



Pittsburgh Office  
325 Beaver St  
Beaver, PA 15009

Mr. David J. Allard, CHP  
PADEP / BRP  
PO Box 8469  
Harrisburg, PA 17105-8469

December 17, 2012

Submitted via email

**RE: Proposal for Comprehensive Study of NORM at Oil and Gas Exploration Well Pads, Supporting Sites and Waste Water Facilities in PA**

Dear Mr. Allard:

Perma-Fix Environmental Services, Inc. (PESI) is pleased to submit this cost estimate to provide a comprehensive study of the naturally occurring radioactive material (NORM) and technologically enhanced NORM (TENORM) related to the oil and gas exploration activities including conventional and unconventional drilling through geological formation(s) and associated waste water operations throughout the State of Pennsylvania (PA). PESI recently purchased Safety and Ecology Corporation (Perma-Fix) which has and continues to provide Health Physics consulting to the PA Department of Environmental Protection (PADEP) through the Technical Services Division, hence the change in name and logo. Technical Services provides health physics, radiation protection and radiological engineering services to commercial and government clients across the country. The division includes six certified health physicists (CHP) as well as sixty health physicists and radiological engineers and has contracted with PADEP in the past.

Throughout PA many companies perform oil and gas exploration and production activities by conventional and unconventional drilling through various subsurface layers of shale and rock to produce oil and natural gas. The drilling industry production and flowback water, as well as drill cuttings and sources of off gassing, are potentially impacted with NORM and/or TENORM. The proposed comprehensive study will focus on the quantification of TENORM, in rock cuttings (both vertical and horizontal), off gas, compressed gas, process and flowback water and waste water generated on drilling sites and on waste water transported off site to publically owned treatment works (POTW's), centralized waste treatment (CTW) facilities and solid waste facilities (landfill leachate). In addition, a literature search of relevant data on all geological formations and currently available data will be included and a sampling of applicable areas potentially impacted through beneficial reuse of brine and other impacted media. This proposal includes all labor, equipment, and travel costs associated with this effort including development of a specific sample and analysis plan (SAP). The sampling and analysis and site surveying, data management, an assessment of potential risk through human exposure to radioactive material and a final report including an assessment of risk and recommendations will be a collaborative effort between Pa DEP and Perma-Fix. The SAP will include both a Field Sampling Plan (FSP) providing details of the survey and sample protocols to be used and a Quality Assurance Project Plan (QAP) providing details of the laboratory analytical methods, the quality control of both field instruments and laboratory equipment and the quality control program including establishing reference background samples where appropriate, blank analyses, duplicate analyses and spike analyses where possible and applicable.



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Unconventional drilling process water sample results indicate significant concentrations of radium-226 (Ra-226) a common NORM radionuclide and the element associated with the natural decay series with the highest mobility. Because NORM is most likely associated with various geologic units, the scope of work presented herein will focus on these units and the operations, equipment, and features related to the drilling and production of natural gas from these geologic units and also in the transfer of water to POTW's and CWT's for processing. Landfill leachate will also be sampled to study whether radium has migrated from POTW and CWT sludge to the landfill leachate. Any beneficial reuse of any of the oil and gas drilling production media will also be surveyed and sampled as appropriate including but not limited to:

- Vertical and horizontal drill cuttings
- Onsite pits containing cuttings
- Production water
- Flowback water
- Filter socks
- Compressed gas lines.
- Off gassing
- Well pads
- Centralized impoundments
- Waste water facility sludge
- Waste water facility influent and effluent water
- Piping and casing scale

It is extremely important to understand the movement and exposure pathways of TENORM through the entire oil & gas exploration and production process in the Commonwealth of Pennsylvania. In this regard we propose this comprehensive study to have a more complete understanding of TENORM in oil & gas industry and waste disposal operations, and to document and evaluate potential radiation exposure to workers and the public, as well as ensure protection of the environment.

The following tasks will be completed in support of the study:

1. Develop a Sample and Analysis Plan (SAP) – A SAP consisting of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP). The FSP will detail the actual sampling including types, quantities, chain of custody, sample technique, specific analyses, etc. and the QAPP will detail the quality assurance and control associated with all of the sample and analytical techniques to be used including blanks, splits, spikes and duplicate analyses. The plan will be submitted to the PADEP for review and comment before finalizing. A draft Gas Well Flow Back Water Sampling and Analysis Program is attached to this proposal as an example of the survey and sample detail to be included. An independent peer review of the SAP is included.
2. Exploration and Production Site Survey and Sampling – The study will include survey and sample events on active and inactive drill sites, waste water facilities and landfills, including:
  - a. Open/Operating Cuttings Pits – Radiological characterization will include field screening (exposure rates/gross gamma activity) of the cutting pits areas using portable survey meters and the sampling and laboratory analysis of the drill cuttings stored in the



