

A Nuclear Services and Waste Management Company



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SELECTED KEY TOPICS IN US COMMERCIAL LLW MANAGEMENT THE PA DEP TENORM STUDY

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NORM – Naturally Occurring Radioactive Material

O&G Production – Oil and Gas Production

TENORM – Technologically Enhanced NORM

On January 15, 2015 PA DEP released the results of a 2 year study of TENORM and the O&G industry. The entire report can be downloaded:

http://www.portal.state.pa.us/portal/server.pt/community/oil_gas_related_topics/20349/radiation_protection/986697



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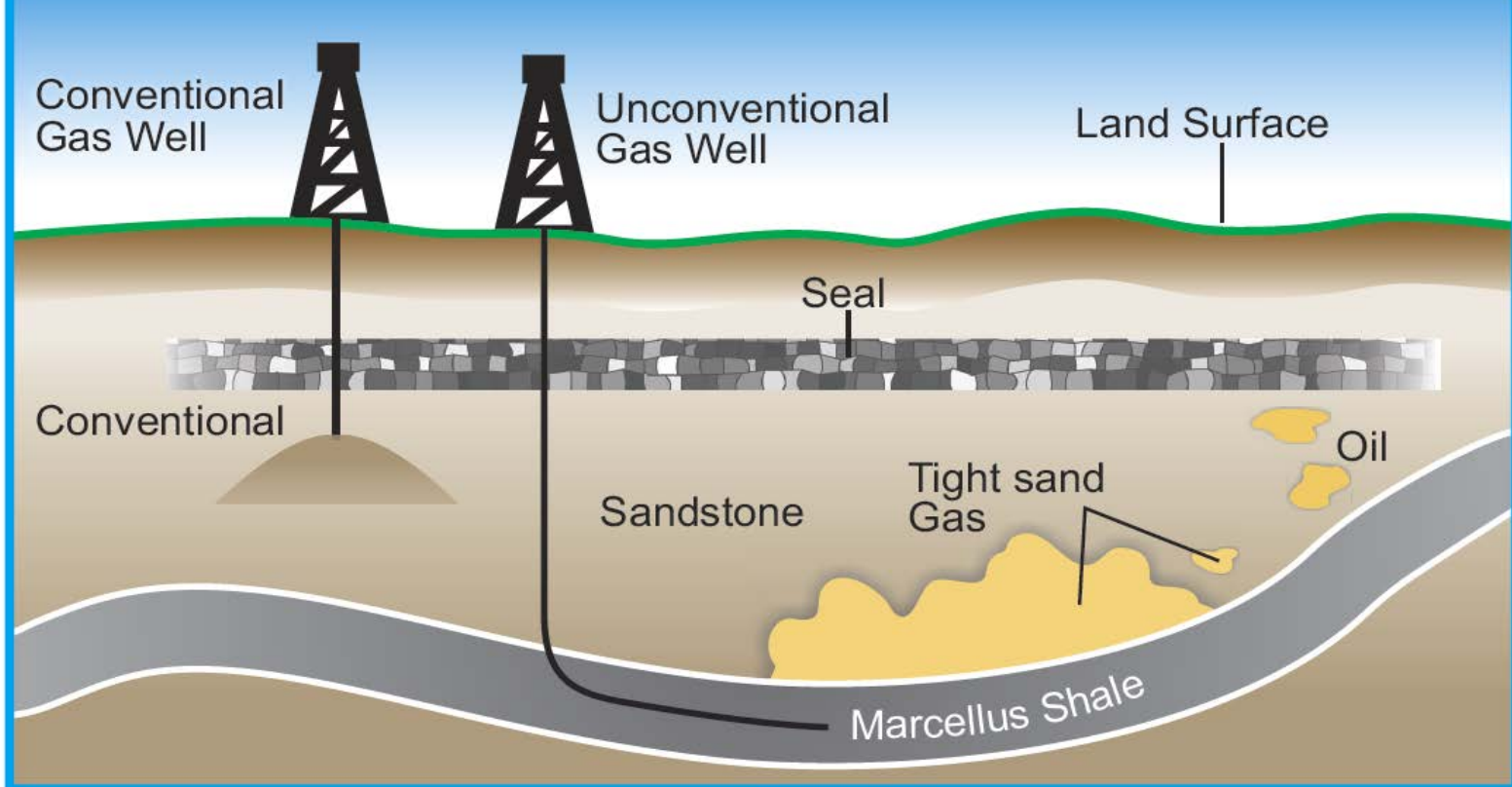


