BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

In the Matter of:	)	
	)	R 2022-018
PROPOSED AMENDMENTS TO	)	
GROUNDWATER QUALITY	)	(Rulemaking – Public Water Supply)
(35 ILL. ADM. CODE 620)	)	

NOTICE OF FILING

To: ALL PARTIES ON THE SERVICE LIST

PLEASE TAKE NOTICE that I have today electronically filed with the Office of the Clerk of the Illinois Pollution Control Board, the **PRE-FILED ANSWERS OF ERIC BALLENGER ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION**, copies of which are hereby served upon you.

Dated: November 23, 2022

By /s/ Claire A. Manning

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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

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) R 2022-018
PROPOSED AMENDMENTS TO)
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PRE-FILED ANSWERS OF ERIC BALLENGER ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION

QUESTIONS FROM THE ILLINOIS POLLUTION CONTROL BOARD

23. *On page 2, you state that it should be understood by the regulating agencies and the Board that landfills are receivers of PFAS, not users or producers. Please comment on whether most of the contaminants in landfill leachate are derived from wastes received by the landfills and not produced by the landfills.*

    ANSWER: Waste companies provide a public service by disposing of waste created by the public in landfills that have been constructed in accordance with regulatory standards long considered safe – utilizing regulatory design standards that include liners and leachate collection systems. PFAS contaminants in landfill leachate would derive from the legally authorized waste received by the landfill and disposed of therein, which includes waste with PFAS-containing compounds. This includes many common household products, food packaging, commercial waste, WWTP biosolids, and many other common MSW Landfill waste streams.

    See Attachment A, Letter to USEPA in Docket ID No. EPA-HQ-OLEM-2019-0341, Nov. 7, 2022.

    See Attachment B, Letter to USEPA from NWRA and Solid Waste Association of North America, in Docket ID No. EPA-HQ-OLEM-2019-0341, Nov. 7, 2022.

24. *On page 2, you state, "this will affect 807 sites as well as "greenfield" sites all the way through post-closure of currently active facilities."*

    a. *Regarding Part 807 facilities, please clarify whether you are referring to landfills or all types of waste disposal facilities regulated under that Part.*

       ANSWER: The concern throughout my comments is that we do not know how IEPA intends to implement these new strict groundwater standards in the context of the landfill regulations, and we have no idea or control over when or whether the IEPA might seek to change the landfill regulations to address these concerns. Thus, we are forced to address the issues based upon our experience with IEPA implementing other Board-promulgated groundwater standards at landfill sites.

Our further concern here is that given the very strict standards proposed, and the ubiquitous nature of PFAS, the proposed standards may not be achievable and/or may reflect background conditions unrelated to possible landfill releases – forcing environmental violations without properly assessing actual environmental or public health risk in the context of landfill operations.

As to the Board's specific question, I am referring to all permitted landfills that have groundwater monitoring obligations – recognizing of course that any landfill still regulated under Part 807 has long ago closed and, while it has different obligations than newer landfills regulated pursuant to Part 814, some old waste units continue to be regulated under Part 807 and still have groundwater monitoring obligations as the IEPA has not released those areas from post-closure care.

b. *If you are referring to landfills, please comment on whether landfills in the State that are still being regulated under Part 807 or they generally regulated under Parts 813 and 814.*

ANSWER: See above**.**

c. Please explain what you mean by "greenfields" in the above statement.

ANSWER: Greenfields is a term used to describe the site upon which a new landfill facility may be located.

25. *On page 2, you state, "data reported by others in various studies and sample results for our landfills in other states indicate PFAS will be detected in landfill leachate especially at such proposed conservative low detection limits."*

d. Please submit the studies you mention above and PFAS sampling data from your landfills in other states into the record.

ANSWER: See Attachment C, Michigan Waste & Recycling Association Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent. March 1, 2019.

See Attachment D, North Carolina Collective Study Report, March 10, 2020.

e. In what states are your landfills located where PFAS were sampled? Do these states require monitoring of PFAS constituents?

ANSWER: Where sampling has occurred, it was generally upon the request of a POTW who is accepting leachate from a nearby landfill or by a request of the relevant regulatory agency. I am aware that limited sampling of leachate and/or groundwater monitoring for PFAS has occurred in New Hampshire, Vermont, Michigan, North Carolina, and California, but I am not aware that it has been mandated by state regulation.

f. *Please clarify whether the PFAS data reported in various studies attribute the presence of PFAS to the waste generating the leachate or to leaching of PFAS from monitoring systems, sampling and/or laboratory equipment.*

ANSWER: Most PFAS in leachate comes from source materials (i.e., waste) but most of that PFAS is sequestered in (remains in) landfills. Yet, some PFAS results from contamination in sampling. Various state sampling Guidance (e.g., Michigan) advise numerous protocols in sampling since PFAS can be introduced from monitoring and sampling equipment or procedures because these compounds are present in so many products and even can be present in rainfall.

See Attachment E, WasteAdvantage article, November 2, 2020.

26. *On page 3 you state because of PFAS background conditions landfills would be required to perform multiple sampling events of upgradient wells and potentially all wells if intrawell statistical values are permitted. Please comment on whether this is the case for any contaminant that is detected in the landfill leachate not just PFAS.*

ANSWER: Since PFAS compounds are so ubiquitous, and potentially in the well materials or sampling equipment, whether in the upgradient well or within the pumping mechanism, the upgradient well and pumping mechanism will have to be fully investigated – and that would not be true for other parameters where there is no concern related to PFAS in the well or sampling instrument itself.

