Presentation by R. Maruska, Ontario Hydro

Radiological vs Chemical Approach

Background Information

Issue:

Exposure to Radiation

NOT

Exposure to Tritium

Radiological vs Chemical Approach

Background Information

What is Ionizing Radiation?

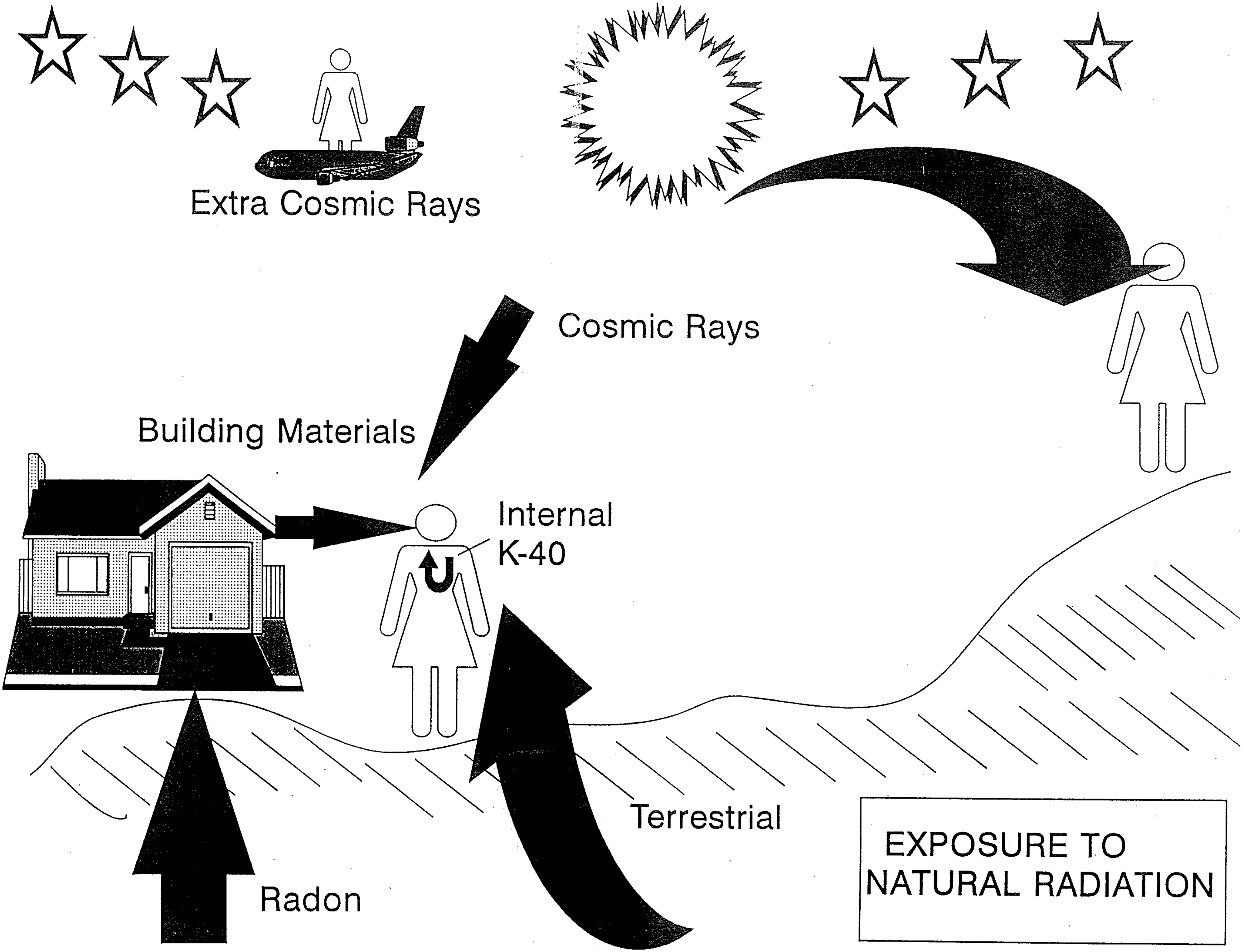
- sub atomic particles or radiant energy which can pass through living matter and cause damage

Types:

- alpha particles
- beta particles
- gamma rays
- x-rays

Measurement of Biological Effects- Dose

- Sievert
- millionth of a Sievert = μSv


Extra Cosmic Rays
Cosmic Rays
Building Materials
Internal
K-40
Terrestrial
Radon
EXPOSURE TO
NATURAL RADIATION

Radiological vs Chemical Approach

Background Information

Origins of Radiation (annual dose):

Natural: 2400 μSv

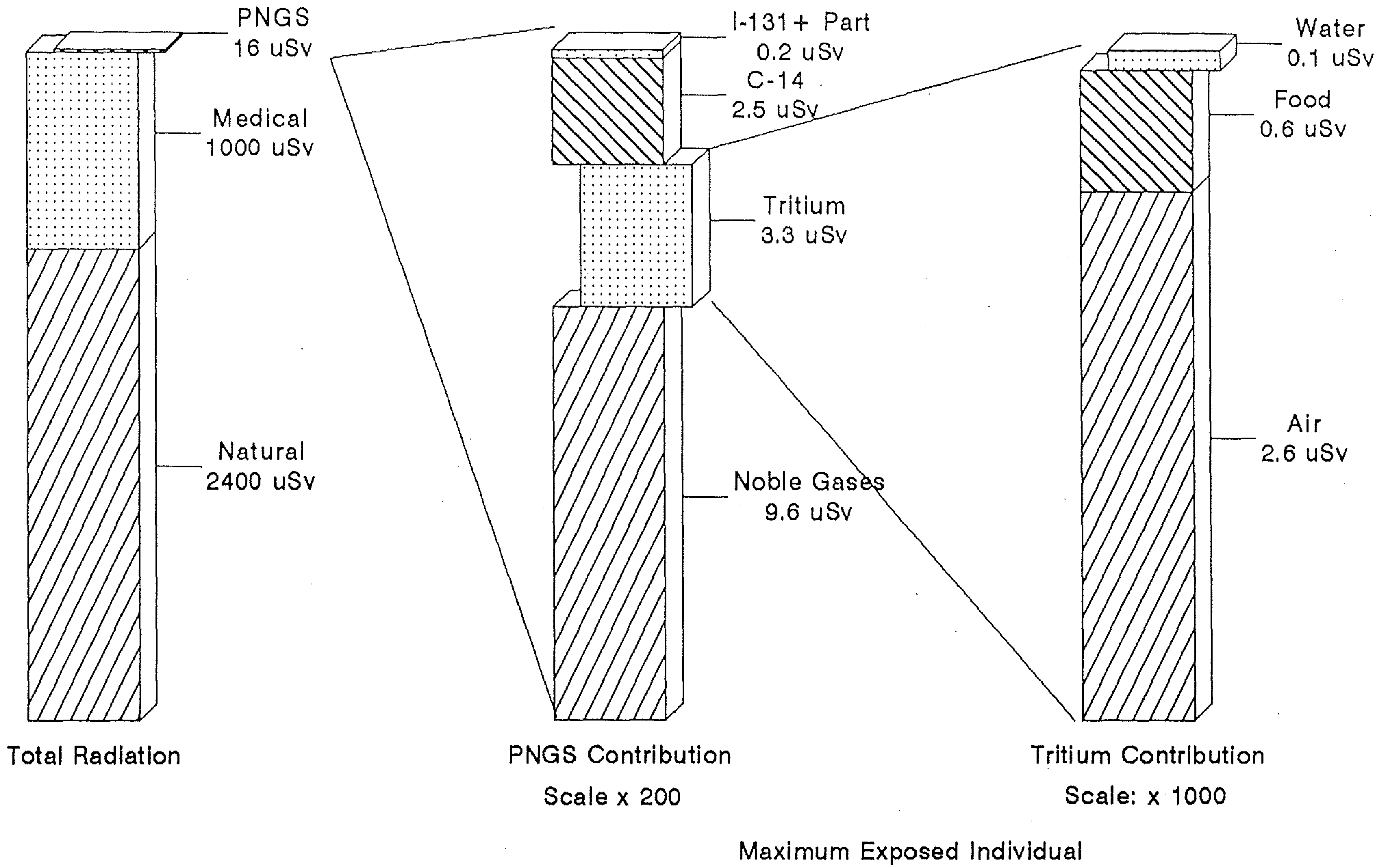
Medical: 1000 μSv

Atmospheric Weapons Testing: 10 μSv

Consumer Products: 100 μSv

Nuclear Power: 16 μSv
(maximum exposed individual)

Exposure to Radiation



Pickering NGS 1993 data

Presentation by R. Maruska, Ontario Hydro

Radiological vs Chemical Approach

Radiological Approach:

Presentation Agenda:

- summary of development of radiological approach

- describe the radiological approach

- the advantages and disadvantages as compared to the criteria

- how do you apply the radiological approach?

