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Sent by Certified Mail

Diana Esher
Acting Regional Administrator
U.S. EPA Region 3
1650 Arch St.
Philadelphia, PA 19103

Re: Revocation of Plum Injection Well Permit

Dear Ms. Escher:

The residents of the Allegheny River Valley urgently ask you to exercise your authority to **revoke the permit for the Penneco Sedat #3A Class II waste disposal well in Plum Borough**. Scientific information released since the original permitting of the well site and a deeper understanding of the geological effects of such wells show that the well presents potentially devastating risks to downstream Allegheny River public drinking water systems, including the Pittsburgh Water and Sewer Authority which provides water to hundreds of thousands of City of Pittsburgh residents and businesses. New scientific evidence suggests there are numerous pathways for pollution, and that injection wells generally are a disaster waiting to happen. Some of the deficiencies include:

1. Engineering Structural Inadequacies

The Plum well was not engineered to be a waste disposal well, but instead was drilled, engineered, and constructed as a conventional well. Conventional wells are not engineered to withstand the repeated pressurization and depressurization of injection wells. This well was also constructed as a 2-string well because of the time-period in which it was constructed, as opposed to more modern wells which include more casings for safety and stability of the well site. It is our understanding that the application documents for this well state, falsely, that it is a 3-string well. Current standards require 3-strings for Class II injection wells.

It is also our understanding that this well was never actually put into production. The theory behind injection wells is that the injected fluid is simply taking the place of the materials that were removed. If nothing was ever removed from the well, however, then there is nowhere for the water to go without increasing the pressure on the formation.

Further concerns are raised by the inadequate cement bond logging that was performed on the well. Given the age of the well casings and cement, a more sophisticated cement bond logging procedure should have been used. The method utilized by the well applicant was only useful for a minimal understanding of the quality of the cement bonding. More modern, omnidirectional ultrasonic methodology would have allowed for a full and complete understanding of the quality of cement bonding given its increased resolution. Given the method used, the actual quality of the bond is effectively unknown. As will be discussed in more detail below, the quality of the cement and its bonding is incredibly important information to understanding the safety of the injection well. Without such an understanding, the risks to the surrounding environment are huge.

Any problems in the cement will be exacerbated by the use of the well as an injection well. Injection wells are repeatedly pressurized and depressurized as liquids are injected. That repeated pressurization and depressurization results in a "fatigue effect".[1] Medeiros, et. al, showed that the fatigue effect of a particular sample of concrete can vary widely. This fatigue effect will affect all cement, but any compromised cement would likely be even more drastically damaged.

In the *Medeiros* study, the study's authors subjected 3 different types of concrete, plain concrete, polypropylene fiber reinforced concrete and steel fiber reinforced concrete, to compressive fatigue tests until failure at various frequencies. The study found that sometimes it took very few cycles for the cement to fail, but also that the number of cycles until failure could differ by several orders of magnitude. Plain cement was especially prone to quick failure at low frequencies of load stress.

This potential for failure after few stress cycles is particularly concerning for injection wells. If the concrete fails, there is nothing separating the contaminated fracking wastewater from the surrounding natural resources. The EPA needs to ensure that the engineering of the injection well will be able to withstand the repeated pressurization and depressurization cycles that it will be subjected to.

The concern of stress causing degradation in the concrete is only exacerbated by the findings of Seong-Tai Yi, et. al, in a study on the effects of hydraulic pressure and crack width on water permeability.[2] The researchers found that water permeating into small cracks in concrete can accelerate deterioration by further widening the cracks and carrying chemicals that may deteriorate the cement deep into the structure. They found that the serviceability and durability of structures decreased with repeated pressurization and depressurization. Further, they found that the issues were only intensified when high hydraulic pressure was applied. In

