NORM/TENORM WORKSHOP

Woodlin School, Woodrow

Colorado Department of Public Health and Environment

March 2, 2005

Welcome!

- Introductions
- Agenda Overview
- Ground Rules
- Amenities

Introduction to NORM and TENORM

March 2, 2005

Philip Egidi
Colorado Department of Public Health and Environment

Topics

- Overview / Definitions
- Natural radioactivity and its origins
- Background radioactivity
- Industrial processes generating TENORM
- Dose and risk comparison: background and TENORM
- Additional resources

Miss Uranium - 1955

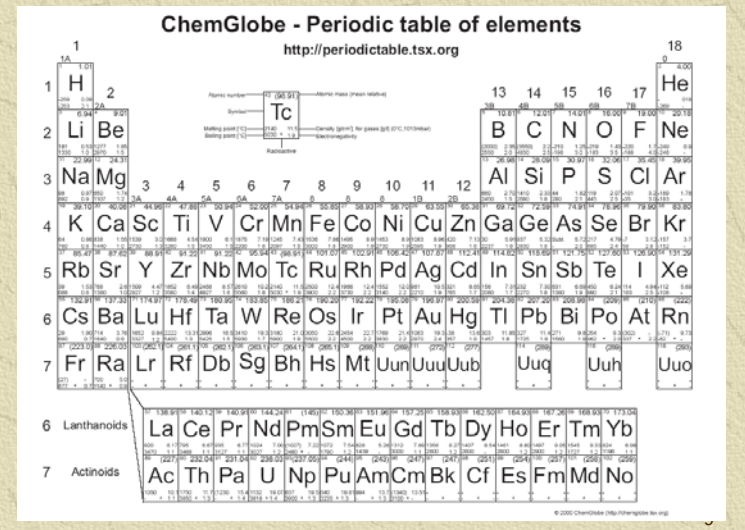
Natural Radioactivity and Its Origins

- Radioactivity and radiation are natural phenomena.
- We are constantly exposed to natural radiation and radioactivity in our everyday lives.

Elements

- Numerous industrial processes generate wastes that concentrate various **elements**, including those that contain some levels of elevated **radioactivity**.
- We will:
  - Discuss what these elements are, where they are found, why they end up in residuals.
  - Attempt to explain terms, units, etc., without math and jargon.
  - Provide context of hazard and risk related to disposal of residuals.

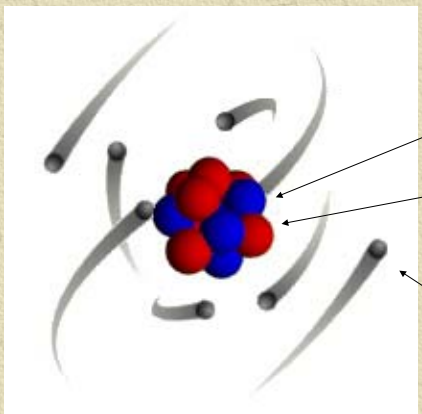
Periodic Table



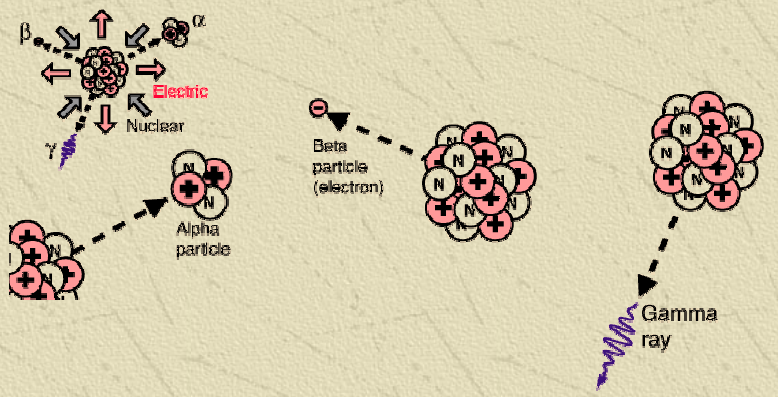
Radioactivity and Radiation

- Atoms have an equal number of protons and electrons.
- The number of neutrons varies. Some elements may have many isotopes, depending in the number of neutrons in the nucleus.
- Atoms that are unstable (have excess energy) want to be stable. Mother Nature does this by a process known as RADIOACTIVE DECAY.
- The particles or energy released are called RADIATION.

