pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Testimony of

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Good morning Chair Muth, Representative Innamorato, and members of the Senate Democratic Policy Committee. My name is David Allard, and I am the Director of the Pennsylvania Department of Environmental Protection Bureau of Radiation Protection. I am joined this morning by Scott Perry, the Deputy Secretary for Oil and Gas at DEP.

I will be presenting testimony this morning to provide a high-level overview of radiation, radiation protection, naturally occurring radiological material (NORM), and technologically enhanced radiological material (TENORM). I will also be covering the disposal of oil and gas waste as it relates to TENORM, both within and outside of the Commonwealth of Pennsylvania. This testimony will also address the potential and magnitude for worker and public radiation exposures, as well as environmental impact, all within relation to other sources of natural and man-made radiation.

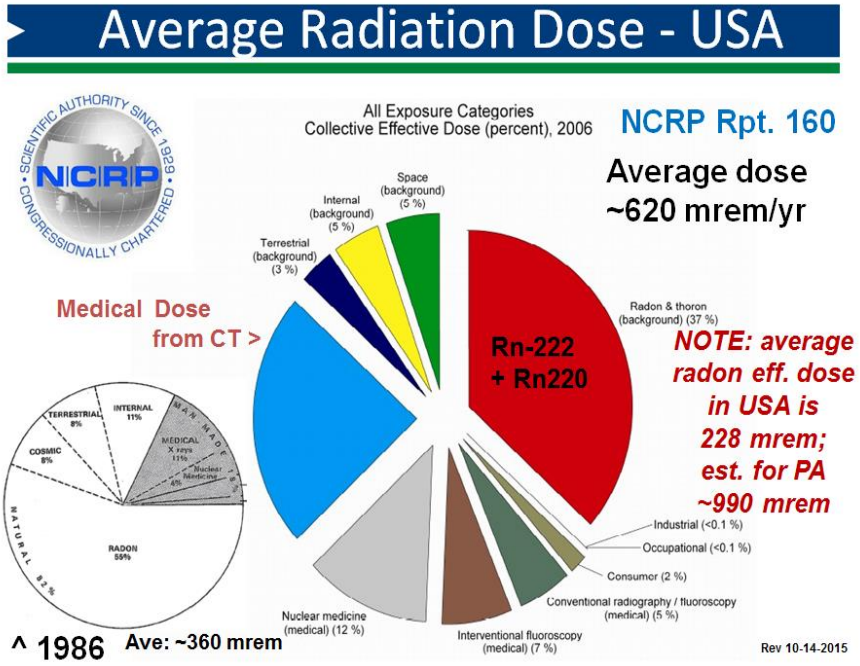
To begin, I'd like to first give a background explanation of radiation in our daily lives. The common unit of measurement for radioactivity in the USA is the 'curie' (Ci) which is 3.7E10 radioactive disintegrations per second. This is a very large amount of radioactivity; thus we often refer to much smaller levels such as mill-, micro- or pico-curies. A picocurie is 1E-12 Ci or 0.000000000001 Ci. The common units of radiation exposure are the roentgen (R), rad or rem

which measure ionization of air, absorbed energy, and ability to cause biological effects in humans.

Common types of ionizing radiation include alpha, beta, and neutron particles, as well as electromagnetic (EM) waves such as X- and gamma rays. These particles can carry specific amounts of energy measured in electron volts (eV). An eV is the amount of energy carried by an electron moving through a potential difference of 1 volt. That energy from particles or EM waves deposited in cells, tissues and organs may cause damage.

Factors that determine the magnitude of radiation exposure include time, distance, shielding; and administrative / engineering controls. Such controls may be through regulatory requirements or good safety practice.

The public's average exposure to radiation was recently reviewed and published in the National Council on Radiation Protection and Measurements (NCRP) Report No. 160, *Ionizing Radiation Exposure of the Population of the United States*. The common types of exposure include medical, radon, cosmic rays, and terrestrial naturally occurring radioactive material (NORM).



Total estimated average level of radiation exposure for the general public in the United States is about 620 mrem per year, with about half from natural sources and the other half from man-made sources. It is important to note, due to the very high natural levels of radium in Pennsylvania's soils and rocks, the average public exposure to radon in Pennsylvania is over four times higher than other areas of the country. Some Commonwealth residents receive on the order of 1,000 mrem/year from just naturally occurring radon.

