

# ICRP Publication 159

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IMPLEMENTATION OF THE ICRP RECOMMENDATIONS  
FOR SURFACE AND NEAR SURFACE DISPOSAL  
OF SOLID RADIOACTIVE WASTE

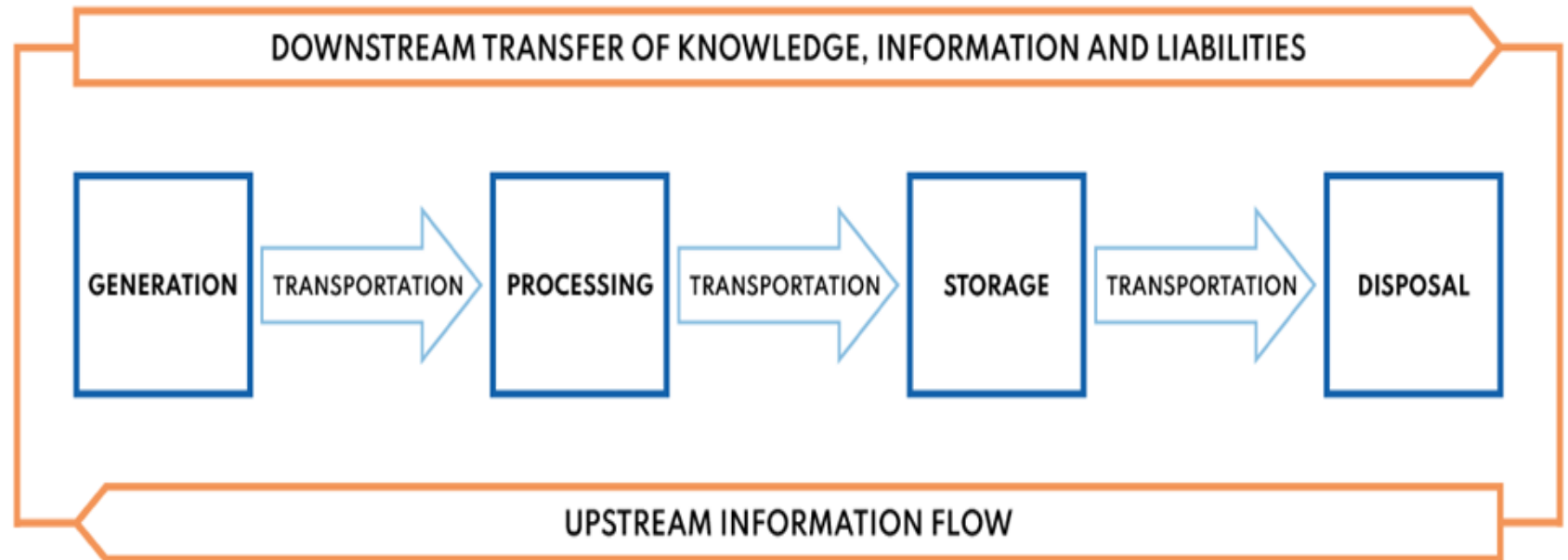
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# Background

- The final management solution for radioactive waste is emplacement of waste in an engineered facility without the intention of retrieval (i.e. disposal)
- Waste management refers to entire process from generation to disposal of solid waste



