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TECHNICAL GUIDELINES

CRITERIA FOR SITING OF DISPOSAL FACILITY FOR WASTE CONTAINING NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM)

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1.0 PURPOSE

This document is prepared to provide guidance for the applicant of Class G license who intent to dispose waste containing Naturally Occurring Radioactive Materials (NORM) at a disposal facility.

2.0 SCOPE

This guidance material addresses the safety requirements and procedure that should be followed and complied for the siting of disposal facility with regard to landfill disposal which is known as engineered surface landfill type facility or near surface disposal facility (NSDF) for waste containing NORM. This guidance material is intended to address both radiological and non-radiological hazards associated with the disposal facility.

However, this document emphasizes on the radiological hazard as its control falls under the purview of Department of Atomic Energy Malaysia. The licensees shall comply to other standards, guidelines and regulatory requirements for more detailed requirements and procedures of non-radiological hazard controls for siting of disposal facility.

3.0 ABBREVIATION

Act 304	Atomic Energy Licensing Act 1984
NORM	Naturally Occurring Radioactive Materials
NSDF	Near Surface Disposal Facility
VLLW	Very Low Level Radioactive Waste
LLW	Low Level Radioactive Waste
ILW	Intermediate Level Radioactive Waste
HLW	High Level Waste
HDPE	High-density Polyethylene
ULLD	Under liner leak detection system

4.0 DEFINITION

“disposal” means the emplacement of radioactive waste or the direct discharge of effluents.

“disposal facility” is an engineered facility where waste is emplaced for disposal.

“waste management” means all the activities, administrative and operational, that are involved in the handling, pretreatment, treatment, conditioning, transportation, storage and disposal of radioactive waste.

“radioactive waste” means substance or article that contains or is contaminated with radionuclides at activity concentrations or activities greater than clearance levels and for which no use is foreseen.

“NORM residue” is material that remains from a process and comprises or is contaminated by naturally occurring radioactive material (NORM).

“NORM waste” is a specific type of NORM residue for which no further use is foreseen.

“near surface disposal facility” is a facility for radioactive waste disposal located at or within a few tens of meters of the Earth’s surface.

“low level waste (LLW)” is radioactive waste that is above clearance levels, but with limited amounts of long lived radionuclides.

“very low level waste (VLLW)” is radioactive waste that does not necessarily meet the criteria of exempt waste, but that does not need a high level of containment and isolation and, therefore, is suitable for disposal in landfill type near surface repositories with limited regulatory control.

5.0 INTRODUCTION

Radioactive waste can be generated by a wide range of activities varying from activities in hospitals to nuclear power plants to mines and mineral processing facilities. It also arises from activities and processes in which radioactive material of natural origin becomes accumulated in waste material and safety needs to be considered in its management. A conceptual illustration of the waste classification scheme and its method of disposal is shown in **Figure 1**.

