Overview of Radionuclides in Drinking Water in Estonia

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COMING UP...

- **Radiological parameters in drinking water**
  - Indicative dose
- **Radionuclides in Estonian groundwater**
  - Where radionuclides come from?
- **Water purification**
  - Where radionuclides go?
  - Why should we remove radionuclides from water?

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RADIOLOGICAL PARAMETERS IN DRINKING WATER

- **Tritium (H-3) activity concentration ≤ 100 Bq/L**
- **Radon (Rn-222) activity concentration ≤ 100 Bq/L**
- **Indicative dose (ID) ≤ 0.10 mSv/year**

Parametric values given by:

- EU Directive 2013/51/Euratom;
- Estonian Minister of Social Affairs, Regulation No. 82 of 31 July 2001, as amended on 01.10.2019, “Quality and monitoring standards and methods of analysis for drinking water”.

INDICATIVE DOSE – DEFINITION

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$$ID = \sum A_i \cdot f_i \cdot V$$

Committed effective dose from all the radionuclides* in water.

*Excluding tritium, potassium-40, radon and short-lived radon decay products.

- A_i – Activity concentration of radionuclide in water (Bq/L)
- f_i – Effective dose coefficient of the radionuclide (Sv/Bq)
- V – Yearly water consumption (2 L per day = 730 L per year)

PARAMETRIC VALUES *versus* LIMIT VALUES

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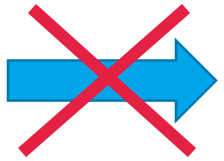
	Parametric value	Limit value
▪ Tritium (H-3)	≤ 100 Bq/L	< 1000 Bq/L
▪ Radon (Rn-222)	≤ 100 Bq/L	< 1000 Bq/L
▪ Indcative dose (ID)	≤ 0.10 mSv/year	< 1 mSv/year

Parametric value – not expected to give any detectable health effects; risk is low enough.

Exceeding parametric values  water unsafe to drink.

Risk assessment:
does it pose a risk to human health?

LOW DOSES *versus* HEALTH RISK?

- **Stochastic effects –** the probability of getting cancer increases
- **Linear-Non-Threshold model –** most supported hypothesis

