THE HASHEMITE KINGDOM OF JORDAN

First National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

October 2017

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ACRONYMS

Acronym	Definition
ALARA	As Low As Reasonably Achievable
CAT	Category
CSF	Central Storage Facility
DOE	Department of Energy
DSRS	Disused Sealed Radioactive Source
DU	Depleted Uranium
EIA	Environmental Impact Assessment
EMRC	Energy and Minerals Regulatory Commission
ERC	Electricity Regulatory Commission
FSAR	Final Safety Analysis Report
GoJ	Government of Jordan
GTRI	Global Threat Reduction Initiative
HLW	High Level Waste
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
JAEC	Jordan Atomic Energy Commission
JNRC	Jordan Nuclear Regulatory Commission
JRTR	Jordan Research and Training Reactor
JUST	Jordan University of Science and Technology
LILW	Low and Intermediate Level Waste
LLW	Low Level Waste
MoE	Ministry of Environment
MoH	Ministry of Health
NORM	Naturally Occurring Radioactive Material
NPP	Nuclear Power Plant
NRA	NATURAL RESOURCES AUTHORITY
PSAR	PRELIMINARY SAFETY ANALYSIS REPORT
QA	Quality Assurance
QAP	Quality Assurance Program
QMS	Quality Management System
R&D	Research & Development
RMS	Radiation Monitoring System
RPO	Radiation Protection Officer
RPP	Radiation Protection Program
RS	Radiation Source
RTF	Radioactive Waste Treatment Facility
RW	Radioactive Waste
RWM	Radioactive Waste Management
SF	Spent Fuel
SNF	Spent Nuclear Fuel
USA	United States of America
VLLW	Very Low-Level Waste
WAC	Waste Acceptance Criteria
WMO	Waste Management Organization

GLOSSARY

"Exempt Waste" means those radioactive materials that can be removed from the regulatory control due to its activity concentration and or total activity, after a limited storage period for decaying;

"Historical Waste" means those radioactive waste treated, conditioned or finally disposed applying criteria beyond the current regulatory frame and that require its re-assay;

"License" means any authorization, permission or certification granted by a regulatory body to carry out any activity related to spent fuel or radioactive waste management;

"Nuclear Facility" means a civilian facility and its associated land, buildings and equipment in which radioactive materials are produced, processed, used, handled, stored or disposed on such a scale that consideration of safety is required;

"Operating Lifetime" means the period during which a spent fuel or a radioactive waste management facility is used for its intended purpose. In the case of a disposal facility, the period begins when spent fuel or radioactive waste is first emplaced in the facility and ends upon closure of the facility;

"Radioactive Waste" means radioactive material in gaseous, liquid or solid form for which no further use is foreseen by the Contracting Party or by a natural or legal person whose decision is accepted by the Contracting Party, and which is controlled as radioactive waste by a regulatory body under the legislative and regulatory framework of the Contracting Party;

"Decommissioning" means all steps leading to the release of a nuclear facility, other than a disposal facility, from regulatory control. These steps include the processes of decontamination and dismantling;

"Discharges" means planned and controlled releases into the environment, as a legitimate practice, within limits authorized by the regulatory body, of liquid or gaseous radioactive materials that originate from regulated nuclear facilities during normal operation;

"Disposal" means the emplacement of spent fuel or radioactive waste in an appropriate facility without the intention of retrieval;

"Radioactive Waste Management" means all activities, including decommissioning activities that relate to the handling, pre-treatment, treatment, conditioning, storage, or disposal of radioactive waste, excluding off-site transportation. It may also involve discharges;

"Radioactive" means any facility or installation whose primary purpose is radioactive waste management, including a nuclear facility in the process of being decommissioned only if it is designated by the Contracting Party as a radioactive waste management facility;

"Regulatory Body" means anybody or bodies given the legal authority by the contracting Party to regulate any aspect of the safety of spent fuel or radioactive waste management, including the granting of licenses;

"Reprocessing" means a process or operation, the purpose of which is to extract radioactive isotopes from spent fuel for further use;

"Sealed Source" means radioactive material that is permanently sealed in a capsule or closely bonded and in a solid form, excluding reactor fuel elements;

"Spent Fuel" means nuclear fuel that has been irradiated in and permanently removed from a reactor core;

"Spent Fuel Management" means all activities related to the handling or storage of spent fuel, excluding off-site transportation. It may also involve discharges;

"Spent Fuel Management Facility" means any facility or installation, the primary purpose of which is spent fuel management;

"Storage" means the holding of spent fuel or of radioactive waste in a facility that provides for its containment, with the intention of retrieval;

"Trans-Boundary Movement" means any shipment of spent fuel or of radioactive waste from a State of origin to a State of destination.

A. INTRODUCTION

The Hashemite Kingdom of Jordan became a member state of the International Atomic Energy Agency (IAEA) on April 1966, and ever since, Jordan attaches the highest importance to international efforts to harmonize and increase all aspects of nuclear and radiological safety. In this respect, Jordan has initiated projects and entered into bilateral agreements with other countries and actively participates and contributes to international activities.

Jordan has signed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, referred to herein as the "Convention" on the 15th of April 2016. The Convention has been ratified and entered into force on the 14th of July 2016.

This report is the first National Report of Jordan for the sixth Review Meeting to the Convention, which will take place in 2018 at the IAEA Headquarters in Vienna. It satisfies the requirements of the Joint Convention for reporting on the safety of spent fuel and radioactive waste management facilities in Jordan.

In 2007, Jordan's Committee for Nuclear Strategy was formed to launch the development of nuclear energy programs in Jordan. One of this committee's goals is for Jordan to generate 30% of its electricity by nuclear power by the year 2030. To support the development of its nuclear energy program, the Jordan Atomic Energy Commission (JAEC) and the Jordan Nuclear Regulatory Commission (JNRC), which later became the "Energy and Minerals Regulatory Commission (EMRC), were developed and that constitute the two main counter parts for the purpose of the Convention, the promoter and regulatory, respectively.

Because Jordan has no nuclear power plants as of yet, spent nuclear fuel (SNF) management is therefore relevant only with the Jordan Research and Training Reactor (JRTR). The JRTR is owned and operated by JAEC, and is located at the Jordan University of Science and Technology (JUST) campus. JRTR has reached its first criticality in April 2016, has completed its commissioning and initial operation testing, and is now undergoing its final licensing process with the EMRC.

Radioactive waste (RW) in Jordan originates from medicine, research, and industry. JAEC is responsible for managing the long-term management of SNF and RW. To discharge its responsibilities, JAEC has commissioned the establishment of the JRTR Radioactive-Waste Treatment Facility (RTF) within the JRTR site for treatment and temporary storage of RW, and is expected to operate in early 2018. The Central Storage Facility (CSF) is another facility that is established to fulfil JAEC responsibilities; it is located at the premises of JAEC headquarters; and is tasked with the safe and secure storage of disused and orphan RW sources, as well as other RW. Another disposal facility of RW is the historical storage facility at the Sewaqa site. The licensing of the SNF and radioactive waste management (RWM) facilities is governed by laws, regulations, and instructions issued by EMRC and other governmental authorities, such as the Ministry of Environment (MoE).

This report covers the legal regime concerning the management of SNF of the JRTR and the management of RW generated from JRTR operations, as well as RW from medical, industrial, and research institutes within Jordan. It also describes the Jordanian policy and current practices concerning the management of SNF and management of RW.

The report has been prepared by JAEC, EMRC, and MoE in accordance with the Guidelines regarding the Form and Structure of National Reports (INFCIRC/604/Rev.3, 13 May 2014), established by the Contracting Parties under Article 29 of the Convention.

B. POLICIES AND PRACTICES

Article 32. Reporting, Paragraph 1

Jordan policy serves as its national commitment to address the management of SNF and RW in a coordinated and cooperative manner with all related national organizations and entities.

B.1. SNF Management Policy

In Jordan, SNF is currently generated at the JRTR,[1] and it is expected to be generated from operations of future NPPs. The following is the policy related to SNF:

- To store the SNF in wet storage at the nuclear research reactor or nuclear power plant site until it decays to sufficient levels to allow for further safe storage externally.
- To establish long term storage facilities.
- Jordan will decide in the future the possibility of returning the SNF to the country of its origin (to the manufacturer) for final disposal or interim storage or to remain in Jordan in dedicated storage facility for either of the two following options:
  - Considering the SNF as strategic resource that can be utilized through reprocessing (nationally or internationally) where the subsequent High-Level Waste (HLW) will be sent for final disposal in a national waste disposal facility at The Hashemite Kingdom of Jordan; or
  - Declare that the SNF as RW thereby permitting for its direct disposal to a dedicated national waste disposal facility.

B.2. Spent Fuel Management Practices

There is currently no spent fuel produced from JRTR. When the current reactor cycle pass, a fuel assembly will be discharged from the reactor core to the service pool for storage until the end of the reactor lifetime.

At the end of each operation cycle, in which core loading activities are to take place, one fuel assembly is discharged to the spent nuclear fuel pool (reactor service pool). The reactor service pool is designed and constructed for safe storage of SNF assemblies, and is sized-sufficiently to store all SNF assemblies produced from JRTR operations during its entire lifetime (»40 years). Figure 1 presents a top view of the SNF storage racks inside the reactor service pool, which have a current storage capacity for 222 SNF assemblies and 10 damaged fuel assemblies. Additional storage racks can be added to accommodate additional assemblies if the need arises.

[1] *Although the fuel assemblies in the JRTR have been irradiated during commissioning and initial operation testing, SNF has not been officially produced at the JRTR, as of yet. Once a JRTR fuel assembly is discharged from the reactor core and is deemed as no longer viable for operation of the JRTR, then the discharged fuel assembly will be considered as SNF.*

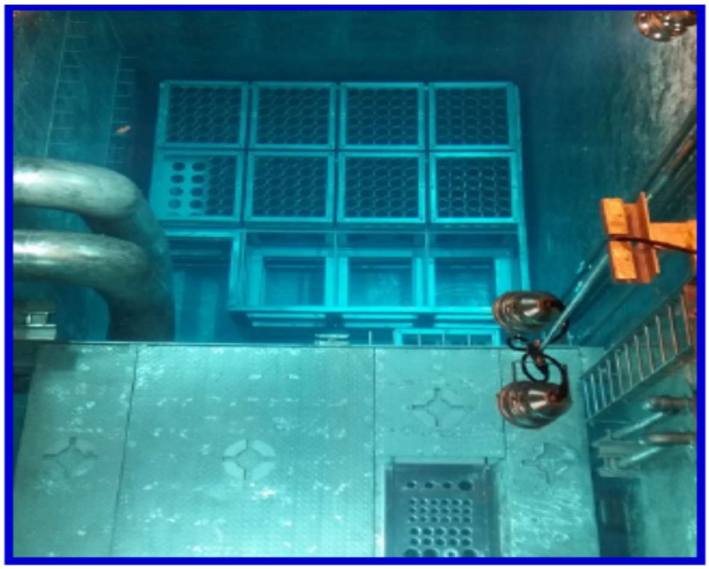


Figure B.1 Overview of the SNF Storage Racks

B.3. Radioactive Waste Management Policy

- **Disused Sealed Radiation Sources (DSRS)**; the management policy for DSRS includes:
  - Return of the disused sealed radiation sources to the supplier.
  - Management of the DSRS in local RWM facilities such as the national CSF at JAEC.
  - Finding international or regional solutions for the DSRS management and disposal options.

- **Other Types of RW**; the other main sources of RW in Jordan are:
  - Orphan radioactive sources found in Jordan.
  - Radioactive sources or contaminated materials and structures that might be found in the scrap yards, custom free zones, or other places within the territory of Jordan.

The management policy for this category of "Other Types of RW" includes:

  - Return of these radioactive sources to their place of origin, if possible.
  - The management of the radioactive sources, contaminated materials, or the orphan sources within the territory of Jordan.

- **Naturally Occurring Radioactive Material (NORM)**;

The extraction and processing of raw materials containing Naturally Occurring Radioactive Material (NORM) including milling and mining of ores containing uranium and thorium, and their radioactive decay products; byproducts of oil and gas industries; and any other activities that contain NORM.

B.4. RWM Practice

- **Institutional RW**

Institutional RW shall be stored at the generator of RW until the RW decays to levels allowing its clearance and management as non-radioactive waste. In case the activity of RW is higher than the clearness level, it shall be transported to CSF at JAEC for processing followed by disposal in a dedicated repository and or to the RTF. RWM process is shown in Figure 2.

Solid and liquid RW from the operation of the JRTR and its auxiliary facilities will be collected, processed (treated), and stored at the RTF until the Low and Intermediate Level Waste (LILW) disposal facility is available.