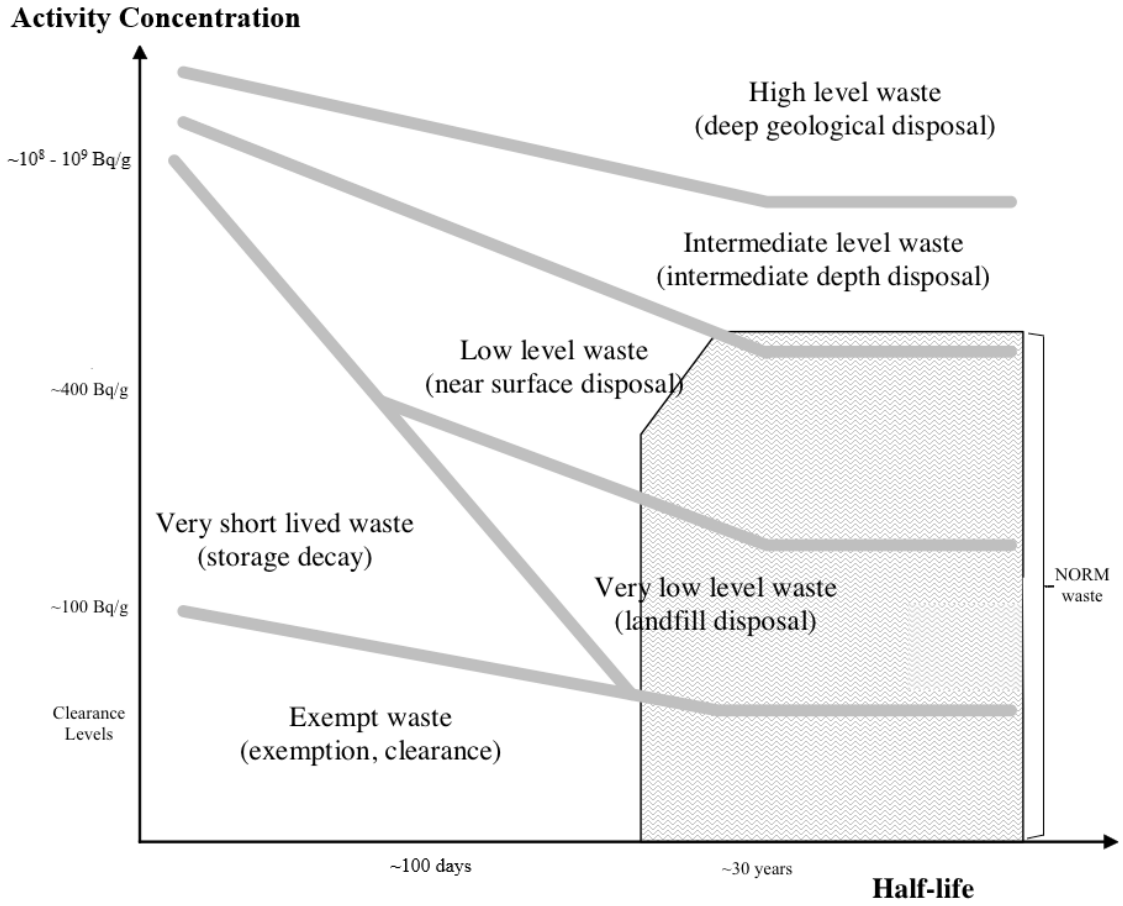

Figure 1: Classification scheme for radioactive waste — Application to NORM waste (Source: IAEA GSG-1, 2009 and IAEA TECDOC 1712, 2013)

The classification scheme reflects the general principle that the higher the activity concentration, the greater the need to contain the waste and isolate it from the biosphere. Figure 1 shows how NORM waste might fit into this scheme and thus gives an indication of the types of disposal option that might be appropriate. In terms of the proposed classification scheme, NORM waste, which generally contains radionuclides

with very long half-lives, would generally be classified as low level waste (LLW), very low level waste (VLLW) or exempt waste. On this basis, non-exempt NORM waste could therefore be expected to be disposed of in surface or near surface disposal facilities. Based on Figure 1, the classification scheme for radioactive waste can be summarized as **Table 1** below:

Table 1: Summarized of the classification scheme for radioactive waste
(Source: IAEA GSG-1, 2009 and IAEA TECDOC 1712, 2013)

No.	Classification scheme for radioactive waste	Activity concentration (Bq/g)
1.	Very low level waste (VLLW)	below 100
2.	Low level waste (LLW)	above 100 up to 400
3.	Intermediate level waste (ILW)	above 400 up to 10^8 - 10^9
4.	High level waste (HLW)	above 10^9

Note: For NORM waste, it is fall under above exempt waste up to low level waste but the half-life of radionuclides is long half-life (exceed 30 years)

A number of disposal facilities of different designs or option may be required in order to accommodate radioactive waste of various types according to the classification of radioactive waste as follows:

a) **Landfill disposal**: Disposal in a facility similar to a conventional landfill facility for industrial refuse but which may incorporate measures to cover the waste with engineered features. Such a facility may be designated as a disposal facility for very low level radioactive waste (VLLW) with low concentrations or quantities of radioactive content. Typical waste disposed of in a facility of this type may include soil and rubble arising from decommissioning activities.

b) **Near surface disposal**: Disposal in a facility consisting of engineered trenches or vaults constructed on the ground surface or up to a few tens of meters below ground level. Such a facility may be designated as a disposal facility for low level radioactive waste (LLW).

c) **Disposal of intermediate level waste**: Depending on its characteristics, intermediate level radioactive waste (ILW) can be disposed of in different types of facility. Disposal could be by emplacement in a facility constructed in caverns, vaults or silos at least a few tens of meters below ground level and up to a few hundred meters below ground level. It could include purpose built facilities and facilities developed in or from existing mines. It could also include facilities developed by drift mining into mountainsides or hillsides, in which case the overlying cover could be more than 100 m deep.

d) **Geological disposal**: Disposal in a facility constructed in tunnels, vaults or silos in a particular geological formation (e.g. in terms of its long term stability and its hydrogeological properties) at least a few hundred metres below ground level. Such a facility could be designed to receive high level radioactive waste (HLW), including spent fuel if it is to be treated as waste. However, with appropriate design, a geological disposal facility could receive all types of radioactive waste.

e) **Borehole disposal**: Disposal in a facility consisting of an array of boreholes, or a single borehole, which may be between a few tens of meters up to a few hundreds of meters deep. Such a borehole disposal facility is designed for the disposal of only relatively small volumes of waste, in particular disused sealed radioactive sources.

f) **Disposal of mining and mineral processing waste**: Disposal usually on or near the ground surface, but the manner and the large volumes in which the waste arises, its physicochemical form and its content of long lived radionuclides of natural origin distinguish it from other radioactive waste. The waste is generally stabilized in situ and covered with various layers of rock and soil.

At present, the NORM waste generated by the milling activities under Class A (Milling) license is stored temporarily at the licensee's premises. However, if the licensee intends to dispose the NORM waste at a proposed disposal facility, the Class G license for disposal is required.

6.0 CRITERIA AND DISPOSAL OPTIONS FOR NORM WASTE

The classification and disposal options of NORM waste are described as follows:

a) NORM waste with activity concentration of each radionuclide in the uranium decay chain or the thorium decay chain (refer **Attachment 1**) which is less than 100 Bq/g is classified as VLLW. VLLW does not need a high level of containment and isolation and, therefore, is suitable for disposal in engineered surface landfill type facilities with limited regulatory control. An adequate level of safety for VLLW may be achieved by its disposal in engineered surface landfill type facilities.

