REAL POWER SOLUTIONS, LLC

Innovative Environmental Solutions

Controlling PFAS Releases from Landfills

Executive Summary

- There are approximately 2,600 geographically dispersed landfills in the United States, with locales generally matching population concentrations.
- Landfills are open to the skies, which allows precipitation to introduce large quantities of water to the waste placed therein. This water, as it percolates down through the waste, leaches out chemicals found there. This is the primary source of the dirty liquid coming out of the bottom of landfills. It is called "landfill leachate". Many of the materials disposed of in the landfill contain per- and polyfluoroalkyl substances (PFAS). Thus, PFAS is one of the many chemical compounds found in landfill leachate. PFAS concentration levels in landfill leachate can be quite high.
- The amount of leachate produced by a landfill is highly dependent on the amount of rainfall and the size of the landfill. Typically, landfills produce between 3 million and 10 million gallons of leachate per year.
- Landfills are currently allowed to dispose of PFAS laden landfill leachate in publicly owned wastewater treatment plants (WWTP's, or POTW's). The biological processes employed by WWTPS' for treatment of wastewater do not remove PFAS from the wastewater stream, so the effluent discharged from the WWTP carries the PFAS compounds unabated into the environment and the drinking water supply.
- Once the PFAS compounds are co-mingled with environmental waters such as streams, rivers, and ground water, which are the raw resources for drinking water, it becomes exponentially more difficult and expensive to remove it.
- The most economical way to prevent PFAS compounds originating in the landfill leachate from contaminating the drinking water supply is to keep the PFAS in the landfill.
- PFAS containing items are routinely disposed of in landfills. Landfills are constructed with a sanitary liner, which prevents PFAS and other dangerous chemicals from migrating into the groundwater. Keeping the landfill aggregated PFAS contained within the current landfill location is both feasible, and economically preferable, to allowing the PFAS to be moved off the landfill to WWTP's or other disposal methods. Landfills are a good place to store chemicals like PFAS.
- The fully amortized cost to extract and concentrate the PFAS from landfill leachate and to have it sequestered in the landfill is between 25 and 38 cents per gallon. This is a fraction of the cost to treat water contaminated by PFAS once it is off the landfill and diluted into the wastewater treatment system or into the drinking water supply. The health care costs from PFAS exposure are orders of magnitude more expensive than preventing PFAS from migrating from landfills into drinking water.
- Concentrated leachate solids that have high concentrations of PFAS may be held indefinitely in a landfill keeping the PFAS from being broadcast into the environment. PFAS remediation can be performed on these concentrated solids at any point in the future as preferred remediation technologies are determined.

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Case Study

Per- and polyfluoroalkyl substances (PFAS) represent a persistent environmental challenge. These man-made chemicals, developed since the 1940s, include thousands of compounds valued for their hydrophobic, lipophobic, and thermally stable properties. They have been widely used in products such as non-stick cookware, stain-resistant fabrics, fire-fighting foams, and food packaging, with notable examples like perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) proving especially problematic.

PFAS compounds resist natural degradation, lingering in the environment and bioaccumulating in the food chain, which leads to contamination of water, soil, air, and food sources. Exposure has been associated with serious health effects, including ulcerative colitis, thyroid dysfunction, high cholesterol, testicular and kidney cancers, and preeclampsia. These links were highlighted in the C8 Health Project, a large-scale study of over 70,000 individuals exposed to elevated PFOA levels in contaminated drinking water.

A significant pathway for PFAS spread involves waste disposal in landfills. Products and industrial byproducts containing PFAS accumulate in landfills, concentrating in the landfill leachate as rainwater filters through the waste. This leachate, classified as a regulated wastewater, is typically transported to wastewater treatment plants (WWTPs) as a preferred means of treatment. However, standard biological treatments at WWTPs fail to break down PFAS, allowing the chemicals to pass through unabated, still present in the effluent discharged to surface waters. From there, PFAS can infiltrate drinking water supplies, groundwater, agricultural systems, aquaculture, and broader ecosystems. The PFAS molecules eventually reach the oceans and then, disperse globally through precipitation cycles.

Research indicates that U.S. landfills contribute a significant fraction of all PFAS released to ground water annually via the practice of disposing of leachate in WWTPs, making this a major contributor to environmental contamination, on par with or exceeding other sources like industrial discharges. This route plays a substantial role in PFAS presence in U.S. tap water, where detectable levels appear in nearly every geographic area. Without intervention, a relatively small volume of contaminated leachate—mere millions of gallons—can pollute billions upon billions of gallons of drinking water. This situation embodies a "Tragedy of the Commons," as landfill operators and WWTP managers currently face no financial incentives under existing regulations to mitigate PFAS releases, resulting in broad societal and ecological burdens.

Real Power Solutions, LLC (RPS) stumbled upon a breakthrough while pursuing a different goal: utilizing waste heat from affiliated landfill-gas-to-energy (LFGTE) plants to evaporate leachate more economically than trucking it to WWTPs. LFGTE systems convert landfill methane, which is derived from decomposing waste placed in the landfill, into electricity. These energy plants also produce surplus (waste) heat in engine coolants and exhaust. RPS decided to harness this waste heat and use it to separate water from the solids and contaminants in the leachate. In refining that process, the team realized they could remove and concentrate over 99% of PFAS—along with other dissolved solids (like mercury)—into compact "cakes." This discovery pivoted RPS toward advanced leachate treatment, enabling zero-liquid discharge (ZLD) and preventing PFAS from entering the environment.