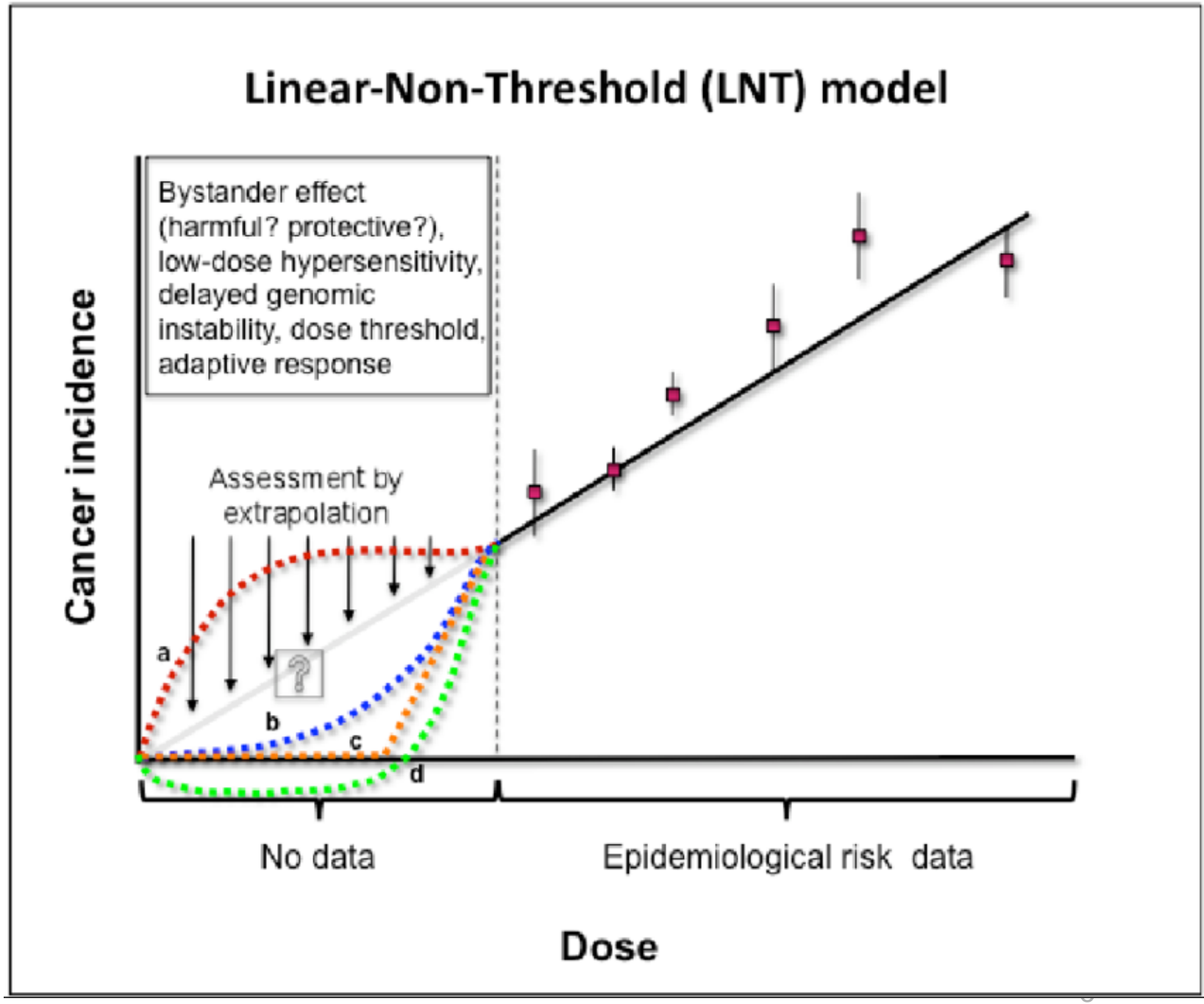


Fig.: Mancuso et al, *2012. Current Molecular Medicine 12(5).*

RADIONUCLIDES IN DRINKING WATER IN ESTONIA

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- ***Ca*. 18 % of Estonian inhabitants (230 000 people)** consume drinking water where ID exceeds 0.10 mSv/yr (Forte *et al*., 2010. Journal of Radiation Protection, 30.)

- High ID caused by ^{226}**Ra** and ^{228}**Ra** in Cambrian-Vendian groundwater.
- Rear findings of ID > 0.10 mSv/yr in Ordovician-Cambrian aquifer

RADIONUCLIDES IN GROUNDWATER

Cambrian–Vendian aquifer system as a source of drinking water supply:

Cambrian-Vendian aquifer system and its two sub-aquifers **Gdov** and **Voronka**