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[1] A. Medieros, X. Zhang, G. Ruiz, R. C. Yu, M. de Souza Lima Velasco, Effect of the loading frequency on the compressive fatigue behavior of plain and fiber reinforced concrete, *International Journal of Fatigue* 70 (2015) 342-350 (doi.:http://dx.doi.org/10.1016/j.ijfatigue.2014.08.005)

[2] Seong-tae Yi, Tae-Yang Hyn, Jin-Keun Kim, The effects of hydraulic pressure and crack width on water permeability of penetration crack-induced concrete, *Construction and Building Materials* 25 (2011) 2576-2583. (doi: 10.1016/j.conbuildmat.2010.11.107)

injection wells, where the water pressure often exceeds 2500 psi, the structural integrity of the cement casing simply cannot last forever.
Again, because the CBL methodology was insufficient, the current structural integrity of the cement is not truly known. The injection process could quickly degrade already subpar cement, resulting in a release into the environment. EPA should require an evaluation of the existing cracks in the concrete casing and an analysis of how the cyclic pressurization of the well and high hydraulic pressure will ultimately affect the concrete casing. The greatly increased risk of failures in cement and/or casings, leaks and other potential impacts must be studied in greater detail.

We are also concerned because while gas pressure of a conventional well decreases over time, the pressure of an injection well increases over time with cyclic pressure. G.S. Swanson, while studying the impacts of repeated pressurization and depressurization on waterflood wells in the LA Basin, found that the repeated damage/stimulation cycles harm the efficacy of the well and the maximum pressure that could be used without damaging the well entirely. Thus, the engineering that must go into an injection well must be radically different to account for the different production pressures.[3] Not only do injection wells go through repeated pressurization and depressurization during the injection process, but they also then stay at a higher pressure for their duration.

All of the potential issues involving the failure and cracking of the concrete well bore are further exacerbated by the close proximity between the wastewater basin and local aquifers. The planned injection of toxic wastewater is scheduled to occur only about 1000 ft. below the groundwater aquifer. The small distance presents a high probability of upward migration of fracking waste through defects in the well's 30-year-old casing. As discussed above, old concrete is more likely to have cracks and fissures. Adding chemical-laden water in repeating cycles of pressurization and depressurization will contribute to an intensifying degradation of what remains of that concrete. Such a failure would most likely result in contamination of the groundwater aquifer.

This particular well also goes through and is near abandoned coal mines, conventional wells, water wells, and seeps, which are all permeability super-highways. A 2016 U.S. Geological Survey study found waste from oil and gas disposal was found in surface waters and sediments near an underground injection well in West Virginia, demonstrating that injection wells can impact the quality of adjacent surface waters.[4] In that study, the researchers found significant downstream evidence of leakage from a Class II injection well.

Their study analyzed samples taken from a stream running through an injection well site in West Virginia. This allowed them to take samples above, within, and below the injection well site. The researchers found signs of impact at all sites sampled within the facility and

[3] G.S. Swanson, Injection Well Rate and pressure Analyses Sugge3st Practical Waterflood Improvements.
[4] Akob, Denise M. et. al. "Wastewater Disposal from Unconventional Oil and Gas Development Downgrades Stream Quality at West Virginia Injection Facility". *ACS Publications*. https://pubs.acs.org/doi/full/10.1021/acs.est.6b00428

downstream of it. They found hydrocarbon odors when sediment was disturbed, elevated specific conductance, and red-orange sedimentation. The chemistry of the water was also tested and showed significant increased concentrations of various chemicals, including chloride (Cl^-), bromide(Br^-), calcium(Ca^{2+}), sodium(Na^+), strontium(Sr^{2+}), barium(Ba^{2+}), lithium(Li^+), strontium(Sr^{2+}), and radium. The elevated chloride and bromide concentrations were at a ratio similar to produced waters. Produced water is the water that is used for fracking then extracted from unconventional wells and, ultimately, what is intended to be injected into the Sedat #3 well. The isotopic concentrations of $^{87}Sr/^{86}Sr$ were similarly in line with produced waters. At one of the testing sites, the researchers found elevated levels of ^{226}Ra and ^{238}U. All of this is consistent with a small contribution of Marcellus Shale produced water. Ultimately, the researchers concluded that activities at the disposal facility were impacting the stream that runs through the area and that the higher concentrations indicated that unconventional oil and gas wastewater was the culprit.

