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September 27, 2024

Via Electronic Mail: <u>karen.knuuti@maine.gov</u>

Karen Knuuti

Environmental Specialist, Bureau of Remediation and Waste Management Maine Department of Environmental Protection 106 Hogan Road, Suite 6 Bangor, Maine 04401

Re:Comments on the Maine Department of Environmental Protection's Draft
Public Benefit Determination for the Expansion of the Juniper Ridge
Landfill (DEP# S-020700-W5-CV-N)

Dear Specialist Knuuti:

Conservation Law Foundation ("CLF")¹ and the Penobscot Nation² appreciate the opportunity to comment on the Maine Department of Environmental Protection's ("MEDEP") Draft Public Benefit Determination ("PBD") for the proposed expansion of the Juniper Ridge Landfill ("JRL"). Pursuant to 38 M.R.S. § 1310-AA(2), MEDEP is accepting public comments as it processes the PBD Application for the expansion of JRL (DEP# S-020700-W5-CV-N).³ JRL is owned by the Maine Department of Administrative and Financial Services' Bureau of General Services and is operated by NEWSME Landfill Operations, LLC, whose parent company is Casella Waste Systems (all together "the Proponent").⁴ On September 13, 2024,

¹ CLF protects New England's environment for the benefit of all people and uses the law, science, and the market to create solutions that preserve our natural resources, build healthy communities, and sustain a vibrant economy. Through its Zero Waste Project, CLF aims to protect communities from the dangers posed by unsustainable waste management practices.

² The Penobscot Nation is the oldest government in the Western Hemisphere; "[s]ince time immemorial, the Penobscot Nation, *penawahpkekeyak*, the people of the place of the white rocks, has inhabited its ancestral homeland situated within the drainage area of the Penobscot River and its many tributaries, lakes, and ponds." *Penobscot Nation*, penawahpkekeyak, WABANAKI ALLIANCE, *available at* <u>https://www.wabanakialliance.com/</u><u>penobscot-nation/</u>. "As a proud riverine people, Penobscot epistemology, culture, and society are rooted in their intimate relationship to the [Penobscot] river- the source of life that provides all that is needed; the river to which the Penobscot people belong," and the river along which JRL is located and polluted. *Id*.

³ Juniper Ridge Landfill, ME DEP'T OF ENV'T PROT., <u>https://www.maine.gov/dep/waste/juniperridge/index.html</u> (last visited Sept. 27, 2024).

⁴ *Id.*; Sevee & Maher Engineers, *Application for a Determination of Public Benefit Juniper Ridge Landfill Expansion*, ME BUREAU OF GEN. SERV. & NEWSME LANDFILL OPERATIONS, LLC (June 2024), *available at* <u>https://www.maine.gov/dep/ftp/Juniper-Ridge/PBD2024/PBDapplication/20240607_APPLICATION%20FOR%</u>20A%20DETERMINATION%20OF%20PUBLIC%20BENEFIT.pdf [hereinafter PBD Application].



MEDEP published their Draft PBD.⁵ In the Draft PBD, MEDEP approved the Proponent's PBD Application with conditions.⁶

CLF and the Penobscot Nation submit these comments expressing disappointment in MEDEP's Draft PBD showing MEDEP's plan to issue a conditioned approval of the Proponent's PBD Application. As CLF and the Penobscot Nation have articulated in previous comments on the PBD Application, MEDEP should issue a negative determination on the Application because the proposed expansion runs counter to the State's Solid Waste Hierarchy and is entirely inconsistent with environmental justice for the affected local communities.⁷ However, if MEDEP chooses to proceed with an approval as indicated by the Draft PBD, MEDEP **MUST** strengthen and add further conditions to the approval.⁸

I. <u>MEDEP Should Not Issue an Approval of the PBD Application in its Final PBD.</u>

Many people have provided comments on this PBD Application, and Commissioner Loyzim has acknowledged that the PBD Application is of significant interest to many members of the community and State.⁹ Approximately 95% of the written comments submitted and verbal comments provided at the in-person and virtual meetings ask MEDEP to **deny** the PBD Application.¹⁰ The overwhelming majority of these comments emphasize environmental justice themes and concepts, including the expansion's effects on the surrounding community and Penobscot Nation, as well highlighting the inconsistency with the State's existing Solid Waste Hierarchy. Comments were submitted by members of the Penobscot Nation, community

Ridge/PBD2024/comments/2024_07_31%20CLF%20and%20Penobscot%20Nation.pdf [hereinafter CLF and Penobscot Nation July 31, 2024 Letter]; see also CLF and Penobscot Nation Letter to MEDEP, Conservation Law Foundation and the Penobscot Nation Supplemental Comment Letter on Application DEP# S-020700-W5-CV-N: Application for a Determination of Public Benefit, Juniper Ridge Landfill Expansion, ME DEP'T OF ENV'T PROT. (Sept. 6, 2024), available at https://www.maine.gov/dep/ftp/Juniper-Ridge/PBD2024/comments/2024_09_06% 20CLF%20and%20Penobscot%20Nation.pdf [hereinafter CLF and Penobscot Nation Sept. 6, 2024 Letter]. ⁸ See CLF and Penobscot Nation July 31, 2024 Letter.

⁵ Opportunity for Comment: Juniper Ridge Landfill Expansion Public Benefit Determination, ME DEP'T OF ENV'T PROT., <u>https://www.maine.gov/dep/comment/comment.html?id=13019262</u>.

⁶ Opportunity for Comment: Juniper Ridge Landfill Expansion Public Benefit Determination, ME DEP'T OF ENV'T PROT., <u>https://www.maine.gov/dep/comment/comment.html?id=13019262</u>.

⁷ See CLF and Penobscot Nation Letter to MEDEP, *Application DEP# S-020700-W5-CV-N*): *Application for a Determination of Public Benefit Juniper Ridge Landfill Expansion*, ME DEP'T OF ENV'T PROT. (July 31, 2024), *available at* <u>https://www.maine.gov/dep/ftp/Juniper-</u>

⁹ Juniper Ridge Landfill PBD meeting 20240716, ME DEP'T OF ENV'T PROT., (July 18, 2024, 00:2:39; 01:48:50), https://www.youtube.com/watch?v=tLxFwPf1shg.

¹⁰ See Juniper Ridge Landfill PBD meeting 07162024, ME DEP'T OF ENV'T PROT. (July 18, 2024), <u>https://www.youtube.com/watch?v=tLxFwPf1shg</u>; See Juniper Ridge Landfill PBD meeting 07262024, ME DEP'T OF ENV'T PROT. (July 26, 2024), <u>https://www.youtube.com/watch?v=nMXTUm2NX-Y</u>; See Juniper Ridge Landfill PBD Comments, ME DEP'T OF ENV'T PROT. (June 20, 2024 – September 26, 2024), available at <u>https://www.maine.gov/dep/ftp/Juniper-Ridge/PBD2024/comments/</u>.



members living within "3,333 feet"¹¹ of the landfill who are routinely exposed to an "overwhelming"¹² smell, those in surrounding communities, government officials, and organizations committed to ensuring Maine remains committed to environmental justice and the State's Solid Waste Hierarchy. A substantial amount of these comments from this diverse group of stakeholders are requesting that MEDEP issue a "negative Public Benefit Determination, pursue an independent environmental review of Casella's landfill practices and the cumulative environmental justice impacts, and focus instead on developing zero-waste solutions that protect our environment and communities."¹³

a. <u>MEDEP's Draft PBD Does Not Satisfy the Legal Environmental Justice</u> <u>Standard for a PBD.</u>

CLF and the Penobscot Nation are disappointed that MEDEP finds the proposed expansion meets the PBD environmental justice criteria. In 2022, legislation was passed that requires MEDEP to consider environmental justice in making its PBD.¹⁴ There are two parts to this environmental justice law: (1) equal protection from environmental pollution; and (2) meaningful involvement.¹⁵ This administrative process is the first time MEDEP must apply this standard and assess the potential environmental impacts on the local communities in this way; the process and outcome cannot be the same as it has been before. MEDEP cannot treat this application as business as usual, as the Draft PBD indicates.

For many reasons, this proposed expansion is entirely inconsistent with ensuring environmental justice for the communities in which the expansion is proposed.¹⁶ The Draft PBD does not do enough to ensure equal protection from environmental pollution nor meaningful involvement. In the Draft PBD, MEDEP finds that the JRL expansion "is not inconsistent with

¹¹ Douglas Shorey, *juniper ridge landfull*, MAINE.GOV (Aug. 1, 2024), <u>https://www.maine.gov/dep/ftp/Juniper-Ridge/PBD2024/comments/2024_08_01%20Douglas%20Shorey.pdf</u>; *see also* Tobey Dutton, *Juniper Ridge Landfill/Baldachi MTN.*, MAINE.GOV (Aug. 1, 2024), <u>https://www.maine.gov/dep/ftp/Juniper-</u>

Ridge/PBD2024/comments/2024 08 01%20Toby%20Dutton.pdf (stating "less than 4k feet from my house"). ¹² Douglas Shorey, *juniper ridge landfull*, MAINE.GOV (Aug. 1, 2024), <u>https://www.maine.gov/dep/ftp/Juniper-Ridge/PBD2024/comments/2024_08_01%20Douglas%20Shorey.pdf</u>.

