ONDRAF/NIRAS

ICRP – TG 97

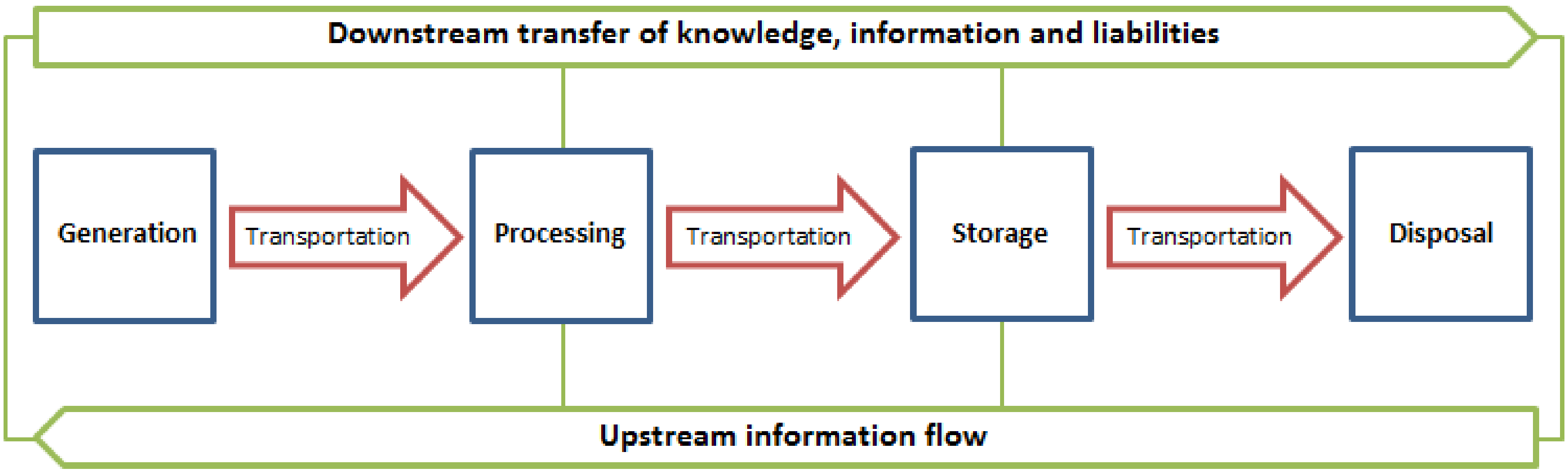
Overview of strategies for surface disposal and lifetime of disposal facilities

Jean-Paul Minon – ICRP

Presentation prepared with the support of Ch. Depaus & P. De Preter (ONDRAF/NIRAS)