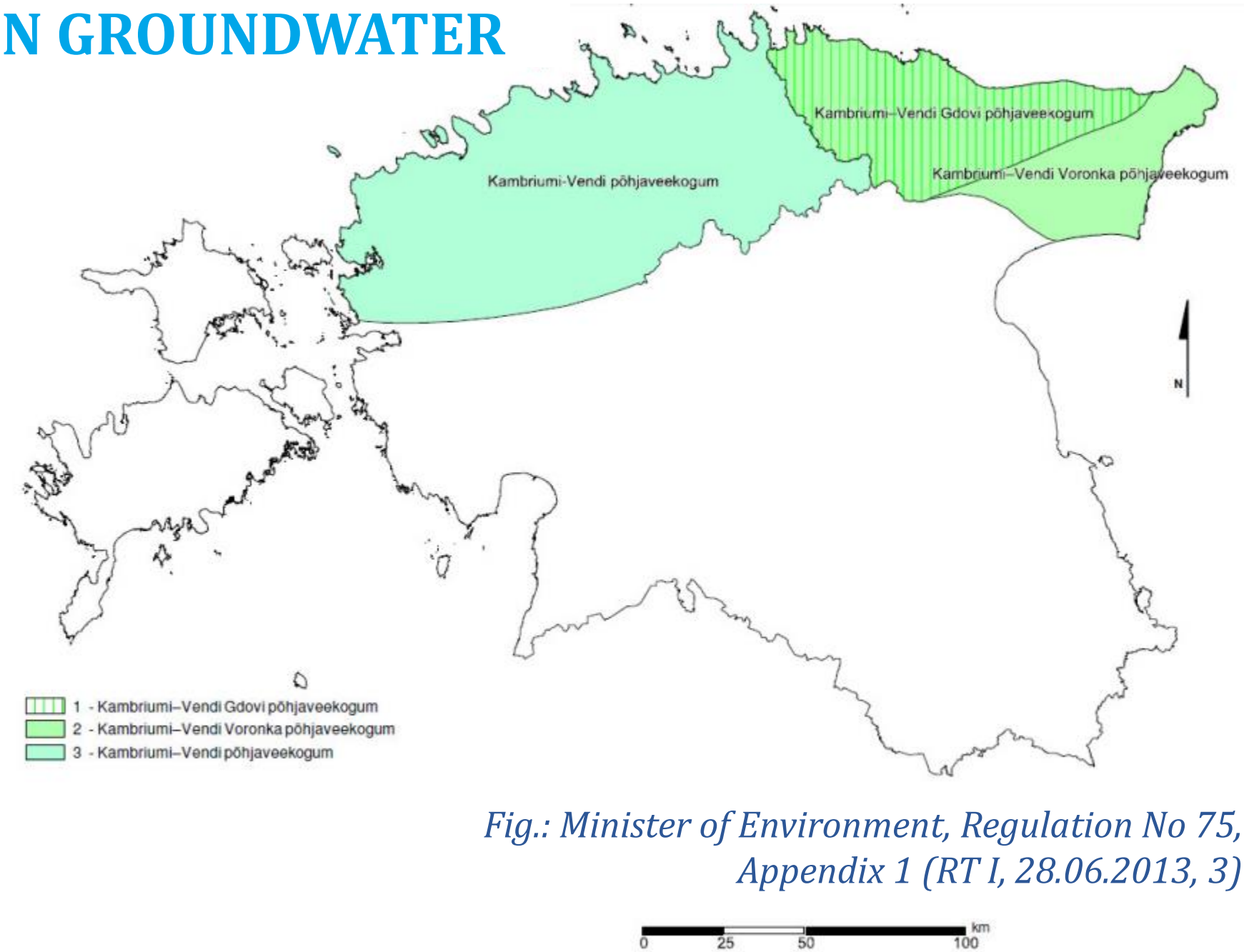

Fig.: Minister of Environment, Regulation No 75, Appendix 1 (RT I, 28.06.2013, 3)

RADIONUCLIDES IN GROUNDWATER

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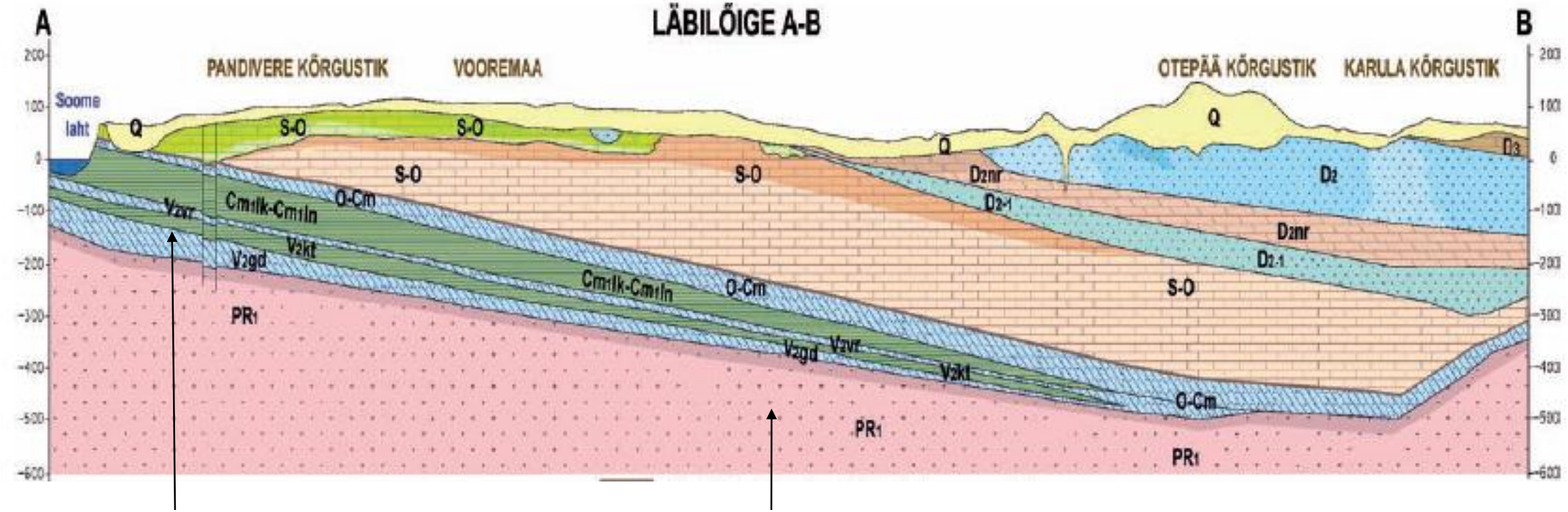
High ID caused by ^{226}**Ra** and ^{228}**Ra** in Cambrian-Vendian groundwater.