The Sedat 3A well was not originally designed to be an injection well that would need to undergo sustained high pressures. On top of that, Penneco failed to use engineering best practices to verify the integrity of the well casing when completing the cement bond log in 2015. Our concerns about the integrity of this particular well are justified. Dr. Ingraffea, the Dwight C. Baum Professor of Engineering Emeritus at Cornell University, an expert in injection well engineering, believes the company employed an inferior testing method which did not take a 360-degree modern circumference ultrasound. The cement bond log should have detected and recorded any deterioration in cement integrity, casing corrosion, and ground movement that would weaken the integrity of the well, but the company's use of a simpler, cheaper method limits the usefulness of the data for making that determination. There was also no information about a camera drop to look for casing cracks and corrosion. Failure to use best practices at that time to ensure the integrity of the wells means that we cannot be sure now that the numerous concerns raised above are not already occurring. Dr. Ingraffea also reviewed the cement bond log and determined that it was not acceptable for the Plum conventional gas well to be converted for use as a waste disposal well.

For all of the above cited engineering reasons, including numerous new studies about the potential of catastrophic failures, we believe that the EPA should revoke the injection well permit until its safety, and therefore the safety of the millions of residents who rely on the groundwater around it, can be ensured.

2. Seismic Activity and Mine Subsidence

In addition to engineering concerns with the site, the safety of this well cannot be guaranteed due to numerous local concerns. The Plum community is severely undermined from decades of coal mining. All of that coal mining has resulted in significant amounts of acid mine drainage impacting local streams and waterways. More importantly, however, this well was drilled directly through the Renton coal mine, a portion of which has been on fire for decades, leaving unknown structural degradation.[5] It is impossible for anyone to guarantee that the mine is still structurally sound or will remain so in the future.[6] It is further impossible to ensure that any mine collapse would not severely damage the injection well, resulting in a release of all of the produced water that has or will be injected. Allowing oil and gas wastes to be pumped into an underground, highly fractured strata raises serious concerns about current and future underground risk conditions.

The dangers of induced seismic activity were also not as well understood when this injection well was originally permitted. Waste disposal wells in and of themselves are very dangerous and unstable activities. Recent studies have shown definitively that injection wells such as this one have caused earthquakes in Oklahoma, the Dakotas and Ohio.[7] The problem occurs when the highly pressurized water finds its way to a fault, thereby lubricating it and allowing it to slip. For example, on New Year's Eve in 2011, a fracking waste injection well near Youngstown caused a 4.0 quake that was felt across hundreds of miles. Ohio governor and fracking proponent John Kasich intervened and shut the well down.[8] When the waste disposal well activity stopped, the earthquakes stopped.[9]

Some recent studies have been able to directly pinpoint the source of the earthquakes to underneath injection wells or very close by.[10] Further, due to the novelty of injection wells, no one can be certain whether the numerous small earthquakes triggered by injection wells are just a precursor to a more substantial earthquake.[11] Regardless, these types of seismic events could be particularly catastrophic given the copious amounts of coal undermining that has occurred in the area and, again, the Renton coal mine that this well is drilled directly through. Any seismic activity in the area could result in coal mines collapsing, loss of lateral support, and the failure of the casing on the well that could result in a release of millions of gallons of produced water into nearby groundwater aquifers. This type of grand geological experiment should not be undertaken without ensuring its long-term safety.

