MANAGEMENT OF RADIOACTIVE WASTE

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Introduction

- All practices that use nuclear and radioactive materials will produce radioactive wastes.
- The nature of radioactive wastes vary from one radioactive waste to another radioactive waste in terms of volumes, chemical and physical compositions and concentration of radioactivity.
- The radioactivity contained in the wastes is hazardous to living organisms.
- The hazardous nature of radioactive wastes to living organisms requires proper radioactive waste management as prescribed by AELB.
- The purpose of proper management of radioactive wastes is to ensure safety and well being of the present and future generations of the general public and the environment.

Definition & Objective

Radioactive Waste means any waste which consists wholly or partly of-

(a) a substance or article which if it were not waste would be radioactive material; or

(b) a substance or article which has been contaminated in the course of the production, storage or use of any radioactive material, nuclear material or prescribed substance or by contact with or proximity to any other waste within the meaning of paragraph *(a)* of this definition (Section 2, Act 304)

Objective of Radioactive Waste Management

To deal with radioactive waste in a manner that protects health and the environment now and in the future, without imposing undue burdens on the future generations

Atomic Energy Licensing Act 1984 (Act 304)

Control & Licensing (Part III)	Section 12(1)(b) – no person shall deal in, poses or dispose of any radioactive material or nuclear material or prescribed substances without a valid licence issued by the Appropriate Authority.
Disposal of Radioactive Waste (Part VI)	Section 26(1) – No person shall dispose of or cause to be disposed any radioactive waste without prior authorization in writing of the appropriate authority. Section 27(1) – No person shall accumulate or cause to be accumulated any radioactive waste on any premises without prior authorization in writing of the appropriate authority.

Atomic Energy Licensing Act 1984 (Act 304)

Disposal of Radioactive Waste (Part VI)	**Section 28 – If it appears to the appropriate authority that adequate facilities are not available for the safe accumulation , storage or disposal of any radioactive waste, the appropriate authority may direct the licensee to rectify situation.** **Section 29– Where any situation endanger life, health, property or the environment is found to exist in or on any site, the appropriate authorities may direct the licensee or any other person to adopt measures as would eliminate or protect against such situation or condition.** **Section 30 – No person shall transport any radioactive waste without prior authorization in writing of the appropriate authority.**

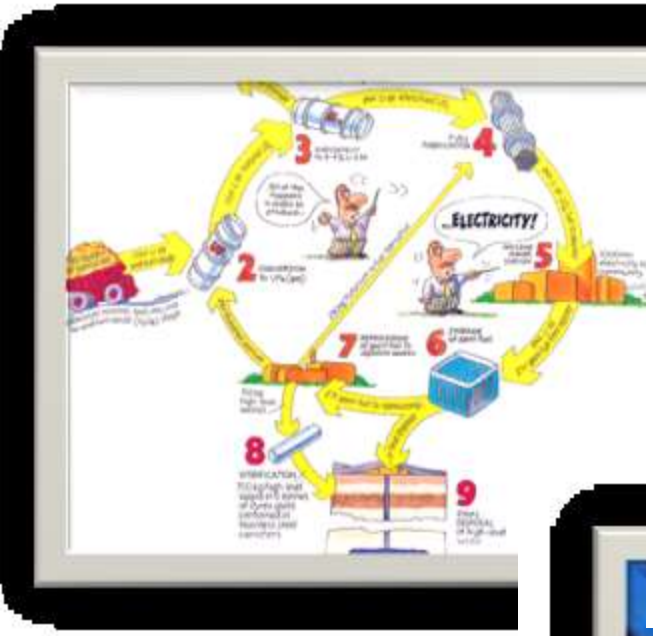
Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011

