Safety Problems of Disposal of Disused Sealed Sources in the Baldone Near Surface Repository

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"**Safety Considerations of Disposal Disused Sealed Sources Near in Surface Disposal Facilities**"

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Prevalence of disused sealed sources(DSS) in the Baldone repository

- **Current Latvian regulations encourage re-export of DSS, however, up to now in the repository has been disposed a lot of DSS**
- Baldone repository has received RW (mainly –DSS) from ~300 Latvia objects; and from Kaliningrad region (from 1964 to 1973)
- In Latvia like as in other countries **earlier** was **allowed DSS disposal** in **near-surface** facilities
- DSS cause **major** part of **activity** of the repository

on 01.2003: -**total activity** in facility – ~ **400 TBq**

-**total activity of DSS** - above **300 TBq**

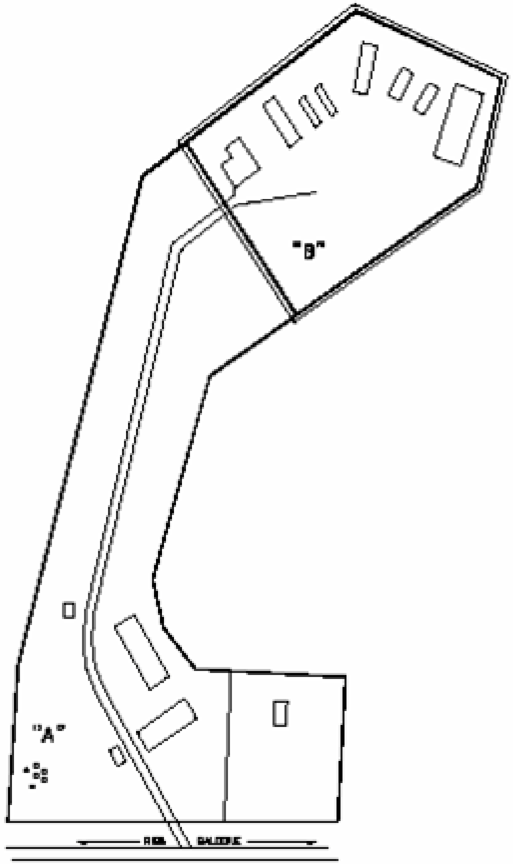
Safety assessment (SA) of Baldone repository

- **Although the practice of near-surface disposal of DSS was internationally accepted, there is a concern on the presence of DSS in the Baldone near-surface repository**
- **In 2000-2001: long term SA of the Baldone *Radon*-type near surface disposal facility performed by consortium *CASSIOPEE*:**
  ***ANDRA* - France, *COVRA* - Netherlands, *DBE* - Germany, *ENRESA* – Spain, *NIREX* – UK, *ONDRAF/NIRAS* - Belgium**
- **recommendations of this SA - as the basic guide for the current RW Management in Latvia**

Waste Disposal System

- **Vaults 1-6 – closed, as permanent disposal site, vault 7 – as a long-term retrievable storage site**
- **2 main components** of the **engineered barriers:** the **capping system** and the **vaults**.
- **Vaults 1** and **3-6** - of prefabricated **concrete** elements, **closed** with reinforced **concrete slabs, covered** with hydroisolating layer completed by a sand/ soil layer.
- The vault No.**7** - of **ten 130 m³** underground concrete walled storage **cells,** protected from the weather by building
- These **10** underground storage **cells** are **adjacent** (**2x5**); **additional concrete walls** in some of them. The cells are covered by 40cm concrete slabs placed side to side.