6/11/2017

National Policy and Strategy for Waste Management



Separation
Characterisation
Packaging

Note: during operation
and decommissioning

Separation
Characterisation
Treatment
Conditioning

Note: all kinds of
radioactive materials

Safety & Security
Long-term behaviour
Aging Management

Siting
Construction
Operation
Closure
Post-closure

ONDRAF/NIRAS

Key aspects for policy and strategy

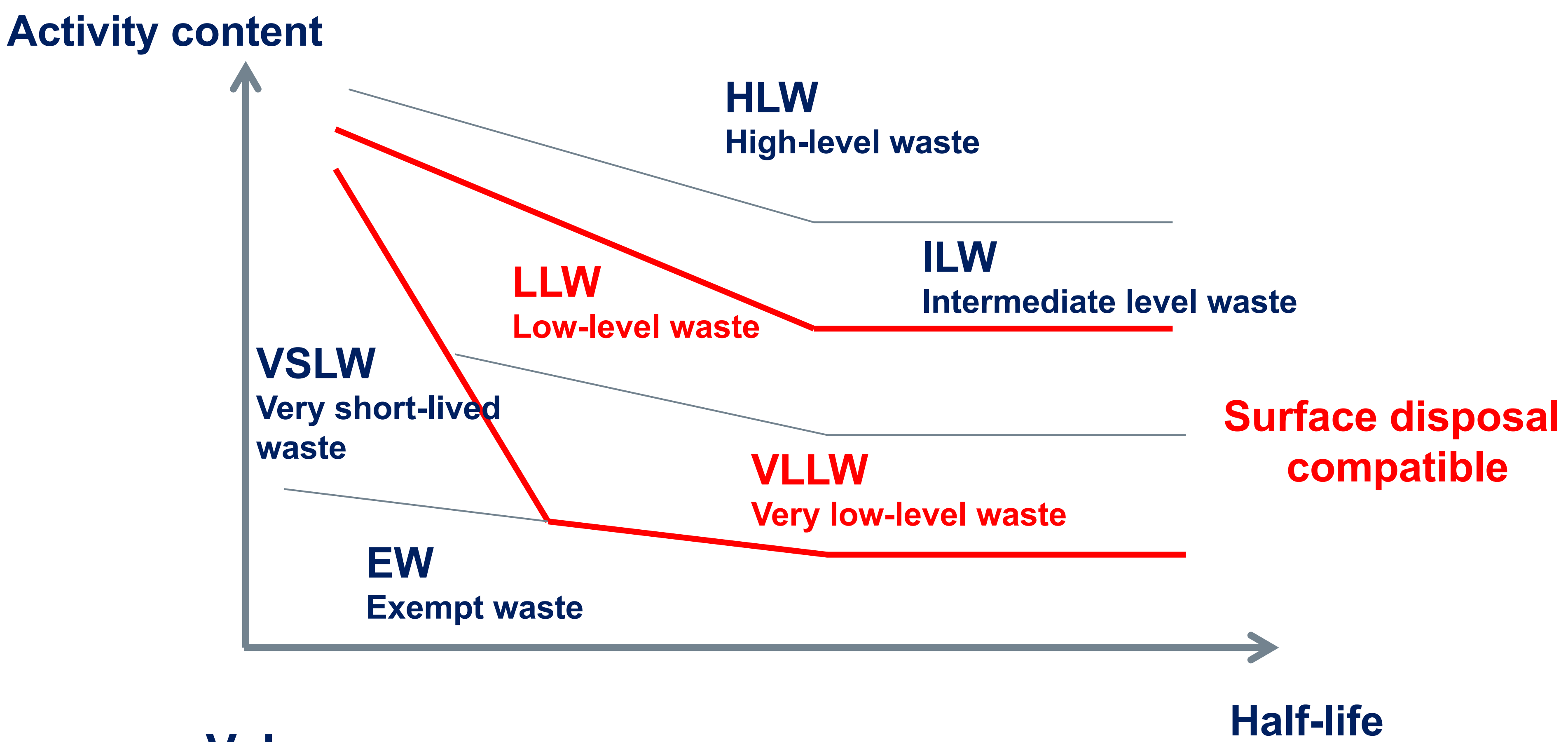
- **Processing and storage**
  - Centralised and/or decentralised
  - Storage capacities and duration - as a function of waste arising and waste disposal implementation
- **Disposal**
  - Centralised and/or decentralised
  - Disposal types
- **Transportation**
  - Depending on location of waste generation and management sites

→ **System to be optimised as a whole – besides facility optimisation**

→ **Challenging (methodological and decisional)**

ONDRAF/NIRAS

Radioactive waste – IAEA classification



- Volumes
- Activity content and concentrations
- Half-life

ONDRAF/NIRAS

Origin of waste

- **Nuclear power plants & nuclear fuel cycle**
- **Medecine, Research, Industry**
- **Specific cases**
  - Dismantling waste → large volumes requiring an operational management chain till disposal
  - Mining waste → very large volumes, VLLW - long-lived
  - Waste from emergency situations → potentially very large volumes and “unpredictability factor”

Waste treatment

- **Aim: inert and stable product for all subsequent management steps incl. disposal**

- **Compatibility with and suitability for next steps : waste acceptance criteria**

→ **Interpendencies between all steps of waste management**

ONDRAF/NIRAS

Disposal systems (1/3)

Disposal system = waste + facility + local environment (host rock / site)

Centre de l'Aube (France)

Rokkasho Mura (Japan)