# Disposal System

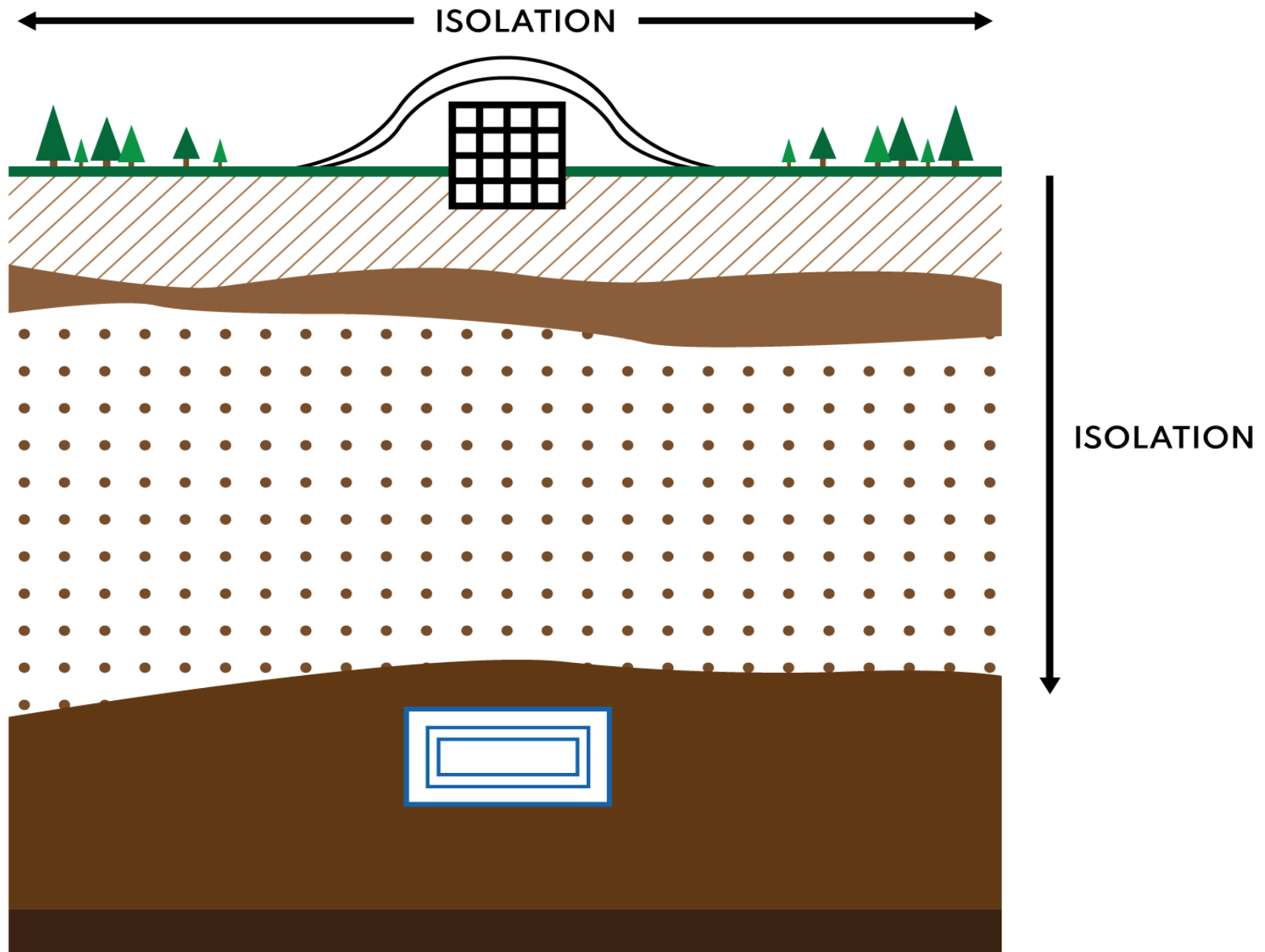
- **The goal of a disposal system is to provide protection of humans and the environment for a time period in accordance with the waste related hazards**
- **The strategy adopted internationally is to**
  - **Isolate** the waste by placing a safe distance between the waste and the man and environment
  - **Contain** the waste in engineered barriers for a predefined period as well as on engineered and natural barriers after this period, in order to limit the dispersion of radionuclides in the environment and to delay in time

# Disposal Options

- **The principal characteristics of waste that determine the selection of management and disposal options are volume, chemical and physical form and radionuclides content**
- **VLLW and LLW are characterised by large volumes and low radioactivity content more specifically:**
  - Short-lived radionuclides with less than 30-year half-life (Cs-137, Sr-90)
  - Long-lived radionuclides with more than 30-year half-life weak-beta or alpha emitters.