This is the usual practice for waste from some mining operations and for other waste containing naturally occurring radionuclides from various operations involving minerals processing and other activities. The designs of such disposal facilities range from simple covers to more complex disposal systems and, in general, such disposal systems require active and passive institutional controls. The time period for which institutional controls are exercised will be sufficient to provide confidence that there will be compliance with the safety criteria for disposal of the waste.

The engineered near surface landfill type facilities for the disposal of NORM waste classified as VLLW shall consist of at least two (2) layers of impermeable liner and equipped with an under liner leak detection system (ULLD). For example, the dual-liner can be made from high-density polyethylene (HDPE) material and clay layer and illustration of the engineered near surface landfill type facility is shown in **Figure 2**. The application of dual-liner system is aimed for an effective separation to prevent from any contamination between the layers with waste containing NORM and groundwater table.

The engineered near surface landfill type facilities shall equip with leachate collection system at the bottom layer to prevent the accumulation of leachate at the bottom of the disposal facility which may absorb into and contaminate the groundwater. The collected leachate shall be channeled to waste water

treatment plant. After the completion of NORM waste disposal into the engineered surface landfill, the landfill shall be capped with the impermeable liners to reduce the water infiltration in order to prevent the water sump that can affect the integrity of engineered surface landfill.

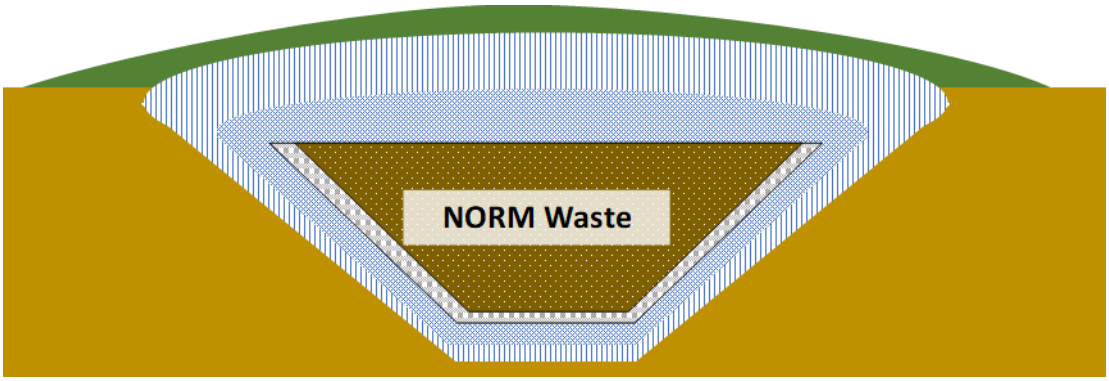

Figure 2: Example illustration of landfill disposal type facility with engineered features

The environmental and radiological monitoring shall be conducted for at least six (6) months prior to construction to get the baseline data and after the completion and closure of the engineered surface landfill to ensure the dose to the public is below 1 mSv/year.

b) NORM waste with activity concentration of each radionuclide in the uranium or the thorium decays chain which is greater than 100 Bq/g up to 400 Bq/g is classified as LLW. LLW is the waste that is above the clearance levels, but with limited amounts of long lived radionuclides. Such waste requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in the engineered near surface facilities. This class covers a very broad range of waste.

LLW may include short lived radionuclides at higher levels of activity concentration, and also long lived radionuclides, but only at relatively low levels of activity concentration. LLW is suitable for near surface disposal. This is a disposal option suitable for waste that contains such an amount of radioactive material that robust containment and isolation for limited periods of time up to

a few hundred years are required. Because LLW may have a wide range of activity concentrations and may contain a wide range of radionuclides, there are various design options for near surface disposal facilities.

These design options may range from simple to more complex engineered facilities, and may involve disposal at varying depths, typically from the surface down to 30 metres. They will depend on safety assessments and national practices, and are subject to approval by the appropriate authorities.

The near surface disposal facility shall consist at least two (2) layers of impermeable liner, for example, the HDPE polymer layer and geosynthetic layer as shown in **Figure 3**.

