

Comprehensive Hazard Identification and Monitoring system for Urban Areas



Konference ODPADOVÉ FORUM RADIOAKTIVNÍ ODPADY

The importance of radiation risk quantification and its communication with the population regarding protection against the impacts of radioactive waste

**J. Sabol, D. Dlouhý, J. Nejedlý,
Police Academy of the CR in Prague
Lhotecká 559/7, 143 01 Praha 4
Czech Republic**



Abstract

The paper concerns the provision of adequate **protection for the population** against the potentially adverse **effects of radioactive wastes**. This also includes employees of specialised workplaces involved in the management of such wastes, where the **collection, treatment, fixation, storage and transport** of radioactive wastes, as well as **temporary or permanent storage facilities** must be considered. Throughout this process, **persons handling or in contact** with waste can be exposed to ionising radiation. It is mainly due to external exposure, but in some cases, the surrounding environment may be contaminated, leading to **internal exposure** as well. All radioactive waste operations must comply with applicable **national legislation and international standards**. **Communication of potential risks to the public** plays an important role in ensuring the protection of persons, especially those with no or **limited knowledge of basic radiation protection**. Without sufficient information about the population, the impacts in this field may be **underestimated or overestimated**, leading to unnecessary panic or chaos.

Effective radioactive waste risk communication

Effective radioactive waste risk communication focuses on **building public trust through transparency, engagement, and clear, accessible information**. Key strategies include addressing public concerns, using message mapping **to simplify complex data**, and involving communities in decision-making.

It involves translating complex technical data on radiation risks into **understandable**, actionable messages to address and mitigate public fear. Official risk assessments (based on technical data) often differ from **public perceptions** (based on **fear or lack of knowledge**), requiring communications to bridge this gap by addressing both technical facts and emotional concerns.

Key principles for effective communication

Transparency and Trust: Regulatory bodies must provide open and accessible information, as public trust is crucial and often low regarding nuclear risks.

Targeted Messaging: Communication should be tailored to specific audiences, considering their knowledge, cultural background, and concerns.

Public Engagement: Shift from simply providing information to engaging in two-way dialogue, including focus groups, workshops, and stakeholder consultations.

Message Maps: It is important to use message maps to outline key facts, anticipated questions, and consistent messaging to reduce confusion.

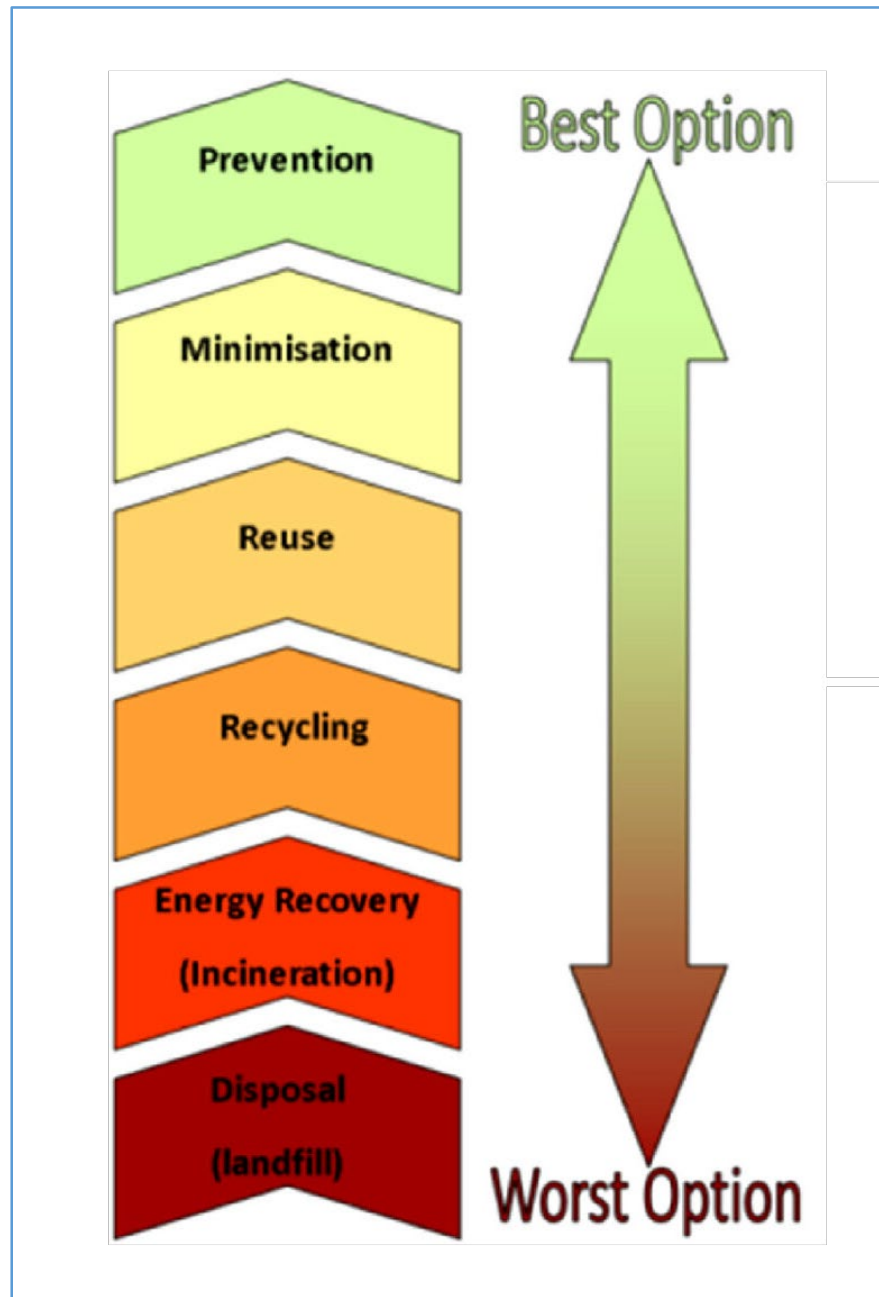
Using Plain Language: Experts are trained to avoid jargon, using simplified terms to explain technical concepts like "radioactive half-life" or "leakage probabilities".

Effective communication

To be trusted, **you must communicate successfully**. To communicate successfully, **you must be trusted**.

The ultimate purpose of risk communication is to enable people at risk to make **informed decisions** to protect themselves and their loved ones.

Risk communication is **a multidimensional, socially and technically complex, and resource-intensive activity**.



Radioactive Waste Management Process



Classification



Treatment and Conditioning



Storage



Transportation

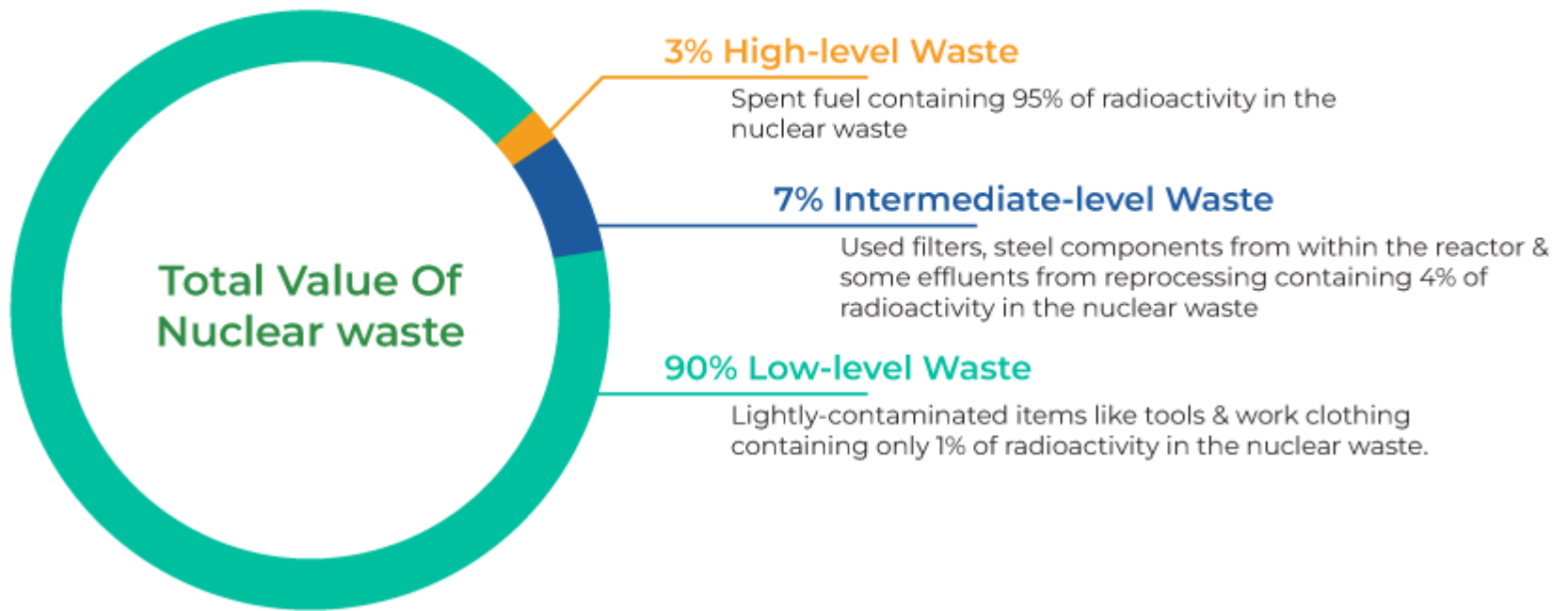


Disposal



Long-Term Monitoring

Types of Nuclear Waste



Total Value Of Nuclear waste

3% High-level Waste

Spent fuel containing 95% of radioactivity in the nuclear waste

7% Intermediate-level Waste

Used filters, steel components from within the reactor & some effluents from reprocessing containing 4% of radioactivity in the nuclear waste

90% Low-level Waste

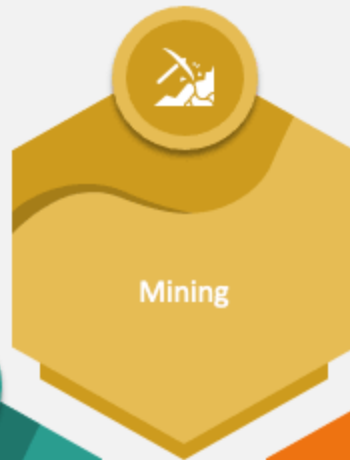
Lightly-contaminated items like tools & work clothing containing only 1% of radioactivity in the nuclear waste.