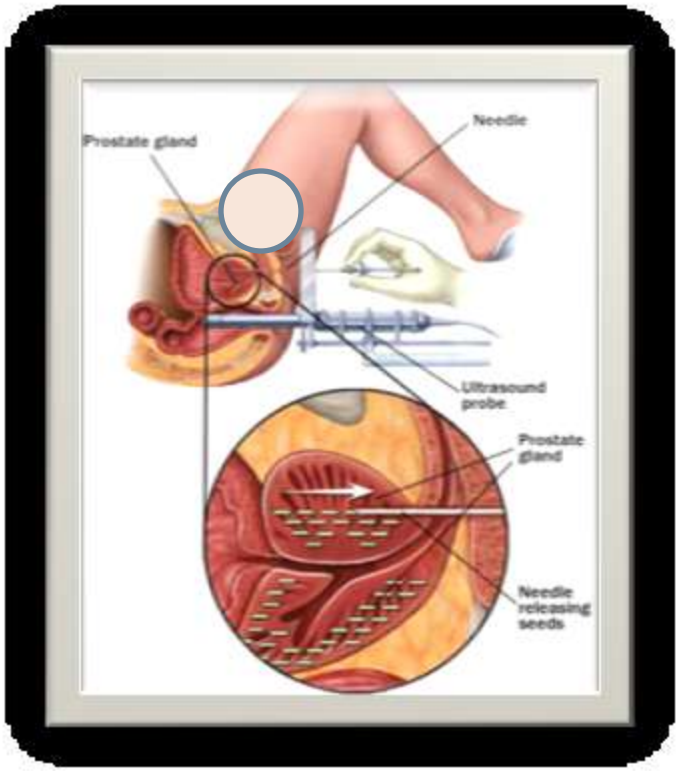
- Come into operation on 16 October 2011
- Apply to all aspect of radioactive waste and waste management arising from medical, industrial and research application.
- Licensee shall appoint RPO or other technically qualified and competent person approved by the Board as a Radioactive Waste Management Officer (RWMO)

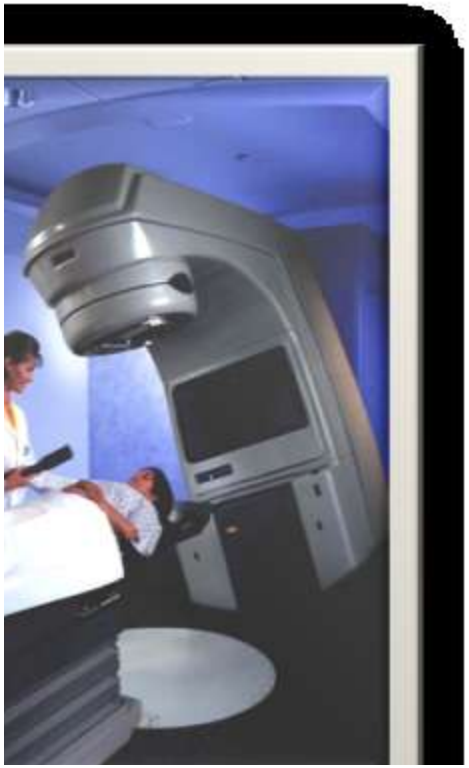
Sources of Radioactive Waste

Radioactive waste arises from many different activities, for example:

- Nuclear fuel cycles;
- Application of radionuclides in industry, medicine, and research;
- Cleanup of contaminated sites;
- Processing of raw materials containing naturally occurring radionuclides.
- Nuclear fall-out







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Principle of Radioactive Waste Management

There are 9 principles of radioactive waste management:

Principle 1: Protection of human health

Radioactive waste shall be managed in such a way as to secure an acceptable level of protection for human health

Principle 2: Protection of the environment

Radioactive waste shall be managed in such a way as to provide an acceptable level of protection of the environment

Principle 3: Protection beyond national borders

Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will be taken into account.

Principle of Radioactive Waste Management

Principle 4: Protection of Future Generation

The generations that receive the benefit of a practice should bear the responsibility to manage the resulting waste, and developing the technology constructing and operating facilities, providing a funding system, sufficient control and plans for the management of the waste.