Cambrian-Vendian aquifer system

Crystalline basement rock

U and Th

Fig.: Põhjaveekomisjon, 2004. "Eesti põhjavee kasutamine ja kaitse"

RADIONUCLIDES IN GROUNDWATER

ORIGIN OF RADIUM

^{226}Ra

- Half life 1600 years
- Alfa-emitter
- ^{238}U decay chain

^{228}Ra

- Half life 5,75 years
- Beta-emitter
- ^{232}Th decay chain

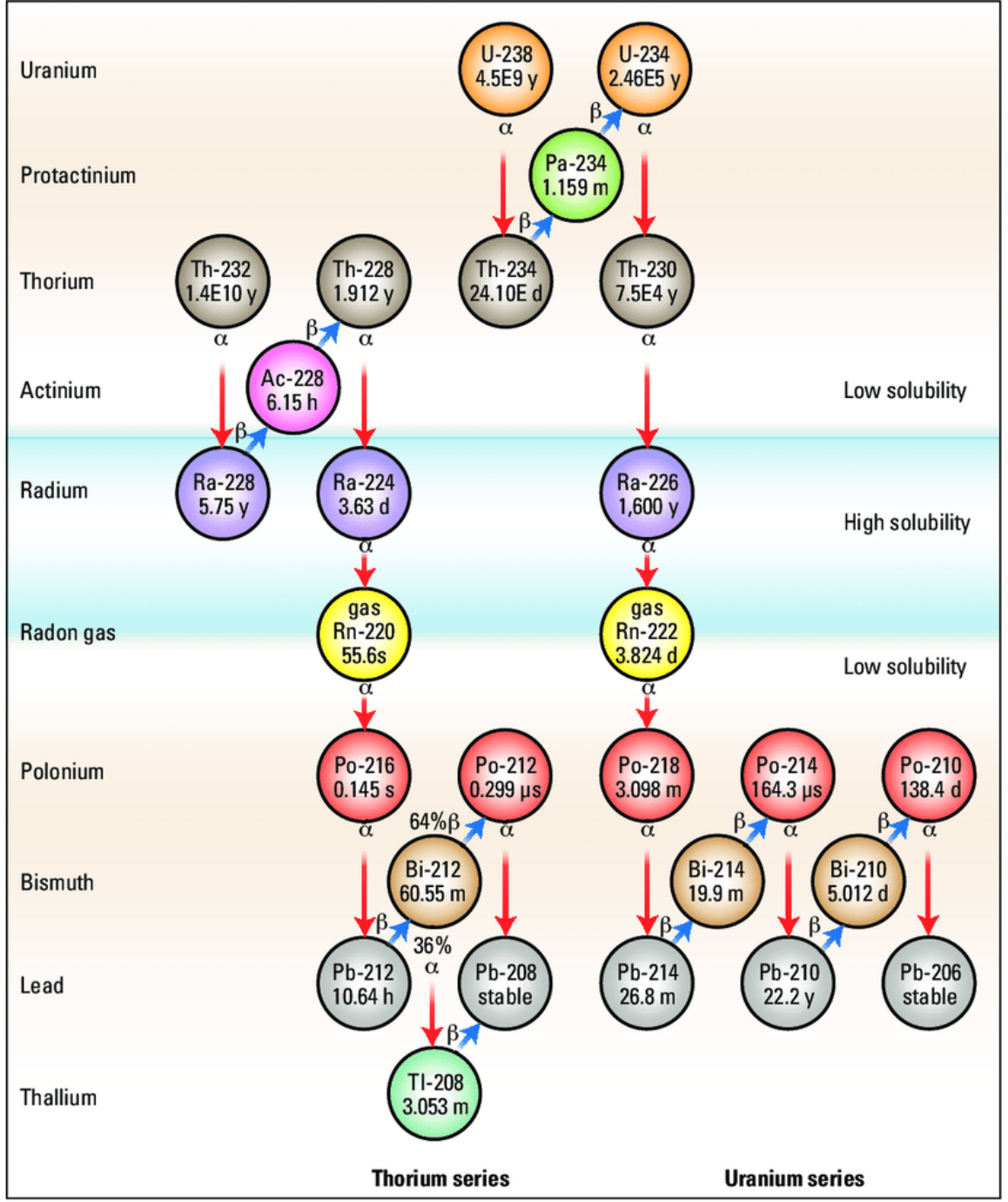


Fig.: Nelson et al, *2015. Environmental Health Perspectives, 123(7).*

