

# Rolling Stewardship

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**Nuclear Transparency Watch**  
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The Quebec Accord  
CANADA – USA - UK

Quebec City  
1943

*Prime  
Minister  
of Canada*

*President  
of the U.S.A.*

*Prime  
Minister  
of Britain*



# Military Links

1941-1943

1941 – Canada is asked to supply uranium for US and UK war efforts

*the only available source of uranium not in German hands*

*– recovered from the residues of 1930s radium mining.*

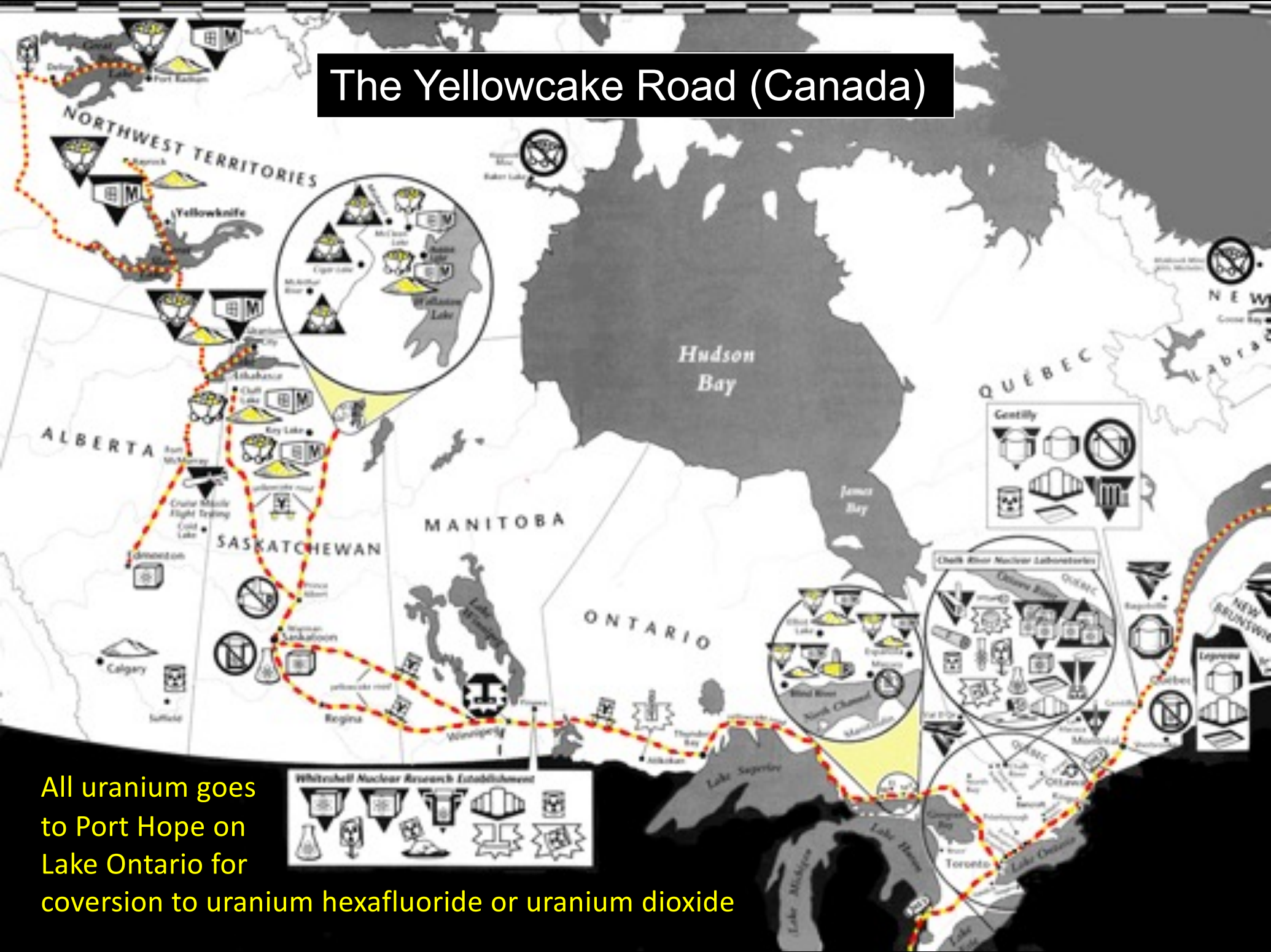
1943 – Quebec Accord on WWII A-bomb Project (US-UK-Canada)

*Canada to supply uranium from Northwest Territories*

*Canada to refine uranium at Port Hope Ontario*






































*Canada to host a secret laboratory in Montreal to study plutonium production using heavy water reactors*




# The Yellowcake Road (Canada)



All uranium goes to Port Hope on Lake Ontario for conversion to uranium hexafluoride or uranium dioxide

# USES OF CANADIAN URANIUM

MILL SITE	URANIUM USE	MILL SITE	URANIUM USE
▼ PORT RADIUM, NWT		ELLIOT LAKE, ONT.	
▼ RAYROCK, NWT		▼ LACNOR	
URANIUM CITY, SASK.		▼ NORDIC	
▼ BEAVERLODGE	 	▼ STANROCK	
▼ GUNNAR		▼ SPANISH-AMERICAN	 
▼ LARADO		▼ MILLIKEN	 
OTHER SASKATCHEWAN		▼ STANLEIGH	 
CLUFF LAKE	 	▼ QUIRKE	 
RABBIT LAKE	 	▼ PANEL	 
KEY LAKE	 	▼ DENISON	  
▲ McCLEAN LAKE	 	BANCROFT, ONT.	
OTHER ONTARIO		▼ DYNO	
▼ AGNEW LAKE, ESPANOLA		▼ BICROFT	
▼ PRONTO, BLIND RIVER		▼ FARADAY	
		▼ MADAWASKA	 

 uranium for bombs (1941-1968)     
  ... for export (from 1968)     
  ... for CANDU (from 1968)

Until 1945, all Canadian uranium was sold to the US military for Bombs. Although military sales ended in 1965, deliveries continued for a few more years.

Over 85% of Canada's uranium is sold to other countries.

# Military Links

1941-1974

## The Plutonium Connection

**MONTREAL LAB:** atomic scientists from UK, France, and Canada work on techniques for producing and separating plutonium 1943-45

**BRITISH RESEARCH:** pilot plant work for Sellafield takes place at Chalk River – involves reprocessing spent fuel to get plutonium metal.

**CANADIAN RESEARCH:** Canada sells plutonium to US military to help finance Canadian non-military nuclear research & development.

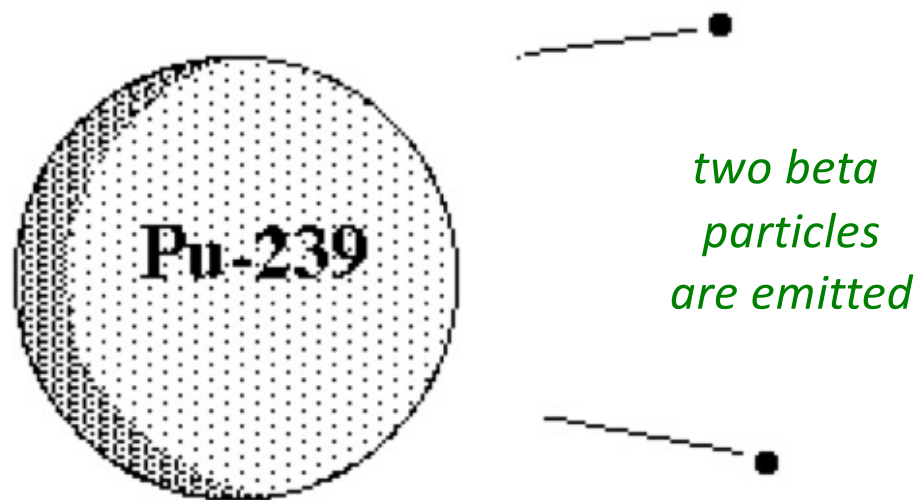
**INDIA'S FIRST A-BOMB:** In 1974 India detonates an A-bomb using plutonium produced in a research reactor given by Canada as a gift.

## Creation of plutonium inside a nuclear reactor ...



... when an atom of uranium-238 absorbs a neutron

Absorption of a neutron creates a heavier (“transuranic”) element



. . . it is transformed into an atom of plutonium-239

*Other transuranic actinides are produced in a similar way.*





This glass paperweight is the exact size of the plutonium ball that was used as a nuclear explosive in the Nagasaki bomb.

*Photo: Robert Del Tredici*

*Howard Morland  
with a model of  
a hydrogen bomb*

*Photo: Robert Del Tredici*



H-bombs use a plutonium “trigger” (at the top) to raise the temperature to 50 million degrees.

When an H-bomb is dismantled, the plutonium is removed – thus making the bomb harmless.

# Atoms For Peace

**IAEA (1956)**: Canada assists in creating the IAEA, mandated to promote nuclear technology world-wide while not contributing to any military use

**URANIUM POLICY (1965)**: US military contracts end and Prime Minister Pearson declares Canada's uranium will now be sold for peaceful uses only

**NPT (1968)**: The Non-Proliferation Treaty divides the world into nuclear "haves" and nuclear "have-nots"; the "have-nots" promise not to develop nuclear weapons and the "haves" promise to get rid of theirs – eventually!  
*India refuses to sign, along with Pakistan, Israel, and South Sudan.*

**BILATERAL AGREEMENTS**: a series of agreements with client countries promising not to use Canadian nuclear materials to build nuclear weapons

**LOOPHOLE**: India claims 1974 A-test was a "Peaceful Nuclear Explosive" (allowed by NPT); but Canada suspends nuclear cooperation with India

# Nuclear Waste Governance in Canada

A Quick Overview

# Irradiated Fuel: The first 30 years

**1945-62 – research reactors produce irradiated fuel**  
*stored at Chalk River ~ no public debate*

**1962 & on & on – power reactors produce irradiated fuel**  
*stored on site in pools ~ no public debate*

**1975 – Canadian Coalition for Nuclear Responsibility (CCNR)**  
**lack of acceptable plan for long-term management**

**1977 – Federal Report “Managing Canada’s Nuclear Waste”**  
*recommendation for “deep geologic repository”*

**1978 – Porter Commission Report : “A Race Against Time”**  
*nuclear moratorium if the problem is not solved*

# BRITAIN

## Sir Brian Flowers (1976)

“We are agreed that it would be **irresponsible and morally wrong** to commit future generations to the consequences of fission power on a massive scale **unless it has been demonstrated beyond reasonable doubt that at least one method exists** for the safe isolation of these wastes for the indefinite future.”