Schematic layout of the Baldone RW repository



Currently operating vault (Nr.7)

Schematic plan of Vault No.7

1.LRW collection

2.Storage of biol.RW

3.Storage of cemented LRW

4.Prelim.treat.&stor.of all RW

5. Storage of low-A sealed α,β,γ

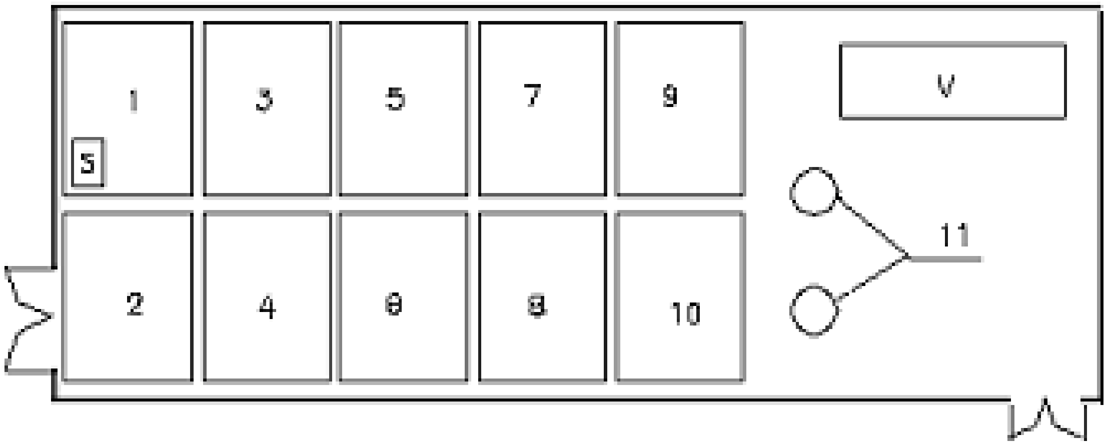
6.Stor.of contamin.mater.,equipm

7.Stor.of lon-liv.nuc.:Pu,Ra,..

8.Stor.of high-act-ty β,γ- sourc

9.Stor.of high-A Co-60,Cs-137

10.Interim stor.of spent sourc



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Assessment Context (1) – Purpose of SA

To provide advice Latvian authorities on safety enhancements and WAC for the Baldone near surface RW disposal site:

- Development of the short and long-term safety analysis of the Baldone repository,
- The planned increasing of capacity for disposal and long term storage
- The radiological analysis for the post-closure period
- Proposal of recommendations for WAC updating
- Recommendations for safety upgrades to the facility.

Assessment Context (2) – Regulatory framework

1. National Regulations:

- *on Protection against Ionizing Radiation*
- *on Activities with Radioactive Waste*

2. IAEA, ICRP, EU Standards & Principles

- ***The Justification Principle,***
- ***The Optimization of Protection Principle***
- ***The Principle of Dose Limitation***

3. **The reference level** for RW practices

– 0,3 mSv/y

Assessment Context (3) - Timeframes

- Supervision period (300 y) considered as assumption in definition of scenarios.
- The exposure doses must be assessed for time 1000y (Regulations on activities with RW)
- 3 different situations with inventory:
- With the current inventory - 'Current Status'
- 'Intermediate Closure Status' – with the mitigation effect of cover
- 'Closure Status' - RW that might be produced over the next years, + The effect of the cover

Evaluations of radiological impact - for both the short and long term: for water pathway – also 30,100, 500, 750 & 1250 years after closure

Assessment Context (4)

In the SA was used **Conservative** approach:

- the **waste** and the **barriers** (except the vault walls) – as totally degraded
- **distribution of nuclides** in each vault is **uniform**
- **complete destruction** of the reinforced concrete slab (cover), **no protection** due to real status and thickness of the cover
- for the **water** pathway the scenario used in this SA is derived from **the worst-case RESRAD** scenarios– the **“family-farm**”

Reduced Uncertainties in the course of SA

- In the course of iterative stages of this SA there appeared necessity to acquire more complete information about several items, mainly – about:
  - additional information on forthcoming activities
  - more precise information about waste inventory

Development of Scenarios

1 of traditional approaches in air-pathway Scenario Generation - to choose following scenarios:

- Construction of roads
- Construction of dwelling houses
- Airplane crush
- Seismic activities

Scenario selection

- the aeroplane crash with disruption of engineering barriers - unlikely - small area of the repository, the **airplane crash** scenario was **excluded**
- **seismic** scenario was **excluded** - insufficient data for calculations

General assessment: due to rather small size of Baldone repository, the road construction and residence scenarios are less relevant for this site than the playground scenario

The chosen scenarios - air pathway

The studied **air-**scenarios constituted two sets:

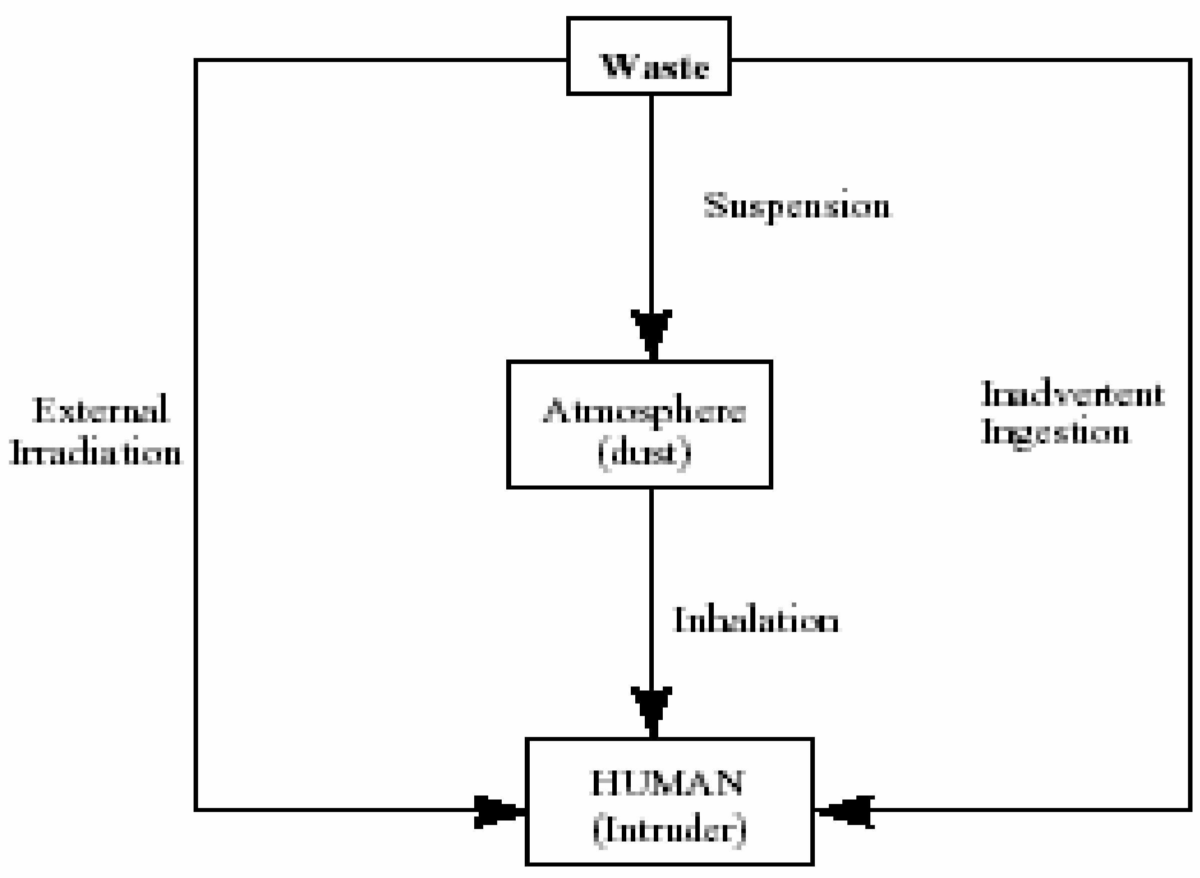
i) the **reference** scenarios derived from **national** regulations:

- the road construction scenario
- the on-site residence scenario, with reinforced concrete slab on the top-side;