The greatest risk to public health from NORM is from radioactive radon – it is the second leading cause of lung cancer (behind smoking cigarettes). DEP does not regulate radon exposure in homes or other buildings like schools but does run an extensive public education and outreach program dedicated to alerting residents of the risk of radon.

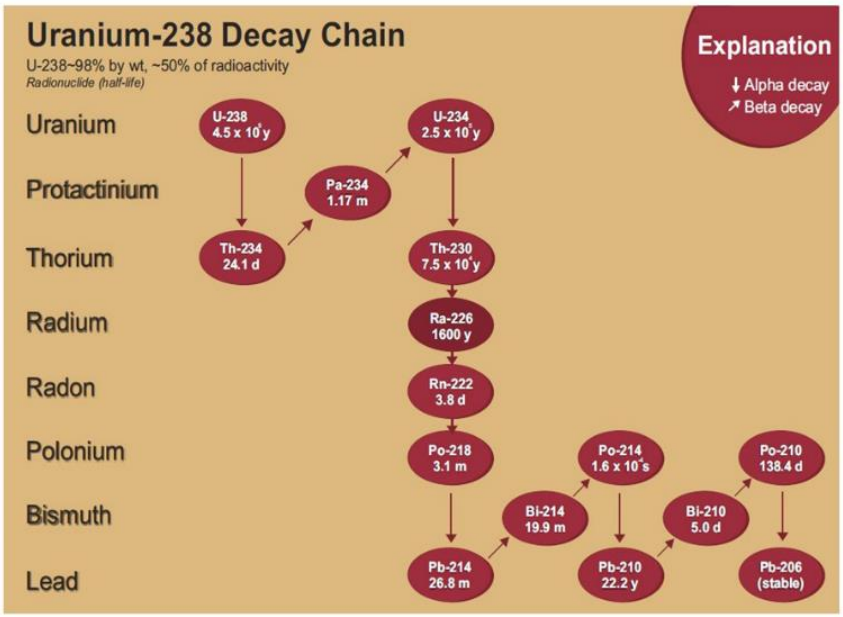
While radiation exposure is often thought of as a danger to the public, radiation itself is a weak cancer-causing physical agent. That is not say that the risk is not there, but that the perceived risk to public health from radiological material can be greater than the actual risk. Nonetheless, radiation protection professionals assume any level of exposure carries some risk, and, the cause and effect follows a linear non-threshold (LNT) response, extrapolating from high-level to low-level exposure. LNT is a model used to estimate the cancer risk caused by ionizing radiation.

When it comes to government standards for protecting the public and workers from radiation, the Nuclear Regulatory Commission (NRC) and the Occupational Safety and Health Administration (OSHA) set Worker and Public Radiation Exposure Limits and Environmental Standards. Trained radiation workers may receive up to 5,000 mrem per year. Federal and state Radiation Control Programs limit public exposure to 100 mrem per year. The cleanup and release criteria for contaminated sites, and disposal of low-level radioactive waste (LLRW), a 25 mrem/yr public dose limit is used.

The EPA sets standards for drinking water supplies in 40 CFR Part 141 to 4 mrem/year, with additional limits of 5 picocuries per liter (pCi/L) for radium (Ra-226 plus Ra-228), and 30 micrograms per liter for uranium. The federal Department of Transportation (DOT) regulates the transport of radioactive material on public roads, and requires proper assay, manifesting, packaging, and labeling of such shipments.