Radiological vs Chemical Approach

Radiological Approach:

Aim:

- reap the benefits

- keep risks at acceptably low levels

Radiological vs Chemical Approach

Radiological Approach:

Framework:

- control doses to the individual from all sources
  - all forms of radiation
  - from all radionuclides
  - from all pathways
  - for so long as it is in your body

- limits are incremental dose above background

- cautious assumptions for low dose effects

Radiological vs Chemical Approach

Radiological Approach:

ICRP Recommendations:

- maximum public exposure of 1000 μSv/y

- use As Low As Reasonably Achievable* (ALARA) principle to ensure actual doses are kept low.

- take into account
    - level of consequence
    - doses from natural sources

* Social and economic factors are taken into account.

Radiological vs Chemical Approach

Radiological Approach:

Summary of Radiological Approach:

- "top - down" approach
- set upper limit on risk
- considers all radiation, all radionuclides, all media
- use ALARA to stay below this value

Radiological vs Chemical Approach

Radiological Approach:

Scope of Application:

- considers multi-media and all radionuclides together

Advantages:

- measurement of actual effects on humans
- cumulative effects assumed
- all exposure pathways covered

Disadvantages:

- more complex to implement
- requires more complete knowledge on effects and pathways

Radiological vs Chemical Approach

Radiological Approach:

Data Quality:

- actual effects on humans used
- several data sets available

Advantages:

- actual effects on humans
- long follow up times, up to 50 years
- epidemiological studies
- different data sets are consistent

Disadvantages:

- data collected at higher dose rates
- have to use cautious assumptions because effects at low doses have never been observed

Radiological vs Chemical Approach

Radiological Approach:

Basis for Acceptable Level:

- minimize probability of cancer
- considers background radiation
- uses ALARA to ensure actual exposures are much less

Advantages:

- exposure considered within the context of total exposure to all radiation
- exposure much less in actual practice
- ALARA is ongoing process
- continuous improvement

Disadvantages:

- perception that a high relative risk is allowed

Radiological vs Chemical Approach

Radiological Approach:

Uncertainty in Risk Estimate:

- based on human epidemiological studies
- moderate uncertainty: less than an order of magnitude

Advantages:

- no need to apply safety factors to consider poor data or animal data

Disadvantages:

Radiological vs Chemical Approach

Radiological Approach:

How do you apply the radiological approach?

Regulation of Drinking Water Quality

- World Health Organization Method:

  - a 10% of public dose limit to apply to drinking water

  -100 μSv/y for drinking water (5% background)

Advantages:

  - considers all radionuclides

  - if tritium only => 7,800 Bq/L
  - if other present allowable level for tritium would be lower

Radiological vs Chemical Approach

Radiological Approach:

Summary of Radiological Approach:

- "top-down" approach
- set upper limit on exposure
- considers all radiation, all radionuclides, all media
- use ALARA principle to stay below

Advantages:

- all encompassing
- low uncertainty
- measure health effects
- considers total exposure to radiation
- exposures much less in actual practice
- dynamic continuous improvement
- cost-effectiveness considered

Disadvantages:

- complex to implement
- requires more complete knowledge of effects and pathways
- have to use cautious assumptions
- perception of a high relative risk

Radiological vs Chemical Approach

Radiological Approach:

Comparison of Dose from various limits:

- background radiation:	2000-3000 μSv/y
- ICRP limit on public exposure:	1000 μSv/y
- WHO recommendation for drinking water:	100 μSv/y
- ACES recommendation:	
100 Bq/L	1 μSv/y
20 Bq/L	0.2 μSv/y

RM 2-12

Radiological vs Chemical Approach

Radiological Approach:

Lifetime Probability of Fatal Cancer:

- Total:	25%
- From natural radiation:	1%
- at ICRP recommendations:	0.3%
- at WHO recommendations:	0.03%
- at ACES recommendations : (100 Bq/l)	0.0005%
- actual risk from tritium added to area Drinking Water by PNGS	0.000002%

0.4% of
100 Bq/L
= 0.4 Bq/L ??