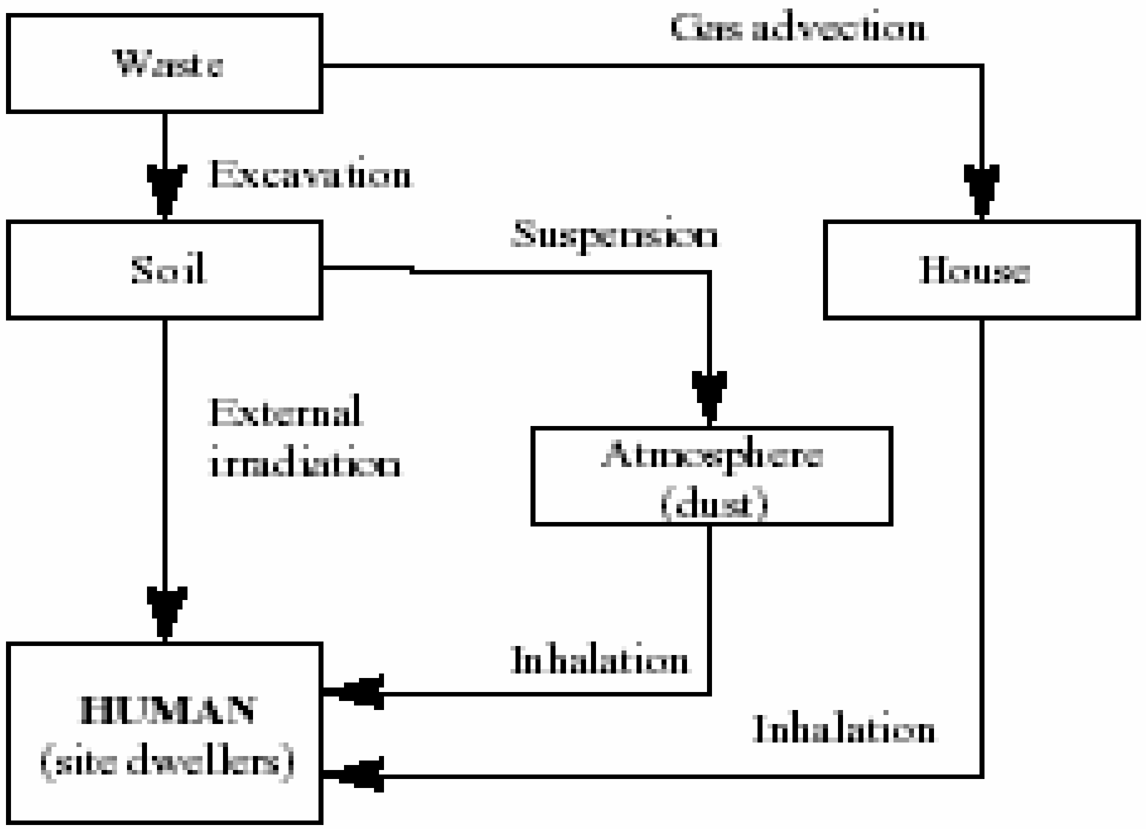
ii) scenarios derived from "**western**" experience:

- the on-site residence with **slab destruction**,
- playground with the slab destruction.

Simplified conceptual model for Road construction scenario



Simplified conceptual model for On-Site Residence Scenario



Mathematical and computer models

- Due to the short exposure distance (1 m adult, 0.5 m children) in comparison with the source term (Excavated surface for road construct.), in all air pathway scenarios, the exposed waste is assumed as infinite slab source
- For inhalation & ingestion – Excel spread/sheet
- For external exposure doses – combination of Excel spread/sheet and the Microshield software.

Computer model validation

Verification & validation of the *Microshield* software was conducted in conformance with Grove's Engineering QA Program implementing the requirements of 10 CFR 50 Appendix B (American Code of Federal Regulations)

Water pathway -“family-farm” scenario **- validity of using RESRAD code**

- **Selection of conservative “family-farm”** scenario **– due to the choice of biosphere pathways, giving:**
  - **- high consumption** of self-produced **water & food**
  - **- outside** activities as **higher risk source** of **exposure**
- **Allows application of the “family-farm” via adjusting scenario parameters for calculation of nuclide transport through the source term and migration through soils**
- **Provides a method suitable for evaluation of the applicable horizontal & vertical dilution factors: take into account the off-site location of the well**

The main Causes of Uncertainties in the results

- The ***model uncertainties***:
  - a uniform distribution of nuclides – instead of the real inventory with a lot of seal sources in their shielding
  - in the road construction scenario: it's not possible to design a road meeting all vaults (as in conservative scenario)
- The ***parameter uncertainties***:
  - in existing nuclide inventory (i.e., Pu-238, .)
  - vault topography
  - in the foreseen waste amount from Salaspils RR decommissioning

