To: US Nuclear Regulatory Commission (NRC)

From: Gordon Edwards, Ph.D., President,
Canadian Coalition for Nuclear Responsibility (CCNR)
53 Dufferin Rd, Hampstead Quebec, H3X 2X8, Canada

Re: Draft Supplemental Environmental Impact Statement for Yucca Mountain, NUREG–2184, Docket ID NRC-2015-0051

The Canadian Coalition for Nuclear Responsibility urges the US Nuclear Regulatory Commission to reject the concept of irretrievable storage of irradiated nuclear fuel and/or high-level nuclear waste at the Yucca Mountain site. The abandonment of these, the most dangerous industrial wastes ever produced by any human activity in history, is both unethical and unscientific. CCNR believes that the abandonment strategy must be rejected in favor of a policy of Rolling Stewardship of nuclear wastes.

Given the many miscalculations that have attended the nuclear age, leading to such startling events as the nuclear meltdowns at Three Mile Island, Chornobyl, and Fukushima Daiichi, as well as the failure of Deep Geological Repositories (DGR) for nuclear waste at Asse-II and Morsleben in Germany, and at the Waste Isolation Pilot Project (WIPP) at Carlsbad New Mexico, it would be foolishly arrogant and even criminal to ignore these lessons from the past.

There is no principle of science that will allow us to prove that these dangerous materials will stay in place for ten million years and more, whether in Yucca Mountain or anywhere else. Certainly, at the present time, using existing tools, this is a scientifically impossible task.

The most sophisticated mathematical models are little more than educated guesses based on partial evidence, and such models cannot be verified over such enormous periods of time. These models essentially have the status of unverified scientific hypotheses, and there is no experimental regime that can be used to test the predictions of the researcher's hypothetical calculations.

The Concept of Abandonment

1. Humans have never permanently disposed of anything.
2. Assumes a permanent solution to waste problem exists.
3. Monitoring the waste ceases after abandonment.
4. Retrieval is difficult or impossible.
5. Containers will inevitably disintegrate.
6. If leakage occurs timely corrective action is not likely.
7. Abandonment will eventually result in amnesia.
8. Difficulty in communicating to unknown future societies.
9. No intention to truly solve the problem of nuclear waste.

The Concept of Rolling Stewardship

1. Humans can contain waste securely for decades at a time.
2. Recognizes a solution to the problem does not yet exist.
3. Continual monitoring of waste is essential.
4. Retrieval is anticipated and actively planned for.
5. Periodic repackaging is an integral part of the process.
6. If leakage occurs timely corrective action will be taken.
7. Rolling Stewardship is based on persistence of memory.
8. Information is readily transmitted to the next generation.
9. Ongoing reminder that the problem remains to be solved.

The concepts of abandonment and disposal are intimately related. According to the IAEA "disposal" means that there is no intention to retrieve the waste in the future – although such retrieval may, with difficulty, be possible; the waste is abandoned. Amnesia ensues.

When disposal attempts fail – as in Port Hope Ontario, the Asse-II salt mine in Germany, the Love Canal in New York State, or the US DOE's "Pit 9" in Idaho – cleaning up and consolidating the waste is often exceedingly costly & difficult because of lack of documentation, failed packaging, and damage already done.

Ironically, the end result of failed disposal is usually some form of Rolling Stewardship – by default, not by intent. Had Rolling Stewardship been instituted from the start, the damage, difficulties and cost could have been greatly reduced.

When abandonment of a repository occurs, the repository becomes a dump. Even if the repository has been well managed, the dump will not be. Consider an analogy. No matter how well designed a large nuclear power reactor might be, it would be foolish and irresponsible to licence it for operation, start it up and then abandon it while it is still operating. Yet that's about what Ontario Power Generation (OPG) hopes to do by abandoning its Deep Underground Dump (DUD) – a proposed deep geological repository (DGR) less than a mile from Lake Huron, for the burial of low and intermediate level waste from Ontario's entire fleet of 20 nuclear reactors.

The pyramids of Egypt are only 5,000 years old. And the Great Lakes did not exist more than 10,000 years ago. But the half-life of plutonium-239 is 24,000 years, and plutonium-239 gradually transmutes into uranium-235, which has a half-life of about 700 million years.

Science is unable to make reliable predictions over hundreds of thousands of years, since the mathematical predictions can't be verified against experience. As the rollout of ObamaCare has shown in the USA, computer bugs often go undetected until subsequent experience reveals them.

Geology is a descriptive science, not a predictive one. Besides, it is impossible to place wastes in an undisturbed geological formation without disturbing it.

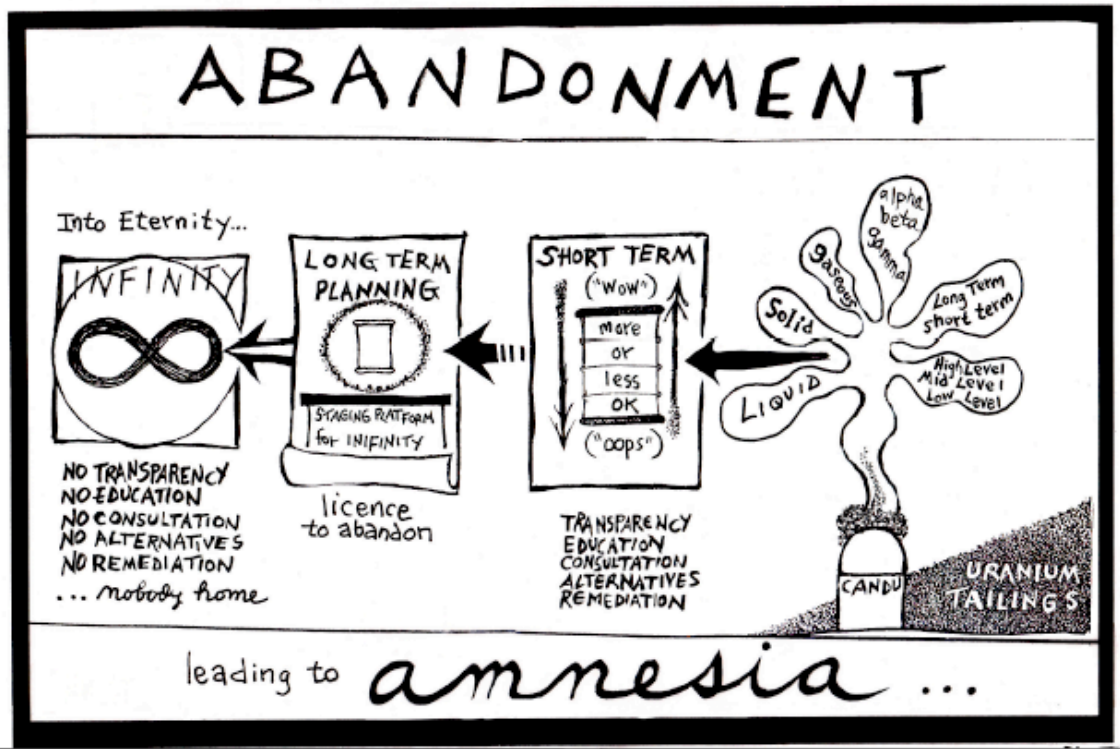
Canadians have much expertise in mining – but a mine is for taking things out, not putting them in. And deserted mines always flood. No one knows how to put a rock formation back together again so that it returns to its original strength and integrity.

