

Column (F2) is given to input RW already disposed of in the NSF-1 facilities.

As an example of such a facility, Centre de l’Aube in France, El Cabril in Spain or Rokkasho in Japan could be used.

Column (G)

Column (G) is provided to input RW to be disposed of and already disposed of in an NSF-2 facility.

Column (G1) is a specific column provided to input the RW amount to be disposed of in an NSF-2 facility. Typically, this type of facility is used to dispose of VLLW. However, when a country decides to dispose of LLW (normally VLLW) in the NSF-2, it should be put in this sub-column.

The RW amount can be presented in “as is” form.

Column (G2) is given to input RW already disposed of in the NSF-2 facilities.

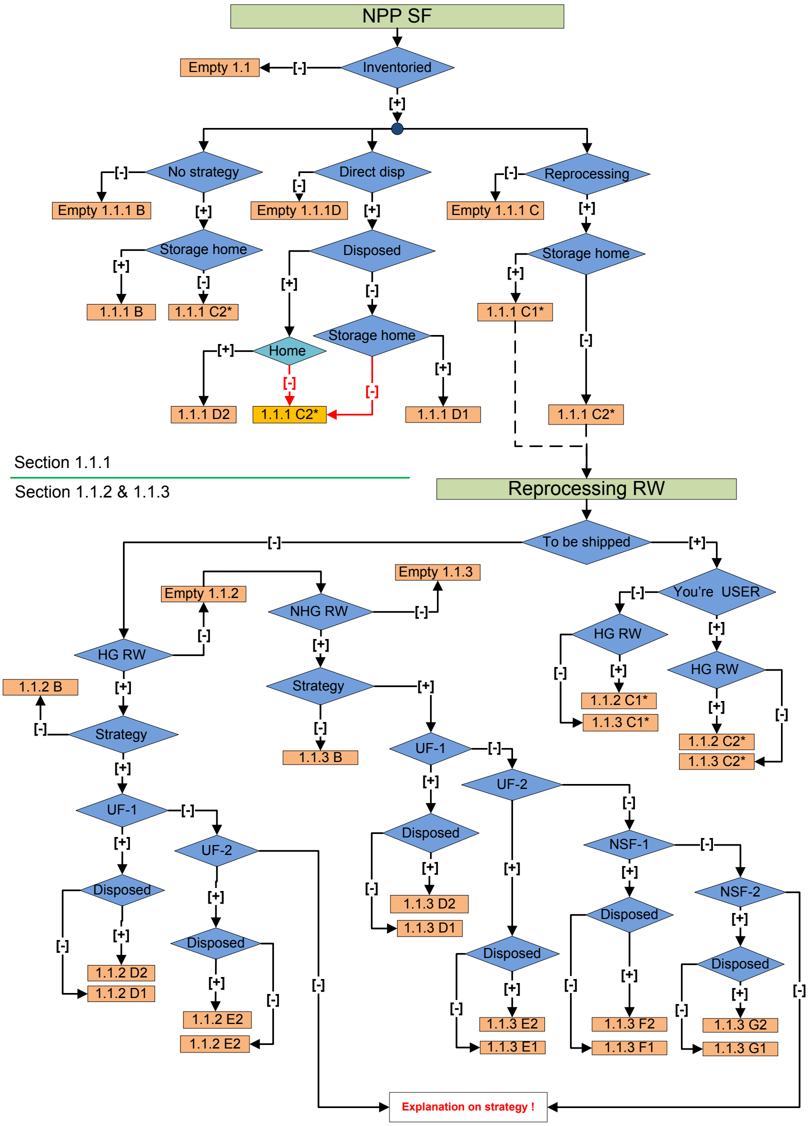
As an example of such a facility, Morvilliers in France, El Cabril in Spain (facility for disposal of VLLW) could be used.

7.5. Flowcharts for completion of the table

To facilitate the process of completing the table, block diagrams (flowcharts) were developed to outline the process to define the cell for a given kind of SF/RW.

Three variants of the flowchart are given below. One is for NPPs’ SF and RW after reprocessing. The second is for SF and RW after reprocessing from other reactors. And the third is for other RW classes and DSRS types (See Figure 1, Figure 2 and Figure 3, respectively).

Figure 1: Flowchart for NPPs' SF and RW after reprocessing



In both flowcharts, Figure 1 and Figure 2, the area over the green line is for the presenting of SF management (1.1.1. and 1.2.1), and below this line, the cells are specified for the presenting of RW after reprocessing management in format "line – column" (1.1.2. D1). In the third flowchart, Figure 3, the steps are given for the distribution of RW amounts into proper cells. When the minimised format of the table (Table 5) is used, the flowcharts (Figure 1 and Figure 2) should be used only in relevance to SF management (over the green lines in the flowcharts). The RW after SF reprocessing should be presented as part of summary RW volumes and distributed in the table as recommended in the flowchart Figure 3.

- "-" means "no".
- "+" means "yes".