Presentation by M. Goldberg, ACES

The Chemical Paradigm In Risk Assessment

- Hazard Identification
- Dose-Response Assessment
- Exposure Assessment
- Risk Characterization

Tritium In Drinking Water- Hazard Identification

- Radioactive with half-life of 12.3 years
- Internal Beta-emitter
- Classified as a human carcinogen by EPA
- Biological half-life 10 days to 2 years
- Organically -Bound Tritium has longer biological half-life

Tritium in Drinking Water-Exposure Assessment

- Main source of new inputs in Ontario-releases from CANDU reactors. + CRNL)
- Pathways of exposure include water, air and food.
- Routes of exposure include inhalation, dermal absorption and ingestion.
- ODWO process assumes 1.5 or 2 litres/day consumed for 70 years.

Tritium in Drinking Water-Dose-Response Assessment

- 0.1 mSv/yr from the consumption of 2 litres/day will result in 5 fatal cancers per million people exposed (ICRP).
- Over 70 years, this exposure will result in 350 excess fatal cancers.
- BEIR V estimates 520-600 excess fatal cancers for the same exposure.

Tritium in Drinking Water-Risk Characterization

- Negligible level of cancer risk is one additional cancer in 100,000 or 1,000,000 people.
- Proposed ODWO of 7,000Bq/L imparts risk of about 350 cancers per million exposed.
- ACES recommended ODWO of 100 Bq/L imparts risk of 5 cancers per million exposed (a negligible risk).

Tritium in Drinking Water-Risk Characterization (cont.)

- Uncertainties in Risk Charaĉterization :
- Non-cancer effects
- Dose Conversion factors
- Effect of Organically-Bound Tritium
- Relative Biological Effectiveness >1