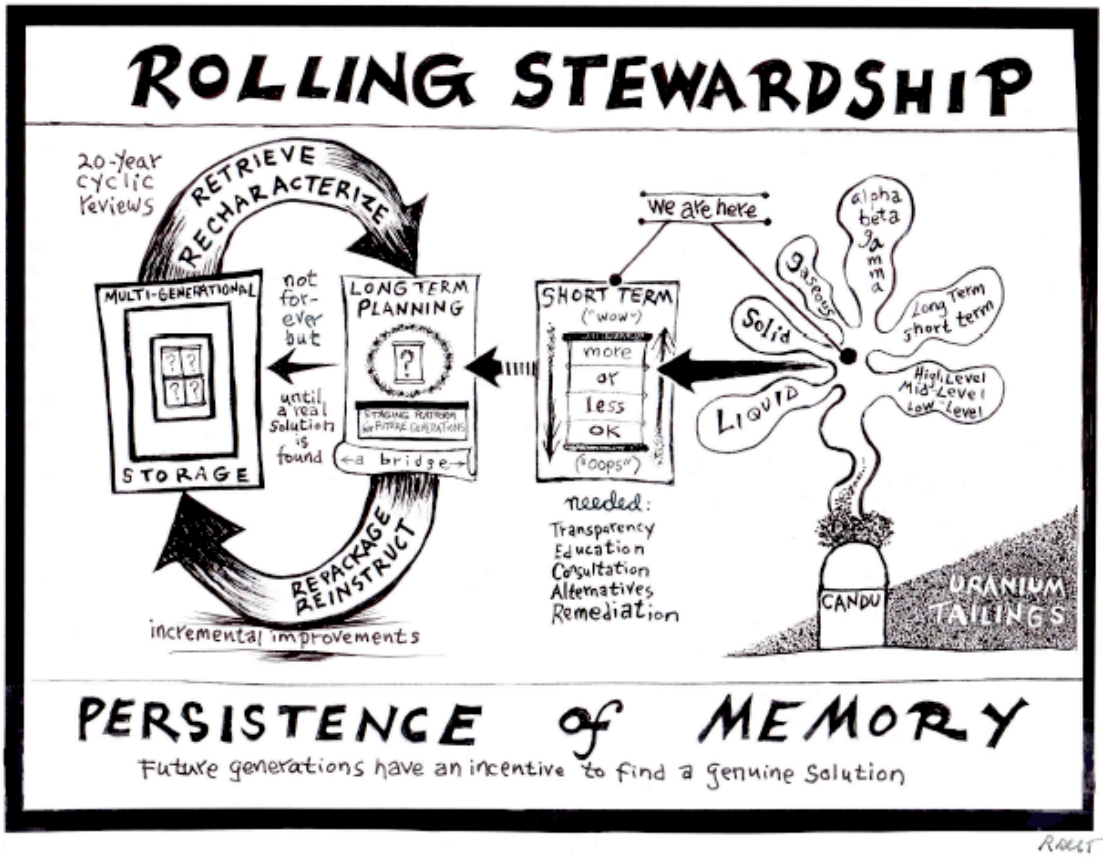
Abandon (n) : to cease to support or look after; to desert.
Disposal (n): the process of throwing away or getting rid of something.
Management (n): the process of dealing with or controlling something.

Abandonment is intended to dispose of nuclear waste – to get rid of it by throwing it away. But no one knows how to truly get rid of long-lived nuclear waste or any other persistent toxic material in this manner.

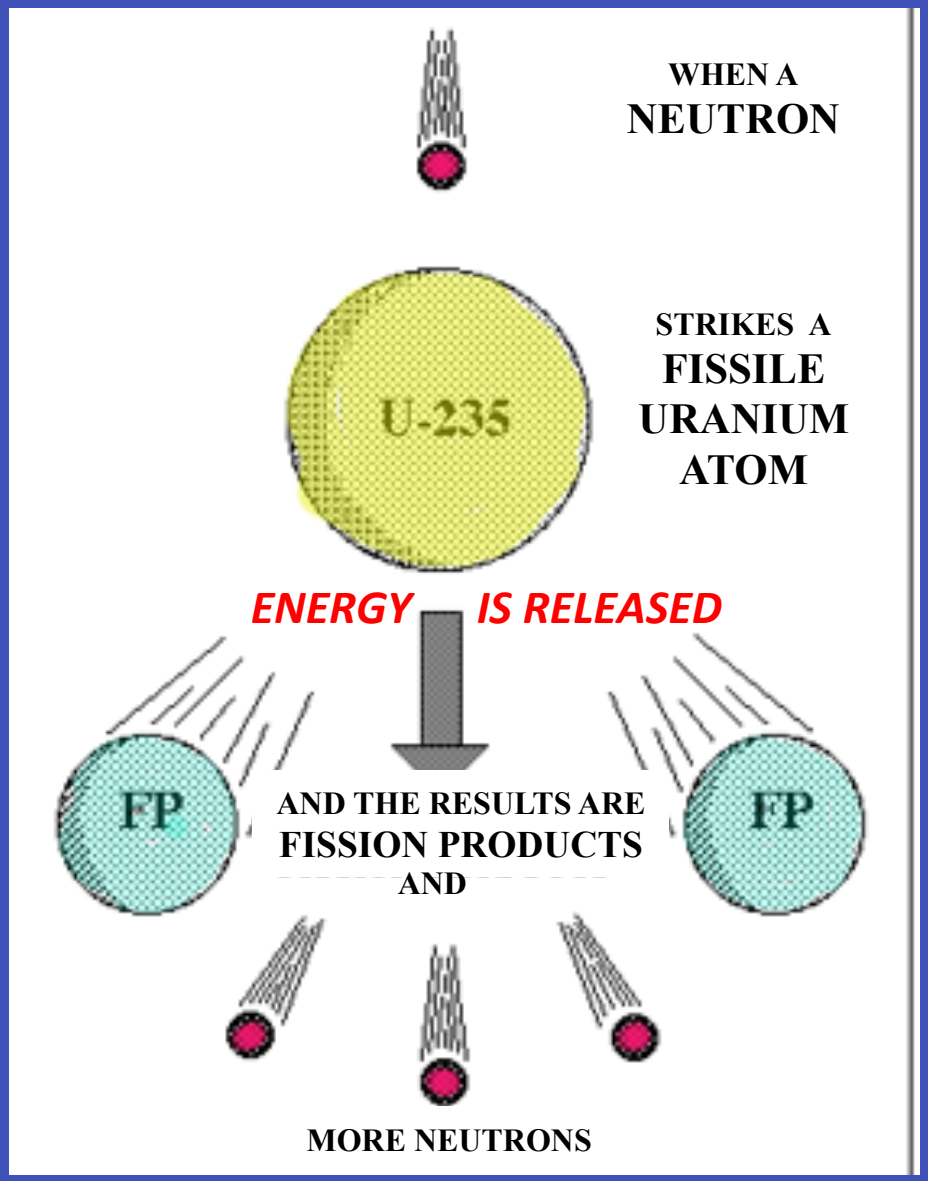
A corporation may rid itself of toxic waste but only at the risk of burdening others – present or future generations – with the obligation of coping with the waste or living with the consequences.