Nuclear Power and the Environment  
UK Royal Commission on Environmental Pollution  
London September 1976

# UNITED STATES

## Report to US Congress (1977)

“Growth of **nuclear power in the US is threatened** by the problem of how to safely dispose of radioactive waste potentially dangerous to human life. Nuclear power critics, the public, business leaders, and government officials all concur that a solution to the **disposal problem is critical to the continued growth of nuclear energy.**”

Nuclear Energy's Dilemma:  
Disposing of Hazardous Radioactive Waste Safely  
Washington DC September 9 1977

# CALIFORNIA

Energy Development and  
Conservation Commission –  
after 3 years of hearings on  
Radioactive Waste "Disposal"

**Great Expectations -- but what if we are wrong?**

**If everything worked perfectly  
as far as they are concerned,  
if every one of their ideas  
were correct,  
and we were able to proceed  
on a timely basis,  
waste disposal will not be demonstrated ...  
until sometime around 1987.**

**We, however, have  
a more fundamental problem.  
We think it probable that  
it will never be demonstrated.**

**Excessive optimism  
about the potential  
for safe disposal of nuclear wastes  
has caused backers of nuclear power  
to ignore scientific evidence  
pointing to its pitfalls.**

**That's the real crux of what we found --  
that you have to weigh scientific evidence  
against essentially engineering euphoria.**

**Commissioner Emilio E. Varinini  
California Energy Commission  
quoted in the Los Angeles Times,  
Thursday January 12, 1978**



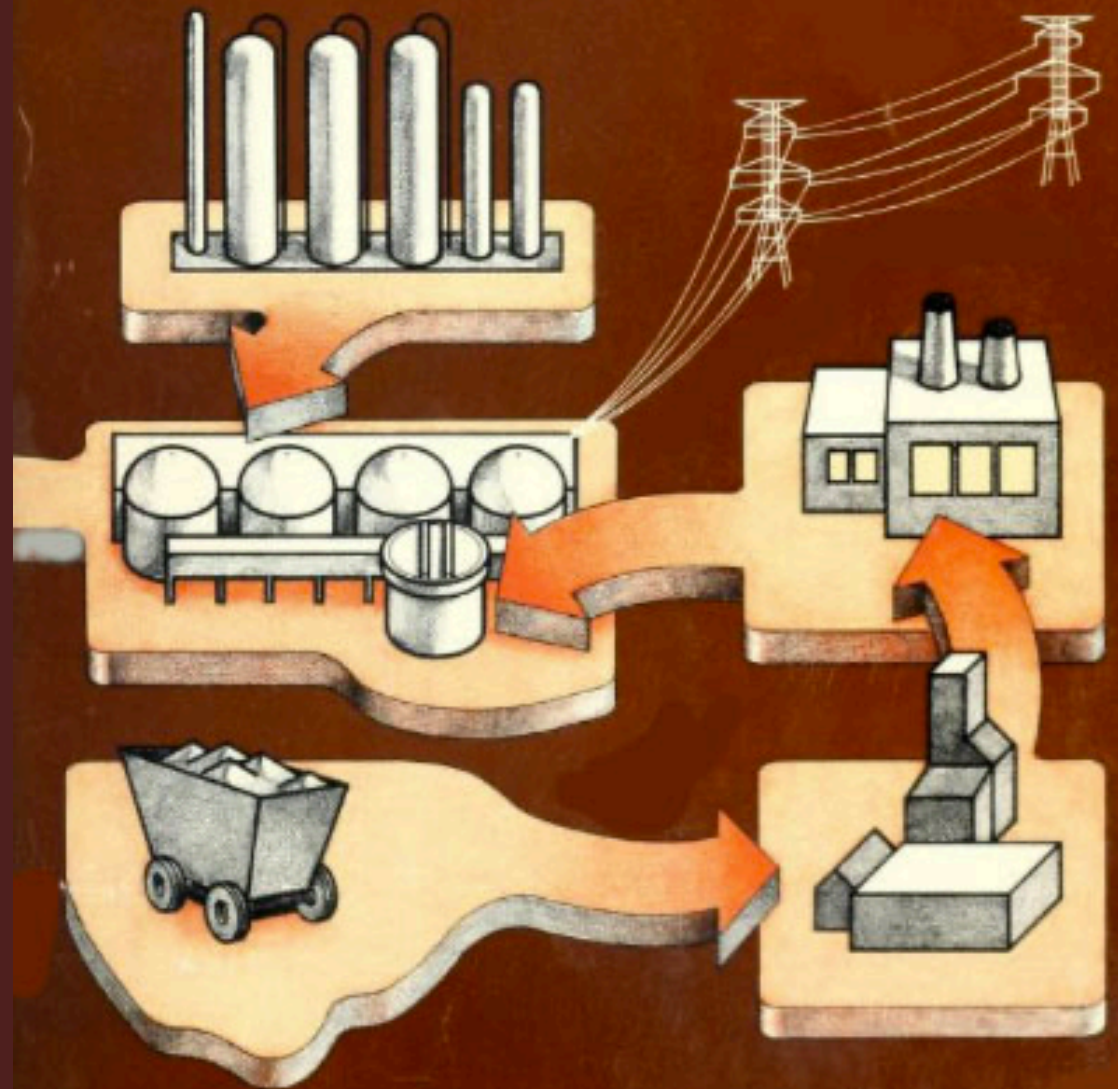
# ONTARIO

## Porter Commission (1978)

“Continuous monitoring of waste disposal research should be undertaken by **an independent panel** of experts. If adequate progress is not being made, say, by 1985, the **nuclear power should be reassessed and a moratorium on additional nuclear stations should be considered.**”

A Race Against Time, Report of the  
Ontario Royal Commission on Electric Power Planning  
September 1978

# A Race Against Time



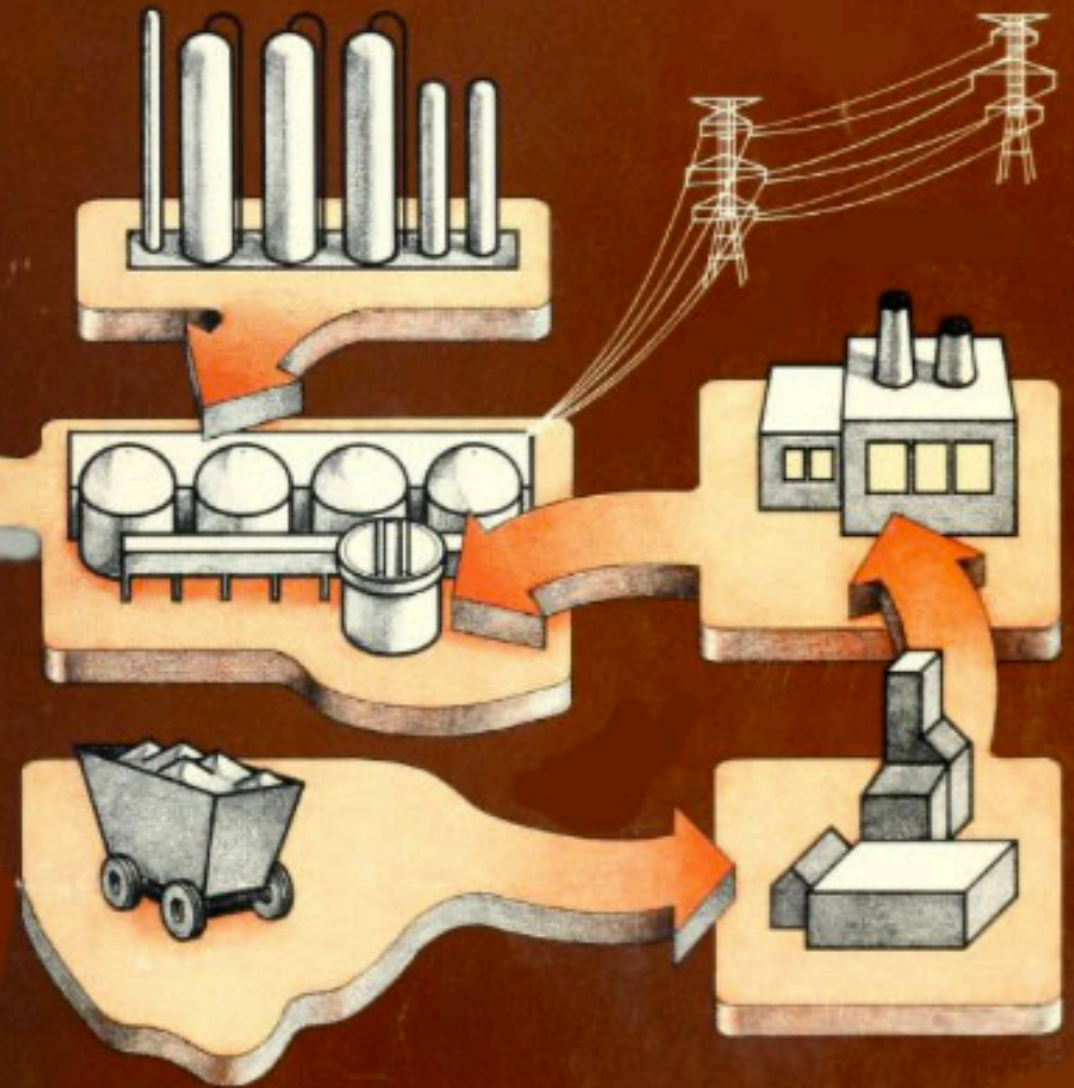
Royal Commission on Electric Power Planning

1978 Report on Nuclear Power

Nuclear Fuel Waste:  
An Unsolved Problem



# A Race Against Time



Royal Commission on Electric Power Planning

# CANADA - 1998

## Seaborn Panel (1998)

**“The [DGR] concept in its current form does not have the level of acceptability to be adopted as Canada’s approach for managing nuclear waste.”**

***RECOMMENDED: A Nuclear Fuel Waste Agency that is independent of the industry, with key stakeholders on the Board of Directors, having multiple oversight mechanisms and frequent public reviews, preferably through parliament.***

“Until the foregoing steps have been completed . . .  
***the search for a specific site should not proceed.***”

Environmental Assessment Report on  
AECL’s High Level Waste Disposal Concept  
February 1998

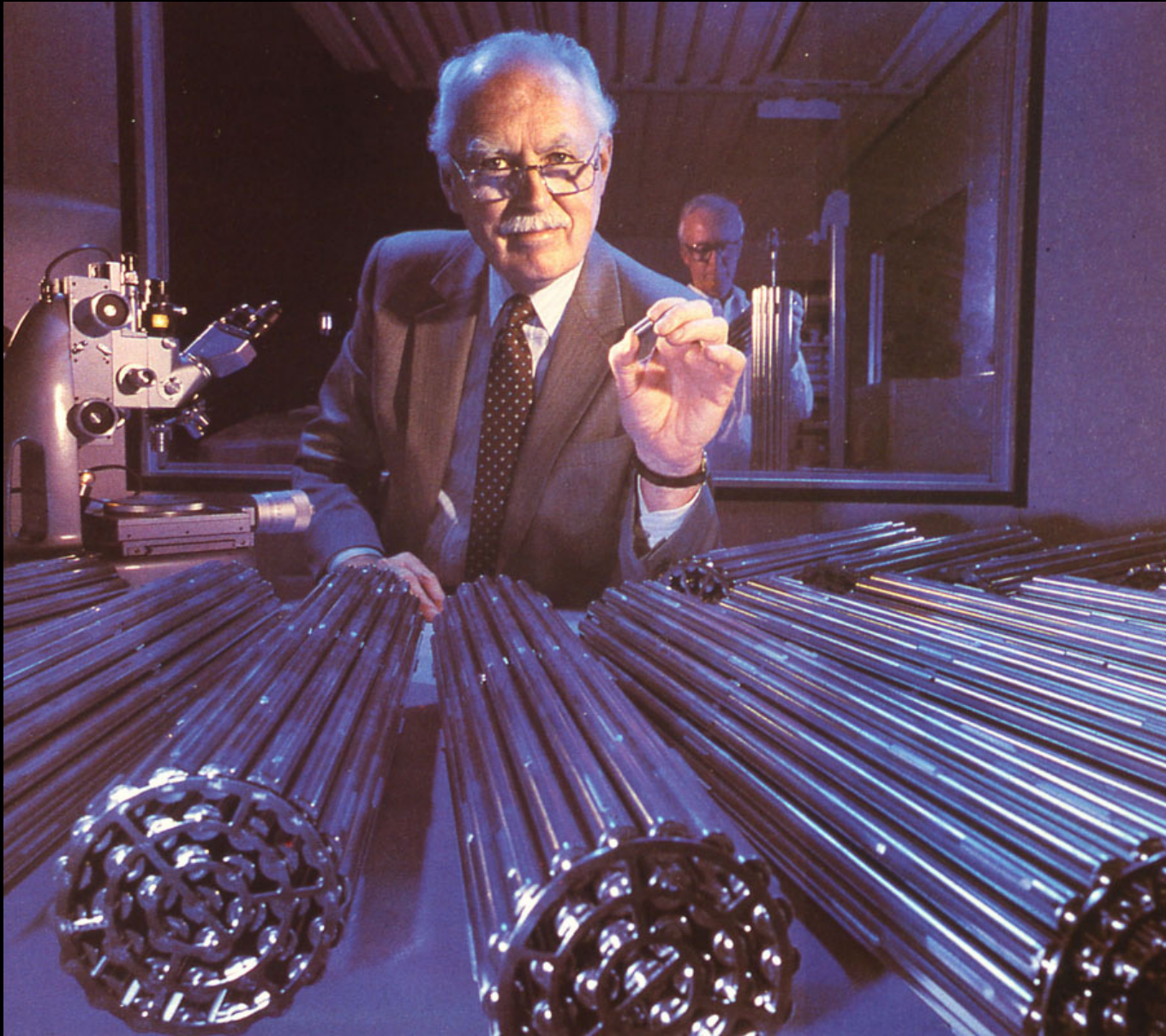
# NWMO

The **Seaborn Panel** recommended (1998) a Nuclear Fuel Waste Management Agency (NFWMA) that would

- *be at **arm's length** from the nuclear industry,*
- *have **stakeholders** on the Board of Directors, and*
- ***report regularly to the Parliament** of Canada.*

