Joint KINS-IAEA-ANNuR/ANSN/FNRBA
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Radioactive Waste Management

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Korea Institute of Nuclear Safety

Contents

I. Introduction

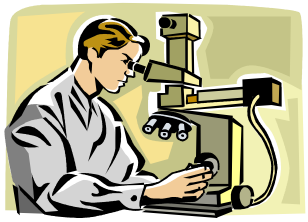
II. Safety Standard for RWM

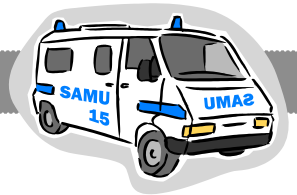
III. Predisposal Management of RW

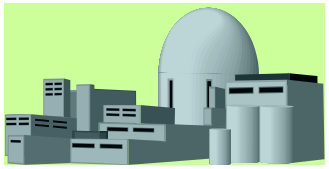
IV. Disposal of RW

V. Korean Approach for RWM

What is Radioactive Waste?







University

Hospitals

Industries

Nuclear Institution

NPP

- Paper
- Shoes
- Gloves
- Clothes
- Syringe
- Bulk trash
- Mech. parts
- Filter
- Ion Exch.
- Concentrate
- Hard wares
- Spent Fuel

Low & Intermediate Radioactive

Highly Radioactive

LILW

HLW

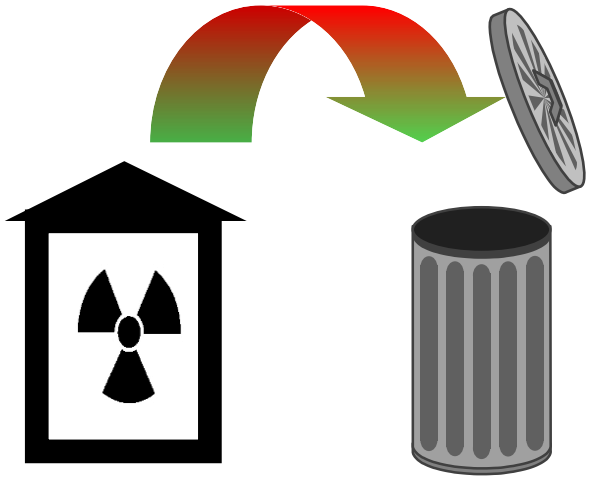
Definition of radioactive waste

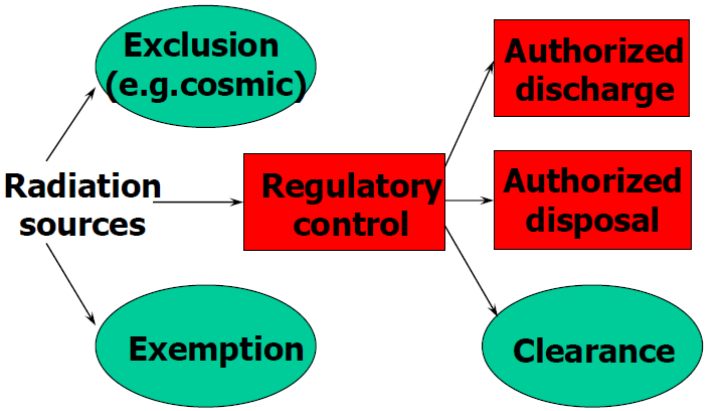
- **IAEA Safety Glossary (2007 edition)**
  - For legal and regulatory purposes,

    Waste that contains, or is contaminated with, radionuclides (RNs) at concentrations or activities greater than clearance levels as established by the regulatory body
  - radioactive material in gaseous, liquid or solid form for which no further use is foreseen and which is controlled as radioactive waste by a regulatory body under the legislative and regulatory framework

Clearance

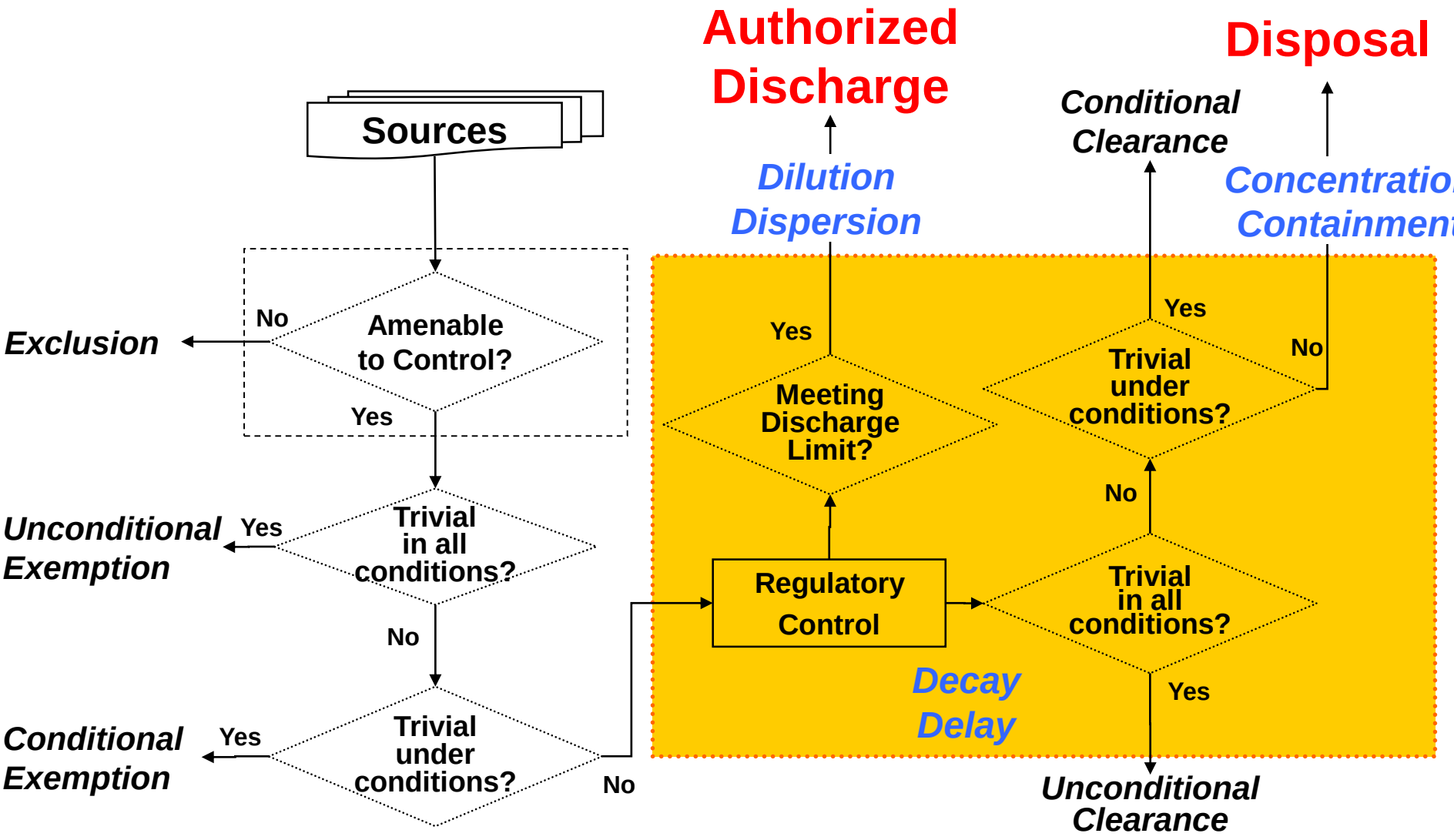
- **IAEA**





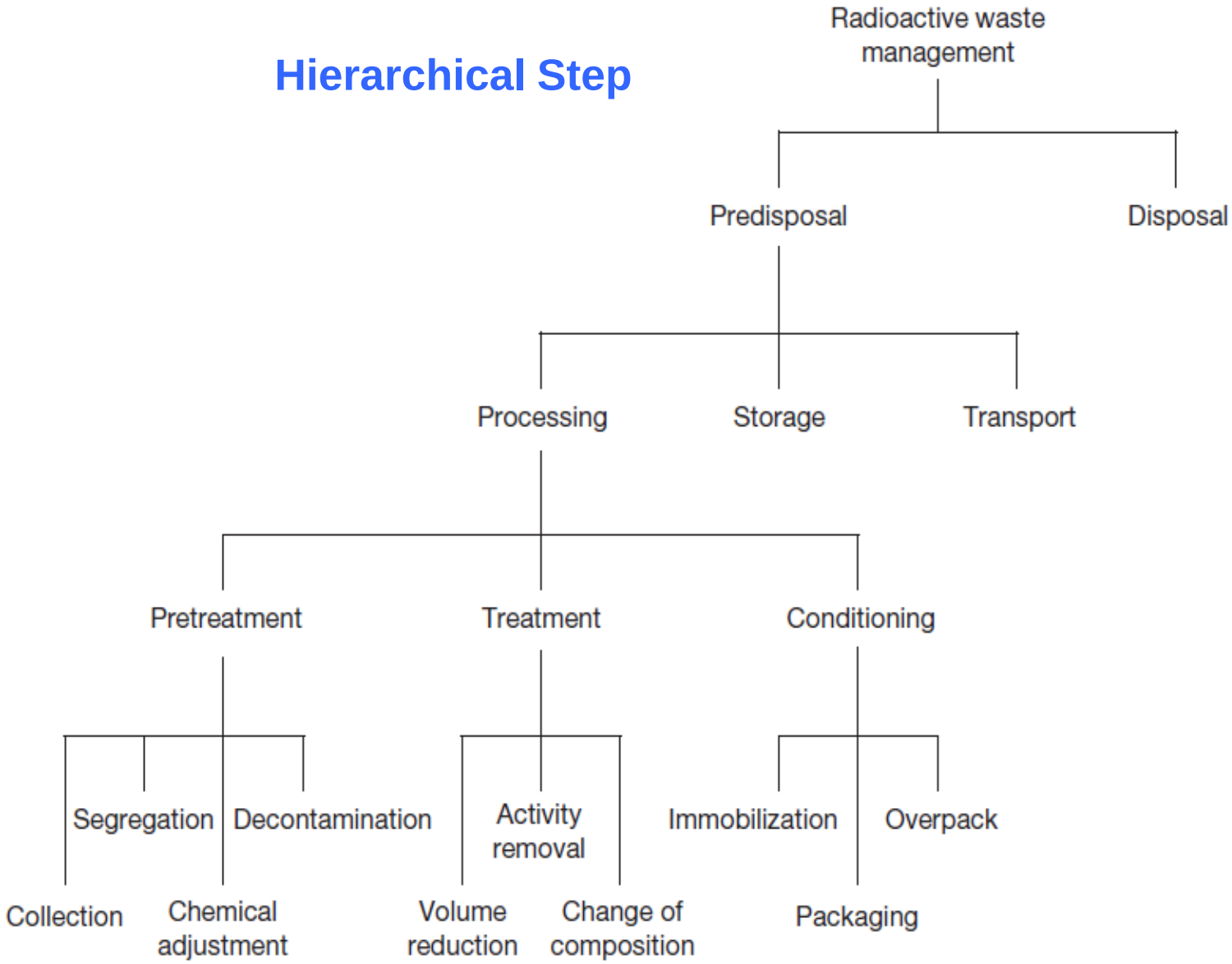
- Clearance : Removal of radioactive material or radioactive objects within authorized practices from any further regulatory control by the regulatory body.
  - According to radionuclide specific clearance levels derived and approved by the regulatory body
  - To minimize the volume of untreated waste to be stored.

Lifecycle of regulatory control on RW



Activities in RWM

Hierarchical Step



Definition of basic terms

Predisposal, disposal, and storage

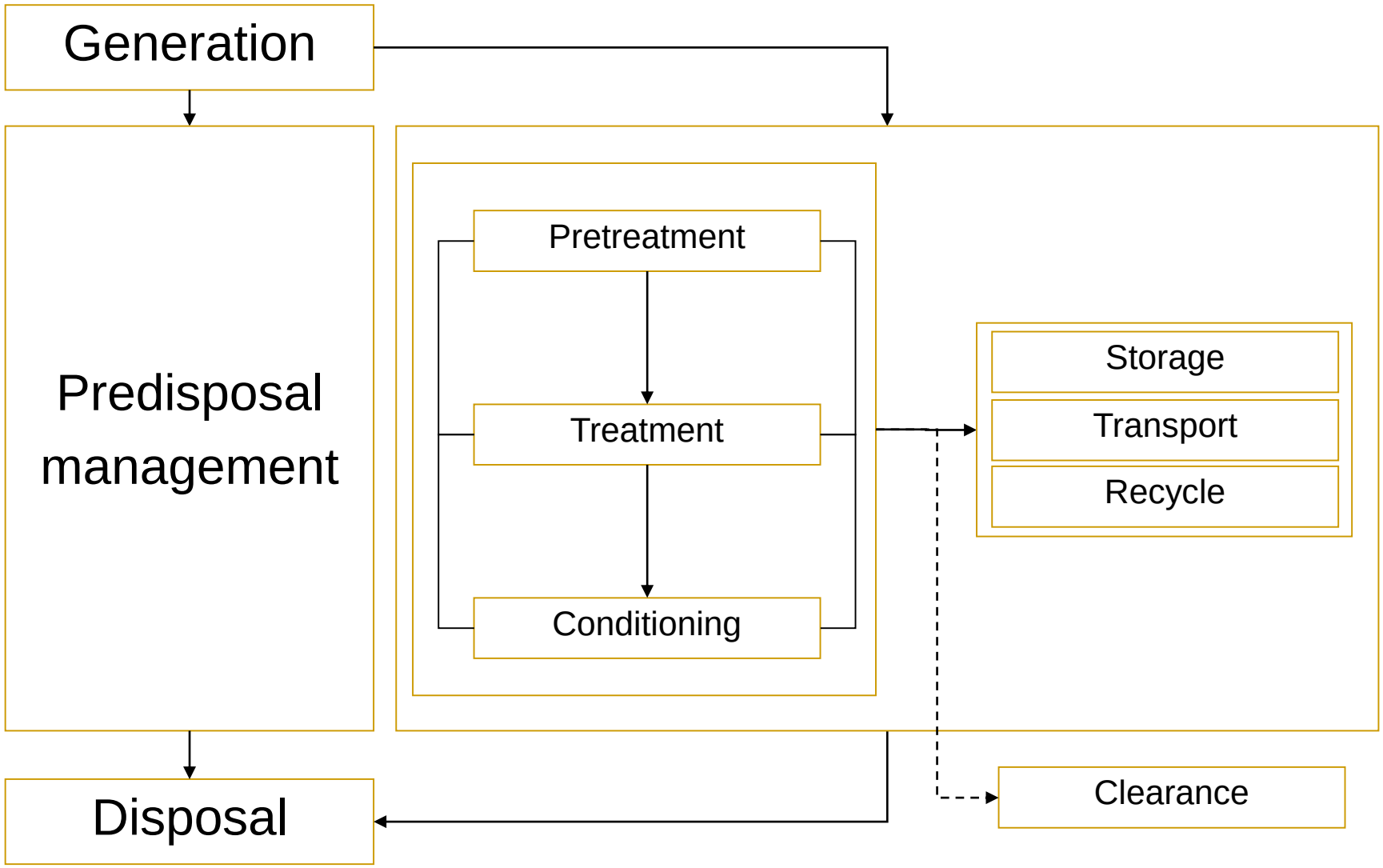
- **Predisposal**
  - Any waste management steps carried out prior to disposal, such as pretreatment, treatment, conditioning, storage and transport activities
- **Disposal**
  - Emplacement of waste in an appropriate facility without the intention of retrieval
- **Storage**
  - Holding of radioactive sources, spent fuel or radioactive waste in a facility that provides for their/its containment, with the intention of retrieval

Basic approach to RWM

- Concentration and Containment
  - Ion exchange, filtration, evaporation, packaging, disposal, etc.
- Delay and Decay
  - Decay of short-lived radionuclides
  - Charcoal delay bed, gas decay tank, etc.
- Dilution and Dispersion
  - Authorized discharge of liquid/gaseous waste

Recycling ??

Interdependence of each step of RWM



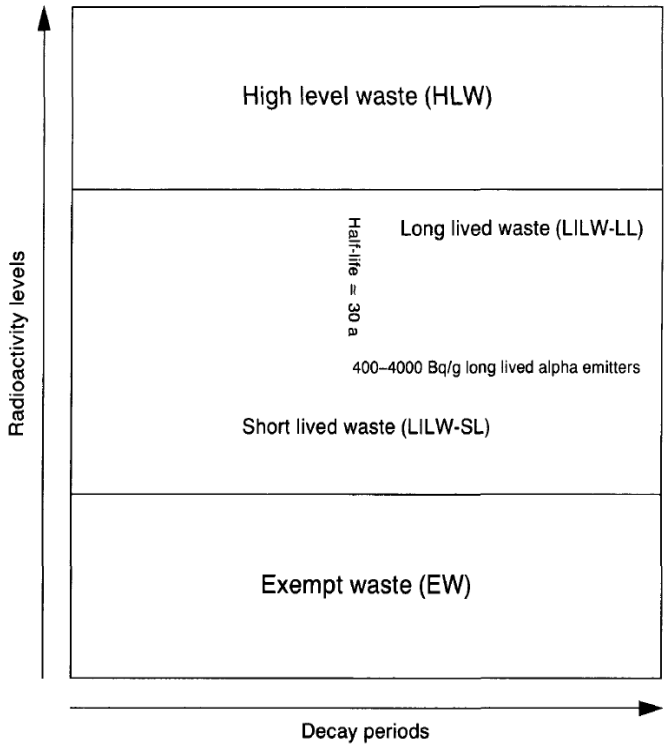
Classification of RW

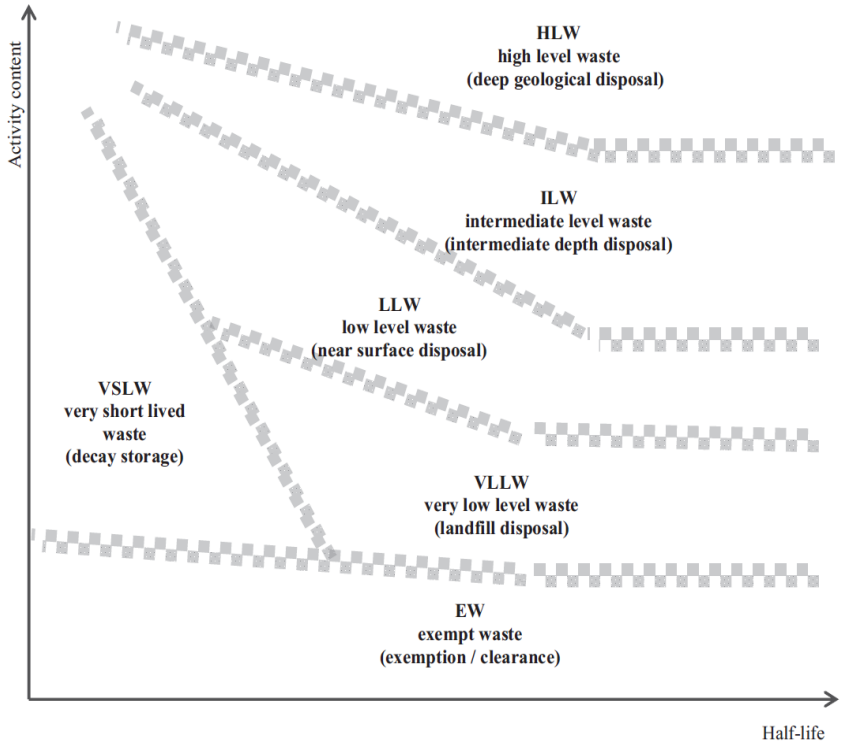
- **Physical/Chemical form**
  - Liquid or waterborne
  - Gaseous or airborne
  - Solid
- **Radioactivity/Radiation level**
  - Exempt level, Low level, intermediate level, high level, etc.
- **Lifetime of radionuclide**
  - Short-lives, long-lived, etc.
- **Heat-generating capacity**
  - Heat-generating, Non heat-generating, etc.