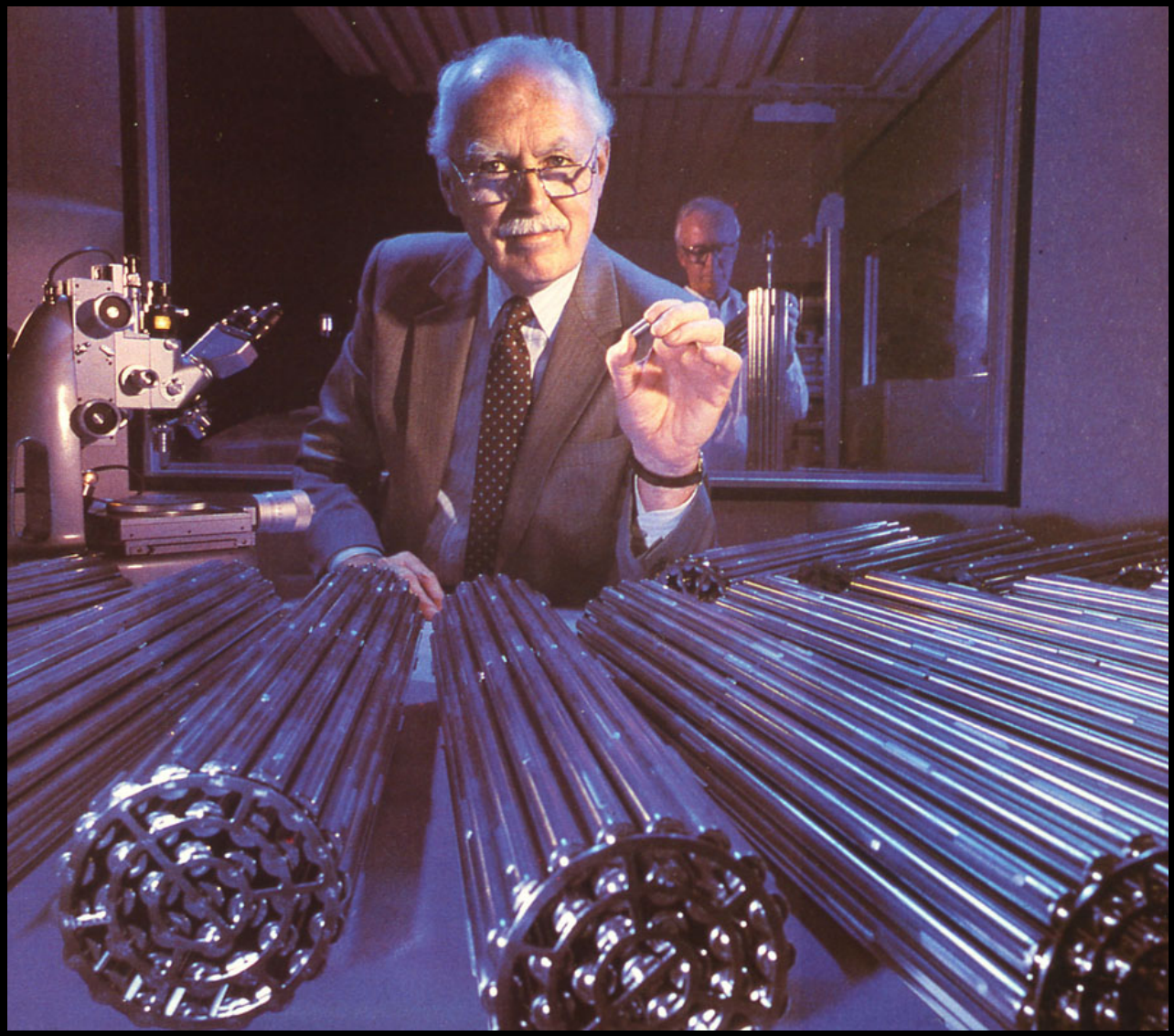
Abandonment eventually leads to amnesia. Future generations have no adequate knowledge or resources to deal with leaks that may go undetected for long periods.





Nuclear Fission

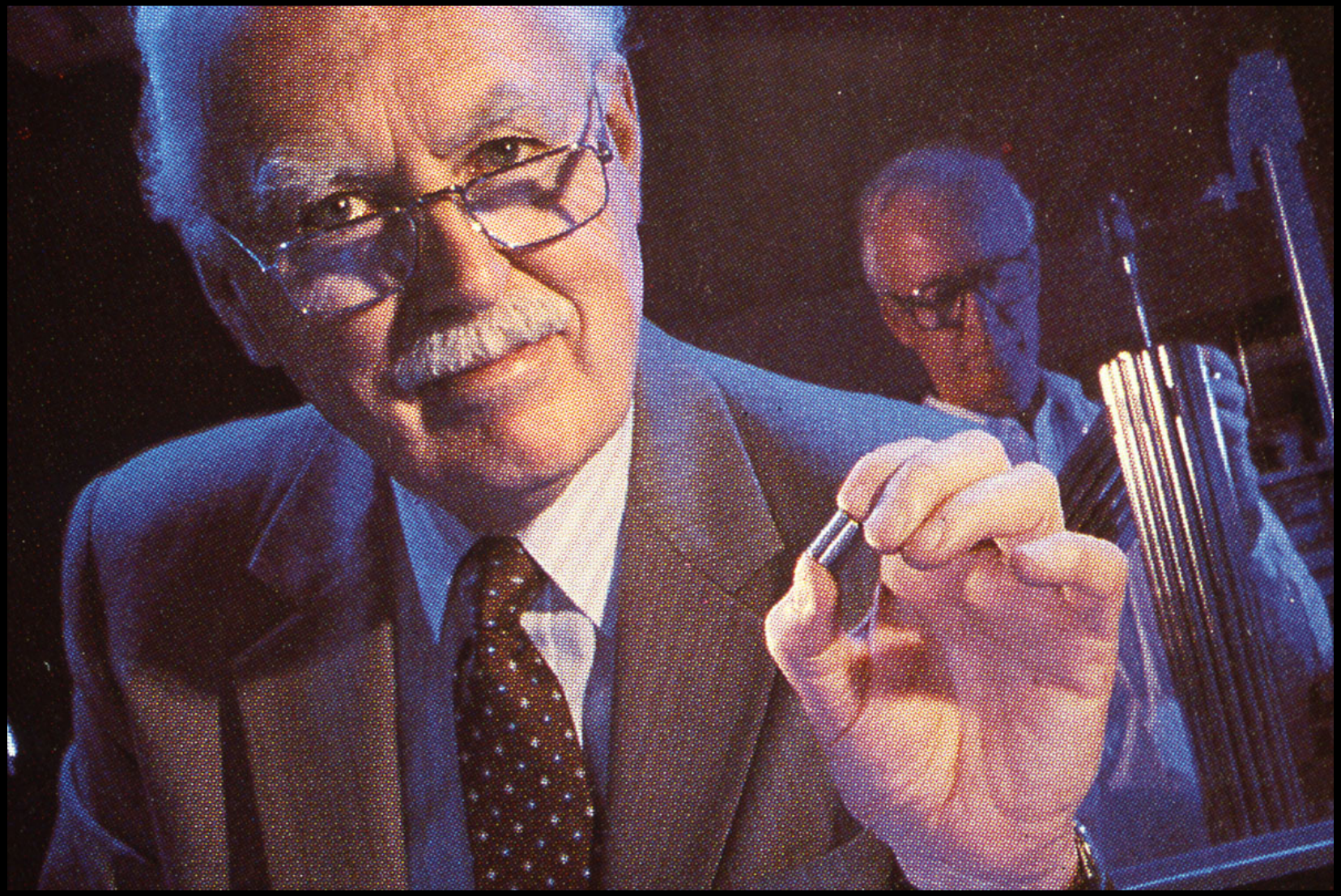




"Small Wonder" : Canadian Nuclear Association Ad

A CANDU fuel bundle can be handled safely before it is used,
but after it is used it delivers a lethal radiation dose in seconds.
This is caused by the intense radioactivity of the fission products.

The main attraction of nuclear energy : one small pellet of uranium fuel, utilizing nuclear fission, gives as much energy as a tonne of coal – with no greenhouse gas.



The main disadvantage of nuclear energy : after it is used you cannot throw that pellet away – you have to keep an eye on it for the next ten million years.