Surmount of limitations imposed by having little/no information/data

- *For* ***System Description*** – inventory,.. - **overestimated values** (at least for certain nuclides) were used – conservative upper bound estimates
- *for* ***parameters in mathematical models*** -the default values proposed by RESRAD were taken (partit.coef. **K_d,...**). For **Al** the **K_d**-value was calculated using several particular proposals.
- **conservative** approach in **evaluation of natural discharge in surface waters**:
  - consider pumping of groundwater for human needs at 1000 m downwards from the repository

Results of SA (I): Conclusions from Water Pathway scenarios

- The current status, or the Baldone status in the **very short term**, is not matter of concern.
- The resulting doses - ~**4 mSv/y at 30 y** in the current status without cover, **justify** the **implantation** of a **cover for** the **closure** period of the repository;
- Building of a cover is recommended for the closure of the Baldone repository;

Results of SA (II): Conclusions from Air Pathway scenarios

- The basic dose target 1 mSv/y (for public) is not satisfied for all scenarios;
- The **origin** of higher doses – vaults N 3 and N 7 (with the **highest content** of **DSS**)
- The resulting effective **dose** for the on-site **"Western" residental** scenario

  - from **vault 3 – 303 mSv/y**

  - from **vault 7 - 204 mSv/y**

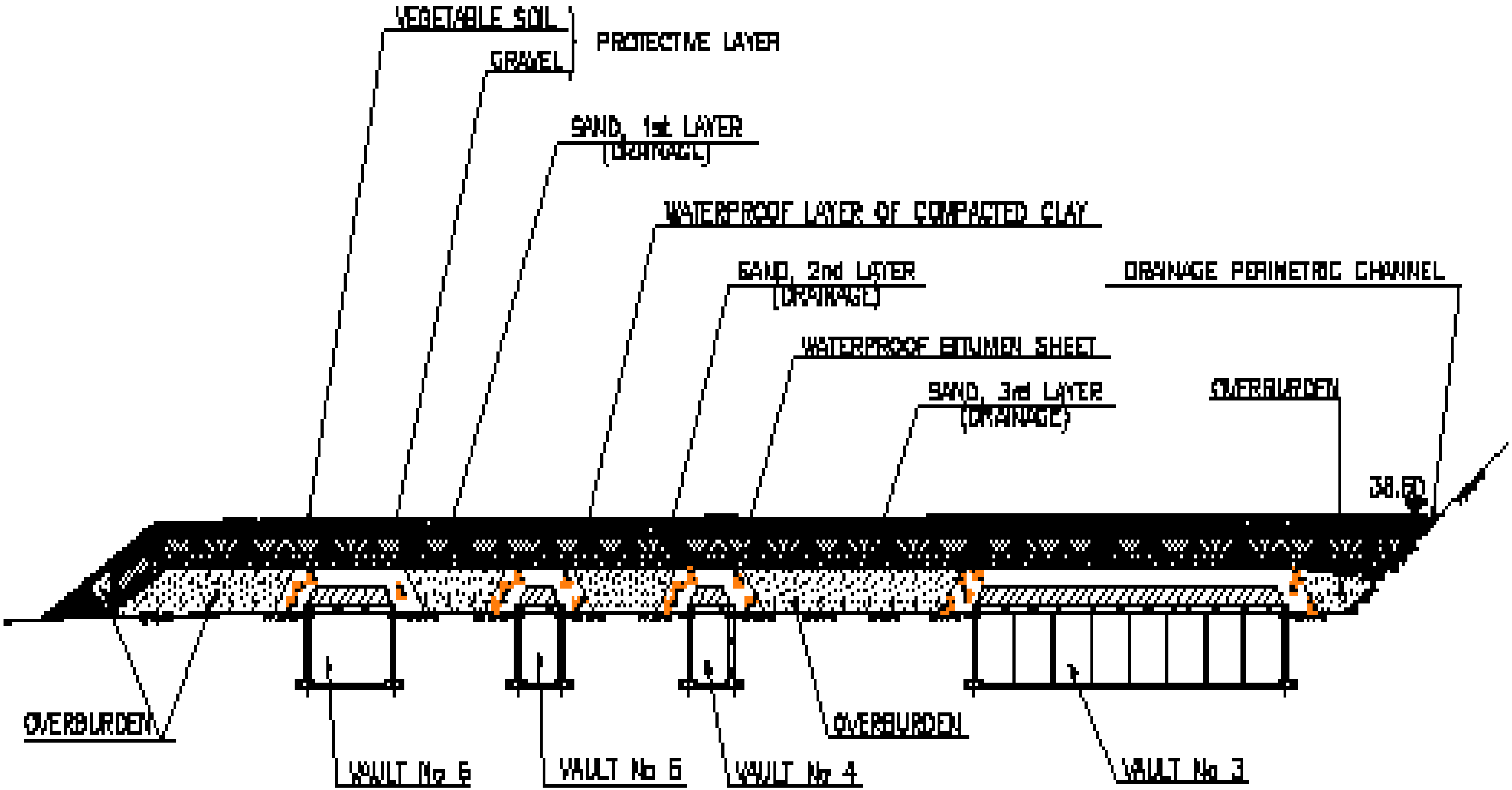
Main Recommendations of the SA

1. **General** Advice – to dispose sources with **half-lives < 5,3 y**; **for** the **spent sources** – to build a **new long-term storage**;
2. To **move DSS from** Vault **7 to** the long-term storage;
3. To dispose only those sources **capable to decay** during functioning of disposal site.
4. To revise and update WAC, especially for disused sealed sources
5. To build a 5 m thick cap over the vaults

Recommended structure of cap

- A form layer mainly made of **site local** materials.
- An **impervious** layer, preferred of **clay** with max permeability 10 (-9) m/s and a **min**imum **thickness** 0.5 m.
- A **draining layer** made of gravel or sand.
- A geotextile, to **protect drainage layer** from plugging during the placement of the upper layers.
- An **anti intrusion** layer, mainly - of crushed rock.
- A **topsoil** layer, with rocks in the slopes to provide erosion resistance.

Layout of the **long-term cover**