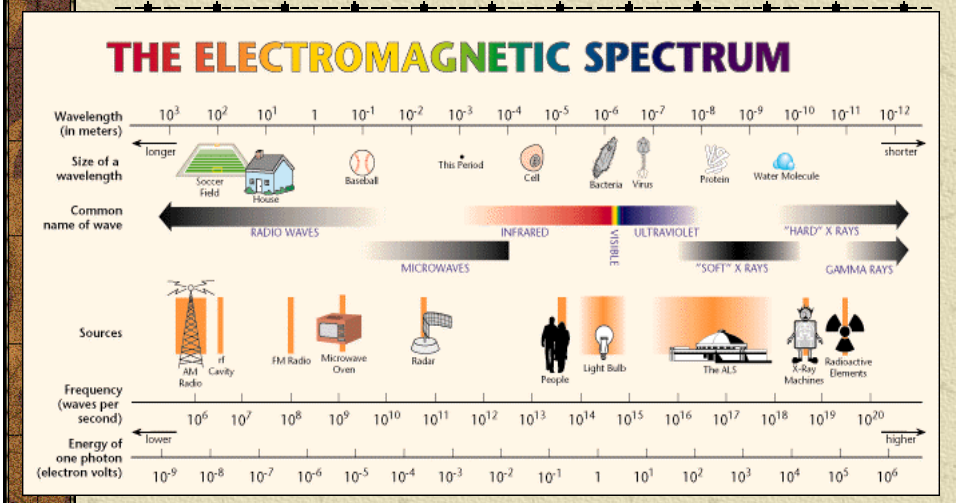
Atoms and elements



Radiation



The Electromagnetic Spectrum



First Definition

"Background radiation" means:

- radiation from cosmic sources;
- naturally occurring radioactive materials, including radon, except as a decay product of source or special nuclear material:
- and including global fallout as it exists in the environment from the testing of nuclear explosive devices.

"Background radiation" does not include sources of radiation from radioactive materials regulated by the Department.

(CDPHE)

Another definition - NORM

- "Naturally occurring radioactive material" means any nuclide that is radioactive in its natural physical state and is not manufactured.

- "Naturally occurring radioactive material" does not include source material, special nuclear material, or by-products of fossil fuel combustion, including but not limited to bottom ash, fly ash, and flue-gas emission by-products.

(CDPHE)

Components of background radiation

- Cosmic
- Cosmogenic
- Terrestrial
- Ubiquitous radioactivity that is man-made and originates from non-site sources (*e.g.*, global fallout).

Altitude dependence on cosmic ray dose.

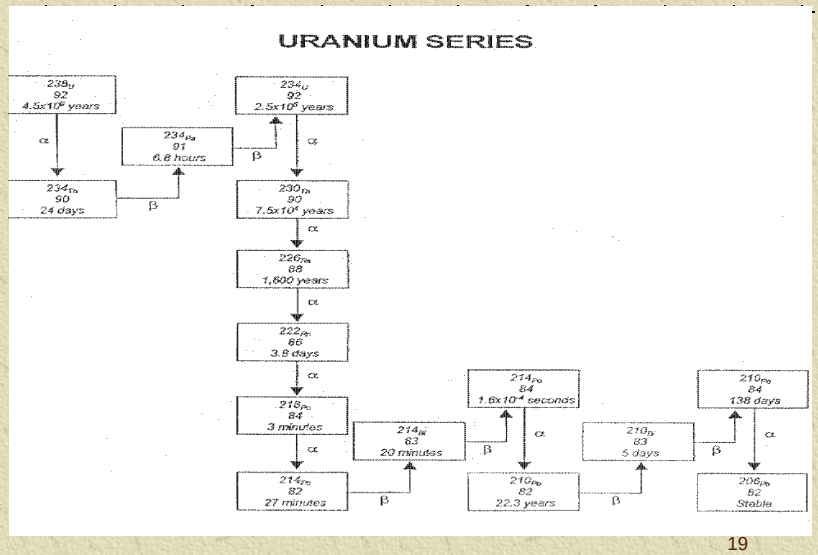
Altitude, m (ft)	Dose Rate, mrem/y	Example
Sea level	31	Los Angeles
1,525 (5,000)	55	Denver
3,050 (10,000)	137	Leadville, Colo.
9,140 (30,000)	1900	Normal jetliner
15,240 (50,000)	8750	Concorde
24,340 (80,000)	12,200	Spy plane

Adapted from Gollnick 1988.