Three types of nuclear fuel waste radionuclides:

1. Fission Products (e.g. cesium-137, iodine-131)

~ the broken bits of uranium atoms
(beta and gamma emitters)

2. Activation Products (e.g. cobalt-60, carbon-14)

~ transmuted versions of non-radioactive atoms
"activated" by absorbing stray neutrons
(beta and gamma emitters)

3. Transuranics (Actinides) (e.g. plutonium, americium)

~ heavier-than-uranium elements that are
created when U-238 absorbs neutrons
(mainly alpha emitters, very long-lived)

These three categories are differentiated in the following table of radionuclides.

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
H (T)	Hydrogen (Tritium)	3	¥¥¥	¥	¥	
Be	Beryllium	10		¥	¥	
C	Carbon	14		¥¥¥	¥¥¥	
Si	Silicon	32		¥	¥	
P	Phosphorus	32		¥	¥	
S	Sulphur	35		¥		
Cl	Chlorine	36		¥		
Ar Ar	Argon Argon	39 42		¥ ¥	¥ ¥	
K K	Potassium Potassium	40 42		¥	 ¥	
Ca Ca	Calcium Calcium	41 45		¥	 ¥	
Sc	Scandium	46		¥		
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
V	Vanadium	50			¥	
Mn	Manganese	54		¥	¥¥¥	
Fe Fe	Iron Iron	55 59		¥¥¥	¥¥¥ ¥	
Co Co	Cobalt Cobalt	58 60		¥ ¥¥¥	¥ ¥¥¥	
Ni Ni	Nickel Nickel	59 63		¥ ¥¥¥	¥¥¥ ¥¥¥	
Zn	Zinc	65		¥	¥	
Se	Selenium	79	¥¥¥			
Kr Kr	Krypton Krypton	81 85	¥ ¥¥¥			
Rb	Rubidium	87	¥			
Sr Sr	Strontium Strontium	89 90	¥ ¥¥¥	 ¥	¥ ¥	
Y	Yttrium	90	¥¥¥	¥	¥	

F.I.A.P. = fuel impurity activation product Z.A.P. = zirconium cladding activation product [source: AECL]

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Y	Yttrium	91	¥		¥	
Zr	Zirconium	93	¥¥¥	¥	¥¥¥	
Zr	Zirconium	95	¥	¥	¥	
Standard Chemical Symbol	**Common Name of element**	**Atomic Mass Number**	**F.P. Fission Product**	**F.I.A.P. Activation Product**	**Z.A.P. Activation Product**	**Actinide (includes progeny)**
Nb	Niobium	92			¥	
Nb	Niobium	93m	¥¥¥	¥	¥¥¥	
Nb	Niobium	94	¥	¥	¥¥¥	
Nb	Niobium	95	¥	¥	¥	
Nb	Niobium	95m	¥		¥	
Mo	Molybdenum	93		¥	¥	
Tc	Technetium	99	¥¥¥	¥	¥	
Ru	Ruthenium	103	¥			
Ru	Ruthenium	106	¥¥¥			
Rh	Rhodium	103m	¥			
Rh	Rhodium	106	¥¥¥			
Pd	Palladium	107	¥¥¥			
Ag	Silver	108	¥	¥	¥	
Ag	Silver	108m	¥	¥¥¥	¥	
Ag	Silver	109m	¥	¥	¥	
Ag	Silver	110	¥	¥	¥	
Ag	Silver	110m	¥	¥	¥	
Cd	Cadmium	109	¥	¥	¥	
Cd	Cadmium	113	¥		¥	
Cd	Cadmium	113m	¥¥¥		¥	
Cd	Cadmium	115	¥			
Standard Chemical Symbol	**Common Name of element**	**Atomic Mass Number**	**F.P. Fission Product**	**F.I.A.P. Activation Product**	**Z.A.P. Activation Product**	**Actinide (includes progeny)**
In	Indium	113m			¥	
In	Indium	114	¥	¥	¥	
In	Indium	114m			¥	
In	Indium	115			¥	
Sn	Tin	113			¥	
Sn	Tin	117m	¥	¥	¥	
Sn	Tin	119m	¥¥¥		¥¥¥	
Sn	Tin	121m	¥		¥¥¥	
Sn	Tin	123	¥		¥	

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Sn Sn	Tin Tin	125 126	¥¥¥		¥	
Sb Sb Sb Sb	Antimony Antimony Antimony Antimony	124 125 126 126m	¥ ¥¥¥ ¥ ¥¥¥		¥ ¥¥¥ ¥	
Te Te Te Te Te	Tellurium Tellurium Tellurium Tellurium Tellurium	123 123m 125m 127 127m	¥ ¥ ¥¥¥ ¥ ¥		¥ ¥ ¥¥¥ ¥ ¥	
I	Iodine	129	¥		¥	
Standard Chemical Symbol	**Common Name of element**	**Atomic Mass Number**	**F.P. Fission Product**	**F.I.A.P. Activation Product**	**Z.A.P. Activation Product**	**Actinide (includes progeny)**
Cs Cs Cs	Cesium Cesium Cesium	134 135 137	¥ ¥¥¥ ¥¥¥			
Ba	Barium	137m	¥¥¥			
La	Lanthanum	138	¥			
Ce Ce	Cerium Cerium	142 144	¥ ¥¥¥			
Pr Pr	Praseodymium Praseodymium	144 144m	¥¥¥ ¥¥¥			
Nd	Neodymium	144	¥			
Pm	Promethium	147	¥¥¥			
Sm Sm Sm Sm	Samarium Samarium Samarium Samarium	147 148 149 151	¥ ¥ ¥ ¥¥¥	 ¥ 		
Eu Eu Eu	Europium Europium Europium	152 154 155	¥¥¥ ¥¥¥ ¥¥¥	¥ ¥ ¥		
Standard Chemical Symbol	**Common Name of element**	**Atomic Mass Number**	**F.P. Fission Product**	**F.I.A.P. Activation Product**	**Z.A.P. Activation Product**	**Actinide (includes progeny)**
Gd Gd	Gadolinium Gadolinium	152 153	¥ ¥	¥ ¥		
Tb	Terbium	157		¥		

F.I.A.P. = fuel impurity activation product Z.A.P. = zirconium cladding activation product [source: AECL]

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Tb	Terbium	160		¥		
Dy	Dysprosium	159		¥		
Ho	Holmium	166m	¥	¥		
Tm	Thulium	170		¥		
Tm	Thulium	171		¥		
Lu	Lutetium	176			¥	
Lu	Lutetium	176			¥	
Lu	Lutetium	176			¥	
Hf	Hafnium	175			¥	
Hf	Hafnium	181			¥	
Hf	Hafnium	182			¥	
Ta	Tantalum	180			¥	
Ta	Tantalum	182			¥	
Standard Chemical Symbol	**Common Name of element**	**Atomic Mass Number**	**F.P. Fission Product**	**F.I.A.P. Activation Product**	**Z.A.P. Activation Product**	**Actinide (includes progeny)**
W	Tungsten	181			¥	
W	Tungsten	185			¥	
W	Tungsten	188			¥	
Re	Rhenium	187			¥	
Re	Rhenium	188			¥	
Os	Osmium	194			¥	
Ir	Iridium	192			¥	
Ir	Iridium	192m			¥	
Ir	Iridium	194			¥	
Ir	Iridium	194m			¥	
Pt	Platinum	193			¥	
Tl	Thallium	206			¥	
Tl	Thallium	207				¥
Tl	Thallium	208				¥
Tl	Thallium	209				¥
Pb	Lead	204			¥	
Pb	Lead	205			¥	
Pb	Lead	209				¥
Pb	Lead	210				¥
Pb	Lead	211				¥
Pb	Lead	212				¥
Pb	Lead	214				¥
Standard	**Common Name of**	**Atomic Mass**	**F.P.**	**F.I.A.P.**	**Z.A.P.**	**Actinide**