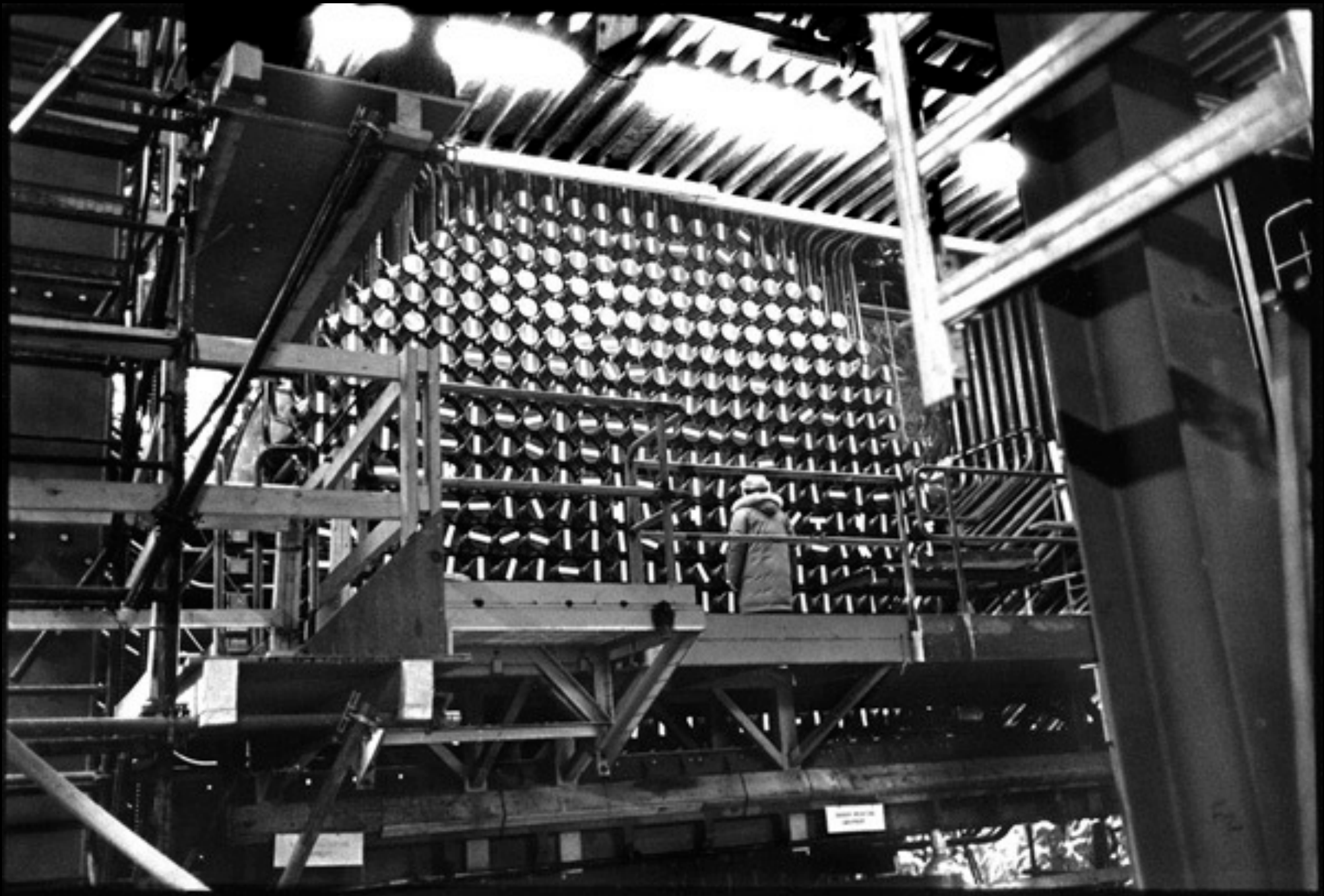
Instead, the **Government** created (2002) an **industry-owned** Nuclear Waste Management Organization (NWMO)

- *whose Board Members are representatives of the **nuclear waste producers**, and*
- *which reports to the **Minister of Natural Resources**,  
– the one responsible for promoting nuclear power.*



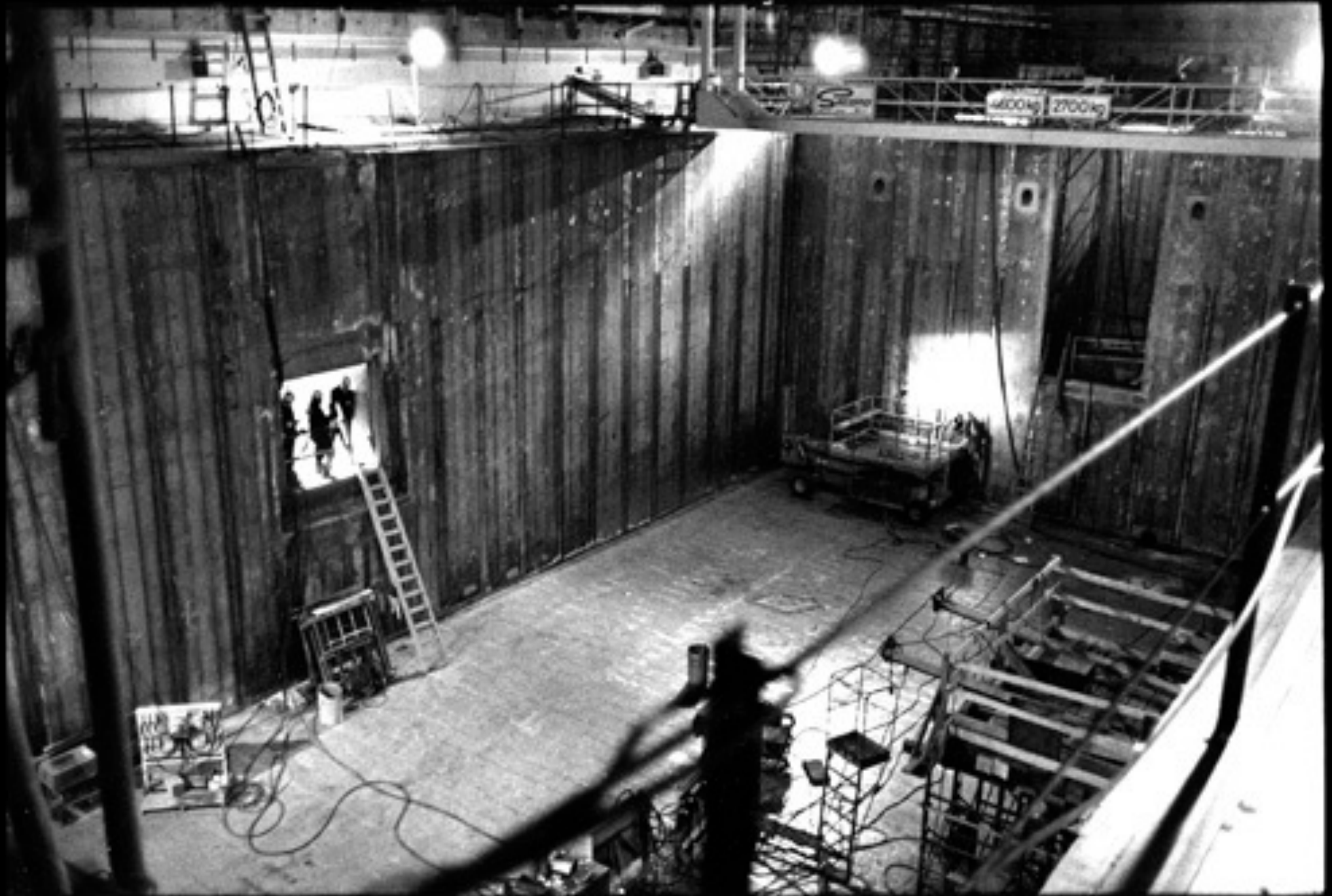
A CANDU fuel bundle like one of these can be handled safely before it is used, but after use in a reactor it delivers a lethal radiation dose in a few seconds.

*"Small Wonder" : Canadian Nuclear Association Ad*



The face of a CANDU reactor loaded with fresh (unused) fuel bundles

*Photo: Robert Del Tredici*



Irradiated fuel must be cooled for several years by circulating water in a spent fuel pool.

*Photo: Robert Del Tredici*





After 10 years in the pool, CANDU spent fuel is put into air-cooled “dry storage” containers.

*Photo: Robert Del Tredici*

AECL's Underground  
Research Laboratory  
near Pinawa, Manitoba



The Nuclear Waste Management Organization will wait 30 years before putting irradiated fuel underground to prevent it from spontaneously overheating due to radioactive disintegrations.

*Photo: Robert Del Tredici*

# CAN Geological Storage Solve the Waste Problem?

Why not get rid of this waste safely  
by **burying it all deep underground?**

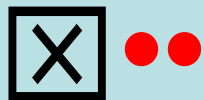
*Let's assume that nuclear fuel waste is  
moved to a distant location as rapidly as  
possible, and buried as quickly as it can be.*

*Will this **solve the nuclear waste problem?***

The following series of graphics explores  
the possibility in very simple diagrams.

# IRRADIATED NUCLEAR FUEL ACCUMULATION WITHOUT GEOLOGIC DISPOSAL

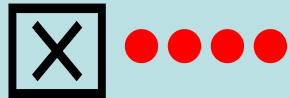
ONE  
REACTOR



*AFTER 2 YEARS*

The “X” represents a single nuclear reactor.  
Each dot represents one year’s production of irradiated nuclear fuel

**IRRADIATED NUCLEAR FUEL ACCUMULATION  
WITHOUT GEOLOGIC DISPOSAL**



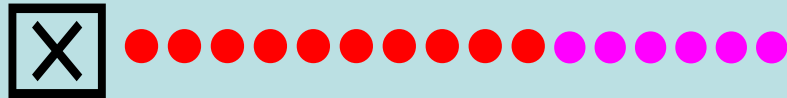
*AFTER 4 YEARS*

**IRRADIATED NUCLEAR FUEL ACCUMULATION  
WITHOUT GEOLOGIC DISPOSAL**



*AFTER 8 YEARS*

# IRRADIATED NUCLEAR FUEL ACCUMULATION WITHOUT GEOLOGIC DISPOSAL



*AFTER 16 YEARS*

As the years go by, more and more nuclear waste accumulates beside the reactor.

# IRRADIATED NUCLEAR FUEL ACCUMULATION WITHOUT GEOLOGIC DISPOSAL



*AFTER 32 YEARS*



# IRRADIATED NUCLEAR FUEL ACCUMULATION WITHOUT GEOLOGIC DISPOSAL



*AFTER 40 YEARS*

***Look at all that nuclear waste right beside the reactor!***

*Shouldn't we get rid of it? Shouldn't we at least get it off the surface?*

*The nuclear industry offers **to solve the problem – by burying the waste.***

## GEOLOGIC DISPOSAL : IS IT INTENDED TO MAKE THE WORLD SAFER?

Why does the industry want to bury its nuclear waste?

- Is it unsafe where it is? [*the industry says “no ”*]
- Will we stop making it? [*the industry says “no ”*]

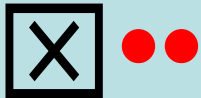


Can we get rid of all the nuclear waste beside the reactors?

*Common sense says “no ” – not if we keep on producing it!*

HERE' S HOW THE PICTURE LOOKS. . .