Principle 5: Burdens on future generations

Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.

Principle 6: National Legal Framework - the radioactive waste shall be managed within an appropriate legal framework including clear allocation of responsibilities and provision for independent regulatory functions.

Principle of Radioactive Waste Management

Principle 7: Control Radioactive Waste Generation

Generation of radioactive waste should be kept to the minimum practicable.

Principle 8: Radioactive waste generation and waste management interdependencies

Interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account.

Principle 9: Safety of Facilities

The safety of facilities for radioactive waste management shall be appropriately assured during their lifetime.

Management of Disused Sealed Radioactive Sources (DSRS)

- Disused Sealed Radioactive Sources (DSRS) are considered as waste:
  - no longer useful to users;
  - taken out of service; and
  - no future use.
- DSRS with long half-life may be reused or recycled to minimize their quantity or volume.
- The DSRS shall be returned to their suppliers or manufacturers.
- The DSRS can be sent to the Radioactive Waste Treatment Facility but shall obtain a written approval first from the AELB.
- The Licensee can keep or store the DSRS at its premises but shall ensure their safety and security

Classification of Radioactive Waste

- The classification of radioactive waste is important to allow for easy handling and transportation and enhancement of safety while going through the process of waste management.

- Radioactive waste is classified according to:
  - its physical form (solid, liquid and gaseous);
  - its activity (low, medium and high);
  - its half-life (short half-life, medium half-life and long half-life); and
  - beta-gamma emitters and alpha emitters.

Classification of Radioactive Waste

[Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011]

Class	Decription
Cleared waste	Materials containing level of radionuclides at activity concentrations less than those specified in the Second Schedule
Low Level (Short Lived)/Decay Waste	Low level radioactive waste containing short lived radionuclides only (half lives less than 100 days) that will decay to clearance levels within three years after the times of its generation.
Low and Intermediate Level Short Lived Waste (LILW-SL)	Radioactive waste which will not decay to clearance levels within three years containing beta/gamma emitting radionuclides with half lives less than thirty years or alpha emitting radionuclides with an activity concentrations less than 400Bq/g and a total activity less than 4000Bq in each radioactive waste package.
Low and Intermediate Level Long Lived Waste (LILW-LL)	Radioactive waste containing radionuclides with activity concentrations more than LILW-SL but which does not generate heat at above 2kW/m^3
High Level Waste (HLW)	Radioactive waste containing radionuclides with activity concentrations more than LILW-SL but which generate heat at above 2kW/m^3

Waste Minimization

- Waste minimization is strongly encouraged to minimize the problem of waste management, in particular, waste disposal.

- The generation of waste can be minimised via the following 3R steps:
  - Reduce the amount or volume of the radioactive material being used.
  - Reuse the use of materials or sources or do decontamination process.
  - Recycle the usage of sources in the same or different fields.

Pre-Disposal Management of Radioactive Waste (1)

Pre-disposal management radioactive waste covers the whole process of waste handling:

- waste collection;
- waste segregation and transfer;
- waste treatment;
- waste conditioning; and
- waste storage;

Pre-Disposal Management of Radioactive Waste (2)