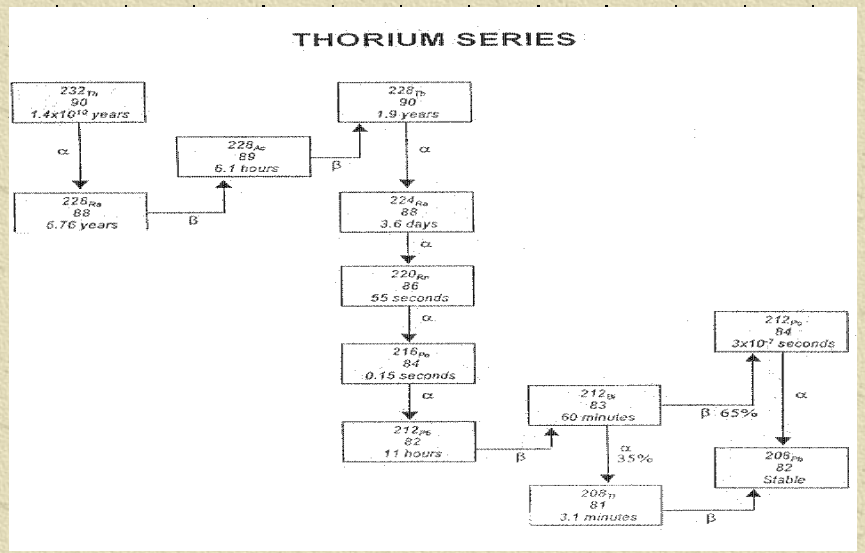
Series Radionuclides

- **There are three naturally occurring series (decay chains)**
  - ^{238}U (Uranium Series)
  - ^{235}U (Actinium Series), and
  - ^{232}Th (Thorium Series)
- Each attains secular equilibrium if the system remains "closed"
- Chemical / physical processing may alter these series and parent - daughter pairs. Much more on this later!
- **Non-series radionuclides – ^{40}K**