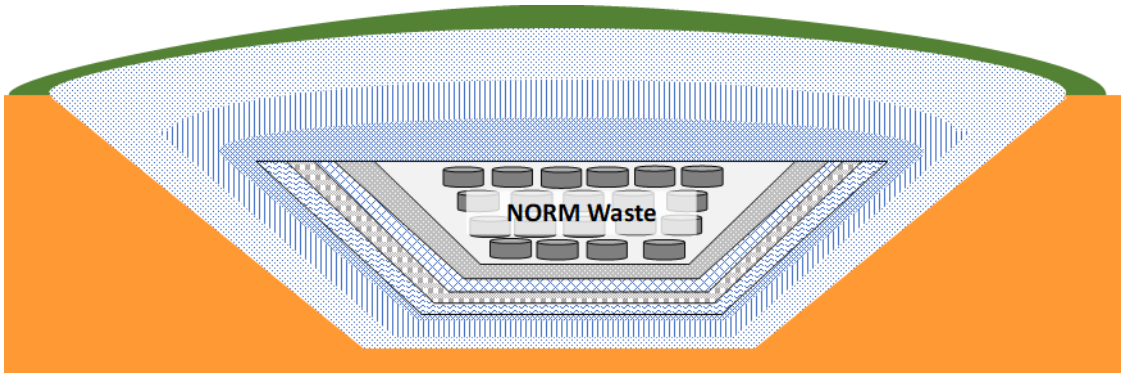

Figure 3: Example illustration of near surface disposal facility

The disposal facility may consists of liners and waste separators with the function that can be described in **Table 2.**

Table 2: Example of the near surface disposal layers

Layer	Function	Example of materials used
i	To put on the top, to protection from machinery vibration during the emplacement of NORM waste into the disposal facility	Sand layer
ii	As a the first layer to prevent water diffuse into the groundwater system	HDPE polymer

Layer	Function	Example of materials used
iii	As the second layer to prevent water diffuse into the groundwater system. Different types of clays have been used as backfill and barrier materials to refill the disposal facilities. Clay can provide a barrier to radionuclide migration and provide some mechanical strength to the near surface disposal facilities.	Clay/ geosynthetic
iv	To stabilize the disposal facility site (if necessary)	Geotextile layer
v	Leakage prevention system/ water diffusion	Under liner leak detection system (ULLD)
vi	To strengthen the ULLD layer (if necessary)	Geonet layer
vii	To stabilize the disposal facility site (as a base on the bottom of disposal facility)	Compact soil layer

After the disposal of NORM waste is completed, the near surface disposal facility shall be capped with the layers of HDPE liner or equivalent material, sand, bio-barrier layer consists of rocks, soil layer and top with fertile soil layer to promote grass growth as vegetation can play an important role in the performance of a capping system, specifically in reducing erosion.

The environmental and radiological monitoring shall be conducted as determined by the Board (based on risk) according to graded approach or for at least six (6) months prior to construction to get the baseline data. The moni toring also shall be conducted after the completion of closure of the disposal facility, to ensure that dose to the public is below 1 mSv/ year.

7.0 SITING OF DISPOSAL FACILITY

The purpose of the disposal facility is to contain and isolate the wastes. The main criteria for the sitting of the disposal facility are the protection to the people and the

environment. Primary option is to have natural barriers and if not possible, the engineered barrier shall be used. An understanding of the site for a disposal facility has to be gained in order to present a convincing scientific description of the disposal system on which the more conceptual descriptions that are used in the safety assessment can be based.

The focus has to be on the features, events and processes relating to the site that could have an impact on safety and that are addressed in the safety case and supporting safety assessment. In particular, this has to demonstrate that there is adequate geological, geomorphological or topographical stability (as appropriate to the type of facility), and features as well as processes that contribute to safety. It also has to demonstrate that other features, events and processes do not undermine the safety case.

Siting is a fundamentally important activity in the disposal of radioactive waste. In the siting process for a radioactive waste disposal facility, four (4) stages may be recognized: -

(a) A conceptual and planning stage;
(b) An area survey stage, leading to the selection of one or more sites for more detailed consideration;
(c) A site investigation stage of detailed site specific studies and site characterization;
(d) A site confirmation stage.

In site selection, one or more preferred candidate sites are selected after the investigation of a large region, the rejection of unsuitable sites, and screening and comparison of the remaining sites. From several, possibly many, prospective sites identified at the start of a siting process, a selection is made of one or more preferred sites on the basis of geological setting and with account taken of other factors. Sociopolitical factors are an important consideration in any site selection process (e.g. demographic conditions, transport infrastructure and existing land use). Applicant shall also refer to other relevant acts and regulations for the site selection methodology.

Applicant shall conduct site characterization and submit the siting documents prior to license application as mentioned in **Attachment 2**.

8.0 EXCLUSION CRITERIA

These exclusion criteria for the disposal facility location include the followings:

- Permanent forest/nature reserves and protected areas including marine parks;
- Archeologically significant areas;
- Tsunami risk areas – coastal belts along the state;
- Seismic risk areas – areas of seismic activity or faults;
- Areas with tectonic activity;
- Hazard risk area (areas prone to slope failures, high erosion rates);
- Surface water features – rivers, streams or lakes with a buffer of 1,500 meters (minimum to preclude encountering areas exhibiting shallow groundwater);
- Floodplains;
- Potable water catchment areas;
- Populated areas including city and town centres;
- Areas where groundwater is utilized for potable uses or agricultural or industrial uses;
- Existing or known mineral resource areas to preclude disruption of the disposal/landfill in the event of future mining activities;
- Aboriginal land/native customary land;
- Geosite and Geoheritage areas; and
- Sensitive receptor

9.0 CONCLUSION

For further questions regarding the matters related to this document, kindly please contact Atom Malaysia at the following contact details:

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10.0 DOCUMENT RECORDS

DATE OF ACCEPTANCE	REVIEW/ AMENDMENT STATUS	DRAFTERS
12 December 2019	0	1. Mr Hasmadi bin Hassan (Contributor) 2. Dr. Teng Iyu Lin 3. Ms. Siti Afidah binti Awang 4. Ms. Lim Ai Phing
03 July 2020	Rev.1	Revised by Jawatankuasa Kecil Keselamatan Pengurusan Sisa Radioaktif comprised of: 1. Mr Hasmadi bin Hassan (Chairman) 2. Mr. Ismail Hj. Tawnie, P.Geol (National Hydraulic Research Institute of Malaysia) 3. Ms. Rohimah binti Ayub (Department of Environment) 4. Dr. Ahmad Riadz bin Mazeli (Ministry of Health) 5. Ms. Hjh. Noraishah Pungut (Atom Malaysia) 6. Dr. Teng Iyu Lin (Atom Malaysia) 7. Mr. Ismail bin Hanuar (Department of Mineral and Geoscience Malaysia)

DATE OF ACCEPTANCE	REVIEW/ AMENDMENT STATUS	DRAFTERS
		8. Ir. Dr. Tuan Suhaimi bin Salleh (Malaysian Public Works Department)
23 December 2022	Amend.1	1. En. Ridha bin Roslan 2. Pn. Erma Hafiza binti Ibrahim @Abd. Aziz

11.0 REFERENCES

(a) IAEA Safety Standards Specific Safety Guide No. SSG-29, Near Surface Disposal Facilities for Radioactive Waste, 2014.

(b) IAEA Specific Safety Requirements No. SSR 5, Disposal of Radioactive Wastes, 2011

(c) IAEA-TECDOC-1484 Regulatory and Management Approaches for the Control of Environmental Residues Containing Naturally Occurring Radioactive Material (NORM), January 2006

(d) IAEA Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (GSR Part 3) 2014

(e) IAEA Safety Guide, Classification of Radioactive Waste, IAEA Safety Standards Series No. GSG-1, 2009

(f) Atomic Energy Licensing Act 1984 (Act 304)

(g) Radiation Protection (Licensing) Regulations 1986 [P.U.(A)149]

(h) Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011 [P.U.(A)274]

(i) Radiation Protection (Transport) Regulations 1989 [P.U.(A)456]

(j) Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010 [P.U.(A)46]

(k) IAEA-TECDOC-1712 Management of NORM Residues, 2013

(l) IAEA Safety Standards Specific Safety Guide No. SSG-31 Monitoring and Surveillance of Radioactive Waste Disposal Facility, 2014.

ATTACHMENT 1

Table 1: Uranium-238 Decay Series

	Half-life	Mode of decay[a]	Gamma energy (keV)[b]
^{238}U	4.468×10^9 a	Alpha	
^{234}Th	24.10 d	Beta	63.29 (4.8%), 92.38–92.8 (5.6%)
^{234m}Pa	1.17 min	Beta	1001.03 (0.837%)
^{234}U	245 700 a	Alpha	
^{230}Th	75 380 a	Alpha	
^{226}Ra	1600 a	Alpha	186.211 (3.59%)
^{222}Rn	3.8235 d	Alpha	
^{218}Po	3.10 min	Alpha	
^{214}Pb	26.8 min	Beta	351.932 (37.6%)
^{214}Bi	19.9 min	Beta	609.312 (46.1%), 1764.491 (15.30%)
^{214}Po	164.3 µs	Alpha	
^{210}Pb	22.20 a	Beta	46.539 (4.25%)
^{210}Bi	5.012 d	Beta	
^{210}Po	138.376 d	Alpha	
^{206}Pb	Stable	–	

[a] Only major modes of decay are shown.
[b] Only major gamma emissions of interest are shown.

Table 2: Thorium-232 Decay Series

	Half-life	Mode of decay[a]	Gamma energy (keV)[b]
^{232}Th	1.405×10^{10} a	Alpha	
^{228}Ra	5.75 a	Beta	
^{228}Ac	6.15 h	Beta	911.204 (25.8%), 968.971 (15.8%)
^{228}Th	1.912 a	Alpha	
^{224}Ra	3.66 d	Alpha	240.986 (4.10%)
^{220}Rn	55.6 s	Alpha	
^{216}Po	0.145 s	Alpha	
^{212}Pb	10.64 h	Beta	238.632 (43.6%)
^{212}Bi	60.55 min	Beta 64.06% Alpha 35.94%	727.330 (6.67%)
^{212}Po	0.299 µs	Alpha	
^{208}Tl	3.053 min	Beta	583.191 (84.5%), 2614.533 (99.16%)
^{208}Pb	Stable	–	

[a] Only major modes of decay are shown.
[b] Only major gamma emissions of interest are shown.