Waste Collection, Segregation and Transfer

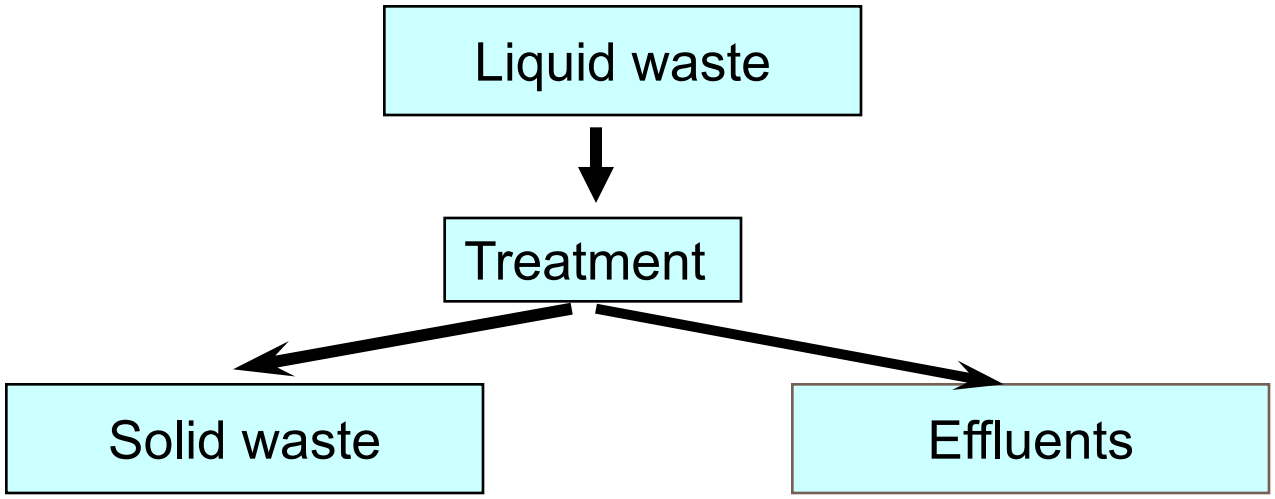
- Waste is collected in suitable containers (with adequate shielding) and labeled.
- It is then segregated at source according to its classes/categories to facilitate the treatment process.
- All information on the waste is recorded and a waste inventory is established.
- A written approval to carry out the waste management process should be sought from AELB.

Pre-Disposal Management of Radioactive Waste (3)

Waste Treatment

- Objective:

  The objective of the treatment process is to reduce the volume, reduce or eliminate potential hazards associated with the waste
- The basic treatment for small volume of waste includes:
  - volume reduction, e.g. solid waste can be compacted or incinerated.
  - Removal/extraction of radionuclide - decontamination for surface contamination, ion exchanging for liquid waste.
  - Change of form or composition – liquid to solid
  - Transformation/change the properties of waste - liquid waste into solid by precipitation or filtration.
- The process of radioactive waste treatment may produce the secondary waste that require attention and should be managed accordingly.



- Liquid waste can be transformed to solid waste by some treatment process such as evaporation.
- Liquid waste can be discharged to the environment if either clearance has been granted for the radioactive substance or the discharge is within the limits authorized by the Regulatory Authority.

Pre-Disposal Management of Radioactive Waste (4)

Conditioning of Treated Waste

- Objective:

  The objective of conditioning is to convert the treated radioactive waste into a more stable form than can:

  - provide easier handling, transportation, storage and disposal; and
  - ensure minimum leakage of radionuclides into the environment over a long period of time after disposal.

- Conditioning is usually done by mixing the waste with more stable matrix materials such as cement, bitumen, polymer and glass (vitrification).

Pre-Disposal Management of Radioactive Waste (5)

Storage

- Storage means storing or keeping conditioned radioactive waste in a proper safe place or facility with intention to retrieve it back at some time in the future.

- The **location** should be selected with due consideration given on the following conditions to minimize radiation risks:

  - isolated area;
  - low risk of flood and fire;
  - it must be stable in order to secure waste from leakage or dispersion of radio nuclides to the environment over a period of time; and
  - free from earthquake threat.

Pre-Disposal Management of Radioactive Waste (6)

- The store should be designed:
  - To limit the radiation risk and radioactive dispersion.
  - With adequate shielding and ventilation.
  - With adequate safety and security features e.g.:
    - o security locks;
    - o label and radiation warning signs; and
    - o a system of heat removal for high activity waste.
    - o far from corrosive, explosive or easily flammable

- Transportation of radioactive waste to the disposal site should comply with requirements of Radiation Protection (Transport) Regulations 1989.