F.I.A.P. = fuel impurity activation product Z.A.P. = zirconium cladding activation product [source: AECL]

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Chemical Symbol	element	Number	Fission Product	Activation Product	Activation Product	(includes progeny)
Bi	Bismuth	208			¥	
Bi	Bismuth	210			¥	¥
Bi	Bismuth	210m				¥
Bi	Bismuth	211				¥
Bi	Bismuth	212				¥
Bi	Bismuth	213				¥
Bi	Bismuth	214				
Po	Polonium	210			¥	¥
Po	Polonium	211				¥
Po	Polonium	212				¥
Po	Polonium	213				¥
Po	Polonium	214				¥
Po	Polonium	215				¥
Po	Polonium	216				¥
Po	Polonium	218				¥
At	Astatine	217				¥
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
Rn	Radon	219				¥
Rn	Radon	220				¥
Rn	Radon	222				¥
Fr	Francium	221				¥
Fr	Francium	221				¥
Ra	Radium	223				¥
Ra	Radium	224				¥
Ra	Radium	225				¥
Ra	Radium	226				¥
Ra	Radium	228				¥
Ac	Actinium	225				¥
Ac	Actinium	227				¥
Ac	Actinium	228				¥
Th	Thorium	227				¥
Th	Thorium	228				¥
Th	Thorium	229				¥
Th	Thorium	230				¥
Th	Thorium	231				¥
Th	Thorium	232				¥

F.I.A.P. = fuel impurity activation product Z.A.P. = zirconium cladding activation product [source: AECL]

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Th	Thorium	234				¥¥¥
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
Pa	Protactinium	231				¥
Pa	Protactinium	233				¥¥¥
Pa	Protactinium	234				¥
Pa	Protactinium	234m				¥¥¥
U	Uranium	232				¥
U	Uranium	233				¥
U	Uranium	234				¥¥¥
U	Uranium	235				¥
U	Uranium	236				¥¥¥
U	Uranium	237				¥¥¥
U	Uranium	238				¥¥¥
U	Uranium	240				¥
Np	Neptunium	237				¥¥¥
Np	Neptunium	238				¥
Np	Neptunium	239				¥¥¥
Np	Neptunium	240				¥
Np	Neptunium	240m				¥
Pu	Plutonium	236				¥
Pu	Plutonium	238				¥¥¥
Pu	Plutonium	239				¥¥¥
Pu	Plutonium	240				¥¥¥
Pu	Plutonium	241				¥¥¥
Pu	Plutonium	242				¥¥¥
Pu	Plutonium	243				¥
Pu	Plutonium	244				¥
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
Am	Americium	241				¥¥¥
Am	Americium	242				¥¥¥
Am	Americium	242m				¥¥¥
Am	Americium	243				¥¥¥
Am	Americium	245				¥
Cm	Curium	242				¥¥¥
Cm	Curium	243				¥¥¥

F.I.A.P. = fuel impurity activation product Z.A.P. = zirconium cladding activation product [source: AECL]

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

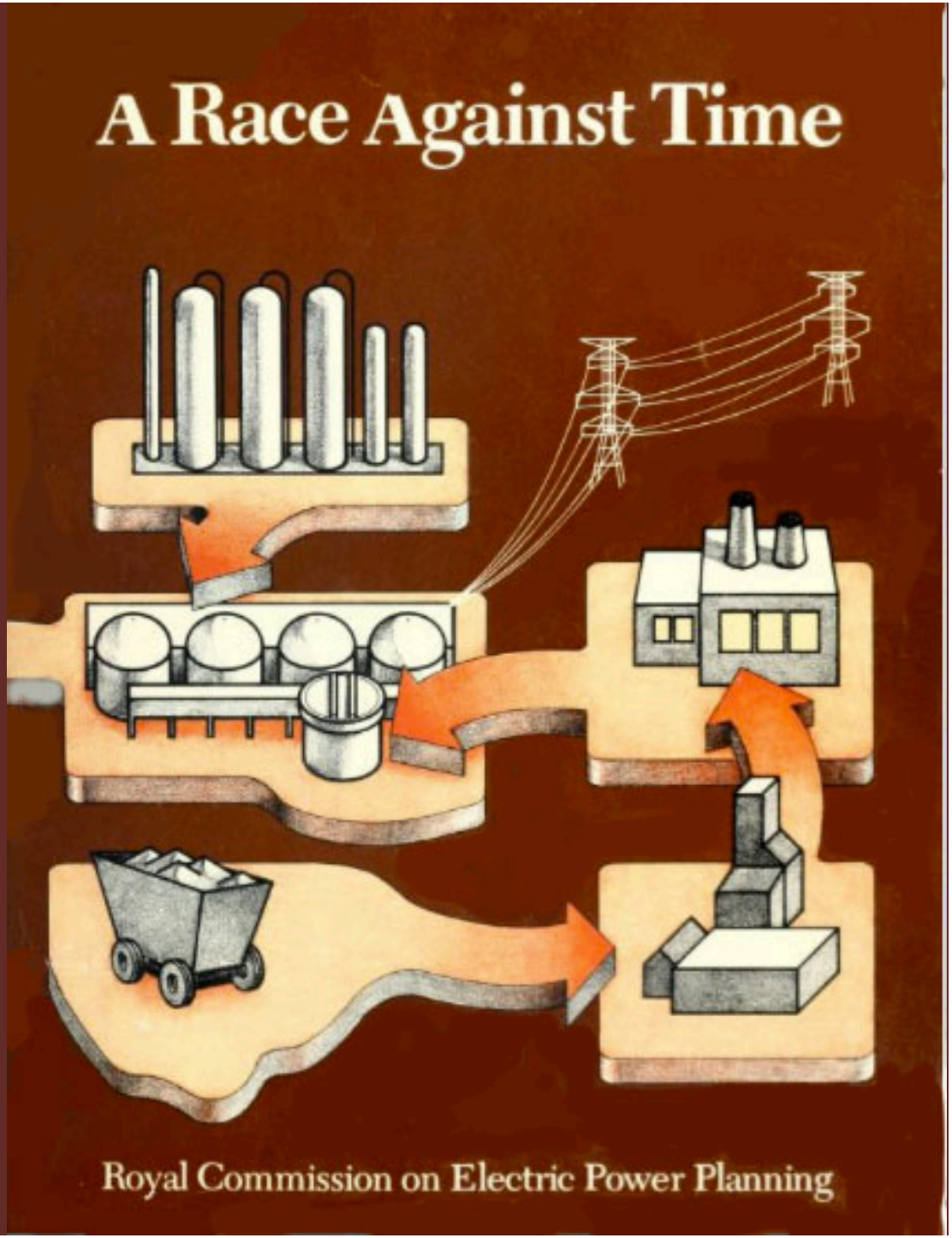
Cm	Curium	244				¥¥¥
Cm	Curium	245				¥
Cm	Curium	246				¥
Cm	Curium	247				¥
Cm	Curium	248				¥
Cm	Curium	250				¥
Bk	Berkelium	249				¥
Bk	Berkelium	250				¥
Cf	Californium	249				¥
Cf	Californium	250				¥
Cf	Californium	251				¥
Cf	Californium	252				¥
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)

F.I.A.P. = fuel impurity activation product Z.A.P. = zirconium cladding activation product [source: AECL]