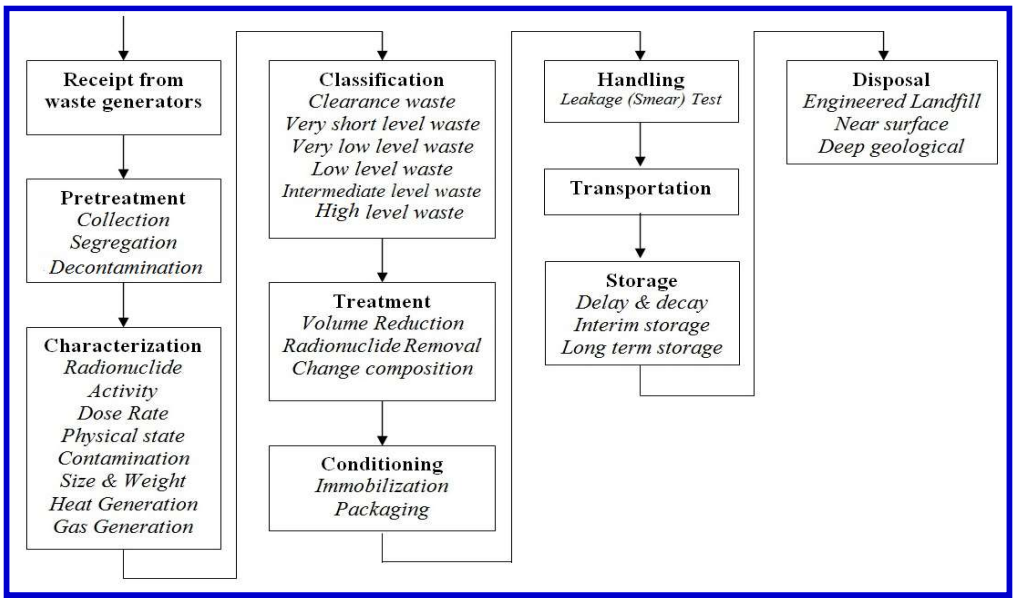


Figure B.2 Radioactive Waste Management (RWM) Process

- **Disused Sealed Radioactive Sources**

This national RWM strategy for the safe management of DSRS is presented schematically in Figure 3. The implementation of the indicated scheme requires that a facility for DSRS conditioning (allowing the management of categories 1 and 2 of DSRS) as well as suitable disposal option are available. Establishment of these facilities is the responsibility of JAEC. JAEC can be the owner and operator directly or through the subsequent Waste Management Organization (WMO) that is to be established by JAEC. The decision on the disposal strategy relies in part of the construction of disposal facilities for Intermediate Level Waste (ILW)/HLW, where adequate storage capacity for conditioned DSRS should be considered.

Figure B.3 Safe Management Diagram for Spent Sealed Radioactive Sources

- **Naturally Occurring Radioactive Materials (NORM)**

The implementation of the national RWM strategy for NORM relies on the availability of national regulations for the management of the NORM (to be issued by EMRC). The required national regulations must include regulations and requirements pertaining to by-product; residue or waste from Uranium mining and milling; Oil and Gas extraction; Tin, Iron, Niobium, zirconium …etc. The required national regulations for NORM are expected to take into consideration the following:

- RW generated form activities involving NORM and other non-radiological aspects of NORM are to be regulated as chemically toxic waste, if their toxicity levels reach the applicable threshold levels, which also need to be defined.
- The management of NORM shall incorporate various processes that increase the safety of storage and disposal sites, reduce the extent of handling and transporting of solid and liquid NORM waste, and reduce the volume of generated NORM waste.
- The disposal of NORM waste shall include consolidated and over-covered piles or sludge beds, or specially designed repositories with lined cells,

protective capping, engineered structures, and by using backfill disused underground mines.

NORM will be processed and disposed of by their generators at or nearby the site of their generation.

B.5. Criteria Used to Define and Categorize Radioactive Waste

According to Article 7 of Appendix I of the EMRC Instructions on RWM:

A. Based on considerations of long term safety, respectively disposal options, solid radioactive wastes are classified as follows:

Category 1 - Transitional waste, that contains small concentrations of significant radionuclides; this category of waste is additionally sub-divided as follows:

(a) Category **1a** - Exempt Waste: Waste that meets the criteria for clearance from regulatory control, as a result of appropriate processing and/or temporary storage for a few years.

(b) Category **1b** - Very Low-Level Waste (VLLW): Waste that does not necessarily meet the criteria of exempt waste, but is suitable for disposal in surface landfill type facilities with limited regulatory control.

Category 2 - Low and Intermediate Level Waste (LILW): Waste that, because of its radionuclides content, requires robust isolation and containment and no special measures for heat removal during its storage and disposal; this category of waste is additionally sub-divided as follows:

(a) Category **2a** - Low and Intermediate Level Waste containing mainly short-lived radionuclides (with a half-life no longer than Cesium-137 half-life) and also long-lived radionuclides, but only at relatively low levels of activity concentration, limited for long lived alpha-emitting radionuclides below 4×10^6 Bq/kg for individual waste packages and an overall average of 4×10^5 Bq/kg.

(b) Category **2b** - Low and Intermediate Level Waste containing long-lived radionuclides at activity concentration levels for long lived alpha-emitting radionuclides exceeding the limits for Category **2a** mentioned in this Subparagraph.

Category 3 - High Level Waste (HLW): Waste with such large concentration of radionuclides that compared to Low and Intermediate Level Waste, a greater degree of containment and isolation from the accessible environment is needed to ensure its long-term safety, and heat generation shall be considered during storage and disposal in deep.

B. Within Category **2a** mentioned in Subparagraph (2/a) of Paragraph (a) of this Article, radioactive waste are classified additionally according to its physical state and based on direct measured parameters in Secondary categories, as follows:

1. For solid waste, depending on dose rate measured at 0.1 m distance from its surface:
   (a) Secondary category 2a-I: with dose rate from 0.001 to 0.3 mSv/h.

(b) Secondary category 2a-II: with dose rate from 0.3 to 10 mSv/h.
(c) Secondary category 2a-III: with dose rate more than 10 mSv/h.

2. For liquid waste, depending on its specific activity:
   (a) Secondary category 2a-H: with specific activity less than 4.105 Bq/l.
   (b) Secondary category 2a-C: with specific activity from 4.105 to 8.107 Bq/l.
   (c) Secondary category 2a-B: with specific activity more than 8.107 Bq/l.

C. SCOPE OF APPLICATION

Article 3. Scope of Application

The scope of application for this report is:

1. **Spent Fuel**: As described in Sections A and B, there are no nuclear power plants in Jordan and only a research reactor (JRTR) exists. Jordan is not reprocessing any SNF and the SNF of the research reactor will be kept at the reactor site for the life time of the reactor. The research reactor SNF will then be managed in a safe manner either by returning the fuel to the vendor or store it at a long-term storage facility in Jordan.

2. **Radioactive Waste Management**: The safe management of RW resulting from use of radioactive materials in industry, medicine, scientific research, education, other branches of national economy and civil activities within the territory of Jordan, and RW arising from operating uranium mines is discussed under the relevant articles.

3. **Military or Defense Program**: No SNF or RW within military or defense programs has been declared as SNF or RW for the purpose of the convention. However, the national RWM legislation covers the safety of RWM from civilian applications as well as from military applications.

D. INVENTORIES AND LISTS

Article 32. Reporting, Paragraph 2

D1. Spent Fuel Management Facilities

There are no spent fuel management facilities in Jordan. JRTR spent fuel management is described in Section B.2.

D2. Inventory of Spent Fuel

No spent fuel elements are in Jordan. The JRTR, which is the only research reactor in Jordan, did not produce spent fuel until the date of this report submission.

D3. Radioactive Waste Management Facilities

There are two radioactive waste management facilities that exist in Jordan. The first facility is the CSF, which is operated by JAEC. This CSF is a national interim RW storage facility, which accepts DSRS from licensees in Jordan[2] as well as orphan sources and other wastes that might be found. The second facility is RTF located at JRTR site, which is designed to accept RW from the JRTR operations as well as waste from other generators that meets the RTF waste acceptance criteria.

JAEC also manages the historical Sewaqa site, which had been used for the storage of some RW and it is now considered a closed site.

D4. Inventory of Radioactive Waste

As Jordan has neither nuclear power plants nor Uranium mines or any other nuclear fuel cycle facilities, HLW is not currently produced in Jordan. The main sources of RW in Jordan are from radioactive materials used in medicine, industry, research, and orphan sources that might be found in Jordan, as well as RW that will be generated from JRTR operations.

As of December 31st, 2016, the following represents the activity of RW inventory in Jordan:

- Total activity at CSF: 2,000 Ci
- Total activity at Sewaqa Disposal Site: 4,665 mCi
- Total activity at the RTF: 0 (RTF expected to operate in 2018)

More details about the inventory are shown it the annexes of this report.

D5. Decommissioned Facilities

No nuclear facilities have been decommissioned in Jordan.

[2] *DSRS are only accepted in the CSF when it is not possible to return them to the original supplier.*

E. LEGISLATIVE AND REGULATORY SYSTEM

Responsibilities

A clear distribution of responsibilities is described among the following stakeholders:

The Government of Jordan (GoJ) has to ensure and maintain the availability of the adequate resources, such as adequate human resources, financial resources and technical (Research and Development (R&D) in this regards) to facilitate the implementation of the management of SNF and RW.

In addition, the GoJ shall establish legislations on the fees needed to support the short- and long-term safe management of SNF and RW.

Energy and Mineral Regulatory Commission (EMRC) is required to ensure the implementation of SNF and RW management. This is performed by the adequacy of national legislations issued by EMRC in a cooperative manner with other national regulatory bodies such as the MoE, Ministry of Health (MoH), and other relevant national entities.

EMRC is to ensure the fulfillment of requirements for public safety and for workers, and the nuclear safety and security for radiological and nuclear activities and facilities including safe and secure practices for RW and SNF management.

Jordan Atomic Energy Commission (JAEC) is required to fulfil national regulations and instructions issued by EMRC in the field of SNF and RW management. These responsibilities include:

- Ensuring adequate competencies and capacity within JAEC in the field of RW and SNF management.
- Fulfilling national and international obligations in terms of international agreements and conventions associated with the long-term management of SNF and RW.
- Implementing an adequate recording and reporting system for RW and SNF.
- Preparing safety, risk, and environmental impact reports for national facilities designated for management of RW and SNF, and any future disposal facility.
- Preparing and updating the national strategy for SNF & RWM emerging from the national policy.
- To setup the waste acceptance criteria for the national facilities designated for management of RWM and SNF, and any future storage and disposal facility.

Operators of SNF and RW including RW storage and treatment facilities are responsible for the technical, financial, and administrative short-term management of their waste within their facilities, and are responsible for the financial aspects of the long-term management (including disposal) of RW they generate - according to the national legislations.

Article 18. Implementing Measures

Jordan has taken legislative, regulatory, and administrative measures and other necessary steps for implementing its obligations under the Joint Convention, as described in Articles 19 and 20 below.

Article 19. Legislative and Regulatory Framework

Overview – Article 19 Para 1

The safety of SNF management and the safety of RWM are mainly governed by the legislation on Radiation Protection, and Nuclear Safety and Security.

Legal Framework

The following laws and regulations are governing the safety of SNF management and the safety of RWM, as issued by the EMRC:

- Law No. (8) for the year 2017, "*Law of Energy and Minerals Regulatory Commission.*"
- Law No. (43) for the year 2007 "*Radiation Protection, and Nuclear Safety and Security Law.*"
- Regulation No. (43) for the year (2014), "*Regulation on the Safe Use of Nuclear Energy,*" and its Instructions.
- Regulation No. (108) for the year (2015), "*Regulation on Radiation Protection,*" and its Instructions.
- Regulation No. (32) for the year (2016), "*Regulation on the Transport of Radioactive Materials,*" and its Instructions.
- Regulation No. (8) for the year (2013), "*Regulation on the Basis and Conditions for Granting Licenses and Permits for the Radiation Work.*"
- Instructions on "*Management of the Radioactive Waste,*" for the year 2015.
- Instructions on "*Spent Nuclear Fuel Management*," for the year 2015.
- Instructions on "*Decommissioning of The Nuclear Facilities*," for the year 2015.
- Instruction on "*Environmental Impact Assessment*."
- Instructions on "*The Criteria for Exemption of the Radiation Practices and Radiation Sources and Clearance of the Radiation Sources from the Regulatory Control*."

Legislations of MOE relevant to the safety of SNF and RW management:

- Environmental Law No. (6) for the year 2017.
- Environmental Law No. (24) for the year 2005.
- "*Regulation of Management, Transportation and Handling of Harmful and Hazardous Substances*."

Other Bylaws and regulations:

- Law No. (27) for the year 2005, "*Solid Waste*."
- Regulation on "*Used Oil*," issued in 2014.
- Liquid Acid Lead Batteries requirements.
- Technical committee of Hazardous Substances and Waste Management is established by Law No. (24) for the year 2005, "*Hazardous Substances and Waste Management*."

- Law No. (37) for the year (2005), "*Environmental Impact Assessment*," governing any radioactive facility, such as NPP and mining of radioactive substances.
- "*The Protocol of Medical Waste between Ministry of Environment and Ministry of Health*," which was issued in 2017, and by this protocol the MoH is responsible for management of waste inside any healthy facility.
- "Regulation on Medical Waste Management No. (1)" for the year 2001, issued by MoH.

Radiation Safety - Article 19 Para 2 (i)

The national requirements for radiation safety are established in Law No. (43) for the year 2007 "*Radiation Protection, and Nuclear Safety and Security*" aims to protect the environment, human health and property from the hazards of contamination and exposure to ionizing radiation.

The radiation protection regulation implements the principles of justification of a practice, optimization of radiation exposure and dose limitation. Detailed radiation protection measures for management of SNF and RW are described in the instructions on "*Management of the Radioactive Waste*" and instructions on "*Spent Nuclear Fuel Management*."

Licensing System – Article 19 Para 2 (ii)

The licensing of the SNF and RW facilities is governed by the legislations mentioned above in the legal framework. Instructions on the management of SNF and RW describe the safety requirements for the management of the spent fuel and the radioactive waste.

Prohibition of Operation without a License – Article 19 Para 2 (iii)

According to Article 14 of Law No. (43) for the year 2007, it is prohibited for any person to carry out any of the following activities without obtaining a license:

(a) Establishing, operating, or managing any nuclear facility in the Kingdom.

(b) Circulation of any radioactive sources or any substances emitting ionizing radiation, importing, exporting, using, dealing, possessing, trafficking, operating, leasing, transferring, storing, destroying, disposing, or producing, including exploring, grinding, milling, crushing, extracting, converting, mining, or manufacturing.