Spent fuel: waste or not?

Standard classification system

Past and Present

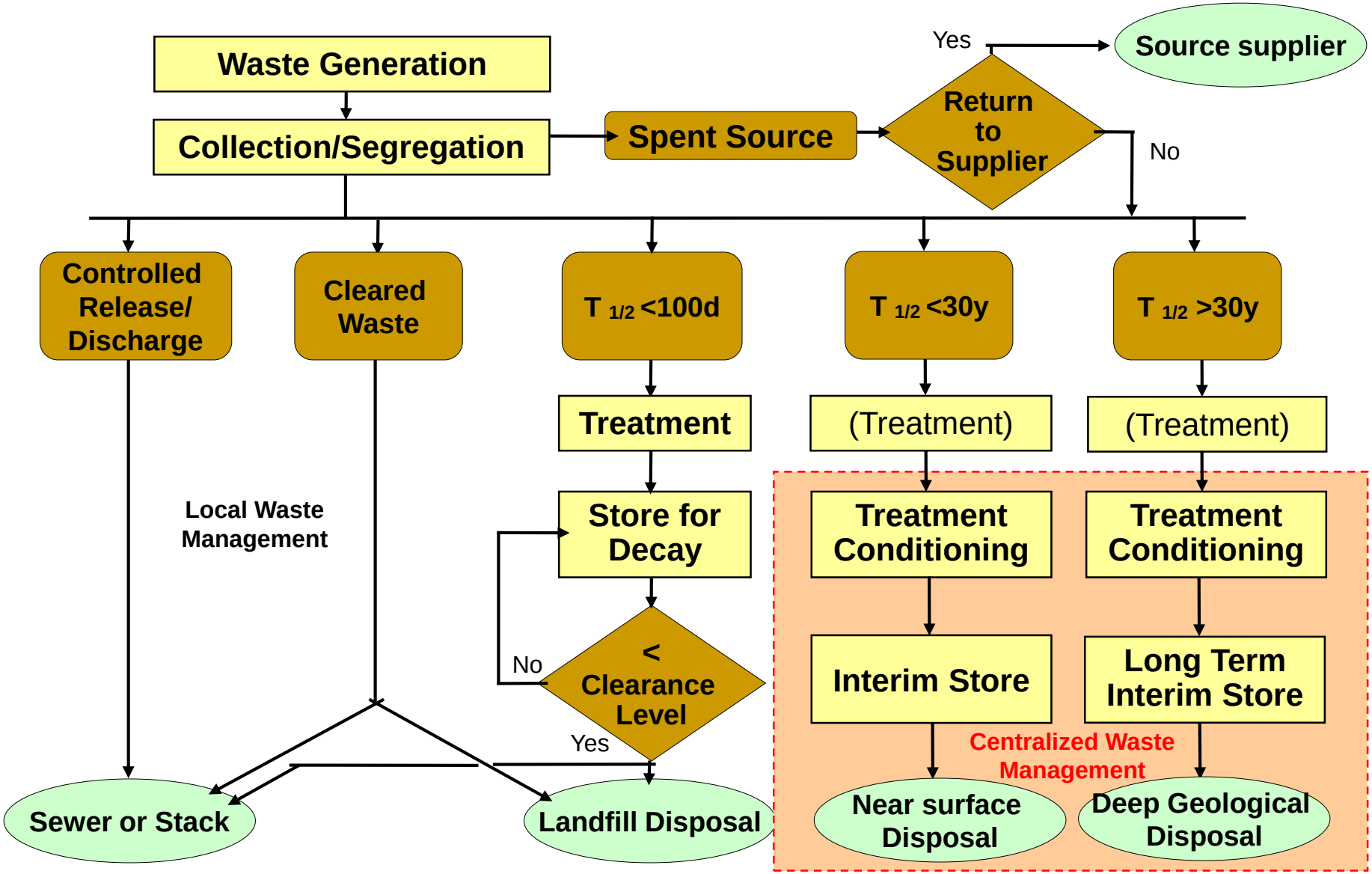




IAEA Safety Series 111-G-1.1 (1994)

IAEA Safety Standards No. GSG-1 (2009)

Typical Strategy of Waste Management



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III. Predisposal Management of RW

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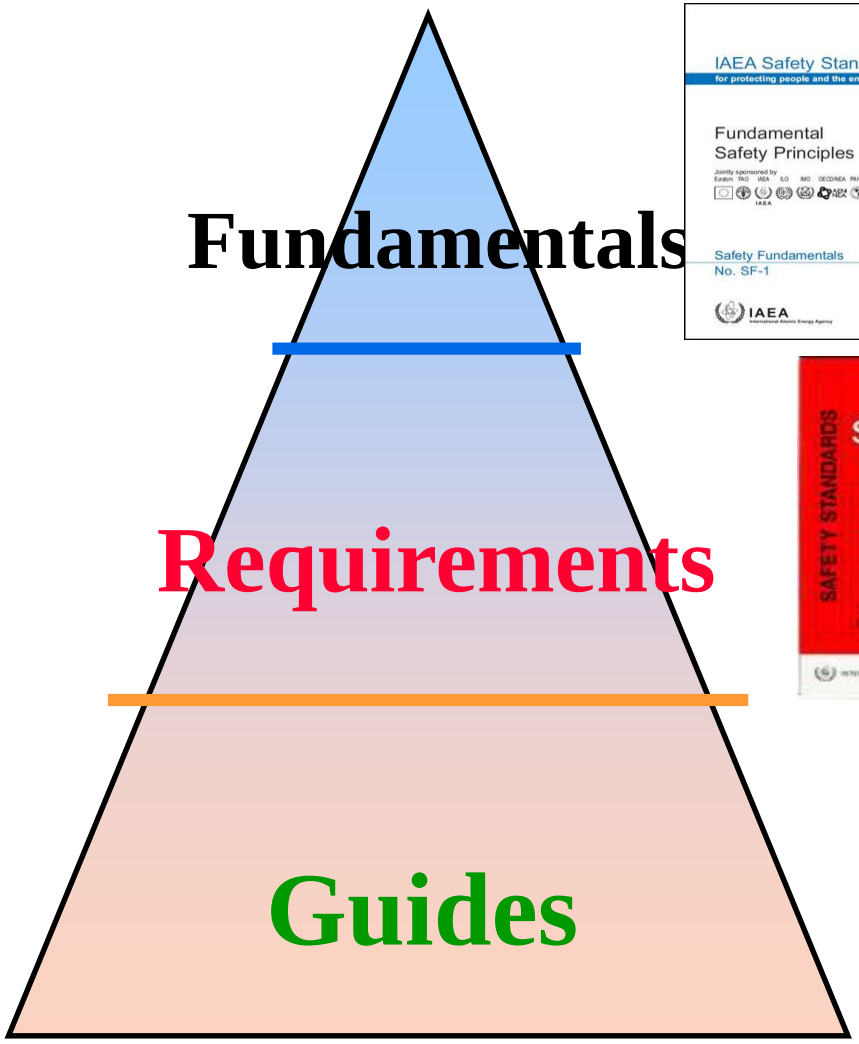
V. Korean Approach for RWM

IAEA Safety Standards

Hierarchy

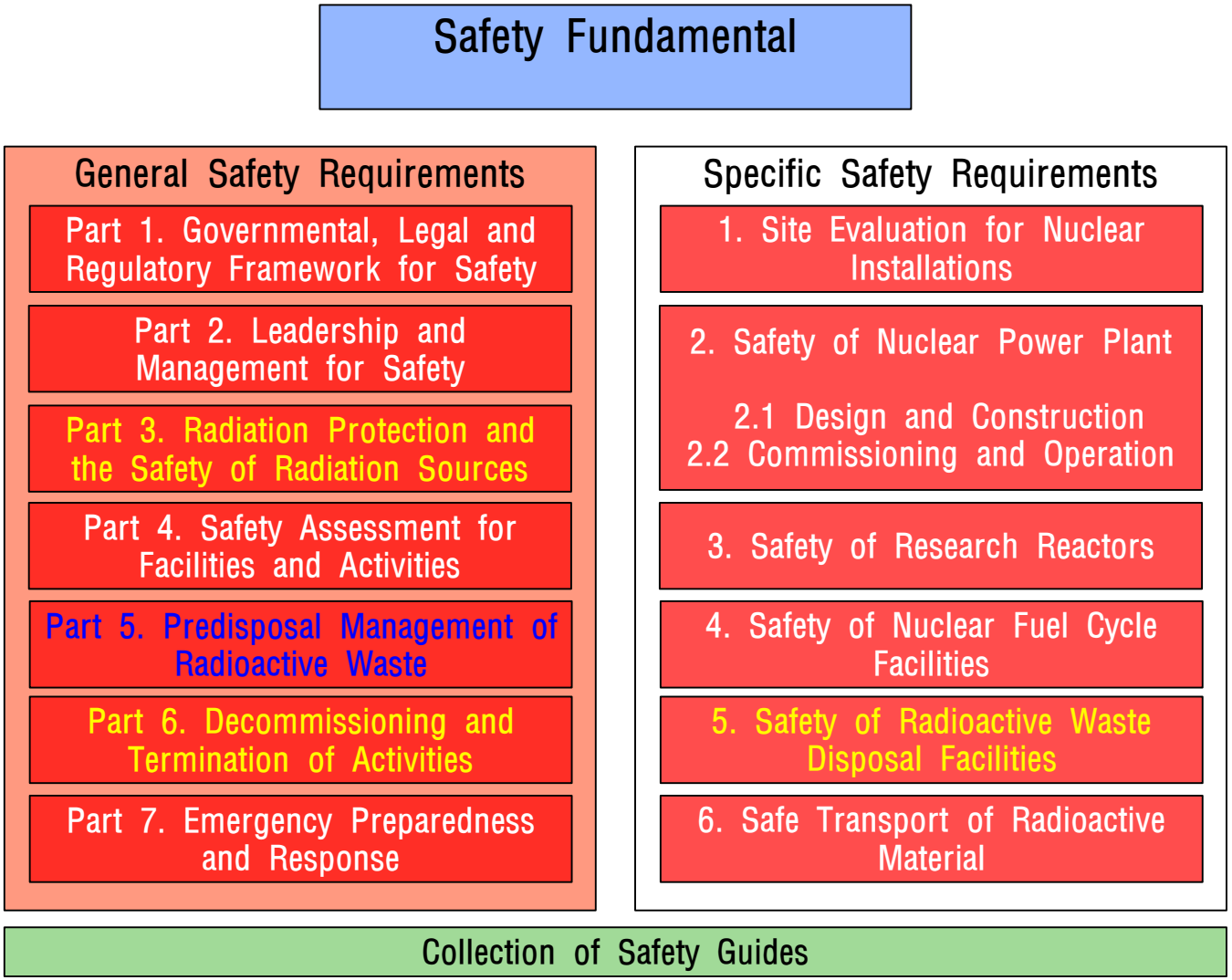


underlying principles
– aimed at politicians and regulatory authorities

obligations and responsibilities
("**shall**" statements)

recommendations to support requirements
("**should**" statements)

IAEA Safety Standard

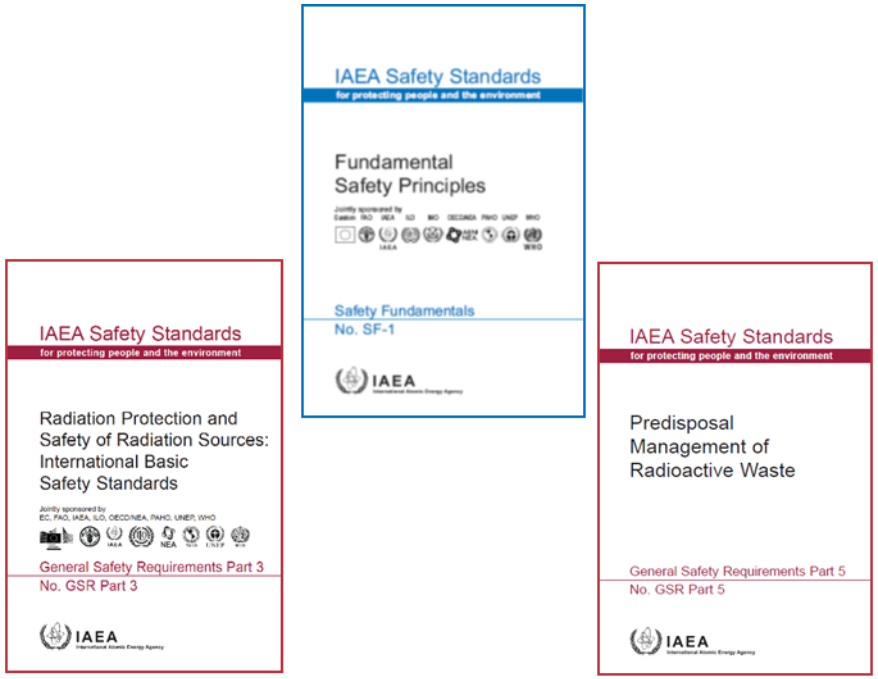


IAEA Safety Standards on RWM

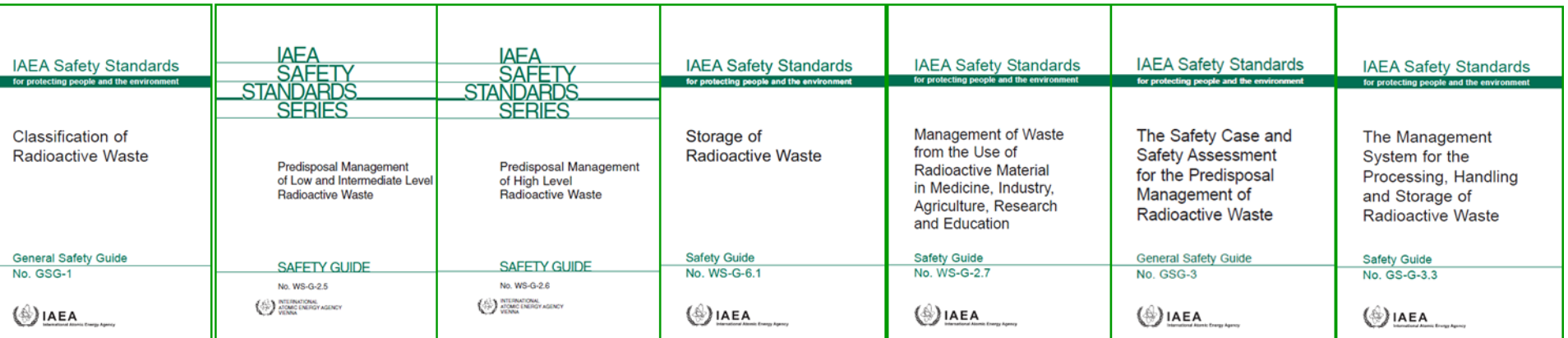
Predisposal

- Classification
- Storage
- Safety Assessm
- Safety Case
- Management System

GSR Part 3



GSR Part 5

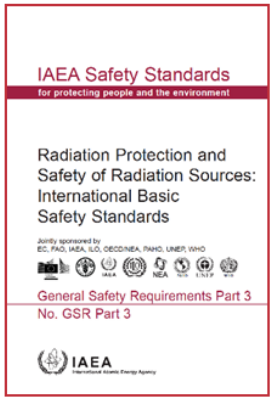


IAEA Safety Standards on RWM

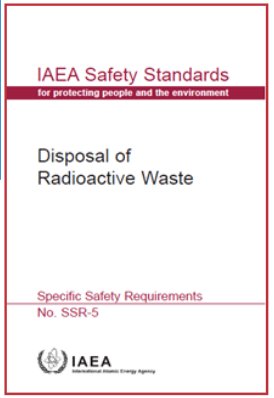
Disposal

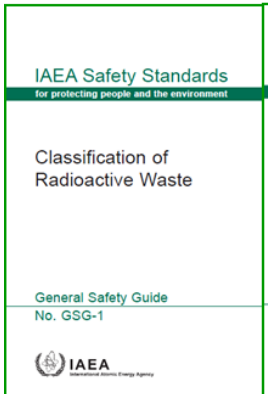
- Site Aspects
- Design
- Construction
- Operation
- Closure
- Post Closure
- Safety Assessment
- Management System