27. *Also on page 3, you state that dedicated sampling systems may include materials with PFAS that have nothing to do with impacts from the facility.*

a. *Please clarify whether PFAS detected in groundwater monitoring wells may be leaching from the sampling systems as opposed to coming from the waste.*

ANSWER: Yes, see response 25.f. There are many sampling sources that might contribute to PFAS detections in monitored groundwater.

See Attachment F, Best Practices for Optimizing PFAS ANALYSIS, Shimadzu

See Attachment G, An Equipment Manufacturer's Perspective on Regulatory Guidance and Ambiguity on PFAS in Groundwater Sampling, QED Environmental Systems, Inc. 2020.

b. If so, what's the basis for your statement? Have there been any studies done to indicate that well monitoring systems contribute significant amounts of PFAS in relation to the amounts leaching from the waste disposed in the landfill? If there are, please submit them into the record.

ANSWER: What is a “significant” contributor in the context of PFAS monitoring remains to be seen, given the very stringent nature of the proposed and developing regulations. I am aware that studies are ongoing. See above answer for guidance offered by equipment manufacturers and laboratories.

28. *On page 3, you repeat your concerns regarding contamination associated with lab or sampling equipment with respect to analysis of PFAS in landfill leachate.*

    a. *Is it your position that any analysis of PFAS in leachate or groundwater samples would be suspect because of contamination from sampling or lab equipment?*

    ANSWER: See previous answers.

    b. *If so, do you have any alternatives for protecting groundwater from potential PFAS contamination from landfills?*

    ANSWER: Neither the proposed regulations nor the existing landfill regulations address cross contamination from laboratory or sampling or well sources. Those should be addressed.

    Further, we believe the federally derived landfill regulations, which require synthetic liners and leachate collection systems, are effective in containing PFAS in landfills. Nonetheless, given the ubiquitous nature of PFAS, more research is required as to the actual potentiality of PFAS-related groundwater contamination from landfills or landfill leachate before the Board adopts such a stringent standard, based upon toxicology that is relevant to human (i.e., infant) consumption, that would then be used, as it has been used historically, to require strict compliance at sources that have no immediate link to human consumption. We certainly support strict standards for drinking water, but we would urge a better understanding of actual risks to human health and the environment prior to adopting such a strict standard as a general groundwater standard applicable to all potential sources throughout Illinois – making them immediately subject to enforcement for any detections above the limit.

    One of the approaches taken by other states is to require screening sampling of PFAS at groundwater near landfills prior to determining if further screening or regulatory monitoring is required, consistent with potential receptors.

    Another approach we would urge is that the Board delay applicability of the PFAS groundwater standard as an enforceable standard as to landfills until it has had an opportunity is to review the landfill regulations in a public hearing and make whatever revisions might be necessary to allow for a reasonable and environmentally protective, but economically reasonable and technically feasible, approach to these ubiquitous emerging contaminants as it relates to landfills. As is, the IEPA has not committed when or whether it will seek to amend the landfill regulations to address the waste industry’s concerns.

29. *Regarding ground water impact assessment (GIA) at landfills, you state that the current modeling requirements have the potential to be substantially affected and become unreasonably complicated. Please comment on whether the Board's Part 811 landfill regulations could be modified to accommodate concerns regarding application of GIA provisions to PFAS.*

    ANSWER: Yes, revising or removing the GIA provisions, and/or making them inapplicable to PFAS compounds, and potentially other compounds, would be a welcome change. My understanding is that the GIA provisions (not required in other states) were designed to predict whether a landfill will fail (i.e., leak). Yet, in my years of experience in Illinois there is no Subtitle D landfill designed cell that I've worked on that has leaked (i.e., caused groundwater contamination from leachate). Given that the IEPA's implementation of the GIA provisions requires the contaminant transport model to presume the most conservative input parameters (i.e., provide the highest predicted model concentration), the landfill industry has significant reason to believe that the GIA model will fail when inputting the PFAS compounds – and will not be an accurate predictor of PFAS contamination from leachate. A failed GIA model will halt development of new or expanded landfills – and may have other adverse permit repercussions.

    The IEPA's current GIA implementation methods are designed to obtain absolute results, based upon overly conservative presumptions, which contribute to the complexity of the GIA. A passing or failing model may be determined by a concentration of one part per billion. Prior to implementation of the proposed rules as standards applicable in the Board's solid waste rules, a thorough evaluation of impacts to the GIA (35 IAC 811.317) should be conducted. By reference, impacts to the GIA will also affect the Assessment of Potential Groundwater Impact defined in 35 IAC 811.319(c) and Corrective Action Measures Assessment provided in Section 811.324.

30. *On page 4 regarding treatment of landfill leachate at publicly owned treatment works (POTWs), you state that there is a significant risk that POTWs will begin to refuse landfill leachate due to concerns about PFAS.*

    a. *Please comment on whether you are aware of any specific POTW in the states you operate that currently do not accept landfill leachate for treatment.*

       ANSWER: Bloomington-Normal Water Reclamation District has advised that it will discontinue accepting leachate from McLean County Landfill, effective January 1, 2023.

    b. *Are you aware of any state or federal PFAS surface water quality standards or NPDES (National Pollution Discharge Elimination System) permit limits that may cause POTWs to refuse acceptance of landfill leachate containing PFAS?*

       ANSWER: I understand that Michigan has begun to add PFAS compliance limits for certain POTWs during permit renewals.