¹³ Sarah Adelberg, *Public Comment on Public Benefit Determination Application for Juniper Ridge Landfill* (DEP# S-020700-W5-CV-N), MAINE.GOV (Sept. 6, 2024), <u>https://www.maine.gov/dep/ftp/Juniper-Ridge/PBD2024/</u> comments/2024_09_06%20Sarah%20Adelberg.pdf.

¹⁴ 38 MRSA § 1310-AA(3)(E); An Act To Protect the Health and Welfare of Maine Communities and Reduce Harmful Solid Waste, S.P. 523 - L.D. 1639 (April 18, 2022), *available at* <u>https://legislature.maine.gov/bills/getPDF.asp?paper=SP0523&item=7&snum=130</u>.

¹⁵ 38 MRSA § 1310-AA(3)(E) ("For a proposed facility or the expansion of a facility, is not inconsistent with ensuring environmental justice for the community in which the facility or expansion is proposed. As used in this paragraph, 'environmental justice' means the right to be protected from environmental pollution and to live in and enjoy a clean and healthful environment regardless of ancestry, class, disability, ethnicity, income, national origin or religion. 'Environmental justice' includes the equal protection and meaningful involvement of all people with respect to the development, implementation and enforcement of waste management laws, rules, regulations and licensing decisions.").

¹⁶ CLF and Penobscot Nation July 31, 2024 Letter; CLF and Penobscot Nation Sept. 6, 2024 Letter.



ensuring environmental justice for the community in which the facility is proposed, as required by 38 M.R.S. § 1310-AA and 06-096 C.M.R. ch. 400, § 5(E)(5), provided that if a license is issued for the construction and operation of the expansion the applicant:

- (1) Designs and installs a Department-approved system for the treatment of landfill leachate for PFAS prior to expansion operations;
- (2) Conducts odor dispersion modeling studies demonstrating that the facility will not cause more than a one-hour average impact of two dilutions to threshold, in any calendar year at any occupied buildings, and implements recommendations from the study prior to expansion operations;
- (3) Conducts two additional surface scans per year of the landfill intermediate cover to determine if there are fugitive landfill gas emissions and conducts repairs of the cover material accordingly; and
- (4) Establishes a system to inform the public about significant landfill events in near real time such as through a website or other means as approved by the Department."¹⁷

While the addition of the PFAS condition listed in the Draft PBD is a step in the right direction, the condition is neither detailed nor stringent enough. The inadequacy of this condition is discussed further in the following section.

The second and third conditions regarding conducting odor dispersion modeling studies and additional surface scans also do not go far enough in addressing the health concerns associated with odor and gas emissions from JRL. As noted in the Draft PBD, "the block group that includes Indian Island is above the 95th percentile when compared to state data for several indexes including wastewater discharge, hazardous waste proximity, underground storage tanks, and toxic releases to air."¹⁸ "For the block group that includes JRL, there are 2 environmental justice indexes (toxic releases to air and wastewater discharge) that are in the 50th to 80th percentile range when compared to state data."¹⁹ While odor itself is a significant problem—and between January 2023 and August 2024, nearly all complaints filed regarding JRL cite odor as the reason for the complaint-community members are also concerned about what is causing the odors and its toxicity. As recently as August 15, 2024, a resident neighboring JRL filed an odor complaint, with the Environmental Analyst confirming that the site had "strong sludge odor at the landfill site this morning."²⁰ Given that direction of the wind determined how and when the odor impacted this particular resident, it raises questions about how this noxious odor is experienced by the adjacent community.²¹ For this reason, real-time continuous air quality monitors should be placed in the block groups with elevated exposure to toxic air releases.

¹⁷ Draft Public Benefit Determination, ME DEP'T OF ENV'T PROT. 20–21 (Sept. 13, 2024), available at <u>https://www.maine.gov/dep/comment/comment.html?id=13019262</u>.

¹⁸ *Id.* at 17 (emphasis added) (internal citations omitted).

¹⁹ Id. at 17 (emphasis added).

 ²⁰ State of Maine, Complaint Report, DEP'T OF ADMIN. & FIN. SERVS. (Aug. 2024), <u>https://www.maine.gov/dafs/bgs/sites/maine.gov.dafs.bgs/files/inline-files/0824%20JRL%20Complaint%20Report.pdf</u>
 ²¹ Id.



The fourth condition, requiring establishment of a system to inform the public about significant landfill events, is far too broad and leaves too many unresolved questions for CLF and the Penobscot Nation to have any confidence that this condition meets the law's environmental justice component. What defines a "significant" landfill event? What information will be included in the notification? Furthermore, when MEDEP is approving such a system, they must make sure the system will address diverse accessibility considerations (e.g., internet access, telephone access, language access). In addition, the community must be engaged in the development of this system as part of "meaningful involvement." MEDEP should work with the community and ascertain what type of notification system would actually be effective for the surrounding communities. Overall, while these types of notification systems are important, this does nothing to **protect** the surrounding communities as required by the environmental justice law. How would such a notification system meet the requirements for meaningful involvement of the surrounding communities as required by the law? For instance, if a significant event has already taken place, at what point would the public be involved in shaping the notification process? While this system should be something that the Proponent should develop, it is misguided to say that this mild condition supports the environmental justice component of the PBD law.

The inadequacy of these conditions, while well-intentioned, reflect the lack of meaningful involvement of the affected communities as required by the environmental justice law. In addition to the regular public meetings required by statute during the PBD process,²² MEDEP and the Proponent should have listening sessions with the affected communities to better tailor any conditions—not just to the communities' specific concerns, but to the communities' desired remedies. Moreover, the conditions should provide for meaningful public involvement over the course of the expansion and once the expansion has begun operations, not just during the PBD process.

The Proponent's lack of regard for environmental justice is further illuminated in the Proponent's September 12, 2024 supplemental letter to MEDEP.²³ In the letter, the Proponent states they will dedicate more resources to building out the administration and award process of the scholarship program they discussed in their PBD Application.²⁴ As CLF and the Penobscot Nation have previously stated, while this scholarship program is a good initiative, it has nothing to do with **protecting** communities from environmental pollution from the expansion, as the law requires, and there is no reason the Proponent cannot be moving forward with the initiative already so as to be a better neighbor now.²⁵ The Proponent is willing to spend money and

²² 38 M.R.S. § 1310-AA(2).

²³ Casella Letter to MEDEP, *NEWSME Landfill Operations, LLC: Application for Determination of Public Benefit,* (Sept. 12, 2024), *available at* <u>https://www.maine.gov/dep/ftp/Juniper-</u>

Ridge/PBD2024/comments/2024_09_12%20Casella%20PBD%20Supplement.pdf [hereinafter Casella Sept. 12, 2024 Letter].

²⁴ Casella Sept. 12, 2024 Letter; PBD Application at 5-1 (PDF page 60).

²⁵ CLF and Penobscot Nation July 31, 2024 Letter at 12.



resources on these types of initiatives rather than fixing the issues that are harming communities. Discussing initiatives like this and purporting that it satisfies the environmental justice component is simply a distraction from what the law actually requires of the Proponent. Historically, the Proponent's operations at JRL indicate no true prioritization of environmental justice. That is no longer legally sufficient; there is now an environmental justice law it must abide by that requires environmental justice be considered to *ensure* its prioritization. MEDEP's decision should reflect that real and legal change.

MEDEP approving the Application with the conditions as laid out in the Draft PBD is essentially endorsing that the environmental justice criterion is meaningless; it is not. As explained above, MEDEP's added conditions in the Draft PBD barely add substance to the environmental justice requirements. These conditions are not the correct interpretation of what the law requires and does not do the Penobscot Nation, Old Town, Alton, and the surrounding communities justice. We urge MEDEP to do what is legally required by this new law and recognize that this expansion is inconsistent with ensuring environmental justice.

i. <u>MEDEP's PFAS Condition in the Draft PBD is Grossly Insufficient.</u>

The issue of per- and polyfluoroalkyl substances ("PFAS") is a serious concern for the community and was brought up by multiple community members at the July 2024 public meetings and through submitted written comments.²⁶ As we have previously explained, sampling of the leachate at JRL shows it has PFAS concentrations that far exceed the 20 parts-per-trillion interim drinking water standard for the six PFAS ("the PFAS(6)") currently regulated by the State of Maine.²⁷ Specifically, the PFAS(6) in JRL leachate were found at levels 20 times greater than allowed in drinking water.²⁸ More concerning still, this sampling does not reflect the levels of the hundreds of other PFAS for which no tests are done.²⁹ PFAS is a serious issue and CLF

²⁶ Ed Spencer, *Environmental Justice and PBD*, MAINE.GOV (Aug. 7, 2024), <u>https://www.maine.gov/dep/ftp/Juniper-Ridge/PBD2024/comments/2024_08_07%20Ed%20Spencer.pdf</u> (referencing "PFAS-laden oversized bulky waste materials" and expressing disapproval at the lack of enforcement surrounding "leachate [that] is full of PFAS and other dangerous toxins"); Kat Taylor, *Kat Taylor Public Comments RE: July 16, 2024 JRL Expansion PBD Application Meeting*, MAINE.GOV (Sept. 5, 2024), <u>https://www.maine.gov/dep/ftp/Juniper-Ridge/PBD2024/comments/2024_09_06%20Kat%20Taylor.pdf</u> (stating that "PFAS contaminated leachate dumped into the Penobscot River" and that there is an opportunity for the Jay facility to provide "wastewater treatment" for the possible removal of PFAS contaminants from landfill leachate."); *see also* Draft PBD at 6 (stating concerns mentioned in comments included: "landfill leachate receives insufficient treatment prior to discharge; exposure of the public to odors, pollutants released during landfill fires, and leachate constituents discharged to the Penobscot River are inconsistent with environmental justice").