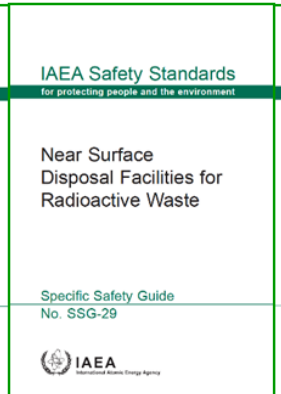
GSR Part 3

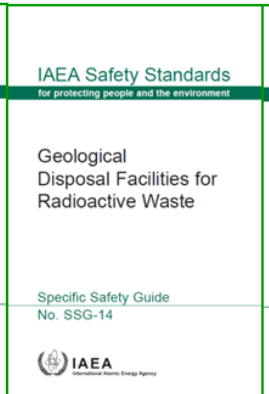


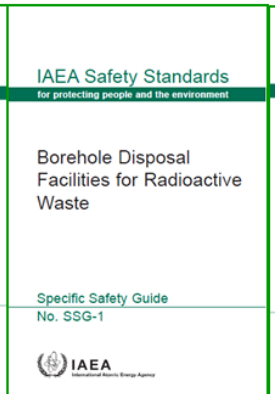
SSR 5

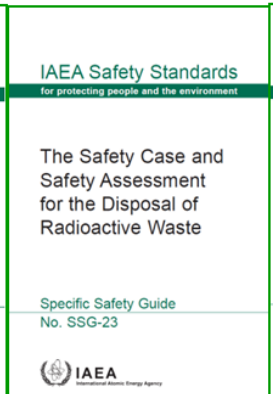


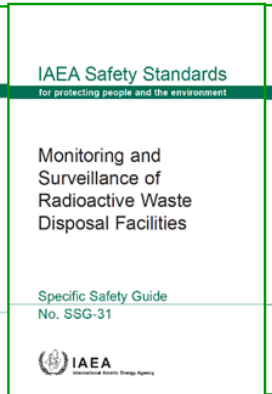


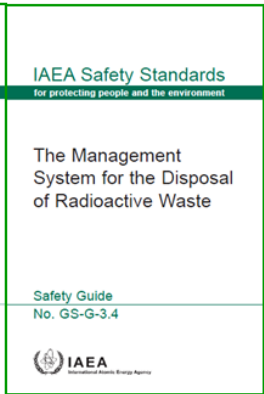












2022.01, IAEA website

Safety Fundamentals

SF-1	**Fundamental Safety Principles**	**2006**

Safety Requirements

GSR Part 3	International BSS(SS-115(1996) **개정본**)	2014
GSR Part 5	Predisposal Management of RW	2009
GSR Part 6	Decommissioning of Facilities	2014
SSR-5	Disposal of Radioactive Waste	2011

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Safety Guides

General	GSG-1	Classification of RW	2009
	RS-G-1.7	Application of the Concepts of Exclusion, Exemption and Clearance	2004
	DS499 DS500	Application of the Concept of Exemption/ Application of the Concept of Clearance(Rev. of RS-G-1.7, 2016~2022)	-
	GSG-9	Regulatory Control of Radioactive Discharges to the Environment	2018
	GSG-16	Leadership, Management & Culture for Safety in RWM	2022
	DS526	National Polices & Strategies for the Safety of RW & SF management, Decommissioning & Remediation(2020~2025)	-
	~~GS-G-3.4~~	~~The Management System For the Disposal of RW~~	~~2008~~
Disposal	SSG-1 DS512	Borehole Disposal Facilities for RW Reversion of Borehole Disposal Facilities for RW(2017~2021)	2009 -
	SSG-14	Geological Disposal Facilities for RW	2011
	SSG-23	The Safety Case and Safety Assessment for the Disposal of RW	2012
	SSG-29	Near Surface Disposal Facilities for RW	2014
	SSG-31	Monitoring & Surveillance of RW Disposal Facilities	2014

2022.01, IAEA website

Safety Guides

Predisposal	GSG-3	The Safety Case and S.A. for the Predisposal management of RW	2013
	WS-G-6.1	Storage of Radioactive Waste	2006
	SSG-15	Storage of Spent Nuclear Fuel	2020
	NS-G-4.6	RP & RWM in the Design & Operation of RRs	2008
	GS-G-3.3	The Manag. Sys. for the Processing, Handling and Storage of RW	2008
	SSG-40, 41	Predisposal Mange. Of RW from NPPs·RRs(40), Fuel Cycle Fac.(41)	2016
	WS-G-1.2	Management Of RW from the mining & milling of Ores	2002
	SSG-17	Control of Orphan Sources & Other RM in the Metal Recycling & Production Industries	2012
	SSG-45	Predisposal Management Of RW from the Use of RM in Medicine, Industry, Agriculture, Research & Education	2019
Decomm.	~~WS-G-3.1~~ DS468	~~Remediation Process for Areas Affected by Past Activities and~~ Accidents/ Rev. of WS-G-3.1(2012~2016)	~~2007~~ -
	WS-G-5.1	Release of Sites from Reg. Control on Termination of Practices	2006
	WS-G-5.2	Safety Assessment for the Decomm. of Facilities Using RM	2008
	SSG-47	Decomm. Of NPPs, RRs and Other Nuclear Fuel Cycle Facilities	2018

Principles of RWM

IAEA Safety Series No. 111-F (1995)

- **Principle 1: Protection of human health**
- **Principle 2: Protection of the environment**
- **Principle 3: Protection beyond national borders**
  - to assure that possible effects on human health and the environment beyond national borders will be taken into account
- **Principle 4: Protection of future generations**
  - predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today
- **Principle 5: Burdens on future generations**
  - not to impose undue burdens on future generations

Principles of RWM

IAEA Safety Series No. 111-F (1995)

- **Principle 6: National legal framework**
  - within a national legal framework including clear allocation of responsibilities and provision for independent regulatory functions
- **Principle 7: Control of radioactive waste generation**
  - Generation shall be kept to the minimum practicable
- **Principle 8: Generation/management interdependencies**
  - Interdependencies among all steps in RW generation and management shall be appropriately taken into account
- **Principle 9: Safety of facilities**
  - The safety of facilities for RWM shall be appropriately assured during their lifetime

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II. Safety Standard for RWM

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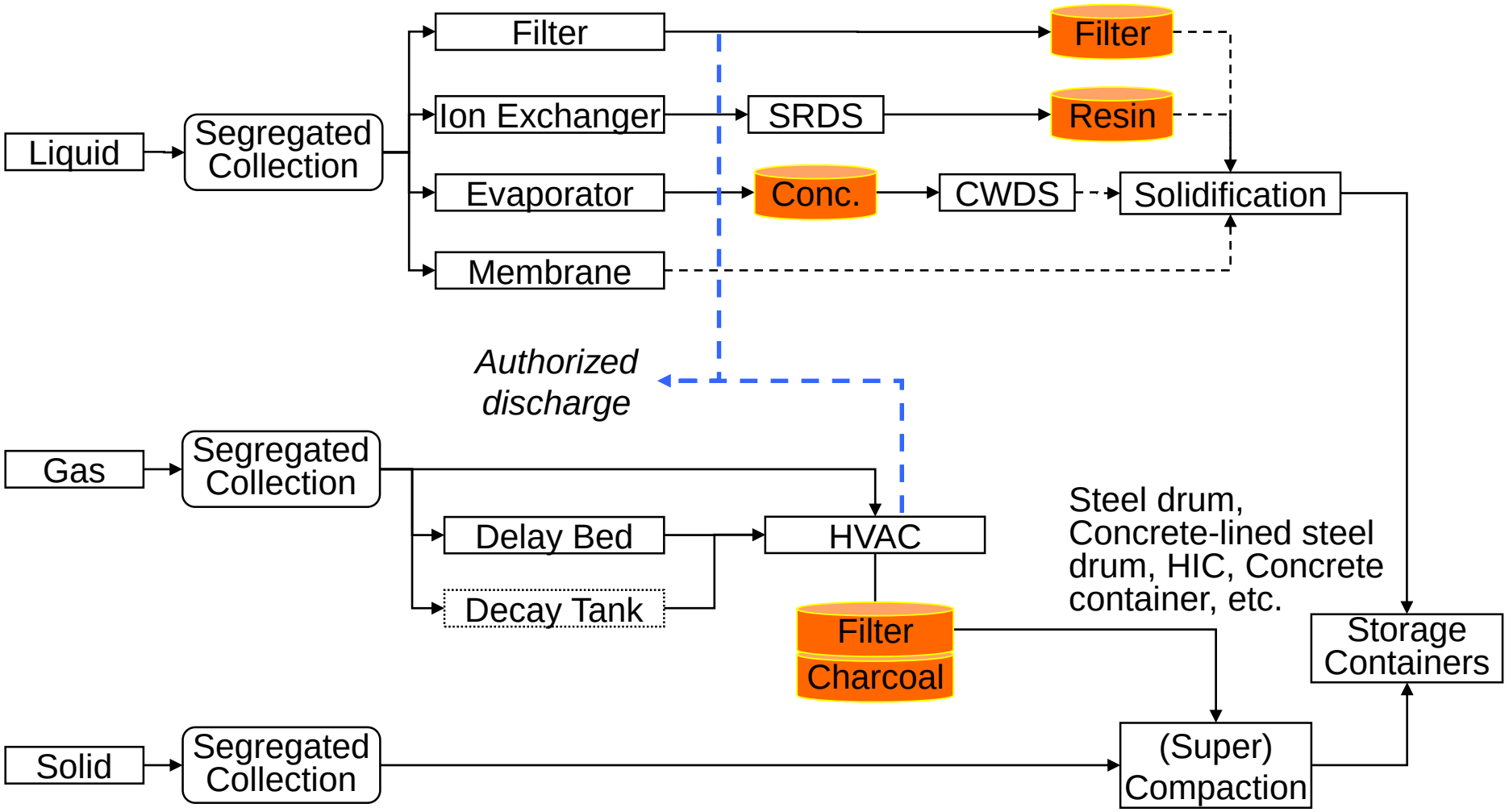
V. Korean Approach of disposal of RW

Source Term

Major radionuclides at reactor facility

- Fission products (FPs)
  - Noble gases: ^{133}Xe, ^{85}Kr, etc.
  - Halogens: ^{131}I, ^{133}I, etc.
  - Particulates: ^{137}Cs, ^{134}Cs, ^{90}Sr, etc.
- Activation Products (APs) or CRUD
  - ^{58}Co, ^{60}Co, ^{59}Fe, ^{51}Cr, ^{54}Mn, etc.
- Others: ^{3}H, ^{14}C, ^{16}N, etc.

Overall scheme of predisposal RWM



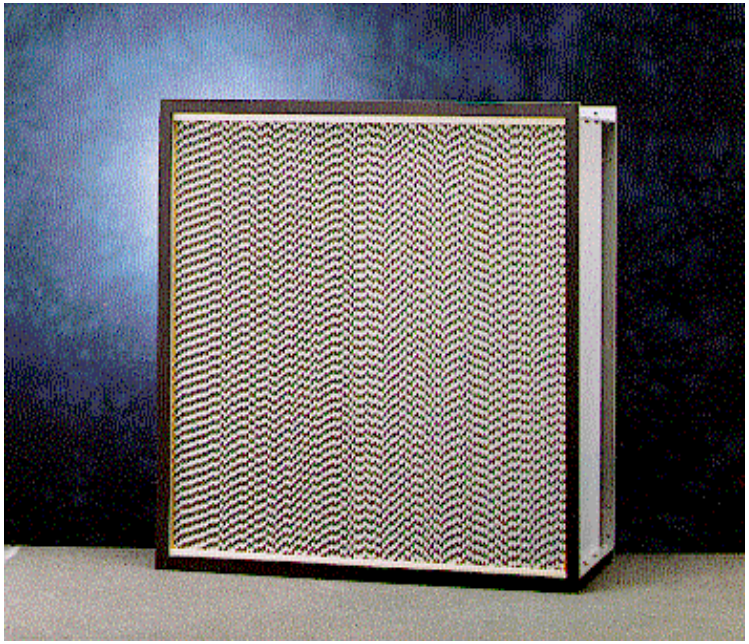
Components in LRWMS

- Filter: Separation of Suspended Solids
- Centrifuge: Separation of Suspended Solids
- Ion Exchanger: Separation of Ionic RNs
  - Organic resin: Cation bed, Anion bed, Mixed bed
  - Cs-Selective Inorganic Resin: Selective Separation of Cs
- Evaporator: Concentration of LRW by Evaporation
  - Distilled water: to be discharged or recycled
- Membrane Separator: Separation of Solids/Salts
  - Reverse osmosis, Nano filtration, Ultra filtration, Micro filtration, etc.

Components in GRWMS

- Filters: Separation of particulates
  - Particulate pre-filter: separation of large particulates
  - HEPA (High Efficiency Particulate Air) filter: separation of fine particulates
- Charcoal filter: Adsorption of iodine
  - Charcoal delay bed: delay of noble gases
  - Dynamic adsorption (~2.5 d for Kr; ~45 d for Xe)
- Gas decay tank: Decay of noble gases (45 to 60 d)
  - Storage of gases in pressurized tank

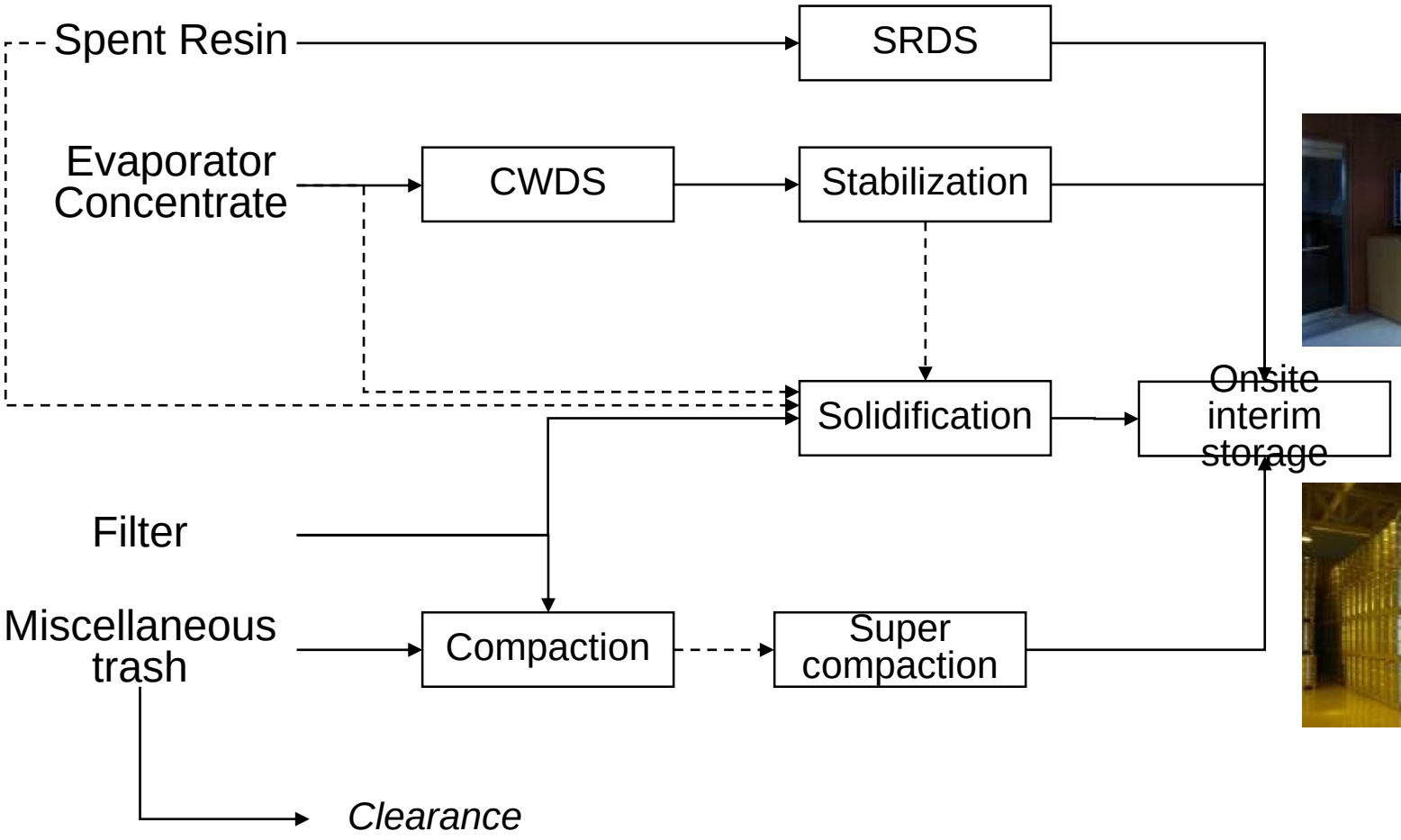
Components in GRWMS



HEPA

Charcoal

Solid radioactive waste management system (SRWMS)



Components in SRWMS

- Compactor: Volume reduction
  - Conventional compactor
  - Super compactor (mobile) : 2,000 tons of compression strength
  - Volume reduction factor : 2 ~ 10
- Solidification/Stabilization process
  - Cementation
  - Paraffin Stabilization
  - Vitrification
  - Polymerization: under development
- Drying process
  - Spent resin drying system (SRDS): in connection with high integrity container (HIC)
  - Concentrate waste drying system (CWDS)

Super compaction system

Super Compactor
(from http://www.h-p-a.de)

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Definition

- Disposal
  - Emplacement of waste in an appropriate facility without the intention of retrieval
- Storage
  - Holding of radioactive sources, spent fuel or radioactive waste in a facility that provides for their/its containment, with the intention of retrieval
- Closure
  - Administrative and technical actions directed at a repository at the end of its operating lifetime — e.g. covering of the disposed waste (for a near surface repository) or backfilling and/or sealing (for a geological repository and the passages leading to it) — and the termination and completion of activities in any associated structures