Storage Facility

Disposal (1)

The International Atomic Energy Agency (IAEA) defines disposal as:

The emplacement of waste in an approved, specified facility (e.g. near surface or geological repository) without the intention of retrieval.

Disposal

- Final part of radioactive waste management process.
- Considered only when there is no intention to recycle or reuse the radioactive material (waste).

- Three basic principles of radioactive waste treatment prior disposal are:
  - Delay and decay
  - Dilute and disperse
  - Concentrate and contain
- Radioactive waste disposal site should be properly selected to ensure its suitability and safety to members of the public.

Disposal (2)

‘Delay and Decay’

hold waste in storage until sufficient decay has occurred for desired management approach

‘Dilute and Disperse’

discharge waste in a manner that environmental conditions reduce concentrations to acceptable levels

‘Concentrate and Contain’

reduce volume and condition and/or containerize waste to limit dispersion in the environment

Disposal (3)

Disposal Site Assessment

Selection Criteria

- Geological and hydro geological suitability
- Demography and future use of land
- Accessibility
- Flora and fauna
- Mineral and deposit
- Meteorology
- Seismic

Exclusion Criteria

- Urban area
- Protected area which has economic, security values
- Historical value

Disposal (4)

Disposal methods

1. Dispose of at Municipal Disposal Site

Conditions :

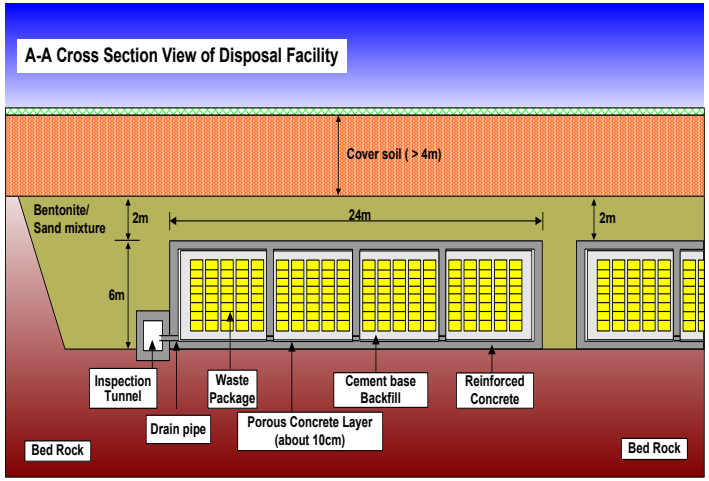
- Radioactive wastes which contain radio nuclides with activities below the clearance levels given by the AELB.
- The radioactivity involved is of extremely low level and the risk of radiation hazard posed by such disposal to individual member of the public or to the whole population is technically negligible or insignificant.

Disposal (4)

