NEAR SURFACE DISPOSAL

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OUTLINES

- Why radioactive waste needs to be disposed of
- Main objectives of the radioactive waste disposal
- The purpose of a disposal design
- Waste classes and recommended repository type
- Low level waste disposal
- Designs for near surface repositories
- Advantages & disadvantages of near surface disposal
- Examples of near surface repositories/concepts

WHY RADIOACTIVE WASTE NEEDS TO BE DISPOSED OF

- The radionuclides (RN) in the waste may be harmful to humans and the living environment:
  - **directly** - external exposure
  - **through intake or inhalation, if released to the environment** - internal exposure
- Owing to its **radiological properties and the potential hazard** it poses, it is important to ensure the safe management of radioactive waste at all stages. It requires containment and isolation from humans and the living environment over a long period of time. The time scale of isolation is in direct connection with the half-lives of the radionuclides content in the disposed waste
- **After adequate treatment, conditioning and packaging, disposal represents the end-point of any radioactive waste management programme**
- The **size of the repositories** reflects generally the **size of the nuclear programme** in the respective country

MAIN OBJECTIVES OF THE RADIOACTIVE WASTE DISPOSAL

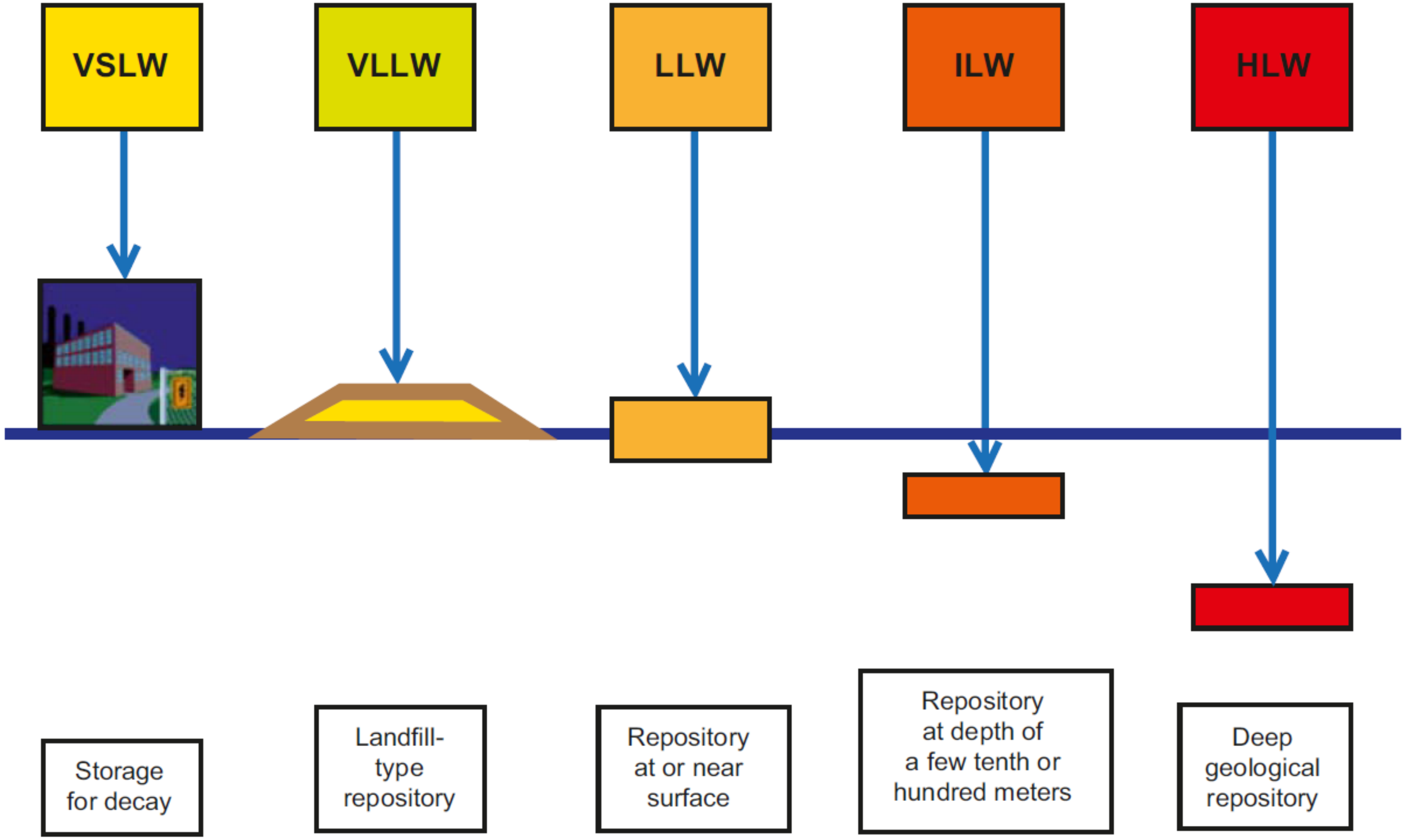
- **Isolation the radioactive waste (RW) and containment of the radionuclides (RN) from humans and the living environment over a long period of time are two of the requirements for any disposal facility.**
- **Isolation means:**
  - design to keep the waste and its associated hazard apart from the accessible biosphere
  - design to minimize the influence of factors that could reduce the integrity of the disposal facility
- **Containment**
  - implies designing the disposal facility to avoid or minimize the release of RN
  - containment shall be provided until radioactive decay has significantly reduced the hazard