²⁷ Crawford Engineers & Sevee & Maher Engineers, *Study to Assess Treatment Alternatives for Reducing PFAS in Leachate from State-Owned Landfills*, STATE OF ME. ES-3 (Jan. 2023), *available at* https://www.maine.gov/dafs/bgs/sites/maine.gov.dafs.bgs/files/inline-

files/Resolves%202021%2C%20ch.%20172%20Study.pdf; CLF and Penobscot Nation July 31, 2024 Letter at 16–17.

²⁸ Crawford, Study to Assess Treatment Alternatives for Reducing PFAS in Leachate, ES-3 to ES-4.

²⁹ In an EPA evaluation of leachate from over 200 landfills, PFAS detections included 63 different PFAS with average concentrations for an individual compound as high as 14,000 parts-per-trillion.



and the Penobscot Nation recognize the addition of the PFAS condition as a necessary step in the right direction. While we appreciate that MEDEP has included the requirement of designing and installing a MEDEP-approved system for the treatment of landfill leachate for PFAS prior to expansion operations, CLF and the Penobscot Nation see significant room for improvement on this condition to bring it closer to ensuring environmental justice.

To start, the condition itself is far too broad and has no criteria for what an acceptable treatment system will look like. It is imperative that MEDEP determine clear criteria for analyzing the capability and suitability of the proposed technology for the treatment system and make sure the public is aware of these criteria, as well. MEDEP must require full transparency from the Proponent when they are proposing said technology and hold them to a high standard of proving why certain technologies should be implemented. There should also be numerous opportunities for the public to be informed throughout the process, as well as the ability to comment on the proposed technology, as is required by the "meaningful involvement" prong of the environmental justice law. There should also be clear guidance on how MEDEP will use the public's input to guide their decision.

Attached to this comment letter as Exhibit A is an expert analysis of Casella's proposed PFAS Pilot Plan for its Coventry Landfill in Vermont, conducted by two experts in the field of civil and environmental engineering, Yang Yang, PhD and Thomas Holsten, PhD; it includes their report ("Expert Report") and respective credentials. While here the Proponent has not put forth any proposed treatment plan, the recommendations from the Expert Report are instructive.

First, the Expert Report notes that an acceptable PFAS treatment program should test for more than just the state-regulated PFAS.³⁰ It recommends using EPA Method 1633 to test for at least 40 PFAS, some of which will likely come under EPA regulation soon.³¹ Moreover, the Expert Report also recommends testing for PFAS precursors, as many of the treatment processes discussed in the legislatively mandated Study to Assess Treatment Alternatives for Reducing PFAS in Leachate from State-Owned Landfills, such as foam fractionation, can break PFAS chains down into PFAS precursors, which then become PFAS once again after the pre-treated leachate is treated in a waste water treatment plant.³²,³³ The report recommends Total Oxidizable

³⁰ *See* Yang Y. & Holsen T., Review of Leachate Treatment Study Plan for New England Waste Service Landfill as Required by Condition I.A.5 of the State of Vermont Agency of Natural Resources, Department of Environmental Conservation, Watershed Management Division Pretreatment Discharge Permit 3-1406 2 (Dec. 7, 2023) (attached hereto as Exhibit A).

³¹ *Id.* at 2 ("[T]he number of regulated PFAS compounds continues to increase at federal and state levels, and the failure to ensure extraction of precursors could undermine the entire stated goal of the system—providing WWTPs with leachate free of the VT5. Increasing regulation of PFAS should be anticipated for and used to evaluate this system."

³² Id.

³³ Barely over a month ago, the Brunswick Executive Airport suffered "Maine's worst toxic foam spill." Penelope Overton, *Foam spill flushes wave of toxic chemicals into troubled Androscoggin River*, PORTLAND PRESS HERALD (Sept. 24, 2024), <u>https://www.pressherald.com/2024/09/24/foam-spill-flushes-wave-of-toxic-chemicals-into-</u>



Precursors Assay ("TOPA") testing to measure the PFAS precursors in the leachate treated onsite, both before and after pretreatment, to ensure the pretreatment is working effectively.³⁴ Once the testing methods and standards are set, the type of pretreatment can be better chosen and evaluated.

Second, as noted in the Expert Report, the foam fractionation process as used at Casella's Coventry Landfill in Vermont, is unlikely to be a successful treatment option on its own.³⁵ Accordingly, either some other type of pretreatment should be required at JRL, or a combination of biological pretreatment and reverse osmosis should be required alongside the foam fractionation process to provide a safer, more established and reliable form of treatment.³⁶

Third, MEDEP must require that the Proponent manage the residual waste from pretreating the leachate in an environmentally responsible manner. If foam fractionation is chosen as a treatment system in conjunction with biological pretreatment and reverse osmosis, the residual foamate should be managed through electrochemical oxidation and plasma discharge rather than encapsulation in Portland cement to avoid creating more PFAS in leachate going forward.³⁷

Fourth, to avoid a spill like the one that happened at Casella's landfill in Coventry,³⁸ any PFAS pretreatment system must include continuous staffing during the operation of the treatment unit in the event that redundant alarms do not function as designed and to ensure that any secondary containment system operates as designed. In Casella's supplemental letter in support of the PBD Application, it notes that there is "room for improvement" at Coventry, but still maintains it is playing a "leadership role" with PFAS pretreatment systems.³⁹ However, it is important to note that the Vermont Department of Environmental Conservation required the PFAS pretreatment as a condition of the permit.⁴⁰ MEDEP can and *should* do the same here,

³⁹ Casella Sept. 12, 2024 Letter.

<u>troubled-androscoggin-river/.</u> "The pipes carried the spill . . . to the sewer plant, where it was treated for some of its nastier contaminants but not the forever chemicals that make aqueous film-forming foam . . . so dangerous. Its next stop? The Androscoggin." *Id.* We want to protect the Penobscot River, and all those who live along it, from the same fate.

³⁴ Exhibit A at 2 ("[T]he non-targeted total oxidizable precursors assay (TOPA) should be included, and the specific compounds produced by the TOPA oxidation process should be determined. TOPA is a method used to quantitatively characterize how many unknown precursors there are in fluid or water. Running such an analysis would enable the permit applicant to determine if precursors are present in the leachate, and if so, if they are being caught by the expanded treatment system proposed below.").

 $^{^{35}}$ *Id.* at 3-4.

³⁶ *Id.* at 5-6.

³⁷ Abagael Giles, *Spill of landfill leachate into stormwater pond leaves Coventry locals concerned*, VT PUBLIC (March 8, 2024), <u>https://www.vermontpublic.org/local-news/2024-03-08/spill-of-landfill-leachate-into-stormwater-pond-leaves-coventry-locals-concerned</u>

³⁸ Id.

⁴⁰ Brown and Caldwell, Leachate Treatment Study Plan for New England Waste Services (NEWSVT) Landfill As Required by Condition I.A.5 of the State of Vermont Agency of Natural Resources, Department of Environmental



especially as Casella did not commit in its PBD Application to beginning a PFAS pretreatment program. Moreover, MEDEP should go further and require a PFAS pretreatment system consistent with the recommendations in this letter and the attached Expert Report to give substance to the environmental justice provision of the PBD law.

Lastly, the PFAS condition as written in the draft PBD does nothing to measure, prevent, or remedy PFAS in landfill air emissions. According to a new study, "PFAS gas that emits from landfill waste ends up highly concentrated in the facilities' gas treatment systems, but the systems are not designed to manage or destroy the chemicals, and much of them probably end up in the environment."⁴¹ In fact, "extrapolated concentrations in this study surpassed previous reports in LFG [landfill gas], in some cases by 2 orders of magnitude, and were more comparable (although much lower) to concentrations recently identified in soil vapor near a PFAS manufacturing facility."42 "[E]ven under more conservative assumptions these findings suggest that LFG, largely unscrutinized for PFAS, contains similar or greater magnitudes of PFAS compared to leachate, mostly attributed to midlength FTOH homologues. As landfills can be viewed as unabating PFAS repositories, the significance of LFG management in mitigating the long-term, long-range atmospheric transport of neutral PFAS, and subsequently derived PFAAs, cannot be understated."43 The lead author of the study characterized these findings as "alarming."44 Accordingly, MEDEP must require regular air monitoring for PFAS to assess the breadth of the problem at JRL and then require the Proponent to use its "alliances" with educational institutions to assess and implement an air treatment program.