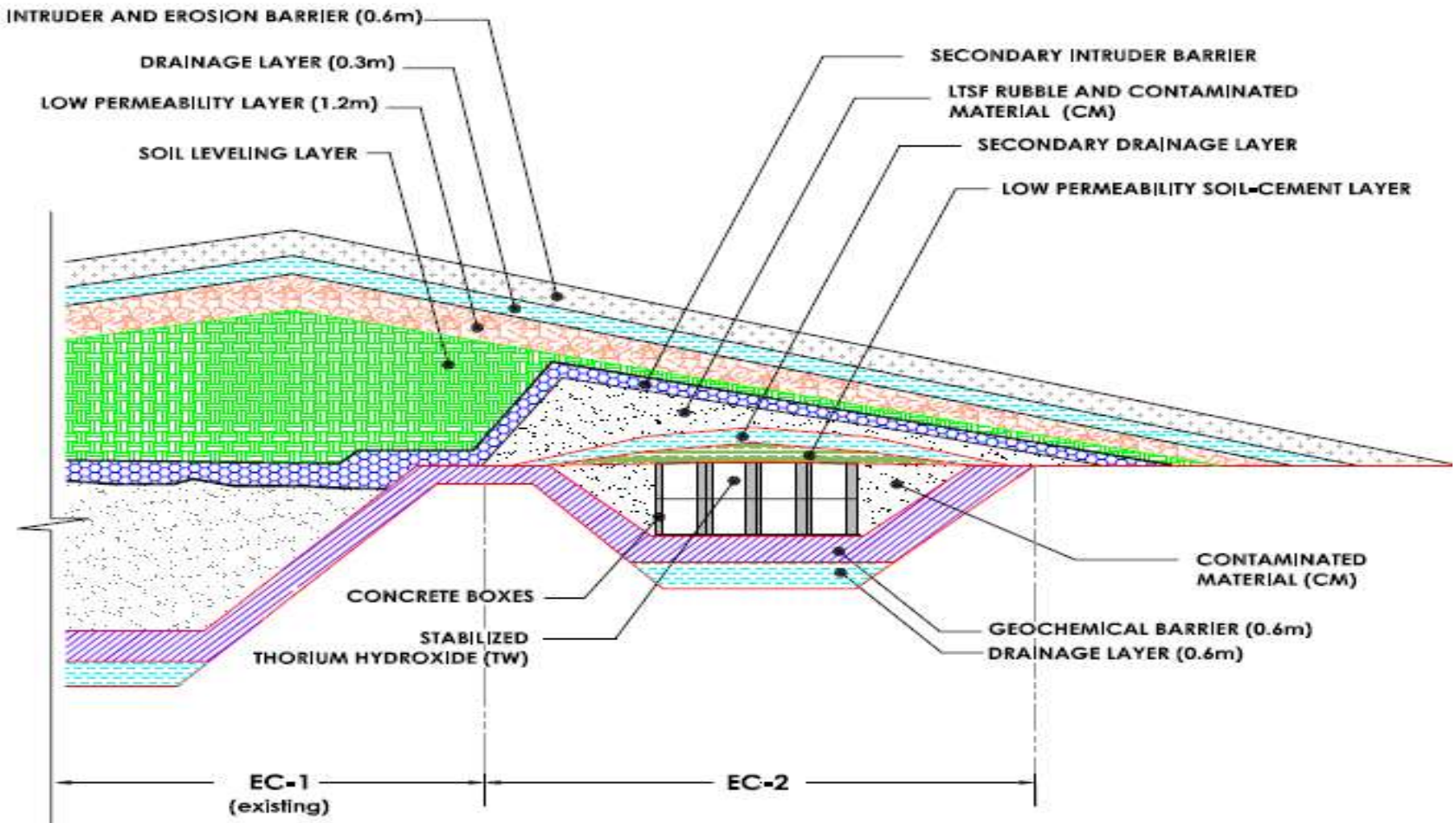
Disposal Methods

(2) Shallow Land Burial (Near Surface)

- For wastes containing short to medium half-lived radio nuclides.
- Waste to be conditioned first.
- If waste is of long half-lived radio nuclides, the option can be considered only for disposal of small quantity.
- e.g. Rokkasho (Japan)



Engineered Cell 1 and Engineered Cell 2 at Bukit Kledang (for TENORM Residue)