RADIONUCLIDES IN GROUNDWATER

CHANGES IN RADIUM CONCENTRATIONS

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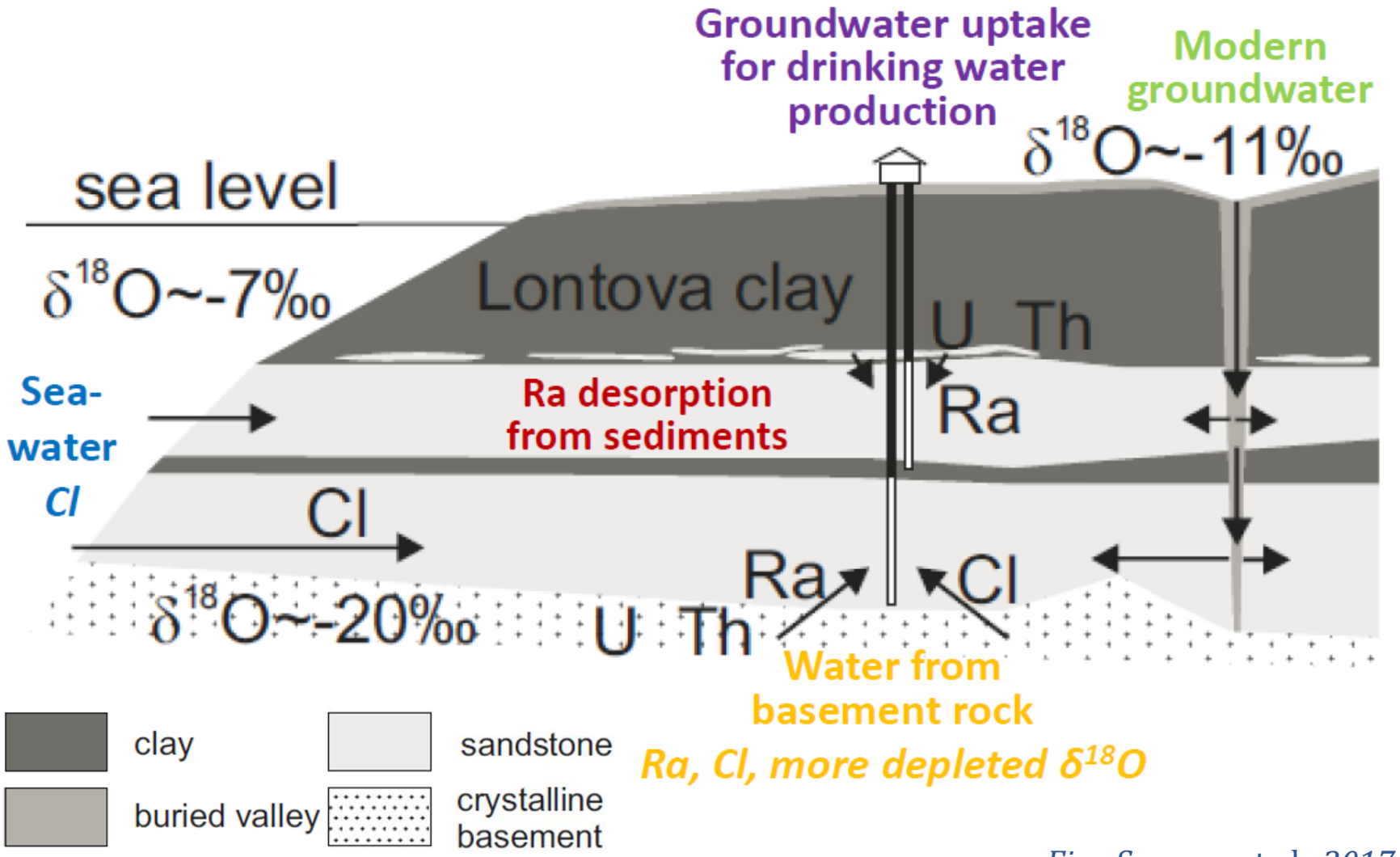
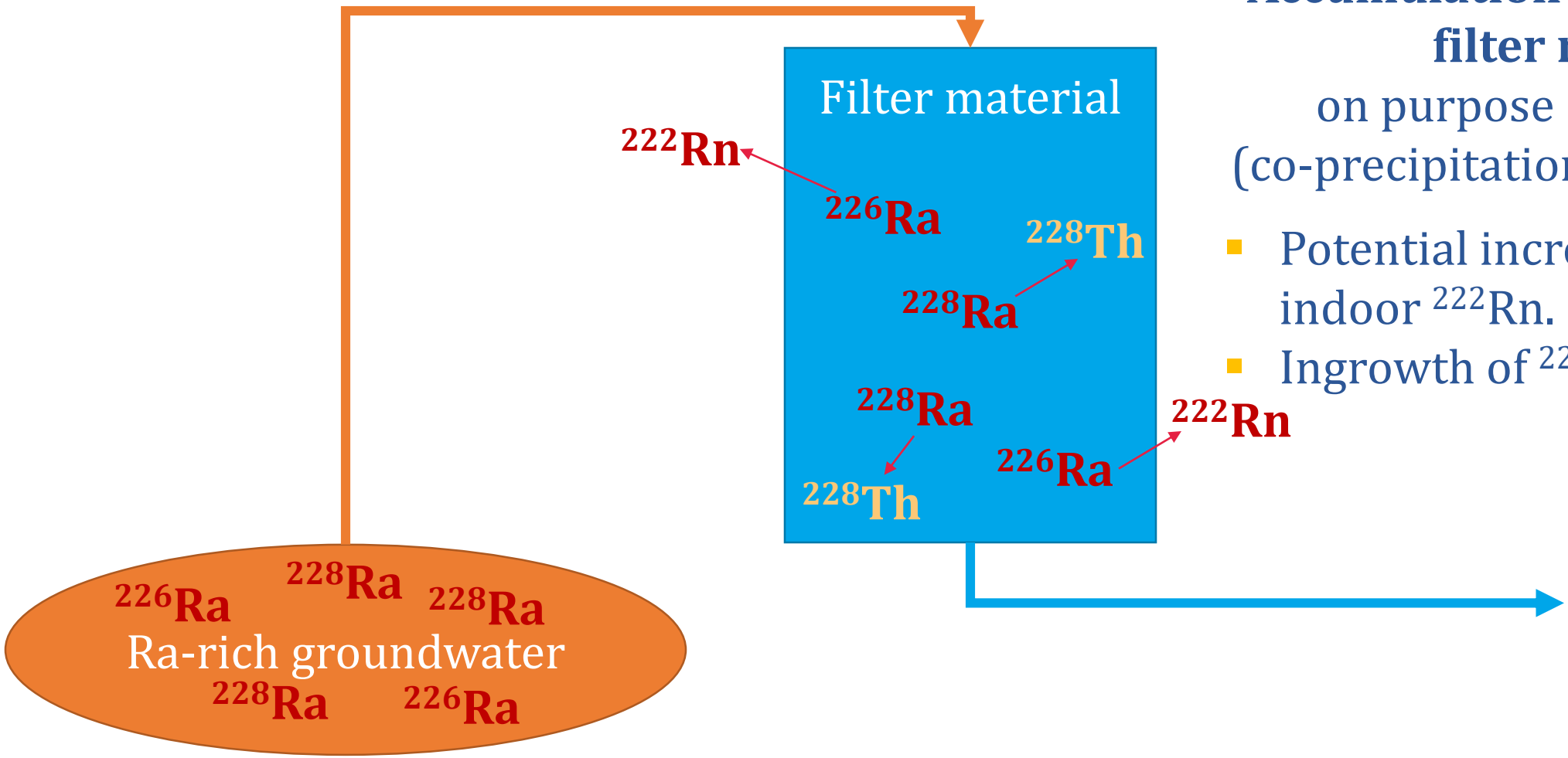