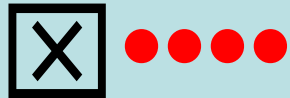
**WITH** GEOLOGIC DISPOSAL



*AFTER 2 YEARS*

*No change at all! irradiated fuel has to be stored in the spent fuel pool.*

## WITH GEOLOGIC DISPOSAL



AFTER 4 YEARS

*Still no change! all irradiated fuel is being stored in the pool.*

## WITH GEOLOGIC DISPOSAL



*AFTER 10 YEARS*

*For the first ten years the **nuclear waste is so radioactive it cannot be moved.** It has to be cooled in water-filled pools to **prevent spontaneous over-heating.***

## WITH GEOLOGIC DISPOSAL



*AFTER 16 YEARS*

*After ten years the nuclear fuel waste can be put into dry storage. It could be transported, but it is still too “hot” to be buried underground.*

## WITH GEOLOGIC DISPOSAL



AFTER 16 YEARS

*THIS PORTION MAY BE TRANSPORTED -- HOORAY !*

*After 10 years the fuel might be moved, but industry plans to wait for 30 years.  
**So: 10 to 30 years worth of unburied nuclear waste stays right beside the reactor!***

**WITH** GEOLOGIC DISPOSAL

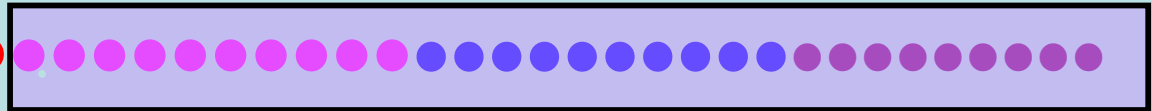


*AFTER 32 YEARS*

*ONLY THIS PORTION MAY BE TRANSPORTED!*



## WITH GEOLOGIC DISPOSAL



*THIS IS NOT REMOVED!*

*ONLY THIS PORTION MAY BE TRANSPORTED!*

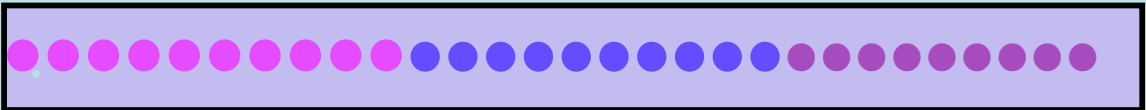
*AFTER 40 YEARS*

***NOTE – The Catastrophe Potential at the Surface Still Remains.  
The hottest, most radioactive fuel waste, is still sitting beside the reactor.***

## WHAT DOES THE INDUSTRY HOPE TO ACHIEVE?

To convince citizens that the waste problem is “solved”

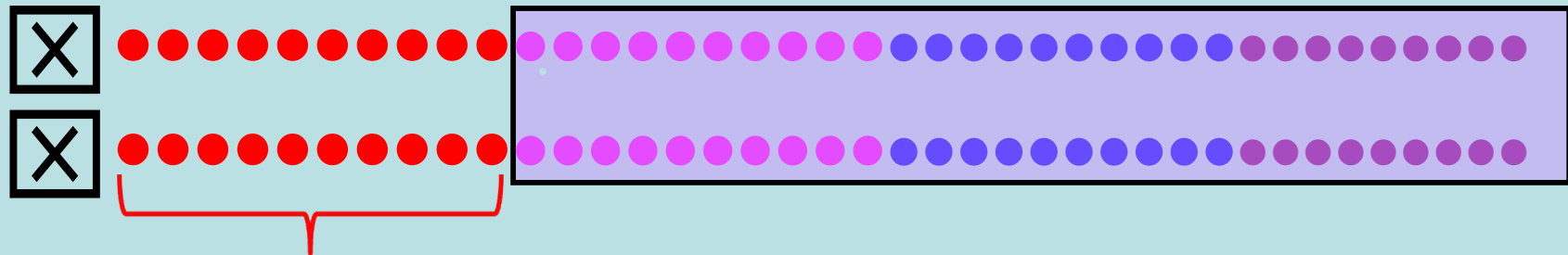
- so the lifetime of old reactors can be prolonged;
- so new reactors can be built at home and abroad;
- so the industry can continue to expand. . . .



*Once the nuclear waste problem is “solved”  
the nuclear industry says it is*

***“TIME FOR A ‘NUCLEAR RENAISSANCE’ –  
MORE REACTORS, PLEASE !”***

*But building more reactors just adds to the problem of UNBURIED waste,*  
**EVEN WITH** GEOLOGIC DISPOSAL

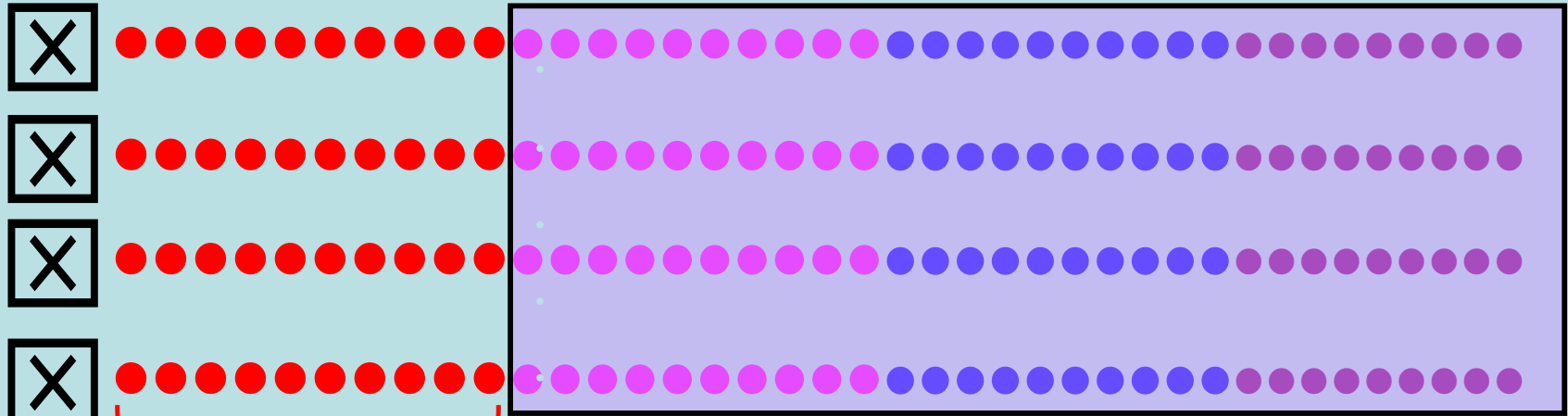


*THIS IS NOT REMOVED!*

*ONLY THIS PORTION MAY BE TRANSPORTED!*

*With 2 reactors, after 40 years there is **TWICE AS MUCH UNBURIED NUCLEAR WASTE.***