Definition

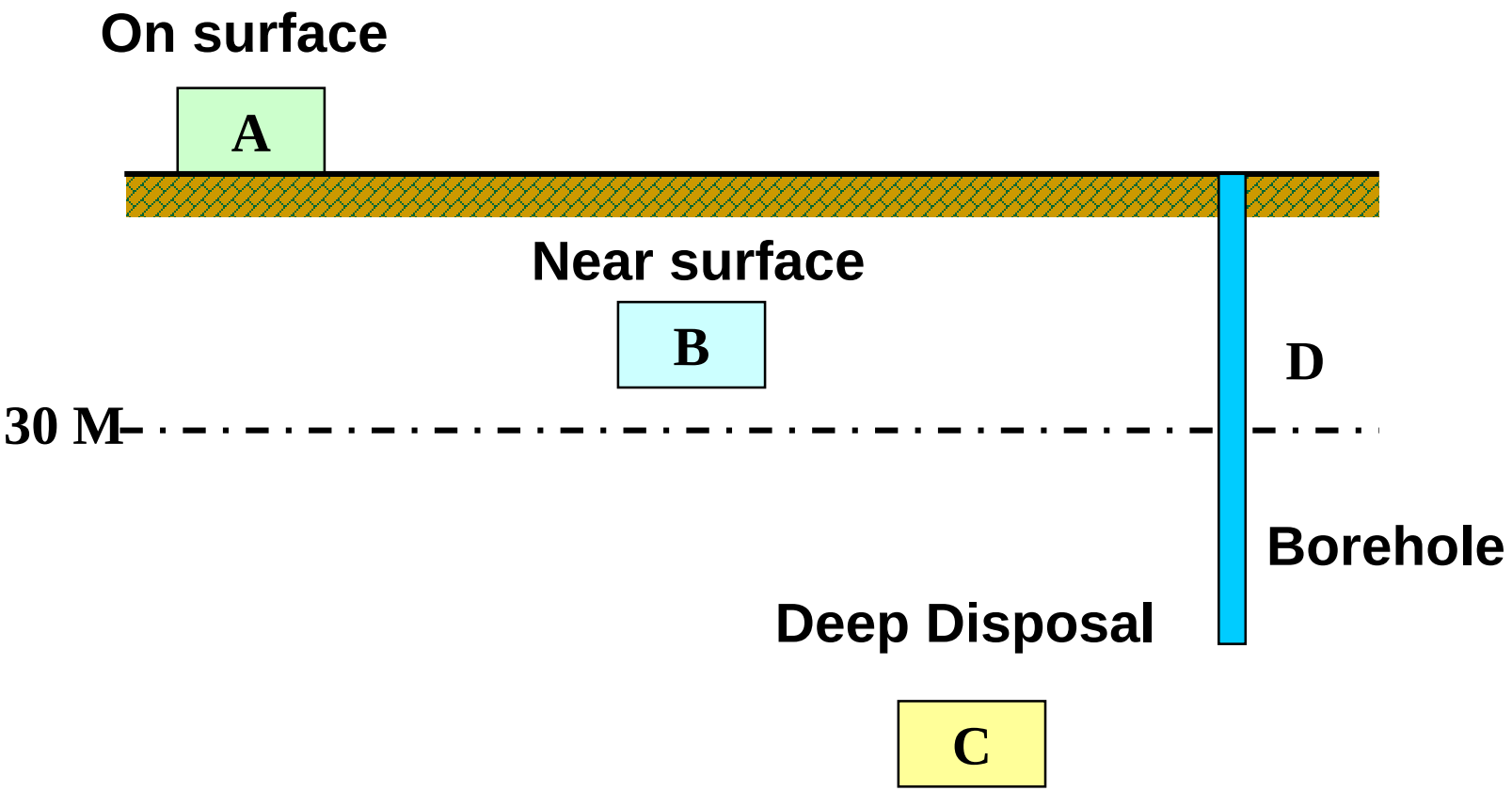
- Waste acceptance criteria/requirements
  - Quantitative or qualitative criteria specified by the regulatory body, or specified by an operator and approved by the regulatory body, for radioactive waste to be accepted by the operator of a repository for disposal, or by the operator of a storage facility for storage
- Safety case
  - A collection of arguments and evidence in support of the safety of a facility or activity

Disposal Options

4 options for waste disposal as follows:

A	**-**	**On surface**	**Storage**
B	**-**	**Near surface**	**< 30 M**
C	**-**	**Deep disposal**	**100’s M**
D	**-**	**Borehole**	

Schematic – Disposal Options



Disposal Option: International Practices

	T½ (Year)	Volumes	Activity Conc.	Preferred option
RI Sources	< 1	Low	High	Storage
	1-5	Low		Storage
	> 30	Low		Deep disposal, borehole
L + ILW	< 30	Medium - Large (10^3 – 10^6 M^3)	Low - Medium	Near surface
HLW	> 30	Medium (10^3 – 10^5 M^3)	Very High	Deep disposals – 100's M
NORM	10^4	Very Large (10^6 – 10^8 M^3)	Low - Medium	Below 30 M ideally

Types of disposal facility

Landfill disposal for VLLW

Sweden (Forsmark)

Spain (El Cabril)

France (Morvillers)

Japan (JAEA)

Specific landfill disposal for VLLW

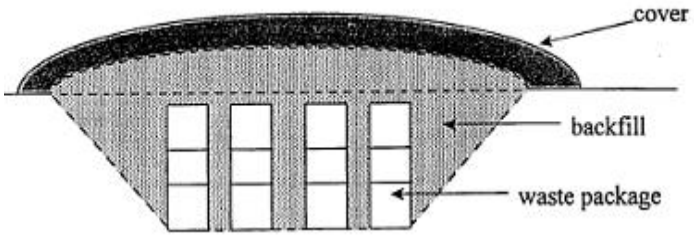
Ringhals, Sweden

- **Type: landfill**
- **Depth: 0m**
- **Capacity**
  - 3,500㎥, existing
  - 10,000㎥, planned
- **Host medium: Crystalline rock (granite)**
- **Landfill for VLLW**
  - Activity content: total 100 GBq
  - Specific activity: max 300 Bq/g
  - Surface dose rate: max 0.5 mSv/h

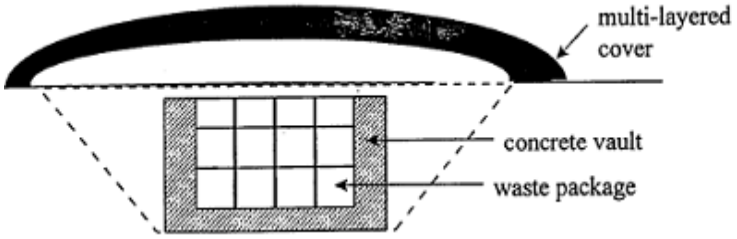
Types of disposal facility

Near-surface disposal for LILW

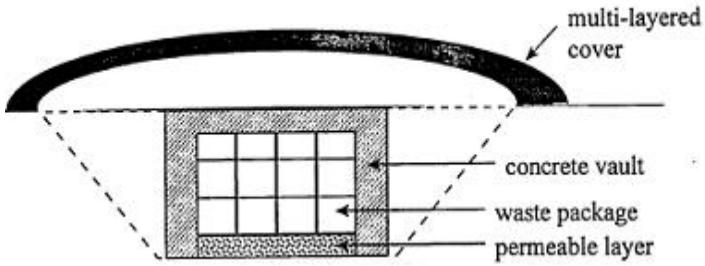
Covered trench



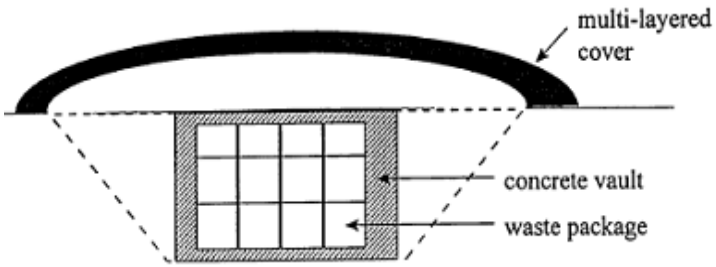
Vault - open



Vault – domed



Vault – closed



Near surface disposal for LILW

La Manche, France

- Type: engineered surface
- Depth: 0m
- Capacity: 527,225㎥
- Host medium: crystalline rock
- Operation: 1969~1994
- Closure: 1991~1997
- Institutional control: 2001~
- Centre de la Manche facility: surface disposal facility for LIL-SL waste

Near surface disposal for LILW

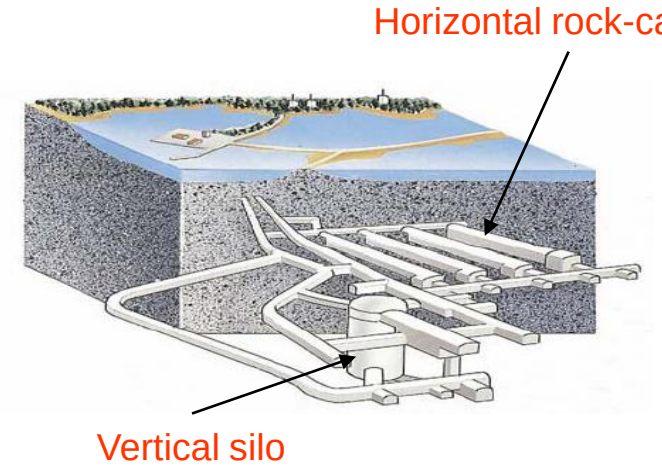
L'Aube, France

- Type: engineered surface
- Depth: 0m
- Capacity: 1,000,000㎥
- Host medium: sedimentary rock (consolidated clay)
- Centre de stockage FMA de l`Aube facility: surface disposal facility for FMA-VC (low- and intermediate-level, short lived) waste

Types of disposal facility

Intermediate-depth and geological disposal

Intermediate-depth disposal

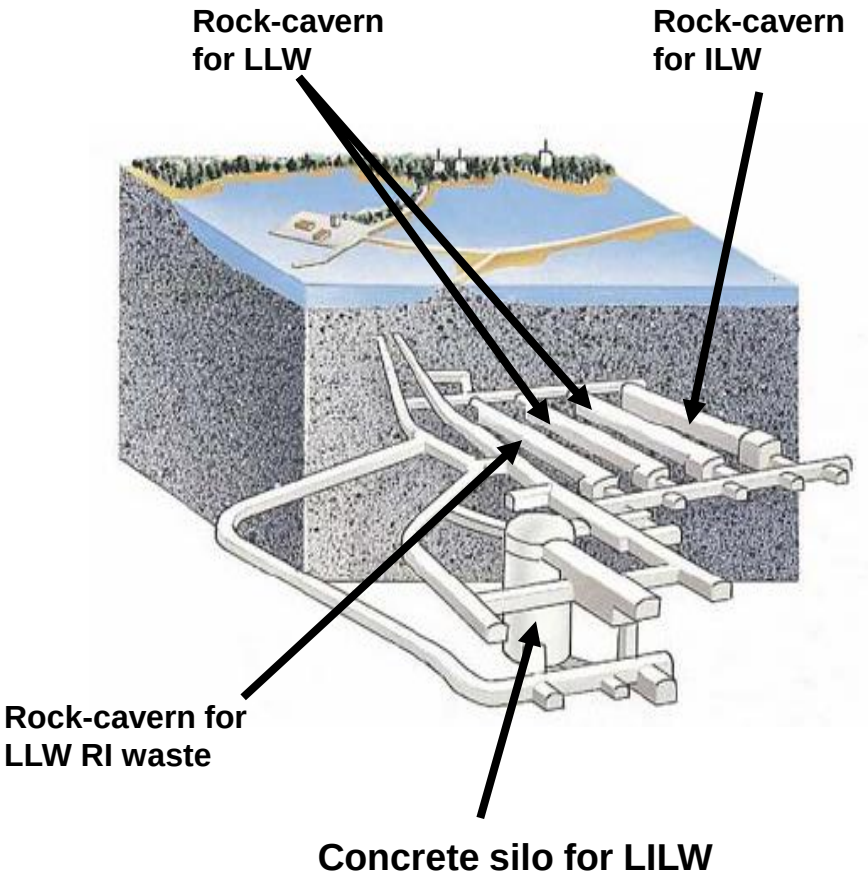


Deep geological disposal

Intermediate-depth disposal for LILW

Forsmark, Sweden

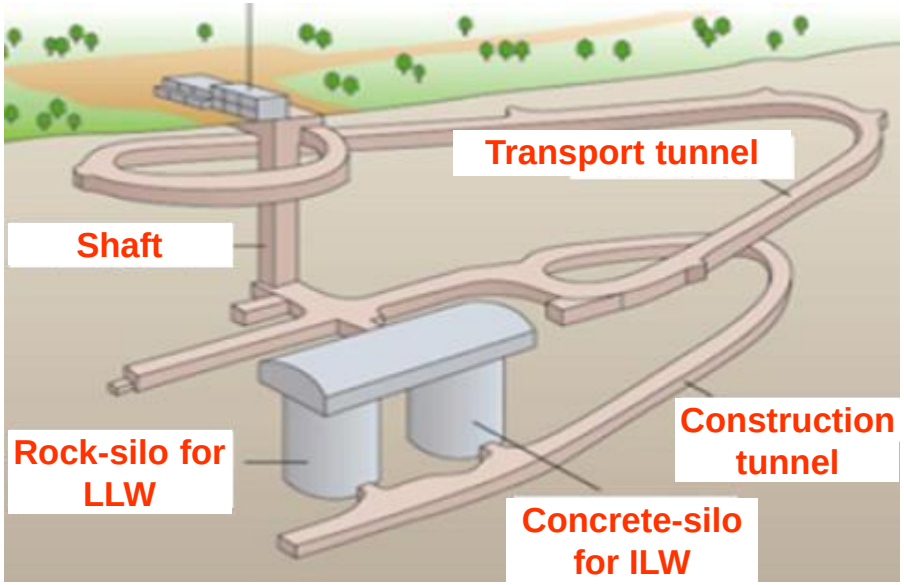
- **Type: rock cavern (under sea, land access)**
- **Depth: > 50m**
- **Capacity: 63,000㎥**
- **Host medium: crystalline rock (granite)**
- **Repository for disposal of operational LILW in underground cavities excavated in crystalline rock**



Intermediate-depth disposal for LILW

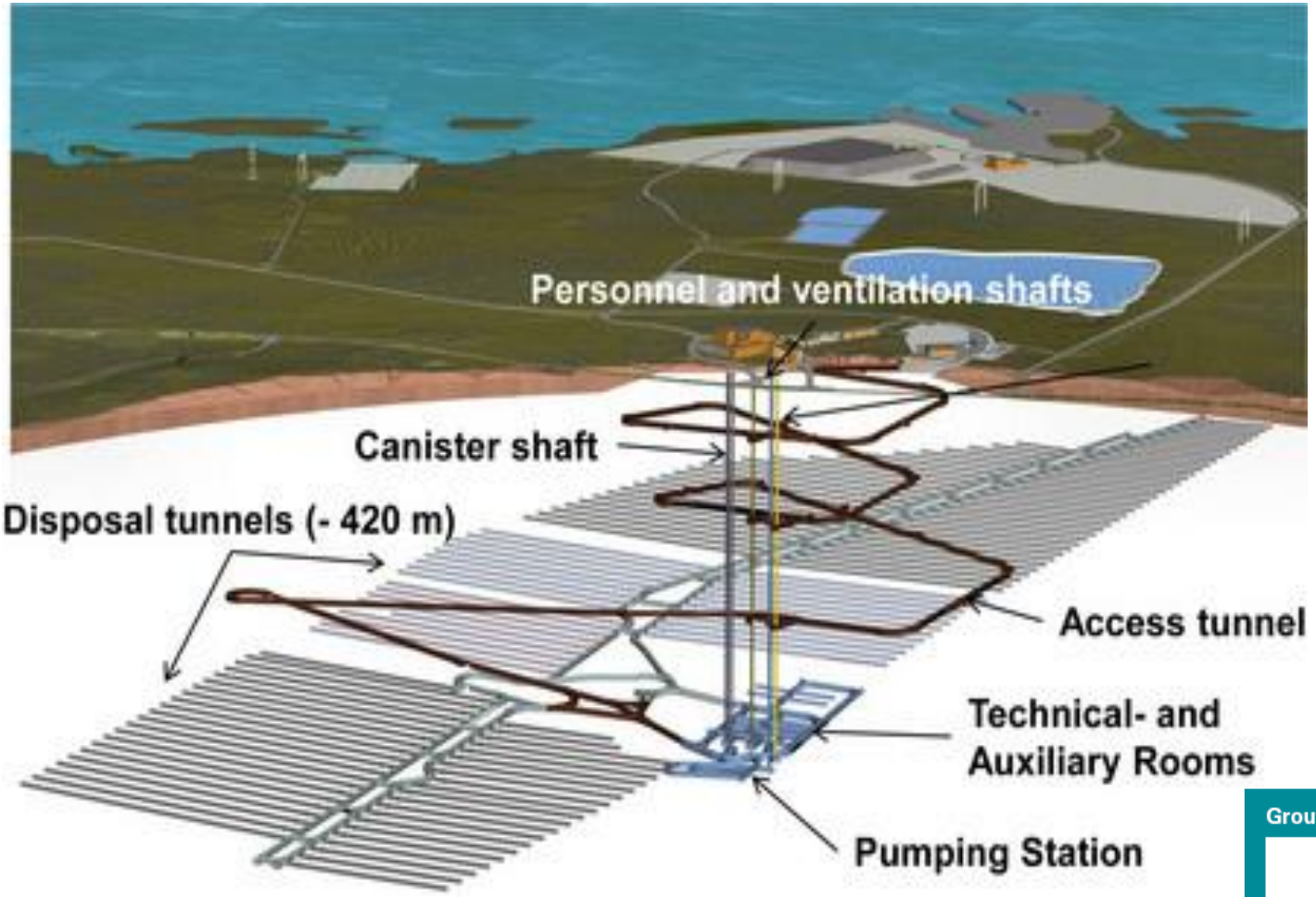
Olkiluoto, Finland

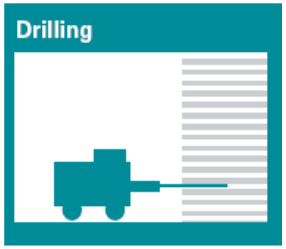
- **Type: rock caverns**
- **Depth: > 100m**
- **Capacity: 6,400 + 9,100 m^3**
- **Host medium: crystalline rock (granite)**