(c) Using ionizing radiation or perform any work in the vicinity of ionizing radiation sources.

(d) Discharging radioactive materials into the environment in the form of gas or liquid.

(e) Management of radioactive waste.

Control, Regulatory Inspection, Documentation and Reporting - Art 19 Para 2 (iv)

All facilities, which have been licensed according to Law No. (43) for the year 2007 are monitored and inspected at regular intervals by EMRC. In the course of these inspections, the compliance of the license holder with the applicable regulations and the terms of the licenses are verified on an annual basis. If necessary, the license holder can be requested to implement additional radiation protection measures.

The radiation protection legislation requires comprehensive documentation on the construction, modification and operation of facilities engaged in handling radioactive material. Detailed specifications on documentation and reporting are set forth in the individual issued licenses.

Enforcement – Article 19 Para 2 (v)
EMRC is in charge of enforcing the legislation and the regulations applicable to facilities for the use of radioactive material as well as other related obligations of the licensee. The EMRC is empowered to take necessary enforcement measures to ensure compliance by the license holder.

The different enforcement tools and authority of EMRC are described in Law No. (43) of 2007, which include:

- Imposition of fines;
- Suspension of a license;
- Revocation of a license;
- Closure of a facility;
- Confiscation of radioactive sources, materials, equipment, or devices;
- Disposal of confiscated materials; and
- Imprisonment.

Allocation of Responsibilities – Article 19 Para 2 (vi)
JAEC was established per Law No. (42) for the Year 2007, and it has responsibility for the long-term management of SNF and RW, which includes disposal of RW. The operator has the prime responsibility for safety throughout the lifetime of the waste management facilities and activities, and this responsibility cannot be delegated.

Person generating and/or managing radioactive waste bear the responsibility for the safety of the generated RW until the RW is transferred out of that facility.

Regulating Radioactive Materials as Radioactive Waste – Article 19 Para 3
According to the instructions of the RWM, RW is defined as any unusable material in gaseous, liquid, or solid form that contains, or is contaminated with, radionuclides at concentrations or activities greater than clearance levels established by EMRC.

EMRC has issued Instructions on the criteria for the exemption of and clearance of radioactive material from regulatory control, which entails the requirements and levels for the clearance of materials in solid, liquid, and gaseous forms.

Article 20. Regulatory Body

Establishment and Designation – Article 20 Para 1
As indicated previously, the regulatory authority in the Hashemite Kingdom of Jordan is the EMRC. EMRC is a governmental body that possess a legal personality with financial and administrative independence, which was formed by merging the Electricity Regulatory Commission (ERC), JNRC, and the Natural Resources Authority (NRA), and as such is considered to be the legal successor of these entities. The EMRC was formed per Law No. (17) for the year (2014) regarding the restructuring of institutions and governmental organizations.

According to Article 4 of Law No. (43) for the year 2007, EMRC in coordination and cooperation with relevant authorities is tasked to achieve the following:

- Regulate and control the use of nuclear energy and ionizing radiation.
- Protect the environment, human health and property from the hazards of contamination and exposure to ionizing radiation in accordance with the provisions of this law.
- Ensure the fulfilment of requirements of public safety, radiation protection, and nuclear safety and security.

According to Article 5 of Law No. (43) for the year 2007, EMRC is required to undertake the following duties and authorities:

- Grant licenses and permits for radiation institutions, nuclear facilities, and workers in the radiation and nuclear fields.
- Verify the commitment of the licensees to implement the terms of this law and any regulations and instructions issued accordingly.
- Control the implementation of the terms of this law and conduct inspection for any installation or entity for this purpose.
- Contact institutions and commissions concerned with regulating and control of nuclear energy, radiation protection, and nuclear safety and security in the Arab and foreign countries to benefit from the expertise, scientific research, and assistance in their field of work.
- Participate in Arab, regional, and international projects concerned with nuclear energy, radiation protection, and nuclear safety and security, related to expertise or research with the consent of the cabinet.
- Regulate relations between Jordanian entities concerned with radiation protection, and nuclear safety and security; as well as with relevant international, regional, and Arab organizations and agencies.
- Implement comprehensive safeguards and create a system to account for and control of all nuclear materials subject to these safeguards.

Independence – Article 20 Para 2

According to the Article 3 of Law No. (8) for the year 2017, Law of Energy and Minerals Regulatory Commission, EMRC possess a legal personality with financial and administrative independence and reports directly to the cabinet.

F. OTHER GENERAL SAFETY PROVISIONS

Article 21. Responsibility of the License Holder

Safety Responsibility – Article 21 Para 1

Pursuant to Article 14 of the "*Radiation Protection and Nuclear Safety and Security*" law for the year 2007" and in accordance with Article 5 (b) of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2013, SNF management and WRM can be conducted only by authorized entities after obtaining required licenses and permits.

The "*Instruction on Safety of Spent Fuel and Radioactive Waste Management*" issued by EMRC under Article 25 of the Regulation clearly defines in its Article 4 that the license holder has the prime responsibility for safety throughout the lifetime of RWM facilities and activities, and this responsibility cannot be delegated. According to Article 7, the license or permit holder that is authorized by EMRC to use nuclear energy, manage RW, or manage SNF shall, among other requirements, ensure compliance with the nuclear safety, security, safeguards, and radiation protection requirements adopted by the EMRC in performing relevant activities in their facilities and installations, and implement all measures and activities associated with the safe storage of nuclear material and management of radioactive material, SNF, and RW generated in their facilities and installations until delivered and transferred to a licensed entity to use such materials or licensed entity for RW and SNF management.

By the "*Nuclear Energy Law*" No. 42 for the year 2007 and its amendments No. 4 for the year 2008, JAEC has been assigned with the responsibility for the long-term management of SNF and RW, as well as for disposal of RW generated within the territory of the Hashemite Kingdom of Jordan.

Generators of SNF and RW shall, among other responsibilities, be responsible for the technical, financial, and administrative short-term management of the waste generated within their facilities, and for the financing of long-term management of their SNF and RW, including final disposal, which will be technically and administratively managed by JAEC. The generators are required to make arrangements and agreements with the JAEC for the long-term management of SNF and RW, including storage, disposal, and all required institutional control measures.

Pursuant to Articles 4 and 5 of the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007," and in accordance with the Merging Law No. 17 for the year 2014, EMRC performs its regulatory functions that include granting licenses and permits for radiation institutions, nuclear facilities and workers in the radiation and nuclear fields; verifying the commitment of the licensees to implement the terms of laws, regulations, and instructions; and conducting periodic inspections of any installation or body for this purpose.

No License Responsibility – Article 21 Para 2

According to Article 20 of the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007, pertaining to revoking the license or discovery of any unlicensed facility, activity or orphan source, the EMRC is authorized:

- to terminate operation or close the installation, facility, institution, or establishment, where radioactive sources, materials, equipment, or radiation devices are kept or used - if keeping, continuous operation, handling, or use is posing risk to human health and environment;

- to confiscate radioactive sources, materials, equipment or radiation devices that cannot be licensed to prevent its use and deposit it in the EMRC's warehouses or in any place deems appropriate until they are licensed, and if not licensed within three months of the date of seizure, to dispose of the confiscated materials in accordance with public interest, including the option returning the imported materials to the country of origin. In this, appropriate precautionary protective measures will be taken by the EMRC or JAEC upon EMRC's request.

Article 11 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2013, defines that any RW or SNF for which the owner is unknown, shall be constituted as state property. The EMRC shall designate a licensee to which such RW and/or SNF shall be transferred to and the relevant conditions for this provision.

The EMRC has the right to enter and inspect any place suspected of containing unlicensed sources, materials, equipment, or radiation devices, or to inspect any activity that is being practiced in violation to the terms of laws, regulations, or instructions.

The GoJ is responsible for bearing the cost for management of orphan sources, RW and SNF of which the owner cannot be defined or no longer exist. Otherwise the occurring costs can be claimed back by recourse to the identified owner.

Article 22. Human and Financial Resources

Staff Qualification – Article 22 (i)

According to provisions of Jordan's national policy on RW and SNF management, the GoJ is responsible to take the appropriate steps to ensure the availability of qualified staff for the RW and SNF management, which can be achieved by recruitment of adequate human resources and ensuring allocation of financial resources for training and qualification of personnel.

Article 7 the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007 lays the foundation for mandating the availability of qualified personnel that are efficient in the areas of radiation protection, nuclear safety and security. Furthermore, Article 7 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2013 also mandates that the license or permit holder authorized by the EMRC to use nuclear energy, manage RW and/or SNF to ensure qualified human resources are attained.

Article 3 of the "*Instructions on Controls of the Radiation Protection Program, Safety of Radiation Sources, the Management System, Quality of Radiation Sources and Radiological Practices, Accidents and Verification of Compliance*" defines that a license holder shall establish a Radiation Protection Program (RPP) in proportion to the radiation risks associated with the exposure situation under their responsibility that is sufficient to ensure compliance with the safety requirements. This Article further requires that the RPP shall identify the Radiation Protection Officers (RPOs) and qualified experts, and certify their appropriateness for their assigned duties, which education, training, qualifications, and fields and years of experience. The RPO is defined as person technically competent in radiation protection matters relevant for a given type of practice, who is designated by the registrant or licensee to oversee the application of relevant requirements established in international safety standards and in accordance with their RPP.

According to Article 64 of the "*Radioactive Waste Management Instruction*," in order to control all waste management activities, the operator shall implement a management system that

integrates safety, health, environmental, security, quality, and economic elements to ensure, among other requirements, improving personnel safety culture and qualification. Article 65 further defines that the documents of the management system shall specify the organization structure of RWM activities, including facility operation, training, and qualification of the personnel.

In full compliance with the legislative requirements, JAEC has assigned RPOs and qualified experts necessary for the safe operation of its facilities. The radiation protection, maintenance, and inspection programs are developed by JAEC, and have been approved. Verification of availability of adequate human resources is part of the licensing process of any waste management facility. Annual inspections are performed by the EMRC to verify compliance to licensing conditions.

Financial Resources – Article 22 (ii)

According to provisions of the Jordan national policy on RW and SNF management the GoJ shall take the appropriate steps to ensure adequate financial resources to support the safety, security and radiation protection for spent fuel and radioactive waste management facilities during their operating lifetime and their decommissioning. The generators of SNF and RW are responsible for securing the adequate human resources and establishing the safe management of SNF and RW and shall be in a position to bear all the cost for the management and safe disposal, which will be carried out by JAEC. The GoJ will be responsible for bearing the cost for management of ownerless RW and orphaned sources.

Financial Provision – Article 22 (iii)

According to provisions of Jordan's national policy on RW and SNF management, the GoJ is required to take appropriate steps to ensure financial provisions are made available for carrying out all institutional controls and monitoring arrangements for national disposal facilities. Because there is no disposal facility currently in operation in Jordan, there are currently no special requirements laid down in the legislation.

Article 23. Quality Assurance

It is stipulated by the national policy for RW & SNF management that generators of SNF and RW or operators or managers of RW storage and treatment facilities are responsible for establishing and implementing a Quality Assurance Program (QAP) for RW and SNF management at their facilities.

According to Article 7 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2013, the license or permit holder authorized by EMRC shall maintain a high level of quality in all activities related to nuclear safety, security, and radiation protection carried out in the licensed nuclear facility.

Adhering to the requirements set forth by the nation legislation, JAEC has established and implemented a management system, covering all its facilities, which is compliant with international safety standards. Programs, plans, and written procedures governing activities and processes that are carried out in its facilities are formulated to ensure these activities and processes are in accordance with radiation protection principles to ensure that no dose constraints or limits are being exceeded.

Quality Assurance (QA) has been considered in the design, construction, maintenance, and modification of RWM facilities owned by JAEC.

Assessment of the availability and level of implementation of an integrated management system to ensure a sustained level of safety and to verify compliance to all the established procedures during the operational phase of the facilities is regularly performed by JAEC. Records are also maintained for these assessments, as well as for activities carried by in these facilities.

As indicated previously, the CSF was established at JAEC premises to provide for the safe, secure, and effective management for the RW, primarily in the form of DSRS which are results of radiological activities and facilities (medical, industrial, and agricultural applications, as well as research institutes).

The main objective of implementing a Quality Management System (QMS) for the safe, secure, and effective management of RW from their generation to their long-term storage (an ultimately disposal), is to reduce radiological risks and hazards and to protect the public health and the environment, at the present time and the future without imposing undue burden upon future generations.

All services or activities pertained to the RWM are conducted through specialized technical CSF staff to ensure the highest level of quality. All services and activities are performed in accordance to the national requirements and regulations, international standards, and the IAEA recommendations.

Verification of the achievement of quality within CSF is the responsibility of the JAEC's QA Department. All CSF personnel have the authority and responsibility to identify quality concerns, recommend solutions, and stop unacceptable activities or practices that may adversely affect quality or safety.

CSF Management is committed to the continual improvement of its performance by monitoring quality issues and through involvement with customers, suppliers, regulatory authorities, and community.

To assist with the above, JAEC has established a dedicated QMS based on the ISO 9001:2008 for CSF. It is the responsibility of the entire CSF team to support effective operation of the CSF Quality Management System in order to achieve the goals and the specified quality objectives.

Article 24. Operational Radiation Protection

For all facilities operated by JAEC, RPP are documented and formally approved. The RPPs have been implemented and cover routine monitoring of the relevant facility and its environment, monitoring of specific operations such as treatment and emplacement activities, and any special monitoring that may be required from time to time. These programs make provisions to monitor occupational exposure, radiation levels, and surface contamination. Documented safety analysis is required by the EMRC for each facility, and is reviewed and is audited by the EMRC, to ensure appropriateness and applicability of its RPP and that it is fully implemented by the respective facility.