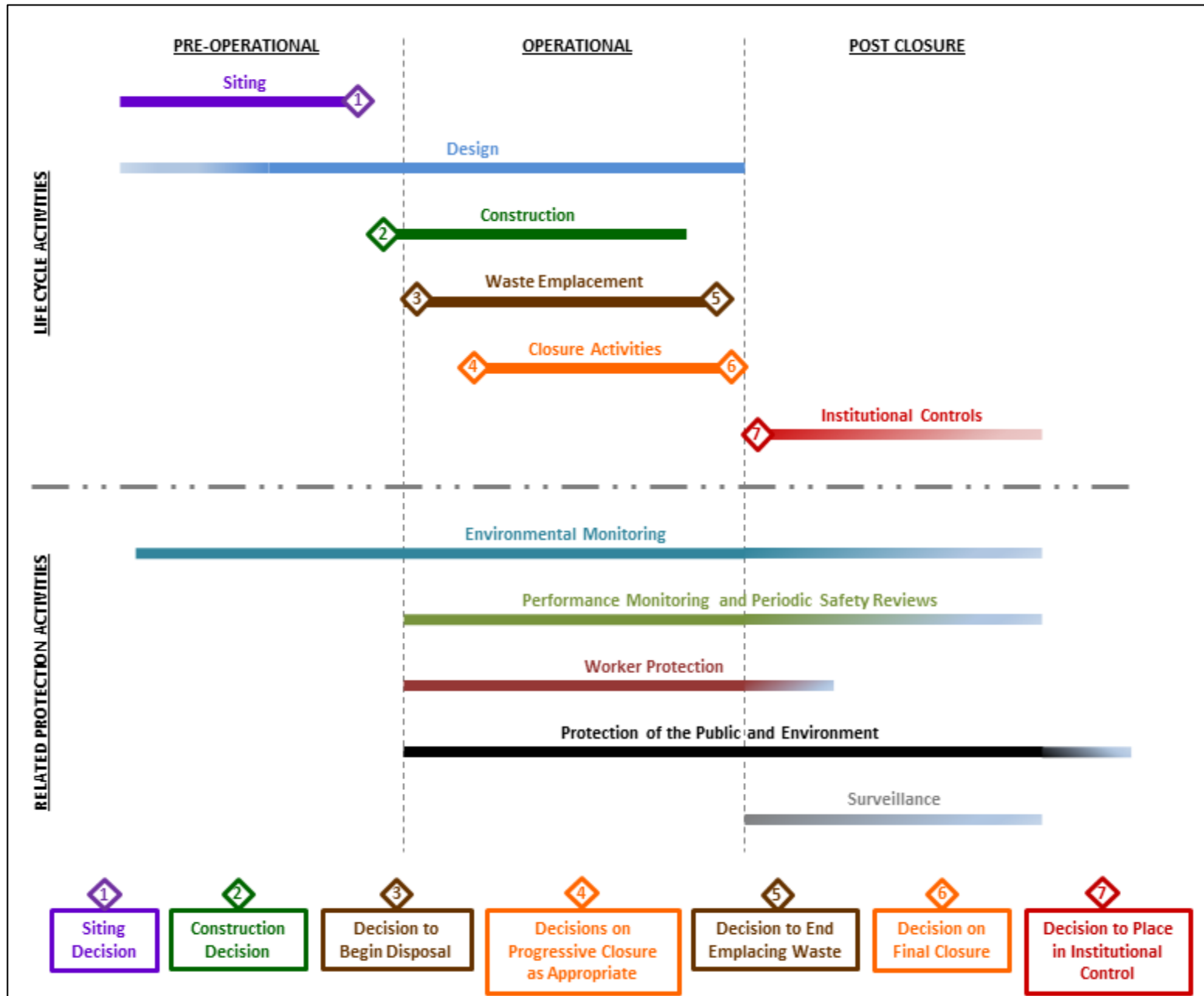
# (Near)Surface facility

- **The disposal system must provide isolation and containment**
  - Until the **short-lived radionuclides have decayed** to levels that can not give rise to significant exposure, this will be a period of **several hundred years**, as the degree of the hazard changes, particularly the hazard from inadvertent human intrusion in the decades and centuries following closure. During this period, containment and isolation by a **combination of physical barriers and institutional control** (access control, land use restrictions)
  - By **limiting the the activity content of long-lived radionuclides** in the disposed waste to reduce the long-term residual risk.
  - By **avoiding site location with mineral and water resources** to limit the likelihood of deterioration of the barriers by deliberate human intrusion



# Phases of (Near) Surface Facility

- **Three main phases: pre-operational, operational, post-closure**
  - Activities can **overlap** (i.e., siting and design) or can **occur at the same time** (i.e., construction of disposal units, emplacement in built units, closure of full units)
  - After closure activities are limited to those included in the planned **institutional oversight and controls** : period of regulatory control, monitoring of the cover, preservation of records, monitoring by society



# Implementation of the System of Radioprotection to the phases of a (Near)Surface Disposal Facility

- Oversight
- Protection during different phases
- Protection of particular circumstances

# Oversight

Ensures that an appropriate control system is in place as long as it is required

- **Direct oversight:** active measures carried out by the operator before operation, during construction, waste emplacement, closure and in the immediate post closure phase
  - Example: inspections, monitoring, keeping of records
- **Indirect oversight:** measures in place after the site has been released from regulatory control (depending on the residual activity)
  - Example: restriction of land-use, records keeping, societal memory of the site
- **No oversight:** prudent to assume the memory of the site will be lost; disposal facility needs to be designed not to rely on oversight in the distant future by providing **passive safety** features