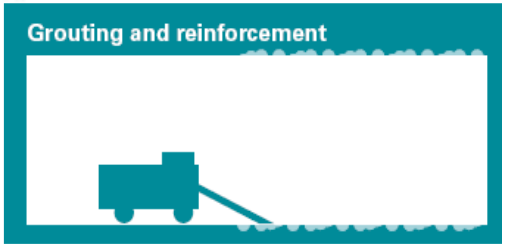


Geological disposal – Finland

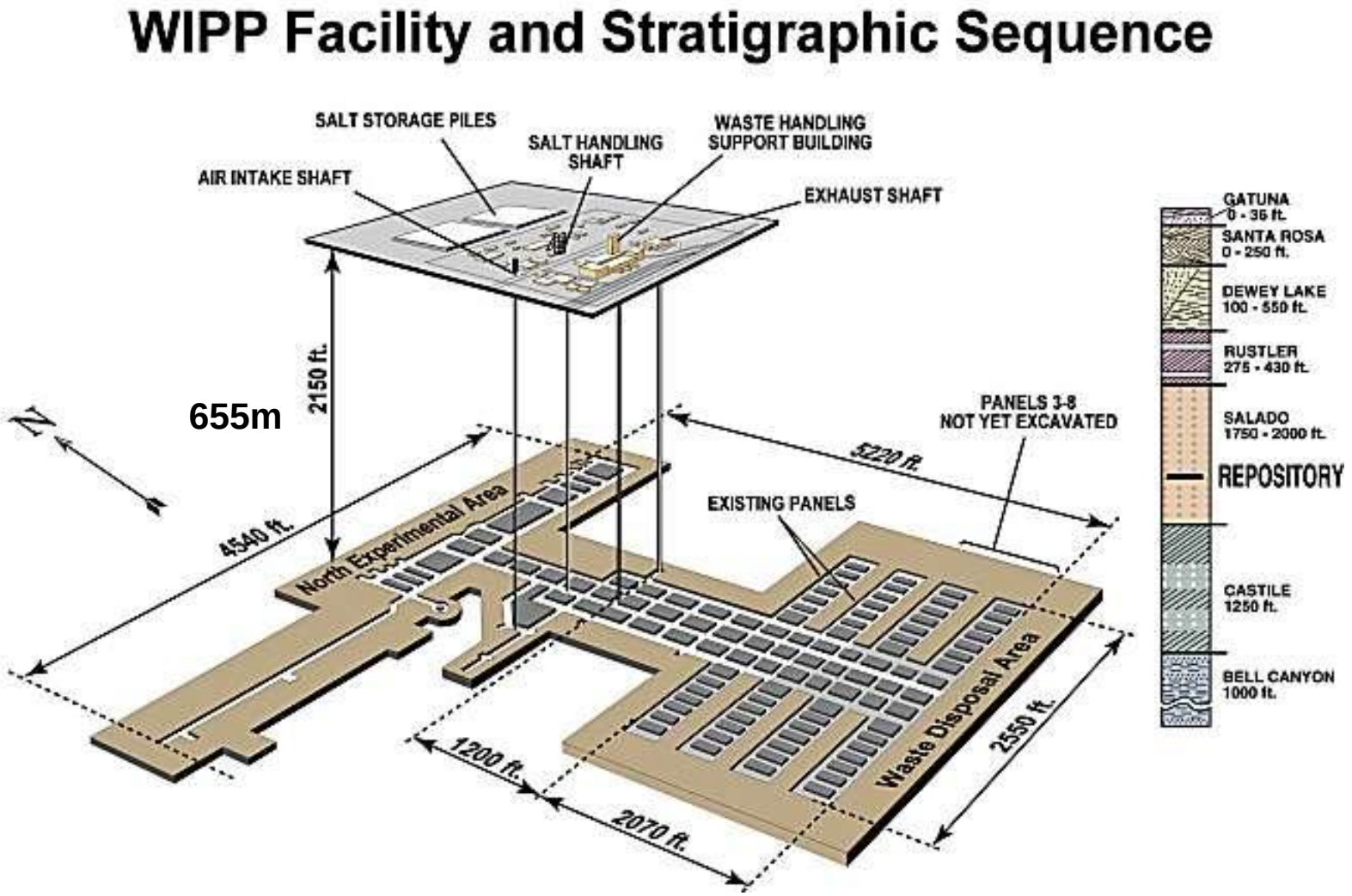
Disposal concept



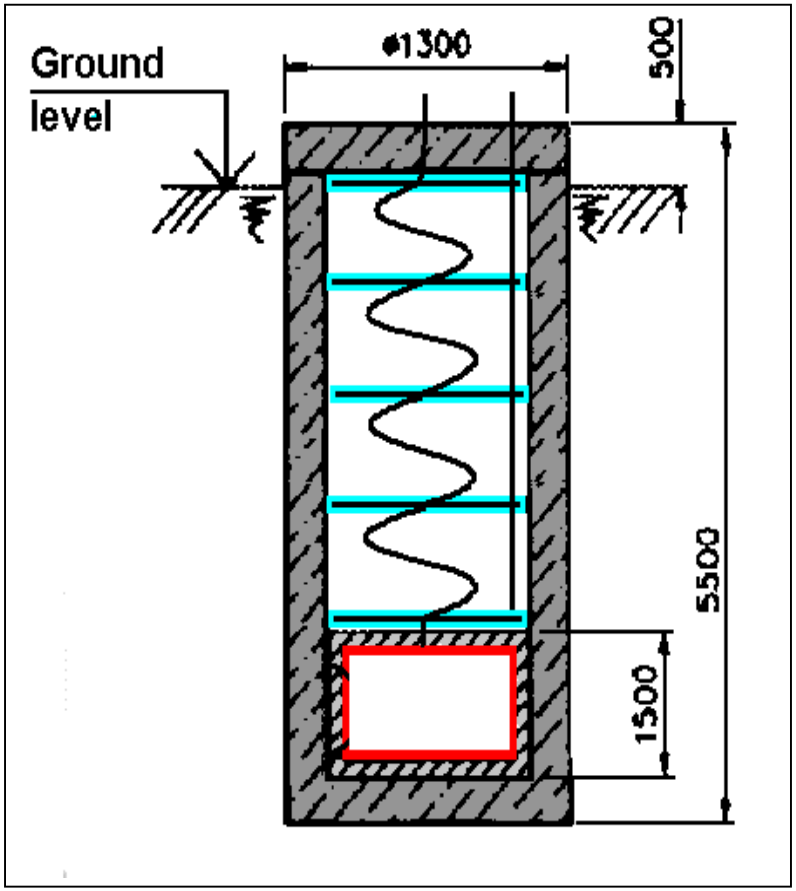




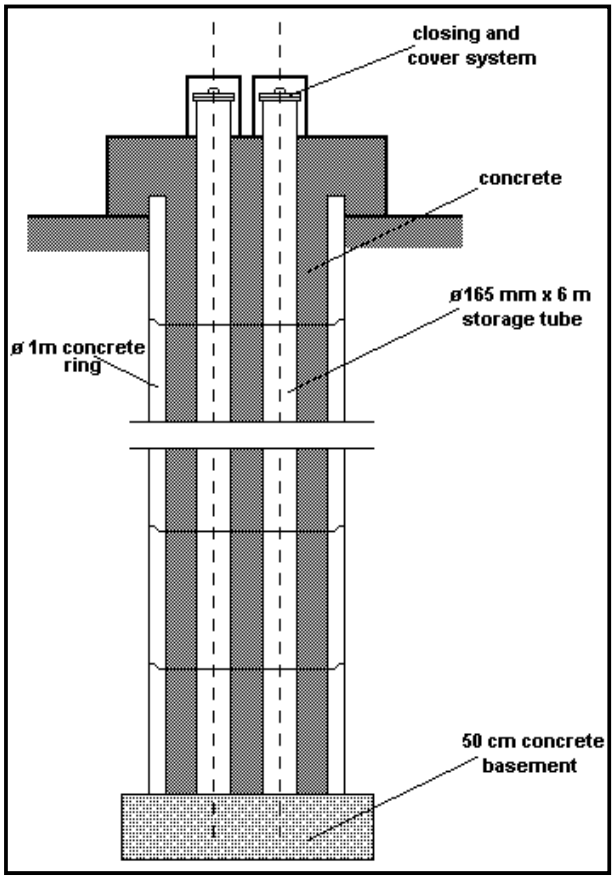
DEEP GEOLOGICAL DISPOSAL: WIPP-USA



Borehole Disposal

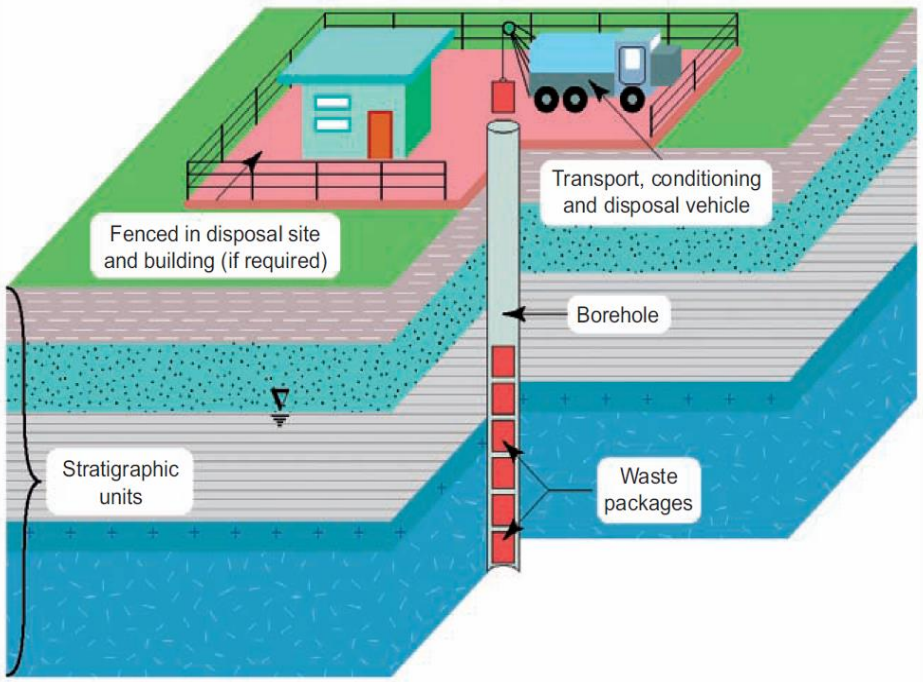


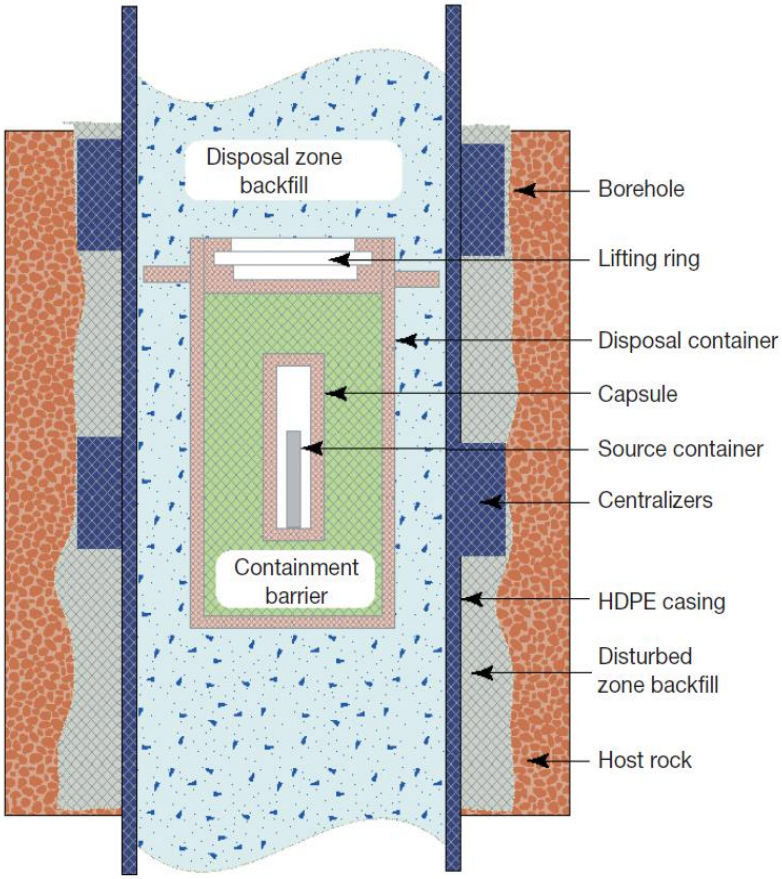
Near surface borehole for disposal (scale size in mm) of unconditioned sealed sources at a Radon type facility.



Borehole disposal of disused sealed sources at the Püspökszilágy repository in Hungary

Borehole disposal for disused sealed radioactive sources





Disposal facilities worldwide

Repository for VLLW

Country	Facility	Disposal capacity	Operation period	Type
France	**Morviellers**	**650,000㎥, planned**	**2003~**	**Simple landfill**
Spain	**El Cabril**	**120,000㎥, planned**	**2007~**	**Simple landfill**
Japan	**Tokai**	**2,520㎥**	**1995~1996**	**Simple landfill**
Sweden	**FKA, Forsmark**	**4,250㎥**	**1989~**	**Simple landfill**
	OKG	**7,500㎥ 16,000 ㎥, planned**	**1987~**	**Simple landfill**
	Ringhals	**3,500㎥ 10,000㎥, planned**	**1993~**	**Simple landfill**
	Studsvik	**900㎥ 1,200 ㎥, planned**	**1987~**	**Simple landfill**

Disposal facilities worldwide

Repository for LILW

Country	Facility	Disposal capacity	Operation period	Type
USA	**Barnwell**	**880,000㎥**	**1971~**	**Near surface**
	Richland	**1,700,000㎥**	**1965~**	**Near surface**
	Clive	**4,571,000㎥ 816,000㎥**	**1991~ 1995~**	**Near surface**
France	**La Manche**	**527,225㎥**	**1969~1994**	**Near surface**
	L'Aube	**1,000,000㎥**	**1992~**	**Near surface**
Spain	**El Cabril**	**100,000㎥**	**1993~**	**Near surface**
UK	**Drigg**	**1,800,000㎥**	**1959~**	**Near surface**
Japan	**Rokkasho**	**1st unit: 40,000㎥ 2nd unit: 40,000㎥**	**1992~ 2000~**	**Near surface**
Finland	**Olkiluto**	**6,400㎥ 9,100㎥**	**1992~**	**Intermediate depth**
	Loviisa	**8,740㎥**	**1998~**	**Intermediate depth**
Sweden	**SFR**	**63,000㎥**	**1988~**	**Intermediate depth**

Safety features of disposal facility

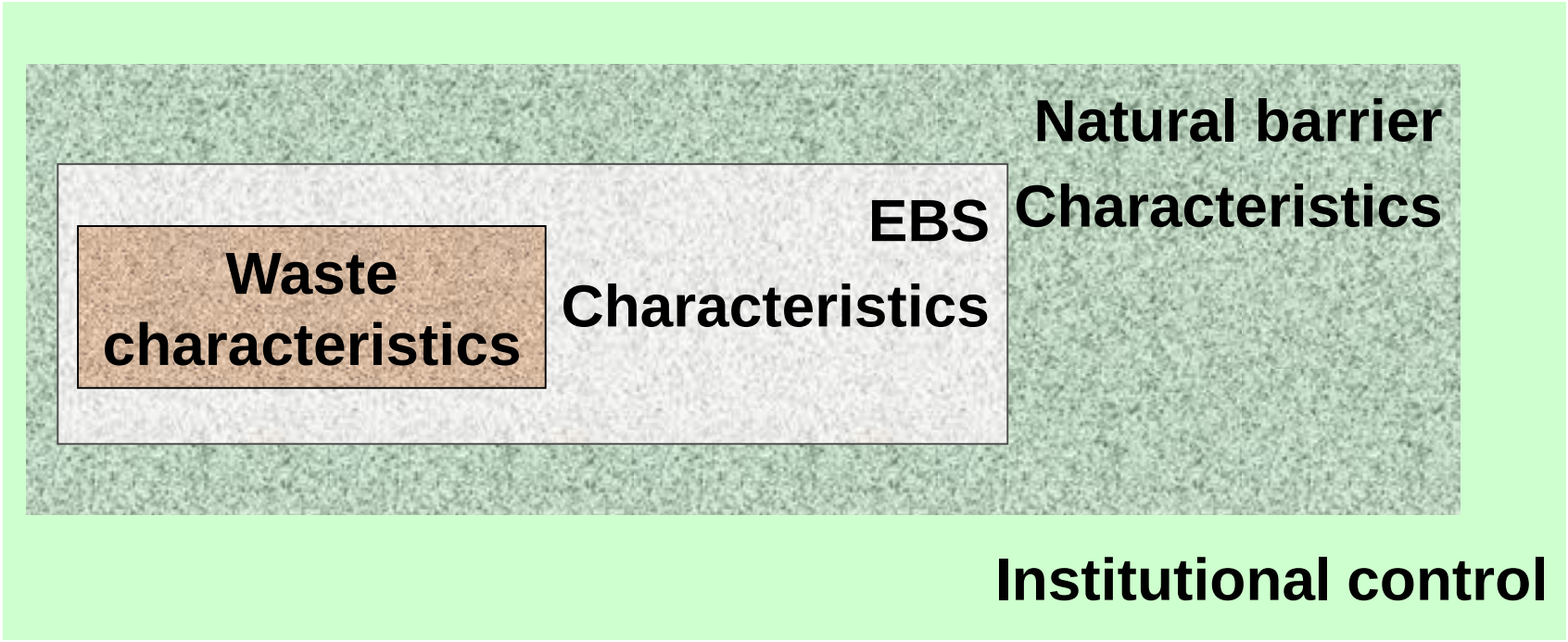
- Long-term (post-closure) safety
  - Depending on the performance of multiple elements in disposal facility such as below
- Waste characteristics
  - Waste form, container, package, radionuclide inventory, etc.
- Disposal system and EBS
  - Disposal unit, disposal container, backfill, drainage, cover, etc.
  - Limiting water infiltration and leaching from waste
- Site characteristics
  - Geosphere, hydrosphere, atmosphere, ecosystem, etc.
  - Ultimate isolation/delay of waste
- Institutional control – post closure phase
  - Precluding inadvertent intrusion, performance monitoring and preventive/corrective actions

Safety features of repository

Waste Acceptance Criteria (WAC)

SSCs criteria

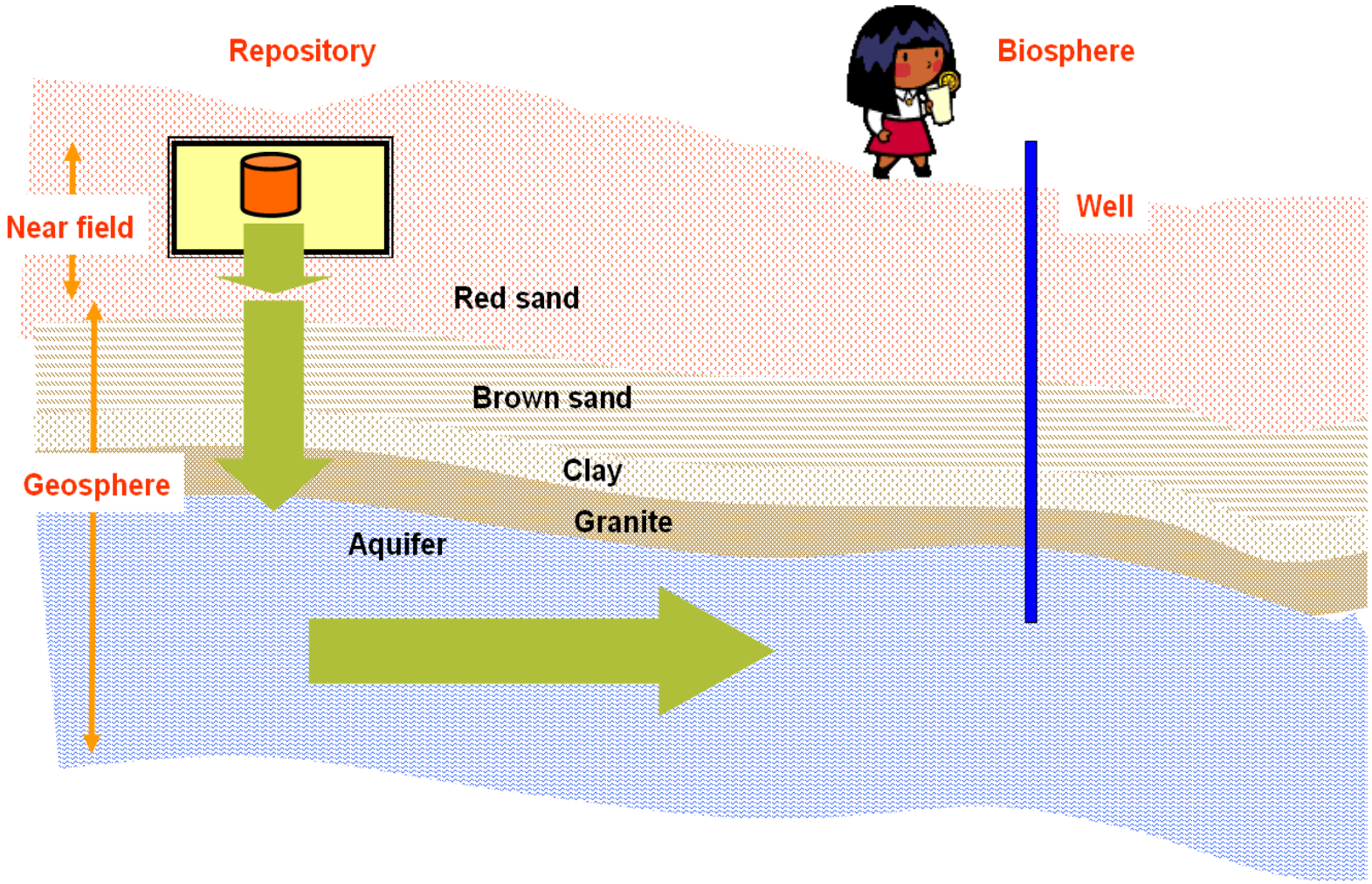
Siting criteria



Overall safety requirement
(Performance objective)