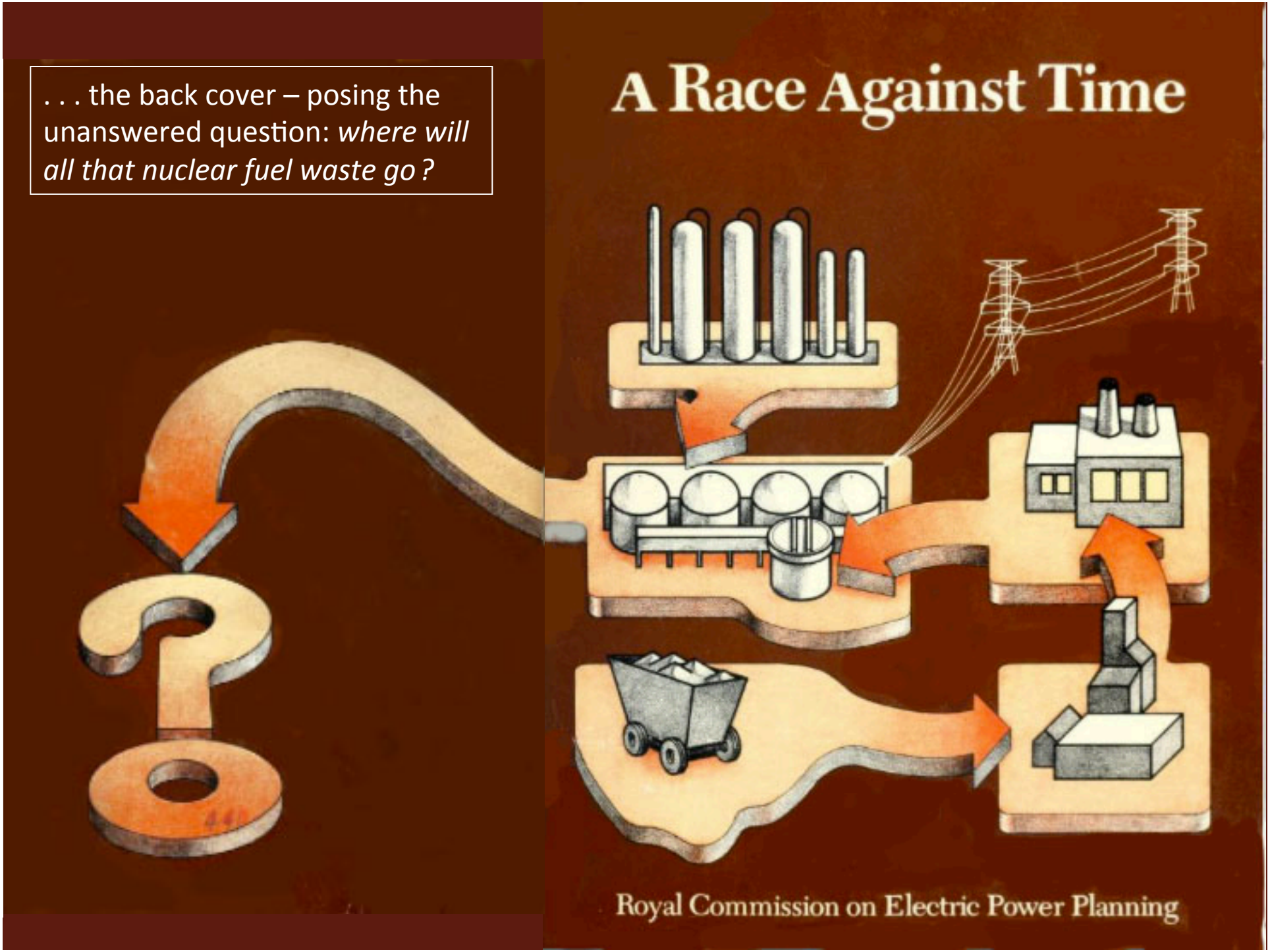
This list of 211 man-made radionuclides contained in irradiated nuclear fuel is by no means complete. (AECL)

[AECL = Atomic Energy of Canada Limited]

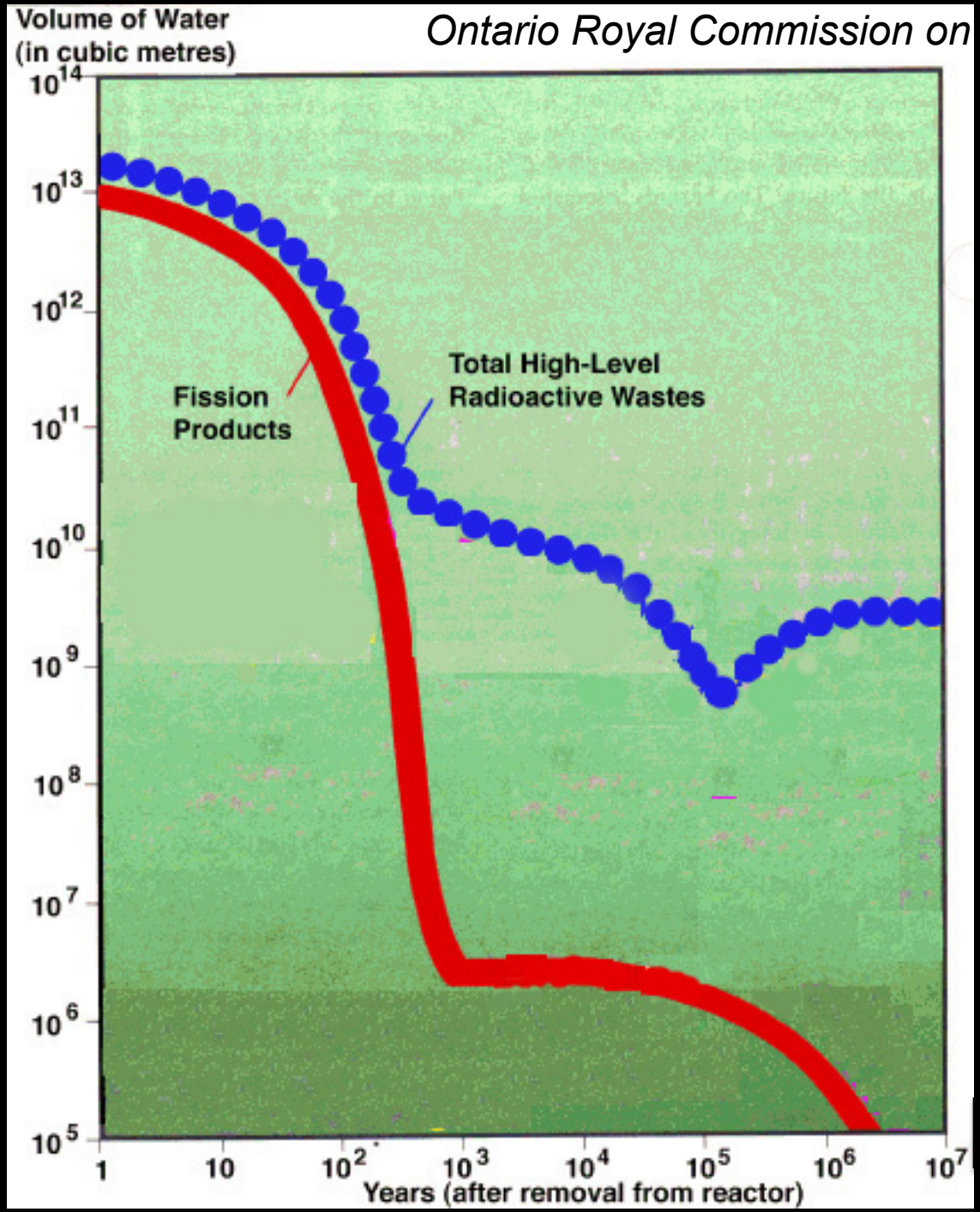
The front cover of the Royal Commission report shows the "nuclear fuel chain", from mine, to mill, to fuel fabrication, to nuclear power plant, to . . .