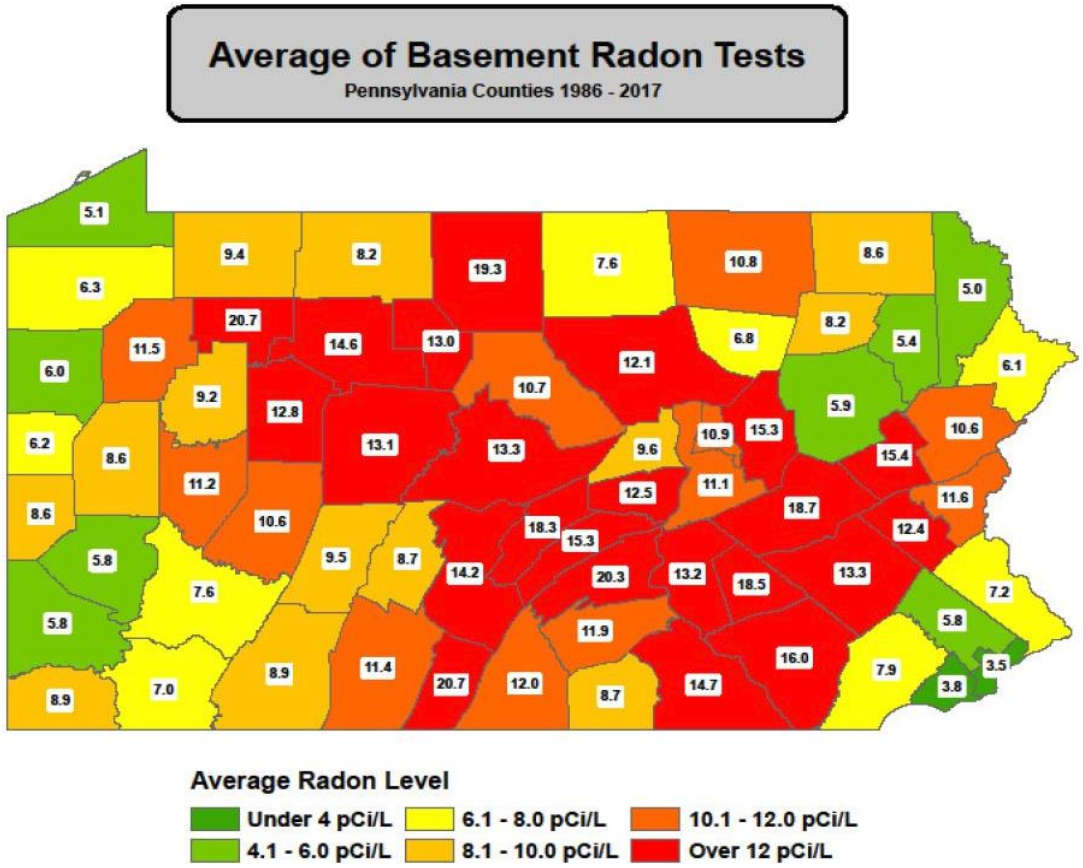
DEP has comprehensive solid waste and oil and gas regulations requiring PA landfills be constructed to 'hazardous waste site' disposal criteria, and oil and gas activities that may generate TENORM are required to perform radiation monitoring. Oil and gas operations that generate TENORM were recently the subject of an extensive study. As the department announced in late July, landfill leachate treatment and discharges will soon be routinely sampled and analyzed for radium.

I'd like to give examples of radiation levels in both NORM and TENORM. Some building materials made from natural stone may have increased levels of uranium (U) and thorium (Th). Granite often has higher than normal levels of U & Th. These radioactive elements decay and produce the Ra-226 and Ra-228, and are directly related to the question of radium in landfill leachate.



All landfill leachate and natural surface and groundwater will have radium to some level. Thus, as demonstrated by a national EPA/Interagency Steering Committee on Radiation Standards (ISCORS) study in the early 2000s, wastewater treatment facility sludge can contain up to 120 pCi per gram (pCi/g), and on average, about 50 pCi/g Radium-226.

Typical background levels of radium-226 in soils in the United States are about 1 pCi/g. However, investigations of high radon areas in the Reading and Allentown areas have detected soil levels up to 50 pCi/g. Radon-222 is the first decay product of Ra-226. Based on circa 1985 investigations of high radon areas in the Commonwealth, the EPA set a radon 'action level' at 4 pCi/L. Above this concentration, mitigation is recommended. Over the past 35 years, DEP has (and continues to) document very high residential radon levels ranging from 100 to 17,000 pCi/L. With the support of EPA grants, significant effort is expended each year to alert the public of the potential for high radon levels, encourage testing, and – if needed – mitigate. DEP recommends that the Commonwealth require routine radon testing in schools/daycare, at the time of any property sale, and, require new homes to have inexpensive 'radon resistant new construction' methods used - especially in EPA Zone 1 & 2 counties.



There is no nationally standardized definition for TENORM; DEP uses and has codified a definition from research of the National Academy of Sciences. Specifically, “TENORM – A naturally occurring radioactive material not subject to regulation under the laws of the Commonwealth or the Atomic Energy Act of 1954, whose radionuclide concentrations or potential for human exposure have been increased above levels encountered in the natural state by human activities.”