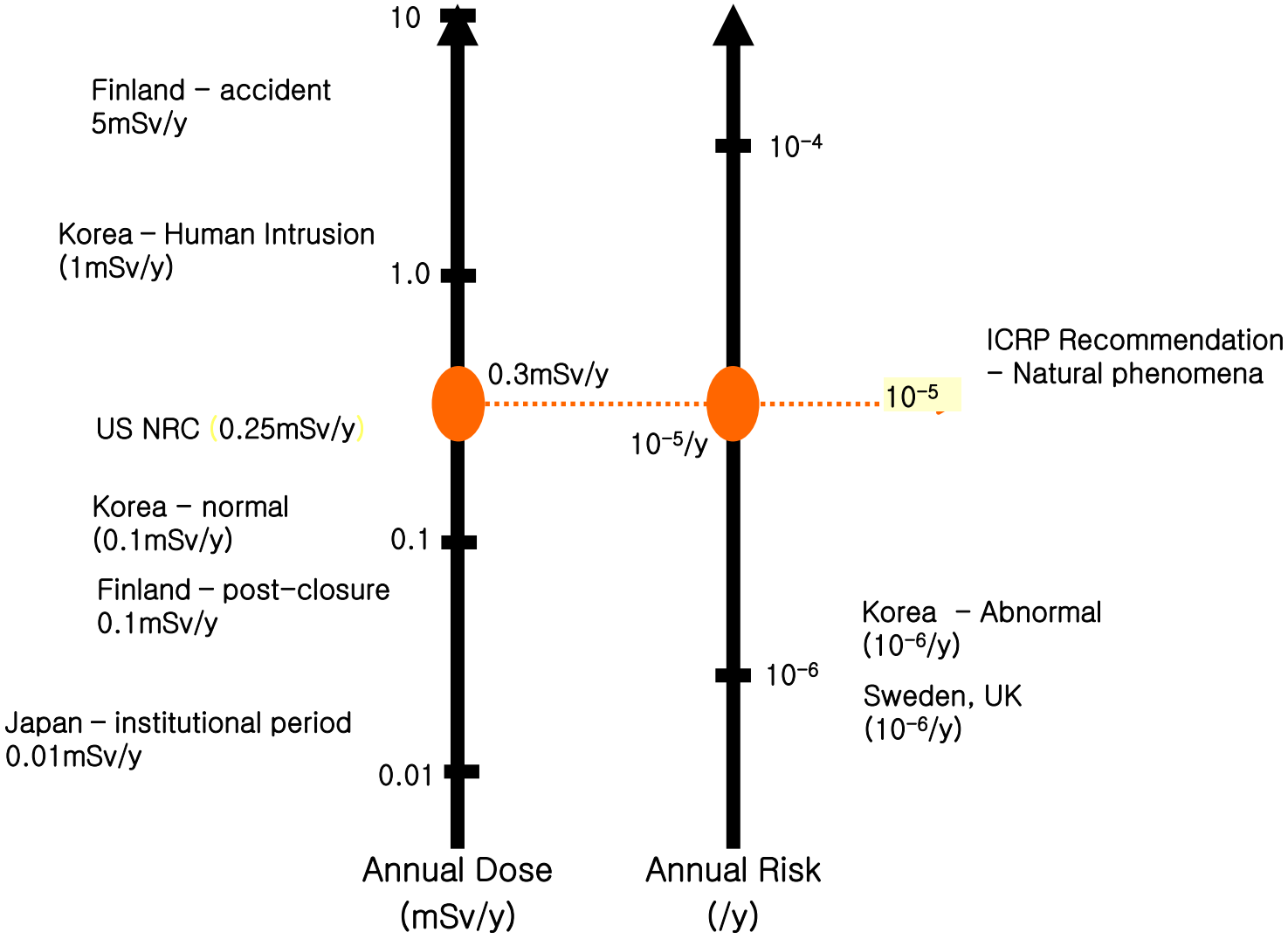
Sample: Safety Assessment Case

Conceptual model



Performance objectives

Performance objectives: limiting prescriptive dose/risk constraints for certain design, operation or post-closure requirements that make health and safety-related practices to be performed as safe enough in view of regulatory point



I. Introduction

II. Safety Standard for RWM

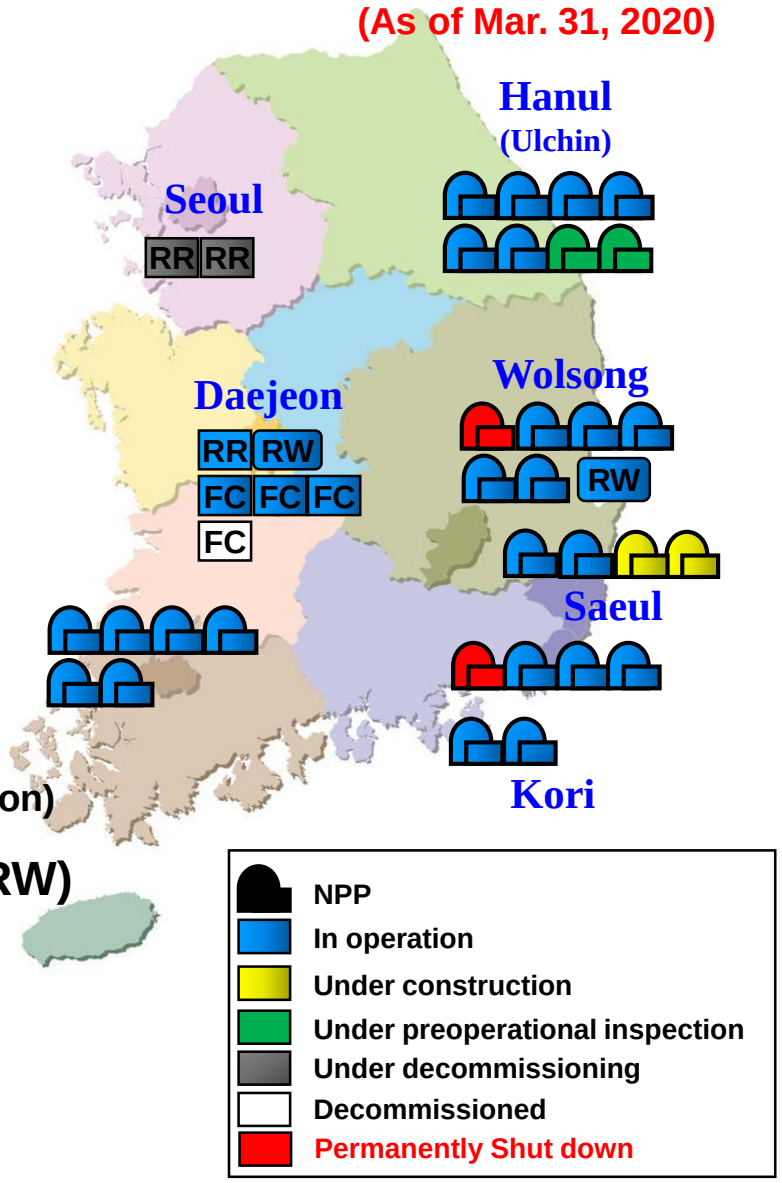
III. Predisposal Management of RWM

IV. Disposal of RW

V. Korean Approach for RWM

Major Nuclear Facilities

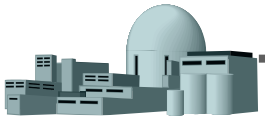
- **Nuclear Power Plants (NPPs)**
  - 24 units in operation and 2 units under construction
  - 2 units under preoperational inspection
  - 2 units in permanently shut down
- **Research Rectors (RRs)**
  - HANARO (RR)
  - KRR 1 and 2 (RR, under decommissioning)
- **Nuclear Fuel Cycle Facilities (FCs)**
  - Fuel Fabrication Plant for NPP
  - Fuel Fabrication Facility for RR
  - Post-Irradiation Examination Facility (PIEF)
  - Uranium Conversion Facility (released from regulation)
- **Radioactive Waste Management Facilities (RW)**
  - RI Waste Management Facility
  - Wolsong LILW Disposal Center (WLDC)
    → in operation since 2015



Framework of RW Management

LILW Management Program

Nuclear Power Reactors (KHNP)



On-site Storage (10)

Most RI Users

(Hospitals, Industries, etc.)

Centralized Storage (1)
RI Waste Management Facility (KORAD)

Commercial Fuel Fabrication Plant (KNF)

On-site Storage (2)

Research Complex (KAERI)

(HANARO, PIEF, Fuel Fabrication Plant)

On-site Storage (2)

KRR1 and 2

On-site Storage

On-site Storage (1)

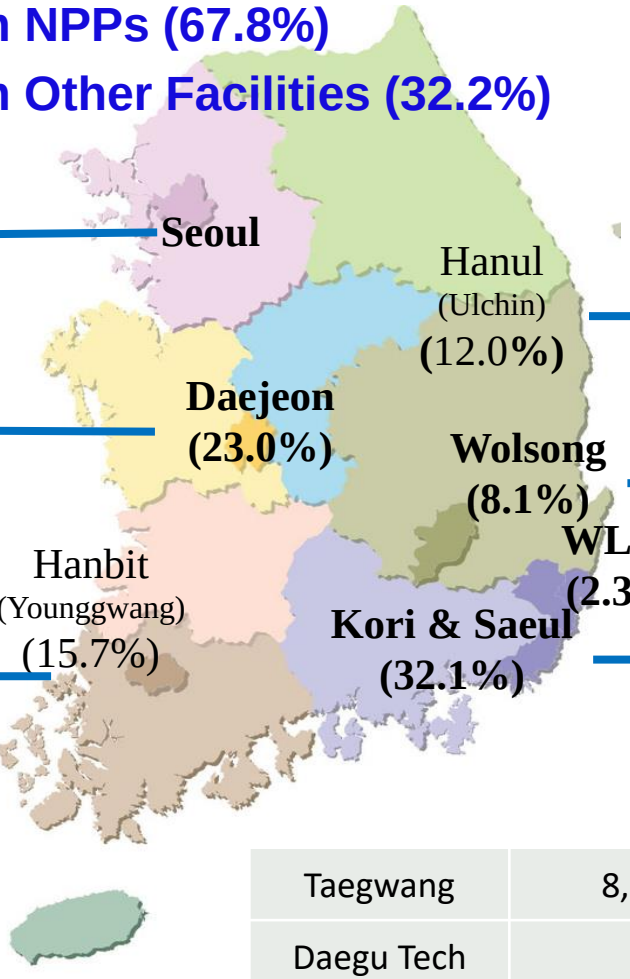
End Point
LILW Repository (KORAD)

Inventory of Radioactive Waste

Total 133,762 [200L-Drum Equivalents]

(As of Mar. 31, 2020)

- 90,658 drums from NPPs (67.8%)
- 43,104 drums from Other Facilities (32.2%)



KRR 1, 2	**641**

KAERI	21,185
KEPCO-NF	9,016
KORAD	561
Sum	**30,762**

Hanbit Site	**20,969**

Taegwang	8,635
Daegu Tech	52
Sum	**8,687**

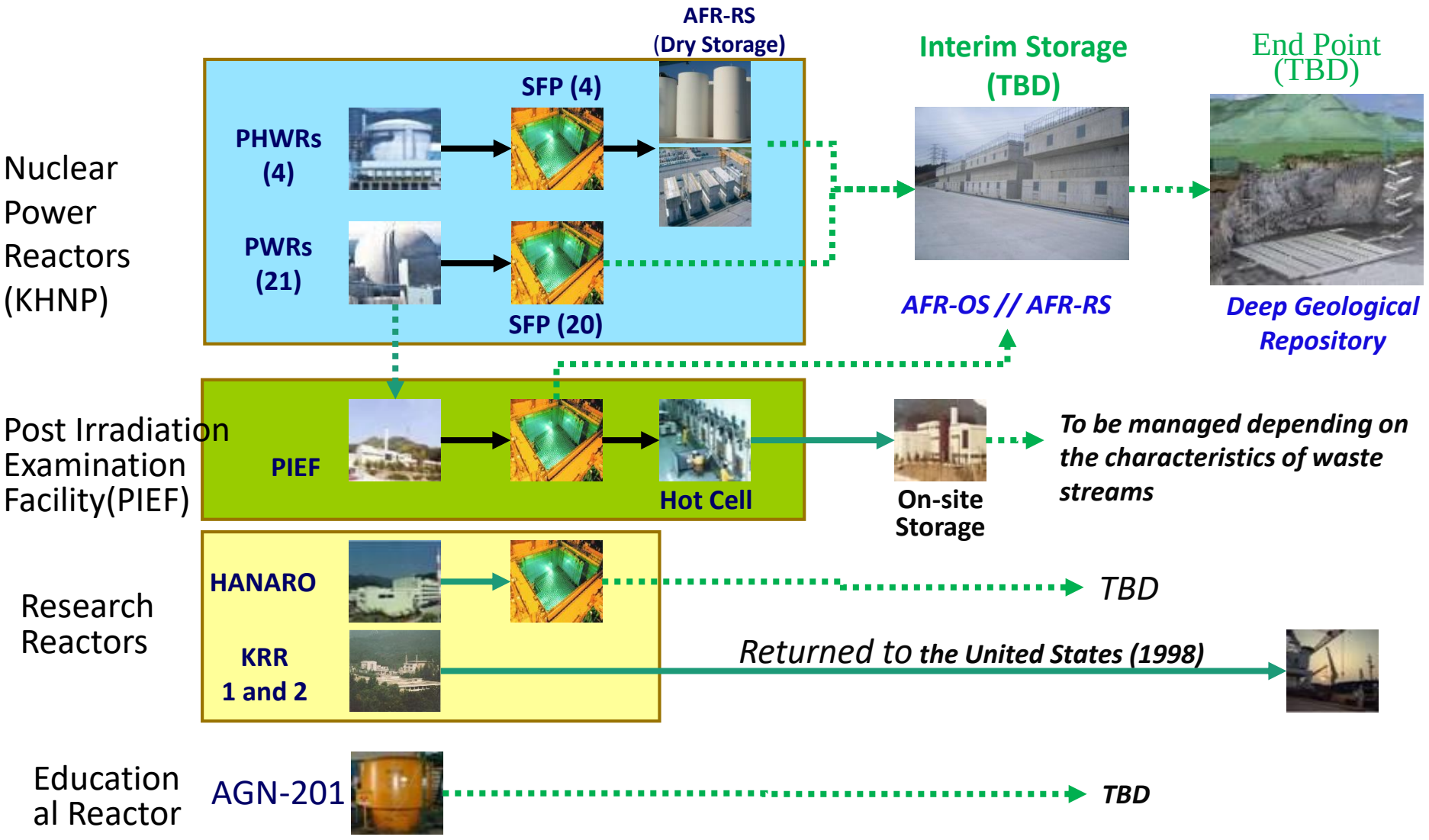
Hanul Site	**16,010**

Wolsong Site	**10,770**

Receipt/storage Building	**3,014**

Kori & Saeul Site	**42,909**

Framework of SF Management

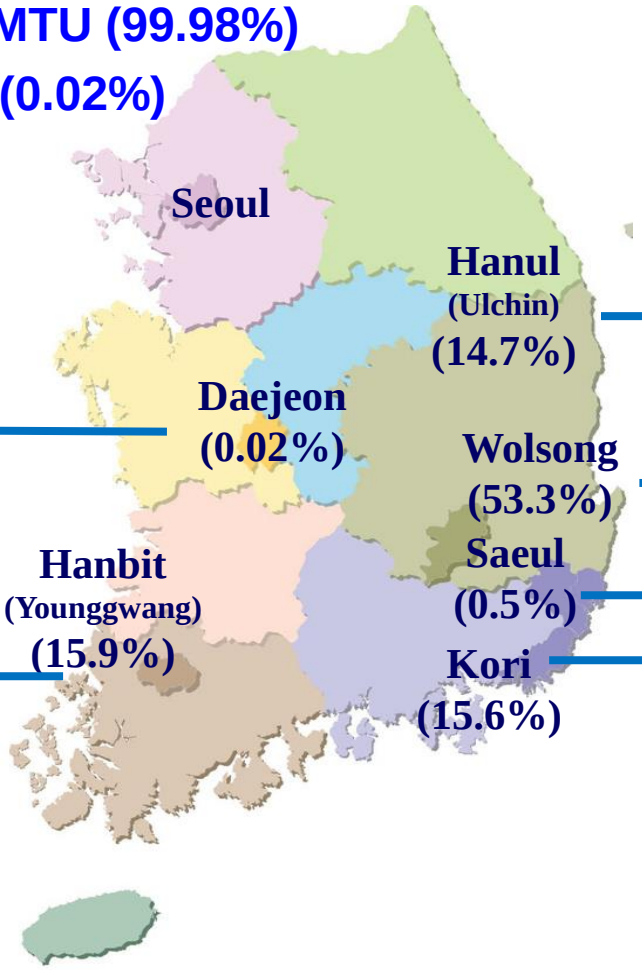


Inventory of Spent Fuel

Total 16,924.82 MTU

(As of Mar. 2020)

- KHNP: 16,920.60 MTU (99.98%)
- KAERI: 4.22 MTU (0.02%)