RADIATION POLLUTION

Sources of Radiation Pollution



Nuclear
Accidents



Mining



Defensive Weapon
Production



Nuclear Explosions
& Detonations of
Nuclear Weapons



Nuclear Waste
Handling and
Disposal

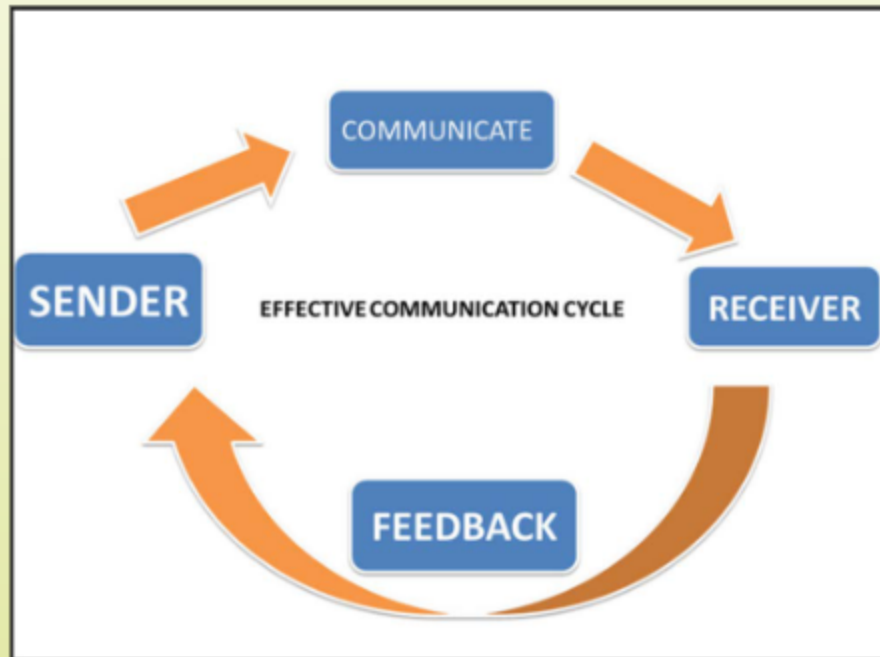
Radioactive waste: Possible impacts

Any close **contact with radioactive materials**, inhalation of contaminated air, or ingestion of contaminated food may result in radiation exposure for the persons involved. Work involving any radiation sources or substances containing radioactive materials should be carried out in accordance with strict **safety and security requirements** consistent with national and international standards. Under normal conditions, the **main aim of radiation protection** is to minimise the impact of radiation on exposed persons' health. In this case, the exposure must not exceed the regulatory dose limits.

The other target of radiation protection is **to prevent any accident** which may lead to overexposure. If such a situation occurs, all possible measures should be taken **to minimise the impact of radiation exposure** and return the situation back to normal, controllable conditions.

Communication

Communication is simply the act of transferring information from one place to another.

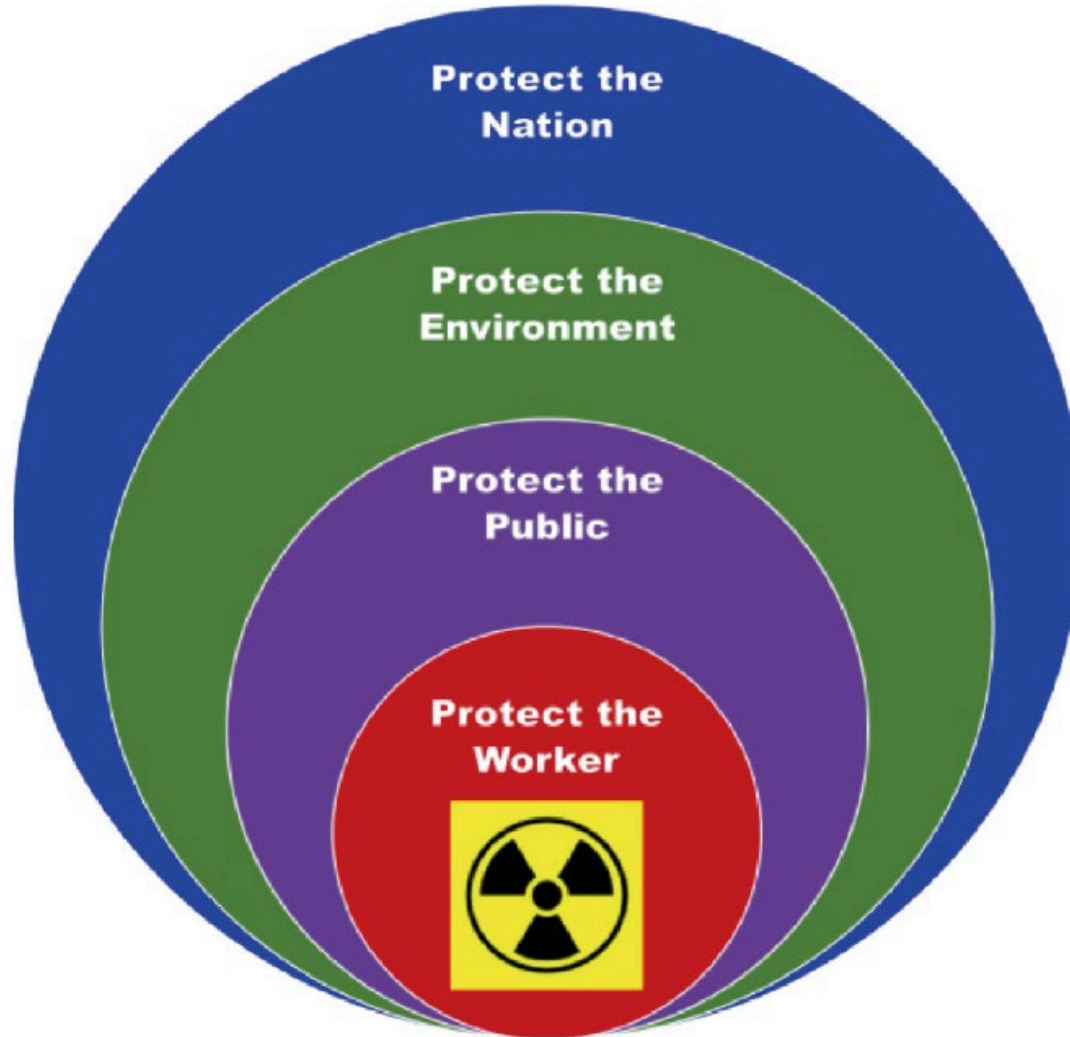


Radiation risk quantification

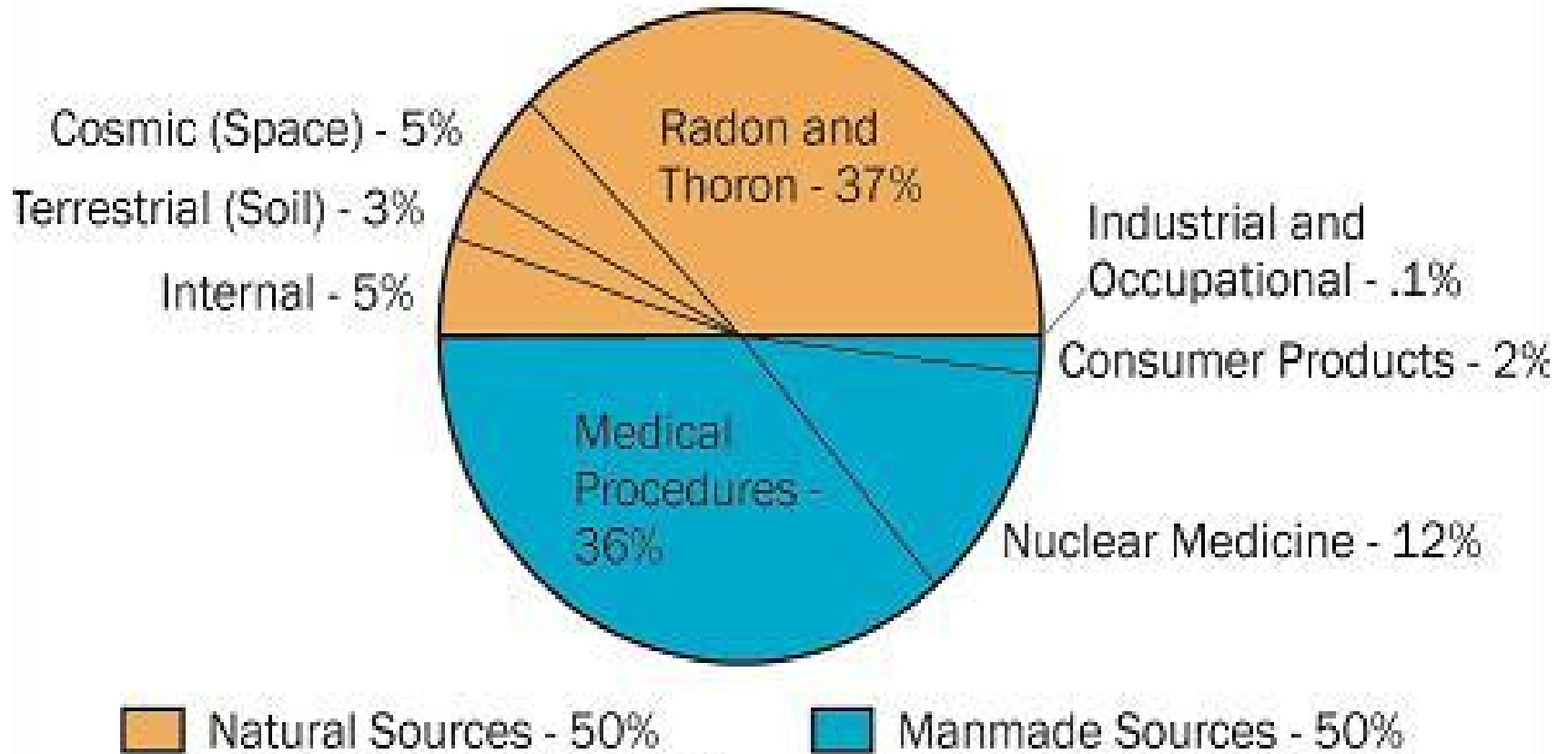
Risks of exposure to radioactive waste arise from **radiation emitted by radionuclides** present in the waste. These exposures may result in health effects, including both **stochastic** (probabilistic) effects at low doses and **deterministic** (tissue reactions) effects at doses above a certain threshold level.