**WITH** GEOLOGIC DISPOSAL

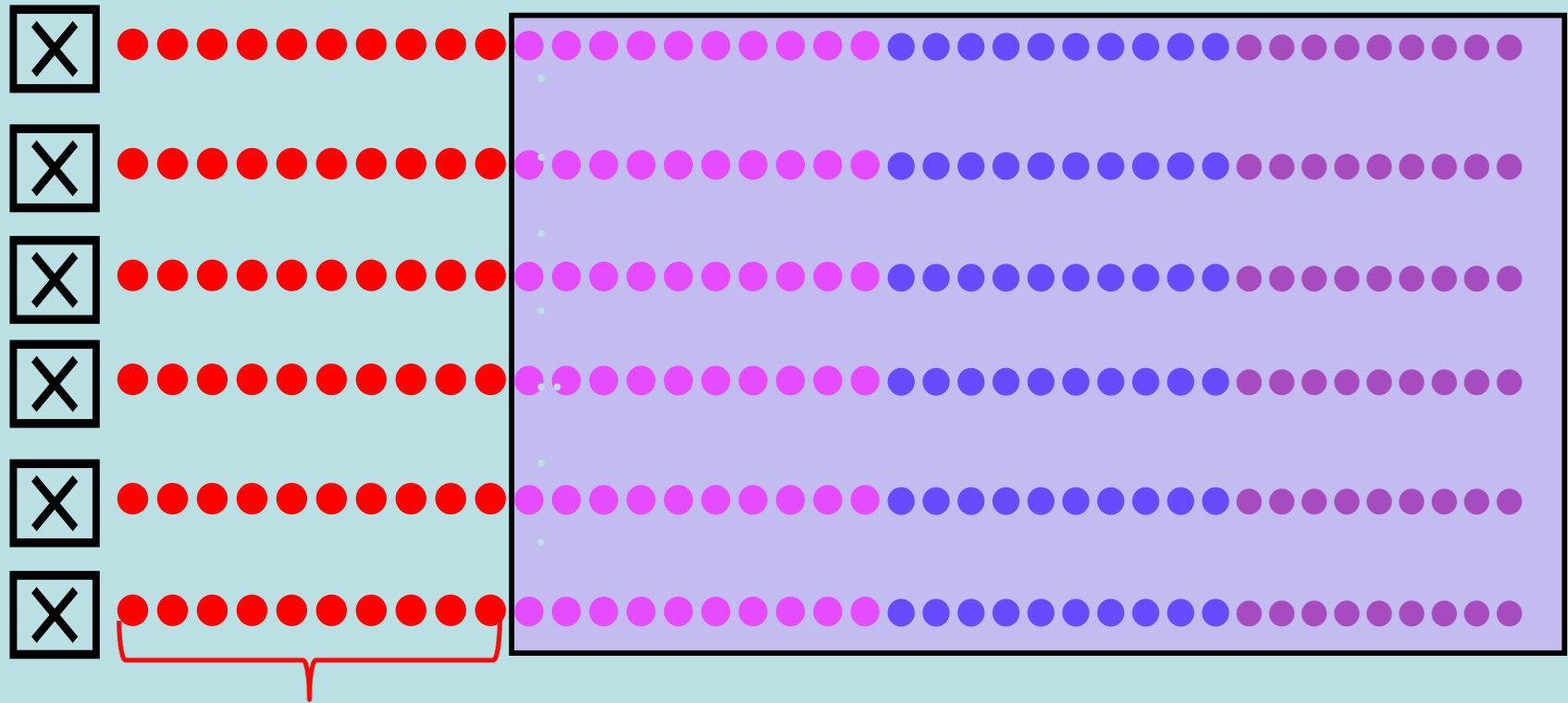


*THIS IS NOT REMOVED!*

*ONLY THIS PORTION MAY BE TRANSPORTED!*

*WITH 4 REACTORS*

**WITH** GEOLOGIC DISPOSAL

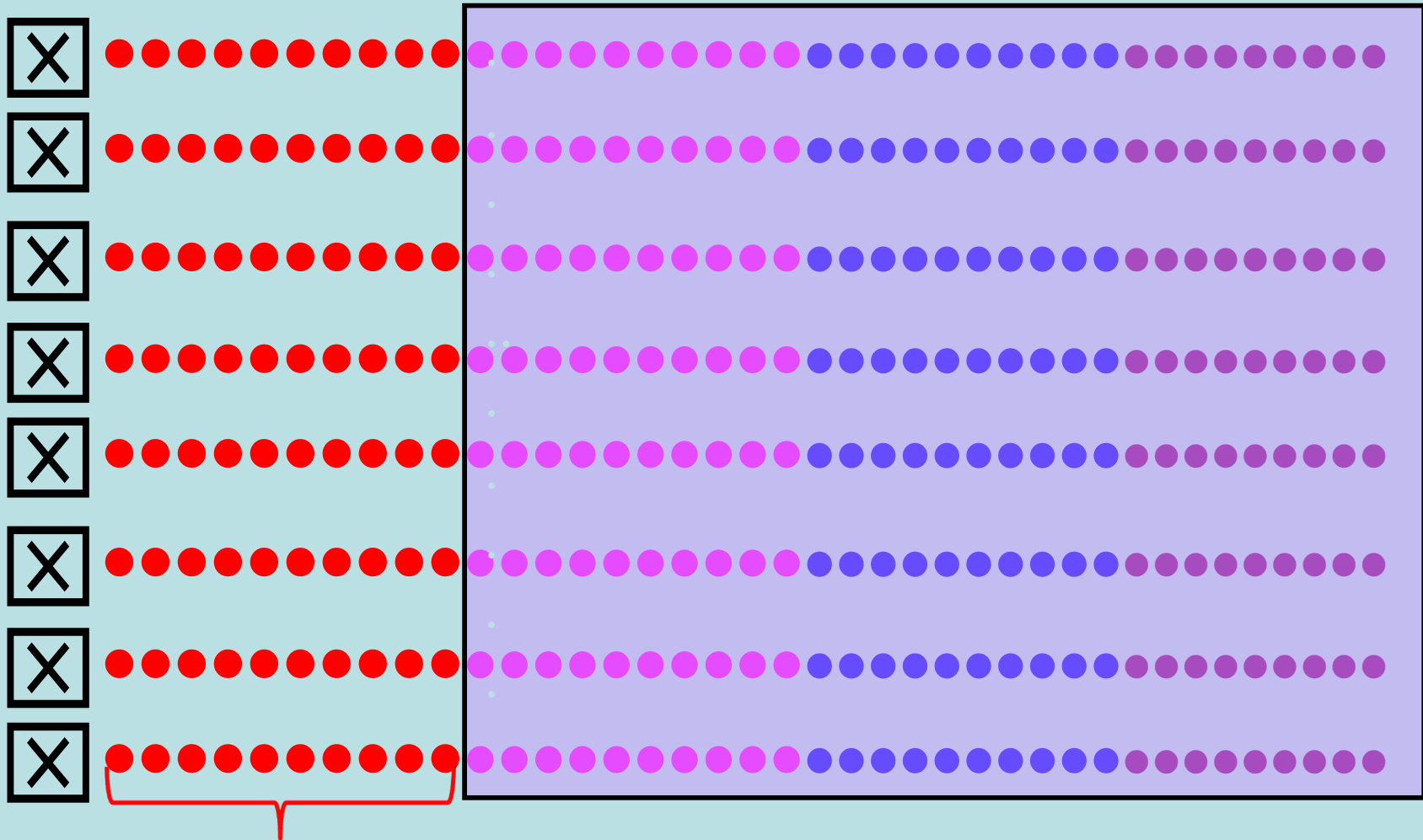


*THIS IS NOT REMOVED!*

*ONLY THIS PORTION MAY BE TRANSPORTED!*

*WITH 6 REACTORS*

**WITH** GEOLOGIC DISPOSAL

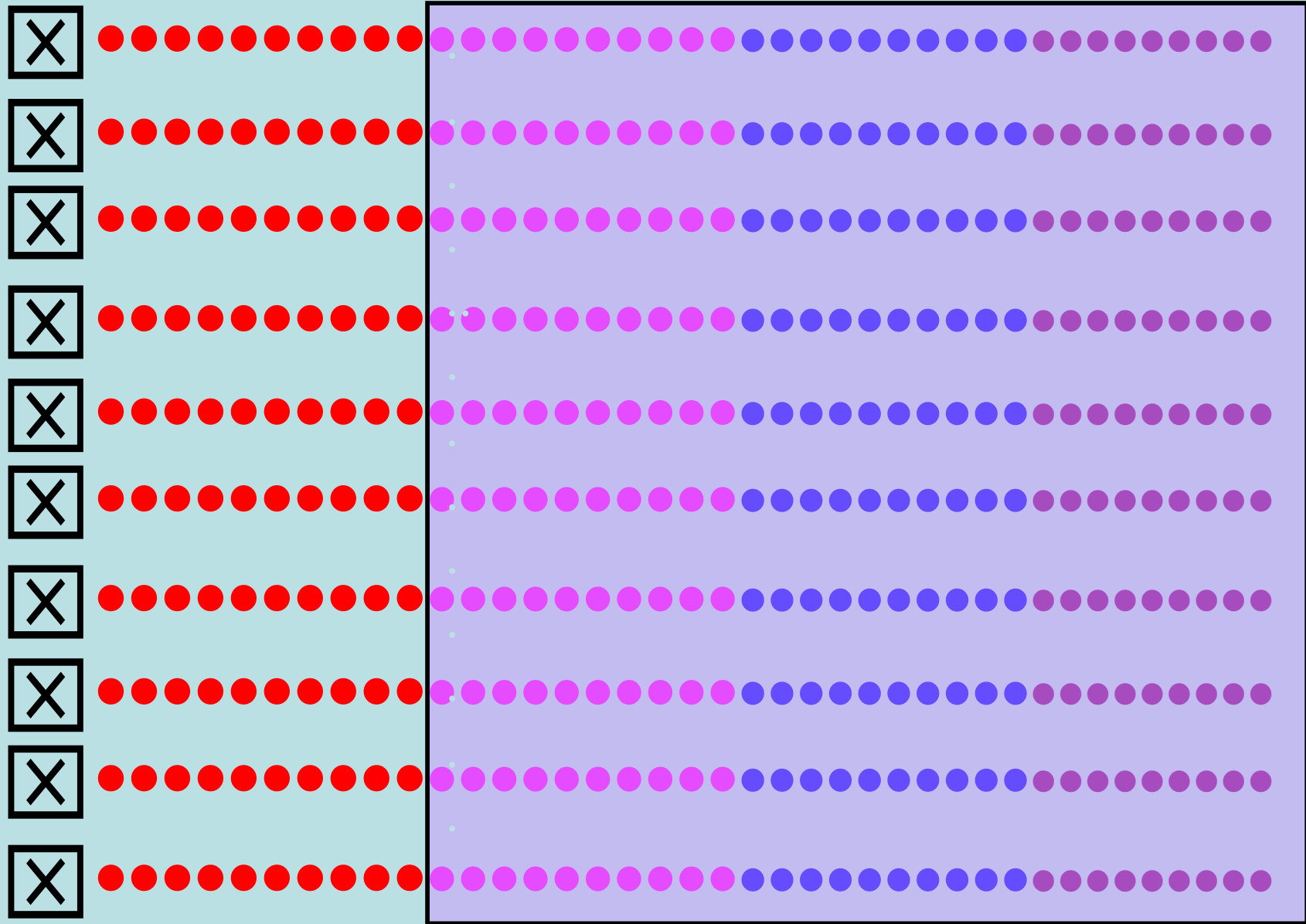


*THIS IS NOT REMOVED!*

*ONLY THIS PORTION MAY BE TRANSPORTED!*

*WITH 8 REACTORS*

**SO EVEN WITH** GEOLOGIC DISPOSAL . . .



***. . . THERE IS AN EVER-GROWING INVENTORY OF UNBURIED WASTE!!***

# HOW is this a solution?

The industry **does not intend to stop** making nuclear waste.

And nuclear waste **can't be shipped** for at least 10 to 30 years.

So if reactors keep running – **unburied nuclear waste builds up.**

With more reactors, **the stock of fresh unburied waste keeps growing**

– **even if the older, colder waste is buried as quickly as possible!**

Unless all reactors are stopped, ***how can burial be a solution?***



## Rolling Stewardship

*~ an alternative to abandonment ~*

amnesia versus

persistance of memory

**Management** (n): *the process of dealing with or caring for something.*

Can we **store nuclear waste safely for decades** at a time?

**YES**

**Disposal** (n): *the process of throwing away or getting rid of something.*

Do we know how to **“get rid” of nuclear waste forever** ?

**NO**

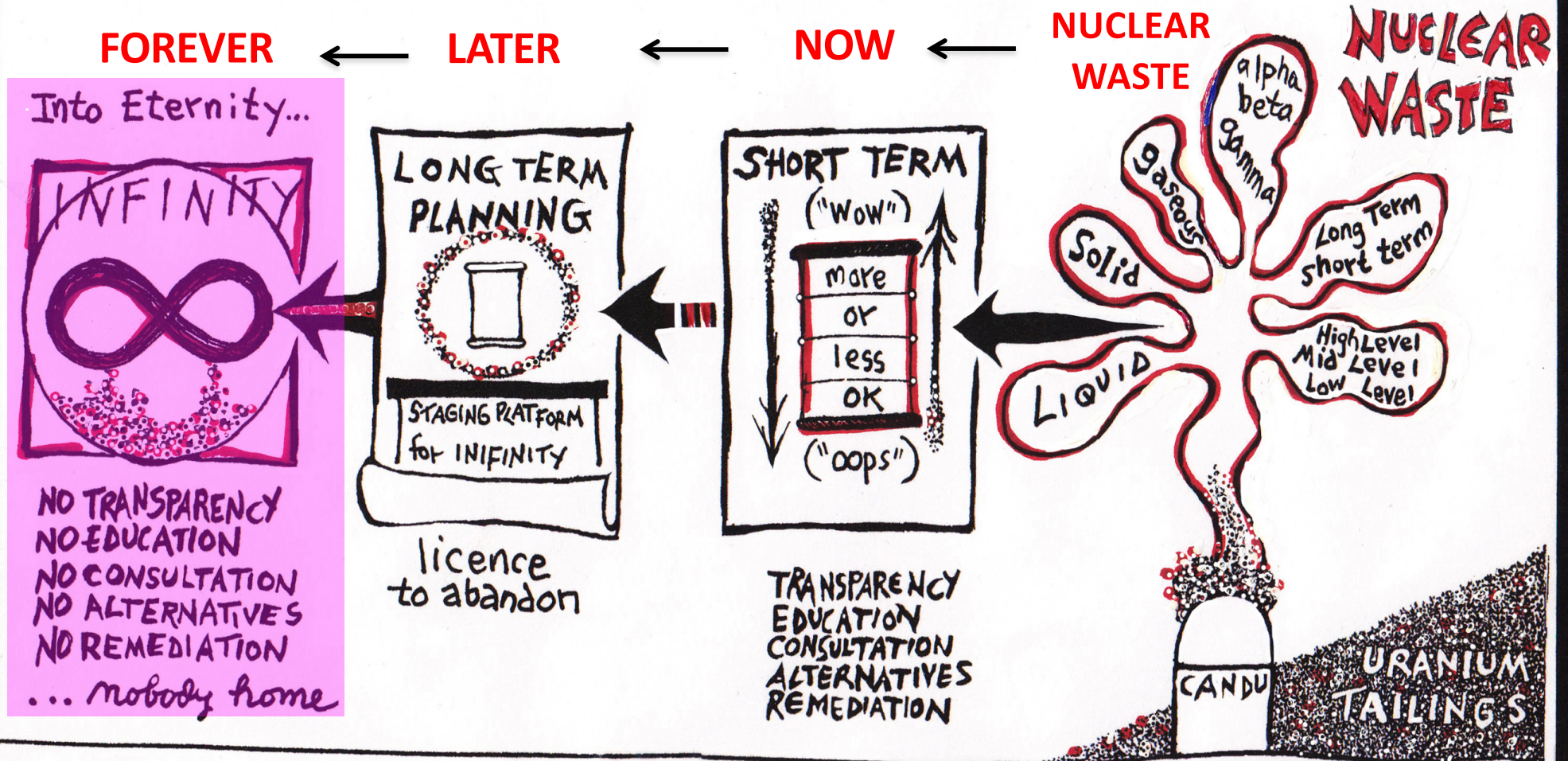
**Abandon** (n) : *to cease to support or look after; to desert.*

Is **abandonment of nuclear waste** ethical? Is it scientific?

**NO**

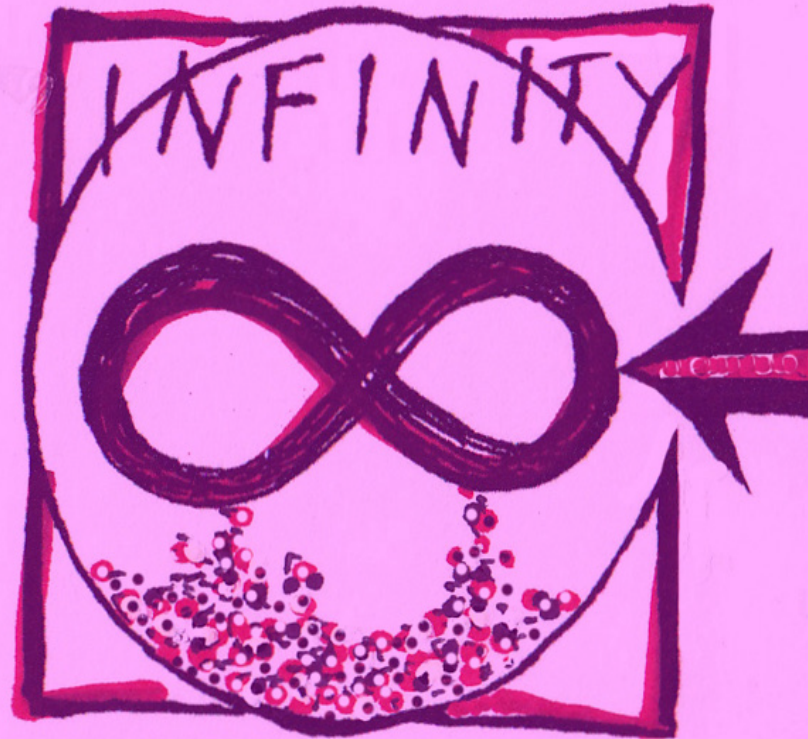
Abandonment leads to amnesia; no one will know what it is or what to do with it ...

# ABANDONMENT



leading to *amnesia* ...

Into Eternity...



NO TRANSPARENCY  
NO EDUCATION  
NO CONSULTATION  
NO ALTERNATIVES  
NO REMEDIATION

... nobody home

after

abandonment ...

... amnesia

sets in !

## Is there an alternative to “Geological Disposal” ?

An alternative is needed because . . .