If MEDEP finds it too technical to include all of these conditions in the PBD approval, it should at least set forth the necessary criteria for evaluation (i.e., the pretreatment system must remove all PFAS found through EPA Method 1633 and all precursors found through TOPA testing; monitoring and studies on air treatment technologies must begin; etc.), and then lay out a process and timeline for both the public and MEDEP to assess the adequacy and effectiveness of the Proponent's PFAS pretreatment system.

Conservation, Pretreatment Discharge Permit 3-1406 (Revised Oct. 5, 2023), *available at* https://anrweb.vt.gov/Pubdocs/DEC/ENB/WWINV/21339-3-1406% 20Fact% 20Sheet% 20Attachment% 20A% 20-% 20NEWSVT% 20PFAS% 20Pilot% 20Study% 20Plan_10052023.pdf; *see also* Permit 3-1406, *available at* https://anrweb.vt.gov/Pubdocs/DEC/ENB/ENB V2/13854-3-1406 DraftPermit.20210920.pdf.

⁴¹ Tom Perkins, *US landfills are major source of toxic PFAS pollution, study finds*, THE GUARDIAN (Aug. 9, 2024), *available at* <u>https://www.theguardian.com/environment/article/2024/aug/09/pfas-landfills-us#:~:text=Toxic%</u> 20PFAS%20%E2%80%9Cforever%20chemicals%E2%80%9D%20that,to%20find%20an%20effective%20solution.

 ⁴² Ashley Lin, et al., *Landfill Gas: A Major Pathway for Neutral Per- and Polyfluoroalkyl Substance (PFAS) Release*, ENV'T SCI. & TECH. LETTERS 2024 11 (7), 730–737 (emphasis added) (attached hereto as Exhibit B).
 ⁴³ *Id.*

⁴⁴ Tom Perkins, *US landfills are major source of toxic PFAS pollution, study finds*, THE GUARDIAN (Aug. 9, 2024), *available at* <u>https://www.theguardian.com/environment/article/2024/aug/09/pfas-landfills-us#:~:text=Toxic%</u> 20PFAS%20%E2%80%9Cforever%20chemicals%E2%80%9D%20that,to%20find%20an%20effective%20solution.



b. <u>The Draft PBD is Inconsistent with the State's Waste Management Plan and</u> <u>Hierarchy.</u>

As currently written, the Draft PBD does not promote the State's Waste Management Plan and Hierarchy. As noted in our original letter, land disposal of waste is the very last priority in the State's solid waste management hierarchy.⁴⁵ Accordingly, there must be meaningful conditions included in an approval to make the expansion more consistent with the plan and hierarchy; the conditions in the Draft PBD do not meaningfully address the need to reduce the volume of disposed waste, increase diversion, and recycle more. Most of the conditions prescribed in the Draft PBD have to do with Casella encouraging recycling at its other facilities in Maine.⁴⁶ For the most part, these conditions do not address the waste that goes to JRL and reward Casella for having a virtual monopoly over the waste services in Maine. The State of Maine owns JRL and what Casella does at its other facilities should comply with the State's Waste Management Plan and Hierarchy *regardless* of whether JRL is expanded.

To really address the inconsistency of the expansion with the Plan and Hierarchy, conditions must be placed on the management of JRL itself. As recommended in our previous letter, CLF and the Penobscot Nation suggested three conditions that would better address the need for increasing diversion and reducing the volume of waste disposed at JRL: (1) a dewatering system for sludge at JRL; (2) the setting of a maximum fill limit; and (3) the place of a cap on construction and demolition debris ("CDD") fines.⁴⁷ MEDEP recognizes the need for a sludge dewatering system, as it required as one of its conditions that the Proponent evaluate "the availability and capacity of facilities in Maine to reduce the volume of municipal wastewater treatment plant sludge prior to landfilling at JRL."48 MEDEP can and should go further by simply requiring the Proponent to dry the sludge at JRL, ensuring that the sludge takes up as little volume as is feasible and preserves JRL's capacity as much as possible. As for CDD fines, while MEDEP notes that "JRL may legally accept a certain amount of residues from in-state CDD processing facilities,"⁴⁹ nothing in the law prohibits MEDEP from conditioning an approval of a PBD on accepting a lower amount of CDD fines than allowed by statute. Similarly, nothing prohibits MEDEP from placing a maximum yearly fill limit to preserve landfill capacity and encourage alternatives to landfill disposal.

CLF and the Penobscot Nation were disappointed that none of these conditions were included in the Draft PBD, but MEDEP should include them going forward if it continues with its approval. Adding these conditions to the approval is necessary to bring the expansion closer in line with the State's Waste Management Plan and Hierarchy.

⁴⁵ CLF and Penobscot Nation July 31, 2024 Letter at 3 (citing 38 M.R.S.A. § 2101).

⁴⁶ See Draft PBD at 15.

⁴⁷ CLF and Penobscot Nation July 31, 2024 Letter at 9–10.

⁴⁸ Draft PBD at 15.

⁴⁹ *Id.* at 11.



II. <u>Conclusion</u>

MEDEP should not issue an approval of the PBD Application. The expansion of JRL runs counter to the State's Solid Waste Hierarchy and is entirely inconsistent with environmental justice for the affected local communities.⁵⁰ However, if MEDEP chooses to issue an approval, conditions as outlined in this letter must be added to the Draft PBD.

Thank you for your consideration of this request. Please do not hesitate to contact us and direct any questions to Alexandra St. Pierre (<u>aestpierre@clf.org</u>) and/or Suhasini Ghosh (<u>sghosh@clf.org</u>).

Sincerely,

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⁵⁰ See CLF and Penobscot Nation July 31, 2024 Letter; see also CLF and Penobscot Nation Sept. 6, 2024 Letter.



CC: Sean Mahoney, Esq. Vice President, Maine & Senior Counsel Conservation Law Foundation

Exhibit A

Review of "Leachate Treatment Study Plan for New England Waste Services (NEWSVT) Landfill As Required by Condition I.A.5 of the State of Vermont Agency of Natural Resources Department of Environmental Conservation Watershed Management Division Pretreatment Discharge Permit 3-1406. Revised December 7, 2023 Project Number: 157518"

Yang Yang, Ph.D.; Thomas Holsen, Ph.D.

1. Synopsis of Treatment Process.

This synopsis summarizes key information related to PFAS monitoring and treatment from the document (denoted as "**study plan**" in the following content). In the study plan, the proposed foam fractionation (FF) treatment system will treat leachate from the existing NEWSVT leachate storage tanks. Raw leachate will be pumped from the onsite leachate storage tanks to the treatment system, and treated leachate will be returned to the storage tanks prior to disposal. The expected system capacity for treatment is up to <u>75,000 gpd</u>. The anticipated PFAS concentration in leachate is listed below.

Parameter	Units	Average Concentrations		
Perfluoroheptanoic acid (PFHpA)	ng/L	710		
Perfluorohexane sulfonic acid (PFHxS)	ng/L	378		
Perfluorononanoic acid (PFNA)	ng/L	863		
Perfluorooctanesulfonic acid (PFOS)	ng/L	214		
Perfluorooctanoic acid (PFOA)	ng/L	1,711		

ng/L = nanograms/liter

Exhaust gas will pass through a granular activated carbon (GAC) unit. PFAS in exhaust gas will not be monitored. Foamate will be solidified by Portland cement and then returned to landfill. Testing of leaching of PFAS from the cement was not planned.

In general, we agree that FF is a plausible component of PFAS treatment. The following content provides concerns about the feasibility, safeguards, and efficacy of the current plan and technical recommendations for the removal and destruction of PFAS beyond those listed in the VT5.

2. Concerns about incomplete coverage of PFAS and inadequate removal of precursors

EPA Method 1633 is a cornerstone for the environmental surveillance study of PFAS. All the listed PFAS that can be quantified by this method have the potential to be regulated in the future upon further

investigation of toxicity and risk assessment. The EPA Method 1633 covers 40 PFAS; $C_{n=3-9}$ perfluorinated carboxylates (n refers to the number of fluorocarbons), C_4 - C_{10} perfluorinated sulfonates, fluorotelomers (4:2, 6:2, and 8:2), and precursors have been detected in leachate.^{1,2} The concentrations of these dominant compounds range from 10-10⁴ ng/L in the USA. Notably, short-chain PFAS ($C_{n=3-7}$) have concentrations commensurate with perfluoroctanoic acid (PFOA) and perfluoroctane sulfonic acid (PFOS).^{3,4}

As will be discussed below, the FF method is inefficient in removing short-chain PFAS as well as precursors that can be converted into the VT5 during wastewater treatment plant (WWTP) processing. Thus, we conclude that the scope of work on monitoring VT5 in the pilot-scale study is concerningly limited as the number of regulated PFAS compounds continues to increase at federal and state levels, and the failure to ensure extraction of precursors could undermine the entire stated goal of the system—providing WWTPs with leachate free of the VT5. Increasing regulation of PFAS should be anticipated for and used to evaluate this system. In addition, the non-targeted total oxidizable precursors assay (TOPA) should be included, and the specific compounds produced by the TOPA oxidation process should be determined. TOPA is a method used to quantitatively characterize how many unknown precursors there are in fluid or water. Running such an analysis would enable the permit applicant to determine if precursors are present in the leachate, and if so, if they are being caught by the expanded treatment system proposed below.