Figure 2: Flowchart for other reactors' SF and RW after reprocessing

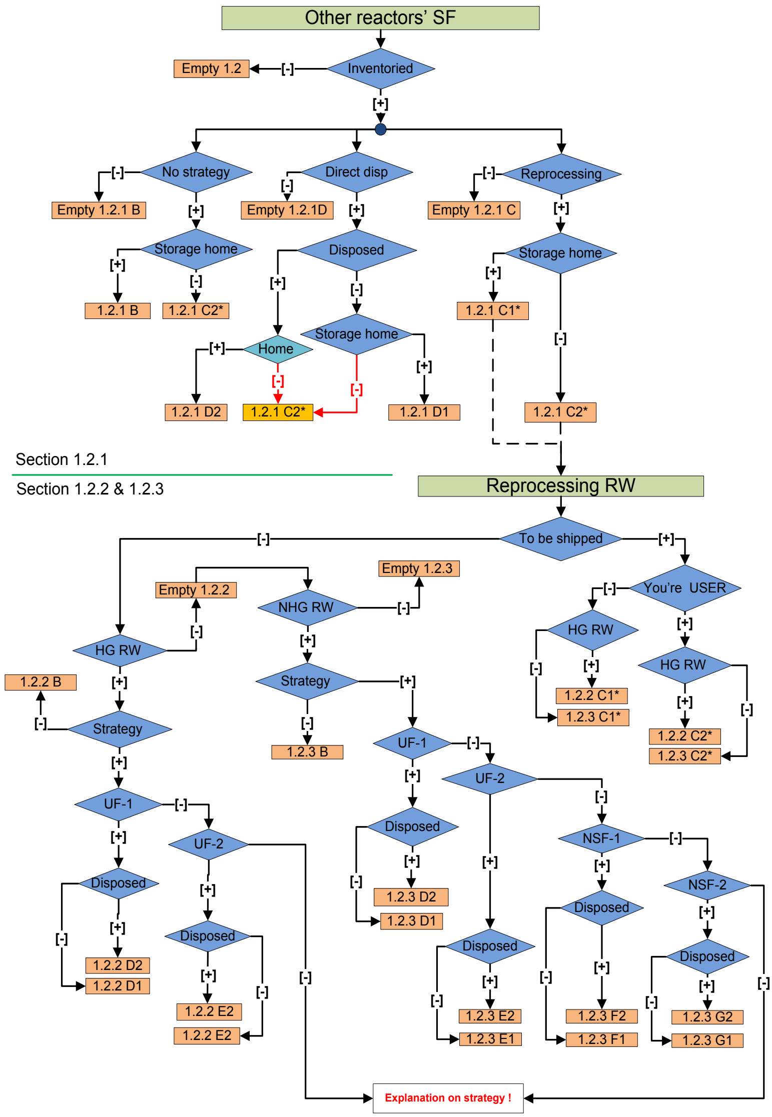
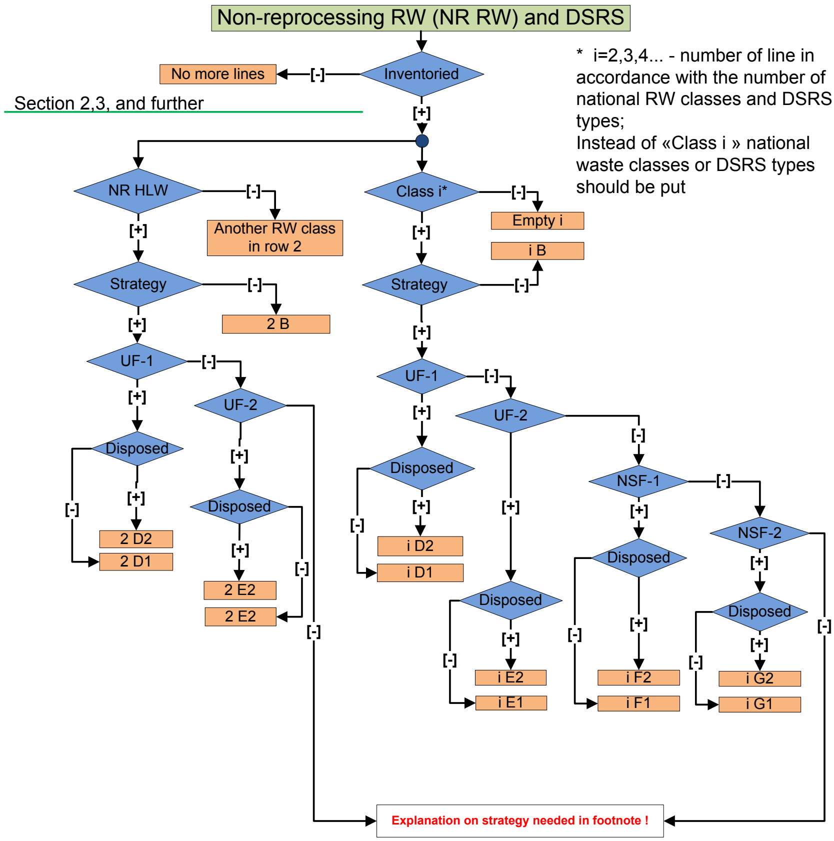


Figure 3: Flowchart for non-reprocessing RW classes and DSRS*



Note: Those national RW classes, for which their disposal is out of this scheme and for which the optional columns are provided in the table, are not considered in this diagram. These RW volumes should be put in relevant cells in optional columns (raws).

* When the minimised table is used, this flowchart is also for distribution of RW after SF reprocessing.

8. Testing of the methodology

After completing of the methodology and the presentation scheme proposed by the Expert Group on Inventorying and Reporting Methodology (EGIRM), testing of the methodology has been performed. Earlier, after the first stage, EGIRM participants tested the methodology and completed the scheme with data related to the spent fuel (SF) and radioactive waste (RW) management in their respective countries.

The methodology was then extended to all amounts of SF and RW, following to the decision by the Radioactive Waste Management Committee (RWMC), and the second round of testing was proposed.