In general, in the case of **CBRN (Chemical, Biological, Radiological, Nuclear) agents**, the risk due to radiation emitted by radionuclides is much better known and quantified than it is in the case of C or B components. This is mainly because great attention was paid in the past to **radioactive and nuclear sources**, reflecting the interest in this area, which was influenced mainly by events and applications of the relevant technologies.

Protection hierarchy



Sources of radiation exposure



EXPOSURE TO NATURAL AND ARTIFICIAL RADIATION



2.4 mSv /year Natural radioactivity (global average)



1 mSv /session Chest X-ray

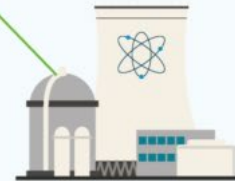


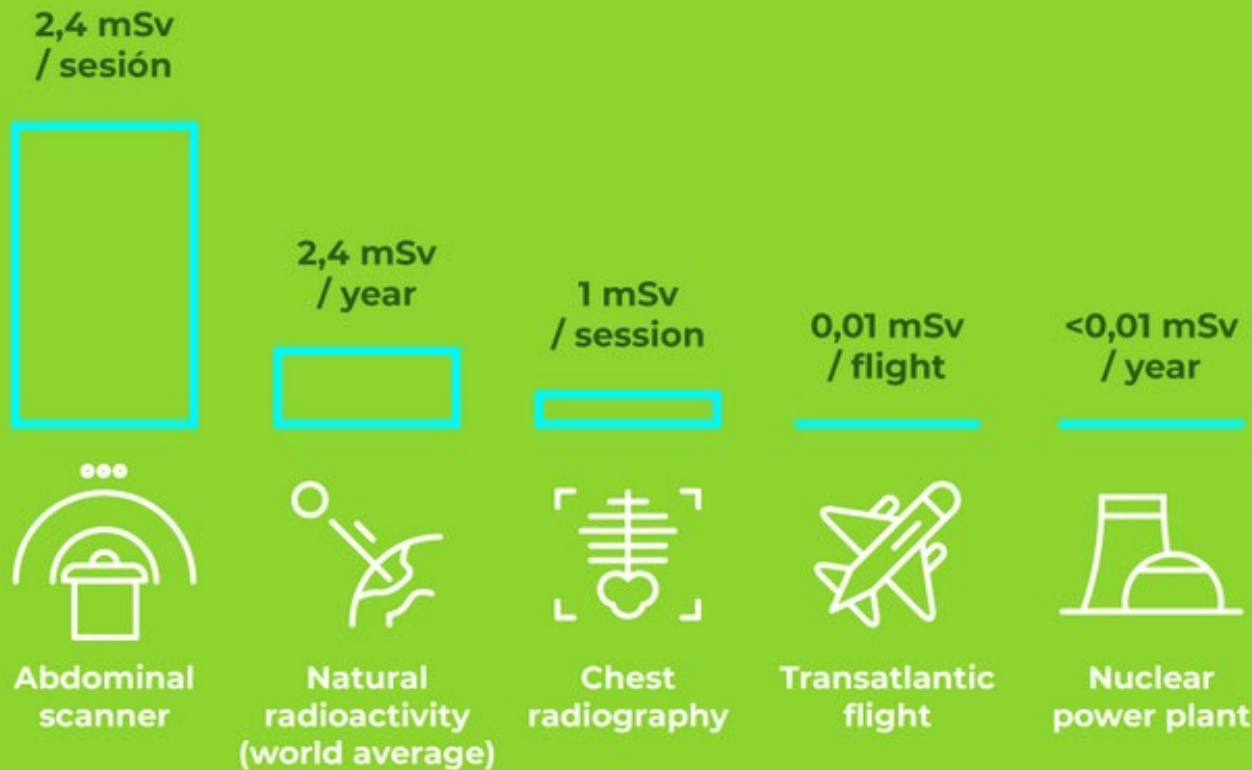
2.4 mSv /session Abdominal CT scan



0.01 mSv /flight Transatlantic flight

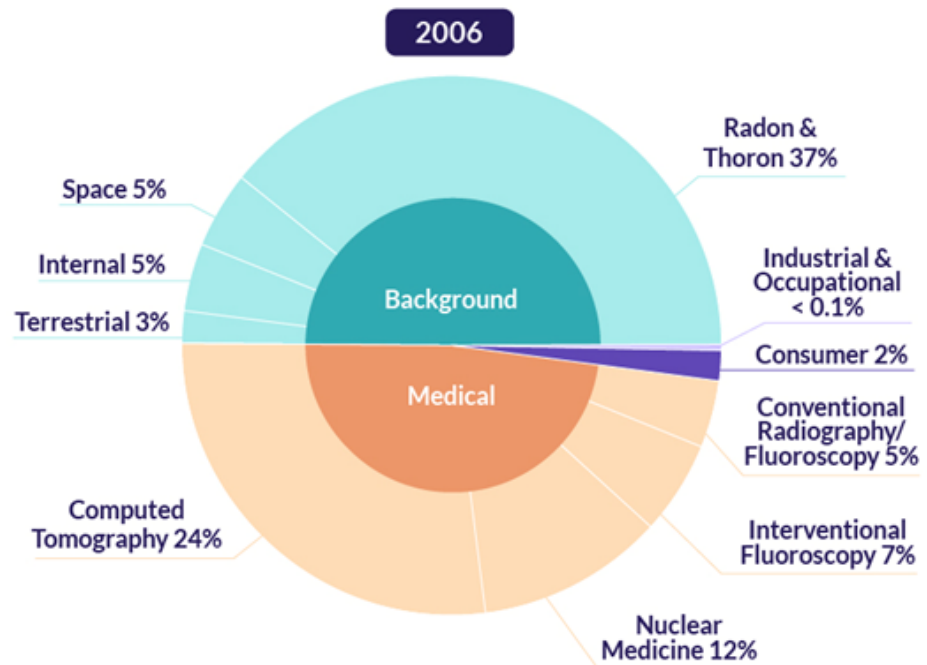
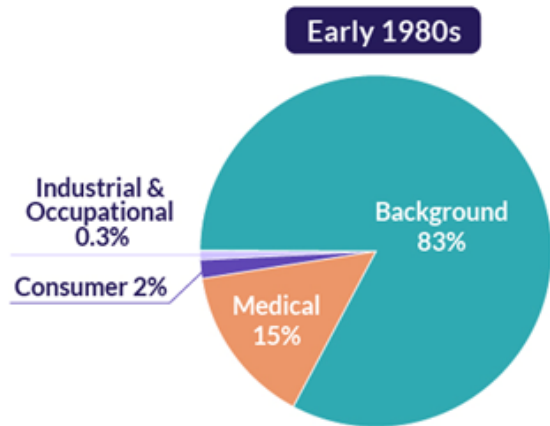
<0.01 mSv per year Nuclear power plant





A person's exposure index to radiation in a nuclear power plant over one year is lower than what is received during a transatlantic flight

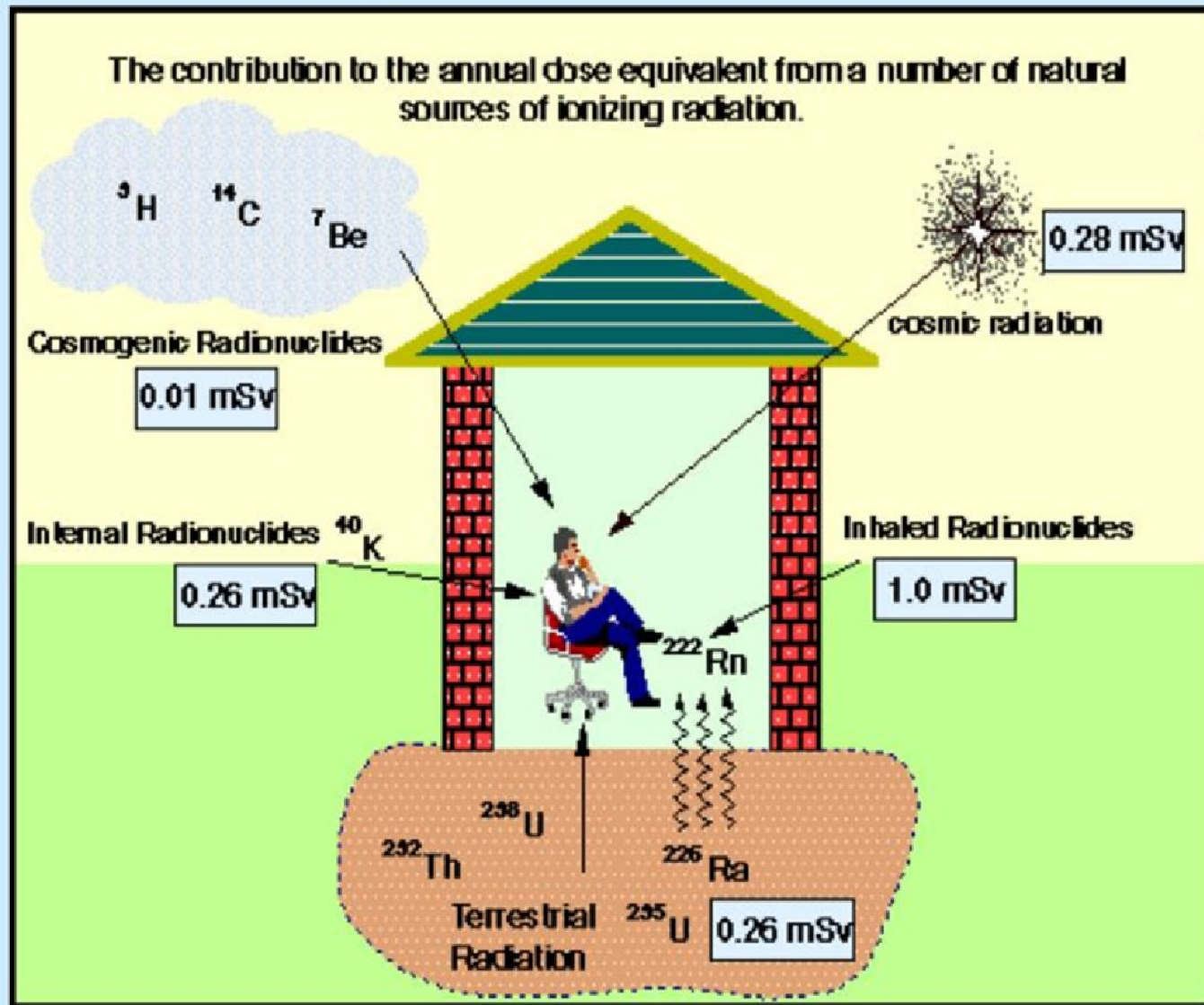
Breakdown of exposure of the population of the United States to ionizing radiation in early 1980s and in 2006