THE PURPOSE OF A DISPOSAL DESIGN

- **Any disposal design has to prevent or reduce interaction between water and RW**
  - This can be achieved by:
    - proper site selection (arid region, unsaturated, mountainous site, etc.)
    - proper depth selection (near surface above/ below surface, intermediate depth, deep geological)
    - water resistant cap (runoff drainage layer, clay barrier)
    - long-lived containment
- **Any disposal design has to protect against inadvertent human intrusion**
    - determined by the degree to which the combination of the disposal depth, institutional controls, and engineered barriers can prevent or minimize this exposure scenario

WASTE CLASSES AND RECOMMENDED REPOSITORY TYPE

- Designs for RW repositories are mainly related to:
  - the **level of activity** in the waste
  - the **amount of long-lived RN**
  - the **RW volumes**
- Selection of a disposal option depends on many technical and administrative factors, such as:
  - RWM **policy**
  - national **legislative and regulatory requirements**
  - waste **origin, characteristics and inventory**
  - **climatic conditions** and **site characteristics**
  - **public opinion**



(U. Bergström, K. Pers, Y. Almén, International perspective on repositories for low level waste)

LOW LEVEL WASTE DISPOSAL

- Around **90% (by volume) of the waste** generated by nuclear technologies are classified as **low-level waste** (LLW, *as defined in IAEA Safety Standard GSG-1*). These waste contains mainly **short-lived RN** (usually with half-life less than 30 years) and **limited amount of long-lived RN**.
- For this RW category, an adequate isolation from accessible environment can be achieved by **disposal in near surface repositories**, after proper treatment and packaging.
- A near surface repository is a facility within which waste emplacement is designed to be undertaken at or within 30 m from the earth's surface (*IAEA definition*).
- In the short term after closure (~ 300 years), **the safety of the surface repositories relies on institutional controls** (active & passive controls) aiming to **keep the integrity of the engineered barriers**.

DESIGNS FOR NEAR SURFACE REPOSITORIES (1/3)

Near surface disposal facilities can be built **at or below ground level**

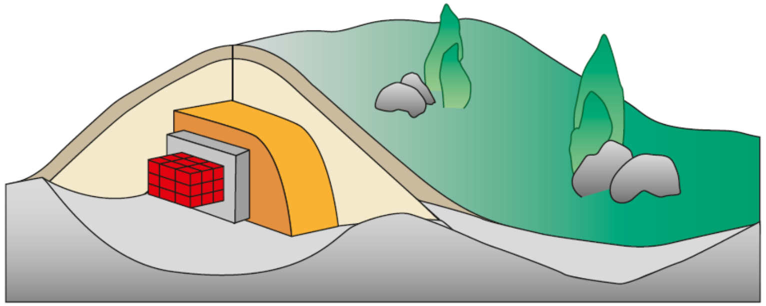
- **Surface**: simple landfill (*adequate for VLLW only*) or engineered structures (vaults)
- **Near Surface - trench**: excavated trenches with only minor civil engineering features
- **Near-Surface - engineered vaults**: facilities in which there is extensive use of concrete walls to partition the disposal cells, construction of drainage channels and other civil engineering structures, etc.
- **Near Surface - Mined or natural cavities** (sub-surface)
- **Near Surface - Shafts/Borehole**