It is well known that WWTPs convert unidentified precursors into identified PFAS, including those on the VT5 list.⁵ For example, in a recent study of three WWTPs, perfluorohexanoic acid (PFHxA), PFOA, perfluorohexanesulfonic acid (PFHxS), and perfluorooctane sulfonic acid (PFOS) had a net mass increases in the effluent of on average 83%, 28%, 37%, and 58%, respectively.⁶ If unidentified precursors are not removed, the release of treated water to the WWTP and the conversion of those compounds into regulated PFAS in the WWTP could cause the release of those compounds in the WWTP effluent. The proper route to avoid this potential violation and public health hazard is to employ the TOPA method to figure out if precursors are present in the leachate, and if they are being removed by the reverse osmosis system proposed below; notably, foam fractionation alone would likely not remove such precursors.⁷. However, there is evidence that reverse osmosis also removes precursors.⁸ The necessity to remove precursors is further reason to expand the treatment system from foam fractionation alone, to the reverse osmosis system outlined below.

In addition to the inadequate coverage of target PFAS, the treatment end goals for removing the VT5 are unclear. There are no success criteria established for this study. What effluent concentrations,

treatment capacity, treatment costs, and reliability must be met for the FF process to be considered acceptable? Specifically for effluent concentrations, the values in the water treatment plant (WWTP) permit for effluent testing of target MDL for PFHxS, PFHpA, PFNA, PFOS, and PFOA of no greater than 20 ng/L would be appropriate to align with Vermont's drinking water standards.

3. Concerns about FF performance

The study plan demonstrated the performance of FF by showing the efficacy of treating Swedish landfill leachate. Although there is a mention that there was a bench study, notably, no data or findings from that study are included. The lack of bench data is concerning because several of the PFAS are present at concentrations that are near an order of magnitude higher than found in the Swedish study. The Australian feed water had higher concentrations, so it's more of an analog, but it still underscores the importance of bench-scale proof of concept testing. More difficult waters may require more reactor contact time, which increases the size and cost of the system. For example, a case study in Australia showed that the leachate samples had poor foamability. The FF was only functional when co-foaming surfactants were added. ⁹ There is no such contingency plan laid out in the Pilot plan, despite the possibility that the leachate may not foam as expected. As of now, there is no proof that the SAFF FF system used in the Swedish study works on the leachate generated at Coventry, either at the bench scale or at a larger scale. Such evidence should be provided before the study plan is approved.

It is well known that leachate characteristics vary throughout the year. This is acknowledged in Section 1.2, where it is stated that "the treatment system will be operated under a variety of conditions to evaluate its response to temporal variations in leachate quality and key operational parameters." However, the current sampling frequency proposed is insufficient to ensure that the effect of the variability in leachate quality throughout the year on removal rates is properly evaluated. Moreover, as mentioned above, no contingency plan was provided in case the leachate has no or less-than-ideal foaming potential. Such a contingency plan could include, but not be limited to, adding co-foaming surfactants.

Notably, even if the FF functions as the applicant proposes it will, the performance of removing PFAS beyond VT5 is limited. The treatment of leachate collected from a 20-year-old cell of an active MSW landfill in central Florida shows that FF has poor performance (<50% removal) on removing $C_{n<6}$ -PFSAs and $C_{n<5}$ PFCAs.¹⁰ Importantly, this bench-scale study in Florida shows that FF could not remove PFBA, ¹⁰ which is a candidate PFAS to be regulated by USEPA. The poor or lack of removal of PFBA and

PFBS was reported at the pilot scale.¹¹ This limitation was also acknowledged by SAFF[®] (technology to be adopted in the pilot plan) at commercial scales.¹² Both PFBA and PFBS have been shown to have toxicology concerns,^{13,14} and have been shown to persist after FF treatment; the public health risks of these chemicals persisting after the FF treatment is further justification to use an expanded treatment system, composed of bio-pretreatment and reverse osmosis, as discussed in Section 6.

Given the lack of any bench or larger-scale data and the variability of leachate throughout the year, we conclude that the SAFF FF process performance on the removal of VT5 in the NEWSVT leachate is yet to be determined. The FF process is incapable of removing short-chain PFAS not included in VT5. It is a missed opportunity for the study plan not to address these candidate PFAS that are facing scrutiny and possible regulation in the near future due to emerging toxicology findings, in addition to non-targeted compounds, as discussed above.

4. Concerns about air emission

Although stack emissions testing techniques are still under development (Other Test Method 45 (OTM-45) Measurement of Selected Per- and Polyfluorinated Alkyl Substances from Stationary Sources), using this approach would add valuable data to the project. Determining if any PFAS will be discharged through the stack gas after carbon absorption is an open question that should be evaluated. In addition, there are relatively simple and proven air sampling techniques that should be employed. For example, air samples can be collected using high-volume air samplers employing sampling modules containing glass-fiber filters (GFFs) and glass columns with a polyurethane foam (PUF)–XAD-2–PUF sandwich.¹⁵ These could be employed in the vicinity of the off gas to determine if PFAS are being emitted from the system. In addition, simple wipe tests of surfaces exposed to the off-gases would be a useful and inexpensive way to determine if PFAS are leaving the system.¹⁶

There are numerous other potentially harmful semi-volatile organic compounds (SVOCs) and volatile organic compounds (VOCs) found in leachate that are likely to be removed by the foam fractionation process and be in the off-gas. A global survey of the VOCs and SVOCs in leachate from 103 landfill sites combined with 27 published manuscripts on leachate treatment showed that polycyclic aromatic hydrocarbons (PAHs), phthalate acid esters (PAEs), and phenols were the most frequently detected SVOCs in leachate. In addition, four VOCs (toluene, ethylbenzene, xylenes, and benzene) were frequently detected at high concentrations.¹⁷ All of these compounds would likely be removed from the leachate during foam fractionation and could end up in the gas phase, potentially leaving the system. All

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could potentially pose a threat and should be monitored. Appropriate methods include EPA Methods TO-4A and TO 13A for SVOCs and TO-14, TO-15 or TO-17 for VOCs.

5. Concerns about foamate solidification

Currently, there is no official guidance for the disposal of PFAS in foamate. The use of Portland cement (or similar) to encapsulate the PFAS in foam fractionate to minimize potential recycling is an unproven technology and the relevant research conducted herein casts serious doubts on the solidification's efficacy. There are no publications or reports available that indicate this treatment is effective. In a recent publication, it was found that for PFAS-contaminated soil treated with cement and bentonite, the leaching of long-chain PFAAs was reduced while the leaching of short-chain PFAAs was enhanced.¹⁸ While there is only the single manuscript cited above on PFAS solidification using cement, there are numerous other articles for similar classes of compounds that suggest it may not be effective. For example, Mulder et al. report that "PAHs leach to a relatively high extent" after solidification,¹⁹ and Yilmaz et al. reported that for adsorbable organic halogens (AOX) in pulp and paper sludge solidified with cement,²⁰ AOX concentrations were above regulatory levels (tested was done with the U.S. Environmental Protection Agency Toxicity Characteristic Leaching Procedure (TCLP)).)). Note that most PFAS are AOX (halogenated substances that are adsorbed from water onto activated carbon). Based on the published evidence it is reasonable to conclude the proposed process will not effectively isolate the PFAS and will allow PFAS in the foam to quickly re-enter the leachate stream

6. Recommendations on separation technology for leachate treatment, and for targeting both longchain and short-chain PFAS, as well as precursors

Given that FF does not target short-chain PFAS and does not sufficiently capture precursors, it is recommended that a separation process capable of removing short-chain ($C_{n<6}$) PFAS and precursors is included in the design. Adsorption by granular activated carbon and resins are not good candidates because of their inefficacy in removing short-chain PFAS and possible compromised performance in the presence of competitive organics and ionic components. However, a combination of biological pretreatment and reverse osmosis (RO) would be a safer and more reliable choice. Biological treatment aims to break down organics to mitigate membrane fouling. The following RO step is a proven process to

treat raw leachate.²¹ Recently, RO demonstrated the capability to remove PFAS at all chain lengths (C_{n>1}).^{22,23} Moreover, as stated above, there is evidence that reverse osmosis also removes precursors.⁸ The Bio+RO process, specifically the combination of membrane bioreactor (MBR) and RO, is a mature technology for leachate treatment.²⁴ Commercialized membranes tailored for PFAS removal in leachate were reported by PCI membranes, Saltworks, and Aclarity (internet sources; no conflict of interests involved).^{25–27} A project of treating 75,000 gpd of leachate is being conducted by SCS Engineers in North Carolina.²⁸

While FF is a plausible component in treating leachate for PFAS, we herein provide a suggested treatment process that can be an add-on (to be placed after FF) or stand-alone (to replace FF) to eliminate VT5 and other PFAS covered by EPA method 1633. As shown in Figure 2, the treatment train contains a bio-pretreatment unit to reduce the organic loads and thereby mitigate RO membrane fouling. PFAS at all chain lengths will then be removed by the RO unit, as well as a larger swath of precursors. The RO concentrate (10-20% volume of the inlet flow) can be treated by destructive technology, EO or Plasma (discussed in detail below), to mineralize PFAS. We believe this treatment train will better protect the practitioner from regulator noncompliance in the face of an increasing list of PFAS of public concern as well as PFAS precursors, and that this treatment train will decrease public health risks, as compared to the FF proposal.