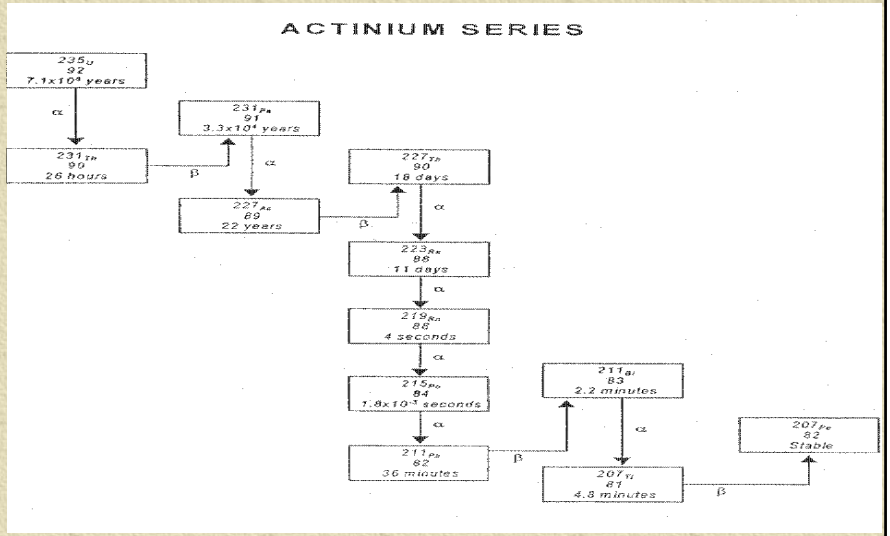
Uranium Series

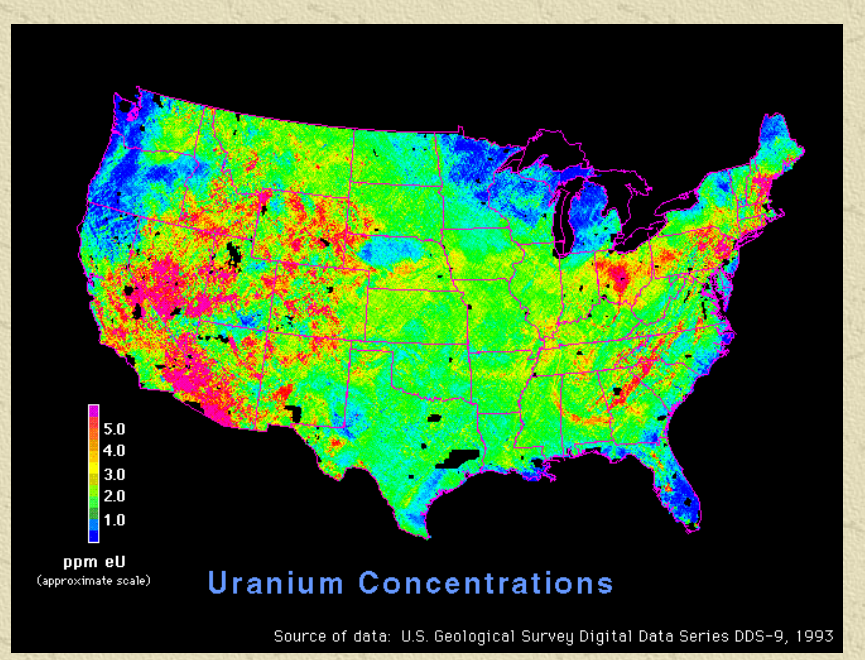


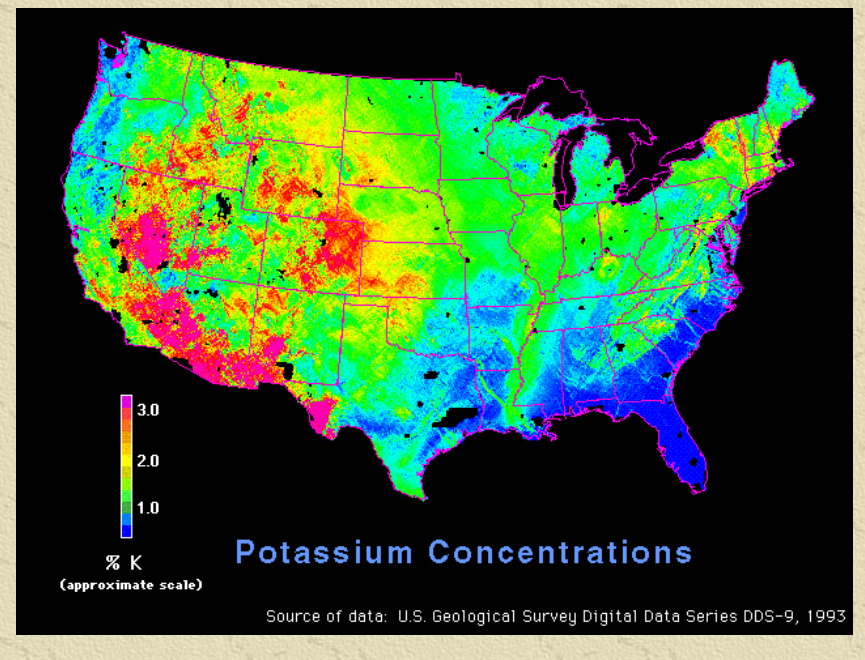
Thorium series

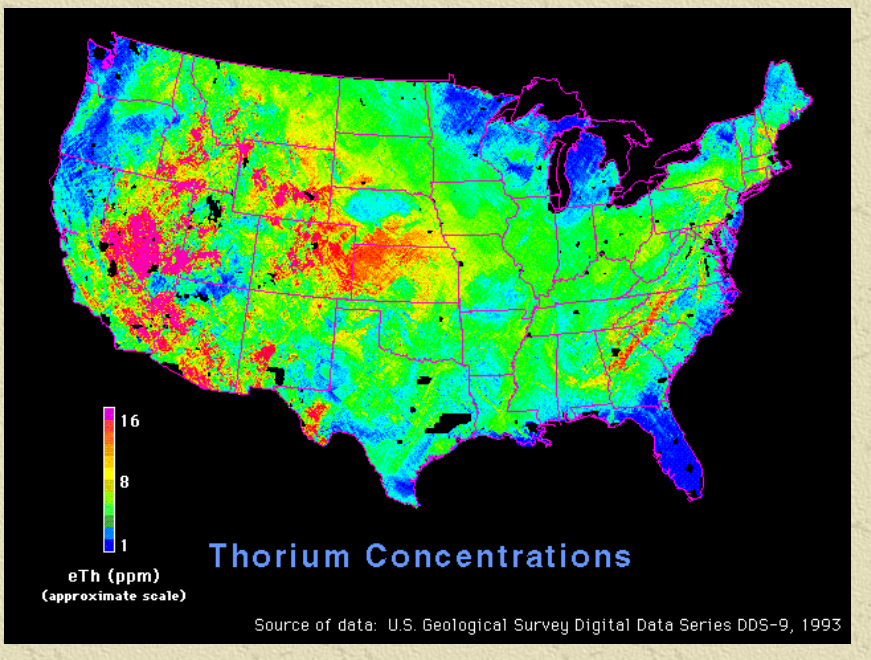


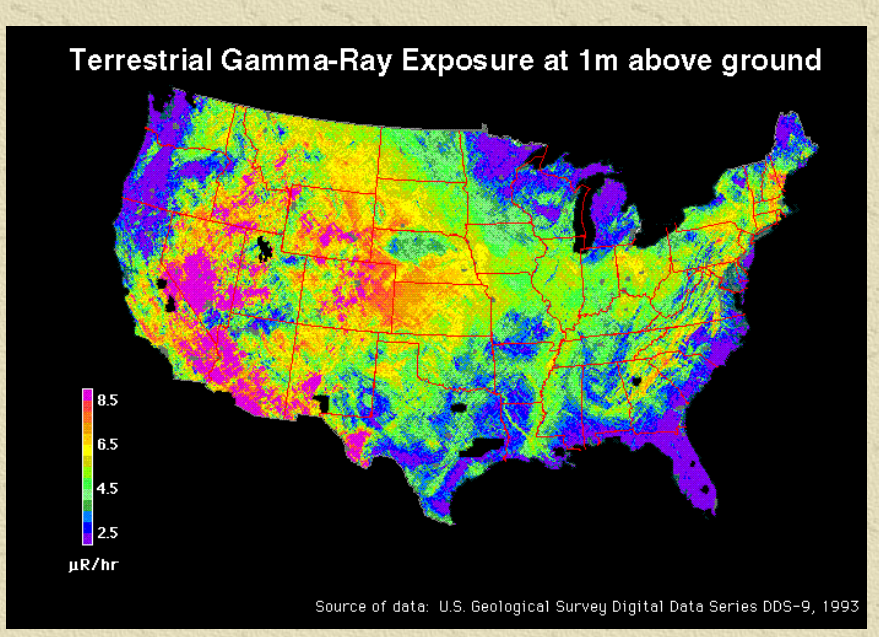
Actinium series






3.0
2.0
1.0
% K
(approximate scale)
Potassium Concentrations
Source of data: U.S. Geological Survey Digital Data Series DDS-9, 1993