**Moving the waste** : **adds another waste site** to those existing.

**Transportation** : **poses new risks** and complicates the picture.

**Centralized storage** : lays the **groundwork for reprocessing**.

# Rolling Stewardship

Our alternative to abandonment is **Rolling Stewardship**.

It is a new nuclear waste policy based on **frankness**.

*We begin by admitting **we have at present no proven solution**.*

Wastes are **monitored and retrievable** for the foreseeable future.

Wastes are **packaged safely** for extended periods & **repackaged later**.

*This is not a solution – but it is an **ethical waste management scheme**.*

Rolling Stewardship is needed **until a “genuine solution” is found**.

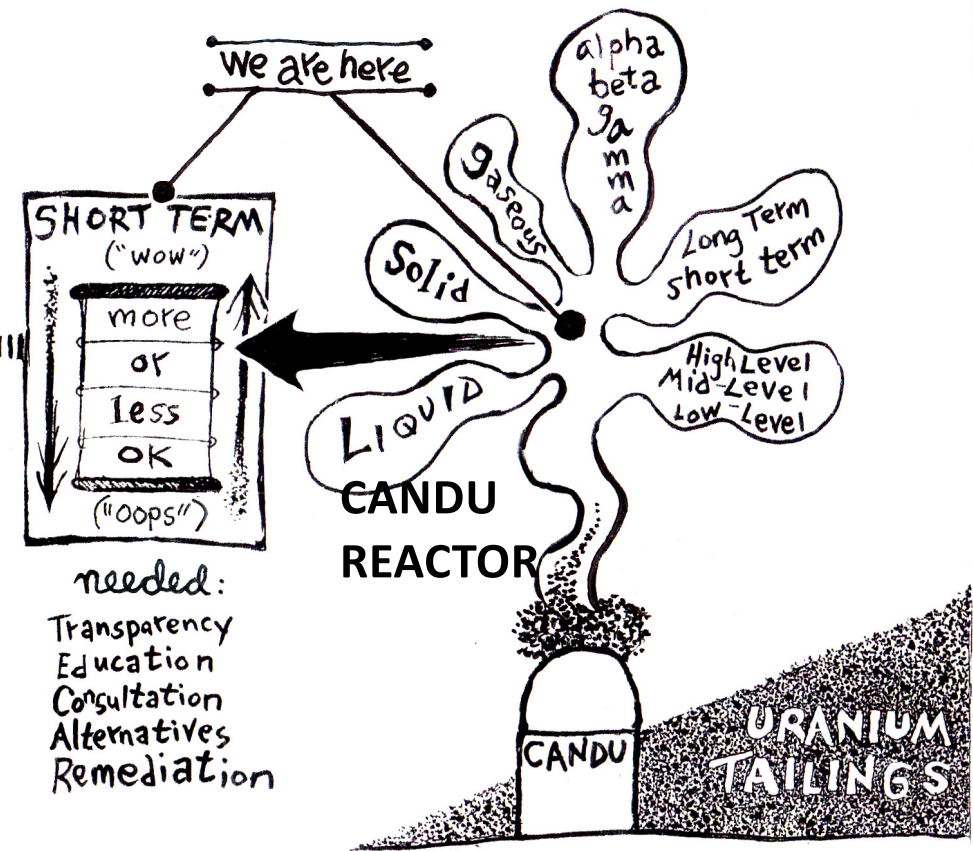
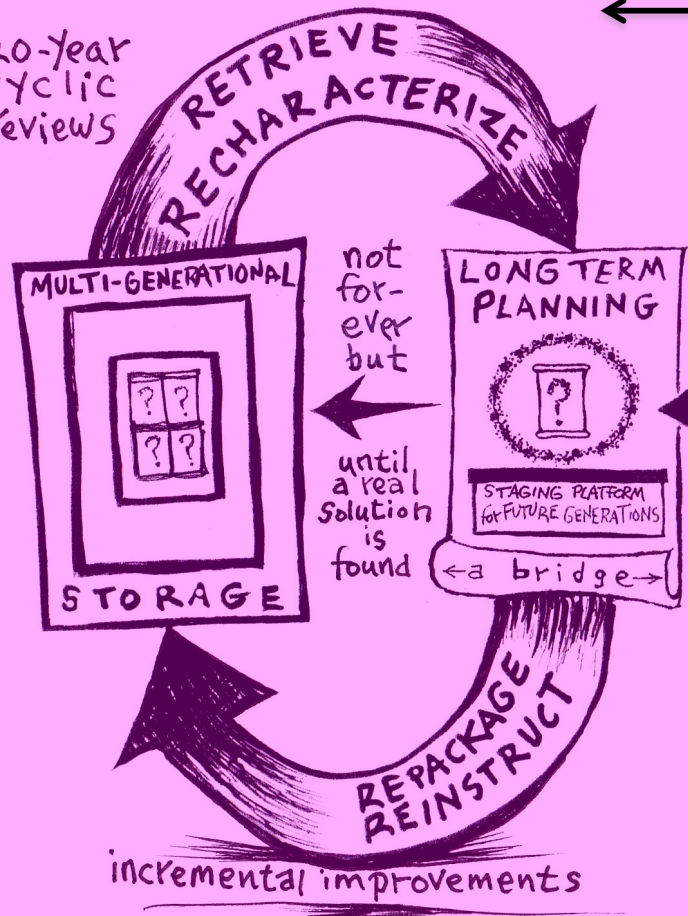
*The production of **additional wastes can & should be stopped**.*

Rolling Stewardship is continuous; it is based on ensuring Persistence of Memory

# ROLLING STEWARDSHIP

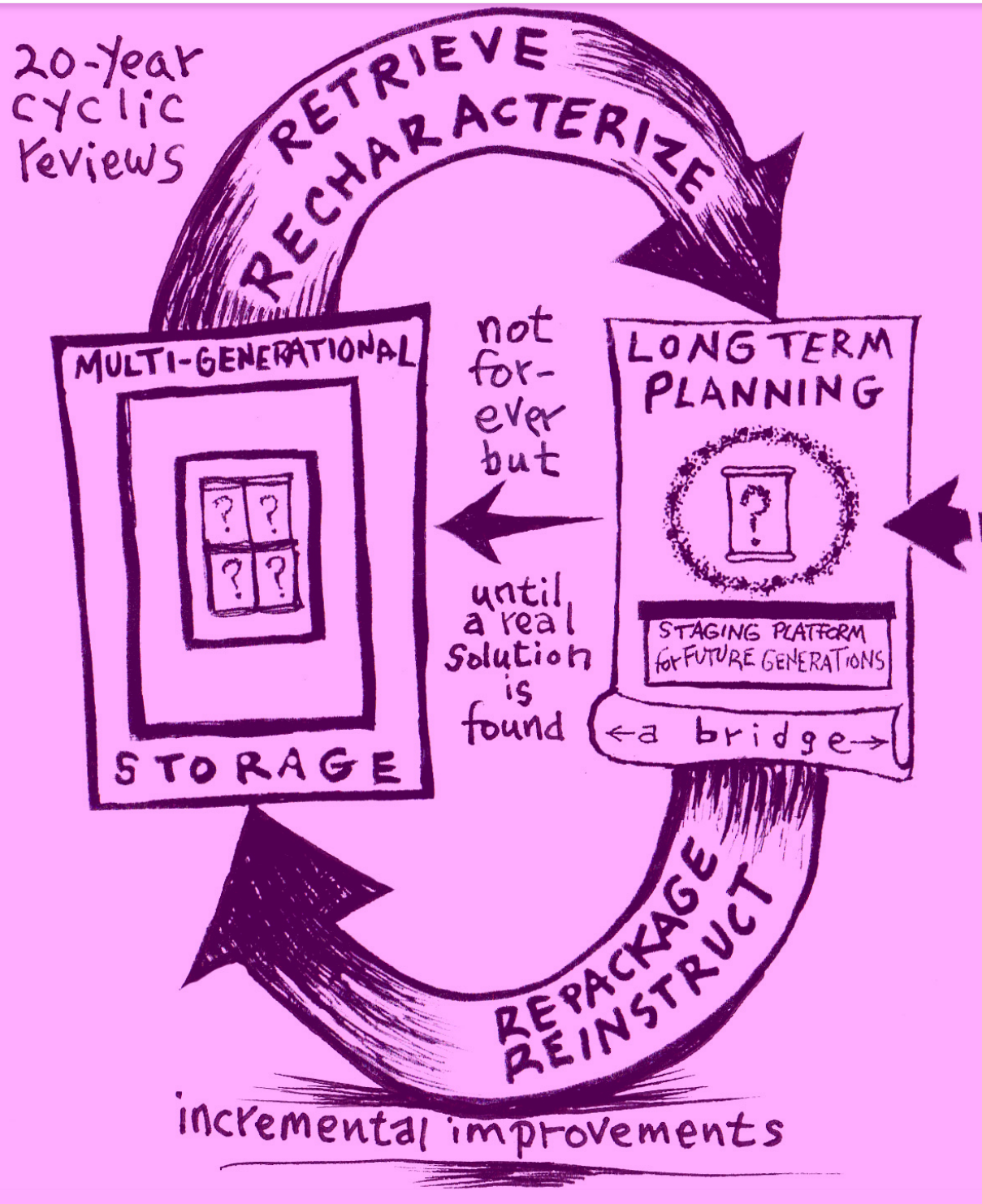
NUCLEAR  
WASTES

20-year  
cyclic  
Reviews



## PERSISTENCE of MEMORY

Future generations have an incentive to find a genuine solution



Rolling Stewardship is an **intergenerational** management strategy

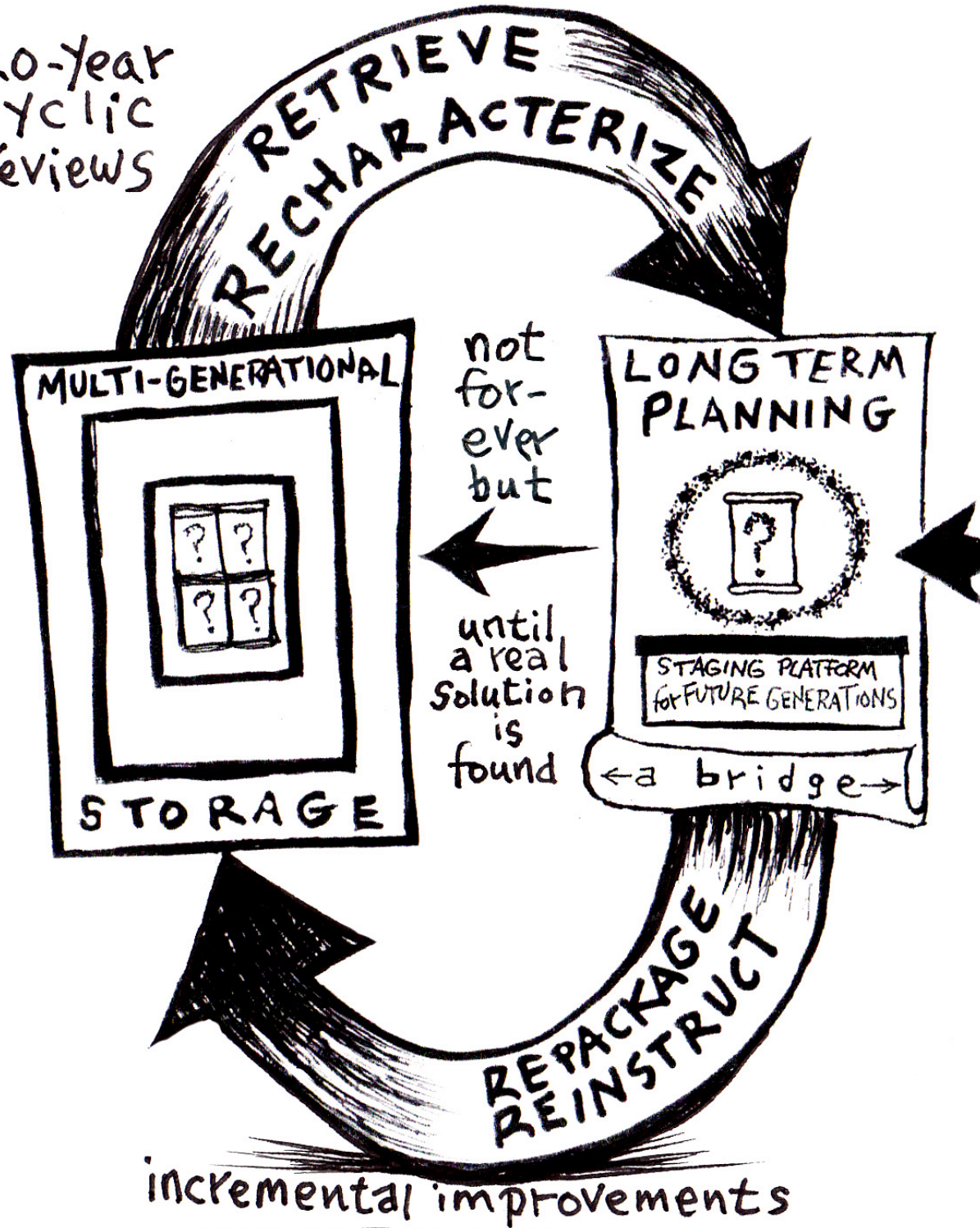
With a “changing of the guard” **every 20 years the necessary knowledge and resources can be communicated** to the next generation.