Intensive water uptake influences the groundwater quality in Gdov sub-aquifer:

- **Cl ↑**
- **^{226}Ra ↑**
- **^{228}Ra ↑**

Fig.: Suursoo et al., *2017. Science of the Total Environment, 601-602.*

WHAT DOES IT MEAN FOR A WATER TREATMENT FACILITY OPERATOR?



Accumulation of radium in the filter material
on purpose or unintended (co-precipitation with Fe and Mn).

- Potential increase of indoor ^{222}Rn.
- Ingrowth of ^{228}Th in the filter.

WHY TO BOTHER?

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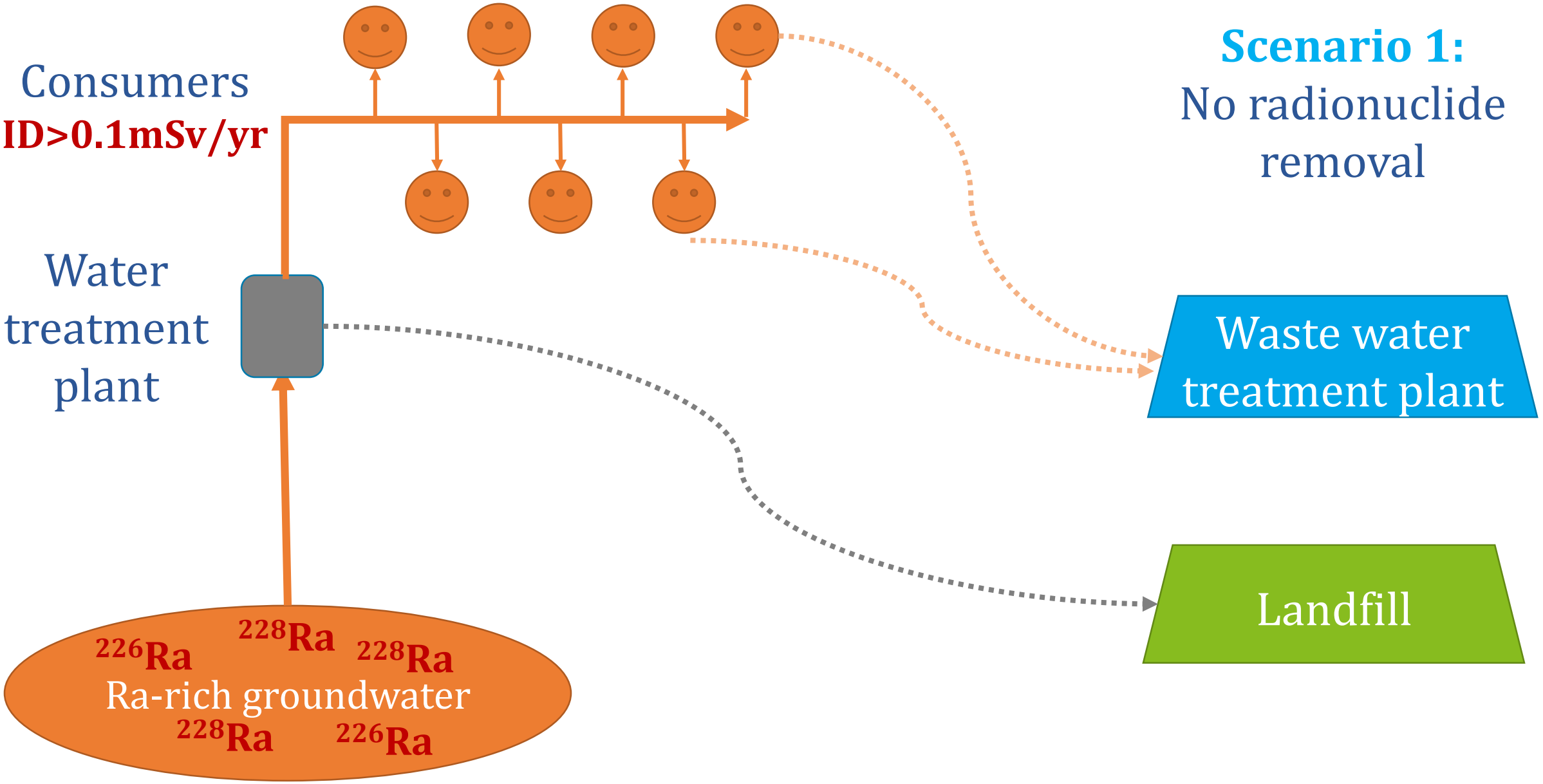