At the heart of the RPS approach is a multi-stage technology that treats landfill leachate to remove PFAS and other contaminants to non-detectable levels. The process starts with sedimentation and clarification to eliminate suspended solids. PFAS is then extracted using specialized filters applied either after clarification or following thermal evaporation, tailored to the site's specific PFAS concentrations.

The system's core is a patented, waste heat-driven evaporator (U.S. Patent #10,859,256), which harnesses heat from LFGTE generators' coolant and exhaust. Coolant flows through heat exchangers to warm the leachate, turning the liquid fraction into flash steam in an open loop setup. This steam is treated with ambient air, which is heated by the exhaust of the LFGTE power plant. The steam is absorbed by the air and vented as vapor, ensuring no liquid or particulates escape. Solids and precipitates collected in the process are continuously filtered to control emissions, safeguard equipment, and control foaming.

The purified water distillate is evaporated onsite to achieve ZLD goals. Concentrated solids, including PFAS-laden cakes, are dewatered and may be returned to the landfill or transported to an appropriate site for remediation or sequestration. Testing demonstrated efficacy of the RPS method, achieving 99.99% overall PFAS reduction in just 20 minutes of filter residence time, with most compounds reaching non-detectable levels in the evaporator output. Extended residence times ensure complete removal of all PFAS molecules down to non-detectable levels. See Appendix A for detailed test results.

Implementing and running RPS systems depends on site specifics, including leachate volume and PFAS loads. Drawing from industry standards for comparable PFAS removal methods—like ultrafiltration combined with Granulated Activated Carbon (GAC) or foam fractionation at

20,000 gallons per day—capital costs typically range from $8–12 million, or approximately $0.18 per treated gallon over the expected life of the system. Annual operating expenses add another $0.12–$0.16 per treated gallon to make all-in treatment costs of approximately $0.34 per gallon. These figures encompass pretreatment, filtration, evaporation, and residuals handling. By leveraging waste heat, RPS cuts energy expenses by 20–30% relative to traditional evaporators, accelerating payback through savings on trucking fees (often $0.10–$0.20 per gallon), all while providing compliance benefits.

Pairing RPS evaporation with adjacent LFGTE plants offers reciprocal advantages. Using leachate as a coolant substitute for air cooled radiators reduces fan-related energy losses, boosting net power generation and efficiency, particularly in warm conditions. This integration also lowers greenhouse gas emissions by combusting landfill gas to convert methane into less harmful CO_2. Further benefits include reduced maintenance on cooling systems, prolonged equipment longevity, minimized leachate handling, and enhanced onsite contaminant management.

To prevent PFAS from landfill leachate leaving the landfill and infiltrating water supplies, stronger regulations are essential. As of 2025, federal rules classify PFOA and PFOS as hazardous under CERCLA, with drinking water maximum contaminant levels established, but leachate specific mandates are sparse. Some states, like Maine, require monitoring and restrictions, while the EPA plans effluent limitation guidelines for 2026. Future EPA policies should ban landfills from sending leachate laden with PFAS to WWTPs, instead requiring onsite sequestration of the PFAS within the boundary of the permitted landfill's sanitary liner. This will create equitable incentives and avoid economic penalties for compliance. Allowing the return of concentrated PFAS-rich cakes to landfills is practical, given that most PFAS already resides in the solid waste. Mandating immediate destruction would impose needless costs, hindering progress toward viable solutions we could put in place today. As economical solutions to destroy PFAS become available, they may be utilized at that time to eliminate the problem permanently. Between now and then, WWTPs should only accept leachate with low, or even non-detectable, PFAS concentrations. By keeping PFAS concentrated onsite at the landfills, this approach paves the way for emerging remediation technologies, such as thermal oxidation or offsite processing, to be applied as they advance, delivering cost effective protection for water resources today.

Appendix A:

PFAS Test Data Summary – Case study conducted in Ocala, FL at Baseline landfill.
Testing conducted by Pace Analytical, US EPA testing method 537.1

PFAS Compound Name	PFAS Filter Influent Conc.	PFAS Filter Effluent Conc.	Evaporator outlet Conc.	Dewatered clarifier solids Conc.	Units
EtFOSAA			ND ***	110,000	PPT *
MeFOSAA			ND	170,000	PPT
Perfluoro-1-butanesulfonic acid (PFBS)	1,900	12	0.1	25,000	PPT
Perfluorohexanesulfonic acid (PFHxS)	15,000		ND	41,000	PPT
Perfluoro-n-decanoic acid (PFDA)			ND	30,000	PPT
Perfluoro-n-dodecanoic acid (PFDoA)			ND	ND	PPT
Perfluoro-n-heptanoic acid (PFHpA)	750		ND	11,000	PPT
Perfluoro-n-hexanoic acid (PFHxA)	1,400	22	2.8	38,000	PPT
Perfluoro-n-nonanoic acid (PFNA)	200		ND	15,000	PPT
Perfluoro-n-octanoic acid (PFOA)	1,000		ND	140,000	PPT
Perfluoro-n-tetradecanoic acid (PFTeDA)			ND	ND	PPT
Perfluoro-n-tridecanoic acid (PFTrDA)			ND	ND	PPT
Perfluoro-n-undecanoic acid (PFUdA)			ND	ND	PPT
Perfluorooctanesulfonic acid (PFOS)	12,000	4	0.5	70,000	PPT
TOTALS	**32,250**	**38**	**3.4**	**650,000**	**PPT**

The total PFAS concentration was reduced from 32,250 PPT to 3.4 PPT, representing a reduction of 99.99%. All PFAS collected using the RPS method can be reinterred in the landfill.

* "PPT" = "parts per trillion" *

** "Conc." = "concentration" **

*** "ND" = "non-detectable" ***