Those in charge must be **independent** of the nuclear industry.



# ROLLING STEWARDSHIP

20-year  
cyclic  
Reviews



# POINTS TO PONDER:

Abandonment is based on the concept of amnesia: forget it!

Rolling Stewardship is based on persistence of memory: look after it!

Rolling Stewardship allows timely corrective action to be taken.

Rolling Stewardship imparts all information to the next generation.

A 20-year “changing of the guard” would officially transfer resources.

Ongoing monitoring, robust packaging, and retrievability at all times.

Recharacterization of the wastes and repackaging when necessary.

This is not a solution – it is a responsible waste management scheme.

Rolling Stewardship is needed until a genuine solution can be found.

A solution might involve destruction or neutralization of the wastes.

*The concept of  
Rolling Stewardship  
was also being invoked  
for the currently cancelled  
Great Lakes Nuclear Dump  
for low & medium level wastes.*

*Public environment hearings were  
conducted under the auspices of the  
Canadian Nuclear Safety Commission  
(Canada's nuclear regulator) as well as the  
Canadian Environmental Assessment Agency.*

*Q: Should society be **ABANDONING** nuclear waste?  
Or should we accept the responsibility to **MANAGE** it?*

## *Four Questions*

- How do we **tell future generations** about the radioactive legacy we are leaving them?

- How do we **safeguard plutonium** from bomb-makers and from profiteers for thousands of years?

- How do we prepare for new **unorthodox nuclear fuel** waste from Small Modular Nuclear Reactors (SMNRs)?

- How do we deal with all the long-lived radioactive waste from **dismantling old nuclear reactors**?

# How do we tell future generations about the radioactive legacy we are leaving them?

## Information and Memory for Future Decision-Making – Radioactive Waste and Beyond

Proceedings of the Stockholm workshop 21–23 May 2019



# The Nuclear Energy Agency (NEA) Radioactive Waste Committee

( 2011 to 2018 ) The Committee launched an RKM initiative on

## Preservation of Records, Knowledge and Memory (RKM) Across Generations

Twenty-one organisations from 14 countries, representing implementing agencies, regulators, policy makers, R&D institutions, and international and archiving agencies, plus the IAEA, contributed to the work

## ANALOGS

SETI (Search for Extra Terrestrial Intelligence)

Preservation of Cultural Heritage and Knowledge

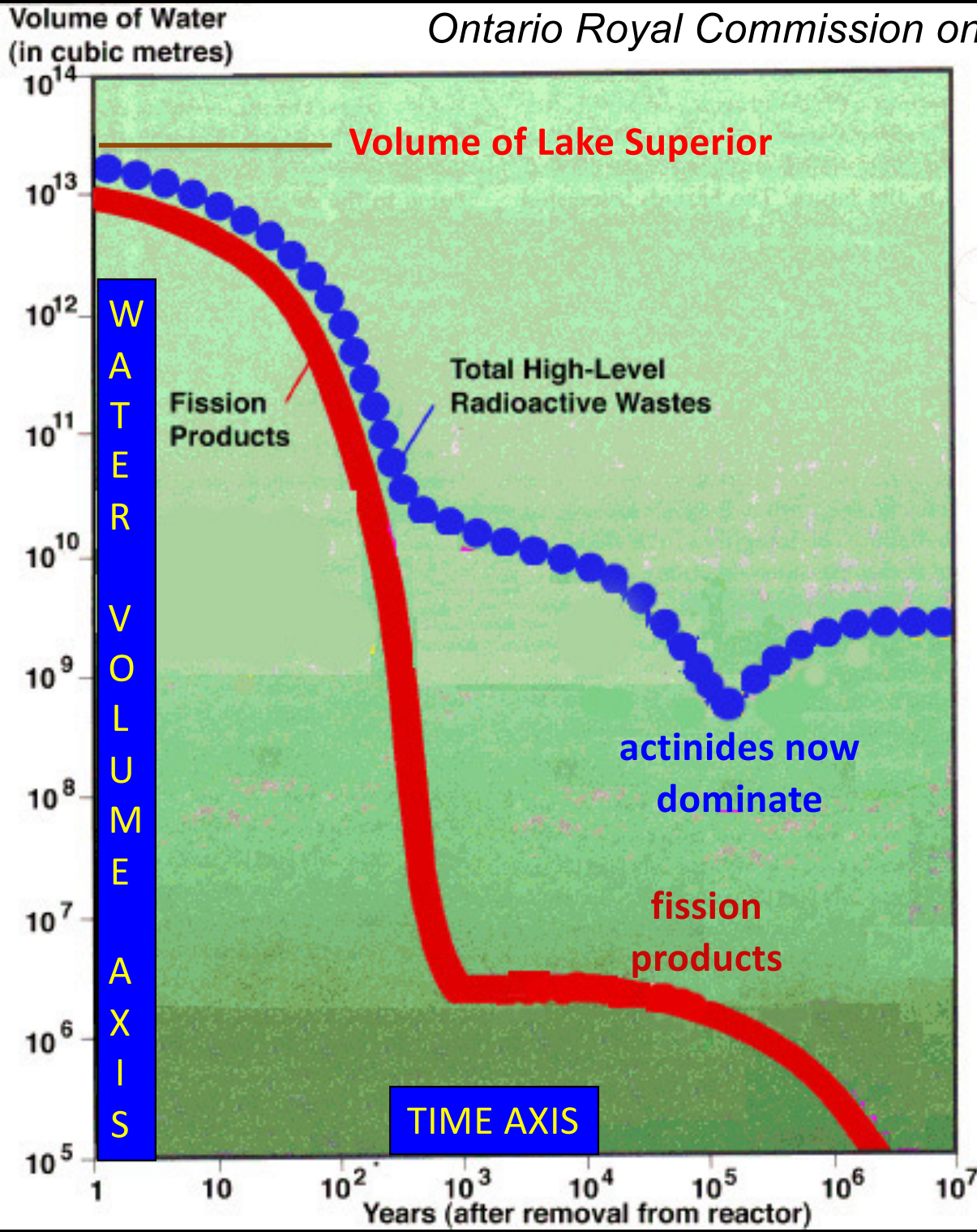
Archives, Libraries,  
Monuments, Art Works,  
Recordings, Inscriptions,  
Ceremonies, Oral Tradition...

What languages will be understood?

What is to be communicated?

Will it be correctly understood?

How will it be interpreted?



For the first 500 – 1000 years, fission products are the deadliest components of nuclear fuel waste.

After 1000 years, actinides are the deadliest components of nuclear fuel waste.

The blue line shows radio-toxicity for a period of 10 million yrs



# How Many Bombs?

*Present inventory of CANDU used fuel > 50,000 tons  
Amount of Plutonium in CANDU used fuel : 200 tons*

Years From Now	Amount of Plute	Number of A-Bombs
Today	200 tons	32,000 Bombs
24,000 years	100 tons	16,000 Bombs
48,000 years	50 tons	8,000 Bombs
72,000 years	25 tons	4,000 Bombs
96,000 years	12.5 tons	2,000 Bombs

## Longevity of SMNR Waste

“... the bulk of the future radiation dose risk *[comes from]* long-lived fission products like selenium-79 and iodine-129 and the activation products carbon-14 and chlorine-36 rather than *[from]* the actinides.” (National Research Council 1996)

Here are some very long-lived fission products

### FISSION PRODUCT

Selenium-79

Technetium-99

Tin-126

Zirconium-93

Cesium-135

Palladium-107

Iodine-129

### HALF-LIFE

327,000 years

210,000 years

230,000 years

1,530,000 years

2,300,000 years

6,500,000 years

15,700,000 years

# How do we deal with all the long-lived radioactive waste from dismantling old nuclear reactors?

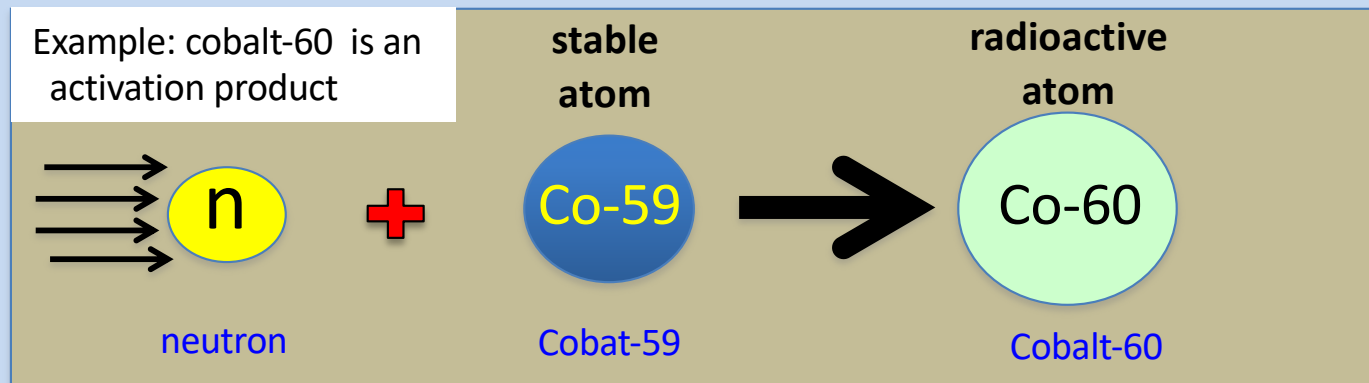
## *Radiation Fields from Reactor Components*

Item	Dose Rate	Lethal Dose (LD50 = 400 rems)
Pressure Tube	850 rems/hr	death in 28 minutes
Thermal Shield	260,000 rems/hr	death in 5.5 seconds
Calandria Shell	49,000 rems/hr	death in 29 seconds
Dump Tank	12,000 rems/hr	death in 2 minutes

Source: Pickering Preliminary Nuclear Decommissioning Cost Study

# What is an Activation Product?

When a stray neutron is absorbed by a non-radioactive atom the result is very often a radioactive atom – an “activation product”.

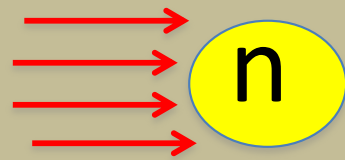


The diagram shows how a non-radioactive atom of cobalt-59 (in metals) becomes a radioactive atom of cobalt-60 when it absorbs a stray neutron.

# There are many activation products.

Deuterium (D) is a non-radioactive isotope of hydrogen (H) with a nucleus twice as heavy as H. Tritium (T) is a radioactive isotope of hydrogen with a nucleus three times as heavy as H.

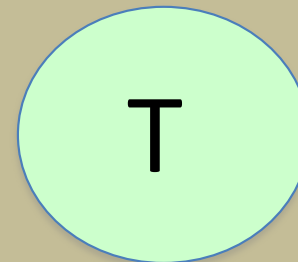
Example: tritium is an activation product



neutron



deuterium



tritium

The diagram shows how a non-radioactive atom of deuterium (in heavy water) becomes a radioactive atom of tritium when it absorbs a stray neutron.

