NORM IX Symposium

Status Report on the NCRP Commentary on NORM/TENORM From the Oil & Gas Industry in the United States

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NCRP

- National Council on Radiation Protection and Measurements
  - Founded in 1928 as the U.S. Advisory Committee on x-ray and Radium Protection
  - Chartered by Congress in 1964 as NCRP
  - Provides Science-Based National Radiation Protection Recommendations
  - Established Scientific Committee (SC) 5-2

SC 5-2 Purpose

- Part 1: *Develop a Commentary to provide an overview of the generation/disposal of TENORM from oil & gas production and recommendations for a full NCRP report*.
- Part 2: *Develop a full NCRP report providing radiation protection recommendations for states, workers, the public, and the environment.*

Focus on the Oil & Gas Industry in the U.S.

- It is recognized that NORM/TENORM are generated by numerous industries (mining, mineral extraction, geothermal, ceramics, phosphate production, water treatment, and more)
- Scope limited to oil & gas production since wastes from these technologies pose public health challenges across the U.S. – may be similar for other NORM/TENORM

SC 5-2 Commentary Contents

- Origins of NORM (natural background 101)
- Overview of oil & gas operations that generate NORM/ TENORM
- Current waste management options
- Other factors (fear) affecting safety
- Historic/current U.S. regulatory framework
- Disposal modeling considerations
- Legal Considerations

NORM/TENORM Issues

- Uranium/radium in geologic formations known and measured since ~1900
- 1980s – Radium pipe scale
  - Radium preferentially soluble in saline
  - Precipitates with barium, calcium, and minerals as pipe scale or heavy sludge
  - Pipe recycling issues
  - Waste disposal issues