FOUR STEPS TO RISK ASSESSMENT

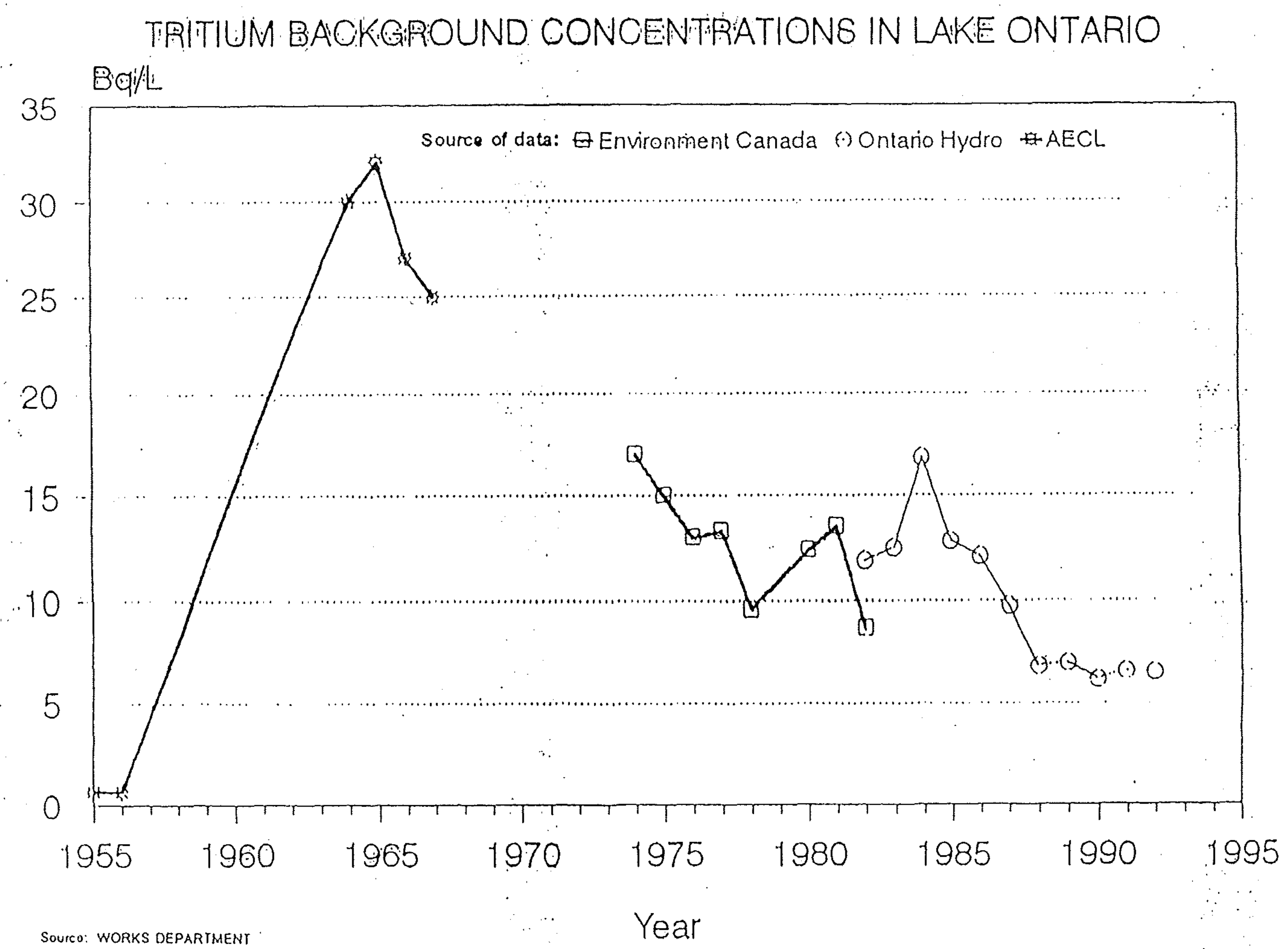
1. Hazard identification

2. Dose-Response Assessment

3. Exposure Assessment

4. Risk Characterization
   (cancer and non-cancer are different)

RISK COMMUNICATION AND MANAGEMENT ARE VERY IMPORTANT BUT ARE NOT PART OF RISK ASSESSMENT.



Source: WORKS DEPARTMENT

ACES Advisory Committee on Environmental Standards

THE EFFECT OF VARIOUS ISSUES ON THE RECOMMENDED ODWO

Issue (Uncertainty)	Effect on ODWO (Reduction Factor)	Resulting Level of Risk (Excess Cancers per 1,000,000 Exposed)	ODWO (Bq/L)
MOEE proposed ODWO Rationale Document (Based on 1 year of exposure)	-	≥ 340	7,000 (MOEE's proposed Interim ODWO)
Lifelong Exposure (Based on a 70 year lifespan)	70	≥ 5	**100** (ACES's recommended Drinking Water Objective)
Risk Reduction from 5 excess cancers per million exposed to 1 excess cancer per million exposed.	5	≥ 1	**20** (ACES's recommended five year target)
RBE* 1 or >1; Dose Conversion Factors; Areas of Uncertainty; Organically Bound Tritium (longer biological half-life)	1 - 3 ?	< 1	**Natural Background** (Ultimate goal)

*RBE is the relative biological effectiveness of tritium

ACES
Advisory Committee on Environmental Standards
Comité consultatif sur les normes environnementales

Presentation by N. Gentner, AECL

INCREASED INCIDENCE OF BIRTH DEFECTS AROUND PICKERING ?

No.

IS THERE ANY REAL EFFECT OF VERY LOW DOSES DELIVERED AT LOW DOSE RATE?