The methodology was tested on national programmes of different sizes. Expert group members from Belgium, Canada, France, Germany, Italy, Russia and the United States applied the methodology and presenting scheme to reflect the situation with SF/RW management in their countries.

Results of testing were collected and analysed by the experts and the expert group then performed an update of the methodology. One of the objectives of this testing was also to determine what problems or difficulties the methodology user might encounter when filling out the scheme.

The main observations made during the testing of the methodology were:

- the methodology works well for SF and RW inventories of countries with a broad diversity of nuclear programmes for all kinds of radioactive materials included in the inventory as RW;
- all kinds of current, past and foreseeable national SF and RW management strategies can be presented by means the methodology;
- a good capacity to improve clarity was provided through footnotes, where experts gave brief, essential explanations about the content of cells marked by numbers in superscript;
- to address more advanced needs of potential users for presenting inventories and strategies, the EGIRM provided specific extended forms of the presenting table where more information could be presented in additional cells (a table in Excel format);
- some difficulties were noted during the testing of the methodology for the future status of SF/RW management; these challenges were mostly connected to the fact that not all parameters of SF/RW management have been established in countries over an extended period of time (2030 and 2050).

The testing demonstrated good workability of the developed scheme and methodology. The form of the presenting scheme was designed to address all possible scenarios of SF and RW management, including those that are not currently implemented. The ability to cover all types of SF and RW was also confirmed. Flowcharts developed and included into the methodology for all categories of SF and RW provided additional understanding on how to complete the cells of the presenting scheme. The text of the methodology was reviewed by the experts to be entirely consistent with the extension of the methodology.

9. Benefits of implementation and potential users

During the methodology development process, members of the Expert Group on Waste Inventorying and Reporting Methodology (EGIRM) considered the benefits that countries can receive after the implementation of the developed table and methodology. The list of potential benefits was presented in the first report of the EGIRM. However, during the second stage of work, experts considered the subject once again. Given the importance of understanding the benefits brought by the implementation of the methodology, it seemed necessary to take a second look for this report.

Detailed below is the reviewed list of potential benefits for users:

- The presentation scheme (table) provides the most comprehensive view of spent fuel/radioactive waste (SF/RW) management in a given country. A populated table can be included in the national inventory as a simplified, consistent format of information about SF/RW management in a country.
- A table populated by a country can be used for reporting in different international programmes (as required by the Joint Convention [IAEA, 1997] and EC Directive [EU, 2011]) as an illustration of the status of SF/RW management in the country during the established periods between the updates of the national inventory.
- The table provides a clear overview of SF/RW management, better visibility and understanding of the SF/RW management status in time – past, present and future (separate table for each point). It could also be useful as a tool for tracking the transboundary movement of SF/RW and for monitoring of the progress of international SF/RW management services, facilitating identification of uncertainties related to the lack of communication between the parties of an international agreement.
- The table combines SF and RW inventories and presents them through diverse national management strategies.
- The table and methodology can be used for compilation and aggregation of data from different countries on different levels. The developed table could be applied as an integral form able to facilitate comparing SF/RW management with the situation in other countries (regions, organisations, etc.). It could also be proposed as one of the forms to be completed during national inventorying by all RW producers (owners).

- The table can be useful for national and international experts as:
  - an official source of information presented in a standardised format;
  - a useful tool and reference for analysis of the national situation, implementation for national reporting under the international programmes (Joint Convention, EC Directive, international conferences, symposiums, etc.);
  - an easy way to compare their own SF/RW management approaches with other countries on different levels (individual, group, region, organisation, global) to develop adequate proposals to government, national strategies and programmes including economic, management, infrastructural planning;
  - a tool for the facilitation of an international dialogue among experts, as well as among stakeholders inside a country.

For international programmes and initiatives (Joint Convention, EC Directive, Status and Trends Project, the NEA *Nuclear Energy Data*, etc.), this table and methodology can be useful for the following reasons:

- the methodology will be proposed to international organisations such as the IAEA and the EC as an addition to the GSG-1 tool for better harmonisation and unification of national and international SF/RW inventory data;
- in 2017, the Status and Trends Project reviewed the NEA proposal, accepted the methodology and included the presenting table into the template of the national profile for the second round of reporting;
- the methodology and table can be an instrument of a harmonisation process for reporting under the Joint Convention and EURATOM Directive 2011/70;
- the table and methodology provide better comparability of inventories and management strategies accepted in different countries; data given in one table can provide a general view of the real situation in a country regarding management of all kinds of SF, RW and disused sealed radioactive sources (DSRS);
- the table and methodology can present a compilation and aggregation of data from countries on different levels and in different time frames (the past, present or future); integral tables presenting the analysis in initiatives such as the Status and Trends Project can be created based on the methodology;
- if used in the national reports for international programmes and initiatives, the table will provide consistency and unambiguity of national data.

The EGIRM also attempted to specify the circle of potential users of the table. The following groups of users were defined as interested in such a tool:

- state decision makers – to have the full picture of SF/RW management in their own country and in others (when needed) in a comparable format;
- national experts (implementer of the nuclear programme (project), regulator, researcher, etc.) – to have one referable source of information given in a common format;
- international experts – to make an analysis of international practices; find trends, common and specific features of SF/RW management and to specify "best practices";
- environmental specialists – to be consistent with "official" data in their analysis and dialogue with implementers;
- non-technical stakeholders (citizens, communities, local authorities, etc.) – to understand the situation in a country and to have consistent data for the dialogue with implementers.