31. *On Page 5, you state that landfills monitor water bearing units that are not potable water sources and we believe that setting potential "drinking water limits", i.e., Class I limits, in these zones is not warranted.*

    a. *Please clarify whether you are referring to "zone of attenuation" under Part 811.*

       ANSWER: The location of the water-bearing unit may or may not be within the zone of attenuation. Many of these water-bearing units are isolated and not functional for obtaining water for potable uses due to the limited extent of the zone, low hydraulic conductivity of the deposit, or limited quantities available. Since these are not viable sources of potable water, there is no reason to apply the Class I or Class II standards. Adjustment of the Class standard should be allowed for such units.

    b. *If so, are you aware that groundwater within the "zone of attenuation" is classified as Class IV under Part 620 where Class I standards will not apply.*

       ANSWER: Yes, I am aware that Section 620.240(a) states that groundwater within a zone of attenuation is Class IV – but that's not how these regulations work in practice. The Class IV standards for organic constituents (as PFAS is) will default to Class II, except for a few not relevant here. As to PFAS constituents, as with many other organic constituents, the Class II standards are equivalent to the Class I standards – and that's what's being proposed here.

    c. *If not, clarify whether you are referring to Class I groundwater outside the zone of attenuation that is currently not being used as a drinking water source.*

       ANSWER: See above answer, but also when evaluating risk to public health and environment, actual risks associated with whether the water will be used as a potable water source should be considered – and to not do so is to not properly evaluate economic reasonableness and technical feasibility.

CERTIFICATE OF SERVICE

I, the undersigned, certify that on this 23rd day of November 2022, I electronically served the **PRE-FILED ANSWERS OF ERIC BALLENGER ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION** upon the individuals on the attached service list. I further certify that my email address is cmanning@bhslaw.com.

Dated: November 23, 2022

By /s/ Claire A. Manning

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November 7, 2022

Submitted electronically to: *https://www.regulations.gov*

Ms. Michelle Schutz
Office of Superfund Remediation and Technology Innovation (5202T)
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Re: Docket ID No. EPA-HQ-OLEM-2019-0341; Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances

Dear Ms. Schutz:

The undersigned organizations—representing “passive receivers” of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) that may be present in drinking water, wastewater, and solid waste facility influent—are concerned that the U.S. Environmental Protection Agency’s (EPA’s) proposal to designate these compounds as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), without accompanying relief, could result in significant increased costs for essential public service providers and the communities they serve while undercutting the Administration’s broader human health and environmental protection goals.

Drinking water treatment plants, municipal wastewater treatment facilities, and solid waste landfills and composting facilities neither manufacture nor use per- and polyfluoroalkyl substance (PFAS); instead, they are passive receivers of media containing PFAS—compounds that are ubiquitous in the stream of commerce and environment. Each of these public services is interdependent; landfills rely on wastewater treatment facilities for their leachate discharge while water and wastewater treatment facilities depend on landfills for biosolids management and disposal of spent water filtration systems. Designating PFOA and PFOS as CERCLA hazardous substances would disrupt this interdependence by driving each sector to revisit its acceptance of influent streams containing concentrations of PFOA and PFOS.

CERCLA designation thus would lead to significant cost increases on public service providers and the communities they serve while impeding EPA’s commitments espoused in the agency’s PFAS Strategic Roadmap:

- There currently are no cost-effective techniques available to treat or remove PFOA or PFOS for the sheer volume of drinking water, wastewater, and landfill leachate managed daily by passive receiver facilities, as advanced treatment techniques at this scale are very costly. Undertaking additional treatment for PFOA and PFOS would add significantly to the costs of facility operation.
- Drinking water and wastewater facilities must manage media containing concentrations of PFOA and PFOS generated from influent treatment. The management of biosolids via incineration or land application, for example, is under increasing scrutiny in many states, and any additional disruption to available disposal outlets could result in additional cost increases for wastewater treatment.
- Passive receivers could be held liable for the entire cost of cleanup of a contaminated site, both on a prospective basis and for lawful activities going back decades. Regardless of EPA’s use of enforcement discretion in initiating remedial actions, CERCLA designation would result in third-party contribution and cost recovery claims, likely leading to substantial litigation costs for public service providers and the communities they serve.
- These foreseeable cost increases, combined with actions taken by passive receivers to curtail acceptance of influent with concentrations of PFOA or PFOS, could impact the ability of some public service providers to continue operating, frustrate EPA cleanup activities around military installations and other affected communities, and disproportionately impact low-income communities that rely on the affordability of passive receiver services.

ATTACHMENT A

The undersigned organizations recommend that EPA, the Interagency Policy Committee on PFAS, and the broader Administration acknowledge the full unintended consequences of the proposed rule, evaluate all relevant authorities that could provide relief to passive receivers and the communities they serve, and reinstate the “polluter pays” principle of the statute in lieu of a “community pays” approach in which public service providers would be subject to CERCLA liability. Thank you for your consideration of our input, and we look forward to continuing to partner with EPA on actions to address PFAS under the PFAS Strategic Roadmap.

Sincerely,

Scott D Grayson

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National Waste & Recycling Association℠
Collect. Recycle. Innovate.

SWANA
SOLID WASTE ASSOCIATION OF NORTH AMERICA

November 7, 2022

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Washington, DC 20460

Re: Docket ID No. EPA-HQ-OLEM-2019-0341; Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances

Dear Ms. Schutz:

The National Waste & Recycling Association (NWRA) and Solid Waste Association of North America (SWANA) are pleased to submit comments on the U.S. Environmental Protection Agency's (EPA's) proposal to designate perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). NWRA and SWANA represent companies, municipalities, and professionals in the solid waste industry. NWRA is a not-for-profit trade association representing private solid waste and recycling collection, processing, and management companies that operate in all fifty states. SWANA is a not-for-profit professional association in the solid waste management field with more than 10,000 members from both the private and public sectors across North America. Members of both organizations strive to deliver collection, composting, recycling, and disposal services that are protective of the environment in a safe, science-based, and technologically advanced manner.