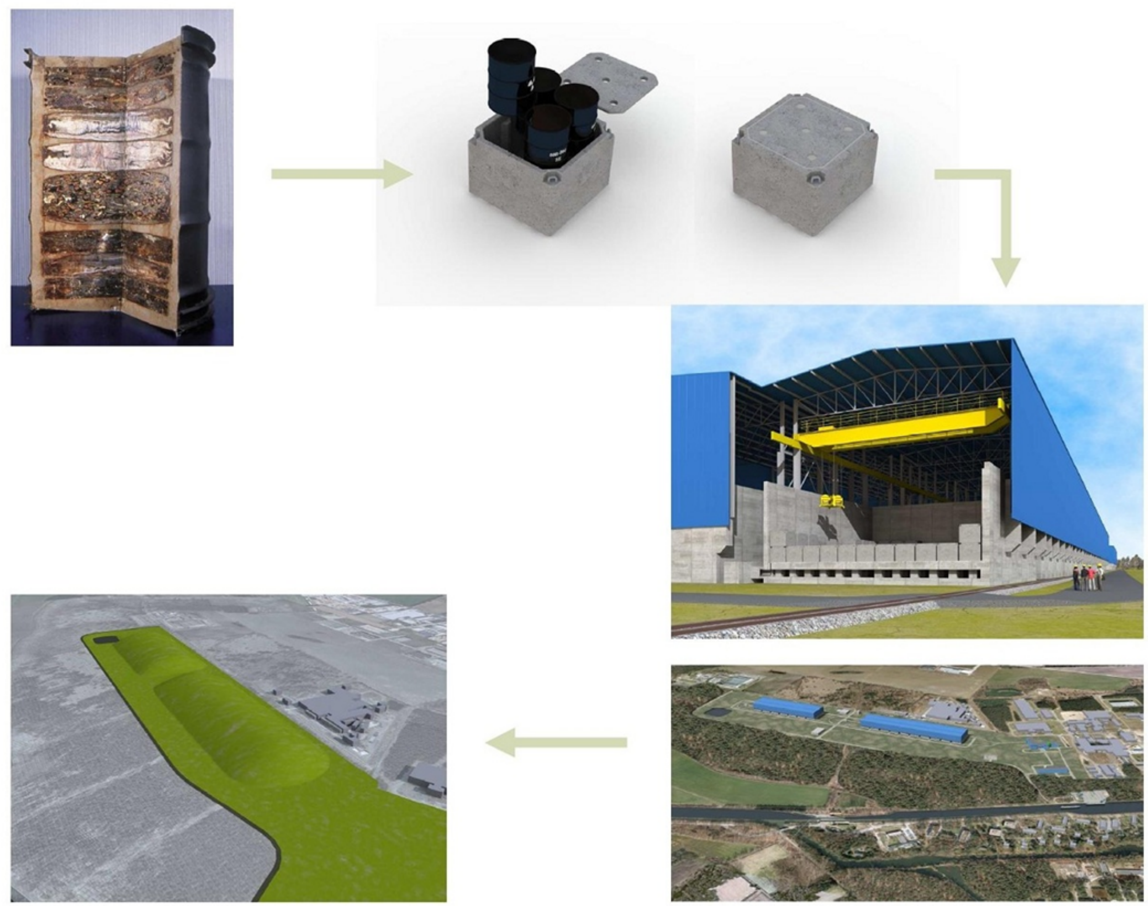
ONDRAF/NIRAS

Disposal systems (2/3)

Surface disposal

- Disposal facility in the biosphere
- Only for LLW and VLLW

→ **Limitation of total and long-lived activity**
→ **Institutional control needed**