Article 25. Emergency Preparedness

Emergency Plan – Article 25 Para 1

Article 15 of the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007 stipulates that every licensed establishment shall develop an emergency plan proportionate with the nature of the work of the establishment. Article 14 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2013 requires the licensee to establish measures for emergency

planning and emergency preparedness for all its activities, to include the design, construction, commissioning, operation, and decommissioning of nuclear facilities and processes related to the manufacturing, transportation, and storage of nuclear material. This Law and Regulation requires the on-site emergency plan to be prepared in coordination with the off-site national emergency plan.

The EMRC coordinates with relevant governmental entities the development of the off-site emergency plan. The off-site emergency plan is submitted by the EMRC to the Higher Civil Defense Council for official adoption. Article 15 of the former regulation states that the licensee shall ensure the connection between on-site and off-site emergency plans with all relevant national organizations to protect the public, their properties, and environment in the event of nuclear accidents or emergencies.

Article 16 of "*The Safe Use of Nuclear Energy*" Law No. 43 for the year 2014 requires that six months prior to the commissioning of a nuclear facility, licensees is required to submit the on-site emergency plan to the EMRC and to other competent authorities. Approval of the on-site emergency plan is required prior to fuel loading in any nuclear facility in accordance with the draft "*Instructions for Emergency Preparedness for Nuclear and Radiological Facilities,*" which is to be issued by the EMRC under subparagraph M of Article 25 of "*The Safe Use of Nuclear Energy*" bylaw No. 43 for the year 2014.

It is stated in subparagraph B of Article 16 of the bylaw that the emergency plan shall be exercised in practice prior to commissioning of the nuclear facility and in the course of facility operation, and the separate parts of the plan shall be periodically tested and evaluated and the licensees or relevant permit holders are obligated to conduct special training for the employees designated to perform functions in implementing the emergency plans as required by Article 17 of "*The Safe Use of Nuclear Energy*" bylaw No. 43 for the year 2014.

Article 18 of "*The Safe Use of Nuclear Energy*" bylaw No. 43 for the year 2014 defines that the terms and procedure for preparation of the emergency plans, the persons responsible for their implementation and their duties, the measures for mitigation and remediation of the consequences, the arrangements for warning of the public, as well as measures for conducting the emergency preparedness exercises shall be in accordance with the Instructions and Regulations issued by EMRC.

In the national policy for RW and SNF management, it is stated that SNF and RW shall be managed in accordance with national and international accepted practice principles, such as the following:

- Emergency preparedness and response: Arrangements must be made for emergency preparedness and response in case of nuclear or radiation incidents;
- Prevention of accidents: All practical efforts must be made to prevent nuclear or radiation accidents.

In the national regulation for SNF, particularly Articles No. 112 and 113, emphasis that the safety of the facilities for SNF management shall be ensured by the development of emergency plans and their on-site and off-site execution when necessary.

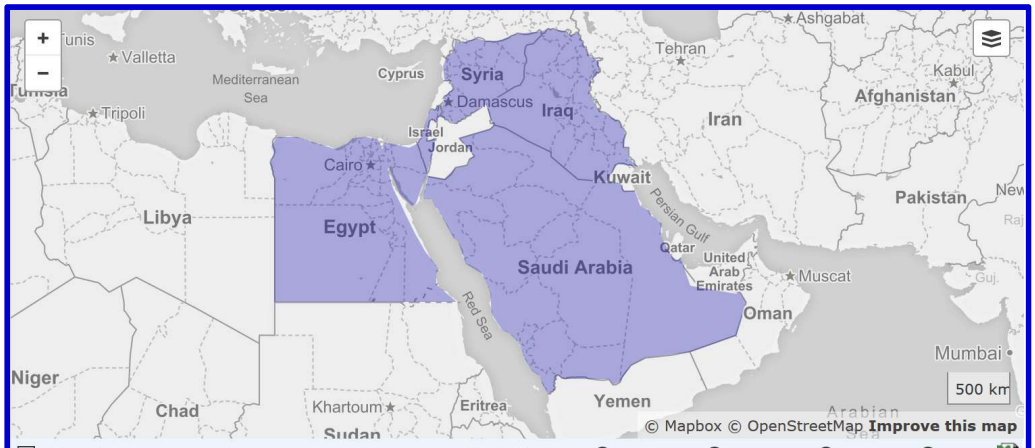
JAEC has developed an emergency plans for each of its licensed radiological facilities and activities, a drill with all concerned governmental parties has been conducted to test the emergency response of the technical team within JAEC with off- site emergency response

organizations and the technical emergency response JAEC team has been also involved with other concerned governmental emergency response organizations in drills and exercise on national level to examine and test the integration of overall national emergency response plan in case of radiological or nuclear emergencies.

Outside Effects – Article 25 Para 2

There is no NPP in construction or operation in the vicinity of Jordan territory. However, there are several research reactors in the neighboring regions, as shown in Figure 4, which could raise a need for an emergency response system in place in case of any radiological emergency event at their sites.

EMRC will further study potential implications and related demands in establishing national early warning system within Jordan's territory and seek for regional cooperation with this regard.



Select All Facilities Pagination : 20 Per Page 10 Per Page 5 Per Page None

Report	Country	Facility Name	Type	Thermal Power (kW)	Status
☑	Saudi Arabia	LPRR	POOL	30.0000	UNDER CONSTRUCTION
☑	Egypt	ETRR-2	POOL	22000.0000	OPERATIONAL
☑	Israel	IRR-1	POOL	5000.0000	OPERATIONAL
☑	Israel	IRR-2	HEAVY WATER	26000.0000	OPERATIONAL
☑	Syrian Arab Republic	SRR-1	MNSR	30.0000	OPERATIONAL
☑	Egypt	ETRR-1	TANK WWR	2000.0000	EXTENDED SHUTDOWN
☑	Iraq	IRT-5000	POOL, IRT	5000.0000	PERMANENT SHUTDOWN
☑	Iraq	TAMMUZ-2	POOL	500.0000	PERMANENT SHUTDOWN

Figure F.1 Research Reactors in the Neighboring Region

Article 26. Decommissioning

There is currently no facility under decommissioning or approaching decommissioning phase in Jordan. Nevertheless, EMRC has established the relevant national legislation to coupe with decommissioning issues, as well as operators give due consideration to ensure preparedness for the decommissioning starting from design through to operation of their facilities.

There is no requirement on obtaining license for decommissioning posed by the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007, however, according to the Article 6 (d) of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2013, the EMRC issues a permit for Decommissioning of a nuclear facility under the operating license of a nuclear facility or installation. All phases of decommissioning, from the initial plan to the

final release of the facility from regulatory control is to be regulated by EMRC, as set forth in Article 3 of the "*Instruction on Decommissioning of Nuclear Facilities*." Therefore, any decommissioning activity cannot be implemented without a permit issued by the EMRC. EMRC requires the decommissioning plan to be prepared and maintained by the operator throughout the lifetime of the facility, where for newly designed facilities, decommissioning planning should be considered on three stages: initial, intermediate, and final; while in the case of nuclear facilities in operation and under construction, where an initial decommissioning plan does not yet exist, an intermediate decommissioning plan reflecting the current operational status is required to be prepared as soon as possible for establishment of compliance with the Instruction.

Pursuant to Article 8 (f) of the "*Instruction on Decommissioning of Nuclear Facilities*" for sites that house more than one facility, a global decommissioning program is required to be developed for the entire site to ensure that interdependences are considered in the planning for each individual facility.

Staff Qualification – Article 26 (i)

Since the permit for decommissioning of a nuclear facility is issued by the EMRC under the license for operation of nuclear facility, Article 7 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2013 requires provision of qualified human resources is applicable to the decommissioning phase of the facility. The "*Instructions on Radiation Protection Requirements Against Occupational Exposure*" issued by EMRC under Article 7 of "*The Radiation Protection, and Nuclear Safety and Security*" Law No. 43 for the year 2007, and by its Article 4, which stipulates that in order to guaranty the necessary level of competence for all workers engaged in activities in which they are or could be subject to occupational exposure, a registrant or licensee shall ensure suitable and adequate human resources and appropriate training in protection and safety are provided. Furthermore, Article 28 (b) of the "*Instruction on Decommissioning of Nuclear Facilities*" requires the management system to be applied throughout the entire process of decommissioning to ensure that personnel involved have appropriate qualifications and experience, and the respective training is carried out.

Article 7 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2013 also defines that the license or permit holder authorized by the EMRC to use nuclear energy, manage radioactive waste, or manage spent fuel shall guaranty securing adequate financial resources to ensure safe shutdown and decommissioning of the nuclear facility and the relevant activities. Furthermore, Article 7 (e) of the "*Instruction on Decommissioning of Nuclear Facilities*" sets forth the obligation for the operator to ensure that sufficient funds will be available for decommissioning, where the initial decommissioning plan shall address the costs and the means of financing the decommissioning work, based on preliminary cost estimation, taking into account evaluation of accepted and applied engineering methods and technologies for decommissioning of referent nuclear facilities, and options for collection of financial resources and budgeting in accordance with the applicable national legislation.

Applying Provisions of Article 24 – Article 26 (ii)

Article 7 (e) of the "*Instruction on Decommissioning of Nuclear Facilities*" requires that the final decommissioning plan shall be submitted by the applicant for decommissioning authorization to the EMRC for approval two years before termination of the facility operation. The final decommissioning plan is required to define safety and radiation protection measures. According to the provisions of Article 21 of this instruction, radiation protection during decommissioning of a nuclear facility is required to adhere to and be in accordance with the

principles stated in the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007.

Furthermore, Article 22 of this instruction requires the operator to develop, within the framework of the decommissioning plan, a program for radiation protection of the workers, the public, and the environment.

According to Article 9 of the EMRC instruction, technical measures and solutions that facilitate decommissioning must be considered in at the design phase of a nuclear facility. The initial decommissioning plan must be based on preliminary assessment of the planned decommissioning activities in respect to occupational exposures and potential releases of radioactive substances with resulting exposure of the public. The final decommissioning plan is required to define criteria based on the safety assessment and environmental impact assessment pertaining to such activity.

Applying Provisions of Art 25 – Article 26 (iii)

The provisions of Article 14 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2013 related to emergency preparedness apply to all phases of nuclear facility, including decommissioning.

Records – Article 26 (iv)

According to Article 8 (c) of the "*Instruction on Decommissioning of Nuclear Facilities*," the initial decommissioning plan is required to include nomenclature of documents and records from the sitting, design, construction, and operation relevant to decommissioning planning, which must be retained during the facility lifetime. Article 11 of this instruction defines that the final decommissioning plan address documentation and record keeping requirements.

Article 10 stipulates that during operation, the operator shall ensure the implementation of the plan and take general measures facilitating the decommissioning, including relevant records keeping.

As set forth by Article 34, the quality program developed by the operator as a part of final decommissioning plan is required to address the planning and implementation of all processes on decommissioning, including maintenance and archiving of related documents and records. Relevant documents and records are to be prepared and maintained during the design, construction, commissioning, operation, decommissioning phases of a nuclear facility, and after completion of decommissioning.

G. SAFETY OF SPENT FUEL MANAGEMENT

Article 4. General Safety Requirements

As explained previously, Jordan has only one research reactor (JRTR), which is in the final licensing stage. No power plant is established until now.

Nuclear criticality safety of the SNF stored within the facility is addressed adequately in the safety documentation submitted to EMRC for the JRTR operation license.

Article 5. Existing Facilities

As explained before, Jordan only have a research reactor (JRTR) and all the anticipated SNF resulting from its operation will be stored in the service pool for the life time of the facility.

Articles 6-9. Siting of Proposed Facilities, Design and Construction of Facilities, Assessment of Safety of Facilities, and Operation of Facilities

No plans to design or construct new facilities in the near future.[3]

Article 10. Disposal of Spent Fuel

All spent fuel from JRTR is to be stored at the service pool for the lifetime of the reactor. After the interim storage at the JRTR, SNF will be either returned to the country of origin for final disposal or if declared as a radioactive waste, the SNF is to be disposed of directly to national waste disposal facility. Final decision on SNF disposal should be taken in the future.

[3] *Note that siting studies are currently undergoing in support of the NPP that is under consideration in the Hashemite Kingdom of Jordan.*

H. SAFETY OF RADIOACTIVE WASTE MANAGEMENT

Article 11. General Safety Requirements

EMRC regulations require RWM operator to apply measures that assure compliance to the general safety requirements so that:

- Effects of ionizing radiation on the workers, public, and environment are kept to a level as low as reasonably achievable.
- Sub-critical values ($k_{eff} << 1$) are ensured.
- Removal of residual heat is ensured.

Licensed operators are to implement measures to minimize waste generation and to avoid accumulation of RW on-site. Therefore, the operator is required to apply technologies and methods suitable for keeping the generation of RW to minimum practicable levels, in terms of both activity and volume of the generated RW.

RW is characterized in terms of its physical, mechanical, chemical, radiological, and biological properties. In applying for permits and/or licenses, the operator is required to take into account the chemically or biologically hazardous substances in the safety analysis of its processes and facilities.

Addressing Criticality and Heat Removal – Article 11 (i)

JAEC is required to implement measures and demonstrate that the implemented measures are adequate to assure compliance to the general safety requirements so that removal of residual heat is ensured in all its RWM activities.

EMRC requires that the design and operation of a waste storage facility must incorporate technical features to maintain nuclear sub-criticality and residual heat removal, if necessary.

Minimizing Radioactive Waste Generation – Article 11 (ii)

One of the main objectives of Jordan's National Policy for RWM is to minimiz the generation of radioactive waste to the extent possible.