DESIGNS FOR NEAR-SURFACE REPOSITORIES (2/3)

- **Near-surface repositories at ground level:**
  - are constructed **on or below the surface** where the protective covering is of the order of a few meters thick
  - waste containers are placed in **constructed vaults**
  - the **vaults are backfilled** when full
  - the **vaults will be covered and capped** with an impermeable membrane and topsoil
  - usually incorporate some form of **drainage** and possibly a **gas venting system**

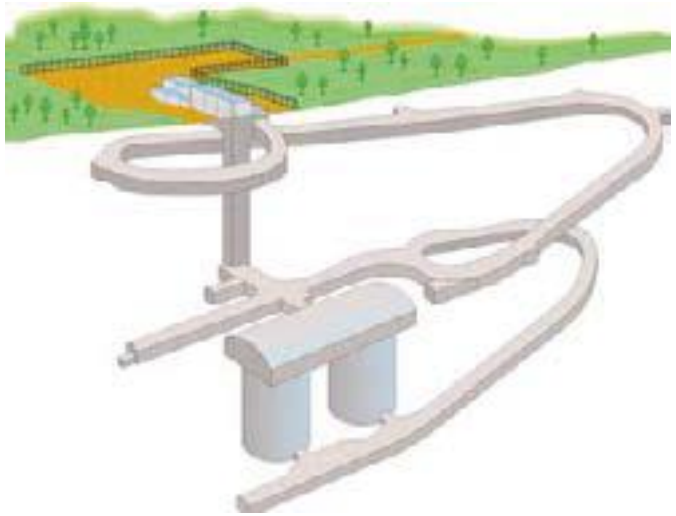
- **Near-surface repositories in caverns below ground level:**
  - require **underground excavation of caverns**
  - the disposal rooms are at a **depth of several tens of meters** below the Earth's surface
  - the **disposal room are accessed through a drift**

DESIGNS FOR NEAR-SURFACE REPOSITORIES (3/3)



Vault type, above ground

Vault type repositories are constructed to **prevent water from entering** into the disposal area and thus ensure **that diffusion is the only transport mechanism for RN** (*an extremely slow process*)
⇒ *the waste stays dry as long as the protective barriers are intact which may be hundreds of years*