'Linearity' started as a cautious assumption; has become dogma

Weight of evidence actually inveighs against linearity

Linear-quadratic vs. linear

DNA Repair

Adaptive Responses

Unlimited faith in linearity→TYRANNY

COST-EFFECTIVENESS OF REGULATIONS

A very real cost--and risk--from ineffectual regulations

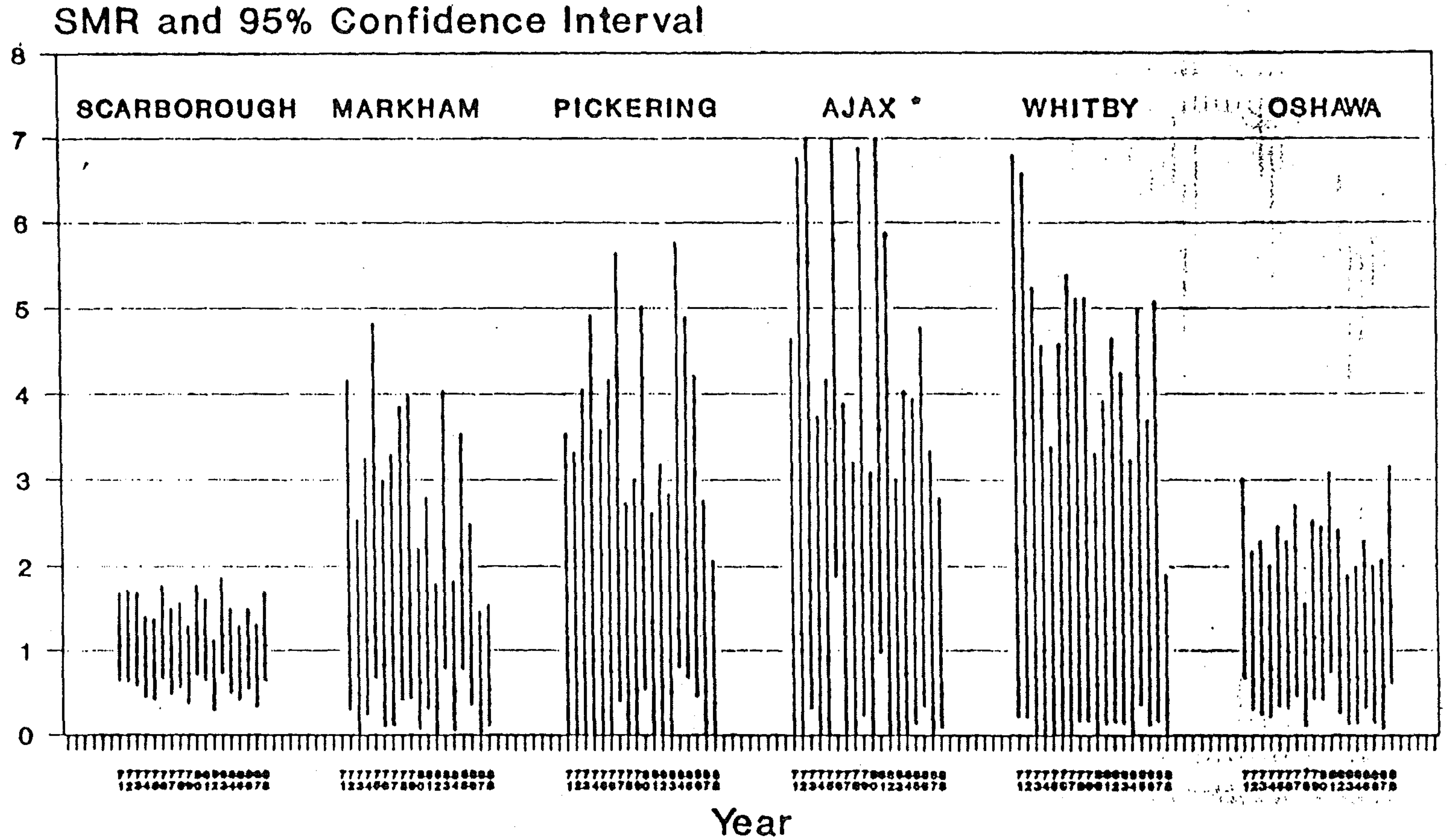
THESE ARE THEORETICAL EXCESSES

Based on linear extrapolation of effects seen in populations exposed to much higher doses in a very short time.

Assuming that risk extends proportionately down to much lower doses received over a lifetime *is a cautious assumption that likely overestimates greatly the risks of exposure to very low doses received over a long time*

THE LIKELY HEALTH IMPACTS ARE ZERO

Fig. 1.6 - Infant Birth Defect SMRs for Pickering and Adjacent Areas 1971-1988



Reference Rates : All Ontario
SMR - Standardized Mortality Ratio
* Upper limit truncated to 7

H6.

DOWN SYNDROME?

The US EPA has been much criticized by the *US Office of Management and Budget* for promulgating ineffective regulations

Table C-2

U.S. Budget for Fiscal Year 1992

"Risks and Cost-Effectiveness of Selected Regulations"

The cost-effectiveness of regulator action varies over more than eight orders of magnitude.