Also, JAEC is keen to apply basic safety standards for RWM and will ensure that the methods applied in Jordan are in full conformance with the recommendations of the international best practice and the IAEA standards in regard with control and minimize of radioactive waste generation. EMRC, as the regulatory authority, is responsible to ensure full compliance of JAEC and its facilities to local regulations and Jordan's international commitments.

JAEC is required to apply measures to minimize waste generation and to avoid accumulation of radioactive waste on-site. In accordance with that, JAEC is required to:

- apply technologies and methods suitable for keeping the generation of waste to the minimum practicable levels, in terms of both activity and volume;
- reuse and recycle materials to the extent possible;
- classify and segregate waste appropriately, depending on its properties and with account taken of the designated options for processing;
- not allow mixing of radioactive and non-radioactive waste;
- avoid spread of contamination in the facilities;
- implement practices for release of materials from regulatory control;

- introduce decontamination processes following cost-benefit analysis;
- apply processing technologies that reduce the volume of radioactive waste;
- provide adequate storage options for the RW subject to subsequent processing, clearance, or disposal; and
- ensure that activities and methods used to manage RW comply with the stated national policy and strategy.

In the JRTR, radioactive material control procedures are established, implemented, and maintained that ensure compliance with the regulatory requirements for minimising volumes of radioactive wastes. This can be shown in some examples in JRTR FSAR report such as:

- a pre-action sprinkler system (fire-fighting system) is used in radiation-controlled areas to minimize the discharge of RW;
- during the operation of the JRTR, considerations should be given to minimize the extent of the contamination of structures and surfaces, to prevent the mixing of waste products of dissimilar categories, minimizing waste generation, and to avoid spillages and leaks;
- minimizing the generation of radioactive materials by neutron activation is one of the design bases in the design of the JRTR; and
- JRTR waste management requires the RW to be characterized, segregated, treated, conditioned, stored, and free discharged and released (when applicable) to minimize the impact of RW.

A number of processes have been incorporated in the design and construction of the RTF to minimize RW, which includes:

- solidification of RW, such as cementation of concentrated radioactive liquid, radioisotope capsules, and spent filters;
- compaction of dry solid radioactive;
- decontamination of reusable tools and equipment; and
- evaporation.

Interdependence – Article 11 (iii)

JAEC is keen to apply the basic safety standards for RWM and will ensure that the methods applied in Jordan are in full conformance with the recommendations of the international best practice and the IAEA standards is obliged to ensure that generation and management of RW is interdependent.

EMRC regulations require the design, construction, operation, and decommissioning of RWM facilities take into consideration the inter-relations between all steps of RW generation and management.

for the JRTR, management of waste generation and waste minimization was considered in all the project's stages from design to decommissioning. Different options for the treatment, conditioning, storage, and disposal of RW were considered for the JRTR. Furthermore, EMRC licensing procedures as well as its periodic inspections provide further assurances of the interdependencies among the different steps in RWM.

Waste management program, including waste acceptance criteria (WAC) is one of the important documents during licensing of JRTR and RTF facility to ensure a proper interrelation between all steps of radioactive waste management processes up to the final disposal option.

Protection of Individuals, Society, and Environment – Article 11 (iv)

JAEC is keen to apply the basic safety standards for SNF and RW management, and seeks to deploy and implement RWM and SNF management techniques that are in conformance with the recommendations of the international best practice and the IAEA standards.

EMRC in coordination and cooperation with relevant authorities aims to protect the environment, human health, and property from the hazards of contamination and exposure to ionizing radiation in accordance with the provisions of the "*Radiation Protection and Nuclear Safety*" Law. No. 43 for the year 2007.

Safety of RWM facilities is to be based on the concept of defense-in-depth, relying on a system of organizational and technical measures for protection of workers, members of the public, and the environment under normal and accident conditions.

During the pre-operational stages of the JRTR project, EMRC has conducted many periodical inspections including monitoring of radioactivity in the environment in order to establish a baseline. By establishing this baseline prior to the operations of the JRTR, and periodic environmental monitoring and assessment, provides assurances and verifications that releases are kept below the discharging limits and to ensure that the ALARA principle has been applied and is in compliance with the environmental legislations.

In case of the RTF, the facility is zoned to minimize the transport of contamination to other areas and to reduce the annual dose received by personnel during normal operation of the facility to minimum levels. In addition, general techniques to accomplish ALARA of operational aspects are adhered to through the design and construction features of the RTF that incorporate shielding, distance, and minimize the residence time of a RTF workers in the high radiation areas.

The Radiation Monitoring System (RMS) is used to measure, indicate, and record the radiation dose rates and airborne concentrations of radioactive materials in selected areas of the RTF, as well as the radiation or radioactivity levels in the radioactive effluents released to the environment. The RMS is also used to provide personnel with timely information regarding alarm and readout.

There are currently no final disposal facilities for radioactive waste in operation or under construction in Jordan.

Jordan RWM policy aims to manage RW in accordance with national and international accepted practice principles for the protection of present and future generations.

Considering Biological, Chemical, and Other Hazards – Article 11 (v)

EMRC regulations require the operator of RW storage and disposal facility to develop and apply WAC. The WAC is required to be developed based on the safety analyses report for the respective facility and is required to contain requirements (acceptance criteria) pertaining to the chemical and/or biological hazards of substances in the waste and waste packages.

Impacts on Future Generations – Article 11 (vi)

There are currently no final disposal facilities for RW in operation or under construction in Jordan.

Jordan's RWM policy aims to manage RW in accordance with national and international accepted practice principles, in order to protect present and future generations.

Burdens on Future Generations – Article 11 (vii)
Jordan policy includes all specific steps and stages related to the safe management of RW, starting from its generation to its final disposal, and to ensure nuclear safety and security provisions that aims to protect human health and the environment against the radiological and nuclear contamination, currently and in the future and without imposing undue burden upon the future generations.

Currently, DSRS are the main component of the current national RW inventory in Jordan. The management options for DSRS include finding international or regional solutions for the DSRS management and disposal.

EMRC is aiming by implementing its legislations during licensing, that the operator has to achieve proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards.

The operator shall make suitable arrangements to ensure that maintenance, inspection, and testing appropriate to the preservation of the provisions for protection and safety can be carried out without undue occupational exposure.

JAEC is studying options for dealing with their inventory of DSRS and other RW, including SNF that will be generated from the operations of the JRTR. Options being considered by JAEC include international and/or regional solutions for the management and disposal of these RW (for SNF, processing abroad is being considered).

Article 12. Existing Facilities and Past Practices

There are three RWM facilities in Jordan as shown in Table H.1 below.

Table H.1 RWM Facilities in Jordan

Name	Site	Status	Description
CSF	Amman-Shafa Badran	In operation since 2010	Treatment and Storage of DSRS
RTF	Irbid-JRTR	Under Licensing	Liquid and Solid RWM
Sewaqa	Amman-Sewaqa	Out of Use	Hazardous Waste Management

The RTF at JRTR is expected to manage solid and liquid wastes generated from JRTR, as well as waste from other generators, which meet the RTF's WAC.

RW is stored in an underground concrete pit at the historical Sewaqa hazardous waste management center. More details about existing radioactive waste management facilities are given in this report ANNEXES.

Article 13. Siting of Proposed Facilities

Site Evaluation – Article 13 Para 1 (i)
By virtue of EMRC regulations, JAEC is required to take into account in the safety assessment significant changes that may occur on the site considered for RWM and disposal facility that could affect the safety of the facility or of activities on the site.

The licensee or permit holder authorized by EMRC to use nuclear energy, manage RW, or manage SNF is required to monitor the environment for radiological, and chemical where appropriate, characteristics and levels at the site and its surrounding..

Site selection of RW processing, storage, and disposal facilities is made based upon evaluation of:

1. inventory, characteristics, and location of the existing waste, as well as the perspective for generation of radioactive waste;
2. impact of naturally-induced or man-induced initiating events on the safety of the facility;
3. impact of the facility upon the environment;
4. radiological impact of the facility on the public;
5. specific characteristics of the site as it pertains to significant for migration and accumulation of radioactive substances;
6. possibilities for application of protective measures to the public in case of an accident in the facility; and
7. size of the special statutory areas and the emergency planning areas.

The JRTR facilities, including its RTF, were designed and constructed to comply with the requirements of the site characteristics. All criteria for the JRTR site met the requirements of the EMRC.

Safety Impact – Article 13 Para 1 (ii)
Siting of waste disposal facilities is required to be based on a comparative analysis of at least three alternative sites taking into account the potential impact of the facility on the public and the environment.

However, there are no disposal facilities in Jordan, therefore, there are no safety impact of such a facility on individuals, society, and the environment.

Information for Public – Article 13 Para 1 (iii)
The license or permit holder authorized by the EMRC to use nuclear energy, manage radioactive waste or manage spent fuel is required to ensure:

1. Plans covering the roles and responsibilities of the relevant parties according to its competence to provide for the provision of the necessary measures to raise awareness of the dangers resulting from the use of nuclear energy, and any measures in order to inform the public and the relevant authorities for any possible effects on health and the environment, and maintain these measures transparently.
2. Make suitable arrangements to ensure that all relevant safety documentation is available in the appropriate languages understandable to users.
3. An environmental impact assessment is made per the governing requirements (MoE) to inform the public for any possible effects or hazards that are expected from such a facility.

For the JRTR, there were scoping sessions undertaken between the applicant and in the interested parties of public. These were organized by the MoE and observed by EMRC. There was an open discussion between the concerned parties and the public to answer many questions

and respond to concerns of the public. These sessions were also use to inform the public and interested parties on the expected releases from that JRTR, and demonstrate it is within the allotted limits.

For the CSF, JAEC is ensuring that the required information for the public is available and JAEC is accepting visitors to tour the facility and provide access to relevant information to assure transparency and openness.

Other Parties Consultation – Article 13 Para 1 (iv)
Jordan national policy intends to inform the public about the proposed plans for SNF and RW management, and to consult with all concerned parties and members of the public to aid in making related decisions.

The license or permit holder authorized by EMRC to use nuclear energy, manage radioactive waste or manage spent fuel shall ensure:

> Plans covering the roles and responsibilities of the relevant parties according to its competence to provide for the provision of the necessary measures to raise awareness of the dangers resulting from the use of nuclear energy, and any measures in order to inform the public and the relevant authorities for any possible effects on health and the environment, and maintain these measures transparently.

Article 14. Design and Construction of Facilities

Design Consideration – Article 14 (i)
The design, technologies, and procedures developed for RWM facilities shall ensure that radioactive substances are contained within the established boundaries under all operational conditions and design-basis accidents.

Main design characteristics of a waste disposal facility are to be determined based on the safety assessment for the operational and post-closure periods.

Closure of radioactive waste disposal facilities shall be performed in accordance with the detailed closure activities plan, where the plan is required to include design, technologies, and materials needed.

The RTF design complies with IAEA safety standards and EMRC requirements, and adheres to the established radiological protection policy and measures. The design of the RTF and its operational procedures are formulated to ensure that internal and external exposure to radiation workers and the public is within the applicable recommendations of IAEA and is in compliance with ALARA principle.

Decommissioning Consideration – Article 14 (ii)
EMRC requires that the design stage of a nuclear facility must incorporate technical measures and solutions that facilitate decommissioning, which include the following:

- lay-out of the structures, systems and components of the nuclear facilities and access routes to facilitate:
- the dismantling and removal of large components;
- allowance for detachment and remote removal of significantly-activated components;
- future mounting of decontamination and waste handling equipment;

- decontamination or removal of embedded components such as pipes and drains;
- control of radioactive material within the facility; and
- construction materials are to be selected to reduce activation and to minimize contamination, spreading of radioactive products, and the amount of generated radioactive waste.

During the design and construction stage of the JRTR a preliminary decommissioning plan was submitted within the FSAR. The objectives of decommissioning plan are to reduce radiological exposure to workers, to minimize waste generation, reduce impacts on the environment, to simplify the dismantling procedures, and to reduce the cost. The decommissioning plan is required to include all of the necessary steps that lead to the ultimate completion of the decommissioning to the point that safety can be assured with minimal or no surveillance.

Closure Consideration – Article 14 (iii)

EMRC requirements mandate that major design characteristics of a waste disposal facility is to be determined based on the safety assessment for the operational and post-closure period. The design of a waste disposal facility is required to establish the following:

a. waste acceptance requirements;
b. maximum total activity of the waste disposed of on site;
c. composition and structure of the multi-barrier system;
d. necessary requirements to the materials of each barrier;
e. minimum durability for each barrier;
f. provision of sub-criticality; and
g. maximum allowable thermal generation and required heat conductivity between the package and natural barriers.

Furthermore, EMRC requirements mandate that closure of radioactive waste disposal facilities are to be performed according to a detailed closure plan, which must be submitted to the EMRC at least three years prior to the start of its implementation. The closure plan must address the following:

1. design of technologies and materials needed;
2. final safety assessment following closure, using the information as result of analyses and operational experience accumulated during the previous stages; and
3. description of the control measures during closure, which include:
    a) frequency and periods of controls;
    b) radiation monitoring program on-site and within the protected and supervised areas;
    c) program for inspections and tests of the facility; and
    d) records keeping system.

Proving Technology – Article 14 (iv)

JAEC, by virtue of its permits, licenses, and EMRC regulations and instructions, is required to develop and implement measures that assure compliance to general safety requirements while considering available technologies in its RW facilities. The design solutions, technologies, and

procedures implemented by JAEC must be justified and compared with current achievements of science and technology and the internationally recognized operational experience.

The design of the JRTR is based on a proven technology / design of open – pool reactor, which is operated in south Korea (HANARO).