10. Conclusions

At the second stage of work, the Expert Group on Waste Inventorying and Reporting Methodology (EGIRM) completed the methodology development in accordance with the mandate and programme of work established by the Radioactive Waste Management Committee (RWMC). The presenting scheme focuses on spent fuel (SF) and all types of radioactive materials that can be included in national inventories as RW.

The methodology covers all existing strategies for the management of SF, all RW classes and international activities on SF reprocessing and RW treatment.

The EGIRM used unified units, forms and notations to allow comparability of national inventory data as much as possible. The EGIRM successfully combined in one form the options for presenting the SF inventory as well the RW inventory. Both inventories are presented in a scheme in direct relevance with the disposal strategy for each type of SF/RW.

To facilitate the use of the presenting scheme, the EGIRM developed the detailed instructions on how to fill in the table. The table can be easily completed manually or generated automatically from most databases with little programming effort.

For the methodology objectives, the EGIRM has developed the arrangement of disposal facilities by types. This arrangement is based on simple and clear technical features that allow quick and unambiguous attribution of the national types of facilities to the proposed common arrangement.

The EGIRM developed the presenting scheme and methodology as a useful and additional tool to support international programmes in the collection and aggregation of the national SF/RW data. Based narrowly on the technical aspects of SF/RW management (especially the disposal stage), the methodology can provide an additional opportunity to harmonise and present the national data in the framework of each international programme.

EGIRM members and some volunteering countries have tested the methodology on their national inventories. The testing demonstrated the methodology's workability in a broad range of programmes, strategies and classifications.

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Annex 1: Other disposal routes

Additional disposal facilities (routes) categories for the table

During the methodology extension phase, the EGIRM noted the need to pay attention to some specific disposal concepts. To be universal, the methodology should also address the needs of countries to present radioactive waste that is disposed of or is planned to be disposed of with the implementation of unique approaches. For example, there is one specific method of disposal that has been implemented for a long period in only one country and briefly used in another country (Russia and the United States, respectively) – i.e. a method of deep injection of liquid LLW and ILW into confined aquifers. The method is recognised as a practice of RW disposal in Russia and is now implemented in three sites. From 2011, the law "on radioactive waste management" prohibits development and implementation of this technology for RW management in new sites.

Technically this approach might be attributed to the practice of RW disposal in underground facilities: UF-1 and UF-2. However, it is necessary to take into account the physical status of RW (liquid with no package) and specificities of the underground disposal area (no artificial safety barriers underground). Thus, for this approach, the EGIRM proposed to introduce a particular type – BH (boreholes for liquid waste injection).

Additionally, the EGIRM has discussed the disposal of solid RW in different types of boreholes and selected two options:

- currently being implemented in some countries, disposal in boreholes with depth between tens and hundreds of metres; these boreholes are used to dispose of DSRS, LLW or ILW;
- currently being considered (in the United States, for example) concept of disposal in deep boreholes with the depth of more than a thousand metres; this concept is considered for possible disposal of HLW or SF.

The EGIRM introduced a group of disposal approaches that are characterised by the absence of limited excavated underground area for emplacement of RW:

- BH-1 – boreholes for disposal of non-heat-generating RW (DSRS, ILW/LLW when accepted in country) without intention to dispose of heat-generating RW;
- BH-2 – boreholes (deep) for disposal of heat-generating RW (HLW/SF); heat generation of RW is considered in the design of facilities; currently this option is not implemented;

- BH-3 – the route with the use of boreholes for injection of LLW and ILW into confined aquifers, liquid, without a package, and heat emission due to radioactivity is not considered during placement (heat generation due to chemical processes is considered).

The proposed approach allows for the presentation of specific types of disposal practices in additional groups of columns in the table. These columns can be added to the table when it is necessary or required by the programme. An initial requirement of the methodology was to propose the reasonably minimal number of categories in the presenting scheme, and this requirement was addressed in the methodology.

Disposal practices now banned

The presenting scheme should also be able to address the presentation of RW disposed of in the sea or ocean. This practice (sea dumping) was implemented by several countries in the past and was subsequently banned in 1975 by the London Convention (Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter) then fully stopped in 1993. Although this practice is prohibited and no longer applied, the methodology should review waste dumped in the sea and provide relevant options in the presenting scheme. Noting that waste was dumped both in solid and liquid state, the EGIRM provided two special columns in the presenting scheme to put liquid and solid radioactive waste respectively:

- SDL – liquid radioactive waste disposed of in the past in the sea;
- SDS – solid radioactive waste disposed of in the past in the sea.

It is necessary to note that the methodology only covers radioactive waste and does not consider authorised discharges from land-based facilities.

Consideration of non-traditional disposal approaches

There is one more approach to waste management that could be considered – when waste disposed of or decided to be disposed of in situ. There is a wide variety of facilities/sites that could potentially be managed with disposal in situ (RW is not removed from its current location). The reasons for such a solution can be different and, in general, be presented as a combination of the economic, technical and safety factors. When it is proved that extraction of radioactive waste from such facilities or sites leads to more radiological risks (and rather more expensive or technically difficult, as option) for humans and the environment than when the waste is safely disposed of in the place of storage/origin, the concept of in situ disposal can potentially be considered. Finally, the decision on this disposal option is made by the responsible authorities of a country and the state is ultimately responsible for the safety of this solution.