NWRA and SWANA members are pleased that EPA has committed to numerous actions under the agency's PFAS Strategic Roadmap to safeguard public health, protect the environment, and hold accountable manufacturers and heavy users of these compounds. Our sector also supports EPA's focus on broadening and accelerating the cleanup of per- and polyfluoroalkyl substance (PFAS) contamination; nevertheless, we are concerned that designating PFOA and PFOS as CERCLA hazardous substances, without providing accompanying relief in recognition of the unique role served by the solid waste industry, would impede cleanup efforts and lead to substantial environmental cleanup liability, impose significant additional costs on essential public services and their customers, and have broad repercussions throughout the economy, without any measurable environmental benefit. We therefore request that EPA consider these comments in ensuring that the rulemaking adheres to the "polluter pays" principle of CERCLA.

ATTACHMENT B

I. Modern Landfills are Effective Solutions to Manage Wastes Containing PFAS.

Modern landfills are essential public services[1] that are subject to extensive and evolving federal, state, and local environmental, health, and safety requirements, including the Resource Conservation and Recovery Act (RCRA), the Clean Air Act, and the Clean Water Act. Regulations established under Subtitle D of RCRA establish minimum federal criteria for the operation of municipal solid waste, industrial waste, and special waste landfills, including design criteria, location restrictions, financial assurance, strict environmental monitoring, corrective action protocols (if triggered), and closure and post-closure periods to ensure facilities will not be a threat to human health and the environment. Similarly, Subtitle C of RCRA and its accompanying regulations govern the permanent disposal of hazardous wastes, and these facilities employ even greater environmental controls, which can include double liner systems, waste immobilization techniques, advanced leachate collection systems, extensive groundwater monitoring systems, offsite discharge mitigation protocols, leak detection systems, and enclosed and controlled offload areas. Both Subtitle C and Subtitle D landfills are highly regulated by permit(s) at the state level, as they typically are subjected to additional monitoring obligations as well as construction and operational requirements that go beyond the federal framework.

As a result of the stringent environmental controls required by federal and state regulation, and in recognition of our role as stewards of the environment, our industry has made significant investments to ensure that landfills are designed, constructed, and operated to reduce their environmental impact. For these reasons, EPA recognized in its *Interim Guidance on the Destruction and Disposal of PFAS and Materials Containing PFAS* that disposal of PFAS-contaminated wastes at hazardous or solid waste landfills can be effective options for managing PFAS by sequestering these compounds and preventing society from being re-exposed.[2]

II. The Proposed Rule would Replace CERCLA's "Polluter Pays" Principle with a "Community Pays" Model, Imposing Significant Costs on Landfill Customers and Ratepayers.

It is important for EPA to recognize that landfills neither manufacture nor use PFAS; instead, they are passive receivers of materials containing PFAS—compounds that are ubiquitous in residential and commercial waste streams—that must be managed once discarded. Research has shown that landfills effectively sequester a high percentage of PFAS compounds, especially longer-chain compounds such as PFOA and PFOS.[3] As rain percolates through landfills, the liquid will pick up some contaminants including a small amount of PFAS compounds not sequestered in the landfill environment. The resultant liquid is called leachate. Landfills are legally required to remove leachate from landfill collection systems and to properly manage this wastewater in order to protect groundwater resources. These management techniques can include onsite management, treatment prior to disposition or discharge, or collection and transport to wastewater treatment facilities. All of these activities are subject to regulatory permitting and oversight.

Despite the stringent management processes currently followed by our industry, a designation of PFOA and PFOS as CERCLA hazardous substances virtually guarantees that private parties—manufacturers of these compounds and other parties responsible for site contamination—will bring CERCLA claims for contribution

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[1] *See Guidance on the Essential Critical Infrastructure Workforce: Ensuring Community and National Resilience in COVID-19 Response*, V. 4.0, CYBER SECURITY & INFRASTRUCTURE SECURITY AGENCY (Aug. 18, 2020).

[2] *See Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances*, U.S. ENVT'L PROT. AGENCY (Dec. 18, 2020), *at* https://www.epa.gov/system/files/documents/2021-11/epa-hq-olem-2020-0527-0002_content.pdf.

[3] *See, e.g., PFAS Waste Source Testing Report*, SANBORN, HEAD & ASSOCIATES, INC. (Oct. 2019), *at* https://anrweb.vt.gov/PubDocs/DEC/SolidWaste/OL510/OL510%202019.10.15%20NEWSVT%20PFAS%20Source%20Testing%20Rpt%20-%20Final.pdf.

against landfills and other essential public service providers such as water and wastewater utilities that are also passive receivers of PFAS. Given that CERCLA imposes joint, several, and retroactive environmental cleanup liability to parties connected with the presence of a hazardous substance at a site, designating PFOA and PFOS as hazardous substances will, at a minimum, generate significant litigation costs for lawful PFAS-containing waste disposal and discharges going back decades.

This type of inequitable outcome has occurred in previous CERCLA matters. As an example, industrial parties determined to be responsible under CERCLA for the cleanup of the Passaic River in New Jersey brought contribution actions against 261 third-party defendants—including 70 municipalities and other public entities—contending that they bore site cleanup responsibility. This action resulted in litigation spanning eight years and culminating in a payment of $35.4 million by these minor parties, many of whom were merely passive receivers of the contamination at issue.

Extensive litigation costs, as well as potential significant costs relating to PFAS remediation, would be passed along to communities, drinking water and wastewater treatment facilities, and the biosolids management sector—all of which rely on landfills for disposal of media containing PFAS. These cost increases, as well as similar cost increases passed through to drinking water and wastewater treatment ratepayers, likely would have a significant and disproportionate impact on low-income households that rely on the affordability of services that the waste sector and other passive receivers provide.