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- open/operating pits. The sampling and analysis of the drill cuttings (solid material) will assist in determining radiological isotopes of concern and in evaluating their potential mobility in the environment.
- b. Closed/Reclaimed Cuttings Pits - Radiological characterization will consist of field screening (exposure rate/gross gamma activity) using portable survey meters to evaluate the potential for elevated radiological activity (above a background reading from a non-impacted site location) at the ground surface above the closed/reclaimed pits.
  - c. Sample and analyze flowback and produced water on sites in accordance with the SAP. Evaluate solid and aqueous phases separately as specified in this program.
  - d. Perma-Fix will coordinate with PADEP central and regional office staff, radon division and well operators to perform radiological surveys and radon sampling of gas as appropriate.
  - e. Temporary Water Storage Vessels and Recycle Systems (Frac Tanks, Produced Fluids Tanks, Filtration Equipment, Water Trucks)
    - i. Exposure Rate/Gross Gamma Activity survey of temporary water storage vessels to identify potential areas of NORM accumulation.
    - ii. Collect and screen samples of solids accumulated in vessels for gross activity.
    - iii. Collect swipe (smear) samples to determine removable surface contamination in units of disintegrations per minute per 100 centimeters squared (dpm/100cm<sup>2</sup>). Removable surface activity is an indicator of potential airborne exposure through inhalation and/or ingestion of removable contamination.
  - f. Drilling Rigs and Associated Equipment
    - i. Structural surface survey of drilling rigs and equipment to identify potential areas of NORM accumulation. The survey will consist of scanning with portable survey meters for gross gamma activity and/or total surface contamination (dpm/100cm<sup>2</sup>) and collecting swipe (smear) samples to determine removable surface contamination (dpm/100cm<sup>2</sup>). Total contamination is the sum of fixed and removable contamination. As mentioned above, removable surface activity is an indicator of potential airborne exposure through inhalation and/or ingestion of removable contamination.
    - ii. Collect and screen samples of solids (scale) accumulated on rigs, pipes, used well casings and associated equipment.
    - iii. Perma-Fix will coordinate with PADEP radon division and well operators to perform radon sampling of gas as appropriate.
  - g. Offices, Office Trailers, Trucks, etc.
    - i. Instrument surveys (exposure rate, gross gamma and/or total contamination) of offices, trailers, trucks, etc to identify potential areas of NORM accumulation.
    - ii. Collect swipe (smear) samples to determine removable surface contamination.
  - h. Production Equipment (Separators, Heater/Treaters, Dehydration Units, Compressors, Pig Stations)
    - i. Instrument surveys (exposure rate, gross gamma and/or total contamination) of production equipment to identify potential areas of NORM accumulation.
    - ii. If possible, collect and screen samples of solids and/or liquids accumulated in/on production equipment.



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- iii. If possible, collect swipe samples to determine removable surface contamination.
  - iv. Perma-Fix will coordinate with PADEP radon division and well operators to perform radon sampling of gas as appropriate.
3. Waste Water Facilities Sample and Analysis
- a. Eleven (11) of the highest volume Marcellus shale waste water treatment facilities will be included in this estimate. Seven (7) are located in the Western sector of Pennsylvania. The other four (4) are located in the Central or Eastern sector. Facilities will include normal POTWs and specialized MS frack water treatment operations.
  - b. Each of the 11 waste water treatment facilities will be sampled three (3) times to establish a trend.
  - c. A total of three (4) samples will be taken at each facility during each of the 3 sample events: influent Marcellus shale industry water, facility effluent discharge water, sludge from the treatment of the water and sediments at the effluent discharge point.
  - d. Perma-Fix will perform a gamma exposure rate survey at the facility each time a sample event occurs. Gross gamma radiation will be measured on the outside of sludge tanks as access allows, at the effluent discharge point and around the incoming waste water truck if available.
  - e. Perma-Fix will record any other pertinent data during each sample event, e.g., influent volume from Marcellus shale, total influent flow, effluent flow. To the extent possible Perma-Fix will coordinate the sampling of the influent water, the sludge and the effluent water with the facilities such that the samples are all related to the processing of the influent Marcellus shale industry water.
  - f. Each of the samples will be analyzed for gross alpha and beta and by gamma spectroscopy to identify TENORM radionuclides.
  - g. One third of the samples, based on the gross alpha and beta, and gamma spectroscopy results, will also be analyzed by alpha spectroscopy for uranium (U-238, U-235 and U-234), thorium-232, radium (Ra-226 and Ra-228) and for any unsupported decay chain radionuclides; and for radon (Rn-220 + Rn-222)
  - h. Sample and analysis will be coordinated and performed by Perma-Fix, through the Beaver, PA office, in accordance with the Sample and Analysis Plan (SAP) developed by Perma-Fix and approved by Pa DEP prior to implementation.
  - i. For facilities located in the Western sector of PA, five (5) days will be required to sample the seven (7) locations. Two field technicians will travel to each facility (day trips).
  - j. For facilities located in the Central and Eastern sectors of PA, 5 days will be required to sample all 5 facilities. Two field technicians will travel to each facility (overnight trips).
  - k. Each sample will be surveyed for gross gamma radiation and loose alpha and beta surface contamination. The sludge within the facility will also be surveyed for gross gamma activity at the time the sample is taken.
  - l. In addition to the media sampling, indoor working level measurements for radon gas exposure will also be performed within any buildings, trailers, or enclosures where personnel occupancy is required.
  - m. Samples will be packaged and delivered to an appropriate radiochemistry laboratory for the analyses, or, the Pa DEP Lab.