Analysis & effectiveness of recommended measures(vaults 3,7)

- The radiological impact after removal sources from vault 7 and applying 5m cover remains negligible
- **Removal** of **DSS** from vault **7** and building of **5 m cover** reduces the annual dose: from 204 mSv to 8,3 mSv
- Application of 0,5 m concrete slab over the vault 3 reduces annual dose in the "**Latvian**" **residential** scenario: from 67,8 mSv/y

  to 1% of nSv

Final Conclusions of SA

- To build a new long-term storage space (LTSS) for disused sealed sources (DSS)
- To move DSS from vault 7 to the new LTss
- To build a 5 m thick cover over all vaults
- For the closed vaults with DSS (i.e.,vault 3) to build additional 0,5 m thick upper slab of reinforced concrete
- In existing repository to dispose only those sources capable to decay during repository functioning

Provision of appropriate level of information for future SAs

- further **specification of inventory and site characteristics**,
- literature studies with a purpose to **optimize scenario choice** (with **removal** of **DSS**, **archeol**.activities)
- mathematical models and **choice** from literature **most appropriate parameter data**
- comprehensive and critical **analysis of derived results and existing uncertainties**
- **Requirements on** performing corresponding **SAs** were **developed** in Cabinet **Regulations** No.129 **„Requirements for the practices with RW and related waste"**

Updated WAC in Latvia

On the basis of conclusions of **this SA** have been **updated Waste Acceptance Criteria** and **Requirements**

expressed in the **new** Cabinet **Regulations** (No. 129, **19.03.2002**) ***"On Practices involving Radioactive Waste and related Materials"***

WAC: **problems on DSS disposal**

Activities of **sealed sources in V.7** versus **Regulations**

Nuclide	**Max** permitted act-ty (GBq) in 100cbm volume of a Vault	Max perm.act-ty (GBq) of dis. sealed source	Total actual activity (GBq) in vault 7
Am-241	0,3	0,0003	**18,3**
Cf-252	10	0,0003	**44**
Pu-239	0,3	0,0003	**1000**
Th-232	0,3	0,0002	**0,01**
Co-60	1,00E+13	100	**200 000**
Cs-137	1000	3	**28 000**
Sr-90	100	3	**75**

Updated WAC in Latvia

Activity related criteria (I)

1. In the **near-surface** facility shall be disposed RW which **don’t contain** radionuclides with **half-life > 30 years**.
2. The maximal activity of RW in a package and in a vault for disposal is prescribed in Annex 3 of Cabinet Regulations No. 129.