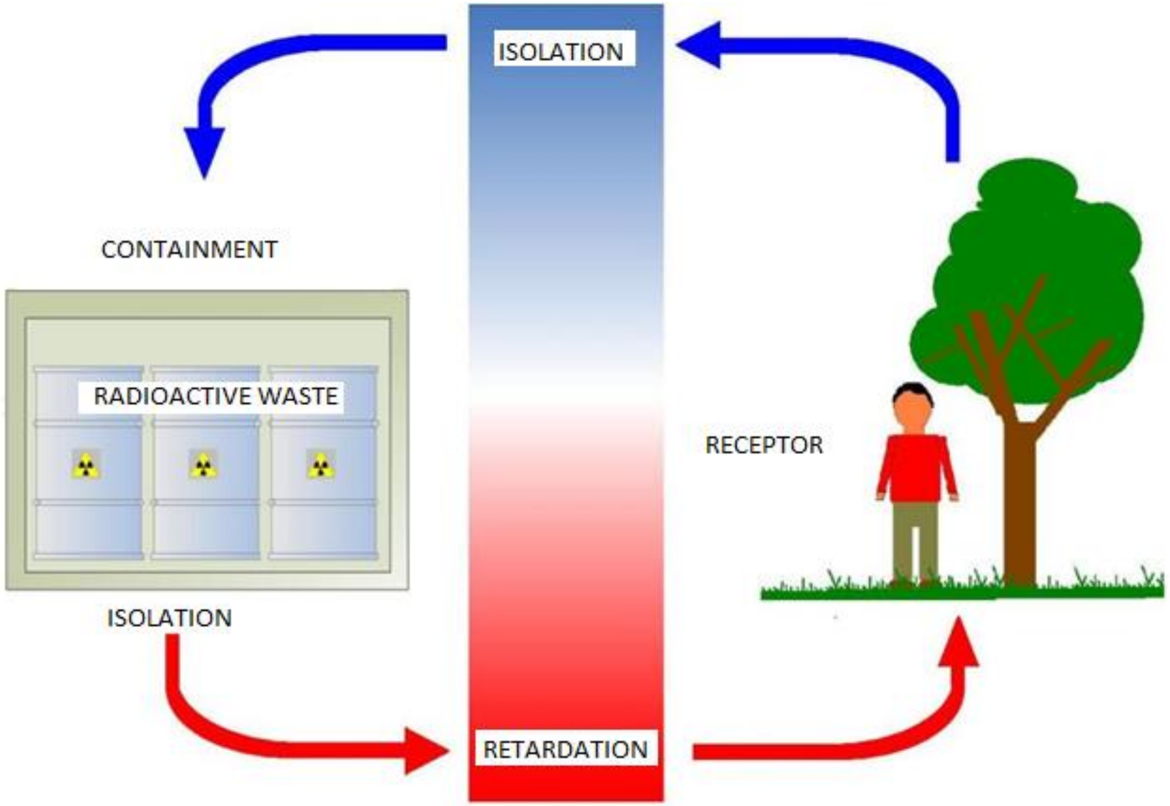
Cavity type, underground

Vault type, below ground

Repositories **below ground** provide **additional protection** compared to those on the surface against man-made hazards (e.g. aircraft accidents or sabotage) and natural hazards (e.g. flooding and erosion)

SAFETY OF NEAR SURFACE DISPOSAL

- **The safety of near surface repositories relies on a system of barriers to prevent, or delay, the transport of RN into the biosphere**
  - the barriers can be a **combination of engineered and natural barriers**
  - the **design of the barriers** may **differ significantly** between repositories
- The barriers shall provide **physical and chemical properties that contributes to containment and isolation**
- **Usually, high reliance on engineered barriers, supported by natural site characteristics**
- **Long term institutional control may continue after repository closure to ensure safety**



ADVANTAGES & DISADVANTAGES OF NEAR-SURFACE DISPOSAL

- **Advantage:**
  - the requirements on the conditions at the site are moderate ⇒ normally **easy to find a suitable site** that conforms to the technical requirements
- **Disadvantages:**
  - the protective **cover and barriers are exposed to weathering**, especially erosion, that can jeopardize the integrity of the repository
  - require **institutional control period** (active and passive) to ensure long time safety
- The **impact** of weathering and erosion processes is **lower for cavity type underground facilities** compared to the **vault type facilities** (above- or below ground)
- In underground cavities, the waste is normally placed below the ground water table
  - the environment outside the engineered barriers is water saturated soon after closure of the repository;
  - higher risk for corrosion and degradation of structures

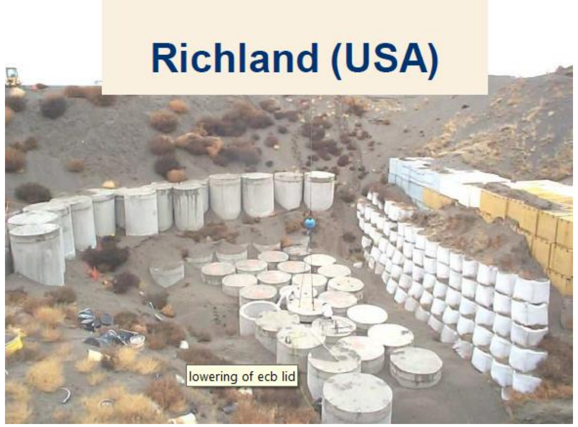
EXAMPLES OF NEAR SURFACE REPOSITORIES

- **Facilities at ground level:**
  - **Centre de l'Aube** (France) - operated by ANDRA
  - **El Cabril LLW and ILW disposal facility** (Spain) - operated by ENRESA
  - **LLW Repository at Drigg** in Cumbria (UK) - operated by UK Nuclear Waste Management on behalf of the NDA
  - **Dukovany repository** (Czech Republic) - operated by SURAO
  - **LLW Disposal Center at Rokkasho-Mura** (Japan) - operated by Japan Nuclear Fuel Limited
  - LLW disposal facilities in USA:
    - **Texas Compact facility (USA) -** operated by Waste Control Specialists;
    - **Barnwell (South Carolina), Clive (Utah) and Oak Ridge (Tennessee)** - operated by EnergySolutions;
    - **Richland (Washington)** – operated by American Ecology Corporation

- **Facilities below ground level:**
  - **SFR final repository for short-lived radioactive waste at Forsmark** (Sweden) – operated by SKB
  - **Olkiluoto and Loviisa underground repositories for LLW and ILW** (Finland) - operated by POSIVA
  - Bátaapáti (Hungary) repository for LILW disposal - operated by PURAM

TRENCH-TYPE REPOSITORIES

- A trench can be divided into **individual compartments to increase radionuclide containment** and flexibility of operation;
- After filling, a **waterproofing top cover** is installed;
- **Surveillance and monitoring** are required after closure during the period of institutional control;
- The **WAC will limit the type, concentration and quantity of radionuclides allowed in waste packages**, reflecting the limited retention capability of this facility type.