Table C–2. RISKS AND COST-EFFECTIVENESS OF SELECTED REGULATIONS

Regulation[1]	Year Issued	Health or Safety?	Agency	Baseline Mortality Risk per Million Exposed	Cost per Premature Death Averted ($Millions 1990)
Unvented Space Heater Ban	1980	S	CPSC	1,890	0.1
Aircraft Cabin Fire Protection Standard	1985	S	FAA	5	0.1
Auto Passive Restraint/Seat Belt Standards	1984	S	NHTSA	6,370	0.1
Steering Column Protection Standard[2]	1967	S	NHTSA	385	0.1
Underground Construction Standards[3]	1989	S	OSHA–S	38,700	0.1
Trihalomethane Drinking Water Standards	1979	H	EPA	420	0.2
Aircraft Seat Cushion Flammability Standard	1984	S	FAA	11	0.4
Alcohol and Drug Control Standards[3]	1985	H	FRA	81	0.4
Auto Fuel-System Integrity Standard	1975	S	NHTSA	343	0.4
Standards for Servicing Auto Wheel Rims[3]	1984	S	OSHA–S	630	0.4
Aircraft Floor Emergency Lighting Standard	1984	S	FAA	2	0.6
Concrete & Masonry Construction Standards[3]	1988	S	OSHA–S	630	0.6
Crane Suspended Personnel Platform Standard[3]	1988	S	OSHA–S	81,000	0.7
Passive Restraints for Trucks & Buses (Proposed)	1989	S	NHTSA	6,370	0.7
Side-Impact Standards for Autos (Dynamic)	1990	S	NHTSA	NA	0.8
Children's Sleepwear Flammability Ban[4]	1973	S	CPSC	29	0.8
Auto Side Door Support Standards	1970	S	NHTSA	2,520	0.8
Low-Altitude Windshear Equipment & Training Standards	1988	S	FAA	NA	1.3
Electrical Equipment Standards (Metal Mines)	1970	S	MSHA	NA	1.4
Trenching and Excavation Standards[3]	1989	S	OSHA–S	14,310	1.5
Traffic Alert and Collision Avoidance (TCAS) Systems	1988	S	FAA	NA	1.5
Hazard Communication Standard[3]	1983	S	OSHA–S	1,800	1.6
Side-Impact Stds for Trucks, Buses and MPVs (Proposed)	1989	S	NHTSA	NA	2.2
Grain Dust Explosion Prevention Standards[3]	1987	S	OSHA–S	9,450	2.8
Rear Lap/Shoulder Belts for Autos	1989	S	NHTSA	NA	3.2
Standards for Radionuclides in Uranium Mines[3]	1984	H	EPA	6,300	3.4
Benzene NESHAP (Original: Fugitive Emissions)	1984	H	EPA	1,470	3.4
Ethylene Dibromide Drinking Water Standard	1991	H	EPA	NA	5.7
Benzene NESHAP (Revised: Coke By-Products)[3]	1988	H	EPA	NA	6.1
Asbestos Occupational Exposure Limit[3]	1972	H	OSHA–H	3,015	8.3
Benzene Occupational Exposure Limit[3]	1987	H	OSHA–H	39,600	8.9
Electrical Equipment Standards (Coal Mines)[3]	1970	S	MSHA	NA	9.2
Arsenic Emission Standards for Glass Plants	1986	H	EPA	2,660	13.5
Ethylene Oxide Occupational Exposure Limit[3]	1984	H	OSHA–H	1,980	20.5
Arsenic/Copper NESHAP	1986	H	EPA	63,000	23.0
Haz Waste Listing for Petroleum Refining Sludge	1990	H	EPA	210	27.6
Cover/Move Uranium Mill Tailings (Inactive Sites)	1983	H	EPA	30,100	31.7
Benzene NESHAP (Revised: Transfer Operations)	1990	H	EPA	NA	32.9
Cover/Move Uranium Mill Tailings (Active Sites)	1983	H	EPA	30,100	45.0
Acrylonitrile Occupational Exposure Limit[3]	1978	H	OSHA–H	42,300	51.5
Coke Ovens Occupational Exposure Limit[3]	1976	H	OSHA–H	7,200	63.5
Lockout/Tagout[3]	1989	S	OSHA–S	4	70.9
Asbestos Occupational Exposure Limit[3]	1986	H	OSHA–H	3,015	74.0
Arsenic Occupational Exposure Limit[3]	1978	H	OSHA–H	14,800	106.9
Asbestos Ban	1989	H	EPA	NA	110.7
Diethylstilbestrol (DES) Cattlefeed Ban	1979	H	FDA	22	124.8
Benzene NESHAP (Revised: Waste Operations)	1990	H	EPA	NA	168.2
1,2-Dichloropropane Drinking Water Standard	1991	H	EPA	NA	653.0
Haz Waste Land Disposal Ban (1st 3rd)	1988	H	EPA	2	4,190.4
Municipal Solid Waste Landfill Standards (Proposed)	1988	H	EPA	<1	19,107.0
Formaldehyde Occupational Exposure Limit[3]	1987	H	OSHA–H	31	86,201.8
Atrazine/Alachlor Drinking Water Standard	1991	H	EPA	NA	92,069.7
Haz Waste Listing for Wood Preserving Chemicals	1990	H	EPA	<1	5,700,000.0