## *Longevity of Some Activation Products*

Radionuclide	Half-Life	Ten Half-Lives
Nickel-59,	76,000 years	760 thousand years
Nickel-63,	101,000 years	1.01 million years
Niobium-94,	20,300 years	203 thousand years
<b>Plutonium-239,</b>	<b>24,000 years</b>	<b>240 thousand years</b>
Technetium-99,	120,000 years	1.2 million years
Iodine-129,	15,700,000 years	157 million years
Chlorine-36,	301,000 years	3.01 million years
Calcium-41,	102,000 years	1.02 million years

*Note: plutonium is not an activations product. It is included for comparison only.*

*Draft EIS, in-situ decommissioning of the Whiteshell WR-1 Reactor*

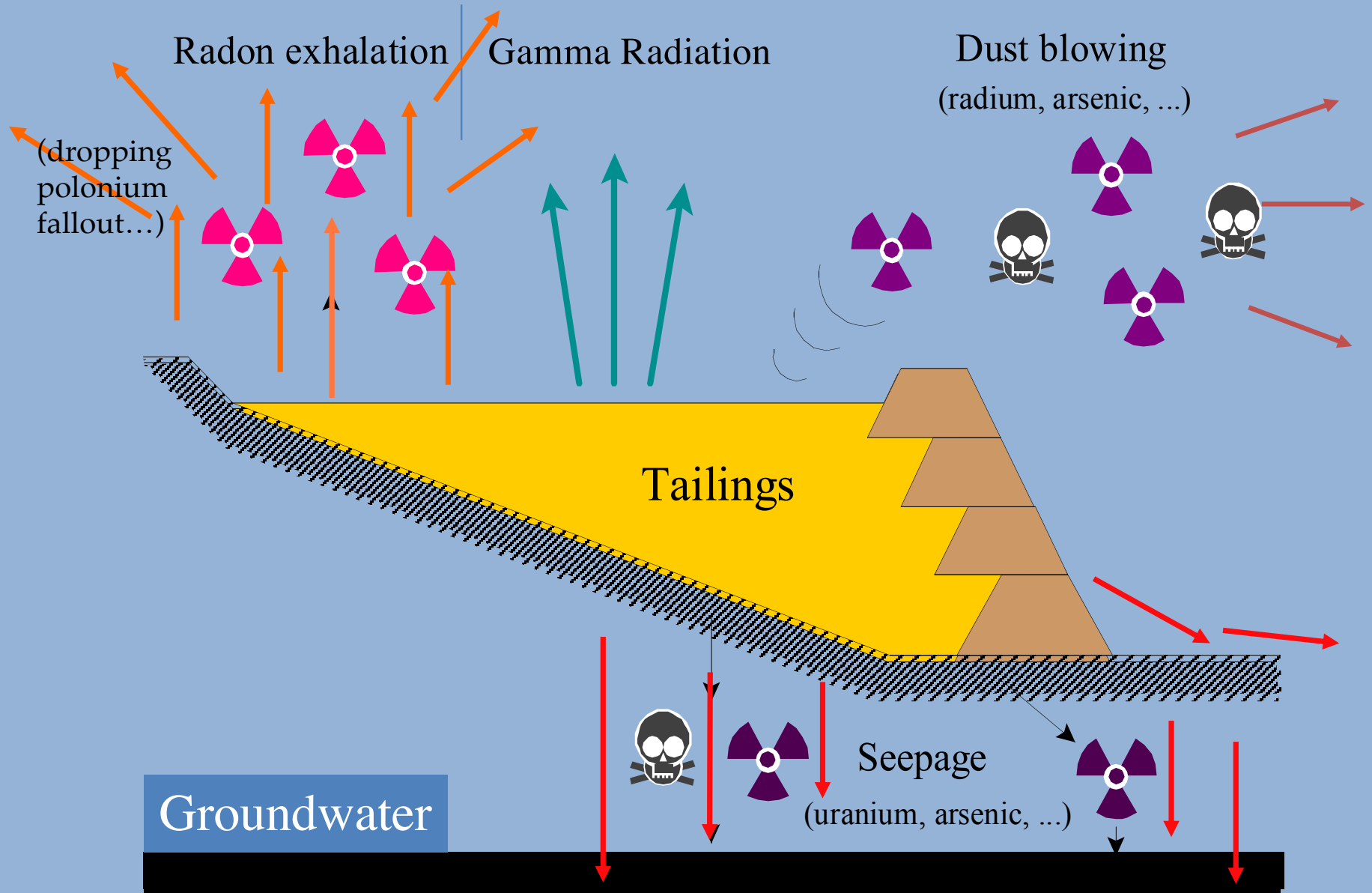
And let's not forget the 220 million tons of radioactive sand-like uranium tailings . . .



This 10-metre high wall is part of a deposit of 70 million tonnes of U tailings in Elliot Lake area.

*Photo: Robert Del Tredici*

# Uranium Mill Tailings Hazards

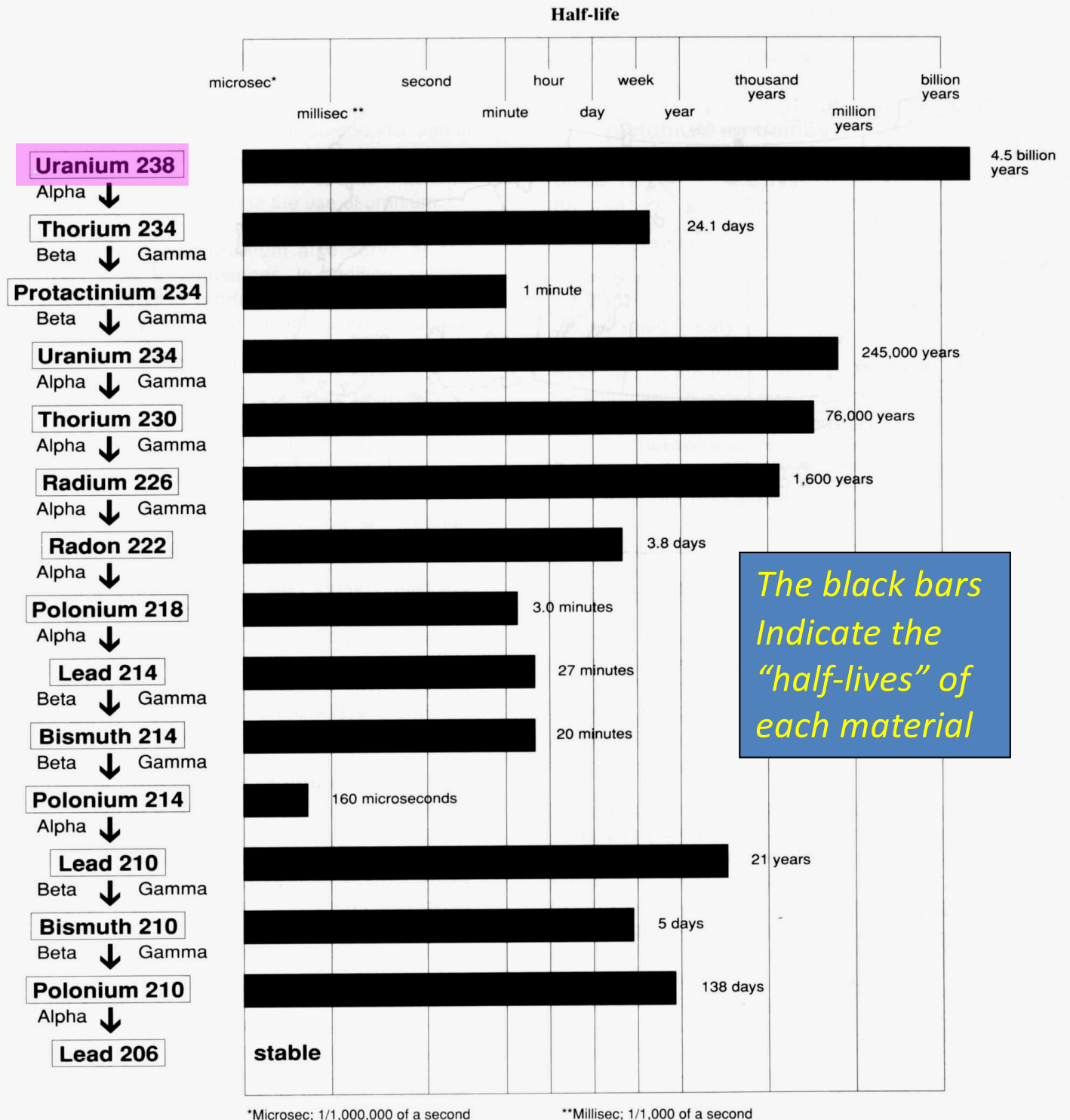




# URANIUM

When uranium atoms disintegrate they change into more dangerous radioactive elements.

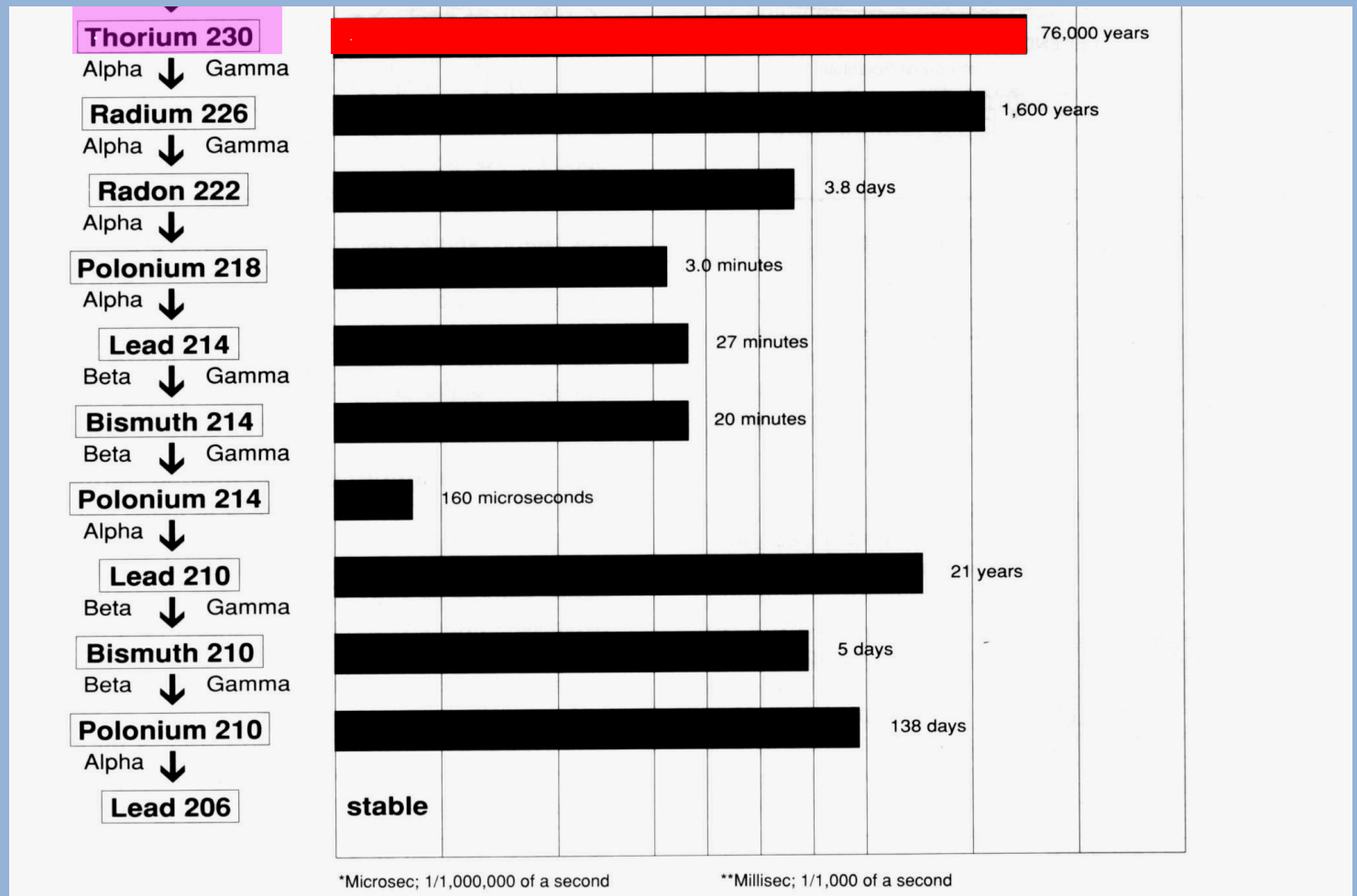
This is the “decay chain” of U-238. There is a similar decay chain for U-235.



When uranium is extracted, the radioactive decay products are left in the mill tailings as radioactive wastes.

As thorium-230 atoms disintegrate, they continually replenish the supply of radium, radon, and polonium in the tailings.

Thus ALL of these radioactive poisons will remain present for hundreds of thousands of years.



# Nuclear Transparency Watch

The End . . . (or is it?)