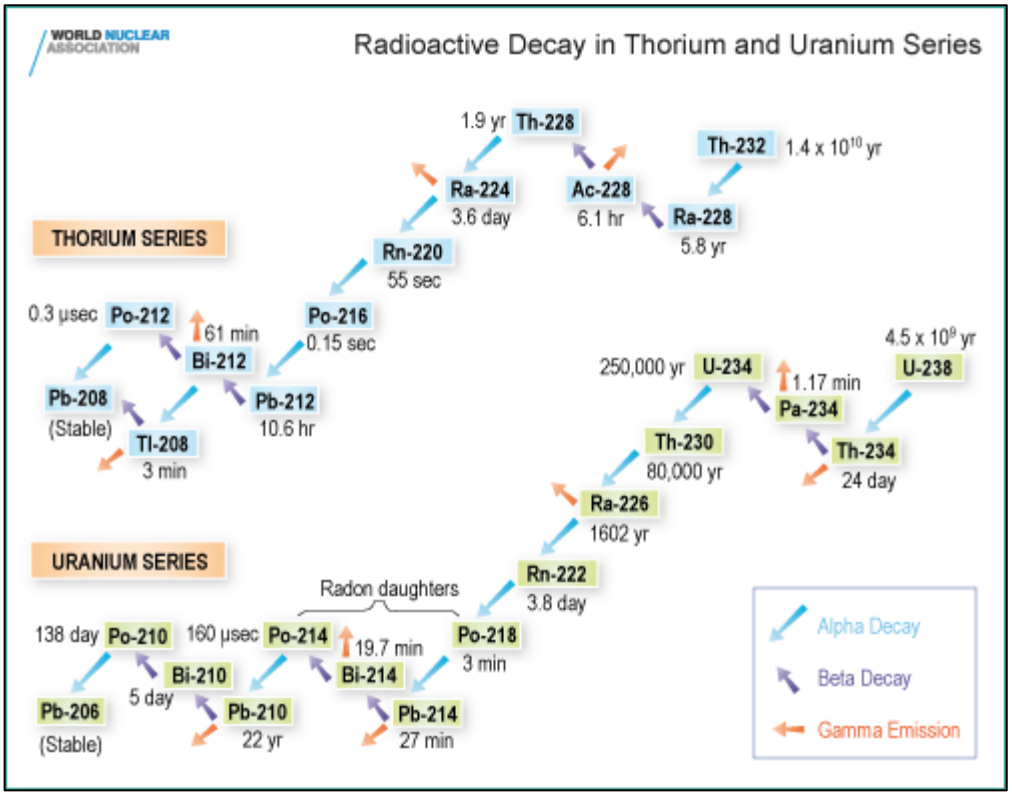

Figure 1: Diagram of the Radioactive Decay in Thorium and Uranium Series

ATTACHMENT 2

CONTENT FOR SITING OF RADIOACTIVE WASTE DISPOSAL FACILITY

No	Requirements	Remarks
1.	Executive Summary (for Siting of Disposal Facility)	Both languages
2.	Objective of Siting Process	Basic objective of the siting process is to select a suitable site for disposal and to demonstrate that this site has characteristics which, when combined with the facility design and waste package, provide adequate isolation of radionuclides from the biosphere for desire periods of time. Sites generally serve as a principal barrier, but engineering measures can enhance site performance and improve overall safety and environmental protection. To keep releases within acceptable limits, the disposal system should be developed such that the design of the facility and the type and amount of wastes intended for emplacement are in concert with the characteristics of the site and the surrounding natural media.
3.	Scope of Siting Process	Covers siting of a disposal facility for the disposal of very low and low level wastes from NORM processing associated contaminated materials arise from decommissioning of the plants.
4.	Stages of the Siting Process	One systematic siting process for a disposal facility may be considered to consist of several stages as follows: - (a) Conceptual and planning stage (b) Area survey stage (c) Site Investigation (d) Site characterization stage (e) Site confirmation stage

No	Requirements	Remarks
	(a) Conceptual and Planning Stage	The purpose of the conceptual and planning stage is to develop and overall plan for the site selection process, to establish the siting principles and to identify desirable site features which can be used as a basis for the area survey stage. The human and financial resources, materials, equipment and time requirements should be estimated to the extent practicable, and responsibilities for the siting studies defined. The types of wastes to be disposed of should be defined and characterized, including the projected waste volumes and radionuclide contents, generic facility design concepts should be developed. The likely waste acceptance criteria should be identified and the overall performance criteria for the facility should be developed. The available methodologies for safety analysis should be reviewed and basic methods and models should be selected. On the basis of these conceptual studies various desirable features, such as land area, geology and hydrogeology, could be identified as a basis for the area survey stage.
	(b) Area Survey stage	The purpose of the area survey stage is to identify one or more potential sites. This is often accomplished by the systematic screening of a region of interest, which results in the selection of potentially suitable areas. During this stage, it is necessary to take into account engineering, operational, socioeconomic and environmental constraints. The area survey stage generally involves two phases: • Regional mapping to identify areas with potentially suitable sites • Screening to select potential sites for further evaluation

No	Requirements	Remarks
	(c) Site Investigation Stage	The site investigation stage involves the detailed study of one, or several, potential sites identified in the area survey stage to determine whether they are acceptable in various respects, and in particular from the safety point of view. The information necessary to develop a preliminary site specific design should be obtained at this stage. Site investigation may progress in a number of stages that involve acquiring and interpreting consecutively more information, in order to select one or more preferred sites for detailed characterization. A preliminary safety assessment should be carried out at a relatively early stage to indicate whether a site is potentially suitable for a disposal facility. The preliminary safety assessment should include the results of the preliminary site investigations and a description of the decision process used. If several sites are under consideration, a reasonable comparative evaluation may be made between sites on the basis of judgements about their ability to meet all safety requirements and about their acceptability for construction of the disposal facility. At the conclusion of the site investigation stage, the preferred site or sites will have been identified. A report on the entire process should be prepared, with documentation of all data and analytical work including the preliminary safety assessment. It is expected that the final site selection will also involve judgements based on socioeconomic and political considerations.