[1] 70-year lifetime exposure assumed unless otherwise specified.

[2] 50-year lifetime exposure.

[3] 45-year lifetime exposure.

[4] 12-year exposure period.

NA=Not available.

Agency Abbreviations.—CPSC: Consumer Product Safety Commission; MSHA: Mine Safety and Health Administration; EPA: Environmental Protection Agency; NHTSA: National Highway Traffic Safety Administration; FAA: Federal Aviation Administration; FRA: Federal Railroad Administration; FDA: Food and Drug Administration; OSHA–H: Occupational Safety and Health Administration, Health Standards; OSHA–S: Occupational Safety and Health Administration, Safety Standards.

Source: John F. Morrall, III, "A Review of the Record," *Regulation*, Vol. 10, No. 2 (1986), p. 30. Updated by the Author, et. al.

U.S. Government, 1992 Budget

Section IX.C: "Reforming Regulation and Managing Risk Reduction Sensibly"

"Many cancer risks from environmental exposure (excluding smoking and diet) are very small relative to other threats to human health.

Nevertheless, about half of the significant regulations listed are aimed at reducing these small cancer risks.

The many regulations targeted at occupational and dietary cancer risks have been extraordinarily costly."

"WHAT IT COSTS TO SAVE A LIFE"

Globe & Mail, 1994 July 12, page 8

Harvard School of Public Health,
<u>Center for Risk Analysis</u>

	THE BOTTOM LINE Average cost of a year of life saved
Childhood immunizations	Less than zero
Prenatal care	Less than zero
Flu shots	\$600
Water chlorination	\$4,000
Pneumonia vaccination	\$12,000
Breast Cancer screening	\$17,000 (\$224,000 for >20y) (\$ 11,000 for >60y)
Construction safety rules	\$38,000
Home radon control	\$141,000
Asbestos control	\$1.9 million
Radiation controls	\$27.4 million (≡ \$300 million per fatal cancer)

RADIATION PARADIGM VERSUS CHEMICAL PARADIGM

In fact, they are <u>not incongruous</u>

ONTARIO DRINKING WATER OBJECTIVE (ODWO) "for tritium"

Is really, effectively, for <u>all</u> radionuclides

CHEMICAL "STANDARDS"

are for each singly

dozens or hundreds add up to the same level of risk as the ODWO

Presentation by M. Measures of AECB

Atomic Energy Control Board

Commission de contrôle de l'énergie atomique

DOSE LIMITS
to a member of the public
5 mSv/a (1 mSv/a)

↓

Derived Effluent <u>Limits</u> (DEL)
for
Emissions from Nuclear Facility

↓

ALARA principal used to arrive
at
operating targets (<u>averages</u>)

1% of DEL

Canada

Atomic Energy Control Board
Commission de contrôle de l'énergie atomique

A Regulation Must Be

- Practical
- Enforceable
- Cost Effective

Canada

Atomic Energy Control Board

Commission de contrôle de l'énergie atomique

Examples of One-in-a-Million Risks

- Drinking water containing 20 Bq/L H-3 over lifetime
- Smoking 1.4 cigarettes
- Travelling 10 miles by bicycle
- Travelling 50 miles by car
- Flying 1000 miles by jet
- Working 13 hours in the construction industry
- Working 9 1/2 hours as a coal miner

(AC-1)

Canada