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Conventional and Unconventional Gas Wells



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The study was as comprehensive as possible and included:

- Thirty-eight well sites, including four conventional wells and 34 unconventional wells, were sampled from June 2013 through July 2014.
- Data from five phases of well development and completion were collected:
 - vertical drilling,
 - horizontal drilling,
 - hydraulic fracturing,
 - flowback, and
 - production.
- Samples of solids (cuttings), liquids and natural gas were taken and analyzed for NORM radionuclides.



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PA DEP TENORM Study



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Well Sites Results

- Horizontal drill cuttings contain Uranium (U), average 0.311 ± 0.248 Bq/g (8.40 ± 6.70 pCi/g), and Thorium (Th), average 0.053 ± 0.011 Bq/g (1.42 ± 0.331 pCi/g).
- Radium-226 (Ra-226) within hydraulic fracturing fluid ranged from 2.37 – 777 Bq/L (64.0 – 21,000 pCi/L). Radium-228 (Ra-228) ranged from 0.166 – 60.7 Bq/L (4.5 – 1,640 pCi/L).
- Ra-226 within flowback fluid ranged from 20.4 – 944 Bq/L (551 – 25,500 pCi/L). Ra-228 ranged from 9.18 – 64.4 Bq/L (248 – 1,740 pCi/L).
- Ra-226 within produced water samples ranged from 1.50 – 984 (40.5 – 26,600 pCi/L). Ra-228 ranged from 0.962 – 70.3 Bq/L (26.0 – 1,900 pCi/L).
- The radon (Rn) in natural gas ranged from 0.111 to 5.46 pCi/L (3.0 to 147.5 pCi/L), with a median of 1.51 Bq/L (40.8 pCi/L).



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Well Sites Observations

- The Ra-226 activity in unconventional well site produced water is approximately 20 times greater than that observed in conventional well site produced water. The ratio of Ra-226 to Ra-228 in unconventional well site produced water is approximately eight times greater than that found in conventional well site produced water.
- There were no statistically significant differences observed between filtered and unfiltered liquid sample analytical results.
- Worker and public exposure scenarios evaluated resulted in little risk.
- Environmental impacts are possible from spills of fluids on site.



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Wastewater Treatment Plants (WWTPs) were also surveyed and included:

- A total of 29 WWTPs were surveyed and/or sampled. This included:
 - 10 Publicly Owned Treatment Works (POTWs),
 - 10 Centralized Wastewater Treatment Facilities (CWTs) and
 - 9 Zero Liquid Discharge Facilities (ZLDs).
- Surveys of gross gamma activity and exposure rates, and surface alpha and beta radiation were performed.
- Samples of solids (surface soil), liquids and ambient air were taken and analyzed for NORM radionuclides.



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WWTP Site Survey and Sampling



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Wastewater Treatment Facilities Results

- POTW filter cake analytical results -
 - average Ra-226 result was 0.744 Bq/g (20.1 pCi/g) with a large variance in the distribution,
 - maximum Ra-226 result was 2.06 Bq/g (55.6 pCi/g),
 - average Ra-228 result was 0.308 Bq/g (8.32 pCi/g), and
 - maximum Ra-228 result was 1.18 Bq/g (32.0 pCi/g).
- Indoor Rn results from POTW-I results ranges from 0.007 to 0.32 Bq/L (0.2 to 8.7 pCi/L).