Updated WAC in Latvia

Activity related criteria (II)

3. Low- and intermediate level RW containing containing only nuclides whose **activity** after the state **supervision period** should have **decreased to** the **Exemption limits** prescribed in Licensing Regulations**.**

4. **RW containing nuclides whose activities after the end of the state supervis. period will > the Exemption limits, if, according to the long-term SA, it is proven that:**

after establishment of the additional layer and the backfilling of voids, the anticipated dose will < 300 μSv/y.

Predisposal packing of DSS

Sealed gamma – according their activity, quantity and size – packed in **1 of 3** ways:

- Emplaced into **steel container** (as **exception** - in industrial containers where DSS were emplaced during their use, by ensuring melting all container's openings and ducts) being emplaced in middle of 0.2 cbm steel drum,
- Packaged into **stainless steel container** filled with steel pellets and emplaced into a special **socket** of reinforced **concrete container**,
- Packaged into stainless steel container filled with steel pellets and emplaced into the middle of 0,2 cbm steel drum, the void space is filled with **melted lead**

Predisposal packing of DSS

II. Sealed **beta–**treated in one of 2 ways:

1. **Emplaced** into **stainless steel or plastic container** (as **exception –** in plastic bags ensuring packaging of **a DSS** in **3 bags simultaneously**), which is **emplaced** into the middle of **0,2** cbm **steel drum**, the **void** space is filled **with concrete**,
2. **Packaged in stainless steel container filled with heated quartz sand and emplaced into a special socket in a reinforced concrete container.**

Predisposal packing of DSS

III. Radium sources **- Ra**-containing sources are treated in such sequence:

- Emplaced in **Cu**-ampule, which is made air-tight,
- The Cu-ampule is emplaced into stainless steel ampule, which is **welded** (as exception, the ampule may be screwed air-tight).

Size & thickness of stainless steel ampule must be sufficient to endure, without damage, the gas pressure from Ra decay

Predisposal packing of DSS

III. Radium sources **– stages 3 & 4** of their packing:

3. The stainless steel ampule is emplaced into a lead container,
4. The lead container is emplaced into the middle of 0,2 cbm steel drum, the void space is filled with concrete.

Method for **Ra-sources** is also applied for **Am**-241 sources

Predisposal packing of DSS

IV. Alpha DSS **(Pu,..; *not Ra*): in one** of **2** ways:

- Are packaged into **stainless steel containers filled with heated quartz sand** and emplaced into special **sockets** in **reinforced concrete container**.
- Are packaged in stainless steel or plastic container. As **exception** - **if activity at the end of supervision period will be < the Exemption limits – may be packaged in at least 3 plastic bags emplaced in the middle of 0,2 cbm steel drum**;

The void space between the bag/container and the drum is filled with concrete.

Predisposal packing of DSS

V. Neutron sources: sequence of packing

- Emplaced in a stainless **steel ampule** which is welded (as **exception-** the ampule may be screwed air-tight).
- Dimensions & thickness of the ampule must be sufficient to **endure the generated gas pressure**,
- The stainless steel **ampule** is **emplaced** into a **lead** container,
- The lead **container** is emplaced into the middle of 0,2 cbm **steel drum**, the void space is filled with concrete.
- Dismounting of Neutron sources occurs in the hot cell. Sometimes the ampules are embedded in paraffin or polyethylene container being stored in isotope storage room of Salaspils RR

Problems and Solutions

Construction of new storage and disposal spaces (I)

1. Strategic aims:

a) To build a *long-term storage* for disused sources that must not be stored in a near-surface repositories;

b) To investigate the possibilities for building of geological repository in Latvia

Depending on b) - the long-term storage space should ensure safe storage of DSS until their activity decay the level for their safe disposal in near-surface RW repository.