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- n. Survey and analytical data will be reviewed and validated by a radiological engineer. The data will be compiled in tables and trended as appropriate.
  - o. A final report specific to waste water treatment facilities will be prepared and submitted to Pa DEP for review and comments. The report will include the sampling protocol, the data presentation, the data review and assessment and recommendations.
4. Sampling of Landfill Leachate – a sample of landfill leachate will be taken at each of the 54 active landfills in PA and analyzed for gross alpha/beta and Ra-226/Ra-228 by gamma spectroscopy. The results will be used to evaluate if the disposal of NORM impacted materials in landfills is increasing the radioactivity in landfill leachate. Pa DEP has historical trend data for gross radioactivity in landfill leachate to use as a start point.
  5. Beneficial Reuse Areas – areas adjacent to road beds where brine has been used will be surveyed for residual NORM/TENORM and sampled as appropriate.
  6. Data Assessment, Exposure and Pathway Analysis and Final Report – Perma-Fix will receive, review and validate all of the survey and analytical data generated as part of the study. The data will be used to evaluate potential exposure through various environmental and occupational pathways and a final report will be prepared including the following. An independent peer review of the assessment/report is included:
    - Perma-Fix will compile all of the survey data and the results of all laboratory analyses, and compile in tables including the activity, uncertainty and minimum detectable concentration (MDC) values for each parameter measured.
    - An evaluation of the average and maximum activity concentrations within each media sampled. Activity concentrations will be compared relevant and potentially appropriate criteria including US Department of Transportation (DOT) values for transporting NORM without labeling as radioactive material, e.g. 270 pCi/g for solid material, EPA Drinking Water Standards, 10CFR20 Effluent Discharge for Air and Water values and federal and state public exposure criteria.
    - An evaluation of all potential exposure pathways, both internal and external, and including radon, based on survey and sample analysis results for drilling sites as well as waste water facilities.
    - An evaluation of all byproducts of the oil and gas production industry including crystalline salts from the evaporation of brine water and the sludge associated with the floccing of process and flowback waters impacted with solids, in regards to worker exposure, public exposure and future exposure from the disposal of the products.
    - An assessment of secular equilibrium for the full uranium and thorium natural decay series as well as the Ra-226 and short-lived progeny sub-series, including the rapid buildup of radon and progeny in samples/waste streams impacted with radium. The evaluation of waste containing Ra-226 is subject to the buildup of radon gas and the other short-lived progeny of Ra-226, complicating any decision made to transport or dispose such materials based on an exposure rate survey of the container. The



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exposure rate is directly proportional to the degree of secular equilibrium and NOT proportional to the activity concentration of Ra-226 (remains the same as radon and other progeny buildup).

- An assessment of the current landfill conceptual model used to determine the blanket authorization activity and quantity for disposal of TENORM in Pa municipal landfills.

This work will be performed under our PO with the PADEP/BRP as Task #17. Perma-Fix will not exceed the value of the budget without prior approval from PADEP.

Perma-Fix appreciates this opportunity to provide this information to Pa DEP and would be pleased to meet with you to further discuss the proposed scope of work.

If we can provide you with additional information at this time, or if you may have any questions, please do not hesitate to contact us.

Very truly yours,

Perma-Fix Environmental Services Inc.

A handwritten signature in black ink, appearing to read "Andrew J. Lombardo".

Andrew J. Lombardo, C.H.P.  
Vice President Technical Services