HANARO	0.90
PIEF	3.32
Sum	**4.22**

Unit 1-6	**2,682.89**

Unit 1-6	**2,493.27**

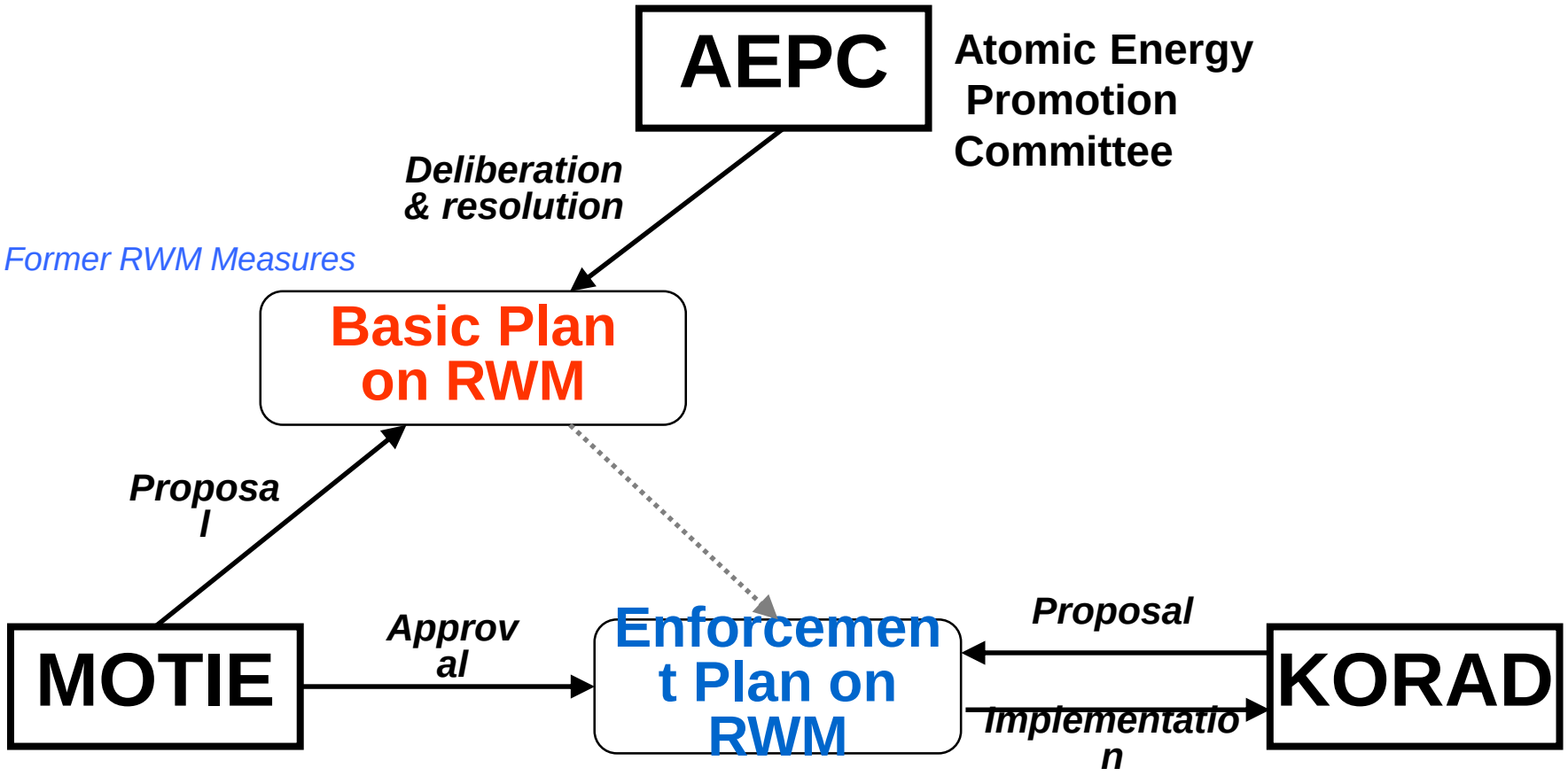
Unit 1-4 (PHWR)	8,811.37
Unit 5-6 (PWR)	214.83
Sum	**9,026.2**

Unit 1	**81.61**

Unit 1-6	**2,636.63**

National policy and implementation

RWM Policy-making process



Ministry of Trade, Industry and Energy

Korea Radioactive Waste Agency

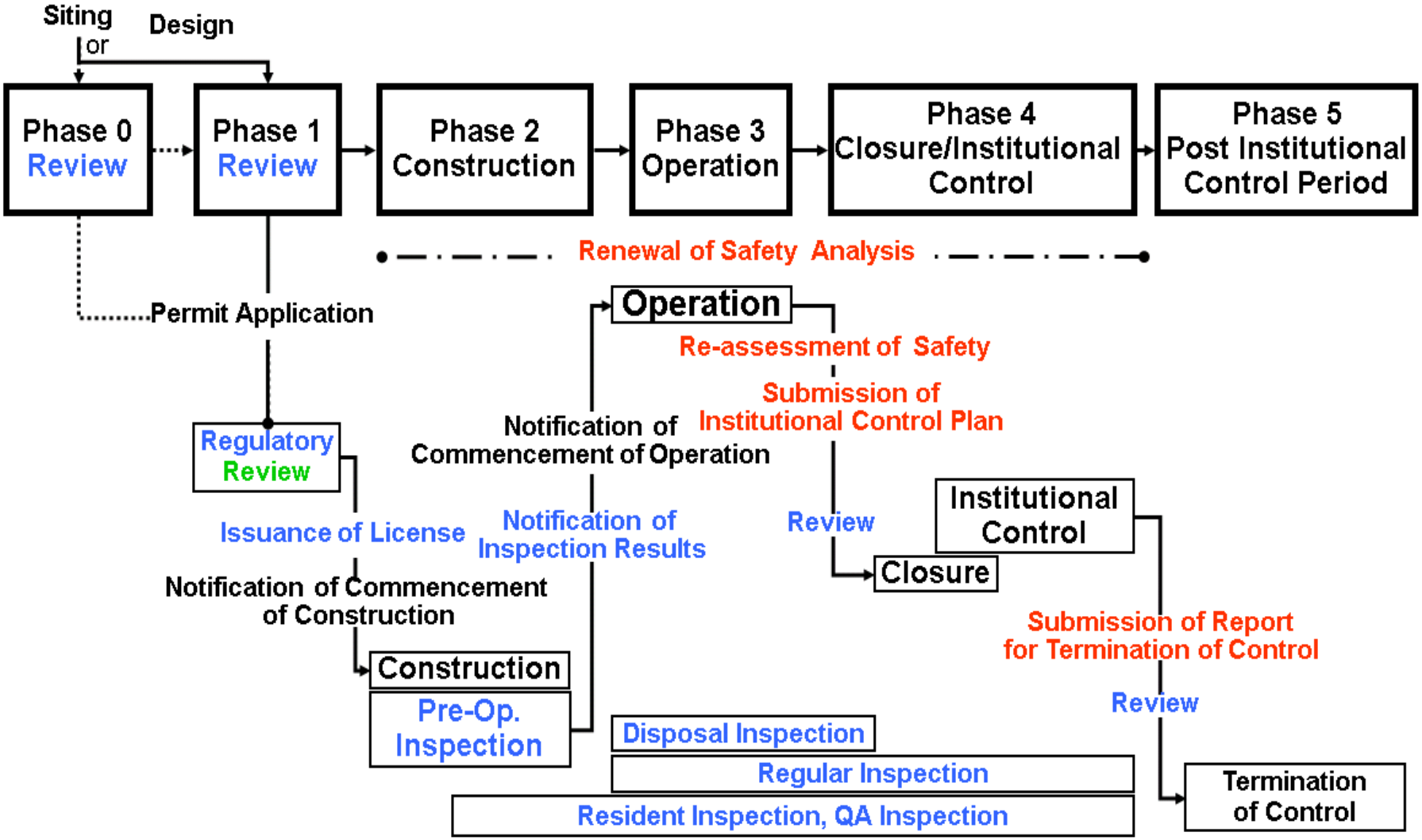
Basic Plan for LILW Management

- Amendment of Basic Plan for LILW management
  - Basic Plan for RW management revised in January 2015
    - Plan of operation for the 1st phase facility of WLDC (from 2015)
    - Plan of construction for the 2nd phase facility of WLDC (by 2019)
    - Exclusion of basic plan for SF management in this amendment

      → Because public engagement activities were in progress at that time.

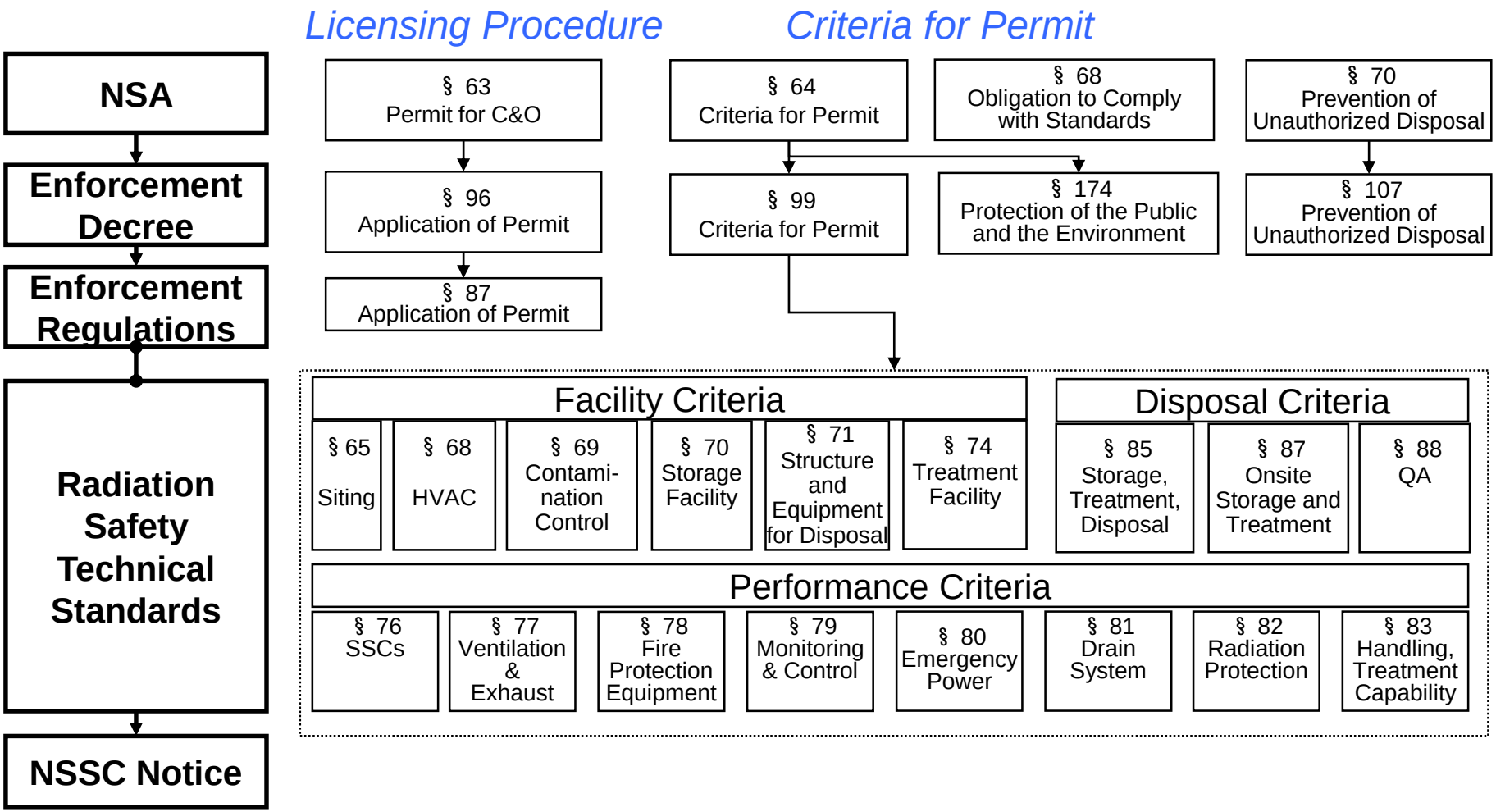
Regulation for Disposal Facility

Stepwise regulatory procedure



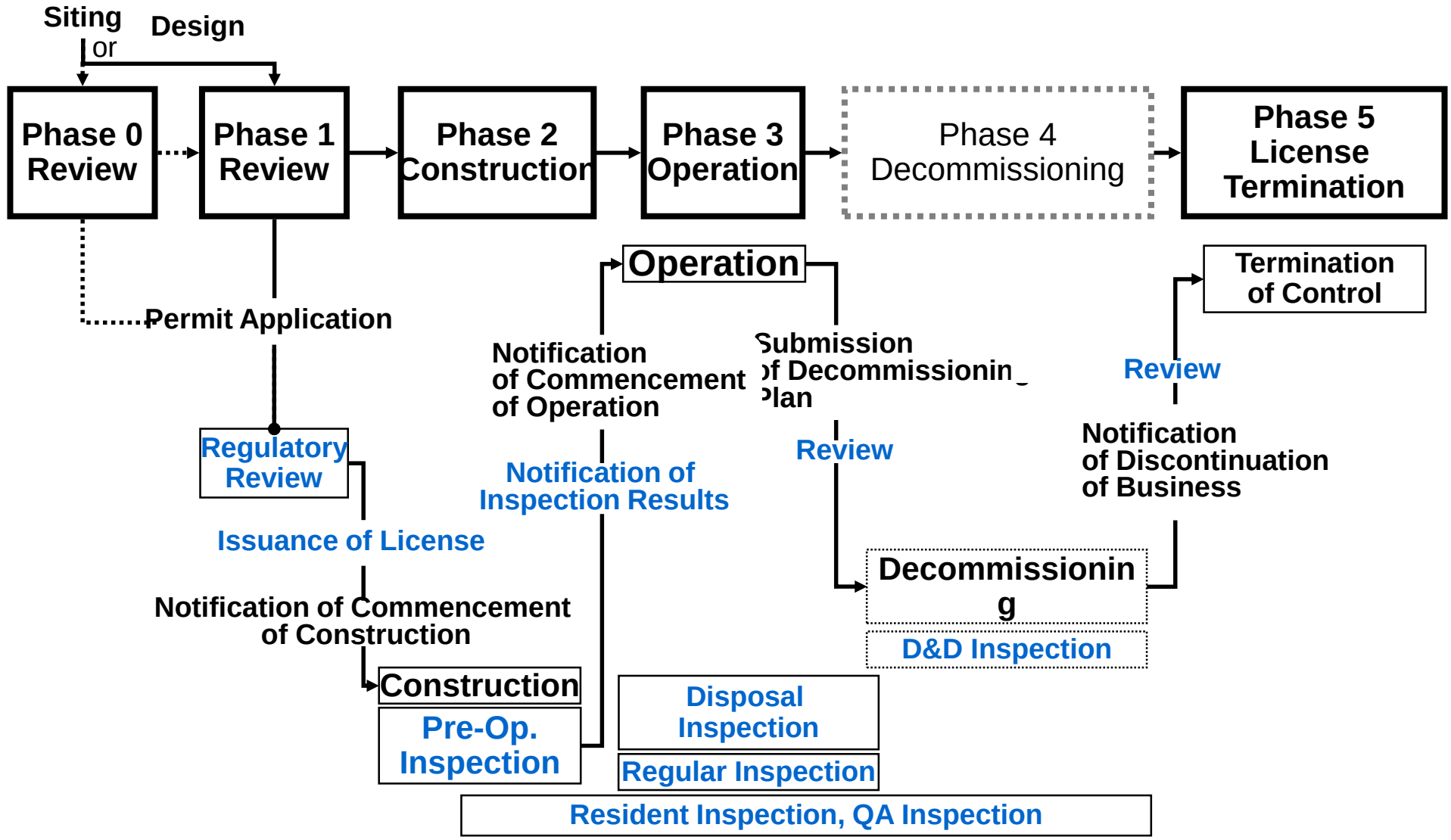
Regulation for Disposal Facility

Regulatory framework



Regulation for Interim Storage of SNF

Stepwise regulatory procedure



Current Satus of Construction of the 2nd phase of Disposal Facility

- PHASED CONSTRUCTION PLAN OF WLDC

Phase3 Near Surface Trench-type(planning)

- Capacity : 160,000 drums (52,640 m^3)
- Site area : 25,118m^2 (Max 260,000 drums)
- Disposal target : VLLW
- Duration : 8years(`19.1.~`26.12.)
- Total Cost : 157.3 Billion KRW($16 million)

Phase2 Engineered Vault-type (in progress)

- Capacity : 125,000 drums (32,875 m^3)
- Site area : 67,490m^2(Max 250,000 drums)
- Disposal target : LLW
- Duration :11years(`12.1.~`23.12.)
- Total Cost : 257.1 Billion KRW($26 million)

Phase1 Underground Silo-type (operating)

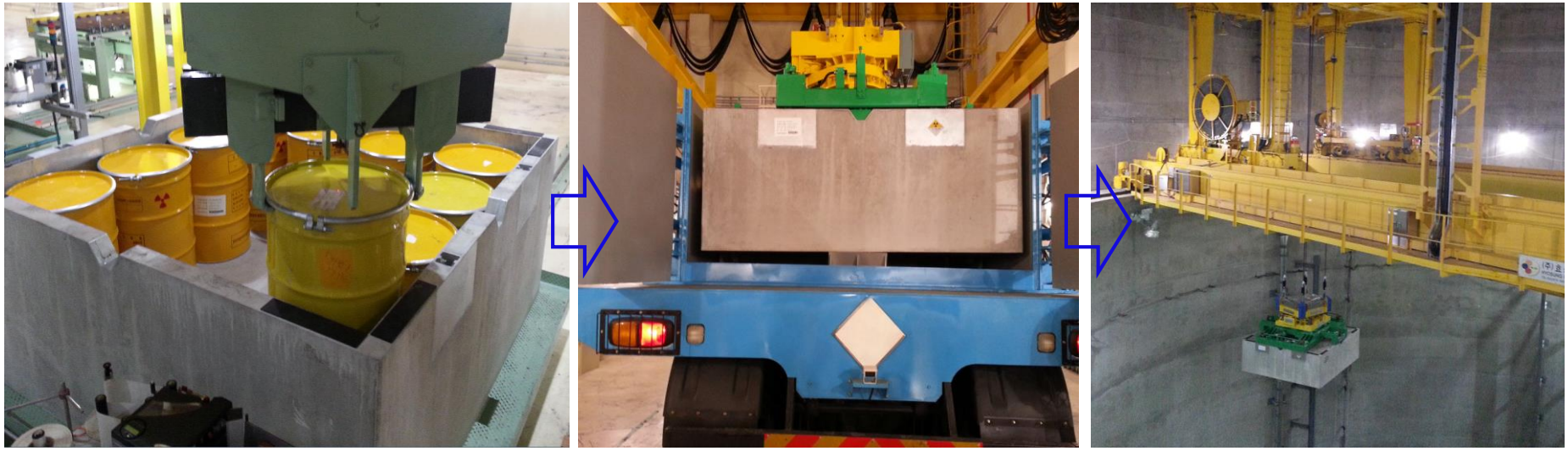
- Capacity : 100,000 drums (35,200 m^3)
- Site area : 206ha(Total area of WLDC)
- Disposal target : LILW
- Duration : 9years(`06.1.~`14.12.)
- Total Cost : 1.5 Trillion KRW($1.5 Billion)