Figure 1. Suggested treatment train to remove and destroy long and short chain PFAS.

7. Recommendations on destructive technology for concentrate treatment

Current PFAS destruction technologies include (1) electrochemical oxidation (EO), (2) plasma discharge, (3) UV-sulfite reduction, (4) hydrothermal treatment (including two subset technologies: Hydrothermal alkaline treatment and supercritical water oxidation), and (4) sonolysis. The performance of UV-sulfite could be compromised by organics.²⁹ Hydrothermal treatment requires the addition of excessive alkaline (1-5 M NaOH) and specialized equipment to withstand high temperatures and pressurization.^{30,31} These technologies have attracted significant investments and become the backbone of several start-up companies (Aquagga and 374Water). Though these hydrothermal approaches can destroy PFAS in concentrated AFFF and sorbents, no study reported the treatment of leachate or foamate derived from leachate. Our evaluation is that the hydrothermal process is still limited by the treatment capacity. The Aquagga system has a maximum capacity of 240 gpd (based on a personal conversation with a developer). Sonolysis is known for its higher energy consumption than peer approaches.³² This leaves EO and plasma as feasible options. More importantly, their performance on PFAS destruction was validated in leachate treatment.^{33,34} Direct deployment of these technologies in leachate treatment is difficult given the volumes generated, although plasma technology, in particular, is rapidly advancing and may be able to treat the needed volumes in the near future. However, EO or plasma could be used to treat concentrates of leachate with higher PFAS loads and a lower volume, which would eliminate the need for solidification and limit PFAS recycling in the leachate. These destructive technologies could be applied at the end of the treatment process, so that the PFAS in the RO concentrate as well as the foamate (discussed below) were eliminated.

If FF is to be used as the first step toward PFAS control in landfill leachate, based on the Swedish data provided, in the ideal scenario, >97% of the VT5-PFAS may be removed from the leachate. The volume of foamate is unclear in the study plan, although the volume of foamate could be 10% of the total inlet volume.¹¹ Assuming >99% removal of PFOA in leachate, as the Swedish study attained, the foamate could have a concentration of ~17,000 ng/L at a volume of 7,500 gpd. This is a very large volume of foamate and shows how challenging treating the foamate could be.

Recommended destructive technologies include EO and plasma, for both the RO concentrate from the recommended treatment train, and the foamate from the existing plan. EO treatment of PFAS in leachate has been extensively reported. Destruction of PFOA and PFOS was readily achieved.³⁵ Directly applying EO to treat leachate may convert precursors to shorter-chain PFAS, leading to the net concentration increase of PFAS in the treated effluent.³⁶ Extended treatment duration (from 8 to 30 h) or

operation at a higher current density (from 20 to 80 mA/cm²) could lead to the net decrease of PFAS.^{34,37} A more appropriate niche for EO is to use it to treat foamate. A pilot-scale study in Uppsala, Sweden, demonstrated the destruction of 60% of total PFAS. Specifically, ~20% of $C_{n<6}$ PFAS and >80% of C_n >6 PFAS were destroyed. The study used PFOA degradation as a benchmark. The energy consumption of the FF+EO treatment train to remove and destroy >90% of PFOA is 75 kWh/m³.

Plasma treatment is another promising PFAS destruction technology with high technical readiness and is being applied at pilot and commercial scales.^{38,39} These studies utilized an enhanced-contact plasma reactor, in which plasma was generated in argon gas and contacted the gas-liquid interface occupied by PFAS. In this reactor, argon is pumped through a submerged gas diffuser to transport PFAAs and precursors to the liquid surface, where they form a layer of foam that is degraded by the plasmagenerated species. Though there was no literature report, plasma should be effective in the treatment of leachate foamate since the process already involves gas purging and reactions in the foam phase. With the aid of additional surfactants (e.g., CTAB), the plasma treatment exhibited broad-spectrum reactivity toward the destruction of both short- and long-chain PFAS in synthetic wastewater and leachate.^{33,40} The energy consumption to destroy >90% of PFOA and PFOS ranged from 20 to 36 kWh/m³. This information would be the starting point for designing the plasma treatment system for the foamate.

8. Recommended workflow for controlling VT5 in management of residuals (foamate)

One of our major concerns with the pilot plan as it stands is that VT5 will be accumulated in foamate rather than destroyed, as the proposed solidification process is not a validated approach. As discussed above, contrasting results in the published studies suggest PFAS leaching is possible, even likely. Therefore, it is suggested that the study plan include destructive technology to destroy PFAS in the foamate (**Figure 1**). EO and plasma are two commercially viable options, as explained above.





10. Major conclusions

- The current study plan is not supported by preliminary data on treating VT5 PFAS in NEWSVT's leachate. Major technical risks reside in (i) uncertainties in the foamability of NEWST's leachate, (ii) uncertainties in the removal efficiencies of VT5 and (iii) no contingency plan to cope with the variations of PFAS concentrations and water qualities,
- The lack of air monitoring is concerning because the proposed technology is likely to result in toxics being released into the atmosphere, as described above. Determining if any PFAS discharged through the stack gas after carbon absorption is an open question that should be evaluated. There are relatively simple and proven air sampling techniques that should be employed, as described above. Moreover, various EPA methods outlined above should be employed to monitor the air for SVOCS and VOCS.
- The current residuals management plan is not recommendable. PFAS solidification in Portland Cement is unlikely to prevent PFAS leaching back into the leachate. There are destructive technologies currently available that can destroy PFAS removed by FF, limiting their recycling in the leachate. For the removal and destruction of VT5 in foamate, we recommend the use of EO or plasma. We also recommend the use of EO and plasma for the destruction of RO concentrate, if our recommended additional treatment system is incorporated.
- The current proposed system--even if it works as claimed, despite the lack of evidence--does not account for treating other PFAS of emerging or proven public health concern. For the removal and destruction of long- and short-chain PFAS covered by EPA Method 1633, we recommend the use of bio pretreatment + RO or FF+bio-pretreatment + RO to concentrate long- and short-chain PFAS, including PFBA and PFBS. The concentrate could then be treated by EO or plasma.
- Limiting the scope of the PFAS study to only VT5 may expose the practitioner to regulatory noncompliance for controlling other PFAS, including short-chain perfluorinated PFAS covered in EPA Method 1633 in the future; limiting treatment to VT5 also ignores public health concerns of other PFAS, as described above. In addition, if unknown precursors (cannot be detected by EPA Method 1633), polyfluorinated compounds (covered by EPA Method 1633), and sulphonamides (covered by EPA Method 1633) are not removed by the FF process, their conversion into regulated PFAS (those in the VT5) after leachate discharge may expose the facility and the WWTP to future liabilities, as well as posing a risk to public health.

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Exhibit B



Landfill Gas: A Major Pathway for Neutral Per- and Polyfluoroalkyl Substance (PFAS) Release

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however, FTOHs dominated concentrations (87-97% total neutral PFAS), with most detections surpassing utilized calibration levels. Even under conservative assumptions, the mass of fluorine leaving in landfill gas (32-76%) was comparable to or greater than the mass leaving in landfill leachate (24-68%). These findings suggest that landfill gas, a less scrutinized byproduct, serves as a major pathway for the mobility of PFAS from landfills.

KEYWORDS: volatile, emissions, GC, fluorotelomer alcohol

1. INTRODUCTION

Widespread per- and polyfluoroalkyl substance (PFAS) contamination has been a mounting environmental concern due to their chemical persistence and toxicity to human and biotic health.¹⁻⁴ While numerous industries are being confronted with PFAS-related management challenges, the burden of remediation and PFAS removal has often fallen on downstream industries—namely, the solid waste sector.⁵⁻⁹ Discarded, PFAS-laden consumer products including textiles, wood products, and packaging and commonly landfilled industrial byproducts like MSW incineration ash and wastewater biosolids are known contributors to PFAS loading in landfills.^{10–16} Existing research suggests most discarded PFAS mass is retained within landfills^{9,17} with liquid-phase byproducts of waste decomposition, leachate and gas condensate, currently considered prevalent pathways for PFAS mobilization.^{2,7,9} However, the extent of PFAS release to another major byproduct, landfill gas (LFG), has remained largely unscrutinized.