JAEC constructed the CSF with the best international standards for protecting human health and the environment from the long-term effects of radioactive waste and to prevent the accidents associated with the DSRS. The construction and security systems were funded by GTRI/DOE/USA. Characteristics such as geology and external events such as seismic events have been taken into consideration in the construction of the CSF.

Article 15. Assessment of Safety of Facilities

Preconstruction Consideration – Article 15 (i)
Jordanian regulations require that safety assessment be developed for different stages of the RWM facility (design through decommissioning and closure). Assumptions employed in the safety assessment are required to be justified and implemented when performing the activities associated with the RWM facility.

Initiating events considered in the safety assessment are to be reevaluated during progress of the design and safety assessment of the facility, and must be subjected to an iterative approach with feedback from the safety assessment. Compliance with the safety requirements and criteria shall be proven by safety assessment of the RWM facility.

The safety assessment is required to contain analyses for the capability of the facility to fulfill its safety functions under normal operation and anticipated occurrences conditions, as well as under accident conditions and low-probability events. For RW disposal facilities, degradation of the protective barriers as a result of human activity in the post closure period must be considered and evaluated. Furthermore, the safety assessment shall describe and justify measures for reducing the probability for propagation of radionuclides into the environment, as a result of human activity in the post closure period.

Environmental impact assessment – radiological impact deals with assessment of the future potential environmental impact of nuclear facilities and its associated waste treatment facilities based on the graded-approach. In particular, the instruction and its attached documentation provides additional guidance on the scope of information required in connection with the potential radiological environmental impacts directly associated with construction, operation, and decommissioning of a facility.

Adequate information for all areas relevant to the assessment of the radiological impact on the environment of the construction of the facility, its operation under normal operational conditions as well as under accident conditions including severe accidents, and its decommissioning shall be covered. For non-radiological impacts of the facility are addressed under MoE Legislative framework.

Prior to the construction of the RTF, JAEC submitted the preliminary safety analysis report (PSAR) which is evaluated by EMRC and covered a systematic safety assessment, and environmental impact assessment of the facility, which is cover the lifetime operation.

Systematic and Environmental Safety Assessment – Article 15 (ii)
Main design characteristics of a waste disposal facility shall be determined on the basis of safety assessment for the operational and post-closure periods.

Closure of the RW disposal facility is to be performed according to a detailed closure activity plan, and must be submitted to the EMRC at least three years prior to the start of its implementation. The plan must contain the final safety assessment after closure, using the information as result of analyses and operational experience, accumulated on the previous stages.

The period of the institutional post-closure controls is to be determined depending on the waste and site characteristics, the facility design, social, and other factors and must be substantiated in the safety assessment.

In Jordan, there is no disposal facility up to now.

Updating Safety Assessment before Operating – Article 15 (iii)
Safety assessment is to be developed for different stages of lifetime of the radioactive waste management facility. The assumptions adopted when carrying out the safety assessment must be reflected when performing the activities, for which the respective assessment was prepared.

The safety assessment must contain analyses of the capability of the facility to fulfill its safety functions under normal operation and anticipated occurrences conditions, as well as in cases of accidents and low-probability events. The disposal facility must also address degradation of the protective barriers as a result of human activity in the post closure period.

Description of environmental impacts of facility construction shall include specification of potential sources of radioactive material or radiation sources available on the site during construction, such as adjacent nuclear installation or sealed radiation sources used for control of materials during the construction, and determination of the radiological impact of these sources on construction workers of the facility under construction or members of the public.

Description of environmental impacts of normal operation shall include determination of the radiological impact both of direct ionizing radiation from the buildings and facilities, as well as ionizing radiation emitted by radionuclides in any gaseous and liquid effluents/discharges from the facility. On-site management of radioactive waste as well as of nuclear fuel must also be addressed. Estimates of the radionuclide concentration in various components of the physical environment shall be given, including information concerning any cumulative buildup of radionuclides in the environment, such as on land or in sediments. Both estimates of radiological impact which includes the radiation dose to people as well as to non-human biota shall be provided.

For the RTF, Final Safety Analysis Report (FSAR) summarizes the updated version of the safety assessment necessary to obtain the operating license. The Environmental Impact Assessment (EIA) is submitted with an updated version in order to approve on the operation license.

Article 16. Operation of Facilities

RWM facilities exist in Jordan. The CSF at JAEC has been issued an operation license by the EMRC after submitting a safety assessment of all the general and specific safety requirements including radiation protection for all stages of radioactive waste management in the RWM facilities as mentioned in Article No. (15) of this report. The RTF is undergoing final stages of commissioning and licensing.

It is required by the operator of RW processing, treatment, and/or storage facilities to develop and apply facility specific operational limits, conditions, and controls for all operations and

activities important to safety, assuring compliance of the facility operation with the design safety requirements. During the operation of RW processing, treatment, and/or storage facility, the operator is required to perform analyses and report on operational events that are significant to safety to the EMRC.

The application for a License for Nuclear Facility operation shall comply with the requirements under *Article 12*, *Article 13*, *Article 14*, *Article 19*, *Article 43*, and *Article 59* of the instruction on the procedure for issuing licenses and permits for nuclear facilities and associated activities. This include operation, maintenance, monitoring, inspection, and testing programs that must be developed and maintained by the facility operator, as well as relevant reports that must be submitted to the EMRC for review. Engineering and technical support must be made available over the operating life of RWM facilities. All radiation protection requirements including incidents reporting and emergency planning and preparedness, and general and specific safety requirements including segregation and characterization of the generated waste, decommissioning and closure plans are outlined in the EMRC regulation on the RWM and regulation on the safe use of nuclear energy and instruction on licensing nuclear facilities.

Article 17. Institutional Measures after Closure

Preserving Records – Article 17 Para 1
Closure of radioactive waste disposal facilities shall be performed in accordance with detailed closure activities plan, which must be submitted to EMRC at least three years prior to the start of its implementation. The plan must address the Records Keeping System.

Any person or entity that possess, manufacture, process, store, use nuclear materials, or manage SNF and RW, shall maintain physical inventory and keep records of all nuclear and radioactive material, as well as for spent fuel.

The responsibilities for the management of SNF and RW in Jordan are distributed over the following main pillars JAEC, Generators, and Operators, which they are obliged for keeping record for radioactive waste and spent nuclear fuel.

There are no disposal facility under construction or in operation in Jordan. Nevertheless, the Jordanian legislation does contain legal requirements for closure of a disposal facility. There are currently no structured plans for closure of the existing long-term storage facilities in Jordan.

Institutional Controls – Article 17 Para 2
An institution authorized by EMRC shall perform post-closure control of the radioactive waste repository site. Controls may include:

Active Controls by carrying out monitoring, access control, maintenance of the facility's systems and infrastructure;

Passive Controls by implementation of administrative measures for control over land-use.

JAEC is required to implement provisions of institutional control over the closure of disposal facilities for RW and storage and processing facilities during operations and decommissioning stages. The waste generator is administratively, technically, and financially responsible for the short-term safe management of the RW and SNF in accordance with the national and international principle mentioned in the national policy, and is responsible for ensuring the availability of financial resources for the long-term management of its RW and SNF. Furthermore, JAEC is responsible for the long-term management of RW and SNF at the national

level. Therefore, the GoJ must take the appropriate steps to ensure the availability of financial provisions required for the institutional controls and monitoring arrangements for national nuclear decommissioning facilities and activities and disposal facilities related to the RW and SNF.

Unplanned Release – Article 17 Para 3

The estimated average effective dose to the relevant critical groups of members of the public as a result of a waste disposal facility after its closure must not exceed 0.15 mSv in a given year. This criterion is to be used in assessing the post-closure safety of the disposal facility in case of anticipated events (normal evolution of the disposal system). The intervention levels, as established by the EMRC, serves as safety criteria in case of low-probability events and human activity on-site in the post closure period.

Jordan legislation requires the implementation of radiation monitoring system to guard against the release of radioactive material to the environment that may result in doses or levels of contamination that exceed international intervention levels or action levels for protective actions.

I. TRANSBOUNDARY MOVEMENT

Article 27. Transboundary Movement

The Jordanian laws and regulations used to control the import and export of radioactive materials are:

- Law No. (43) for the year 2007 "*Radiation Protection, and Nuclear Safety and Security Law*''
- Regulation No. (43) For the year (2014), "*Regulation on the Safe Use of Nuclear Energy*", and its Instructions.
- Regulation No. (108) for the year (2015), "*Regulation on Radiation Protection*" and its Instructions.
- Regulation No. (32) For the year (2016), "*Regulation on the Transport of Radioactive Sources*" and its Instructions.
- Regulation No. (8) for the year (2013), "*Regulation on the Basis and Conditions for Granting Licenses and Permits for the Radiation Work*."

Import and export of radioactive waste is addressed in national policy for radioactive waste and spent fuel management. Note that RW cannot be imported into the Hashemite Kingdom of Jordan.

The transport of radioactive contaminated materials, radioactive waste and spent fuel is governed by regulation No. (32) for the year 2016, "*Regulation on the Transport of Radioactive Material*." Transport of RW and SNF is subject for authorization by EMRC. Each consignment is to be licensed separately. It is prohibited to execute transport of radioactive material in import, export, transit through the border crossing points, from customs bonded yard or to clear it from customs, without the prior approval of EMRC.

Article No. (17) of the Law No. (43) for the year 2007, "*Radiation Protection, and Nuclear Safety and Security*," states that it is prohibited for any person to bring any radioactive material classified as radioactive waste "of non-Jordan origin" to the territory of Jordan, or use, handle, transport, store, dispose of or bury it in the territory of Jordan. Because SNF is not considered as waste, SNF is allowed to be exported abroad to its origin (manufacturer) for treatment or reprocessing; and because the resultant HLW of the processing and treatment of the SNF is of Jordanian origin, its re-import back to Jordan is permitted.

Regulation No. (32) For the year (2016), "*Regulation on the Transport of Radioactive Sources*" and its instructions, which regulate and control the transport of the radioactive materials including the contaminated objects, are in compliance with the IAEA safety standards and security recommendations.

According to Article No. (21) from the "*Basis and Conditions Regulation for Granting Licenses and Permits for the Radiation Work*" No. (8) for the Year 2013, it is required to have a prior permission from the EMRC to import, export, re-export, transit, transport, distribute, or temporary store of the radioactive materials with short half-life that are used in medical fields at least seventy-two hours before receiving.

The permit for transport of nuclear material is issued to a License Holder if the License Holder has performed the following:

1. ensured that transportation will occur with a packaging and by means of transport as specified in the relevant regulation for transportation;
2. has provided for physical protection of the nuclear material; and
3. has submitted to EMRC a document ensuring nuclear safety applied to transportation activities, interim storage, and other on-site activities connected to the nuclear material handling before final disposal.

Jordan imported the fresh (unirradiated) nuclear fuel for the JRTR from France in accordance with the prevailing international and national regulations. No shipments of spent nuclear fuel have been carried out in Jordan, as SNF is yet to be generated.

J. DISUSED SEALED SOURCES

Article 28. Disused Sealed Sources

EMRC has a national inventory for all DSRSs that are at the user's premises, including an inventory of DSRS stored within the CSF at JAEC. As stated previously, JAEC is responsible to collect DSRS from local institutions after they have been declared them as RW and were unable to return them to their place of origin. Once JAEC receives an official request to retrieve the DSRS, JAEC provides for secure transport to the CSF where the DSRS is conditioned for long–term interim storage at the CSF, where they remain there until a final disposal path is made available.

The national policy for the RW and SNF management states clearly that DSRSs are the main component of the current national RW inventory in Jordan. The management options for DSRSs include:

- return to the supplier, if possible;
- long-term storage at CSF; and
- finding international or regional solutions for DSRS management and disposal.

DSRS of foreign origin, which had been use in Jordan and cannot be returned to their manufacturer, JAEC is responsible for their safe management. Jordan will also allow the re-entry of DSRS into its territory for return to their manufacturer.

K. GENERAL EFFORTS TO IMPROVE SAFETY

Efforts related to improvement of the safety of RW and SNF management can be summarized as follows:

K.1 Jordan Atomic Energy Commission (JAEC)

1. Continue research and investigation in identifying disposal options for RW.
2. Identify options for safe management of radioactive waste at the Sewaqa site.
3. Continue, in cooperation with the IAEA, efforts to enable repatriation of DSRS of category 1-2 to the country of origin.
4. Complete the national strategy for the RW and SNF management (including those from the JRTR and future NPPs).
5. Build up the capacity and capabilities of the national RWM organization and strengthening the resources for safe and effective management of RW and SNF.
6. Seek regional solutions for RW and SNF management, including potential for shared regional deep repository site.
7. Establish strong cooperation with international community in the field of RW and SNF management.

K.2 Energy and Minerals Regulatory Commission (EMRC)

1. Continue with developing national legislation striving towards safe and efficient management of RW and SNF in Jordan.
2. Continue work on licensing of historical facility at the Sewaqa site.
3. Continue work on achieving the commitment to the international conventions and treaties related to nuclear application, such as:
    a. Treaty on the Non-Proliferation of Nuclear Weapons.
    b. The Convention on Nuclear Safeguards and Additional Protocol.
    c. The Convention on Nuclear Safety.
    d. The Convention on Physical Protection of Nuclear Material.
    e. The Convention on Civil Liability for Nuclear Damages.
    f. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

L. ANNEXES

N.1. List of Radioactive Waste Management Facilities

JAEC manages the Centralized Storage Facility (CSF), which is located in JAEC's Shafa Badran Complex, Amman, and the historical Sewaqa site located in the Sewaqa Hazardous Site.