. . . the back cover – posing the unanswered question: *where will all that nuclear fuel waste go ?*



Ontario Royal Commission on Electric Power Planning (1978)



This graph shows the radiotoxicity of one year's worth of spent CANDU fuel from one reactor over a period of ten million years

The minimum amount of water needed to dilute one year of "fresh" spent fuel just out of a CANDU reactor is about equal to the volume of Lake Superior.

Royal Commission Report, 1978

FACTS:

There are 100s of radioactive poisons with distinct biological pathways.

We do not know how to destroy or neutralize these wastes.

Nuclear wastes are dangerous for millennia, even millions of years.

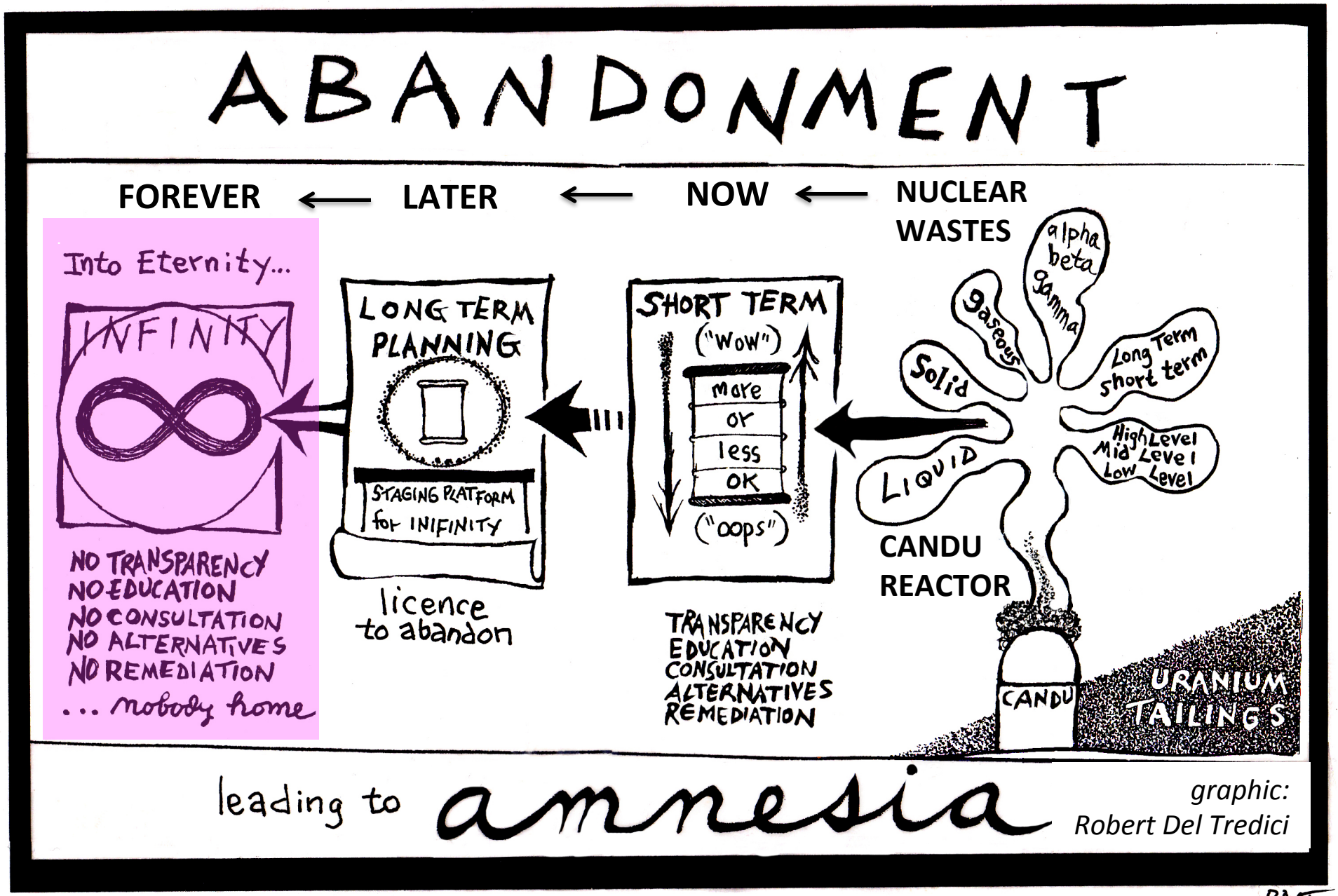
Disposal = abandonment: this approach is not scientifically certain.

Lack of precedent: humans have never safely “disposed” of anything.

USA has tried 8 times to locate a disposal site and failed all 8 times.

Germany has two failed underground repositories: Asse II, Morsleben.

WIPP, the only Deep Geologic Repository in USA, recently failed.


ABANDONMENT
FOREVER
LATER
NOW
NUCLEAR WASTES
alpha
beta
gamma
gaseous
Solid
LIQUID
Long Term
short term
High Level
Mid Level
Low Level
Into Eternity...
INFINITY
NO TRANSPARENCY
NO EDUCATION
NO CONSULTATION
NO ALTERNATIVES
NO REMEDIATION
... nobody home
LONG TERM PLANNING
STAGING PLATFORM for INIFINITY
licence to abandon
SHORT TERM
("WOW")
more
or
less
OK
("oops")
TRANSPARENCY
EDUCATION
CONSULTATION
ALTERNATIVES
REMEDIATION
CANDU REACTOR
CANDU
URANIUM TAILINGS
leading to amnesia
graphic:
Robert Del Tredici
RDelT

PROPOSAL:

A new nuclear waste policy based on frankness.

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

One alternative to abandonment is Rolling Stewardship.

Wastes are monitored and retrievable for the foreseeable future.

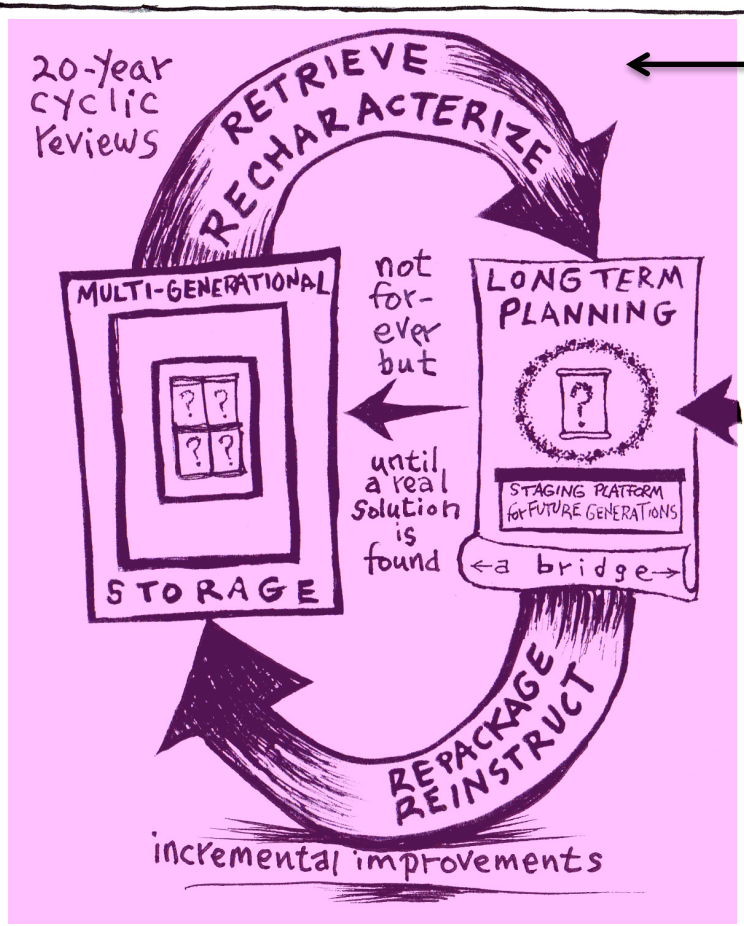
Wastes are packaged safely for extended periods & repackaged later.