The bulk of PFAS characterization studies focus on nonvolatile/semivolatile (ionic) perfluoroalkyl acids (PFAAs) measured in liquid and solid matrices, in part because of a high presence and awareness of these species within the PFAS community but largely because analytical capabilities for ionic

PFAS measurement are better established.¹⁸⁻²¹ Volatile (neutral) PFAS are also utilized in consumer products^{13,22-27,27} and have been determined in a few studies on ambient air surrounding landfills and near wastewater treatment plants,^{28–32} but a lack of volatile analytical standards and latency in methodological development has hindered the progression of gas phase research in environmental matrices. Whereas PFAS characterization in leachate is established, concentrations ranging from thousands to tens of thousands of nanograms per liter are commonly encountered;^{33–38} only two studies characterize volatile PFAS directly in LFG.^{39,40} Titalev et al. identified fluorotelomer alcohol (FTOH), fluorotelomer acrylate (FTAc) and fluorotelomer olefin (FTO) homologues in LFG with combined concentrations ranging from 4,600 to 14,000 ng m⁻³ across three landfills. Goukeh et al., only assessing FTOHs, identified higher combined concentrations than Titaley et al., finding \sim 18,000 ng m⁻³ (sum of 6:2 and 8:2

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Figure 1. Developed system for sampling neutral PFAS directly from landfill gas well heads.

FTOH) in the one LFG sample examined. These studies suggest PFAS variability in LFG, which motivates further investigation, deploying higher sampling volumes³⁹ and larger analyte lists⁴⁰ to understand the potential presence of other neutral PFAS and distribution among landfills of different regions, compositions, and sizes.

With the ongoing development of PFAS regulation,¹⁹ understanding the partitioning behavior of PFAS in major repositories like MSW landfills grows increasingly critical to minimize environmental and human risk. Unlike leachate, LFG is not always captured by collection systems, and management varies broadly across landfills, ranging from no treatment (i.e., passive venting) to some treatment (i.e., flaring, LFG to energy projects), but current treatment, if any, is not intended for PFAS.^{41,42} Emerging research suggests the toxicity of volatile species (specifically 6:2 FTOH) to be significantly higher than their ionic counterparts via the inhalation pathway (a main route of exposure for volatile compounds).⁴³⁻⁴⁷ Further, degradation of neutral species to ionic PFAAs once emitted to the atmosphere is well established.^{48–58} The potential for longrange atmospheric transport of PFAS from landfills underscores the importance of considering neutral species and their fate during management to prevent further environmental contamination of highly scrutinized PFAAs such as perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). As the only studies on LFG primarily identified FTOHs in LFG, the magnitude and significance of other neutral species remains unclear.

Here, LFG was sampled directly from gas well heads at three MSW landfill locations in Florida using a higher volume sampling protocol. XAD-2 resin sandwiched between polyurethane foam (PUF) was utilized for PFAS capture, then samples were analyzed for 27 volatile/semivolatile (neutral) PFAS via targeted gas chromatography high resolution mass spectrometry (GC-HRMS). To contextualize release in the gas phase, leachate was also collected at each landfill and analyzed for ionic PFAS (n = 93) using ultrahigh pressure liquid chromatography tandem mass spectrometry (UHPLC-MS/MS). The observed LFG and leachate concentrations were normalized on a mass of fluorine basis to compare the potential mobility in gas versus leachate matrices. This study provides foundational data critical for understanding the role of

landfills in anthropogenic PFAS release and for informing LFG management.

2. METHODS AND MATERIALS

For brevity, materials and methods associated with ionic PFAS analysis in landfill leachate are provided in section 1 of the Supporting Information (Tables S-1 through S-4).

2.1. Standards and Reagents. Targeted neutral PFAS (\geq 97% purity, n = 27) were purchased from Wellington Laboratories Inc. (Guelph, ON, Canada), SynQuest Laboratories (Alachua, FL), and Chiron (Stiklestadveien, Trondheim, Norway). Nine classes of neutral PFAS (perfluoroalkane sulfonamides (FASAs), perfluoroalkane sulfonamidoethanols (FASEs), fluorotelomer acetates (FTOAcs), fluorotelomer methyl acrylates (FTMAcs), fluorotelomer iodides (FTIs), fluorotelomer secondary alcohols (sFTOHs), FTOHs, FTAcs, and FTOs) were measured using eight isotopically labeled internal standards (IS) from FASA, FASE, FTOH, and FTMAc classes for quantitation (Table S-5).

2.2. Sample Preparation and Collection. Polyvinyl chloride (PVC) cartridges filled with 4–5 g of Amberlite XAD-2 resin retained between two polyurethane foam (PUF) discs were utilized for PFAS capture.^{29,59,60} Before use, XAD-2 sorbent was made PFAS-free through sequential Soxhlet extractions.⁶¹ All cartridge components, sampling vessels, and tubing were sonicated in a mixture of Liquinox and PFAS-free water, rinsed, and then sonicated in methanol and methanol rinsed before use. Once dried and assembled, cartridges were stored in individually sealed polyethylene bags at 4 °C until sampling.

As neutral compounds were the focus of this investigation, aerosolized/particulate-bound PFAS were not specifically targeted for capture; however, a condensate collection system was included to prevent moisture interference. The developed sampling system (Figure 1) consisted of a condensate knockout (borosilicate, barbed Erlenmeyer flask contained in a cold box), two PUF/XAD-2 cartridges (installed in-series), a rotameter for flow control, a portable vacuum pump, and PFAS-free Tygon tubing. Before each sampling event, gas well head connection to the larger landfill gas collection system was disabled to create a neutral to positive pressure, workable for flow through the sampling system, then gas composition/

В

Table 1. Average Concentrations (n = 2) of 13 Neutral PFAS (ng m⁻³) from Three Municipal Solid Waste Landfills in Florida (Site Characteristics Are Provided in Table S-9)^{*a*}

analyte	concentration (ng m^{-3})						
	landfill 1	Е	landfill 2	Е	landfill 3	Е	
4:2 FTOH	220		ND		57		
6:2 FTOH	>9,900	170,000	>6,000	22,000	>6,500	62,000	
8:2 FTOH	>6,800	200,000	>6,000	140,000	>6,500	740,000	
10:2 FTOH	>5,100	14,000	>3,000	23,000	>5,000	120,000	
12:2 FTOH	860		1,400		5,000		
5:2 sFTOH	>2,900	8,800	>1,700	9,000	>1,900	5,900	
7:2 sFTOH	320		>1,300	13,000	>1,400	11,000	
8:2 FTO	2,500		1,300		550		
10:2 FTO	650		840		540		
12:2 FTO	97		580		160		
8:2 FTOAc	610		90		490		
10:2 FTOAc	99		19		140		
6:2 FTMAc	3,800		56		150		

"Concentrations of 6:2, 8:2, and 12:2 FTOH and 5:2 and 7:2 sFTOH consistently exceeded the upper limit of developed calibration ranges; therefore, both a minimum concentration (assuming the highest calibration concentration) and a maximum extrapolated concentration are provided. Italicized values denote a minimum concentration. Column "E" presents average maximum concentrations. "ND" denotes non-detect measurements. FTAcs, FASAs, FASEs, FTIs, and 8:2 FTMAc were not detected in any samples. Analyte acronyms and details are provided in Table S-5.

temperature was recorded using an Optimax Biogas analyzer (MRU Instruments, Humble, TX). Duplicate sampling trains were connected to existing gas well sampling ports. Approximately 1,200 L was sampled through each train at a flow rate of 5 L min⁻¹. After sampling, PUF/XAD-2 cartridges were sealed and individually stored at ≤ 4 °C for transport/ storage. Quality control (QC) procedures are provided in the SI, section 2.

2.3. Extraction and Analysis. Spent XAD-2 from each cartridge was weighed and transferred to a 50 mL polypropylene centrifuge tube and vortexed, and approximately 2 g aliquoted for extraction. Samples were spiked with a mixture of mass labeled IS (Table S-5), rotated end-over-end for 18 h in 4 mL of 75/25% (v/v) ethyl acetate and methanol, and centrifuged for 10 min at 4,000 rpm. Supernatants were transferred to 15 mL centrifuge tubes, and the extraction process was repeated, combining supernatants from the two-fold extraction. Extracts were concentrated to 3 mL via gentle nitrogen evaporation, aliquoted, and stored no more than 30 days at -20 °C until analysis. QC details are provided in the SI, section 2 (Table S-6 and Figure S-1).

Targeted analysis of 27 neutral PFAS by positive chemical ionization (PCI) with selected ion monitoring (SIM) was conducted using a Thermo Scientific TRACE 1310 gas chromatograph coupled to a Thermo Scientific Orbitrap Exploris GC 240 mass spectrometer (GC-HRMS; see SI, section 2 for details regarding GC separations and instrumentation). A 12-point external calibration curve (from 1 to 2,000 pg μ L⁻¹) was developed for quantitation, prepared through serial gravimetrically derived dilutions of primary stock solutions. A mixture of mass labeled IS at concentrations of 150 pg μ L⁻¹ was added to each calibration level. When a labeled standard was not available for a compound, a labeled standard with a similar retention time or structure was utilized for quantitation (Table S-5).