Pipe Scale

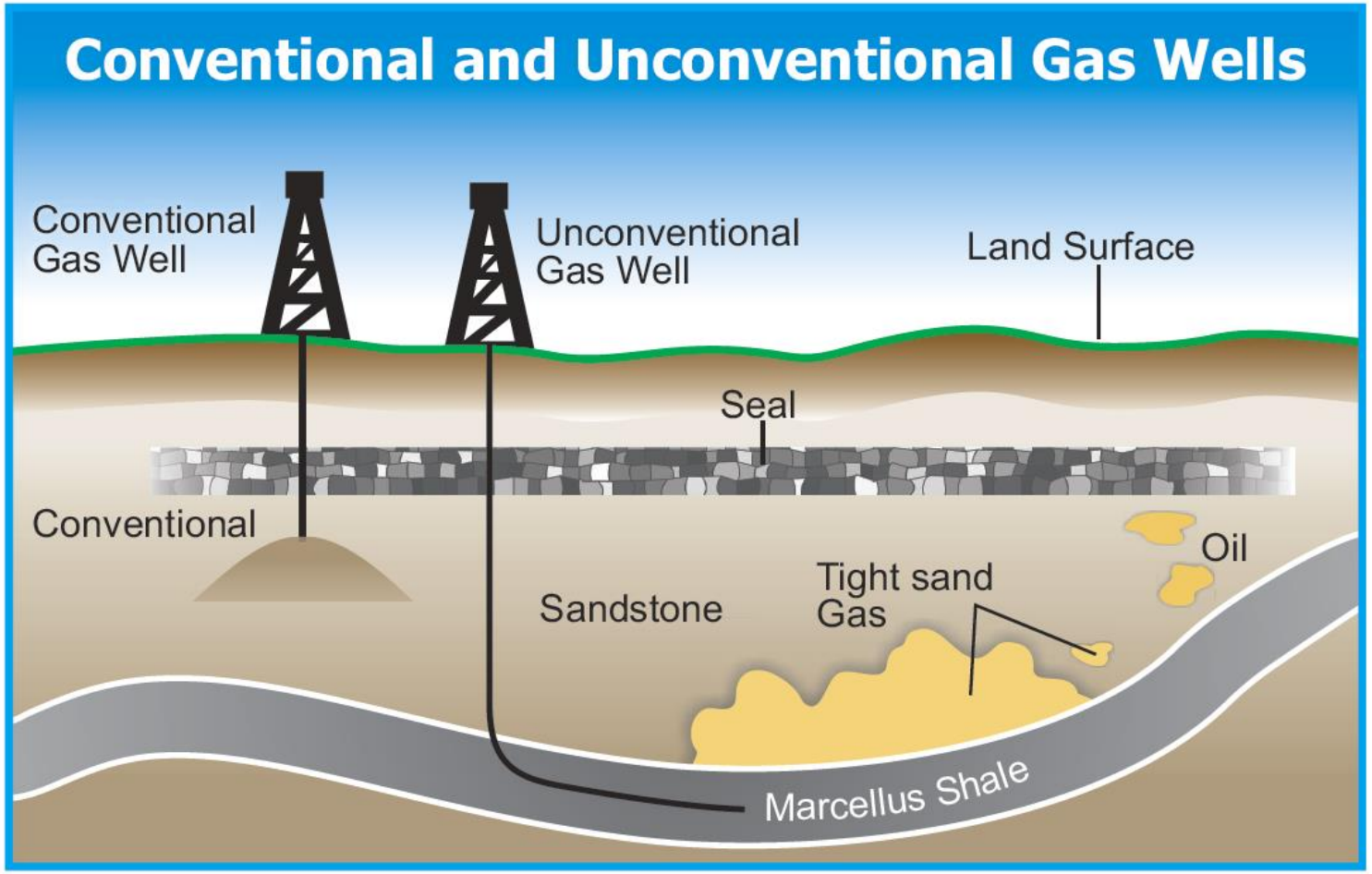
Oil & Gas Operations

- Conventional geology and drilling methods
  - Vertical well to trapped resources
  - Limited remaining resources in the U.S.
- Unconventional geology and drilling
  - Impermeable, deep rock formations (shale)
  - Oil & Gas “bound” by rock (doesn’t flow and difficult to produce)
  - Conventional drilling doesn’t work (slow or no recovery)