III. PFAS Treatment and Residuals Management Will Increase Costs to Communities but Will Not Reduce CERCLA Liability.

It has been suggested that the industry could simply treat leachate to eliminate any PFAS prior to discharging to wastewater treatment plants in order to reduce potential CERCLA liability presented by the proposed rulemaking. This premise is flawed for several reasons. Firstly, implementing treatment methods in the present day and into the future does not address potential liabilities for contribution actions that may be brought for cleanups stemming from prior POTW discharges.

Secondly, this premise does not recognize the current limitations of PFAS treatment technologies and their associated uncertainties and costs. Our industry is at the forefront of developing technologies for PFAS treatment and residuals management, however technologies for PFAS removal from leachate at scale are still developing and require a multi-step process that includes (1) pretreatment of leachate to address non-PFAS constituents, (2) subsequent PFAS treatment using one or more removal technologies (which creates PFAS-containing residuals), and (3) PFAS residuals treatment/management. Since most landfills rely on wastewater treatment plants for their leachate discharge, undertaking leachate pretreatment followed by PFAS treatment will add significantly to the costs of landfill operation.[4] The estimated capital cost to implement leachate pretreatment and PFAS treatment at a moderate-sized landfill (i.e., biological treatment of 30,000-40,000 gallons per day of leachate) to the extent necessary to minimize PFAS in leachate ranges from $2 million to $12 million, or potentially far more.[5] An additional layer of potential CERCLA liability could drive up these costs significantly and would ultimately be borne by the communities that rely on economical solid waste management services instead

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[4] These costs will be driven, in part, by potential future regulation under the Safe Drinking Water Act, Clean Water Act, and other federal and state authorities.

[5] The standards that would govern a PFOA or PFOS cleanup action currently are unclear, complicated by a patchwork of state regulatory standards, unknown criteria that would be required for remedial actions, and EPA's interim drinking water health advisories for PFOA and PFOS. As such, the costs of PFAS treatment borne by landfills and their customers could far exceed these estimates.

of PFAS producers and manufacturers.

Moreover, since current technologies are unable to completely destroy PFAS, further management of residual PFAS waste streams—including biosolids and spent filters—is necessary to stabilize or otherwise limit their ability to reenter leachate. The costs and operational effectiveness for PFAS residuals management is less understood as most technologies have not been evaluated at full-scale. Based on general conversations with technology developers and estimates/extrapolations from small-scale studies, however, we anticipate that implementing new technologies for PFAS removal and subsequent residuals management could increase the costs of treating landfill leachate by approximately $0.06 to $0.39 (potentially even higher) per gallon of raw leachate processed (i.e., a cost increase of at least 400% to 800%). <u>Increased costs associated with PFAS management thus could total approximately $966 million to $8.187 billion per year for municipal solid waste landfills alone.</u> These costs typically cannot be absorbed by local governments with municipally operated landfills.

IV. The Mere Prospect of Designating PFOA and PFOS as CERCLA Hazardous Substances Already is Disrupting the Interdependence of Drinking Water and Wastewater Treatment Facilities, Biosolids Management, and Landfill Operations—and Could Have Much Broader Unintended Consequences on Administration Priorities.

Wastewater treatment facilities generate biosolids as a byproduct of their treatment activities. Similarly, drinking water treatment facilities generate spent filter materials from their operations. Expectedly, these biosolids and spent filter media may contain some amount of PFAS removed from the final treated wastewater and drinking water. Wastewater treatment facilities rely on landfills for biosolids management and drinking water treatment facilities depend on landfills for disposal of filter materials that may contain PFAS. At present, there are three viable options for management of biosolids: incineration, land application, and landfilling. At a time when incineration and land application are increasingly being prohibited, any further disruption to biosolids management could have a tremendous impact on municipal budgets and the environment.

Designating PFOA and PFOS as hazardous substances under CERCLA would impel landfill operators to revisit their waste acceptance criteria, likely choosing to limit inbound wastes with known elevated concentrations of PFAS—including filter materials, biosolids, and impacted soils—and/or increase disposal costs for certain media. Indeed, the mere prospect of a CERCLA designation has begun to disrupt the interdependence of the drinking water, wastewater, and solid waste sectors, as wastewater treatment facilities have begun to prohibit the acceptance of leachate while landfills are considering similar restrictions on the acceptance of biosolids and other PFAS-containing materials.

Regulation of PFOA and PFOS under CERCLA also could inadvertently undercut the Administration's broader environmental goals. The increased costs associated with disposal that are attributable to the rulemaking could incentivize bad actors to seek alternative means of disposal of PFAS-contaminated media and remediation wastes that are less protective of public health and the environment. Landfill operators choosing to limit specific inbound streams of waste containing elevated levels of PFAS also could curtail the ability of some wastewater treatment facilities to continue operating and <u>frustrate EPA and DOD cleanup activities around military installations</u> and other affected communities.

Moreover, EPA's action could lead to decreased composting services nationwide. Food waste compost may contain PFAS due to contact with PFAS-lined packaging materials. As a result, a CERCLA designation could result in communities diverting food waste from organics recycling programs, hindering federal, state, and local climate and waste reduction goals. Finally, and as mentioned above, the increased costs on ratepayers that are attributable to the proposed rule likely will have disproportionate adverse impacts on low-income communities and frustrate the Administration’s broader policies around environmental justice.