The EGIRM has discussed possible storage or other facilities or sites that could be managed with this approach and found that there are some possible options to attribute them to the types of disposal solutions arranged by the expert group. The experts reviewed different types of facilities entombed or likely to be entombed, radioactive waste storage facilities that potentially could be transferred into the status of repositories and after accident sites. As examples of such specific facilities, the following can be given: 4th unit of Chernobyl NPP (Ukraine), Techa cascade of "Mayak" plant (Russia), military reactors for Pu production, some of the underground caverns after nuclear explosions, abandoned mining facilities, tails, old closed storage sites, etc.

To the NSF-1 or NSF-2, depending on the level of engineering, the following can be attributed:

- Entombed facilities (reactors, units, the other nuclear installations).
- Non-removable waste in storage facilities ("especial" waste in Russia, old closed storage facilities, etc.).
- Post-accident or legacy facilities, areas.

To the UF-2 the following can be conditionally attributed:

- Underground caverns after nuclear explosions (nuclear tests, peaceful explosions).
- Former underground nuclear facilities (reactors, installations, etc.) and mining facilities.

To the BH-3 the following can be conditionally attributed:

- Underground caverns after nuclear explosions when they filled with liquid.
- Any underground former nuclear facilities abandoned and flooded.

These attributions are given as proposals to the methodology users, and users will make a final decision based on the national radioactive waste management policy.

A summary of the proposed arrangement of disposal routes is given in Table 6.

Table 6: Other disposal routes

Type of route	Features	RW classes (in terms of the GSG-1) that can be disposed of	SSR-5 equivalent (1.14)
OTHER DISPOSAL ROUTES			
BH – 1	- no direct, open connection with the surface during construction and operation stage; - no excavated underground space for RW emplacement; - heat emission is not considered in design; - package for RW – possible.	DSRS, ILW, LLW	Intermediate depth boreholes
BH – 2	- no direct, open connection with the surface during construction and operation stage; - no excavated underground space for RW emplacement; - heat emission is considered in design; - package for RW required.	SF, HLW, DSRS (1st category)	Deep boreholes
BH – 3	- no direct, open connection with the surface during construction or operation stage; - conditional application of artificial barriers (only around boreholes); - heat emission is considered in design; - package for waste – no package.	Liquid ILW; LLW	No equivalent
SDL	Past practice of disposal, banned now, performed as dumping of liquid RW into sea/ocean.	LLW	Now banned
SDS	Past practice of disposal, banned now, performed as dumping of solid RW into sea/ocean.	ILW; LLW	Now banned

Columns for other disposal routes

Column (H) is proposed for the case when a country needs, or it is required by an international programme to present RW (DSRS) to be disposed of and already disposed of in a BH-1.

Column (H1) is a particular column provided to input the RW (DSRS) amount to be disposed of in a BH-1. DSRSs can be presented in pieces.

Column (H2) is given to input RW (DSRS) already disposed of in the BH-1.

Column (I) is proposed for the case when a country needs, or it is required by an international programme, to present RW to be disposed of and already disposed of in a BH-2. This column can be probably used in future when deep boreholes concept will be implemented. Now it is given to address presenting of such a route when it appears.

Column (I1) is a specific column provided to input the RW (HLW/SF) amount to be disposed of in a BH-2. DSRS (of 1st category) can be presented in pieces.

Column (I2) is given to input RW (HLW/SF) already disposed of in the BH-1.

Column (J) is proposed for the case when a country needs, or it is required by an international programme to present RW to be disposed and already disposed in a BH-3.

Column (J1) is a specific column provided to input the RW amount to be disposed of in a BH-3 facility. Only liquid RW produced on sites where three existing facilities are implemented and that intended to be disposed of in the BH-3 can be put into this column.

The RW amount can be presented in "as disposed" form that, in this case, is not different with "as is" volume.

Column (J2) is given to input RW already disposed of in the BH-3.

The list of sites, where the BH-3 is implemented, is as follows: State Scientific Centre – Research Institute of Atomic Reactors (JSC "SSC RIAR") (Dimitrovgrad, Volga region), Siberian Group of Chemical Enterprises (SGChE) (Tomsk, Siberia) and Mountain Chemical Combine (MCC) (Krasnoyarsk region, Siberia).

Column (K1) is a specific column provided to input the liquid RW amount disposed of in the sea/ocean with the method of sea dumping in the past. This method of disposal was used in the past to dispose of liquid LLW and is now prohibited. This column is provided for the case when the country needs, or it is required by an international programme, to present liquid RW disposed of in the sea/ocean.

Important: the methodology only considers liquid RW disposed of in the sea in the past and the authorised discharges should not be presented in this column.

Column (K2) is a specific column provided to input the solid RW and SF (several cases) amount disposed of in the sea/ocean with the method of sea dumping in the past. This method of disposal was used in the past to dispose of solid ILW and LLW (and a few times for SF contained in the reactor vessels), and now it is prohibited. This column is provided for the case when a country needs, or it is required by an international programme, to present solid RW/SF disposed of in the sea/ocean.

Annex 2. Examples

Example of the scheme reading

An example of a completed table for a hypothetical inventory is given below to illustrate the interpretation of data.