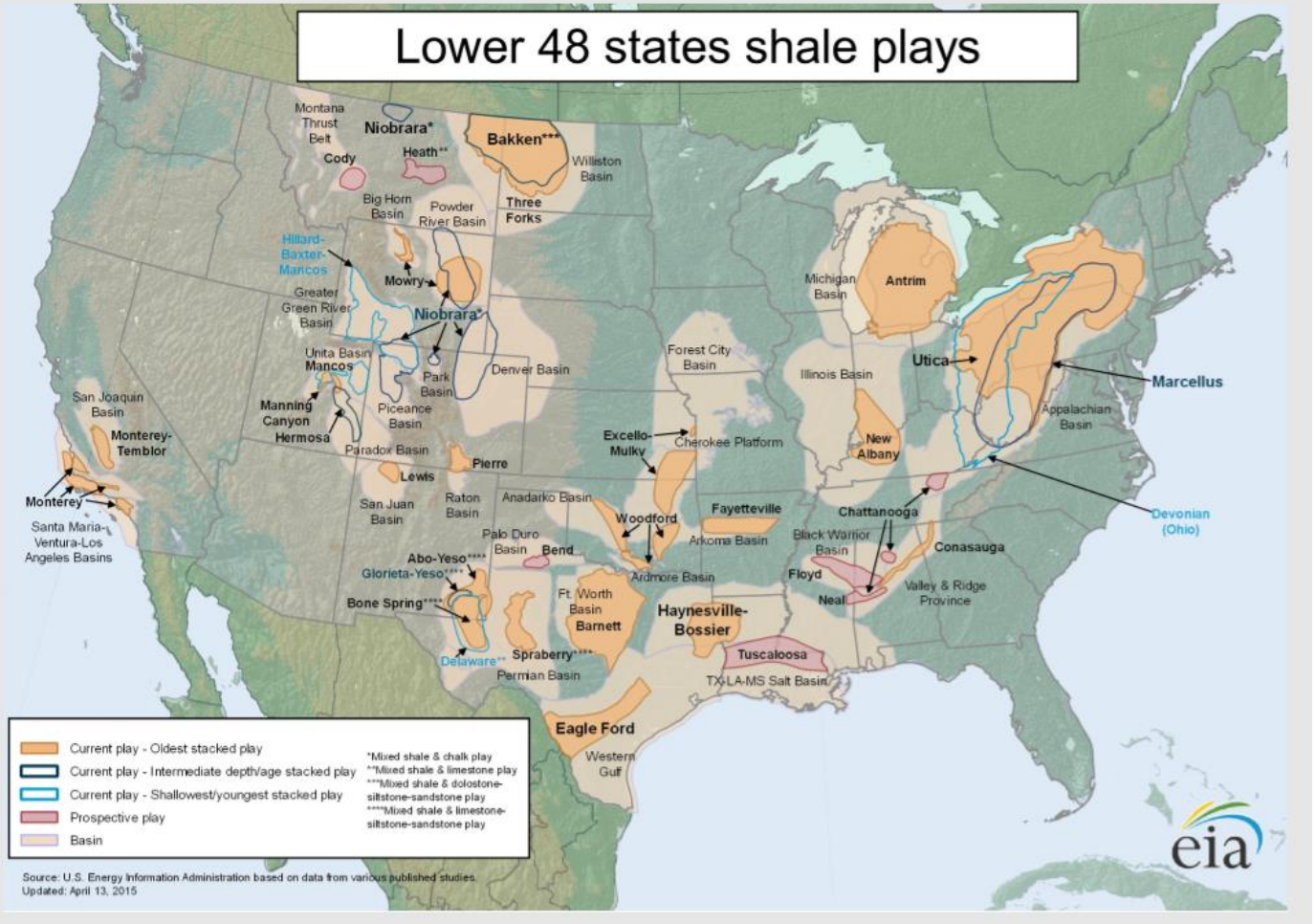
Unconventional Methods

- Hydraulic fracturing
  - Use of hydraulic pressure to fracture shale
  - Fractures allow oil & gas to flow for recovery
- Horizontal drilling
  - Allows for lengthy (up to ~ 2 km) horizontal wells in shale formations
  - Numerous horizontal wells from a single vertical well greatly expands the well footprint

Conventional vs Unconventional Wells



Shale Deposits (Plays)



Hydraulic Fracturing – A Brief History

- Technology began in 1857 – Preston Barrymore lowered black powder into oil wells – explosion stimulated production
- Process proved to be “unreliable”
- 1940s – Standolind oil used hydraulic pressure to fracture rock
- Quickly commercialized in the 1960s in Kansas/Oklahoma/Texas for conventional wells

A Brief History of Hydraulic Fracturing

- 1975 – President Ford promoted *development of shale oil resources as part of his overall energy plan (reduce imports)*
- 1990s – Modern day fracking, George P. Mitchell, combined fracking with horizontal drilling; greatly increased production
- Injection of fluids (water), sand, and/or chemicals below ground to the host rock under high pressure (10s of megaliters!)

Horizontal Drilling

- In the 1970s-1980s, vertical well could be curved in a horizontal direction parallel to and within shale formations
- Allowed numerous extended lateral wells from a single vertical well to create a large well oil & gas recovery zone
- Newer methods (computerized seismic mapping) helps keep the horizontal well in the shale layer

Staged Equipment

Drill Rig

Recovered Waste Water

Removal of a Gas Pipeline Pig

Solid Waste Options

- Hazardous Waste Landfill (RCRA)
- Low Level Radioactive Waste Landfill
- Onsite management (disposal onsite)
- Down-hole disposal
- Clearance/abandonment
- Land spreading
- Reuse/recycling (steel pipe/equipment)