3. RESULTS AND DISCUSSION

Unexpectedly, several neutral PFAS concentrations in LFG exceeded the implemented calibration levels. Because of

considerable exceedance for some compounds, dilution would reduce IS below instrument detection; therefore, in instances where sample concentrations exceeded calibration limits, two concentrations are presented (Equation S-1): a minimum value which assumes the highest calibration concentration and a maximum extrapolated concentration. Fluorine mass release calculations utilize minimum values, preventing overextrapolation while providing a conservative estimate for leachate comparison. Even under these assumptions, substantial concentrations of neutral PFAS, higher than those previously observed, were identified. Future assessments should deploy shorter sampling durations to refine findings.

3.1. Neutral PFAS in Landfill Gas. Except for 4:2 FTOH in one landfill, 13 PFAS were detected in duplicate samples across the three sites (site characteristics are provided in Table S-9). Observed concentrations are displayed in Table 1. At minimum, combined concentrations of neutral PFAS in LFG ranged from 22,000 to 33,000 ng m⁻³. Considering extrapolated values, total concentrations ranged from 210,000 to 940,000 ng m⁻³, an order of magnitude higher than those previously reported in LFG.³⁹

3.1.1. FTOHs and sFTOHs in Landfill Gas. Like previous studies on LFG and air surrounding landfills, FTOHs dominated neutral PFAS concentrations;^{28,31,32,39,40} however, extrapolated concentrations in this study surpassed previous reports in LFG, in some cases by 2 orders of magnitude, and were more comparable (although much lower) to concentrations recently identified in soil vapor near a PFAS manufacturing facility.⁵⁵ While there are uncertainties given the degree of extrapolation, the magnitude of FTOHs found in this study compared to existing research suggests fundamental differences potentially related to sampling methodology (e.g., much larger sampling volumes) and/or sampled landfill characteristics (e.g., waste type, age, air intrusion), although these data were not available for comparison. Across the three sites, 6:2, 8:2, and 10:2 FTOH, combined, made up 87 to 97% of total concentrations, but 8:2 FTOH alone constituted 50 to 79%. The shortest and longest analyzed homologues, 4:2 and

12:2 FTOH, were significantly lower in concentration (Table S-10). This is supported by previous FTOH distributions determined from source fluoro-telomer polymers⁶² and observations in LFG, urban air, and air surrounding wastewater treatment/landfill sites.^{28–31,39,40,63} Concentrations of 12:2 FTOH were of similar magnitude to those in Titaley et al., but 4:2 FTOH has not been detected in LFG, suggesting MSW landfills to be a previously unidentified potential source of atmospheric 4:2 FTOH.³⁹

Secondary FTOHs have not been targeted in gas-phase landfill research but have been identified in condensate associated with LFG collection systems.³⁷ As intermediary byproducts of 6:2 and 8:2 FTOH biodegradation to PFAAs, 5:2 and 7:2 sFTOH, were unsurprisingly elevated, they were at least an order of magnitude lower than respective parent FTOH homologues.^{64–66} All detections of 5:2 sFTOH and two out of three detections of 7:2 sFTOH were above calibration, combined sums attributed to 2 to 10% of total concentrations.

3.1.2. Other Neutral PFAS in Landfill Gas. Other neutral PFAS fell within acceptable calibration ranges and together accounted for 0.22 to 1.9% of total concentrations. FTO homologues have been encountered in other LFG and ambient air studies, but in past assessments 8:2 and 10:2 FTO were below limits of quantitation and 12:2 FTO concentrations were consistently an order of magnitude higher than those reported here.^{39,59} To the authors' knowledge, 8:2 and 10:2 FTOAc and 6:2 FTMAc have not been determined in LFG. FTOAcs are not commonly assessed analytes but are associated with fluoropolymer textile treatments and have been identified in one indoor air study from Japan.^{67,68} Similarly, 6:2 FTMAc has only been analyzed in a few studies on cosmetics and wastewaters but at lower concentrations.

3.2. Comparative Fluorine Mass Release between Landfill Byproducts. Normalizing PFAS concentrations on a fluorine basis allows comparisons to be drawn between different matrices and PFAS types (e.g., gas—liquid, neutral ionic, precursor—terminal). This methodology is widely used to assess the "mass balance" of PFAS within systems, given that the long-term environmental fate of measurable PFAS is transient, whereas the mass of fluorine is conserved.^{17,72,73}

Here, the same approach is utilized to compare the PFAS mobility in leachate versus LFG pathways. Neutral (Table 1, minimum values) and ionic (Table S-4) PFAS concentrations in LFG and leachate from this study were individually normalized to a mass of fluorine (Equation S-2) using compound specific fluorine mass fractions (Table S-8). Summed fluorine masses in leachate and LFG were then scaled according to site-specific annual generation volumes reported for each landfill (Table S-9).41 A caveat of this comparison is the absence of measurements for neutral species in leachate and ionic species in LFG; however, the literature suggests FTOHs (the dominant neutral class identified) predominantly exist in the gaseous phase, while PFAAs exist in liquid or particulate phases.^{28,74} Subsequent research should assess neutral and ionic compounds in both matrices to validate findings and further elucidate the PFAS behavior in landfills.

Even utilizing minimum concentrations observed in LFG, equal magnitudes of fluorine release are observed between LFG and leachate at each site (Figure 2)—contrasting from existing estimates of PFAS mass flow from landfills.⁹ Existing



Figure 2. Annual fluorine mass release in landfill leachate versus landfill gas (LFG) from three municipal solid waste landfills in Florida. Fluorine masses in leachate are derived from ionic PFAS (\sum_{93} PFAS) concentrations measured in leachate from each site (Table S-4) multiplied by the annual leachate generation volume and scaled using each detected compound's fluorine mass fraction (Tables S-8, S-9). The same methodology was applied for neutral PFAS (\sum_{27} PFAS) in LFG by using the average of minimum concentrations (Table 1). Asterisked (*) values denote input FTOH/sFTOH concentrations which were above calibration levels developed for this study and therefore assumed to be at the highest calibration concentration. Consequently, these findings should be viewed as minimum values which conservatively estimate the magnitude of PFAS mobility in leachate versus LFG.

estimates, based on limited data, suggest that most PFAS mass mobilized from landfills releases through leachate (\sim 62%).⁹ However, our data from Landfill 1, showing over 76% fluorine release in LFG, along with substantial masses released by LFG in Landfills 2 and 3 (at minimum 40% and 32%, respectively), indicate that LFG may serve as an equal, likely greater, conduit of PFAS mobility from landfills than leachate, concurring with previous reactor studies on FTOH volatilization and neutral/ ionic PFAS assessments of select waste materials.^{17,75,76}

At least 79 to 92% of the fluorine mass in LFGs were derived from FTOH/sFTOH classes, with minimal contribution from FTOs, FTOAcs, and FTMAcs. In this conservative assessment, fluorine from LFG surpassed leachate in only Landfill 1. Although actual fluorine emission from LFG is higher than reported here, the elevated ratio of gas-to-leachate generation at Landfill 1 likely caused this difference (Table S-9). Landfill 2, the largest site, demonstrated the highest combined fluorine release from leachate and LFG, followed by Landfill 3, and then Landfill 1, corresponding to descending waste mass in place at each location.

4. IMPLICATIONS

This study provides fundamental data about neutral PFAS in LFG from MSW landfills. Unexpectedly, FTOH/sFTOH detections in LFG from this study exceeded implemented calibration levels; subsequent research should deploy shorter sampling durations. Regardless, even under more conservative assumptions these findings suggest that LFG, largely unscrutinized for PFAS, contains similar or greater magnitudes of PFAS compared to leachate, mostly attributed to midlength FTOH homologues. As landfills can be viewed as unabating PFAS repositories, the significance of LFG management in mitigating the long-term, long-range atmospheric transport of

neutral PFAS, and subsequently derived PFAAs, cannot be understated. Unlike landfill leachate, LFG collection systems (when in place) are not fully efficient, collecting an estimated ~50–70% of generated biogases.⁷⁷ Though this is a considerable collection efficiency of biogas and presumably neutral PFAS, management of captured LFG fractions varies globally, from no treatment to degrees of carbon filtration and thermal treatment (i.e., flaring, advanced renewable natural gas technologies). Because the feasibility of PFAS destruction through thermal treatment remains unclear, research is needed to determine the treatment/removal efficiency of existing LFG management technologies. Considering the range of LFG capture efficiency, the retention and emission of neutral PFAS via fugitive emissions (i.e., migration through the waste layer) should also be examined, along with the role of landfill waste type, age, and temperature in neutral PFAS variability.

ASSOCIATED CONTENT

3 Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.estlett.4c00364.

Acronyms, structures, and instrumental parameters for neutral PFAS via GC-HRMS and ionic PFAS via LC-MS/MS; detailed QC information and results; and fluorine mass balance/extrapolation details and assumptions (PDF)

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Notes

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