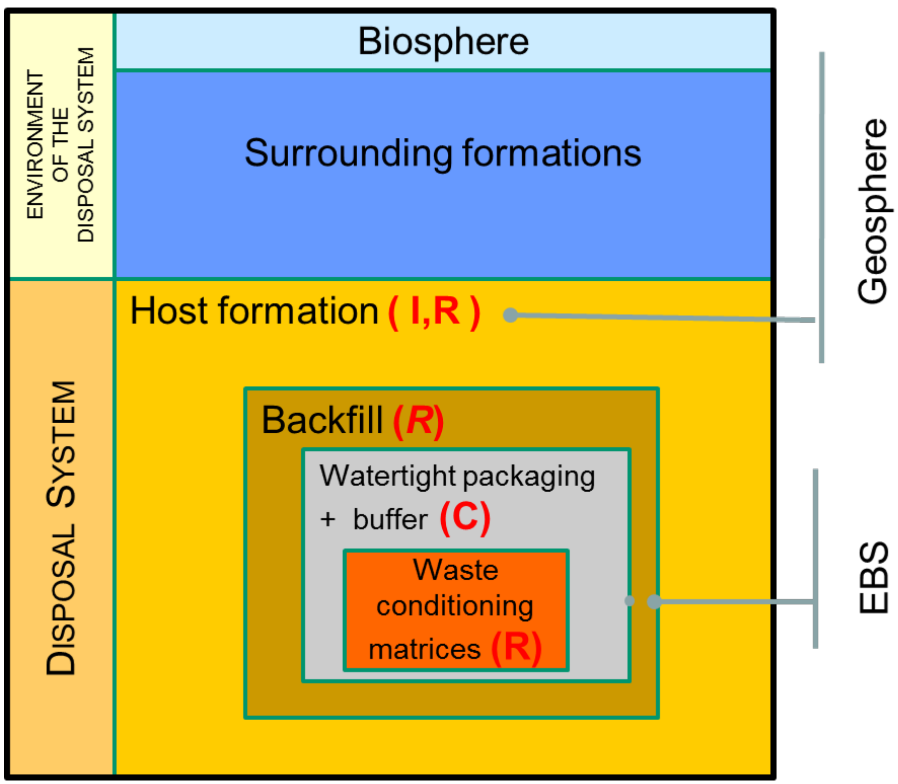
ONDRAF/NIRAS

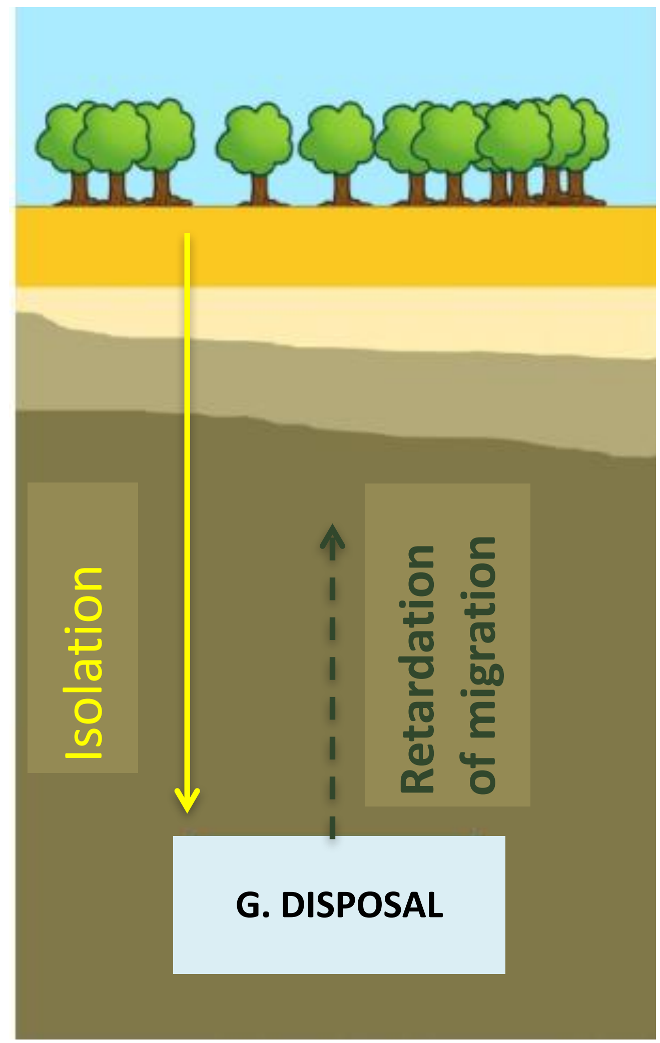
Disposal systems (3/3)

Geological disposal

- **Disposal facility out of the biosphere**
- **Valid for all waste types**

→ **In principle no limitation activity**
→ **Institutional control can contribute to safety**





Safety functions as applied to surface disposal systems

Time line phases	Siting Design Construction	Operation Closure	Control Direct with operator	Control Indirect without operator	Stand alone
	Decades	Decades	Centuries		Indefinitely
Containment	OPTIMISATION	IN BUILT + improvements & repair Optimisation	IN BUILT + limited repair	IN BUILT	IN BUILT
Retardation	OPTIMISATION	IN BUILT + improvements & repair Optimisation	IN BUILT + limited repair	IN BUILT	IN BUILT
Isolation	OPTIMISATION	ACTIVE : surveillance PASSIVE : structures & Inventory restrictions Optimisation		ACTIVE : indirect surveillance PASSIVE : structures & Inventory restrictions	PASSIVE : structures and markers & Inventory restrictions

ICRP fundamental principles

- **ICRP system (ICRP-103, 2007) evolves :**

  from 'practices and interventions approach'
  to an 'exposure situations approach'

  … and applies to disposal *(see further)*

- **Fundamental principles of radiological protection remain:**

  1. justification,
  2. **optimisation of protection** and,
  3. the application of dose limits

  Principle of optimisation is reinforced by similar application to all exposure situations (but dose constraints ≠ reference values)

  ....but is bounded by uncertainties of several types:

  1. Dose-effect (linear-non-threshold) relationship;
  2. Relevance of dose and risk for exposures in the long term ;
  3. Behaviour of disposal over time.