A wide range of external low-levels of radiation are observed with varying levels of TENORM in oil and gas and other industry waste. The evaluation to be made in each case study is, ‘does the exposure scenario cause a member of the public or worker to exceed the ‘public radiation dose’ limit of 100 mrem/yr?’ And, ‘is there any environmental contamination, and if so, what are the levels and potential for public exposure?’

Oil and gas TENORM have often focused on drill cuttings and wastewater fluids from conventional and unconventional well development and operations. In the early 1990s, the then PA Department of Environmental Resources (DER) performed a comprehensive ‘NORM Survey’ of the conventional oil and gas industry. That report did find elevated levels of Ra-226 and Ra-228 in produced waters, but nothing that would have triggered tighter regulatory control at that time.

DEP's recent TENORM study was begun in 2013 and published in May 2016. This TENORM study was an enormous effort involving scoping of sampling at well development operations as well as production, storage, processing, and down-stream transport of natural gas. Sampling and analysis protocols, as well as results and conclusions, were peer reviewed by national experts in government and academia. RadioChem laboratory and radiological survey methods included: gamma spectroscopy, portable radionuclide identification, liquid scintillation proportional counting, X-ray fluorescence analyzer, radon Lucas Cells, trac-etch and charcoal detectors, field micro-R meters, Geiger-counters, vehicle mounted NaI(Tl) crystals, and other stable element analysis instrumentation.

The study results have been presented at numerous national and international scientific meetings, and it is regarded as one of the most comprehensive evaluations of oil and gas TENORM to date. Dozens of sampling locations were included in the study, including well pads, wastewater treatment facilities, landfills, natural gas at the wellhead, at underground storage facilities, electric generator high volume use locations, etc. Both conventional and unconventional oil and gas operations were included.

Findings from the study, sample results, supporting information, conclusions, and recommendations for follow-up work are all published on the DEP website. Some of the findings include:

- Oil and gas wastewater radium levels ranged from a few hundred to over 25,000 pCi/L Ra-226.
- Drill cuttings from both vertical and horizontal rock cuttings were about 2 pCi/g and 7 pCi/g Ra-226 respectively.
- Radon in natural gas was about 50 pCi/L Rn-222 on average.
- Landfill leachate was 54 to 416 (112 avg) pCi/L Ra-226.

The study concluded that TENORM is a low risk to the public and workers. Conclusions also noted a potential for environmental impact from liquid oil and gas wastewater spills, and some wastewater treatment sludge exceeded DOT criteria. Acknowledgement of areas needing more research included: continued sampling of landfill leachate, further investigation of roads treated with oil and gas brines, and sampling during gas pipeline pigging operations.

There are many measures that DEP takes to prevent radiation exposure risks to the public from TENORM related to oil and gas operations. DEP has had solid waste and oil and gas Radiation Monitoring Action Plans in place beginning around 2000. All loads of solid waste entering landfills are required to be tested for radiation levels, and if radiation is detected, they must be evaluated for the type of radioactivity. DEP regulates TENORM waste disposal in PA landfills so that it is limited to ensure the public dose will not exceed 25 mrem/year for 1,000 years into the future. DEP also ensures compliance with federal DOT regulations related to transport of radioactive material. In 2019, the technical guidance for spill cleanup requirements and standards was updated to be more protective, and as noted previously, DEP is now requiring all landfills to provide leachate samples for radium analysis each quarter for at least the next two

years. Based on the data reported by landfills, DEP will implement longer-range steps including collecting and analyzing two years of quarterly data, so that fluctuations in oil and gas waste disposal volume are adequately captured, and will take any immediate action that is necessary to protect human health or the environment if it finds that federal action levels are exceeded.

DEP has and continues to lead the country in the evaluation of oil and gas industry generated TENORM waste handling, storage, and disposal. Through extensive evaluation, there have been no data to support the public or workers exceeding public radiation dose limit of 100 mrem/year. But, the potential for environmental impact from spills or leaks of TENORM contaminated material is real. DEP will continue to closely monitor and evaluate landfill leachate for radium content above natural background levels to ensure public health and safety.

Thank you for the opportunity to provide testimony today on this important topic.