	Early 1980s	2006
Collective effective dose (person-Sv)	835,000	1,870,000
Effective dose per individual in the U.S. population (mSv)	3.6	6.2

Source: National Council on Radiation Protection and Measurements, 2009

Radiační pozadí



PATHWAYS OF EXPOSURE



WASTE

- MOST WASTE IS NOT REGULATED
- SOME HIGH LEVEL RADIOACTIVE
- BOTH SOLID & LIQUID WASTE
- CONTAINS HIGH LEVELS OF RADIOACTIVE SUBSTANCES
- LIQUID WASTE IS SOLIDIFIED IN ORDER TO IMPROVE WASTE
- THE BACKFILL OF SOLID WASTE IS SENT TO MUNICIPAL LANDFILLS
- WASTE IS BARRICADED BY SPACED TRUCKS

LANDFILL BARRIER
SANDSTONE OR CLAY
ATTACHED TO RAIN OR MIST

RADIOACTIVE LEAD PARTICLES

RADON GAS

MUNICIPAL LANDFILL

LEACHATE

- LANDFILL LEACHATE IS SENT TO MUNICIPAL WASTEWATER TREATMENT PLANTS WHO STRUGGLE TO REMOVE THE ABILITY TO REMOVE RADIOACTIVE SUBSTANCES
- RADON IS HIGHLY WATER SOLUBLE
- "HEAVY" METALS IS RELEASED INTO RIVERS WHICH WE RELY ON FOR DRINKING WATER, RECREATION, AND FISH



DRILLING

- DRILLING BEINGS NATURALLY OCCURRING RADIOACTIVE MATERIALS TO THE SURFACE
- MUST BE COVERED BUT LEAKS FROM SEALATION PROBLEMS
- SCALE OF MEDICAL WASTE (PARTICULAR) HIGH LEVELS OF RADON (SOLUBLE IN WATER)

HYDRAULIC FRACTURING WELL PAD



PIPELINES

- LOW-LEVEL RADIOACTIVE MATERIALS END UP IN STREAMS AS URANIUM
- THIS LINE CARRIES RADIOACTIVE LEAD-210 AND POLONIUM-210



WASTEWATER LADEN AS "URINE" IS DUMPED IN "MUD" AS "URINE" ARE "JUST SUPPRESSANT"

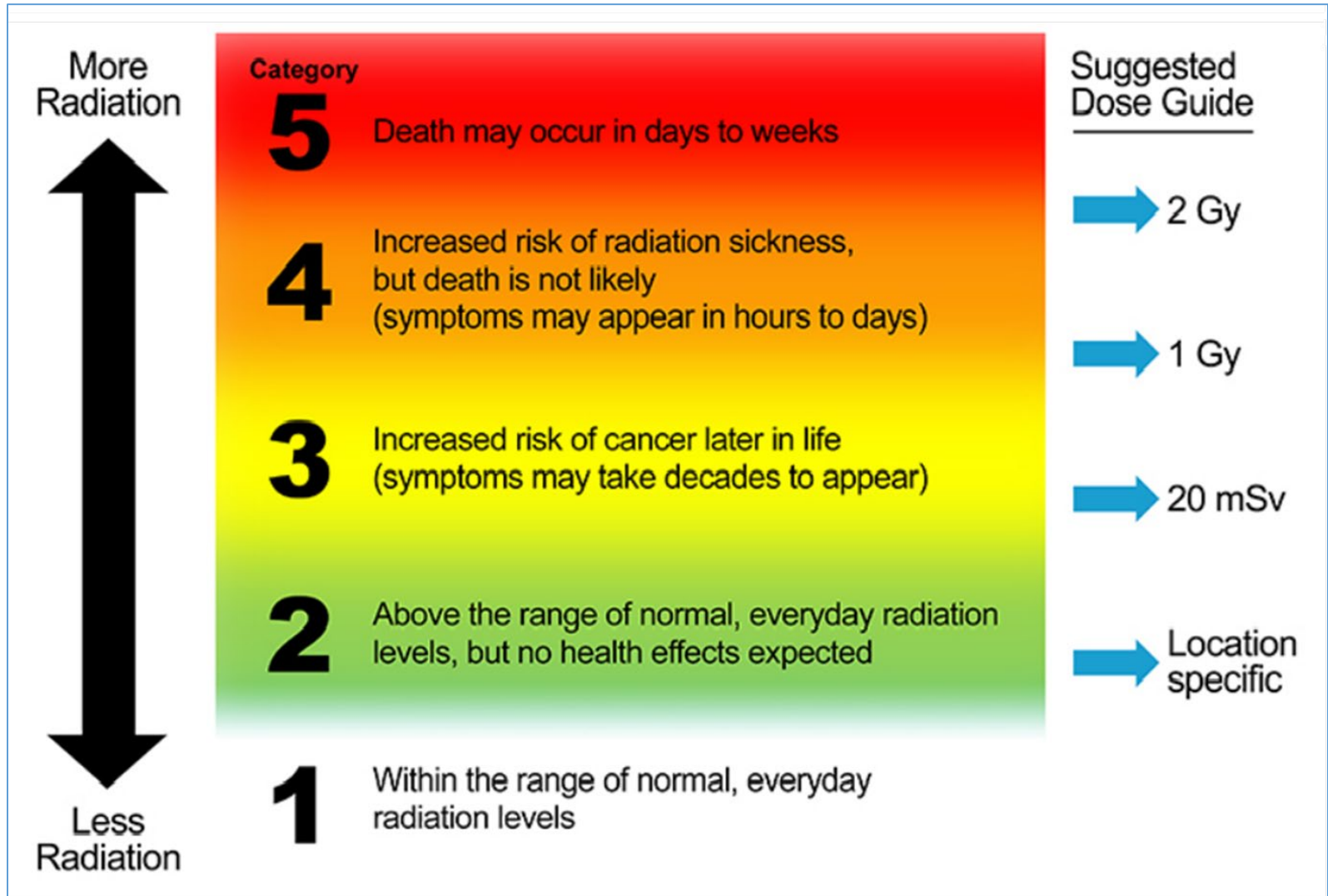


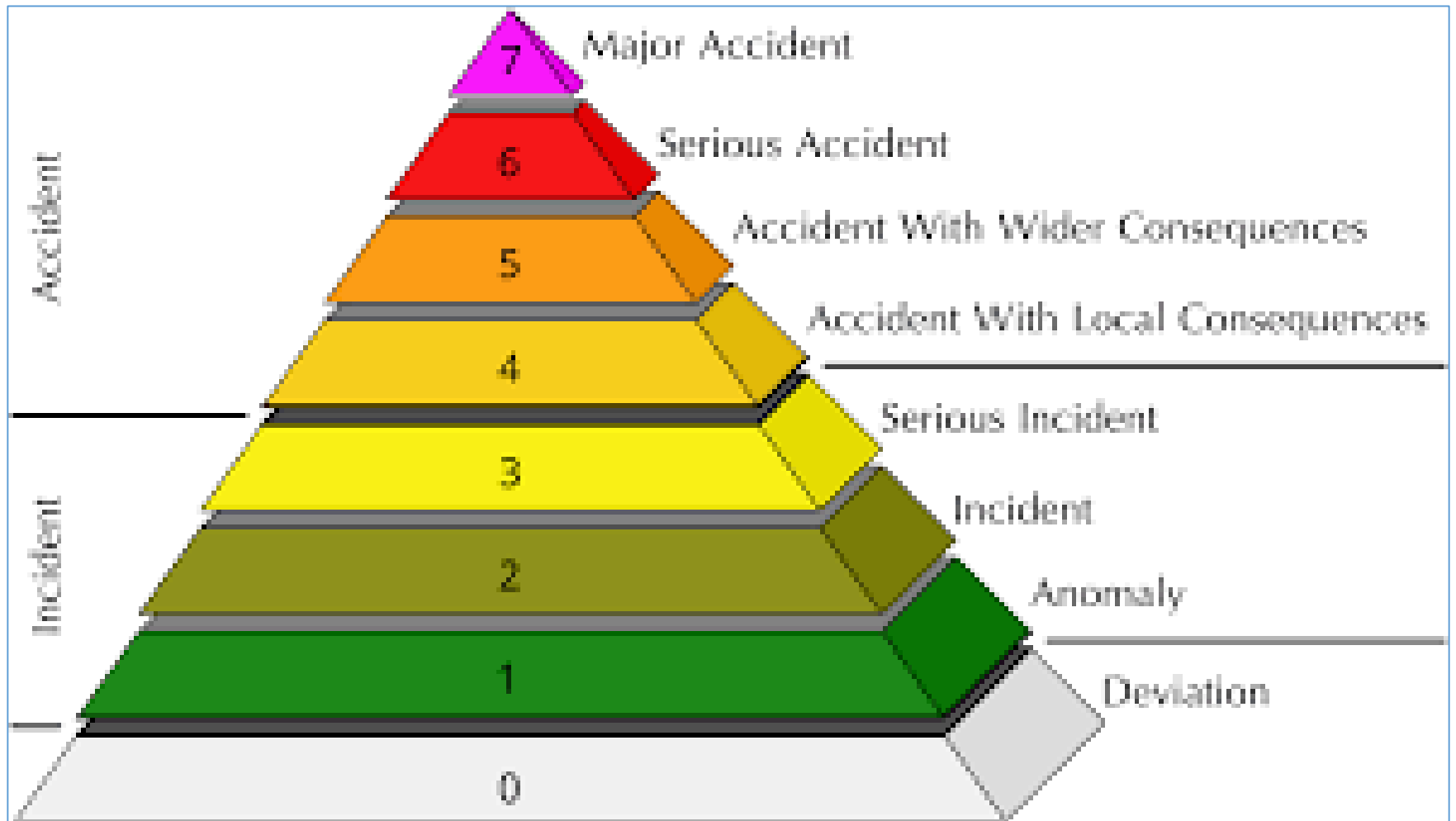
WASTEWATER TREATMENT PLANT

LANDFILL LEACHATE

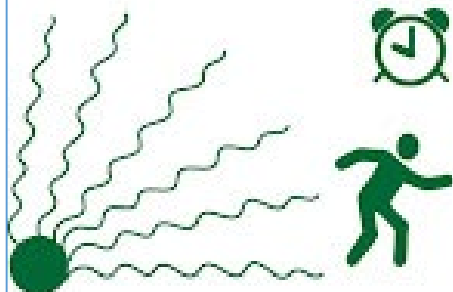
PIPERNS USE UP TO 17 GALLONS PER MINUTE AND ARE NOT TESTED BY REGULATORY AGENCIES

Radiation protection is crucial, not just in the medical field but also in national security, emergency response, and civilian use.