16
8
1
eTh (ppm)
(approximate scale)
Thorium Concentrations
Source of data: U.S. Geological Survey Digital Data Series DDS-9, 1993



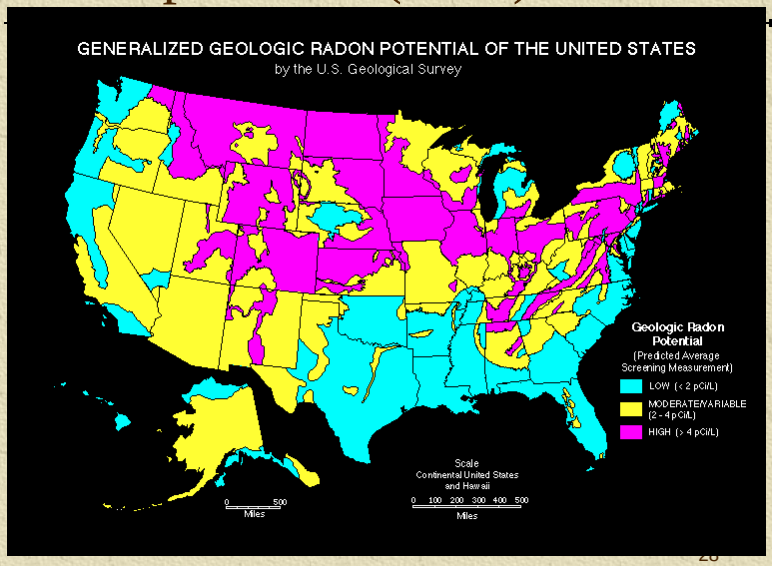
Sources and Variability of Background

- **Geology / Igneous Rocks**
  - Transported to the crust in magmas (lava).
  - Magmas are molten rock - these crystallize at or near the Earth surface
  - The result is NORM in igneous rocks (granite)
- **Geology / Sedimentary Rocks**
  - Shales, sandstones, and carbonate rocks are relatively low in NORM except for minor minerals. Clays contain some NORM.
  - These include zircons, biotites, *etc.* which do contain NORM in relatively elevated amounts.

Sources and Variability of Background Due to Radon (^{222}Rn)

- The source of Radon (^{222}Rn) is Radium (^{226}Ra).
- Rn emanation rate varies with material.
- Soils and Mine Tailings ~ 20 - 30%.
- Slags and vitrified materials ~ 1%.
- Rn emanation rates also fluctuate:
  - Daily
  - Seasonally
  - Annually

Radon potential (EPA)



More definitions - TENORM

- "Technologically enhanced naturally occurring radioactive material" or "tenorm" means naturally occurring radioactive material whose radionuclide concentrations are increased by or as a result of past or present human practices. (Radiation Control Act)

More definitions - TENORM

- "TENORM" does not include:
  - (a) Background radiation or the natural radioactivity of rocks or soils;
  - (b) "Byproduct material" or "source material", as defined by Colorado statute or rule; or
  - (c) Enriched or depleted uranium as defined by Colorado or federal statute or rule.

Technologically enhanced?

- TE means that the physical, chemical, radiological properties and activities have been altered such that there exists a potential for:
  - Exposures to individuals or population groups,
  - Environmental contamination or redistribution,
  - Increased environmental mobility,
  - Incorporation in products or materials,
  - Inadvertent recycling or re-use,
  - Improper disposition.

  (HPS)

Industrial By-Products that Contain TENORM

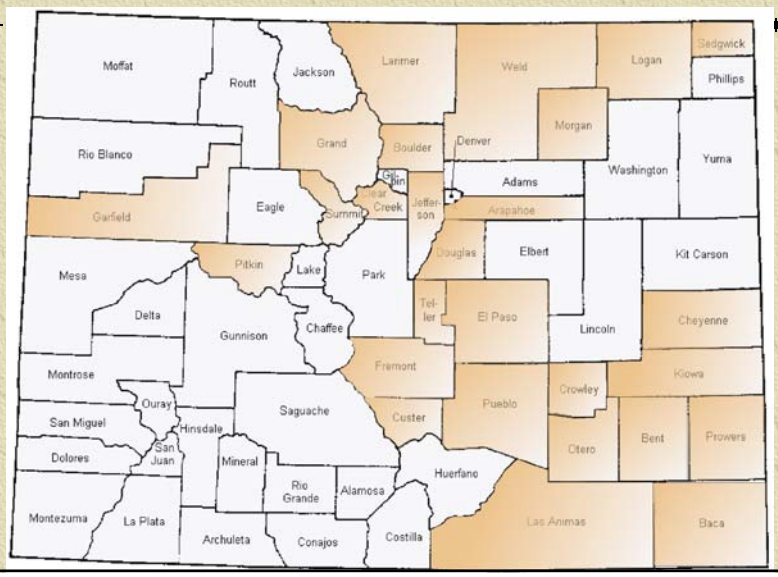
- Generally large-volume, low specific activity by-products of industrial processes:
  - **Uranium overburden,**
  - Phosphate Industry wastes,
  - Fertilizers and Potash,
  - Coal Ash,
  - Oil and Gas production scales and sludge.