L'AUBE: CIRES FACILITY FOR VLLW DISPOSAL (FRANCE)

- In operation since **2003** (it was considered on that time the first of its kind in the world);
- trenches of 176 m long and 25 m wide, dug **several meters deep in a clay layer**;
- reference capacity of 600,000 m^3 (~ 30,000 m^3 yearly);
- once filled, the disposal trenches are covered by a **capping system** composed of natural materials and a geomembrane, ensuring water tightness;
- all operations from the construction/digging of the trench to the preliminary capping are conducted while protected from the outside, under a mobile shelter;
- the mobile shelters, developed and patented by Andra, and known as Prémorail, can be moved from one trench to the next one by means of rail-sliding system.

EL CABRIL - VLLW DISPOSAL ZONE (SPAIN)

- in operation since **2008**;
- **one platform designed** to accommodate **four disposal structures**, to be built as disposal requirements dictate (two structures have been constructed up to now);
- VLLW arrives at the facility in **large sacks, drums or casks** and it is directly deposited in the specific disposal structure - if treatment is required, it is sent to the corresponding area;
- when the disposal structures are full of capacity, they are **covered with various layers and topped with a final layer of topsoil** to enable integration into the environment;

VAULT-TYPE REPOSITORIES

- **All vault-types repositories follow essentially the same design:**
  - disposal units are usually located **above the water table**; in some countries, however, the local conditions require that the disposal vaults be constructed below the water table;
  - following emplacement of the waste, **the space between the packages is generally backfilled** with soil, clay or concrete grout;
  - a **low permeability capping system** is placed over the backfilled disposal units to minimise the ingress of surface water and to prevent intrusion by plants and animals;
  - the **covers integrity** is maintained during the **institutional control** period.

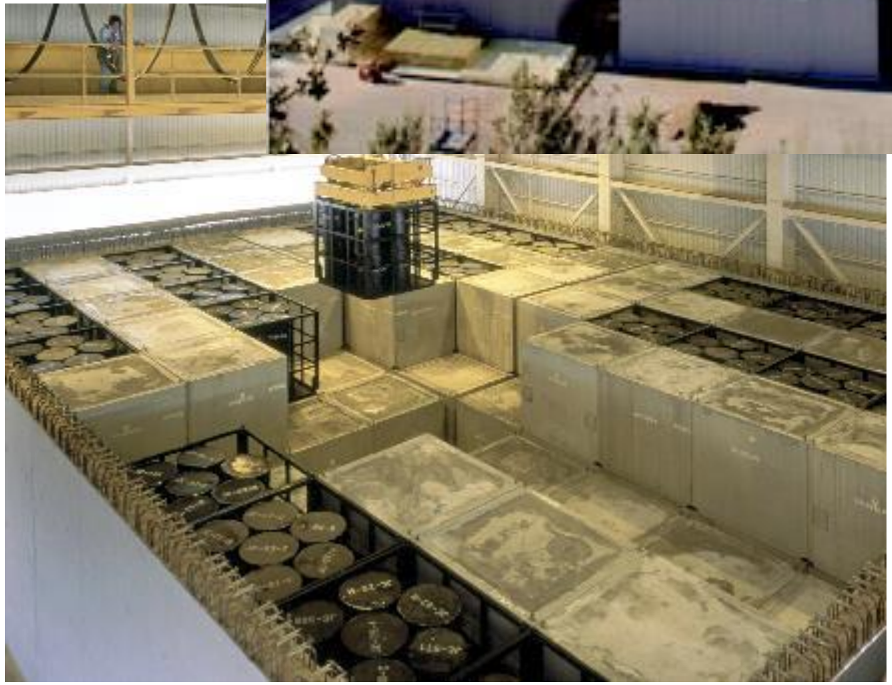
L'AUBE WASTE DISPOSAL FACILITY - CSA (FRANCE)

- in operation since **1992**
- the reinforced concrete disposal vaults are **constructed as needed**;
- the disposal vaults are divided by 8.5 m high internal concrete walls into a series of **four or five cells designed to isolate the waste from groundwater and to have mechanical integrity for 300 years**;
- once they are filled, the **vaults are closed with a concrete slab and then sealed with an impermeable coat**;
- at the end of operations, **a cap formed mainly of clay will be placed over the structures to ensure long-term waste containment**;

- **two types of disposal vaults are used in the CSA**:
  - so called "perishable" **metallic waste packages** are disposed of in vaults that are backfilled, layer -by-layer with special concrete;
  - **durable waste packages** in concrete are disposed of in stacks; when full, such vaults are backfilled by gravel.