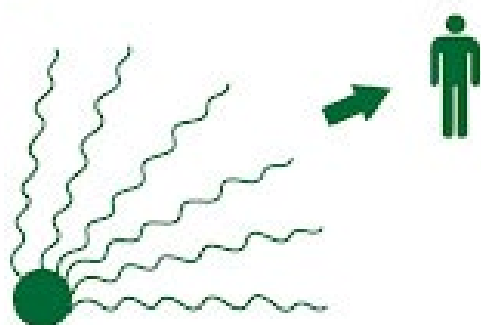




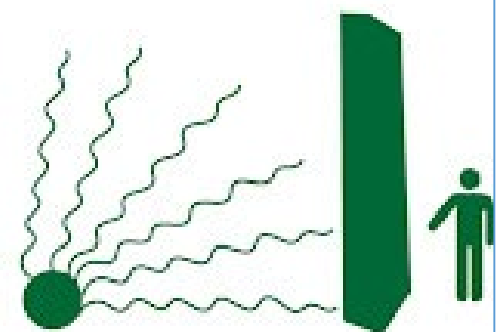
To reduce radiation exposure:



Limit Time

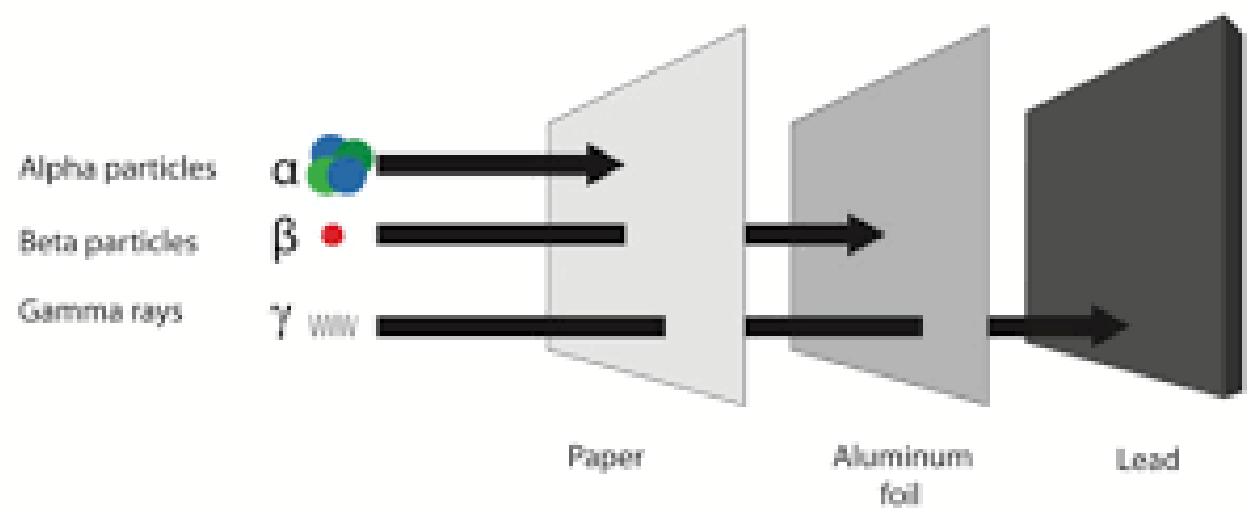


Increase Distance



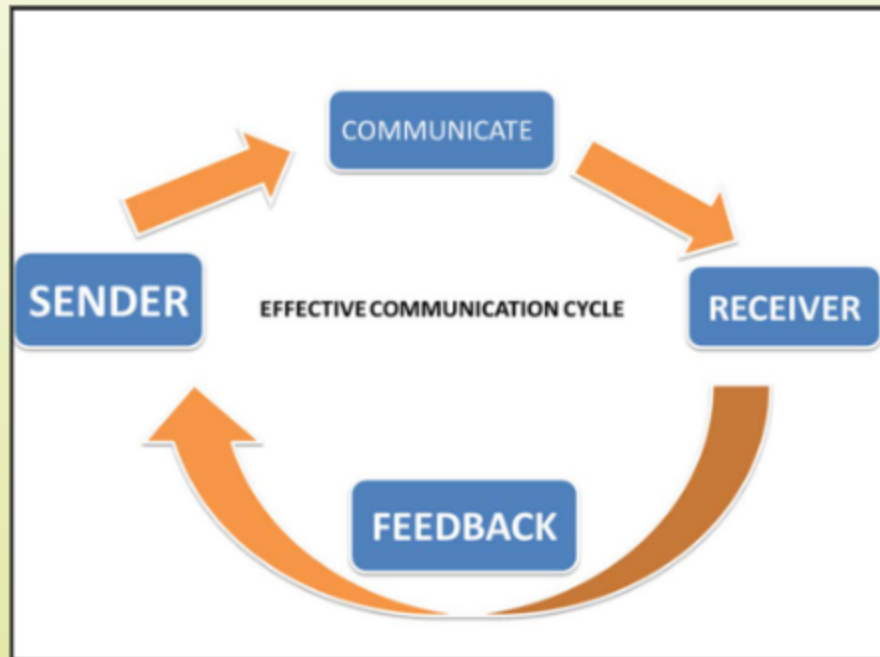
Use Shielding

Radioactivity Penetration Range

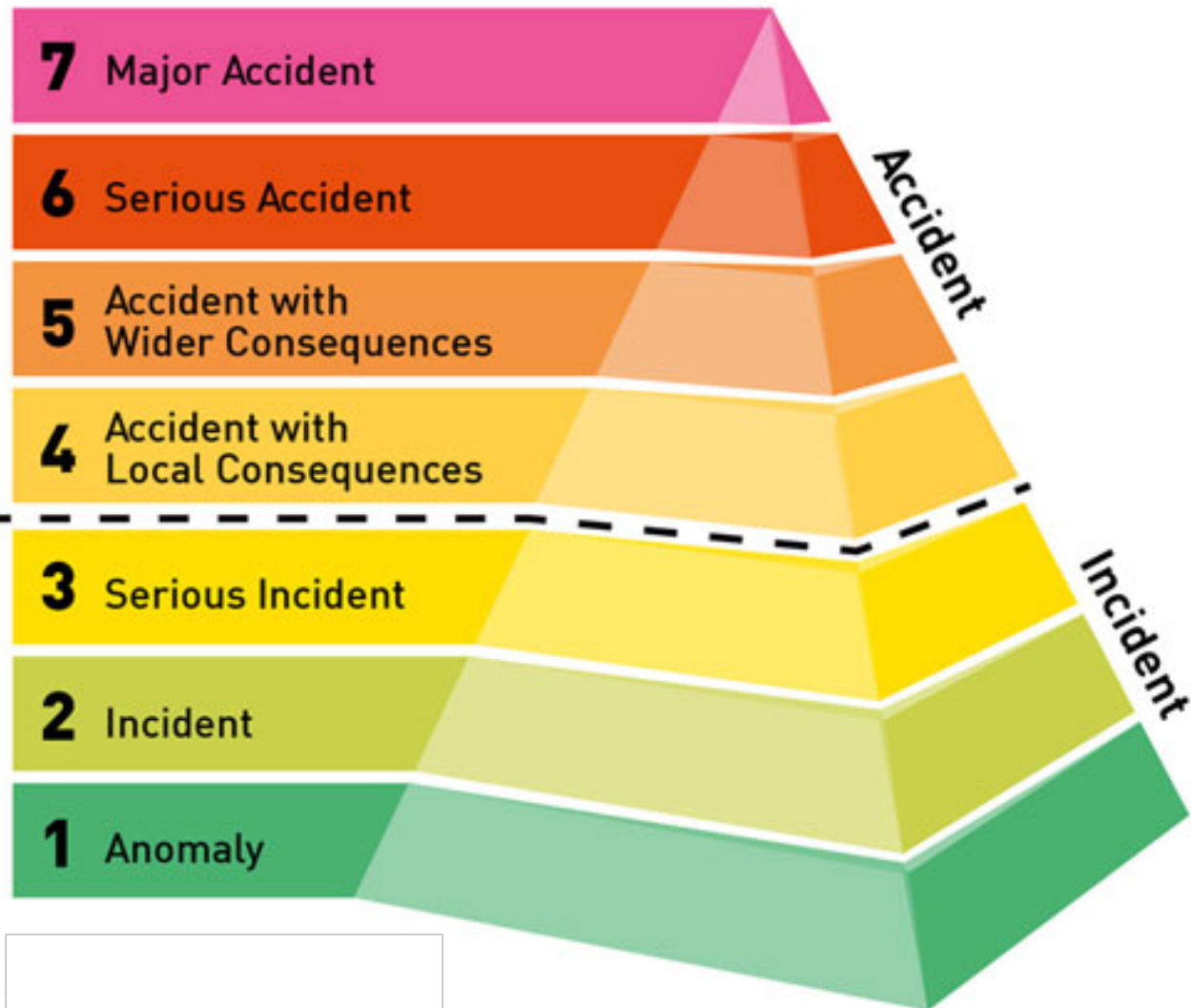


Communication

Communication is simply the act of transferring information from one place to another.