Scenario 1:
No radionuclide removal

WHY TO BOTHER?

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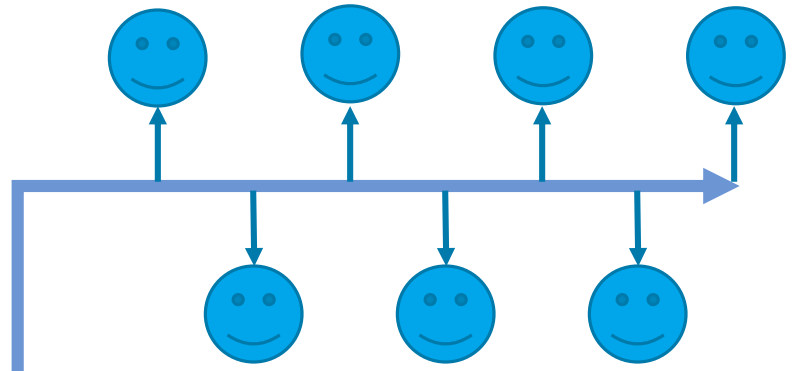
Consumers
ID~0 mSv/yr



Water treatment plant

Scenario 2:
Un-optimized radionuclide removal

Waste water treatment plant

Landfill

^{226}Ra ^{228}Ra ^{228}Ra
Ra-rich groundwater
^{228}Ra ^{226}Ra

WHY TO BOTHER?

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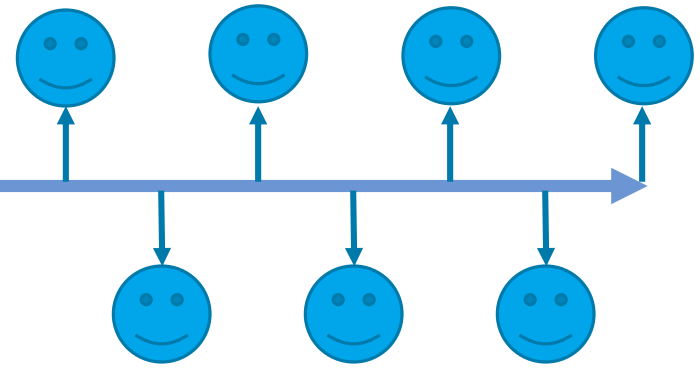
Consumers
ID<0.1mSv/yr



Water treatment plant

Scenario 3:
Optimized radionuclide removal

Waste water treatment plant

Landfill

^{226}Ra ^{228}Ra ^{228}Ra
Ra-rich groundwater
^{228}Ra ^{226}Ra

CONCLUSIONS

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- Radiological parameters in drinking water are parametric values, not limits.
  - ID ≤ 0.10 mSv/year ensures an appropriate level of protection for the consumer
- High ID problem in Cambrian-Vendian aquifer
  - Natural contamination with radium – ^{226}Ra and ^{228}Ra
  - Water treatment → accumulation of radionuclides in filter material

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Thank you!
Questions?

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