CSF

Figure L.1 presents pictures of the CSF. General characteristics of the CSF include the following:

Figure L.1 Central RW Storage Facility at JAEC

1. CSF is currently the only operating radioactive waste management facility in Jordan;
2. The CSF is located within JAEC headquarters perimeters in Shafa Badran;
3. It has an area of 250 m^2;
4. CSF is licensed by EMRC.
5. CSF staff are licensed by EMRC, and they are qualified to manage RW of the CSF, including DSRS;
6. The national centralized RW storage facility consists of two main separated areas (Figure L.2):
    a. The main area (Radioactive Area-Red Color) that designed to have several rooms: receipt/dispatch room, operational room for sources to be conditioned, a room with underground stainless-steel wells, a decay room, and rooms for intermediate and low activity sources, Figure (2).
    b. The second area (Clean Area-Green Color) that houses support facilities (change room, bathroom/and shower room, sanitary room,

radiation equipment and health physics room, office room, documentation, and security monitoring room.

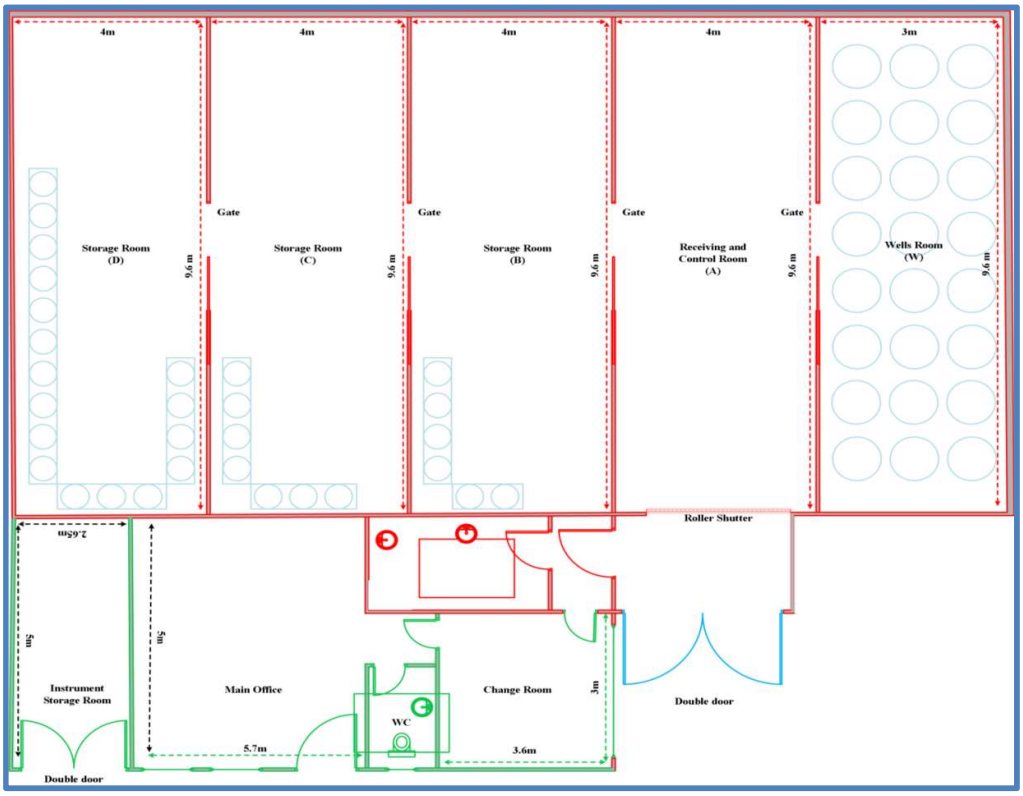


Figure L.2 Floor Layout for the CSF Clean and Dirty Areas

7. There are four storage rooms in the CSF, as shown in Figure L.2:
   a) Room **W** has underground storage capacity in the form of silo type facilities cladded with stainless steel, as shown in Figure N.3. This facility is designed to house drums with conditioned gauges.
   b) Room **B** contains characterized and uncharacterized DSRS in working shields and lead containers.
   c) Room **C** contains empty prepared drums for conditioning as well as a storage place for neutron sources. This room also includes two sources (Cat. 1 & 2) inside transportation container with the original manufacturer shield.
   d) Room **D** contains conditioned drums as well as some DU and a Cat 1 source inside its active original shields.
   e) The receiving area (**A**) is a long rectangular shaped area on the inside of the main access door. This area is the central area, which leads to all the storage rooms inside.

- Figure L.3 depicts containers stored in storage racks, as well as pictures of retrieved gauges and sources.

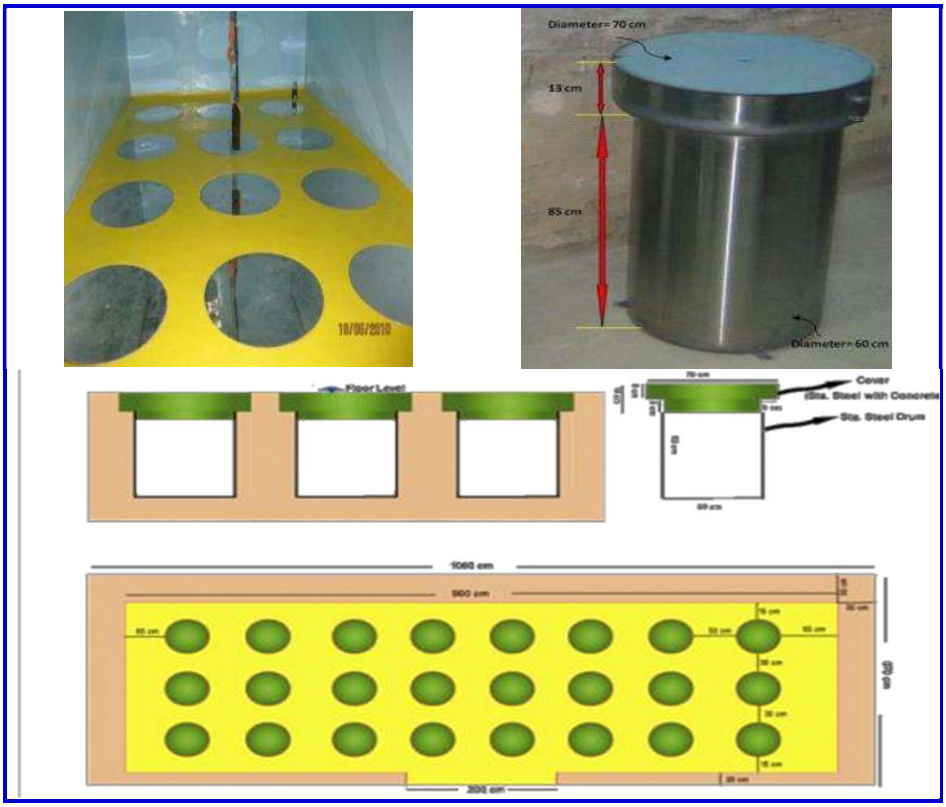


Figure L.3 Underground Storage Capacity, Wells & House Drums with Conditioned Gauges

Figure L.4 Current Radioactive Waste Stored at the CSF

The operation of the CSF is carried out in a systematic manner and is governed by a set of procedures that are well implemented throughout the CSF for DSRS management. Figure L.5 depicts the process for RW retrieval, conditioning, and storage at the CSF.

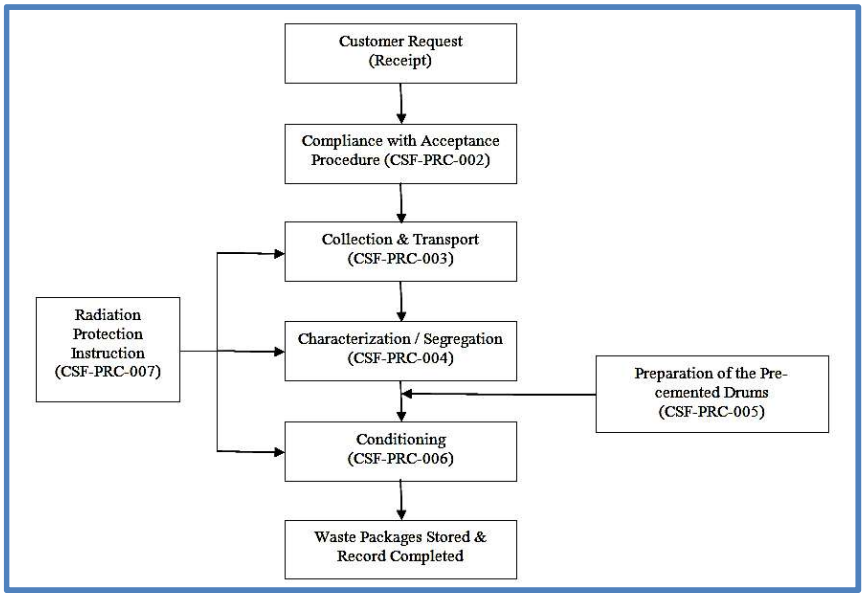


Figure L.5 DSRS Management at CSF

Main Safety and Security Related Design Features are presented in Figure L.6 and discussed as follows:

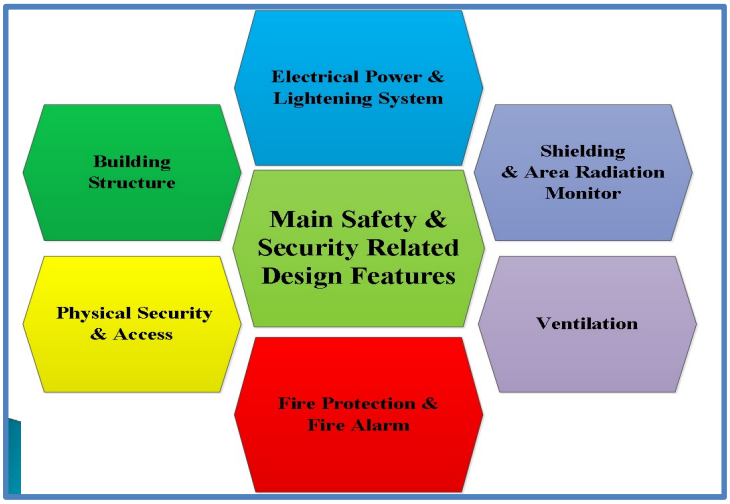


Figure L.6 Main Safety and Security Related Design Features

- **Building Structure**
  - The foundations, columns, walls and roof have been designed to support all super imposed structural loads as well as all applicable dead loads;
  - The floor slab is able to support the concentrated point loads of the radioactive waste containers 5 t/m^2, and an impact load of resulting from accidental dropping of radioactive waste container of 5 tons from a height of 2 meter, as well as live loads of equipment used to load the packages;
  - The slab is sufficiently thick around the building perimeter to support the walls and locally around all internal stanchions;
  - Rain water is prevented from entering the buildings by surface contouring and drainage channels around the buildings;

- Resistance to water penetration from the ground is provided by a polyethylene damp proof membrane to the underside of the slab;
- The interior construction of the building is such that the risk of any liquids being released to the environment is minimized;
- The buildings are provided with an internal floor drain system to direct any internal liquid traces generated to a sump pit of capacity at least $2m^3$. The floor is sloped to facilitate movement of liquid away from the storage areas toward the floor drains. Inspection of the sump and sampling of accumulated liquid is a part of the operational procedures;
- The floor slab has a steel floated finish with an epoxy paint coating to provide a hard wearing and surfaces that can be easily decontaminated; and

➢ **Shielding**

The CSF structure provides sufficient shielding from radiation in order to limit exposures outside the building to be within natural background levels. The design and construction ensure the required shielding is obtained and no major cracks or shine paths are present in the as-built configuration. Individual packages are shielded by other packages, internal building structures, and/or by the design of the facility. The conditioned concrete lined drums are stored in silo type underground storage units, which then make use of the foundation of the building for shielding purposes.

➢ **Physical Security and Access**

Physical security is provided primarily by a number of passive physical barriers including a site perimeter fence (around the whole JAEC site), a site access point with security guards, strong building construction, and high integrity doors and locks to the treatment and storage areas. Buildings are equipped with intrusion alarms. Furthermore, the CSF storage areas have no windows to improve the shielding and enhance its security posture.

➢ **Fire Protection and Fire Alarm**

Fire protection is provided by the utilization of construction materials that are non-flammable and by forbidding any flammable materials to be introduced into the CSF, with the exception of the wooded pallets, which are used to lift and easily transport the drums from the control room (A) to any point of the storage rooms, such as room (D) and to place these drums on the shelf by using a forklift. Fire detection and fire-fighting equipment are being installed and will be upgraded to have automatic alarms/alerts in the event of fire inside the CSF. Such equipment is to be tested and maintained. High quality electrical equipment complying with the national quality standards are installed in the CSF and are maintained in accordance with the national and local fire regulations. The site is clear of any vegetation or combustible materials. Fire system alarms are installed in each room of the CSF building, which can initiate a sound alarm in case of fire in any room of the CSF building.

➢ **Ventilation**

The CSF is provided with natural ventilation. A local extraction hood is installed at the characterization and conditioning area. The extracted air is filtrated by using three different types of filters to prevent the potential release of radioactive materials to the environmental.

➢ **Electrical Power and Lighting**

All installations and equipment are of high quality and comply with the national standards. Good lightening levels is provided throughout the treatment and storage facilities, long-life components are used to reduce replacement and maintenance.

- **Mechanical Handling Equipment**

Readily available and good quality manually operated mechanical handling equipment are available. Such equipment is subjected to the national regulations/requirements as applicable to statutory equipment and are operated by trained/licensed personnel.