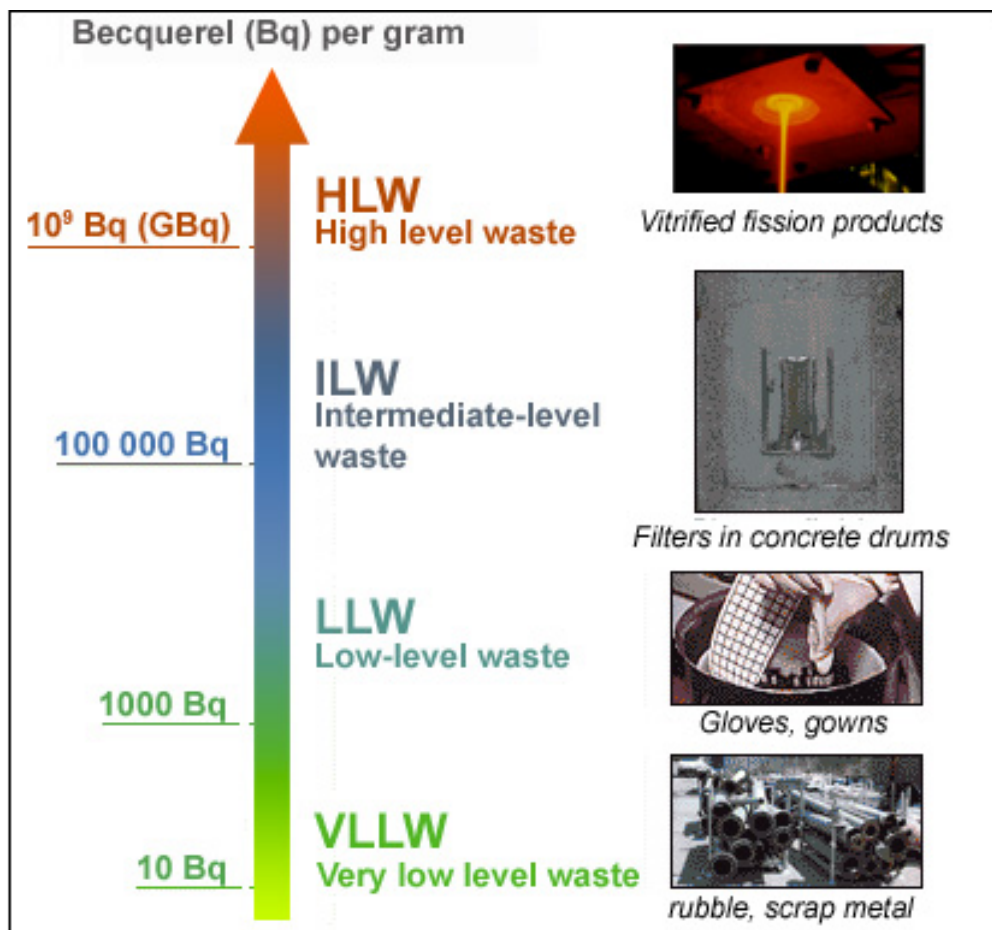
The International Nuclear and Radiological Event Scale



**Examples of three types of imaging modalities
and their equivalence to the exposure and risks**

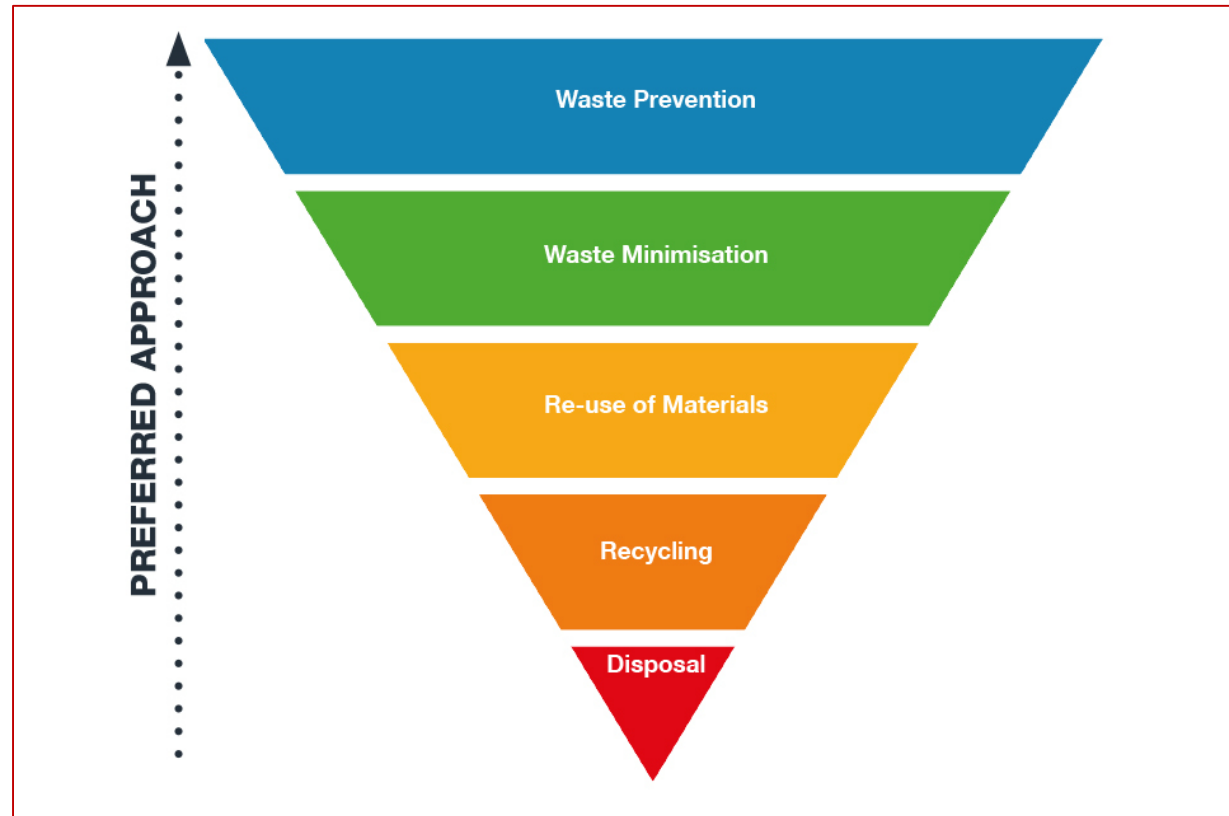
Imaging example	Effect dose range (mSv)	Background equivalent radiation time	Risk	Probability of cancer (%)
CT scan of NM scan	1-10	Years	Minor	~ 0.05
Abdominal radiograph	0.1-1	Months	Minimal	~ 0.005
Chest radiograph	< 0.1	Days to weeks	Negligible	~ 0.0005

Radioactive materials differ in terms of their physical and chemical properties, the **intensity and nature of the radiation** they emit, and the **risks** they entail. The management of each **waste category** must suit its characteristics. For waste to be managed properly, a complete **inventory** of it must be compiled.




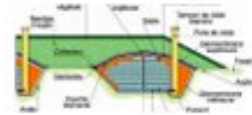






Waste producers must take sustainability into account and demonstrate the application of the **waste hierarchy** to manage waste effectively and help preserve **disposal capacity**, to achieve the best overall outcomes for people and the environment by optimising the management of radioactive waste. This should **minimise the environmental impacts** of waste treatment, including through the **reuse or recycling** of materials wherever possible, and provide for the effective and safe management of waste which is generated.

Application of the waste hierarchy and sustainability



Two criteria for classifying waste

Radioactive waste is classified according to the level of activity and the lifetime – short or long – of its main elements. For low (VLLW) and very low-level (VLLW) categories, no distinction is made between short- and long-lived waste. Research is being conducted into the management of two long-lived intermediate (ILW-LL) and high-level activity (HLW) waste forms.

HALF_LIFE ACTIVITY LEVEL	Short lived (SL) <i>main half-lives < 30 years</i>	Long lived (LL) <i>main half-lives > 30 years</i>
Very low level (VLL) 	<i>Surface disposal</i>  + Redevelopment of sites for uranium mining residues	
Low-level (LL) 	<i>Surface disposal</i> 	<i>R & D (Type LLW-LL)</i> <i>Radium-bearing & graphite waste</i> 
Intermediate level (IL) 	LIL-SLW Low and intermediate level short-lived waste	TYPE ILW-LL Intermediate Level long-lived waste <i>R & D (1991-2006 Acts)</i>
High level (HL) 	TYPE HLW  <i>R & D (1991 and 2006 Acts)</i>	

Radiation protection quantities

Absorbed – Equivalent – Effective Dose

The **effective dose** is a dose quantity defined as the sum of the tissue-equivalent doses, weighted by the ICRP organ (tissue) weighting factors, w_T , which account for the varying sensitivity of different organs and tissues to radiation.