Commissioning Wolsong LILW Disposal Center

- Completion of construction of WLDC
  - CP and OL issued in July 2008
  - Construction period: August 2008 – June 2014 (about 71 months)
  - Pre-operational test conducted from July to December 2014
  - Approval of operation from NSSC in December 2014

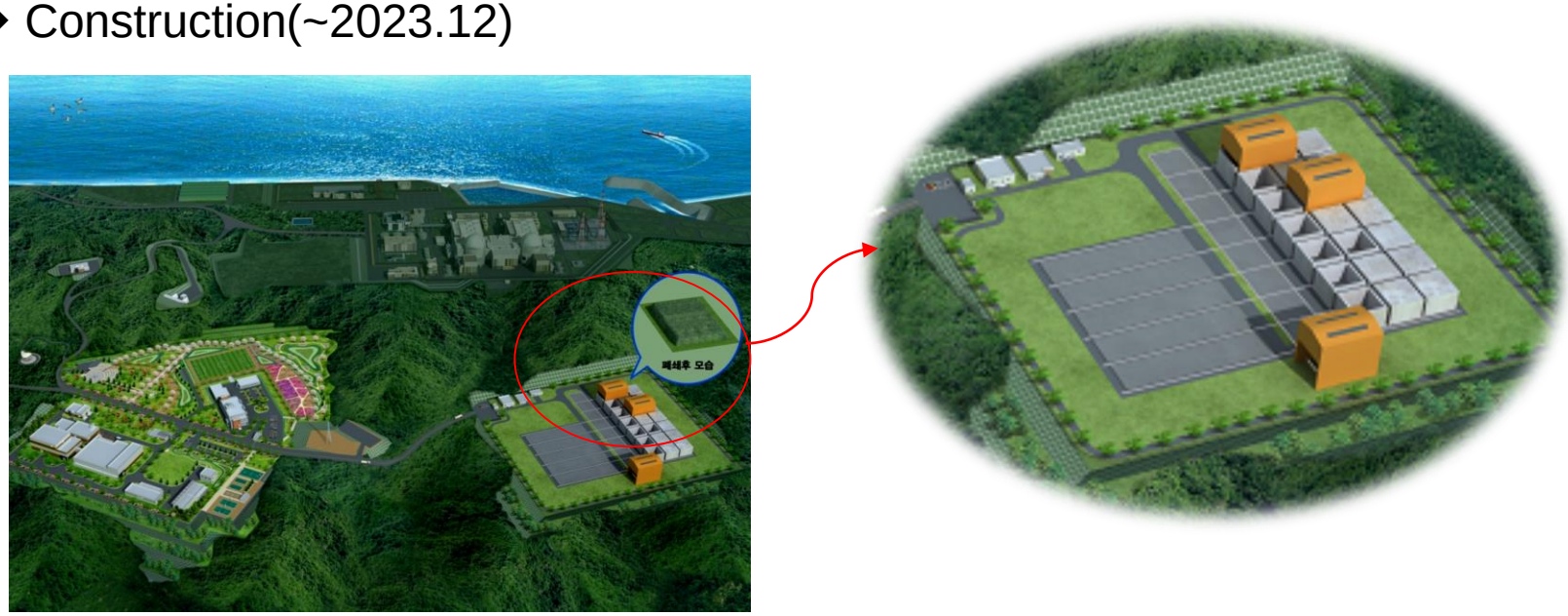
    → after passed pre-operational inspection and implemented a follow-up program prior to operation

- The emplacement of waste package has started in July 2015.



Development of the 2nd Phase of WLDC

- KORAD's Development Plan for the 2nd Phase of WLDC
  - Location: Site of WLDC
  - Disposal capacity: 125,000 drums (200L drum equivalents)
  - Disposal type: Engineered shallow land disposal
  - Time schedule (based on KORAD's Plan)
    - Site investigation: Jan. 2012 – Aug. 2015
    - Application of CP/OL: Nov. 2015
  - CP and OL issued in July 2022
  - Construction(~2023.12)



Dedicated transport ship for LILW

- **Name:** Cheong-Jeong Noori
- **Purpose: Sea Transport of LILW packages**
- **Design Specifications**
  - Applicable Codes and Standards: IMO-INF Level II, NSSC Notice , etc.
  - Dead weight tonnage: 950 ton (~ 1,000 Packages of 200 or 320L Drums)
  - Length: ~ 78 m
  - Width: ~ 16 m

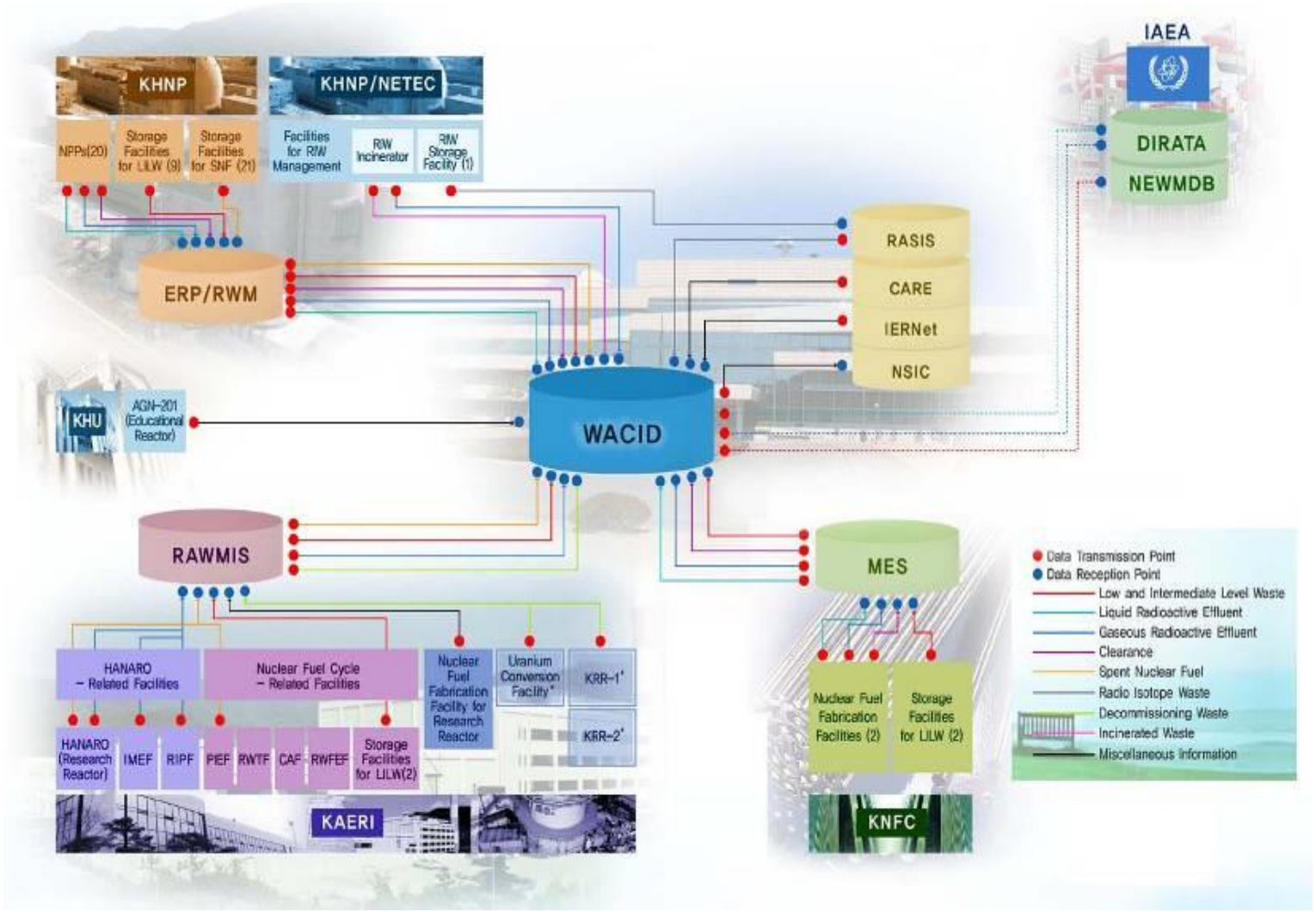
LILW transport container

- Type: IP-2
- **Applicable Codes and Standards: NSA and subsequent transport regulations, IAEA Safety Requirement No.TS-R-1**
- **Design Specifications**
  - Capacity: 8 Drums of 200L or 320L LILW Package
  - Dimension: 3.4m×1.6m×1.2m (H)
  - Weight: 3.1 ton (empty)
  - Load Limit: 6.5 ton (including Waste Packages)
  - Max. Permissible Activity: $100A_2$ / vessel
  - Max. Permissible Dose Rate:
    - 2 mSv/h at surface
    - 0.1 mSv/h at 2m-distance

RW inventory database

WAste Comprehensive Information Database (WACID)

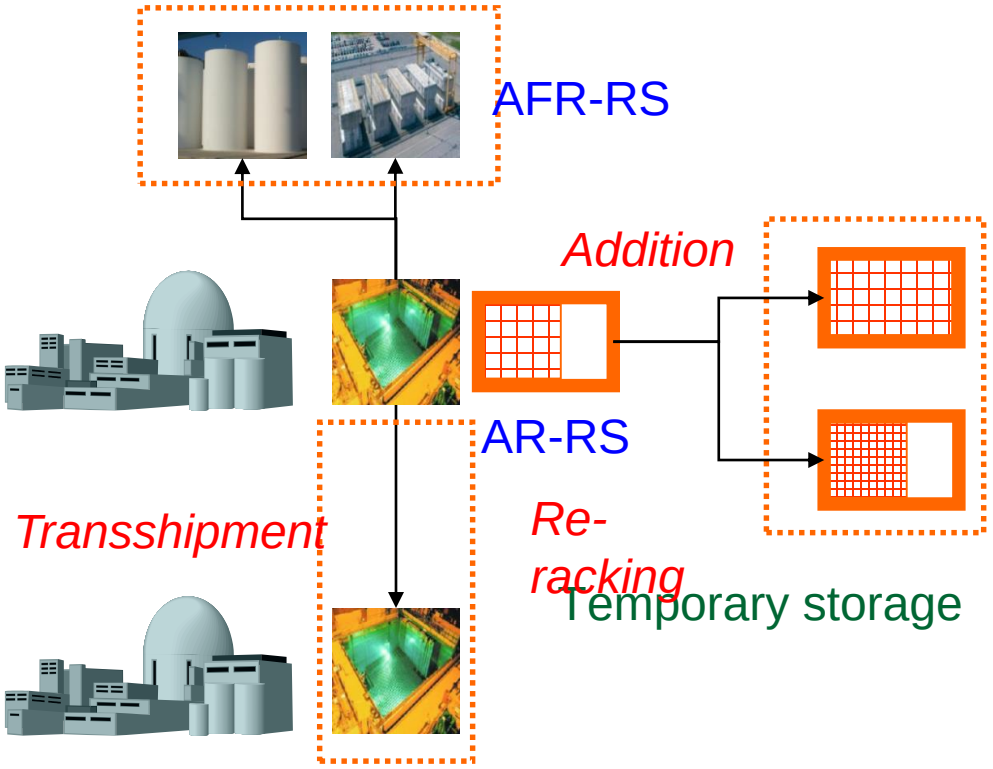
wacid.kins.re.kr



Actions to Secure Storage Capacity for SF

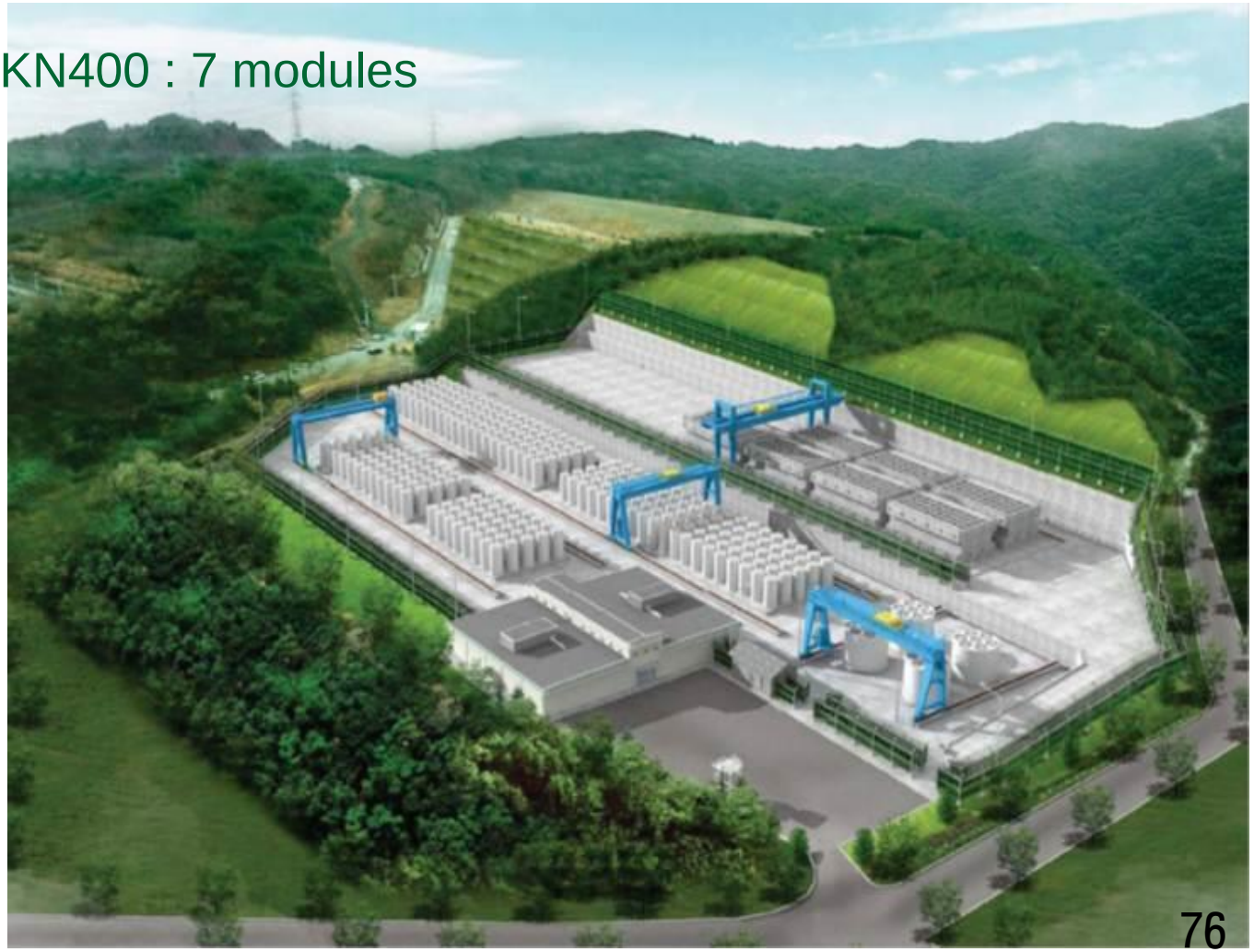
- PWR: expanded by re-racking and transshipment to other units
- PHWR: dry storage facility(300 Silo) since 1991 and the 7 modules of dry storage facility (MACSTOR/KN-400) since 2010 on site

NPP Site	Measures
Kori	Unit 1 and 2: Transshipment Unit 3 and 4: Addition and Re-racking
Hanbit (Yonggwang)	Unit 1: Addition and Re-racking Unit 2: Addition Unit 3 and 4: Re-racking Unit 5 and 6: Re-racking is planned in 2012
Hanul (Ulchin)	Unit 1 and 2: Transshipment Unit 1 to 4: Re-racking Unit 5 and 6: Re-racking is planned in 2013
Wolsong (PHWR)	AFR-RS Dry Storage: Silos and Vaults



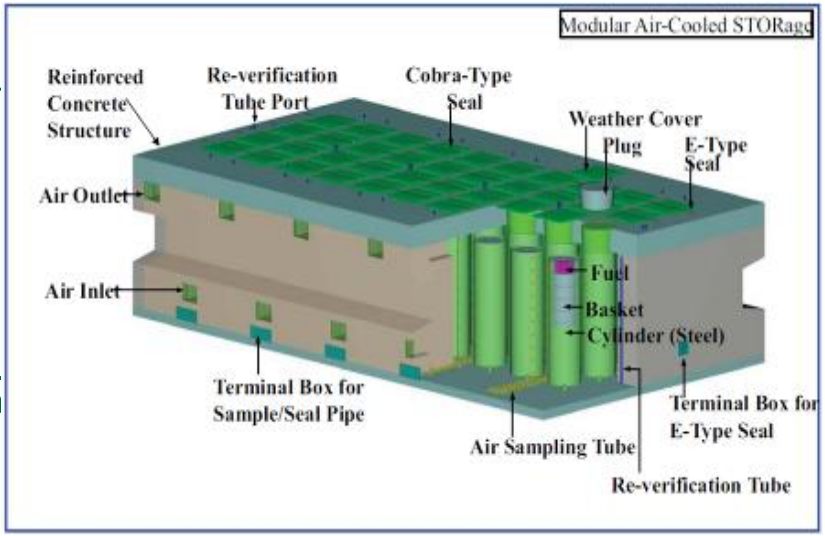
Actions to Secure Storage Capacity for PHWR SF

- Dry Storage for PHWR Spent Fuel – Silo & Vault
  - Silo : 300 units
  - MACSTOR/KN400 : 7 modules



Actions to Secure Storage Capacity for PHWR SF

- Silo
  - 300 units of silos
  - 9 fuel baskets per silo
  - 60 bundles per basket
- MACSTOR/KN-400
  - Capacity
    - 7 modules (24,000 bundles per modu
    - 40 cylinders (4×10 array) per modul
    - 10 fuel basket per cylinder
    - 60 bundles per basket
  - constructed since September 200
  - started operation in 2010



Safety First KINS,
trusted by the public

Thank You

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