EL CABRIL - LLW DISPOSAL AREA (SPAIN)

- In operation since **1992**
- LLW disposal areas consists of **two platforms**:
  - the north platform - with 16 disposal vaults
  - the south platform - with 12 disposal vaults



- The disposal concept is based on a multibarrier system aiming to **isolate the metal waste packages inside concrete containers** (cask) that are **emplaced in disposal vaults**. There are three types of barriers:
  - the conditioned waste and the cask
  - engineered structures (vaults) that house the RW
  - the natural hydrogeology of the site and the covering layers placed over the structures once they are full to capacity
- A **drain control system** exists in inspection galleries constructed beneath the disposal vaults

NATIONAL LOW-LEVEL WASTE REPOSITORY NEAR DRIGG (UK)

- in operation since **1959**;
- original practice was essentially landfilling, with change to vaults;
- where possible the **waste is treated, containerized and grouted** before placement in the vault;
- Waste Acceptance Criteria (WAC) includes **tight concentration limits for alpha-bearing waste**. This is due to past practices of accepting wastes containing high inventories of radium, thereby consuming a large percentage of the alpha-bearing waste inventory for the site.

MINED DISPOSAL FACILITIES

- **Sometimes mined disposal facilities were originally created for other purposes, for example to exploit metal ores or other resources, or to create safe storage areas for ammunition or other potentially hazardous materials**
- **RICHARD Repository (Czech Republic) - Former limestone mine subsequently enlarged to act as a munitions factory**
- **Baita Bihor Repository (Romania) a former uranium mine, used now for disposal of short-lived institutional waste**

CAVITY TYPE UNDERGROUND FACILITIES

The primary distinguishing feature of this option concepts is that **the distance below the ground** surface is usually **adequate to eliminate potential intrusion by plants, animals and humans during periods of time beyond 300 years**.

The disposal caverns may be **unlined or lined with concrete**, and may incorporate a number of **engineered barriers to limit or delay radionuclide migration** from the disposal facility based on site-specific geological conditions and the waste characteristics.

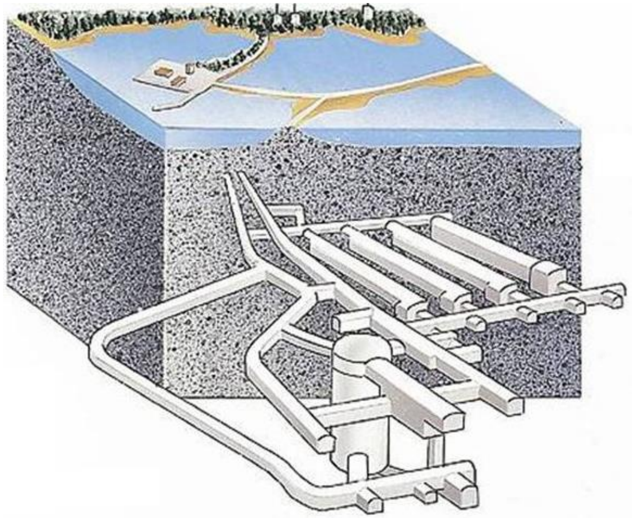
Such facilities **may accept a broader spectrum of radioactive wastes** including higher proportions of long-lived waste.

These facilities are generally **more secure against intrusion** but may require **more extensive barrier systems to prevent water ingress** if located below the water table.