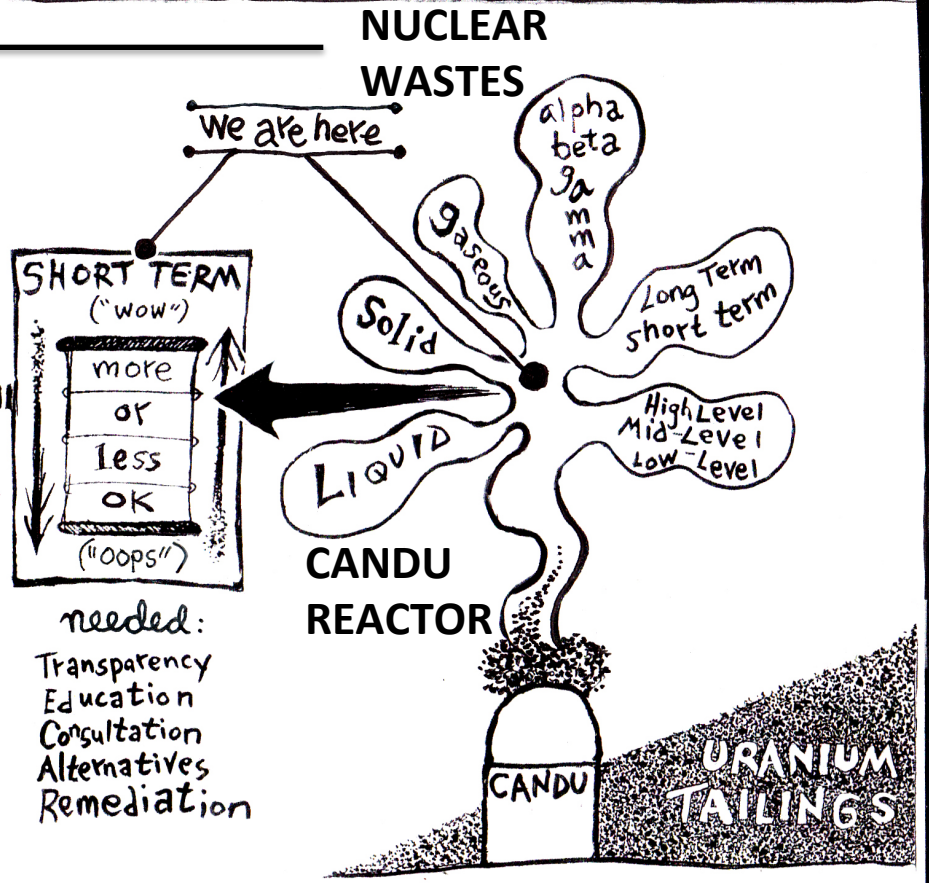
This is not a solution – it is only an ethical waste management scheme.

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

The production of additional wastes can/should be phased out.

ROLLING STEWARDSHIP

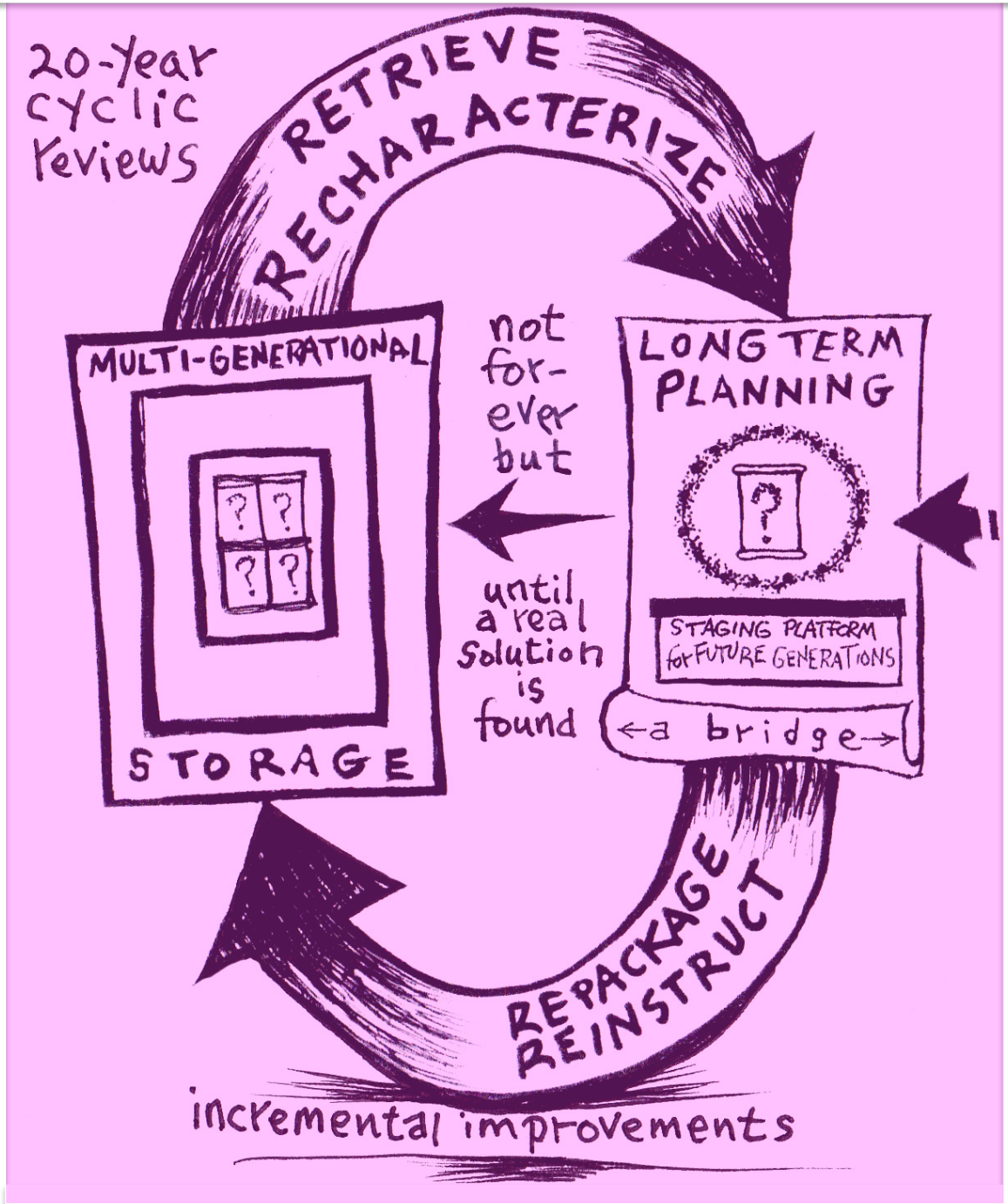




PERSISTENCE of MEMORY

Future generations have an incentive to find a genuine solution

graphic: Robert Del Tredici



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 should be

independent

of the nuclear industry.

Graphic by Robert Del Tredici