Problems and Solutions

Construction of new storage and disposal spaces (II)

- An independent measure: building of additional vault(s) for the existing repository – preferably 2
- The detailed project draft of ***long-term storage space*** for **DSS** is prepared under the PHARE project. After the receipt of the draft, the EIA is performed and the open tender is organised for construction of additional storage vault(s) and the ***long-term storage space*** for **DSS.**
- **Detail drafts for long-term storage space must be prepared by 2004.**

Design Criteria (I) for a Centralised Disused Sealed Source(DSS)Facility

- **Shielding - to ensure that the dose rate at any accessible place < the prescribed value**
- **Additional shielding for containers with high surface dose rates**
- **Proper ventilation - where is a risk of airborne activity, in particular, in the places with a lot of I-125, I-131 and Ra-226 stored,**
- **Fire detection system (photoel. smoke detectors)**
- **Storage areas - as controlled areas, to limit the spread of possible contamination and minimise the workers exposure**

Design Criteria (II) for a Centralised Disused Sealed Source(DSS)Facility

- DSS for **decay storage** be **separated** from DSS **in use,** and from **DSS not suitable for decay storage**
- Regular **monitoring** of **storage areas** for radiation and **contamination** levels (every 6 months). For **Ra**-sources – weekly (monthly) - **Radon monitoring**
- For **safe storage of Ra** sources - **measures**:

 - **High integrity containment** of DSS (robust, gas-tight)
   - Adequate **shielding** of DSS
   - **Physical security**

Records of maintenance be kept - to **permit safe retrieval** for further management,

Physical security of sources – Cabinet Regulations N 508 (2002)

- The user of sources ensures fulfillment of requirements to physical security, in order to prevent unauthorized actions:

diversion, theft of a source, unauthorized use, transfer, transformation & destroying

- Physical security consists of such systems:

1) detection syst., 2) assessment syst.,

3) detaining syst., 3) responding syst.

- Levels of physical security – 4 categories

Management of operating sealed sources

- Due to the fact that Latvian Regulations encourage re-exportation of DSS, the most powerful sources in medicine (teleterapy, blood irradiation) are foreseen to return to producers.
- Currently in Latvia is funtioning a Categorization system of radiation sources with 3 levels – high-, medium- and low-level risk activity, as well as 4 levels of physical security.
- For future management practices is planned to implement the new IAEA Categorization system of sealed sources with 5 levels (TECDOC-1344)

Encourage of DSS re-export (1)

The law **"On Natural Resources Tax**" and the law **"**On Radiation Safety and Nuclear Safety**":**
– in case of import into Latvia of radioactive mat.that, after use generates RW which needs to be disposed in Latvia, **a natural resource tax** is payable on the **import** of such mater**.** The tax payments for import of radioactive mater.shall **not** be paid:

- if purchase contract stipulates the consignment of used radiation sources back to the country origin.

Encourage of DSS re-export (2)

Regulations No. 129 state:

the operator, who plans to import sealed ionizing radiation sources, containing radioactive materials whose radioactivity when using given sources for a period of 10 years will exceed 100 MBq, prior to acquisition of said sealed ionizing radiation sources into possession or tenure, must take all possible measures so that possibility to send back mentioned sealed sources to the producer be specified in the purchase and sales contract or in the grant agreement.

Further work and needed International assistance

- To continue **training** of national experts in **SA methods** for near surface repositories, especially - on the use of **heterogenous** models for safety analysis of DSS disposal.
- To accomplish - with desirable participation / assistance of international experts (option – in the frame of ASAM DSS&HW WG) - **more realistic SA of Baldone near-surface repository**, using proper **heterogenous** models for inventories with prevalence of DSS

Essential specific goals for the forthcoming SA

- To determine the real (optimal) inventory

a) to be disposed (remained) in the vault 7

b) to be removed from the vault 7

- Include scenarios being in Latvian Regulations:

  - **radiological accident by doing actions with RW packages – actual due to the CASSIOPEE recommendation to remove DSS from vault No. 7**

  explosion (due to a diversion act) – a common concern