According to the United States Geological Survey, earthquakes induced by fluid injection can be extremely dangerous, often yielding earthquakes with a magnitude in the range of 4.5-5 in

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[5] See Louis E. Dalverny and Robert F. Chalken, Mine Fire Diagnostics and Implementation of Water Injection with Fume Exhaustion at Renton, PA, U.S. Department of the Interior, Bureau of Mines, 1991.

[6] Stanley R. Michalski, Lawrence J. Winschel, and Richard E. Gray, Fires in Abandoned Coal Mines, *Bulletin of the Association of Engineering Geologists*, Vol. XXVII, No. 4, 1990, pp. 479-495.

[7] Choy, G., J. Rubinstein, W. Yeck, D. McNamara, C. Mueller, and O. Boyd, A rare moderate-sized (Mw 4.9) earthquake in Kansas: Rupture process of the Milan, Kansas, earthquake of 12 November 2014 and its relationship to fluid injection, *Seismological Research Letters*, 87 (2016); Injection-Induced Earthquakes, Ellsworth, W. L Science, 341 (2013); Keranen, K., M. Weingarten, G. Abers, B. Bekins, and S. Ge (2014), Sharp increase in central Oklahoma seismicity since 2008 induced by massive wastewater injection., *Science*, 448 (2014).

[8] *See* Preliminary Report on the Northstar 1 Class II Injection Well and the seismic events in the Youngstown, Ohio, Area, Ohio Department of Natural Resources, March 2012.

[9] Induced seismicity associated with fluid injection into a deep well in Youngstown, Ohio, Won-Young Kim, *Journal of Geophysical Research: Solid Earth*, Vol. 118, 1—13.

[10] *Determinants of earthquake damage liability assignment in Oklahoma: A Bayesian Tobit censored approach*, John N. Ng'ombe, Tracy A. Boyer, Energy Policy 131, pp. 422-433 (2019).

[11] *Hydromechanical Earthquake Nucleation Model Forecasts Onset, Peak, and Falling Rates of Induced Seismicity in Oklahoma and Kansas*, J.H. Norbeck and J.L. Rubinstein, *American Geophysical Union*, 2018.

multiple states. Arkansas, Kansas, and Oklahoma have experienced four earthquakes with a magnitude greater than 5.[12] These earthquakes do not always occur in close proximity to the fluid-injection wells, but they can cause an earthquake 10 or more miles away through injection pressures that may counteract frictional forces on faults.[13,14] The pressure and weight created through fluid injection can exacerbate this earth movement, triggering widespread seismic activity and subsidence within the extensively mined voids beneath Plum.

There have also been multiple reported cases in recent years where residents living near disposal wells have been negatively affected by waste contamination reaching drinking water.[15] Similarly, scientists have documented numerous pathways by which injected wastewater could reach aquifers through the fractures that were either originally there or caused by hydraulic fracturing.[16] Natural processes can also lead naturally to the migration of contaminants in the injected wastewater to shallow aquifers.[17] The cited study shows that there are hydraulic connections between deep underlying formations and shallow drinking water aquifers that potentially allow Marcellus brine to reach those shallow aquifers.

In Plum, our geology is very different from that of Ohio. Our steep and rolling hills, heavily coal-mined subsurface and abundance of underground freshwater aquifers make this an especially dangerous site for a waste disposal well. The proximity of the well to the Allegheny River and its tributaries makes contamination highly likely -- and catastrophic for hundreds of thousands of Pennsylvanians, not to mention the millions more living further downstream. Studies have also shown that nearby abandoned wells can provide a path for contamination of groundwater sources.[18]

3. Radioactive Contamination and Cancer

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[12] *How Large Are the Earthquakes Induced by Fluid Injection?*, *Science Changing for a Better World*, USGS, www.usgs.gov/faqs/how-large-are-earthquakes-induced-fluid-injection?qt-news_science_products=0

[13] *Are Earthquakes Induced by fluid-injection activities always located close to the point of injection?, Science Changing for a Better World*, USGS, https://www.usgs.gov/faqs/are-earthquakes-induced-fluid-injection-activities-always-located-close-point-injection