Intrinsic Uncertainties : health detriment and system impact

Categories of uncertainties for post-operational radiological dose and risk assessment of disposal

Health detriment uncertainties

- Relationship dose – effect
- Future ability to mitigate and cure
- General future health status

Disposal system impact uncertainties

1. **System performance uncertainties**
- Assessment of long term containment and isolation
- Cautious bounding assessment approach
- Uncertainties related to the knowledge and assessment of system characteristics, processes, evolution, including probabilistic uncertainities

2. **Exposure pathway uncertainties**
- Future biosphere uncertainties
- Future Reference Person uncertainties

→ Limitations on using dose calculations and dose criteria to decide on long term system safety

→ Need for complementary elements for deciding on an optimal disposal system

Supplementary elements to provide long term safety for an optimum disposal

Instead of assessments on hypothetical populations in the very far future, rather an **assessment of various designs and material choice options** to face a wide range of events and processes:

- Designs should be developed and implemented on effective (well-proven) construction processes;
- Effective management systems are needed for design options and construction
- Therefore, the optimisation process as a whole is undertaken within an effective management system, ensuring performance, durability and robustness of the barriers

→ **Long term impact assessment is an indicator** in testing facility design options against safety criteria applying

ICRP system applied to the near surface disposal facility

The system of protection is organised according to 3 types of exposure situations:

1. **Planned exposure situations: deliberate introduction and operation of sources of exposure**
   a. Normal exposure situations: exposures anticipated to occur
   b. Potential exposure situations: exposures that could occur but not anticipated
2. **Emergency exposure situations: loss of control of a planned source** (e.g. accident)**, unexpected event** (e.g. malevolence)
3. **Existing exposure situations: control to be decided on existing sources** (e.g. past activities, natural radiation)

➔ A near surface disposal facility is a planned exposure situation

Radiological exposure situations for public as function of surface disposal facility evolution

Disposal status	Exposure situations	Doses // risks (mSv/year)//(year-1)	Optimisation	Scenarios/ POIEs (postulated initiating events)
Non-design basis	Emergency (Or/followed by) Existing	100mSv **reference value**	Non applicable *(Beyond the scope of assessment)* Mitigation	Extreme and unlikely events (what-if cases) with off site impact
Design-basis	Emergency (Or/followed by) Existing	20mSv **reference value**	Applicable	Human intrusion/ Extreme disturbing events (stylised and penalising scenarios)
Planned exposures	Potential	1 mSv / 10^{-5} **Dose limit / risk constraint for potential exposures**		Disturbing events possible but not expected
	Potential	0,3 mSv /10^{-1} - 10^{-3}		Events occuring from time to time (during operation)
	Normal	**Dose constraint for disposal/ risk constraint for potential exposures**		Expected circumstances (during operation)

The Optimisation principle (1/2)

- **Defined by ICRP -101 (2006) & ICRP -103 (2007), it has been applied to geological disposal by ICRP -122 (2013) →**

  to keep the likelihood of incurring exposures, the number of people exposed and the magnitude of individual doses as low as reasonably achievable, taking economic and societal factors into account.

- **Broadened at all levels (ICRP, 2017):**

  1. **National Policy**: number + type + location of disposal facilities considering radiological & non radiological aspects including transport safety

  2. **Facility level**:

     — Processes to be defined/implemented in order to decide protection measures to be taken;

     — Aim to enhance isolation and containment capabilities in order to avoid any significant impact on humans and the environment;

     — By siting, design, construction and operation considerations;

     — Through iterative, systematic and transparent assessment of options

The Optimisation principle (2/2)

- **Bounded :**
  - By uncertainties related to post closure radiological impacts (cautious assumptions & margins in the assessment);
  - By socio-economic and policy factors
  - By available siting options including environmental conditions

    → should keep a realistic focus w.r.t. **site** AND **inventory**

- **Covers all elements of the disposal facility in an integrative approach**
  - Site characteristics, facility design, waste package design, waste characteristics, oversight measures and all relevant time periods

- **Supports the design process but becomes less important as decision factor in the distant future while the importance of sound design and system performance dominate decision process over time (= forward-looking process)**

Concluding remarks

- Following the step by step decision process, the choice of a site is prior to decisons on the detailed design.

  If several suitable sites are identified , the decision of one specific site will result from a multifactor judgment based on both qualitative and quantitative aspects, directly (e.g. geology) and indirectly (e.g. transport) linked to the site;

- The greatest opportunity to optimise system safety (site + inventory+ facility) is in the site & design phases;

- The long-term safety is supported by robust design implemented throughout sound and effective management systems;

- At siting stage, the radiological assessment will be only one of the factors but will be unlikely to dominate the decision due to its preliminary nature and associated uncertainties at this stage.

Thank you for your attention !!!

Questions ?