Industrial By-Products that Contain TENORM (Cont'd.)

- **Water Treatment Sludges and Ra Resins,**
- **Metal Mining and Processing,**
  - Rare Earths,
  - Zirconium, hafnium, titanium, tin,
  - Large Process - Cu, Fe,
- Geothermal Energy Production Wastes,
- Paper and Pulp Processing Wastes.

Material/Waste Stream	Production Rate (metric tons per year)	Average ^{226}Ra Concentration, Bq/g (pCi/g)
Uranium overburden	3.8E+07	0.92 (25)
Phosphate waste		
- Phosphogypsum	4.8E+07	1.2 (33)
- Slag	1.6E+06	1.29 (35)
Phosphate fertilizers	4.8E+06	0 .31 (8.3)
Coal ash	6.1E+07	0.14 (3.7)
- Fly ash	4.4E+07	0.14 (3.9)
- Bottom ash and slag	1.7E+07	0.11 (3.1)
Oil and gas scale and sludge	2.6E+06	3.33 (90)
Water treatment	3.0E+06	0.59 (16)
- Sludges	2.6E+06	0 .59 (16)
- Radium selective	4.0E+04	1295 (35,000)
Metal mining and processing	1.0E+09	0.18 (5)
- Rare Earths	2.1E+03	33.3 (900)
- Zirconium, hafnium,	4.70E+05	1.59 (43)
- Large volume	1.0E+09	0.18 (5)
Geothermal energy production wastes	5.4E+04	4.9 (132)

Counties with systems near or above MCLs in water source



Drinking Water Treatment Residuals

- Wastes include:
  - Sludges from alum/ferric, MHO treatments,
  - Filters and media,
  - Ion-exchange resins,
  - Granulated activated charcoal,
  - Water from filter backwash,
  - Reject waters from reverse osmosis.

By-Products of Metals Mining and Processing

- Processing and refining ores can result in appreciably higher activities of TENORM compared to the ore.
- Levels of NORM in ores depends on the geologic formation and the region being mined as well as the specific mineral being mined and processed.
- Some processes not only concentrate the TENORM, but enhance its mobility.

Dose and risk comparison: background and TENORM.

- Definition of Units
- Dose
- Risk

Back to definitions

- We measure radiation with different units:
  - In air (exposure):
    - Roentgen
  - When it is a dose:
    - When it interacts with matter:
      - Absorbed dose
      - Rads (Gray)
    - When it interacts with tissue:
      - Dose equivalent
      - Rem (Sievert)

More units

- We measure radioactivity by:
  - Concentration
    - Mass (ppm)
    - Activity (pCi/g)

It's all Greek to me

- Numbers can vary over 30 orders of magnitude:
- Series of Greek letters
  - Every three orders of magnitude
- Most common for low activity materials very small values.

It's all Greek to me

SI Prefixes					
Factor	**Prefix**	**Symbols**	**Factor**	**Prefix**	**Symbols**
10^{18}	exa	E	10^{-1}	deci	d
10^{15}	peta	P	10^{-2}	centi	c
10^{12}	tera	T	10^{-3}	milli	m
10^{9}	giga	G	10^{-6}	micro	µ
10^{6}	mega	M	10^{-9}	nano	n
10^{3}	kilo	k	10^{-12}	pico	p
10^{2}	hecto	h	10^{-15}	femto	f
10^{1}	deka	da	10^{-18}	atto	a

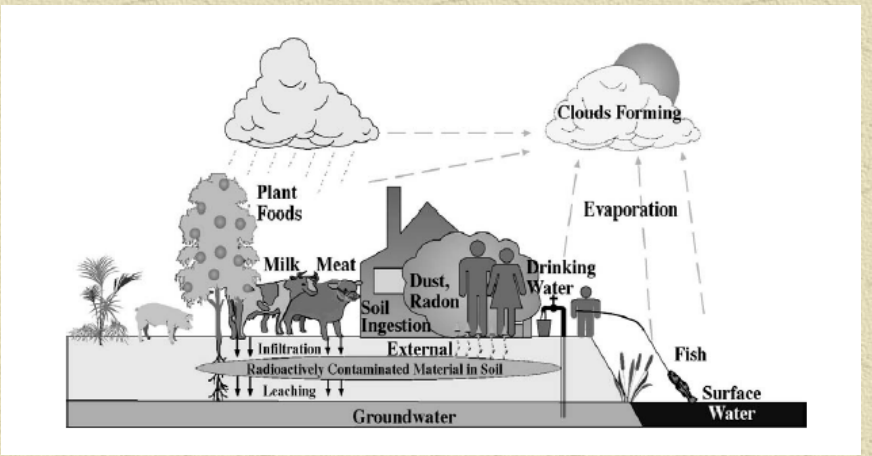
More definitions

- Dose:A general term used to refer to the effect on a material that is exposed to radiation.
- We measure radiation by:
  - Total dose
  - Dose rate
  - Whole body dose
  - External dose
  - Internal dose
  - Individual dose
  - Collective dose