[14]T.H.W. Goebel, M. Weingarten, X. Chen, J. Haffener, E.E. Brodsky, The 2016 Mw5.1 Fairview, Oklahoma earthquakes: Evidence for long-range poroelastic triggering at >40 km from fluid disposal wells, Earth and Planetary Science Letters, Volume 472, 2017, Pages 50-61, ISSN 0012-821X, https://doi.org/10.1016/j.epsl.2017.05.011. (https://www.sciencedirect.com/science/article/pii/S0012821X17302650)

[15] Brantley, S. L., Yoxtheimer, D., Arjmand, S., Grieve, P., Vidic, R., Pollak, J., Llewellyn, G. T., Abad, J., & Simon, C. (2014). Water resource impacts during unconventional shale gas development: The Pennsylvania experience. *International Journal of Coal Geology*, *126*, 140-156. https://doi.org/10.1016/j.coal.2013.12.017

[16] Myers, T. (2012), Potential Contaminant Pathways from Hydraulically Fractured Shale to Aquifers. Groundwater, 50: 872-882. https://doi.org/10.1111/j.1745-6584.2012.00933.x

[17] Migration of Marcellus brine to shallow aquifers Nathaniel R. Warner, Robert B. Jackson, Thomas H. Darrah, Stephen G. Osborn, Adrian Down, Kaiguang Zhao, Alissa White, Avner Vengosh
Proceedings of the National Academy of Sciences Jul 2012, 109 (30) 11961-11966; DOI:10.1073/pnas.1121181109

[18] *Potential contaminant pathways from hydraulically fractured shale to aquifers*, Myers T., *Ground Water* 50(6):872–882 (2012); http://dx.doi.org/10.1111/j.1745-6584.2012.00933.x.. *See also* Warner NR, et al. Geochemical evidence for possible natural migration of Marcellus Formation brine to shallow aquifers in Pennsylvania. Proc Natl Acad Sci USA 109(30):11961–11966 (2012); http://dx.doi.org/10.1073/pnas.1121181109.

Recent studies have also brought to light the health dangers of unconventional drilling waste. Fracking brings high concentrations of radioactive material to the surface from deep underground where Uranium-238 and other radioactive levels are significantly higher than the background level of earth's crust.[19] The injected waste at the Plum well site would include radioactive materials like ^{226}Ra and ^{228}Ra, heavy metals and other toxins. The safe level of radium in drinking water, as defined by the U.S. EPA is 5 picocuries per liter ("pCi/L"). The levels in fracking waste can exceed 18,000 pCi/L as identified by the USGS and PA DEP.[20] A 2020 nationwide study on the effects of radiation near unconventional oil and gas development wells determined that wells within 20 km showed an increase in particle radioactivity.[21] This could directly cause deleterious health effects on the public if contamination occurred. Unlike freshwater systems where radium would accumulate in the sediments, if you have a condition of high salinity and reducing conditions, radium will dissolve into the water and move with it.[22]

Further, even deep subterranean injection could result in increased radon on the surface. As this wastewater is injected underneath residences above the site, the same conduits for pollution migration discussed in detail above can lead to the accumulation of radon gas in people's homes.[23] Radon is the second leading cause of lung cancer in the US and is already present in high concentrations throughout Western Pennsylvania.[24,25]

Radium exposure is also associated with liver, breast, and bone cancer.[26,27] Studies are urgently needed to examine the potential that the radium and other harmful chemicals present in fracking waste is linked to the inexplicable spike of rare childhood cancers, including Ewing's sarcoma, in highly fracked counties in Pennsylvania's Marcellus Shale region. The enormous risk of radioactive contamination from fracking waste disposal cannot be ignored. New studies come out regularly linking fracking wastewater with cancer clusters. The Plum injection well would put hundreds of thousands of Pennsylvanians at risk of known health impacts that are not fully understood.