V. Recommendations

The solid waste sector and the communities we serve should not be held financially or legally liable under CERCLA for PFAS contamination, as landfills are only passive receivers of PFAS and are part of the long-term solution to manage these compounds. In its proposed designation, EPA announced that it “will use enforcement discretion and other approaches to ensure fairness for minor parties who may have been inadvertently impacted.”[6] We greatly appreciate EPA’s apparent willingness to exercise its discretion to foster equitable outcomes in direct enforcement matters; however, our industry remains concerned that this assurance would not sufficiently insulate landfills from third-party contribution litigation as discussed above. Accordingly, we suggest that concrete liability protections should be implemented in conjunction with this proposed rulemaking and respectfully request that EPA and the Interagency Policy Committee on PFAS[7] consider exercising existing legal authority to provide relief to landfills and other passive receivers of PFAS. *See, e.g.,* 42 U.S.C. §§ 9602(a) and 9615 (providing flexibility in the promulgation of regulations under CERCLA).

In the event EPA opines that it has limited authority to provide the solid waste sector with relief from third-party contribution litigation, the Administration should work with Congress to support a narrow legislative exemption from CERCLA liability in cases where a landfill discharges leachate in compliance with all applicable laws and regulations. Doing so would keep CERCLA liability on the industries that created and profited from these PFAS compounds —not on taxpayers.

Thank you for your consideration of our comments, and we look forward to continuing to partner with EPA to ensure the safe and effective management of waste streams containing PFAS. Should you have any questions about this letter, please contact Anne Germain, COO & SVP of Regulatory Affairs for NWRA, at agermain@wasterecycling.org. You may also contact Jesse Maxwell, Senior Manager, Advocacy & Safety for SWANA, at jmaxwell@swana.org.

Very truly yours,

Darrell K. Smith

Darrell K. Smith
President & CEO
National Waste & Recycling Association

David Biderman
Executive Director & CEO
Solid Waste Association of North America

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[6] *EPA Proposes Designating Certain PFAS Chemicals as Hazardous Substances Under Superfund to Protect People’s Health*, U.S. ENVT’L PROT. AGENCY (Aug. 26, 2022), *at* https://www.epa.gov/newsreleases/epa-proposes-designating-certain-pfas-chemicals-hazardous-substances-under-superfund.

[7] We request that the interagency committee broaden its scope when considering CERCLA liability concerns caused by the use of PFAS-containing firefighting foams at airports to include similar concerns from the waste sector. Just as certain airports are required by law to use firefighting foam containing PFAS, permitting authorities often require landfills to accept waste streams containing PFAS.

Michigan Waste & Recycling Association
Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent

TECHNICAL REPORT

Completed in Collaboration with Michigan Department of Environmental Quality
March 1, 2019
(Second Revision March 6, 2019)

1.0 INTRODUCTION & OVERVIEW

This report summarizes the results of a statewide study completed on behalf of the Michigan Waste & Recycling Association (MWRA) to determine levels of PFOA and PFOS in the leachate of those landfills participating in the study, and to estimate the leachate's relative contribution to the total amount found in wastewater influent at water resource recovery facilities (WRRFs) (aka POTWs or publicly owned treatment works, or sewage or wastewater treatment plants). The study involved testing leachate at 32 active municipal solid waste landfills (Type II landfills) located throughout the state. This report presents general background information on PFAS, summarizes testing results, and summarizes available PFAS information from WRRFs that receive leachate and those that do not.

PFOA and PFOS are two compounds in a class of compounds known as Per- and polyfluoroalkyl substances (PFAS). They have been used for over 50 years in household products such as non-stick coatings in cookware, in stain and water-resistant coatings and fabrics, and in industrial products such as firefighting foam. More recently, certain PFAS compounds were identified as having potentially adverse effects on human health and the environment. In general, PFAS compounds are resistant to natural degradation, and can therefore persist in the environment for a long time.

Each solid waste landfill in the study is licensed by the State of Michigan to accept household, commercial, and industrial solid waste generated by the communities they serve. Some of the wastes received for disposal contain PFAS. Leachate is the liquid that occurs in landfills when rainwater combines with moisture contained within the waste. Chemicals present in the waste may be present in the leachate. The leachate is effectively captured by utilizing engineered liner and active liquid collection systems. A common method of leachate management is through discharge to a local WRRF where it is handled with other household, commercial, and various industrial wastewaters. In this way, leachate is managed in a closed system where there is no direct exposure to the public.

Landfill leachate sent to a WRRF is typically directly discharged via pipeline or stored in onsite tanks prior to being transferred to tanker trucks and hauled to the treatment facility. WRRFs are engineered structures that apply various technologies to treat wastewater to meet certain regulatory criteria prior to discharge of these waters.

In 2018, the Michigan Department of Environmental Quality (MDEQ) and various WRRFs requested that landfills test for PFAS in leachate as part of a statewide effort to better understand the presence of PFAS in the environment and to work toward plans for PFAS reduction, where needed. The information was also useful to examine the interdependent cycle of waste disposal, leachate generation, wastewater treatment, and wastewater sludge disposal.

Rather than participating landfills sampling and reporting individually, the MWRA (with MDEQ concurrence) conducted a collective study involving 32 active municipal solid waste landfills (Type II landfills) located throughout the state. This effort represents one of the largest studies conducted on active landfill leachate to-date. The main objective of the study was to gather information on PFOA and PFOS concentration in leachate at individual landfills and to examine its potential significance to WRRF influent across the state.

NTH Consultants, Ltd, (NTH), a Michigan-based professional environmental and engineering consulting firm, conducted the MWRA study. NTH prepared this technical report that provides testing results for individual landfills, details of the sampling and analysis procedures, characteristic leachate discharge volumes, and available flow and PFAS testing information from the potentially-affected WRRFs.