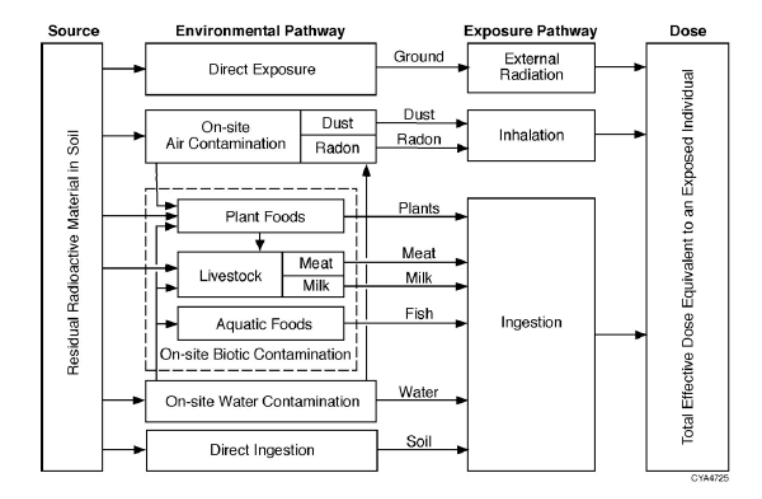
Risk Assessment

- Identify, measure and quantify hazards
- Evaluate pathways to receptors
- Calculate dose to receptors
- Calculate corresponding risk to receptors
- Compare to allowable limits

Conceptual Site Model



Conceptual site model (cont.)



Risk assessment for proposed activities

- Submitted with application
- Under review
- Focus is on occupational exposures
- Environmental pathways projected to be negligible:
  - No groundwater pathway
  - Air emissions minimal
- Current practices for protection against hazardous chemicals very similar to practices for protection against radioactivity.

Dose from proposed activities

- Dose to the public estimated at less than 1 mrem/y
- Dose to workers estimated to be less than 25 mrem/y.
- This is in addition to background dose.
- ALARA approach strives to lower dose as far below the limits as reasonable.

Background – natural sources

Annual Effective Dose Equivalent			
SOURCE	**DOSE (mrem/yr)**	**DOSE (mSv/yr)**	**PERCENT OF TOTAL**
Natural			
Radon	200	2.0	55%
Cosmic	27	0.27	8%
Terrestrial	28	0.28	8%
Internal	39	0.39	11%
Total Natural	**300**	**3**	**82%**

Background – other sources

SOURCE	**DOSE (mrem/yr)**	**DOSE (mSv/yr)**	**PERCENT OF TOTAL**
Artificial			
Medical X ray	39	0.39	11%
Nuclear medicine	14	0.14	4%
Consumer products	10	0.1	3%
Other			
Occupational	0.9	<0.01	<0.3
Nuclear Fuel Cycle	<1	<0.01	<0.03
Fallout	<1	<0.01	<0.03
Total Artificial	**63**	**0.63**	**18%**
Total Artificial and Natural	360	3.6	100%

Comparisons

Limits for Exposures	Exposure
Building materials (concrete)	3 mrem/year
Terrestrial bkd (Atl. coast)	16 mrem/year
Terrestrial bkd (Rockies)	40 mrem/year
X-rays from TV set (1 inch)	0.500 mrem/hour
Natural gas in home	9 mrem/year
Chest x-ray	8 mrem
CT (head and body)	1,100 mrem
Therapeutic thyroid treatment (dose to the thyroid)	10,000,000 mrad

Increase from moving from sea level to 5,000 ft.

- Cosmic:
  - Average increase of ~25 mrem/y
- Terrestrial
  - Average increase of ~24 mrem/y

Dose limits

- Members of the public
  - 100 mrem/y above background
- Occupational limits
  - 5 rem/y plus background

Summary

- Natural radiation is all around us
- NORM and TENORM behave similarly and have similar hazards and risks
- Doses and risks from proposed activities projected at a fraction of natural background
  - Under review

Where to Get More Information

- National Research Council
  - "Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials"
- NCRP Report 94
  - "Exposure of the Population in the U.S. and Canada from Natural Background"
- NCRP Report 118
  - "Radiation Protection in the Mineral Extraction Industry"

Clean Harbors Deer Trail, LLC

Hazardous Waste Treatment, Storage And Disposal Facility Permit Renewal Application

Tanell Roberts
Environmental Protection Specialist

Permit Renewal Application Includes:

- Container Storage
- Tank Storage
- Treatment And Storage In a Surface Impoundment
- Land Disposal In Secure Disposal Cells

Facility History

- Originally permitted in 1987
- Facility has had six corporate owners, last previous owner was Safety-kleen corporation
- Safety-kleen declared bankruptcy in 1999
- Facility sold to Clean Harbors Environmental Services in 2002
- Safety-kleen submitted permit renewal application in 2001
- Clean Harbors submitted their own permit renewal application in 2004

State Health Department Activities

- Involved at national level with bankruptcy and selling of Safety-kleen Environmental Services division
- Site activities and waste acceptance at site have been minimal during the last three years
- State health department continues to inspect at least once a month

State Health Department Activities

- Inspections have resulted in compliance advisories and ultimately an “Order on Compliance”
- To ensure the facility attains compliance, state health department has requested facility to perform a “readiness review”
- Once a schedule to achieve compliance has been accepted, state health department will begin writing a draft renewal permit

Modifications Identified In The Permit Renewal Application

- Closure of the oil and solvent tanks which have never been used
- Acceptance and management of NORM and TENORM material

Radioactive Materials Licensing Process

Jennifer Opila
Health Physicist

Regulatory Framework

- Colorado is an Agreement State
- Radiation Control Act
- Colorado Rules and Regulations Pertaining to Radiation Control
  - Part 3.9 General License Requirements
  - Part 4 Standards for Protection Against Radiation
  - Part 14 Licensing Requirements for Land Disposal of Low-Level Radioactive Waste
- All regulations available online at: http://www.cdphe.state.co.us/op/regs/radiationregs.asp

Regulatory Aspects for Land Disposal

- Authorizations
  - What are they allowed to do?
- Siting
  - Is it a good place for what they want to do?
- Design
  - Is the facility designed to meet performance objectives?
- Operational Safety
  - Do they have procedures to protect their workers and the public?
- Environmental Protection
  - Could their activities negatively impact the environment?

Clean Harbors Deer Trail Facility

- October 14, 2004-Submitted Permit Renewal Application
  - NORM/TENORM wastes from unlicensed sources
- January 31, 2005-Submitted Radioactive Materials License Application
  - NORM/TENORM wastes from licensed sources
- Materials with limited radionuclide concentrations

Materials Requested for Disposal

What they have asked for:

- NORM/TENORM
  - Soils, Scales, Sludges, Other Solids
- Radionuclides in the Uranium, Actinium, Thorium decay series
  - Concentration of all radionuclides <2000 pCi/g with a Ra-226 concentration <400 pCi/g

What they have **not** asked for:

- Wastes from man-made radiation sources
  - Nuclear power plant wastes
  - Hospital wastes
  - Research wastes

Licensing Process for Clean Harbors Deer Trail

- Simultaneously reviewing the permit application and the license application for technical merit and compliance with regulatory guidelines
- When we have questions we will ask for more information from Clean Harbors
- Conclusion of the review will determine:
  - Whether or not they will have additions to the RCRA permit for treatment and disposal of unlicensed NORM/TENORM
  - Whether or not they will be issued a radioactive materials license for treatment and disposal of licensed NORM/TENORM
  - In both cases, what they are allowed to accept

Licensing Process for Clean Harbors Deer Trail (cont.)

- This is the first application for land disposal of radioactive wastes that has been submitted to the state health department
- Working closely with the staff reviewing the RCRA permit application

Application Public Comment

- The Colorado Department of Public Health and Environment is accepting comments on the Radioactive Materials License Application.

Please send your comments to:

Jennifer Opila

Hazardous Materials and Waste Management Division

Colorado Department of Public Health and Environment

HMWM-RM-B2

4300 Cherry Creek Drive South

Denver, CO 80246

1 (888) 569-1831, extension 3403

Email: Jennifer.Opila@state.co.us

Public Involvement Opportunities

Joe Schieffelin
Program Manager
Compliance Program

Upcoming Public Involvement Opportunities

- Mid April : Public Information meeting
  - Permit and License Update
  - Status of review of Permit and License Applications
  - Status of Permit and License drafting
  - Interim decisions made
  - Outstanding issues

Permit Schedule

- Early May: Draft Hazardous Waste Permit Issued
- Early May thru June: Public Comment period for draft Hazardous Waste Permit
- Early June: Public Hearing on draft Hazardous Waste Permit
- Late June: End of Public Comment period for draft Hazardous Waste Permit
- Mid July: Final Permit Issued

License Schedule

- Today thru Late June: Public Comment on License Application
- Early June: Public Meeting on Radioactive Materials License Application
- Late June: Radioactive Materials License Issued

Public Involvement Opportunities

Clean Harbors Deer Trail LLC Website

www.cdphe.state.co.us/hm/hwy36.htm

- Permit Application
- License Application
- Important Correspondence
- Other Important Documents
    - Essentially Real-Time

Contact Information

- Hazardous Materials and Waste Management Division
    - Jeannine Natterman, Public Information Officer
      1 (888) 569-1831, extension 3303