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[19] ALNabhani, K., Khan, F., Yang, M., Technologically Enhanced Naturally Occurring Radioactive Materials in Oil and Gas Production: A Silent Killer, *Process Safety and Environment Protection* (2015), http://dx.doi.org/10.1016/j.psep.2015.09.014.
[20] Rowan, E.L., Engle, M.A., Kirby, C.S., and Kraemer, T.F. "Radium Content of Oil- and Gas-Field Produced Waters in the Northern Appalachian Basin (USA): Summary and Discussion of Data" *U.S. Geological Survey Scientific Investigations Report 2011–5135*, USGS. http://pubs.usgs.gov/sir/2011/5135/
[21] Li, L., Blomberg, A.J., Spengler, J.D. *et al.* Unconventional oil and gas development and ambient particle radioactivity. *Nat Commun* **11,** 5002 (2020). https://doi.org/10.1038/s41467-020-18226-w
[22] Radionuclides in Fracking Wastewater: Managing a Toxic Blend, J. Henry Fair, *Environmental Health Perspectives* 122, Vol. 2, February 2014, pp. A50-A55.
[23] Xu Y, Sajja M and Kumar A (2019), Impact of the Hydraulic Fracturing on Indoor Radon Concentrations in Ohio: A Multilevel Modeling Approach. *Front. Public Health* 7:76. doi: 10.3389/fpubh.2019.00076
[24] Casey JA, Ogburn EL, Rasmussen SG, Irving JK, Pollak J, Locke PA, Schwartz BS. 2015. Predictors of indoor radon concentrations in Pennsylvania, 1989–2013. *Environ Health Perspect* 123:1130–1137; http://dx.doi.org/10.1289/ehp.1409014.
[25] A. Mitchell, W. M. Griffin, E. Casman, Lung Cancer Risk from Radon in Marcellus Shale Gas in Northeast U.S. Homes, *Risk Analysis*, DOI: 10.1111/risa.12570
[26] Kassotis Lustgarten, Abrahm. "Injection Wells: The Poison Beneath Us." ProPublica, 21 June 2012, www.propublica.org/article/injection-wells-the-poison-beneath-us
[27] CD, Tillitt DE, Lin CH, McElroy JA, Nagel SC. 2016. Endocrine-disrupting chemicals and oil and natural gas operations: potential environmental contamination and recommendations to assess complex environmental mixtures. *Environ Health Perspect* 124:256–264; http://dx.doi.org/10.1289/ehp.1409535

Scientists have found that disposal wells have similar risks of leaking as oil or gas wells, therefore they have the same risk of contaminating water because waste seeps out and fills cracks in the ground. Pollution leaks that are undetected could be fatal because pollution dispersal cannot be tracked underground.[28]

Western Pennsylvania residents already suffer from some of the highest cancer rates in the country and other health challenges from decades of fossil fuel development and other industrial activities. The Sedat 3A injection well further undermines residents' rights to a healthy and safe environment and their right under Acticle I, Section 27 of the Pennsylvania Constitution to clean air and pure water.

Given the wealth of scientific studies that have come out since the approval of the Sedat #3A permit that show the harm that the injection well will cause, it is imperative that the EPA revoke the permit for the injection well on behalf of the residents of Plum Township, the residents of the City of Pittsburgh, and the Pennsylvanians that rely on the Allegheny River for clean drinking water. Until the safety of the well can be assured, the EPA should not allow any well injections from occurring.

Sincerely,

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On behalf of Protect PT

[28] Rowan, E.L., Engle, M.A., Kirby, C.S., and Kraemer, T.F., 2011, Radium content of oil- and gas-field produced waters in the northern Appalachian Basin (USA)—Summary and discussion of data: U.S. Geological Survey Scientific Investigations Report 2011–5135, 31 p. (Available online at http://pubs.usgs.gov/sir/2011/5135/)