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2.0 REGULATORY STATUS AND GLOBAL LANDFILL LEACHATE CONCENTRATIONS

2.1 Status Of Regulatory Action In Michigan

Information on various adverse health effects associated with certain PFAS compounds has been evolving since the early 2000's. Two of the most widely-utilized PFAS compounds, PFOA and PFOS, have received early environmental regulatory focus. These and related compounds have been used in thousands of applications worldwide. Largely for these reasons, the manufacture of PFOA and PFOS has been voluntarily phased-out in the United States.

In response to concerns regarding the increasingly common detection of PFAS in the environment, the Michigan PFAS Action Response Team (MPART) was formed by an Executive Directive issued by then-Governor Snyder in November 2017. MPART, a multiagency group, is comprised of a team of local, state, and federal agencies that are working to understand the exposure risks and ways to mitigate PFAS impacts to the environment.

MPART emphasizes the need for cooperation and coordination among agencies at all levels of government charged with identifying PFAS contaminants, informing the public, and mitigating the potential effects.

The EPA established a drinking water health advisory (HA) for PFOA and PFOS of 70 ppt in 2016. Although the HA is not an enforceable drinking water standard, it was established as a protective guidance for the most sensitive subpopulations over a lifetime of exposure. In January of 2018, the MDEQ incorporated the information contained in the HA and established the same 70 ppt value as groundwater cleanup criteria under Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, as amended (Act 451). Currently, this value is used by the Michigan Department of Health and Human Services (DHHS) as guidance when evaluating PFAS concentrations in public and private drinking water supplies.

The MDEQ also promulgated Water Quality Standards (WQS) for PFOA and PFOS in surface water in May 2011 and March 2014, respectively. These WQS values were developed for use by MDEQ when evaluating permits for discharge to surface water and were promulgated in accordance with the Part 4 Rule 57 administrative rules (Rule 57) pursuant to Water Resources Protection (Part 31) of Act 451. Michigan's WQS values include chemical-specific values that represent the water quality values protective of aquatic life, human health, or wildlife; and acute chemical-specific values protective of aquatic life. The applicable most restrictive WQS values developed by the State are listed in below in Table 2-1, Rule 57 Values.

Table 2-1 – Rule 57 Values

Chemicals	HNV (non-drinking water*)	HNV (drinking water**)
PFOS	12 ppt	11 ppt
PFOA	12,000 ppt	420 ppt

HNV: Human Non-cancer Value

ppt: parts per trillion (laboratory reports in nanograms per liter (ng/L)

* "non-drinking water" means the surface water body receiving the discharge is not designated as a public drinking water source

** "drinking water" means the surface water body receiving the discharge is used as a public drinking water source

Other states have or are considering establishing regulatory limits for PFAS compounds. The variability in existing values between states is generally attributable to differences in the selection and interpretation of the choice of uncertainty factors, and the approach used for animal-to-human extrapolation mostly using the same key toxicity data. Differences in values between regulatory agencies may also be due to the choice of exposure assumptions, including the amount of water consumed, life stage used, and the relative source contributions (percentage exposure assumed to come from non-drinking water sources). All of this contributes to the overall uncertainty across the US in how to most appropriately establish risk-based criteria for these compounds and more consistency is needed in this important area.

2.2 Literature Summary Of PFOA & PFOS Concentrations In Landfill Leachate

To provide a basis for comparison of the results of the MRWA landfill leachate study, NTH completed a review of current literature regarding PFOA and PFOS concentrations in landfill leachate. Sources include professional journals, regulatory documents, and government agency websites. A summary of the information we reviewed is presented below.

2.2.1 Worldwide PFOA and PFOS

Literature review focused on documents published over the past 15 years. Two recent and comprehensive publications regarding PFAS concentrations in leachate includes a worldwide perspective by Hamid, et al (2018) and its associated multiple references, and the US-focused paper by Lang, et al (2017).

Unlike Hamid, et al (2018), Lang, et al (2017) focused on an evaluation of climatic effects on leachate PFAS concentrations and associated mass loading to municipal wastewater treatment plants located in the US. This study, which included 87 samples from 18 landfills, representing one of the largest databases of any similar investigation to date, demonstrates PFOA and PFOS concentrations in leachate generally have been decreasing over time, with greater rates of decline in humid regions (i.e., precipitation greater than 75 cm/year), which is where landfills that contain nearly half the annual volume of solid waste disposed in the US are located.

Hamid, et al (2018) compiled data from 11 selected literature sources, published between 2004 to 2017, that include PFAS leachate concentrations from landfills located in Australia, Canada, China, Denmark, Germany, Norway, Spain , Sweden, and the USA . Together, these sources comprise dozens of landfills with a total of more than 162 leachate samples.

To summarize the PFOA and PFOS leachate results from these various studies, we prepared Table 2-2, Study of Literature Study derived from Hamid, et al.'s database (Supplemental Information Table 1) and information from the Lang (2017) et al. study. This information is graphically depicted on Figure 2-1, PFOA & PFOS Concentration in Landfill Leachate (Worldwide – Separate Studies).

Figure 2-2, PFOA & PFOS Concentrations in Landfill Leachate (By Region) summarizes the PFOA and PFOS ranges observed in each of the world regions. As shown, PFOA and PFOS concentrations in landfill leachate vary considerably in different regions of the world and likely reflect the nature of the consumer products and industrial materials used, produced, and disposed in each country. The age of waste materials, as well as climatic conditions to which landfills are subject, appear important factors that govern the rate of degradation of PFAS materials to PFOA and PFOS, both considered "terminal" products of precursor compounds.

In summary, the preceding information reveals a wide range of leachate PFOA and PFOS concentrations worldwide including the United States. China's values are much higher than elsewhere in the world, likely a result of their continued production of consumer goods (as well as industrial waste associated with related manufacturing processes) with PFAS compounds. These products are then distributed throughout the world for purchase, including in the US and eventually disposed.