Life-cycle stage	Activity/Scenario	Protective approach	Optimisation criteria
<b>Pre-operational; Operational; Transition to long-term institutional control</b>	Site preparation; Design; Construction; Waste emplacement; Closure; Decommissioning of auxiliary facilities; final site configuration	Planned exposure situation, implementing: <ul style="list-style-type: none"> <li>• Dose limits</li> <li>• Constraints (dose and risk)</li> <li>• Derived Consideration Reference Levels (DCRL)</li> <li>• BAT</li> </ul>	Optimisation as for the design and operation of any facility
	Expected evolution of facility and environment including reasonably foreseeable disruptive events		Optimisation guided by constraints of 0.3 mSv year <sup>-1</sup> (dose); 10 <sup>-5</sup> year <sup>-1</sup> (risk); and lower end of relevant DCRL
<b>Post-closure; Institutional control and beyond</b>	Severe disruptive events	Planning against framework for management of existing exposure situations: <ul style="list-style-type: none"> <li>• Reference levels</li> <li>• DCRL</li> <li>• BAT</li> </ul>	Optimisation guided by reference levels ≤ 20 mSv and DCRLs
	Inadvertent human intrusion		
	Extreme events	Evaluation against possible consequences	Beyond design basis, not considered in optimisation

# Protection during different Phases

- **Pre-operational phase:** facility design is based on sound and proven engineering practices complemented by optimization, assessment of robustness, consideration for defense in depth and stakeholder feedback
  - **Performance of facility in operational and post-closure phases are determined**
  - Dose calculations are undertaken for a range of evolution scenarios and for inadvertent human intrusion
  - Cautious but realistic assumptions should be made for the different uncertainties to avoid underestimation of exposure, but overly conservative assumptions should be minimized to avoid completely unrealistic outcomes
  - **Numerical compliance with dose criteria alone should not compel acceptance or rejection of a (near) surface disposal facility**

- **Protection during the operational phase:** most of the decision regarding long-term safety have been taken during the pre-operational phase and limited opportunity is left for corrective action
  - Dose limits and constraints for planned exposure situation are applied
  - Environmental conditions are monitored and compared with baseline data
  - After final closure, monitoring and access control provisions are put in place
- **Protection during the post closure phase:** monitoring continue to confirm the ongoing performance (containment and isolation) and necessary maintenance is carried on
  - Period of time activities are continued depends on the activity of disposed waste and the degree of confidence in the long-term performance of the facility
  - Need to meet the **reference level for inadvertent intrusion** if it were to happen; the Commission recommends to select a reference level **from 1 to 20 mSv**
  - For situations with **off-site impacts** the **lower end of the range of 1 to 20 mSv** is recommended

# Protection in particular circumstances

- **Natural disruptive events** (e.g., earthquake, severe flood)
  - **Events for which it is possible to estimate or bound the probability and time frames of occurrence are normally included in the design-basis scenarios.**

The Commission recommends application of the dose ( $0.3 \text{ mSv year}^{-1}$ ) or risk ( $10^{-5} \text{ year}^{-1}$ ) constraint for these **planned exposure situations** and the lower end of the relevant DCRLs Derived Consideration reference Level (ICRP 124) for environmental biota.

Consideration of BAT in the different life-cycle stages supplements optimization, in particular for the longer-term analysis where estimates of exposure become increasingly uncertain.

- **Lower probability events categorised as severely disruptive are also included in the design basis** and should be considered within the framework of existing exposure situations when siting, designing and constructing the disposal facility.

**Optimisation** for these types of events should be guided by **reference levels of  $\leq 20$  mSv** and the appropriate DCRLs for environmental biota, with the analysis supplemented by consideration of BAT.

- **Very-low probability events ( $10^{-6}$  year<sup>-1</sup> or lower)**, e.g. major landform change due to landslide, **can be excluded from design-basis** through an agreed, prudent and transparent methodology.

Should a disruptive event occur and cause degradation of a disposal facility such that dose constraints (or the environmental DCRLs) are exceeded, long-lasting exposure resulting from such natural disruptive events should be managed as an '**existing exposure situation**', using a reference level within the **lower range of the band of 1 to 20 mSv year<sup>-1</sup>**.

- **Inadvertant human intrusion**

- Because human intrusion could occur due to the location of the (near) surface facility in the accessible biosphere it should be included **in the design basis provisions being taken to reduce the possibility and the radiological impact** :
  - limiting the radionuclide content, waste distribution in the disposal facility,
  - reducing the possibility of such events : selecting sites with little assumed valuable resources based on current societal values, incorporating robust design features that make intrusion more difficult, direct (surveillance under regulatory control) and indirect (restrictions on land use, environmental monitoring programmes, archived records and site markersoversight)

The Commission considers **it is prudent to assume intrusion will occur** corresponding to an **existing exposure** situation. Reference levels should be applied in the **1 mSv to 20 mSv year<sup>-1</sup>** band with the objective to reduce progressively to the lower end of the band. In addition, doses to environmental biota should be compared to the appropriate DCRLs

- Reasonable **stylised scenarios** may be used noting that extreme practices should not be adopted. The optimum design of a disposal system may result in a distribution of dose where some are above of the reference levels.

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