Operational activities within the CSF involve receiving; segregation characterization; identification; temporary storage of received items; conditioning of units received; inspection of stored DSRS, equipment, and the conditioned packages; and maintenance of the building and its equipment and tools. It is possible that some minor repairs may be carried out from time to time to the source housings, packaging, or containers

The facility is designed to make these operations simple and to take the least time possible.

- **Facility Assessment**

The assessment is carried out to assist in finalization of the facility design and demonstrating the suitably of the CSF. It provides tentative assessments of radiation doses to workers and members of the public during normal operation of the facility, for comparison with dose limits and constraints over the assumed lifetime of the facility. It makes a tentative assessment of the impact of disturbing events on the facility with a view to demonstrate that the design and safety features are sufficiently robust to withstand such events. The assessment identifies uncertainties and provide some consideration of their importance and possible approaches to the management of those uncertainties that are considered to be important to safety.

The safety assessment reported in the Final CSF's Safety Case & Safety Assessment Report was performed to demonstrate that appropriate means are available for assessing safety both in normal operational and in accident scenarios, and that CSF safety is not jeopardized by any potential events.

The assessment for normal operation covered all operations that have been performed for the dismantling and storage of DSRS that are currently stored at CSF; all operation steps from their collection from the producers and operators to their safe and secure storage at CSF are included. It has been assumed that all these operations were carried out within one year. This gives a conservative estimate of the annual doses to workers, since a lower number of DSRS are usually processed and stored in a single year.

Annual doses to members of the public were also considered in the assessment. However, it was concluded that there is no exposure to the public associated with normal operations with DSRS, since there are no releases of radioactive to the environment from the CSF activities, and becuase members of the general public do not have access to the CSF.

SEWAQA

Sewaqa Site was allocated by the MOE for the disposal of all types of hazardous and dangerous wastes. An area of (1.5) hectares was designated and approved by the MOE for the disposal of RW generated from the peaceful nuclear and radiological applications of radioisotopes in medicine, industry, agriculture, and research and training centers. Figure L.7 presents the location of the Sewaqa disposal site within the Hashemite Kingdom of Jordan.

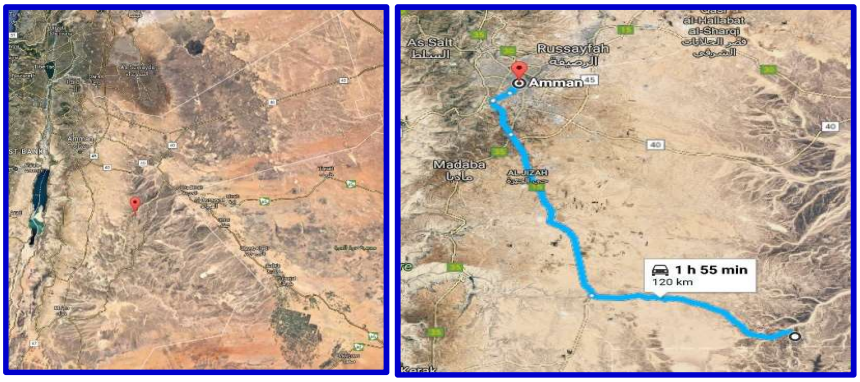


Figure L.7 The satellite location of the national disposal site for the hazardous and dangerous waste at Sewaqa and the designated area for RW disposal

➢ Description

The designated RW area is surrounded by iron fence of (2m) height marked by radiation warning signs with a main gate, as shown in Figure L.8. This RW site is divided into six regions with main paved streets and it contains within two distinct regions, two underground pits.

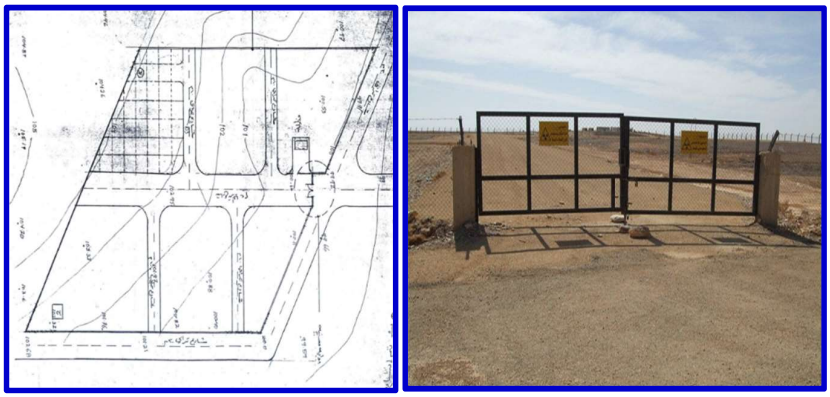


Figure L.8 Left: is the layout of Sewaqa RW Disposal Site, Right: is the main gate to the RW disposal site at Sewaqa

➢ Cylindrical Reinforced Concrete Pit

Cylindrical reinforced concrete pit employs an inner diameter of (1.25) m and a depth of (3.5) m with a concrete base. This pit was built in 1996 but was never used for storing the RW and it is equipped with reinforced concrete cover and lock system, as shown in Figure L.9.

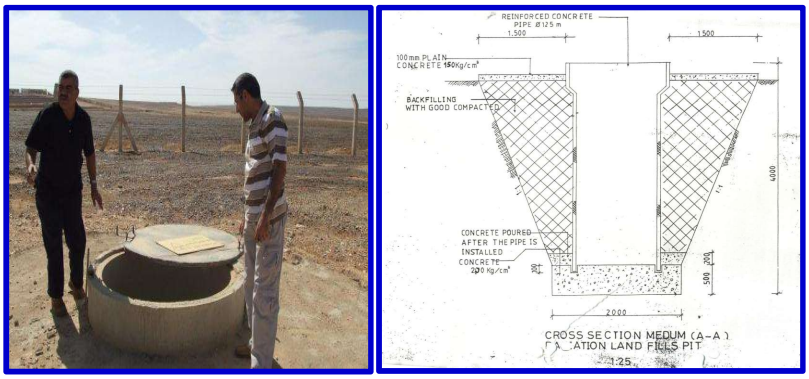


Figure L.9 Left: The cylindrical underground reinforced concrete pit; , Right: The layout diagram of the cylindrical underground pit

➢ **Near Surface Rectangular RW Disposal Site**

Near Surface rectangular reinforced concrete underground pit of (3.6) m length, of (3.6) m width and (3.1) m depth with removable heavy steel cover (2" Galvanized iron of (0.6) mm and two layers of Galvanized iron) by special crane was built in August 2000. Backfilling with good compacted natural materials (gravel, clay) with reinforced concrete base of (0.5 m), with water insulation layer under the base of (0.4 cm), this pit is shown in Figure L.10.

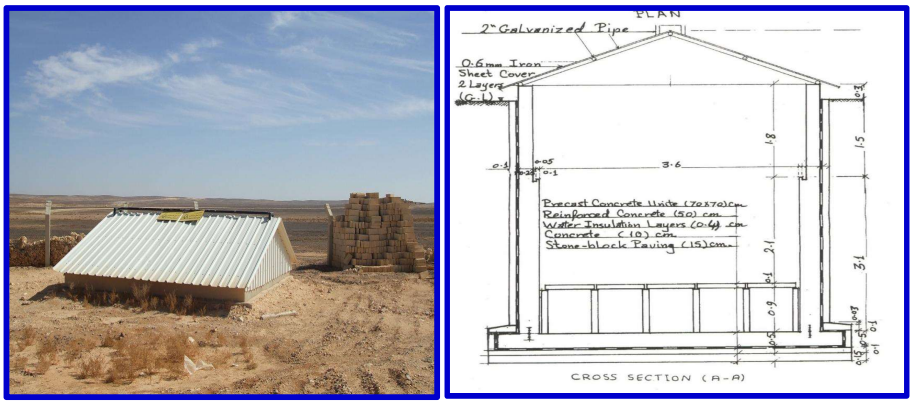


Figure L.10 Left: The rectangular underground reinforced concrete pit, Right: The layout sketch of the near Surface rectangular Reinforced concrete underground pit

This rectangular underground pit consists of three layers, each layer can accommodate up to 25 200-L drums, with a total capacity of 75 200-L drums, as shown in Figure L.11. Further details of the three layers are presented as follows:

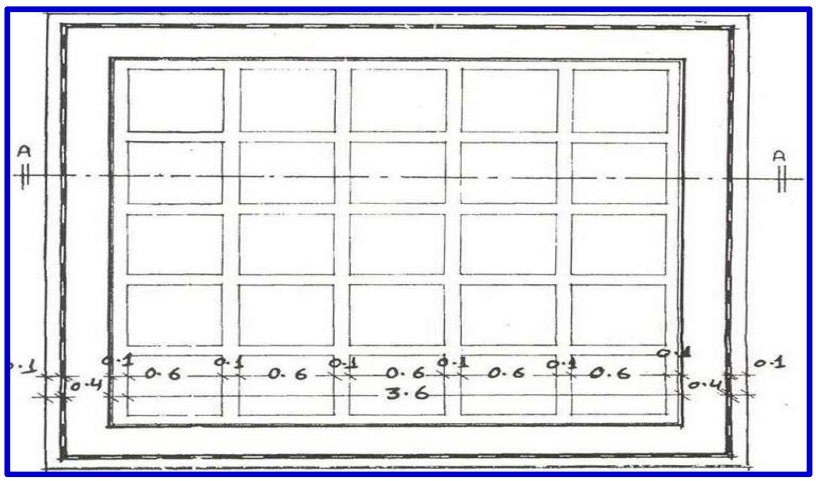


Figure L.11 The layout sketch of the floor layer in the rectangular underground pit

First Layer:

The first layer (bottom layer) was built with 25 rectangular small wells of concrete bricks with dimension of (0.6m (L) × 0.6m (W) × 0.9m (D)) with concrete spacing of thickness (0.1m) between two adjacent small wells, and each small well is closed by reinforced concrete cover with lifting eyes, as shown in Figure L.11.

The first layer is full (contains 25 200L drums), in which the RW were conditioned by cement mortar. The RS is placed at the center of 200L drum then filled with cement mortar. Majority of these radiation sources were kept inside their original shielding.

This conditioning option of RW (cement mortar) was adopted in order to immobilize the RS within a type A package. Furthermore, the cemented drums provides for a massive container, aiding in the prevention of unauthorized removal of the RS, weight of the produced package (≈500 Kg).

The idea at that time is not only to use Sewaqa Site for RW storage, but also for disposal of conditioned RW by this option. A steel reinforcing bar (6 per package) of 5-10 mm diameter and 650 mm long were used to fix and keep the RW at the center of the package.

The number of the total sources in the floor layer is around (111) RS distributed in 25 200L drums. This layer is completely closed by the 25 reinforced concrete covers for each small well.

Second Layer:
The second layer is still open (not covered) and the RW packages are placed directly above the cover of the first layer and contains the following:

- Steel tank (2 m × 1 m) with two nuclear gauges.
- Three drums in which the sources were conditioned by cementation as in the first layer.
- Other (around (36) RS) are within their original shielding canisters/casks and containers and a few of them are removed and dismantled from their original shielding and stored in special homemade shielded containers.

Third Layer:
The third layer was never used because the second layer was never completely filled.

N.2. Inventory of Radioactive Wastes

RW Inventory in the CSF as of December 2016 are presented in Table L.1 and Table L.2, while the DSRS inventory at SEWAQA site is summarized in Table L.3. Note that the RTF does not contain any RW material, as it is expected to be operational in 2018.

Table L.1 The Radioactive Waste Inventory at the Central Storage Facility (CSF) at JAEC by the end of 2016.

Radionuclide	No. of Sources	Activity (mCi)
Am-241	7	2.4E+02
Am-241/Be	11	3.5E+03
Ba-133	2	1.1E-01
Cd-109	4	2.6E-03
Co-57	13	4.6E-04
Co-60	8	1.6E+06
Cs-137	113	3.4E+05
Cs-137 + Am-241	2	1.2E-03
Eu-152	4	8.1E+02
Fe-55	4	1.6E+00
Ir-192	1	1.1E-04
Kr-85	6	4.1E+02
Ra-226	13	5.3E+02
Sr-90	10	9.1E+01
Total	**198**	**2.0 E+03 Ci**
Co-60	2	Unknown
Ra-226	10	Unknown

Table L.2 Existing Sources by Category in the CSF

Category	Radionuclide	No.
1	Co-60	1
2	2*Co-60, Cs-137	3
3	Am-241/Be	1
4	Cs-137, Am-241/Be, Ra-22 Eu-152, Ir-192	78
5	Cs-137, Am-241/Be, Sr-90, Co-60, Co-57, Kr-85, Cd-109, Ra-226	115

Table L.3 DSRS Inventory at SEWAQA Disposal Site

Radionuclides	No. of sources	Total Activity (mCi) at either 1999 or 2007	Total Activity (mCi) at the end of 2016	Number of 200L Steel Drums	Applications
Cs-137	33	3500 (year 2007) 15(Unknown)	2844 15(Unknown)	25 Conditioned Drums	Industrial Nuclear Gauges
Co-60	43	3500 (year 2007)	1072	3 Conditioned Drums	Industrial Nuclear Gauges
Sr-90	6	50 (year 2007)	40	1 Conditioned Drum	Industrial Nuclear Gauges
Cs-137 Tubes	30	560 (year 1999)	378	1 Conditioned Drum	Medical Bracyhtherapy
Cs-137 Needles	54	100 (year 1999)	68	1 Conditioned Drum	Medical Bracyhtherapy
Am-241	5	225	248	2 Conditioned Drums	Industrial Nuclear Gauges
No. of radioactive sources =(171)			4650 mCi	No. of drums = (32)	

N.3. References

1. National Policy for Radioactive Waste & Spent Nuclear Fuel Management, 2015, Rev. 1
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