In comparison with typical near surface disposal facilities, **less reliance may be placed on institutional controls.**

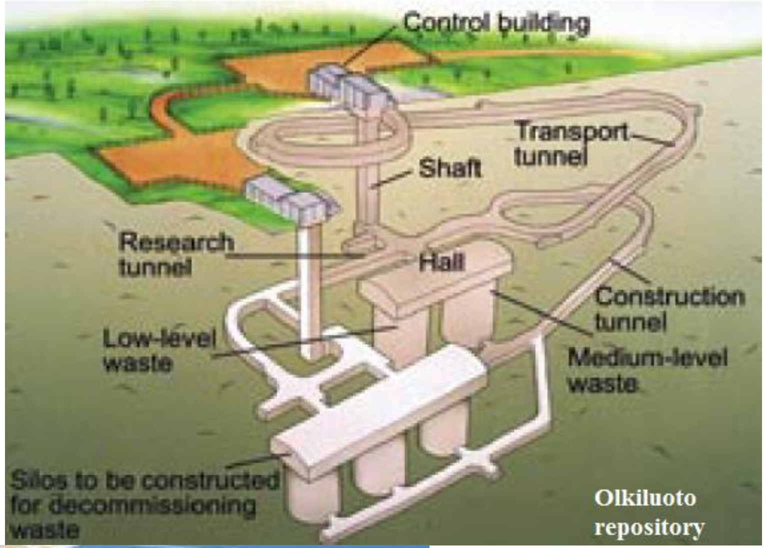
FORSMARK FINAL REPOSITORY - SFR (SWEDEN)

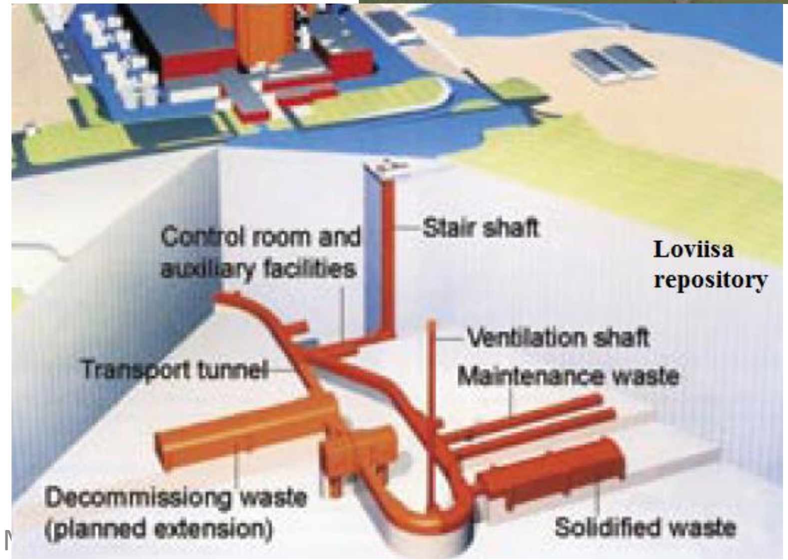
- in operation since **1988**; it was the first of its kind in the world;
- **all the LILW short-lived from the operation and maintenance of the NPPs** is disposed of in SFR, along with institutional RW;
- situated **60 m below the bottom of the Baltic Sea;**
- comprises **four 160 m long rock vaults** and **a chamber** in the bedrock with a 50 m high concrete silo for the most active waste;
- access by two parallel kilometre-long tunnels;
- it is designed to **isolate the waste from humans and the environment for at least 500 years;**
- total capacity: 15600 m^3 for LLW, 48300 m^3 for ILW.



OLKILUOTO AND LOVIISA REPOSITORIES (FINLAND)

- **Olkiluoto repository:**
  - **in operation since 1992**
  - **subsurface silo, located at 70-100 m depth;**
- **Loviisa repository:**
  - **in operation since 1992**
  - **subsurface cavern, placed at 120 m depth;**
- **Both the repositories are excavated in the bedrock**
- **The repositories will accommodate all the operating waste generated during the lifetime of the corresponding NPP**





BATAAPATI REPOSITORY FOR LILW (HUNGARY)

- In operation since October **2008**;
- The disposal chambers are located in pairs, contained in **3 underground caverns** with 90 – 110 m in diameter, **excavated 200 – 250 m deep** (0-50 m above sea level) within the granite bedrock;
- Bataapati is **one of the first (LILW) RW repositories in the world placed at this depth**;
- It is licensed to dispose around 40,000 m^3 of RW;
- The repository is **operated automatically**, with a **closed-line camera network** sending signals to the surface control room;
- The disposal caverns, **accessed via a pair of inclined tunnels**, will be **back-filled** with a combination of **clay and concrete with 50-60% crushed granite;**
- The facility is designed to make it possible to **retrieve all the waste packages until it is finally closed**.

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