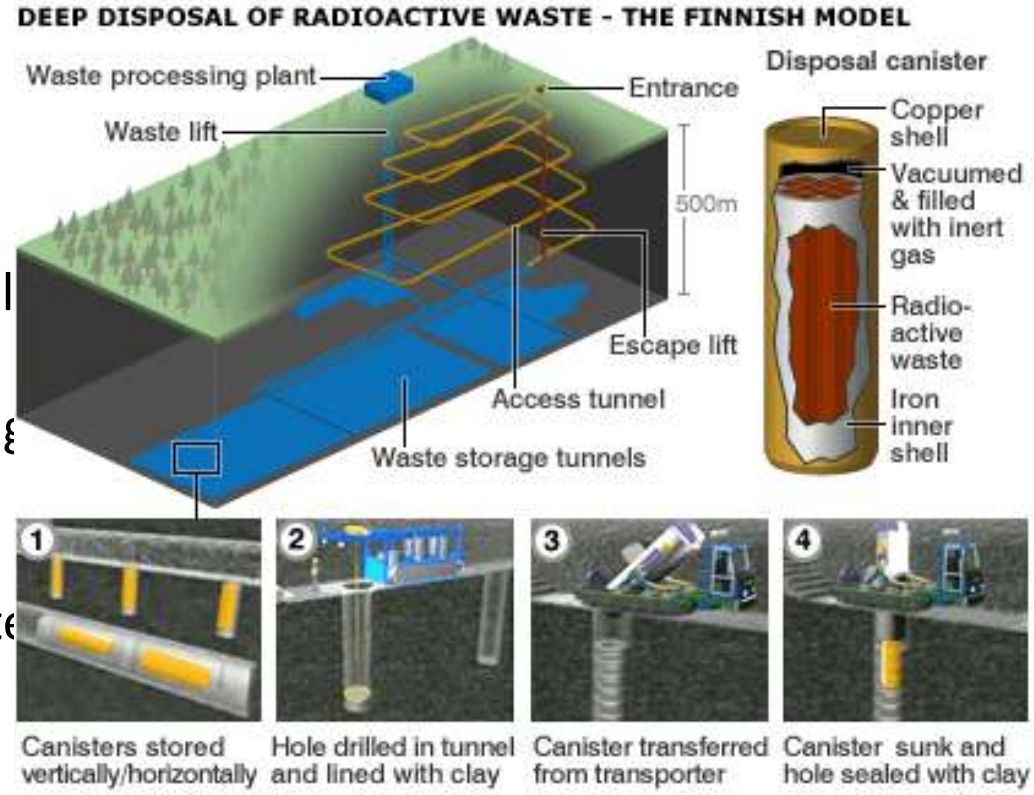


Disposal (3)

Disposal Methods

Deep Geological Burial

- The best option for radioactive waste disposal
- Suitable for waste containing medium to long half lived radio nuclides and high level waste
- An example of suitable site for such disposal is salt dome or granite area.
- e.g. Finland