Table 7: Example of a completed table

Spent fuel and radioactive waste inventory presentation

Country:_XX_______________

Date of inventorying:_31.12.2013

SF/RW types (in national terms)		No strategy	SF reprocessing/ service		Disposal in:								
			home	abroad	UF-1		UF-2		NSF-1		NSF-2		Others
(A)		(B)	(C1)	(C2)	(D1)	(D2)	(E1)	(E2)	(F1)	(F2)	(G1)	(G2)	→
1. SF + reprocessing RW													
1.1. NPP													
1.1.1. SF, [tHM]		13[1]	5063[2]	70[3]									
1.1.2 HLW (HG), [m³]			62[4]	14[5]	156								
1.1.3. RW (NHG), [m³]			20[6]				486	2400					
1.2. Other reactors													
1.2.1. SF, [tHM]		101[7]	265[8]										
1.2.2. HLW (HG), [m³]			13[9]		78								
1.2.3. RW (NHG), [m³]			45[10]				155	456					
2. A class, [m³]							78	564					
3. B class, [m³]									8300	12800			
4. C class, [m³]											45900	98700	
Equivalence with IAEA GSG-1 classification	1.1.2		HLW (YY)		HLW								
	1.1.3		ILW (YY) LLW (ZZ)				LLW ILW	ILW					
	1.2.2	HLW	HLW		HLW								
	1.2.3		ILW				ILW	ILW					
	2.						ILW	ILW					
	3.								LLW	LLW			
	4.										VLLW	VLLW	

1) 13 = 7 (XX) + 6 (QQ)

2) 5063 = 5000 (XX) + 45 (YY) + 12 (ZZ) + 5 (VV)

3) 70 = 56(SS) + 14(PP)

4) 62 (YY)

5) 14 = 12(SS) + 2 (PP)

6) 20 = 12 (YY) + 8 (ZZ)

7) 101 = 56 (XX) + 45 (UU)

8) 265 = 51 (XX) + 14 (ZZ)

9) 13 (ZZ)

10) 45 (ZZ)

Country X has NPPs and obtains SF from there that is partially reprocessed at home (and reprocessing service is provided to three “user” countries) and is partially sent abroad into two “servicer” countries; a part of SF is stored waiting for the management strategy (storage service is provided to one “user” country until it defines the management strategy).

After NPPs’ SF reprocessing, the Country X has stored HE waste (HLW) to be disposed of in the UF-1 and HLW to be sent into two “user” countries. Country X has also stored NHE waste (ILW and LLW) to be disposed of in the UF-2 and ILW to be sent into two “user” countries. ILW is disposed of in the UF-2 to the reference date.

Country X has other reactors (research, transport, etc.) and obtains SF from there. SF is partially reprocessed at home (reprocessing service is provided to one country), and a part of SF is stored waiting for the strategy (storage service is provided to one country until it establishes the management strategy).

After other reactors’ SF reprocessing, the Country X has stored HE waste (HLW) to be disposed of in the UF-1 and HLW to be sent into one “user” country. Country X also has stored NHE waste (ILW) to be disposed of in the UF-2 and ILW to be sent into one “user” country. ILW is disposed of in the UF-2 to the reference date.

Country X has three RW classes. Class A (equivalent to ILW of the GSG-1) is disposed of in the UF-2 and waiting for disposal in the UF-2. Class B (equivalent to LLW of GSG-1) is disposed of in the NSF-1 and waiting for disposal in the NSF-1. Class C (equivalent to VLLW of the GSG-1) is disposed of in the NSF-2 and waiting for disposal in the NSF-2.

Country X as of 31.12.2013 has the following SF/RW management inventory per strategies:

- NPPs’ SF:
  - Stored waiting for strategy [1)] – 7 tHM (own) and 6 tHM (from “user” country X) stored to be sent back when X has a strategy;
  - Stored waiting for the reprocessing [2)] – 5 000 tHM (own), 45 tHM (from “user” country YY), 12 tHM (from “user” country ZZ) and 5 tHM (from “user” country VV);
  - Sent abroad for reprocessing [3)] – 56 tHM into “servicer” country SS and 14 tHM into “servicer” country PP;
- After reprocessing HE waste (HLW):
  - 156 m^3 to be disposed of in UF-1, [4)] 62 m^3 – to be sent into “user” country YY;
  - [5)] 12 m^3 to be received from “servicer” country SS and 2 m^3 from “servicer” country PP;
- After reprocessing NHE waste (ILW/LLW):

  - 2 400 m^3 ILW disposed of in the UF-2, 486 m^3 ILW and LLW to be disposed of in the UF-2, [6)] 12 m^3 ILW to be sent into "user" country YY and 8 m^3 LLW to be sent to country ZZ;
- Other types of reactors' SF:
  - Stored waiting strategy – [7)] 56 tHM (own) and 45 tHM (from "user" country UU) stored to be sent back when UU has a strategy;
  - Stored waiting for the reprocessing – [8)] 251 tHM (own) and 14 tHM (from "user" country ZZ);
- After reprocessing HE waste (HLW):
  - 78 m^3 to be disposed of in UF-1, [9)] 13 m^3 – to be sent into "user" country ZZ;
- After reprocessing NHE waste (ILW/LLW):
  - 456 m^3 ILW disposed of in the UF-2, 155 m^3 ILW to be disposed of in the UF-2 and [10)] 45 m^3 ILW to be sent into "user" country ZZ;
- RW Class A (ILW):
  - 564 m^3 disposed of in the UF-2 and 78 m^3 to be disposed of in UF-2;
- RW Class B (LLW):
  - 12 800 m^3 LLW disposed of in the NSF-1 and 8 300 m^3 to be disposed of in the NSF-1;
- RW Class C (VLLW):
  - 98 700 m^3 VLLW disposed of in the NSF-2 and 45 900 m^3 to be disposed of in the NSF-2.