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Wastewater Treatment Facilities Results

- CWT filter cake results:
 - Elevated Ra-226 and Ra-228 was detected in all samples.
 - The maximum results were 10.9 Bq/g (294 pCi/g) of Ra-226 and 6.55 Bq/g (177 pCi/g) of Ra-228.
 - Five of 27 filter cake samples exceeded the DOT Ra threshold for labeling as radioactive material.
- Sediment-impacted soil was collected at CWT effluent discharge points. Ra above background to a maximum of 18.8 Bq/g (508 pCi/g) of total Ra was identified.
- Indoor air was sampled and analyzed for Rn concentration at various CWT indoor locations such as break rooms, laboratories, offices, etc. The results ranged from 0.033 – 0.185 Bq/g (0.9 to 5.0 pCi/L).



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Wastewater Treatment Facilities Results

- Radium-226 and Ra-228 were measured in ZLD filter cake samples at concentrations above typical background levels for surface soils. Radium-226 concentrations ranged from 0.114 to 17.8 Bq/g (3.08 to 480 pCi/g) and Ra-228 concentrations ranged from 0.021 to 2.50 Bq/g (0.58 to 67.3 pCi/g).
- Radium (Ra-226 and Ra-228) was routinely detected in all liquid influent and effluent sample types with an approximate 50 percent difference between influent and effluent, but little difference between filtered and unfiltered results. Results ranged from 1.01 – 773 Bq/L (29.0 to 20,900 pCi/L).
- Indoor air was sampled and analyzed for Rn concentration at various indoor locations such as break rooms, laboratories, offices, etc. The results ranged from 0.02 to 0.18 Bq/L (0.5 to 4.9 pCi/L).



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Wastewater Treatment Facilities Observations

- Detection of surface alpha and beta radioactivity was prevalent at WWTFs ranging from background to $> 50,000$ dpm/100cm².
- There were no statistically significant differences observed between filtered and unfiltered liquid sample analytical results.
- Worker and public exposure scenarios evaluated resulted in little current risk but there is potential for significant exposure in the future.
- Environmental impacts are possible from spills of fluids on site.
- Radioactive materials controls are needed at WWTFs to prevent additional contamination of surfaces, soils and sediments.



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Landfills were also included:

- Leachate samples were collected at 51 PA landfills.
- Nine of the 51 landfills were selected to be surveyed and sampled in more detail due to the volume of waste accepted from the O&G industry.
- Ambient air at the fence line of these landfills was sampled for Rn analysis.
- Filter cake was sampled from three of these landfills.



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Landfill Results

- Radium was detected above the MDC value in 34 of 51 leachate samples.
- Radium-226 results ranged from 0.981 to 15.4 Bq/L (26.5 to 416 pCi/L) with an average of 4.14 Bq/L (112 pCi/L) in the 42 unselected landfills and 3.92 Bq/L (106 pCi/L) in the nine selected landfills.
- Radium-228 results ranged from 0.0925 to 3.11 Bq/L (2.50 to 84.0 pCi/L) with an average of 0.466 Bq/L (12.6 pCi/L) in the 42 unselected landfills and 0.611 Bq/L (16.5 pCi/L) in the nine selected landfills.



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Landfill Observations

- There was no significant difference between leachate at landfills selected based on volume of TENORM received compared to the other landfills.
- There is no current exposure potential at landfills.
- Future exposure from closed landfills containing measureable TENORM needs further evaluation to determine acceptable activity concentrations of waste disposed of and volumes of waste disposed of.



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IN SUMMARY:

1. Well sites produce cuttings of moderate radioactivity including the entire uranium decay series.
2. Well sites produce large volumes of water with significant radium radioactivity.
3. WWTP clean the water and produce sludge and filter cake with significant radium radioactivity.
4. Landfills currently accepting the cuttings and wastewater sludge have radium in leachate.



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Questions?

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