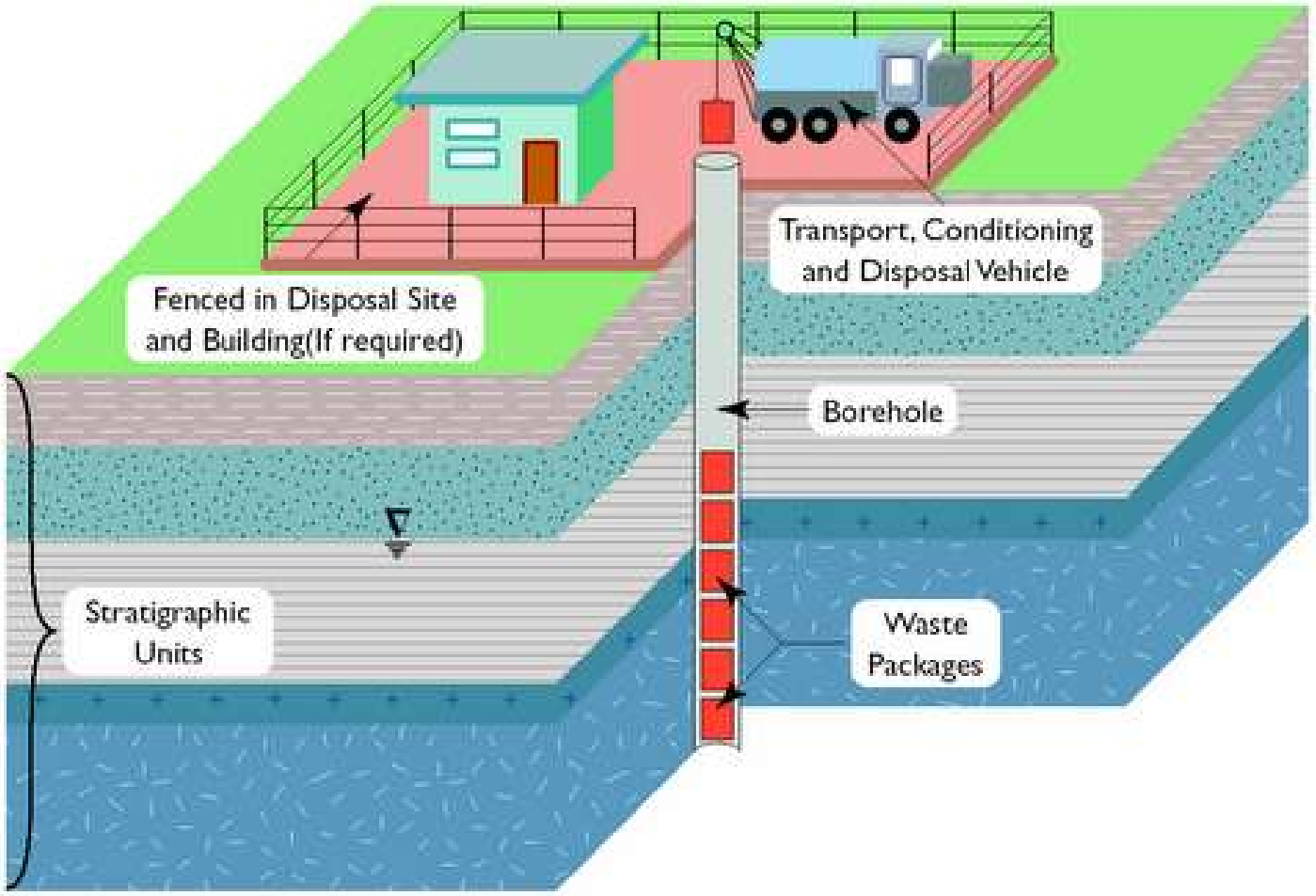
Disposal Methods

BOrehole disposal of Sealed Radioactive Sources
(BOSS)

What is BOSS?
The *BOSS* system is a safe, simple and cost-effective solution for the management of disused sealed radioactive sources (DSRS).
The system consists of:
(i) A mobile facility that allows even high activity DSRS to be safely conditioned and packed;
(ii) A disposal borehole with multi-barrier system able to confine safely conditioned DSRS. The sources are placed inside two high integrity stainless steel containers (one inside the other, expected longevity of thousands of years) and sealed within a 30-100 metre deep, specially engineered borehole in the suitable host geological media.

Disposal Methods

Borehole Disposal Concept



Disposal Methods

Deep Ocean / Sea Bed Disposal:

- Selected due to its high degree of dilution and isolation from human population.
- It had been practised by several nations.
- Not permitted for high activity radioactive waste.
- No longer being practiced and was banned after the London Convention (1972).

Quality Assurance Programme

A quality assurance programme (QAP) for the safe management of radioactive waste is necessary:

- To confirm compliance with regulations and legislations.
- To ensure provision of acceptable and continued protection of human and environment.
- A written QAP, which is commensurate with the scale of intended operations shall be submitted to the AELB

Record Keeping

- The records that have to be provided and maintained include:
  - Radioactive waste inventory (activity, exposure rate, source, location, chemical and physical properties).
  - Disposal/ waste discharges.
  - Records of environmental monitoring and assessments.
  - Records of effluent monitoring.
  - Records of packaging and transport of conditioned radioactive waste.

- Any record required by waste regulations or requested by the AELB.

Terima kasih

Thank You