No	Requirements	Remarks
	(d) Site Characterization Stage	The site characterization stage involves the investigation of one or more candidate sites to demonstrate that they meet safety and environmental requirements. Specific site related to the design bases should also be determined at this stage. It requires site specific information to establish the characteristics and the ranges of parameters of a site with respect to the location of the intended disposal facility. A preliminary safety assessment should be performed for each candidate site to determine that each one is potentially suitable for accommodating a disposal facility. At the conclusion of the site characterization stage, a preferred site or sites should be identified, taking into account the relevant economic, environmental, social and political considerations.
	(e) Site Confirmation Stage	The purpose of the site confirmation stage is to conduct detailed site investigations at the preferred site(s) to: - • Support or confirm the selection; • Provide additional site specific information required for detailed design, safety and environmental impact assessment and licensing. Detailed specifications of the site(s) should be established to allow final detailed design. Radiological, radionuclide transport and ecological evaluations should be carried out in detail. Safety analysis data and models should be updated for the specific site(s), and a detailed safety and environmental impact analysis should be performed using all the detailed information available.

No	Requirements	Remarks
		A final safety and environmental impact assessment based on all the investigations and evaluations should be prepared, summarizing all the relevant data, evaluations and conclusions derived from all site characterization and confirmation activities.
5.	Management of the Siting Process	Selection of suitable sites for radioactive waste disposal facilities involves integration of site investigative studies involving a number of disciplines, including natural and earth sciences, engineering, safety analysis, health physics and social sciences. The process should start with identification of the need for a disposal facility and conclude with selection of a site that is confirmed as meeting all safety and other requirements. Plans for the siting process should take into account activities to provide the local as well as general public with appropriate information, consultation and compensation as needed.
6.	Information Collection and Management	The siting process involves collection and management of information on various site characteristics which are needed for application of guidelines to identify suitable sites. Some of the data required at various stages of the process may be readily available from different sources; other data should be obtained through field investigation studies and laboratory tests. The siting process should be designed to provide the necessary data at various stages to facilitate a series of increasingly accurate estimates of the likelihood of compliance with the safety requirements.
7.	Quality Assurance (QA)	A quality assurance programme for all activities during siting shall be established to ensure compliance with relevant standards and guidelines.

No	Requirements	Remarks
8.	Siting Guidelines and Data needs	For each major stage of the siting process, the allocation data, the guidelines used and the results obtained should be reviewed and recorded so as to contribute to the thorough documentations of the entire process. The information should include (but not necessary limited to): - • A description of the siting process, including the objectives, legal limitations, and the procedures and guidelines to be considered at each phase of the site selection; • Specification of data to be used and the information required for each site characteristic at each phase of the siting process; • The data collected and the guidelines adopted; • The results obtained in the evaluation of each guideline.
	(a) Geology	The geological setting at the site should contribute to the isolation of waste and the limitation of releases of radionuclides to the biosphere. It should also contribute to the stability of the disposal system and provide sufficient volume and engineering properties favourable for implementing disposal. Information to be collected should include stratigraphy, lithology and mineralogy, structural characteristics and geotechnical characteristics. In the area survey stage, the geological information should include identification of the approximate geological structure and stratigraphy, possibly with the depth, thickness and lateral extent of the surface formation and surrounding units. In the site characterization stage, information to be collected should include the following: - (a) Stratigraphy, lithology and mineralogy; (b) Geological structure characteristics; (c) Geotechnical characteristics

No	Requirements	Remarks
		In the site confirmation stage, extensive geological investigations should be undertaken to characterize fully the geology to the level needed for detailed safety assessment, modelling and final facility design.
	(b) Hydrogeology	The hydrogeology setting of the site should include low groundwater flow and long flow paths in order to restrict the transport of radionuclides. In the area survey stage, hydrogeological characteristics of an area or site may not yet be available in sufficient detail. In situations where hydrogeological maps are lacking, the information analyzed should encompass: - (a) Data on existing and projected major water uses; (b) Identification of major discharge and extraction points; (c) An estimate of groundwater flow velocity and direction. For the site characterization stage, the following information should be considered: - (a) Location, extent and interrelationship of the important hydrogeological units in the region (b) Average flow rates and prevailing directions of the groundwater flow (c) Information on recharge and discharge of the major hydrogeological units (d) Information on regional and local water tables and their seasonal fluctuations (e) Demarcation/ delineation/ earmark of main – and sub water catchment.
	(c) Geochemistry	The geochemistry of groundwater and the geological media should contribute to limiting the release of radionuclides from the disposal facility and should not significantly reduce the longevity of engineered barriers.