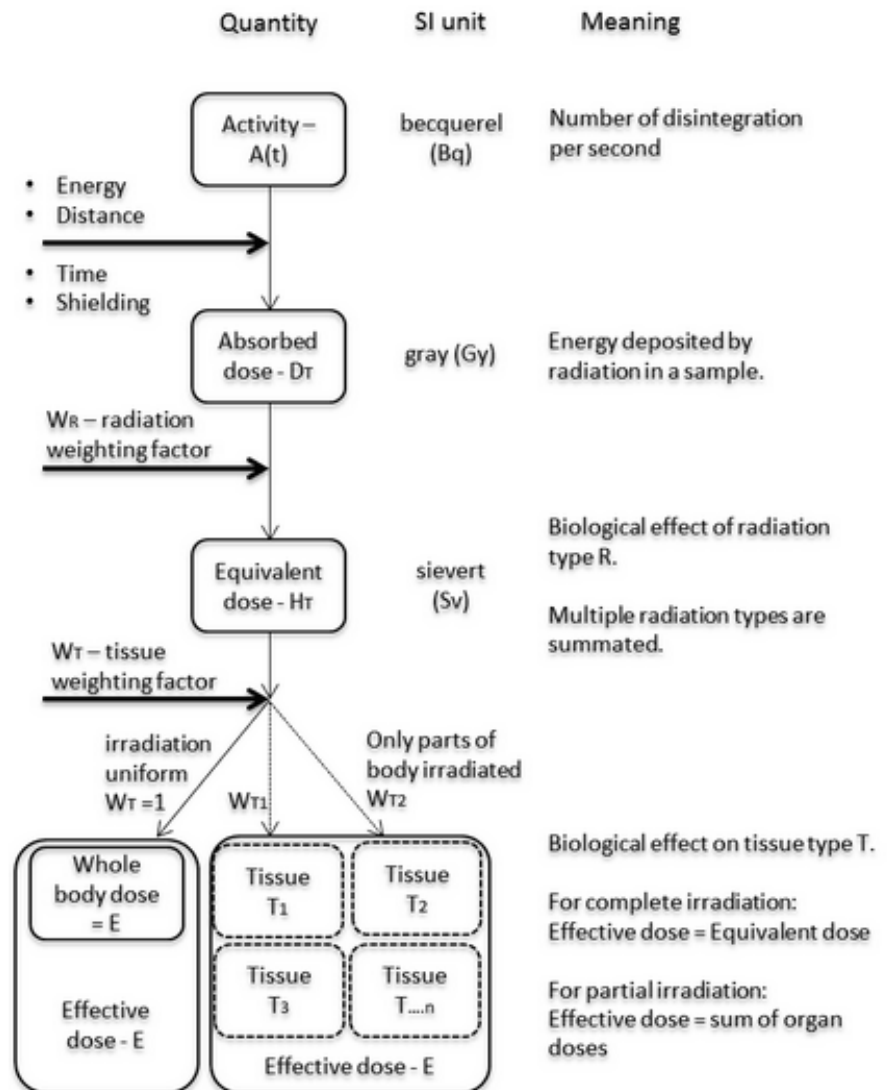
$$E = \sum_T w_T H_T$$

$$= \sum_T w_T \sum_R w_R D_{T,R}$$

where

- H_T is the equivalent dose averaged over the tissue or organ, T , due to the incident radiation, R .
- $D_{T,R}$ is the absorbed dose averaged over the tissue or organ, T , due to the incident radiation, R .
- w_R the radiation weighting factor,
- w_T the tissue weighting factor.

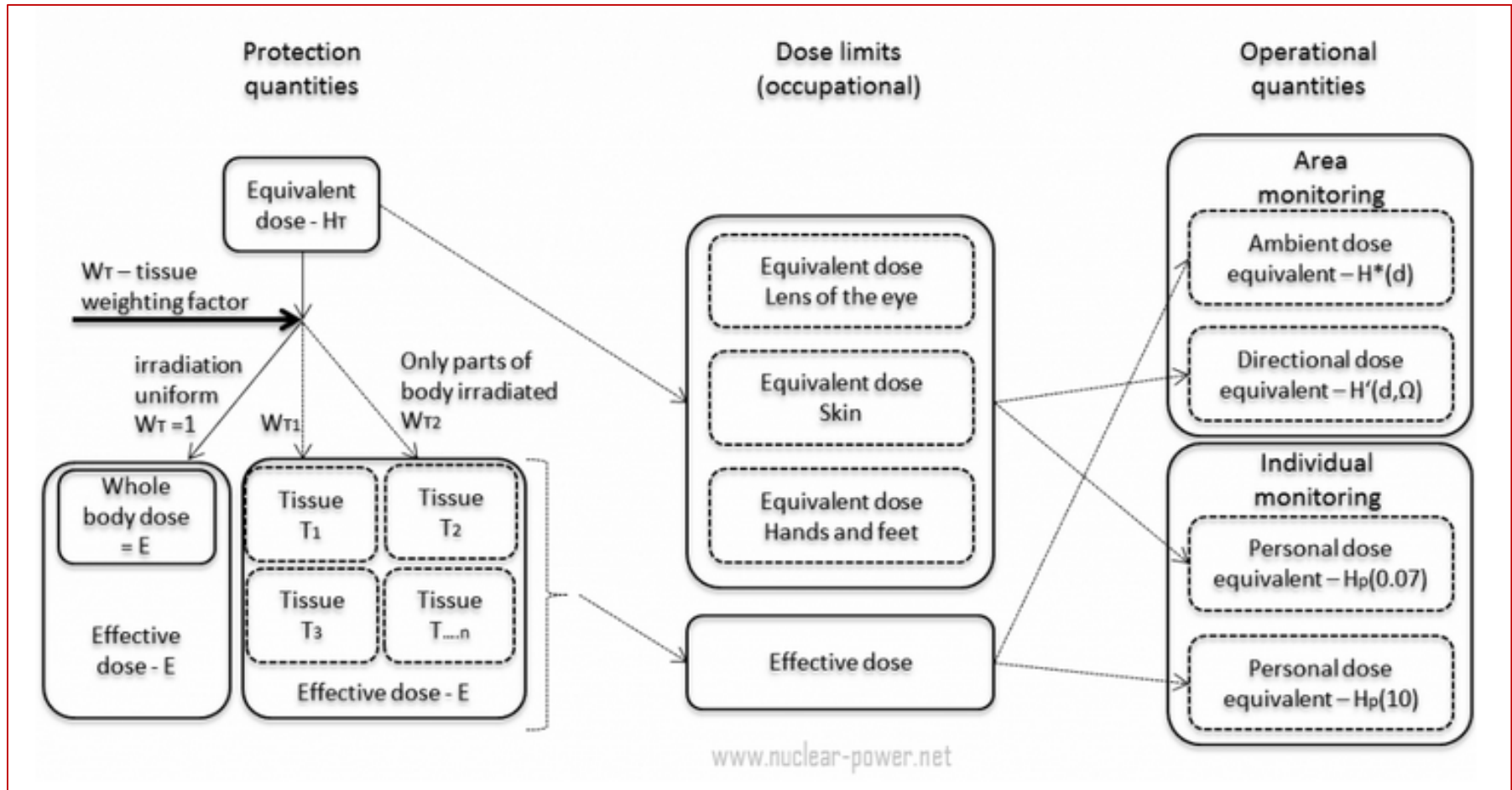
Absorbed – Equivalent – Effective Dose



Radiation protection quantities

Personal dose equivalent, $H_p(0.07)$. The $H_p(0.07)$ dose equivalent is an operational quantity for individual monitoring of the dose to the skin, hands, and feet.

Personal dose equivalent, $H_p(10)$. The $H_p(10)$ dose equivalent is an operational quantity used for individual monitoring in assessing **effective dose**.