The "past practices" consideration

One of the possible options for the methodology implementation was considered the presenting of the status on RW management in the past. To address potential user's need in presenting the results of the past practices, the EGIRM first reviewed the term "the past" from the point of view of reporting. As there is no precise definition of this term, the EGIRM evaluated the methodology ability to address presenting needs per likely variants of understanding of "the past". The expert group tried to complete the presenting table based on some assumed definitions to assess the capacity of the table to present the past practice based on different definitions.

The IAEA Glossary provides the definition of the "practice" as "any human activity that introduces additional sources of exposure or additional exposure pathways, or extends exposure to additional people, or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed".

Moreover, regarding RW management: "Radioactive waste is generated as a result of practices that involve some beneficial effect, such as the generation of electricity by nuclear means or the diagnostic application of radioisotopes. The management of this waste is therefore only one part of the overall practice".

Based on this definition, "the past practices" in relevance to the methodology objectives could be considered each human activity in the past that led to the production of SF/RW.

On the other hand, the definition can focus on the RW management activity and present those RW management activities that were performed and stopped in the past.

The Joint Convention requires reporting RW that is "the results of past practices in order to determine whether any intervention is needed for…." (Article 12). This requirement implies reporting any integral amount of RW produced as results of the past activities.

It is necessary to remember the fact that some of the past RW management practices could be revised and RW retrieved, for example, extraction of RW from closed disposal facility for re-disposal for remediation or to address newly established safety requirements.

The EGIRM confirmed the methodology capacity to address various possible reporting requests relevant to past practices, and the methodology can be applied to this task without changes of the table format.

"The future" consideration for the objectives of inventory presenting

The EGIRM considered that the future situation in SF/RW management can be reported as the SF/RW amounts that are anticipated being stored/disposed of at the dates of reference in future, evaluated in accordance with the national nuclear programme development. One could fill tables for each reference date, in the future. It gives better flexibility when an update of the forecast is needed for the specified date of reference. However, when the international programme requests data collected in one spreadsheet, it can be provided with the division of each column (sub-column) onto several additional sub-columns, one for each requested reference date.

Presenting of the future situation using the developed methodology and table is in principle the same as for the status. However, accounting for some differences in consideration, the EGIRM proposed instructions on how to present forecasted data. The following steps are recommended to fill the table:

- RW/SF that will be produced and stored waiting for the strategy (including imported from "user" countries) should be put into column (B).
- SF that will be stored waiting for reprocessing (including imported from "user" countries) should be put into column (C1), will be exported to "servicer" countries for service there – into column (C2).

- RW/SF that will be produced and consequently disposed of in the UF-1 should be put in column (D1); RW – in lines relevant to RW classes; RW/SF that will have been disposed of in the UF-1 at the reporting date should be put into column (D2).
- RW that will be produced and consequently disposed of in the UF-2 should be put in column (E1) – in lines relevant to RW classes; RW that will be have been disposed of in the UF-2 at the reporting date should be put into column (E2).
- RW that will be produced and consequently disposed of in the NSF-1 should be put in column (F1) – in lines relevant to RW classes; RW that will have been disposed of in the NSF-1 at the reporting date should be put into column (F2).
- RW that will be produced and consequently disposed of in NSF-2 should be put in column (G1) – in lines relevant to RW classes; RW that will have been disposed of in the NSF-2 to the reporting date should be put into column (G2).

When requested, the RW/SF amount that will be produced in total can be presented in an additional summary column or a footnote; RW should be put in relevance to the RW class.

Other disposal routes:

- The RW amount that will be produced to be consequently disposed of in the BH-3 should be put in optional column (J1) – in lines relevant to RW classes; RW that will have been disposed of in the UF-3 to the reporting date should be put into column (J2).

It is necessary to note that fully adequate presentation of a future situation is only achievable when there is a clear and detailed nuclear development programme in a country. This programme should give information on anticipated SF/RW arisings, the rate of SF reprocessing and RW conditioning and programme of SF/RW loading into disposal facilities. The forecasting is rather more challenging when any international management activity is envisaged, but there is no signed international agreement on such an activity. The EGIRM recommends to international programmes that have a requirement for future reporting to provide a maximally clear explanation on data format and level of details in the forecast. The example of a completed table for the hypothetic inventory is given in Table 8.

Table 8: Example of a completed table for the forecast

Spent fuel and radioactive waste inventory presentation

Country:_XX_______________

Date of inventorying:_31.12.2030 - forecast

SF/RW types (in national terms)		No strategy	SF reprocessing/ service		Disposal in:							
			home	abroad	UF-1		UF-2		NSF-1		NSF-2	
(A)		(B)	(C1)	(C2)	(D1)	(D2)	(E1)	(E2)	(F1)	(F2)	(G1)	(G2)
1. SF + reprocessing RW												
1.1. NPP												
1.1.1. SF, [tHM]		7 (XX) 6 (QQ)	18000 (XX) 1500 (YY) 2400 (ZZ) 5000 (VV)	700(SS) 200(PP)								
1.1.2 HLW (HG), [m³]			1000 (YY) 2000 (ZZ) 4200 (VV)		15600							
1.1.3. RW (NHG), [m³]							8600	2400				
1.2. Other reactors												
1.2.1. SF, [tHM]		56 (XX) 45 (UU)	3500 (XX) 600 (ZZ)									
1.2.2. HLW (HG), [m³]			130 (ZZ)		7800							
1.2.3. RW (NHG), [m³]			450 (ZZ)				850	456				
2. A class, [m³]							780	564				
3. B class, [m³]									83000	12800		
4. C class, [m³]											145900	98700
Equivalence with IAEA GSG-1 classification	1.1.2		HLW (YY)		HLW							
	1.1.3		ILW (YY) LLW (ZZ)				ILW	ILW				LLW
	1.2.2	HLW	HLW		HLW							
	1.2.3		ILW				ILW	ILW				LLW
	2.						ILW	ILW				
	3.								LLW	LLW		LLW
	4.										VLLW	LLW

The main information that can be found in this table is the following.