No	Requirements	Remarks
		In the consideration of the likely chemical interactions within the disposal system, the following should be evaluated: - • Corrosive action of groundwater on the engineered barriers • Processes or conditions influencing the solubility and the sorption of radionuclides • Eh and pH of the groundwater • Processes or conditions involving the presence of natural colloids and organic materials • Potential gas generation by the disposal system Information necessary to estimate the potential for migration of radionuclides to the biosphere should include a description of the geochemical and hydro chemical conditions at the site, the surrounding geological and hydrogeological units, and the paths of potential groundwater flow. This information should include: - • Mineralogical and petrographical composition of the groundwater flow system and its geochemical properties • Groundwater chemistry
	(d) Tectonics and Seismicity	The site should be located in an area of flow tectonic and seismic activity such that the isolation capability of the disposal system will not be endangered. The design of the disposal facility should take into account regional and localized tectonic stability and seismic activity of the site that could adversely affect the proposed disposal system. The following information should be analyzed at the site confirmation stage: - • Historical seismicity at the site and surrounding areas.

No	Requirements	Remarks
		• Occurrence of quaternary faults at the site and the age of latest movement • Evidence of active tectonic processes, such as volcanism • Estimate of maximum potential earthquake within the geological setting.
	(e) Surface Process and Potential Geological Hazard and Risk	Surface process such as flooding of the disposal site, land sliding or erosion should not occur with such frequency or intensity that they could affect the ability of the disposal system to meet safety requirements. In the site characterization and confirmation stages, the following information should be collected: - • Topography of the site, showing actual drainage features • Location of existing and planned surface water bodies • Definition of geological sensitive areas of landslides and other potentially unstable slopes, and of materials of low bearing strength or high liquefaction potential • Definition of areas containing poorly drained materials • Data on the flood history of the region • Upstream drainage areas
	(f) Meteorology	The site area meteorology should be characterized such that the effect of unexpected extreme meteorological conditions can be adequately considered in the design and licensing of the disposal facility. In the site characterization stages, the meteorological conditions, as determined from the closest recording station(s), should be known in order to predict potential effects of extreme precipitation on the hydrological and hydrogeological systems at the site, and to evaluate the transport of airborne releases during

No	Requirements	Remarks
		operation of the disposal facility. The types of information should include: - • Wind and atmospheric dispersion characteristics • Precipitation characteristics • Extreme weather phenomena
	(g) Man-induced Events	The site shall be located such that activities by present or future generations at or near the site will not be likely to affect the isolation capability of the disposal system. In the site characterization and confirmation stages, in order to estimate any adverse impact that off-site installations might have on the projected disposal system. The following information should be collected: - • Location of nearby hazardous installations, such as oil refineries, chemical plants, storage depots, pipelines and other facilities that could have an impact on the site operations • Location of airports and important air traffic corridors and flight frequencies • Location of transportation routes with frequent movement of hazardous material
	(h) Transportation of Waste	The site shall be located such that the access routes will allow transportation of waste with a minimal risk to the public. To evaluate existing or required access routes, the information to be collected should include: - • Description of existing routes in the vicinity of the site and analysis of their adequacy for handling waste shipments • Anticipated improvements in the existing transportation network • Estimates of the overall costs and risk of waste transportation

No	Requirements	Remarks
		• Analysis of emergency response requirements and capabilities related to transportation
	(i) Land Use	Land use and ownership of land should be considered in connection with foreseeable development and regional planning in the area interest. The data should include: - • Existing land resources and uses and jurisdiction over them • Foreseeable development of land in the area of interest
	(j) Population Distribution	The site should be located such that the potential hazard of the disposal system on the current population and projected future population is acceptable. In the area survey stage, large scale maps should be prepared showing major population centres and regions with population density as a function of distance.
	(k) Protection of the Environment	The site shall be located such that the environment will be adequately protected during the entire lifetime of the facility and such that potentially adverse impacts can be mitigated to an acceptable degree, taking into account technical, economic, social and environmental factors. Near surface disposal facilities should comply with the requirement to protect the environment. Possible adverse effects which a near surface disposal system may have on the environment include: - • Disturbance of the environment due to the construction and operation of the disposal facility • Impact on areas of significant public value • Disturbance of public water supplies • Impact on endangered species
	(l) Radiological Baseline Data	The Radiological baseline data is required to establish a database of information on the disposal facility, the site and its surrounding. The database is used to

No	Requirements	Remarks
		support the future decisions when proceeding from siting to construction, operation, closure and the period after closure. The database also used to support decisions relating to updating concepts and procedures for monitoring. Baseline data monitoring should be focusing on measurement of the initial values of parameter that will continue to be monitored by either continuous or periodic observations. Radiological baseline data timeline may be varying according to the type of geological waste disposal. The data collection as determined by the Board according to the graded approach or six (6) consecutive months and will be assessed to determine the adequacy of the data.
9.	Exclusion criteria	List of criteria used early in the siting process to eliminate areas based on consideration of go/no go situations and are generally based on regulatory and/or plant design requirements.