Liquid Waste Options

- Deep well injection – only selected states
- Reuse as hydraulic fracturing fluid
- Effluent discharges – if EPA/state limits can be met
- Onsite treatment (filters/evaporators) – may create concentrated radium-bearing solids for disposal

Uniform Waste Management Strategy

- Waste management plans to identify and resolve issues
- Process knowledge to establish operational basis
- Sampling plans (strategies, methods, QA/QC, & records)
- Coordinated waste disposal methods (regulator and stakeholder involvement)

Additional Factors Affecting Safety

- Worker fears of radiation – overly conservative decisions vs real risks
- Is it safe – how do you know who to trust?
- Radiation measurements unless by trained staff can be confusing or wrong (errors and uncertainties)
- Role of training and communications to reduce fears and improve safety

Complex U.S. Regulatory Framework

- EPA promulgates standards for NRC/DOE implementation
- EPA has authority to regulate NORM radionuclides (air, water, and residuals)
- However, EPA has no comprehensive NORM/TENORM regs
- NORM/TENORM largely outside NRC/DOE authority

Role of the NCRP

- Protecting workers, the public, & environment
- Develop recommendations consistent with ICRP within the national context
- Mission: to provide national framework & recommendations radiation protection
- Provides the scientific basis for promulgating regulations

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- 2018 Recommendations aligned with ICRP for planned, emergency, existing, and existing exposure situations
- Five categories: occupational, public, medical, emergency, and non-human biota
- Expanded discussions of justification, optimization, and numeric protection
- Basis for updated national regulations

States Regulate NORM/TENORM

- By U.S. regulatory framework, individual states regulate
- A nationwide, consistent framework lacks
- States regulate without much scientific or technical support, largely *ad hoc*
- Lack of consistent regulations means monitoring workers or the workplace is inconsistent, rare, or non existent

Uranium Mill Tailings Control Act (UMTRCA)

- Control/remediation of uranium and thorium mill tailings (land remediation)
- Covers abandoned facilities (legacy sites)
- Cleanup criteria for surface soils have been adopted as landfill disposal limits or exempt quantities
- It seems inappropriate that cleanup levels would also serve as disposal limits without justification

Example State Regulations (Simplified)

Waste Form	Radium Waste Acceptance Criteria or Exempt Quantity	State
Solids	0.185 Bq/g (5 pCi/g)	Alabama, Arkansas, Georgia, Louisiana, Kentucky, Maine, Michigan, Mississippi, North Dakota, Ohio, South Carolina, Virginia,
	0.11 Bq/g (3 pCi/g)	Colorado
	1.85 Bq/g (50 pCi/g)	West Virginia

Example State Regulations (Simplified)

Waste Form	Radium WAC or Exempt Quantity	State
Liquids	0.185 Bq/l (5 pCi/l) for protected waters 2.22 Bq/l (60 pci/l) for other waters	Wyoming
Water Treatment	7.4 Bq/g (200 pCi/g)	Illinois
Other	0.15 mSv/y (15 mrem/y)	New Jersey
	Ban Oil & Gas Waste	New York
Landfill Performance	0.25 mSv (25 mrem)	Pennsylvania

Disposal Modeling

- Use of RESRAD family of codes
- Dose-based site-specific RCRA landfill disposal performance (PA, CO, CA)
- Scenario analysis - *reasonable assurance* over 1,000 or 10,000 years
- Groundwater, future site resident scenarios
- Landfill intrusion treated as an accident
- Dose limits as performance objectives

Legal Considerations

- Oil& gas exploration and production litigation in the U.S. increasing
- Negligence, private/public nuisance
- Breach of contract (including trespassing)
- Mergers/acquisitions
- Hazardous substance or activity
- Worker/community right to know

Summary

- Commentary on current state-of-the-industry and potential waste issues
- Makes recommendations for developing a full report to address radiation protection recommendations for workers, the public, and the environment
- Commentary has been through numerous council and peer reviews
- **In Press!!!**

Questions?

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