Country X up to 31 December 2030 will have collected and stored waiting for the strategy SF:

- From NPPs' reactors – 7 tHM (own) and 6 tHM imported from "user" country (QQ);
- From other reactors – 56 tHM (own) and 45 tHM imported from "user" country (UU).

Country X will have stored waiting for reprocessing SF:

- From NPPs' reactors – 18 000 tHM (own), 1 500 tHM will be imported from the "user" country (YY), 2 400 tHM will be imported from the "user" country (ZZ), and 5 000 tHM will be imported from the "user" country (VV);
- From other reactors – 3 500 tHM (own) and 600 tHM will be imported from the "user" country (ZZ).

Country X will have stored/disposed of after reprocessing of SF from NPPs' reactors:

- HE RW (HLW) – 15 600 m³ HLW will be stored waiting for disposal in the UF-1, 1 000 m³ HLW will be stored waiting for sending into "user" country (YY), 2 000 m^3 HLW will be stored waiting for sending into “user” country (ZZ) and 4 200 m^3 will be stored waiting for sending into “user” country (VV);

- NHE RW (ILW/LLW) – 7 800 m^3 ILW will be stored for disposal of in the UF-2, and 2 400 m^3 will have been disposed of.

Country X will have stored/disposed of after reprocessing of SF from other reactors:

- HE RW (HLW) – 7 800 m^3 HLW will be stored for disposal of in the UF-1, 130 m^3 HLW will be stored waiting for sending into “user” country (ZZ);
- NHE RW (ILW/LLW) – 850 m^3 ILW for disposal of in the UF-2, and 456 m^3 will have been disposed of.

Country X will have stored/disposed of RW not related to the SF reprocessing:

- Class A (ILW) – 780 m^3 will be stored for disposal of in the UF-2, and 564 m^3 will have been disposed of;
- Class B (LLW) – 83 000 m^3 will be stored for disposal of in the NSF-1, and 12 800 m^3 will have been disposed of;
- Class C (VLLW) – 145 900 m^3 will be stored for disposal of in the NSF-1, and 98 700 m^3 will have been disposed of.

Annex 3. EGIRM participants

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Annex 4. List of abbreviations and acronyms

AC	Activity concentrations
DGR	Deep geological repository
DSRS	Disused sealed radioactive sources
EC	European Commission
EGIRM	Expert Group on Waste Inventorying and Reporting Methodology
EL	Exemption level
EW	Exempt waste
HE	Heat emitting
HLW	High-level waste
IAEA	International Atomic Energy Agency
ILW	Intermediate-level waste
LILW	Low- and intermediate-level waste
LL	Long lived
LL RN	Long-lived radionuclide
LLW	Low-level waste
MCC	Mountain Chemical Combine
MS	Member states
NEA	Nuclear Energy Agency
NEWMDB	Net-Enabled Waste Management Database
NSF-1	Near surface facility of the first type (well engineered)
NSF-2	Near surface facility of the second type (minimally engineered)
NORM	Naturally occurring radioactive material
NHE	Non heat emitting
NPP	Nuclear power plant
OECD	Organisation for Economic Co-operation and Development
RW	Radioactive waste
RWMC	Radioactive Waste Management Committee
SF	Spent fuel
SFR	Repository for short-lived radioactive waste in Sweden
SGChE	Siberian Group of Chemical Enterprises
SL	Short lived
TENORM	Technologically enhanced naturally occurring radioactive material
TU	Trans-Uranium
TVO	Teollisuuden Voima Oyj
UB	Upper boundary
UF-1	Underground facility of the first type (for heat-emitting RW)
UF-2	Underground facility of the second type (for no heat-emitting RW)
VLLW	Very low-level waste
VSLW	Very short-lived waste
WIPP	Waste Isolation Pilot Plant

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National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste

Radioactive waste inventory data are an important element in the development of a national radioactive waste management programme since these data affect the design and selection of the ultimate disposal methods. Inventory data are generally presented as an amount of radioactive waste under various waste classes, according to the waste classification scheme developed and adopted by the country or national programme in question. Various waste classification schemes have evolved in most countries, and these schemes classify radioactive waste according to its origin, to criteria related to the protection of workers or to the physical, chemical and radiological properties of the waste and the planned disposal method(s).

The diversity in classification schemes across countries has restricted the possibility of comparing waste inventories and led to difficulties in interpreting waste management practices, both nationally and internationally. To help improve this situation, the Nuclear Energy Agency developed a methodology that ensures consistency of national radioactive waste and spent fuel inventory data when presenting them in a common scheme in direct connection with accepted management strategy and disposal routes. This report is a follow up to the 2016 report that introduced the methodology and presenting scheme for spent fuel, and it now extends this methodology and presenting scheme to all types of radioactive waste and corresponding management strategies.

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