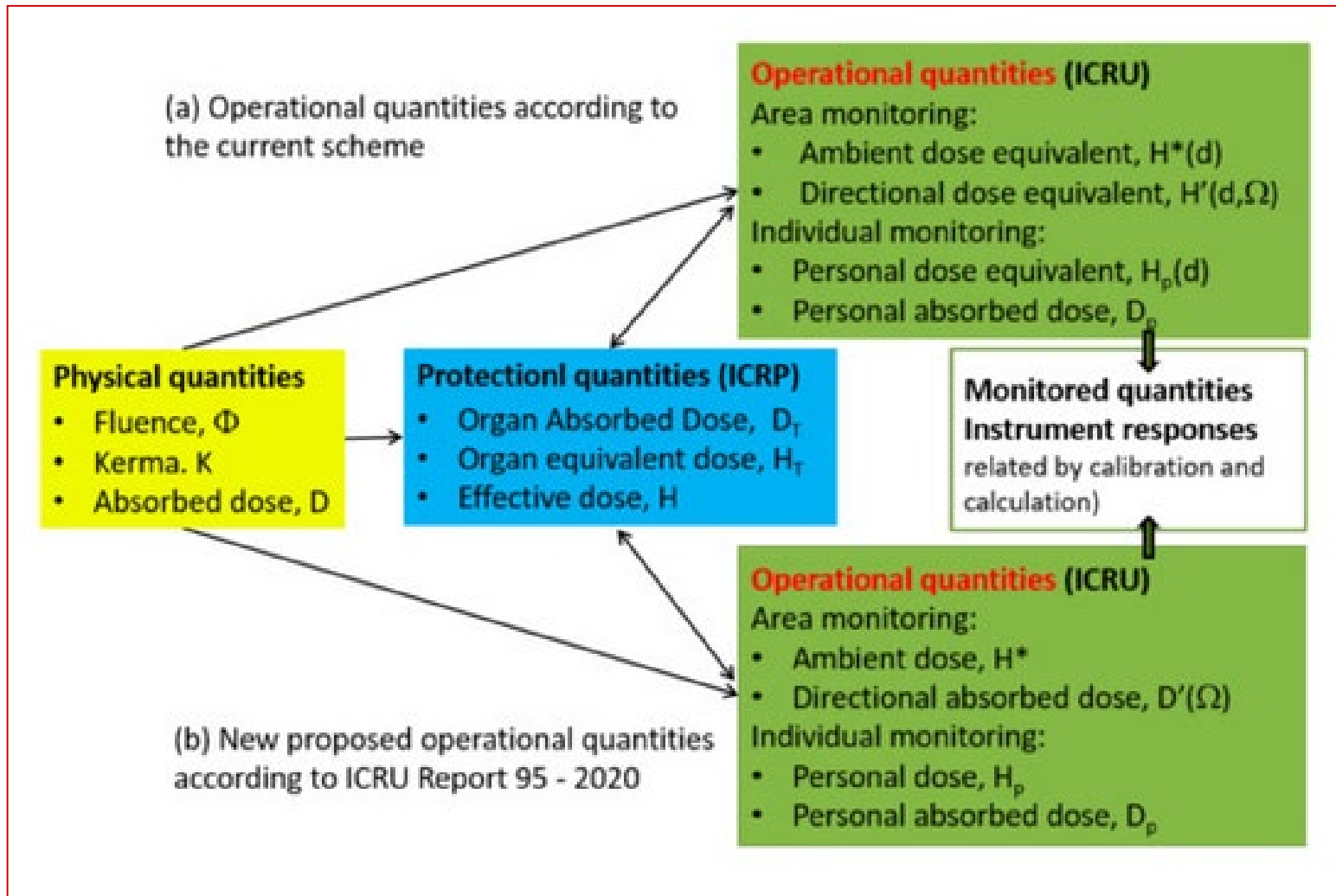


Relationship of ICRU/ICRP computed protection dose quantities and units

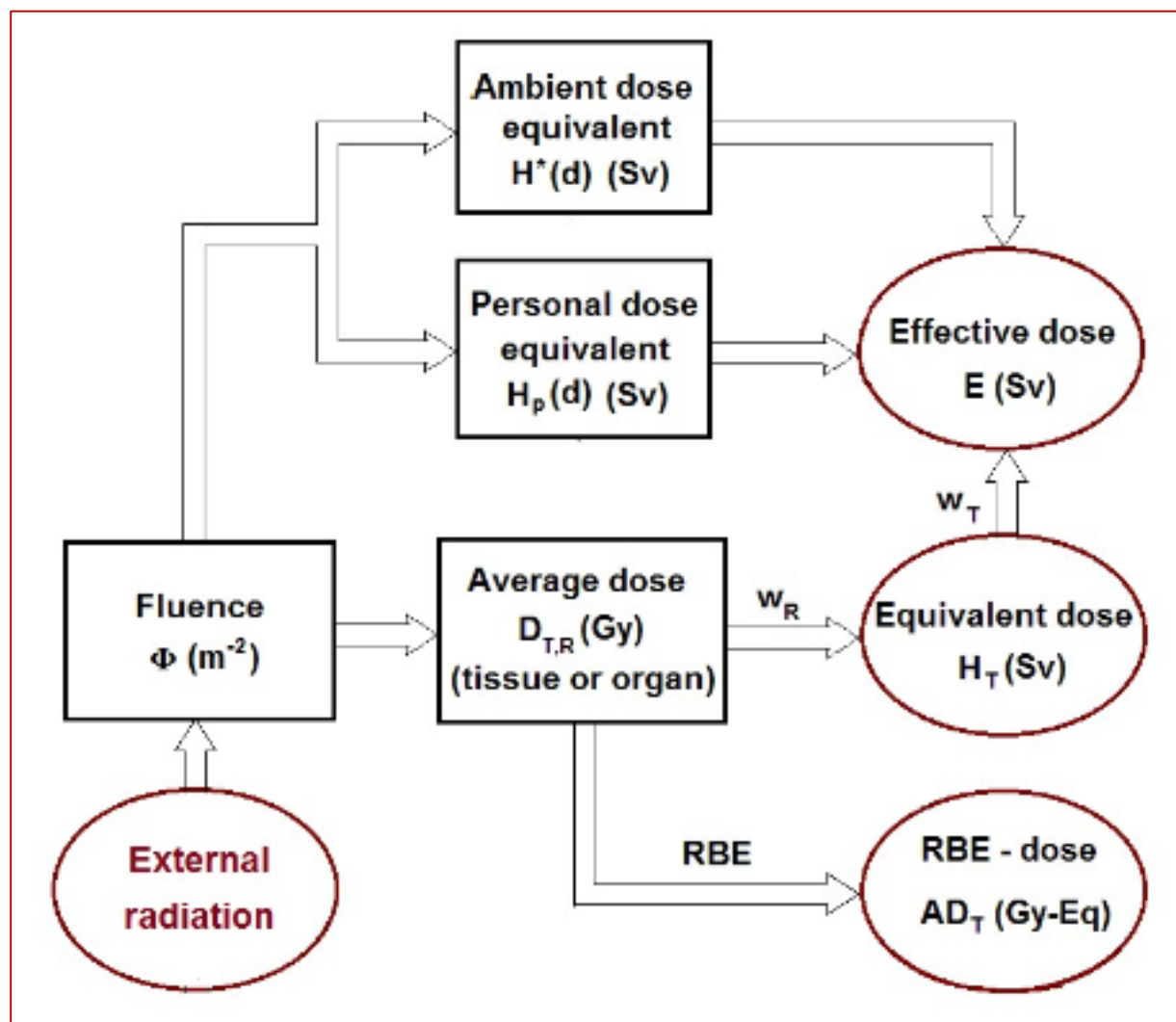
Ionising radiation - Protection Dose quantities in SI units

<i>Quantity</i>	Absorbed dose D_T	W_R	Equivalent dose H_T	<p>All parts of body uniformly irradiated $W_T = 1$</p> <p>Only some parts of body irradiated: tissues T_1, T_2, T_3, etc</p> <p>W_{T_1}</p> <p>W_{T_2}</p> <p>W_{T_3}</p>	<p>Effective dose E</p> <p>Whole body dose to all tissue = E</p> <p>or</p> <p>Organ dose to tissue T_1</p> <p>Organ dose to tissue T_2</p> <p>Organ dose to tissue T_3 = E</p>
<i>SI unit or modifier</i>	gray (Gy)	Radiation weighting Factor - W_R	sievert (Sv)	Tissue weighting factor - W_T	sievert (Sv)
<i>Derivation</i>	joule/kg	Dimensionless factor	joule/kg	Dimensionless factor	joule/kg
<i>Meaning</i>	Energy absorbed by irradiated sample of matter - a physical quantity.		Biological effect of radiation type R with weighting factor W_R . Multiple radiation types require calculation for each, which are then summated.		Biological effect on tissue type T having weighting factor W_T Partial irradiation Effective dose = summation of organ doses to those parts irradiated Complete (uniform) irradiation If <i>whole</i> body irradiated <i>uniformly</i> , the weightings W_T summate to 1. Therefore, Effective dose = Whole body Equivalent dose

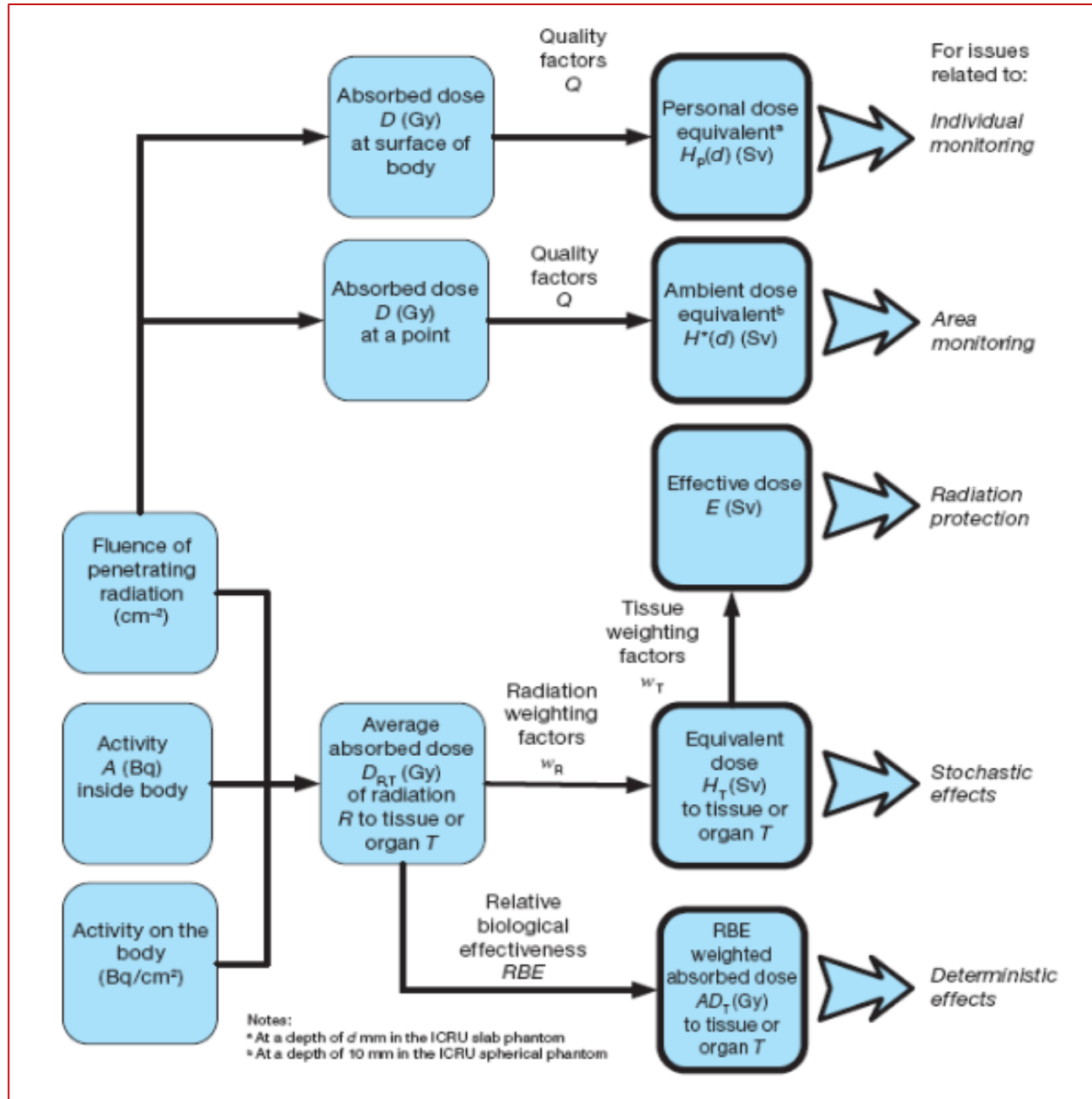
Relationship between the protection quantities of **ICRP** Publication 103 and the operational ones of **ICRU** according to (a), the current scheme; (b) Report 95, the new proposed operational quantities.



Relations between various radiation protection quantities used to assess **stochastic and deterministic effects** following external exposure



Main dosimetry and radiation protection quantities
 showing that the monitoring methods for external
 radiation exposure are not comparable to those for
 the assessment of internal exposure



Quantification of exposure due to external radiation and internal contamination via the inhalation or ingestion of radionuclides (there are no direct operational quantities for the assessment of internal exposure, which can be measured only through activity concentration in air and foodstuffs or by the measurement of body activity using a whole--body counter or bioassay analysis.

Exposure (irradiation)		Type of control	Operational quantities		
			Area monitoring	Individual monitoring	
External		Control of effective dose	$H^*(10)$	$H_p(10)$	
		Control of dose to the skin, lens, extremities	$H'(0.07)$	$H_p(0.07)$	
Internal	Inhalation (workers and population)	Control of committed effective dose (equivalent dose)	Radionuclide concentration in air	Inhaled activity (air samplers)	Body counters, bio-samples
	Ingestion (population)	Control of committed effective dose (equivalent dose)	Foodstuff activity concentration	-	Body counters, bio-samples

Děkuji za pozornost