Figure 2-1

PFOA & PFOS Concentrations in Landfill Leachate
(Worldwide - Separate Studies)

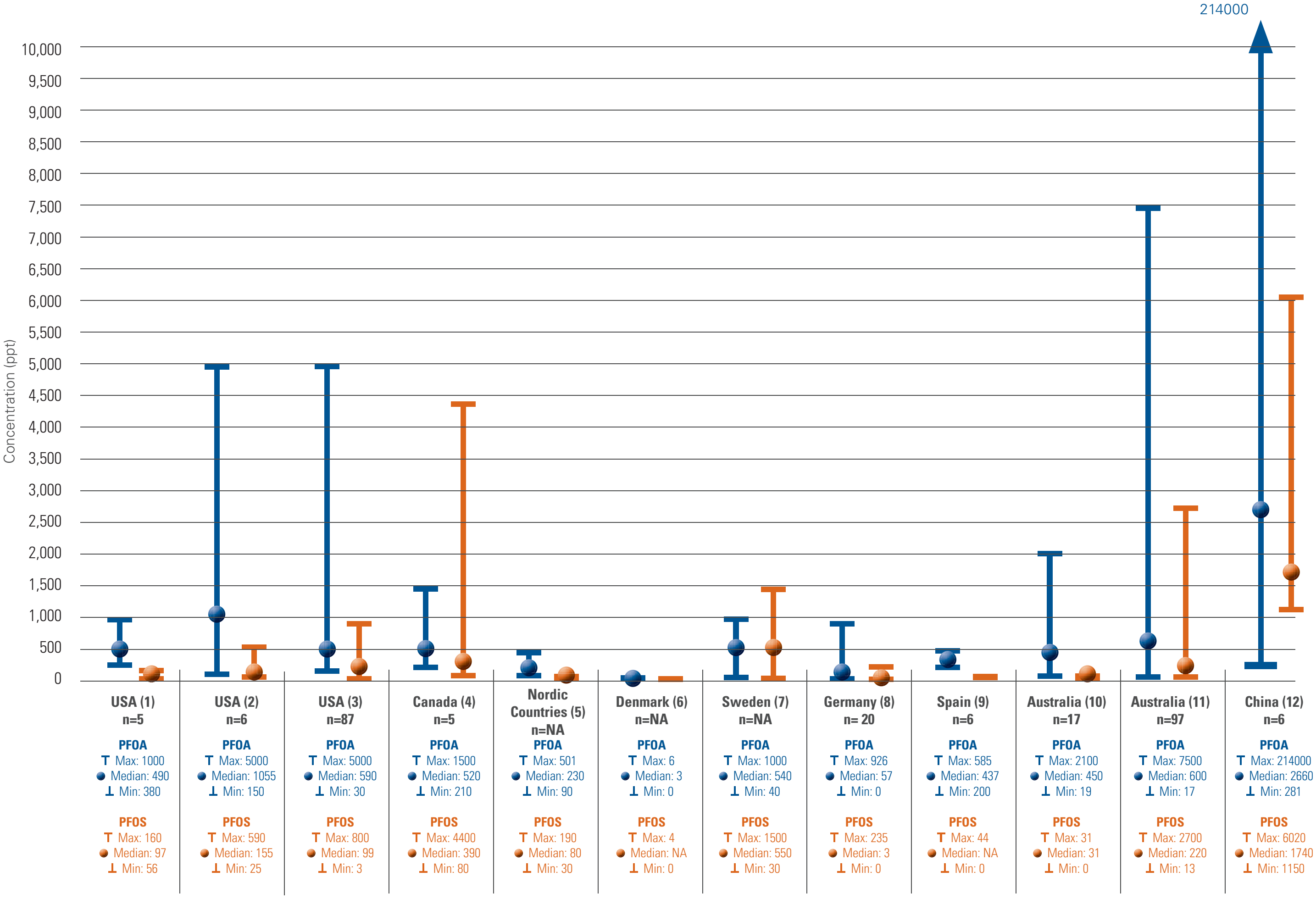


Table 2.2: Summary of Literature Study - PFOA & PFOS Concentrations in Landfill Leachate

Source Cited	Location/ Region	Sample Size	PFOA			PFOS		
			Detection Frequency %	Concentration Range (ng/l)	Median (ng/l)	Detection Frequency %	Concentration Range (ng/l)	Median (ng/l)
1. Huset, et al (2011)	USA	5	100	380 - 1,000	490	100	56 -160	97
2. Allred, et al (2015)	USA	6	100	150 - 5,000	1,055	100	25 - 590	155
3. Lang, et al (2017)	USA	87	100	30 - 5,000	590	96	3-800	99
4. Benskin, et al (2012)	Canada	5	100	210 - 1,500	520	100	80 - 4,400	390
5. Kallenborn, et al (2004)	Nordic Countries	NA	NA	90-501	230	NA	30 - 190	80
6. Bossi, et al (2008)	Denmark	NA	NA	0 - 6	3	NA	0 - 4	NA
7. Woldegiorgis, et al (2008)	Sweden	NA	NA	40 - 1,000	540	NA	30 - 1,500	550
8. Busch, et al (2010)	Germany	20	95	0 - 926	57	100	0 - 235	3
9. Fuertes, et al (2017)	Spain	6	100	200 - 585	437	17	0 - 44	NA
10. Gullen, et al (2016)	Australia	17	100	19 - 2,100	450	89	0 - 100	31
11. Gullen, et al (2017)	Australia	97	64	17 - 7,500	600	65	13 - 2,700	220
12. Yan, et al (2015)	China	6	100	281 - 214,000	2,260	100	1,150 - 6,020	1,740

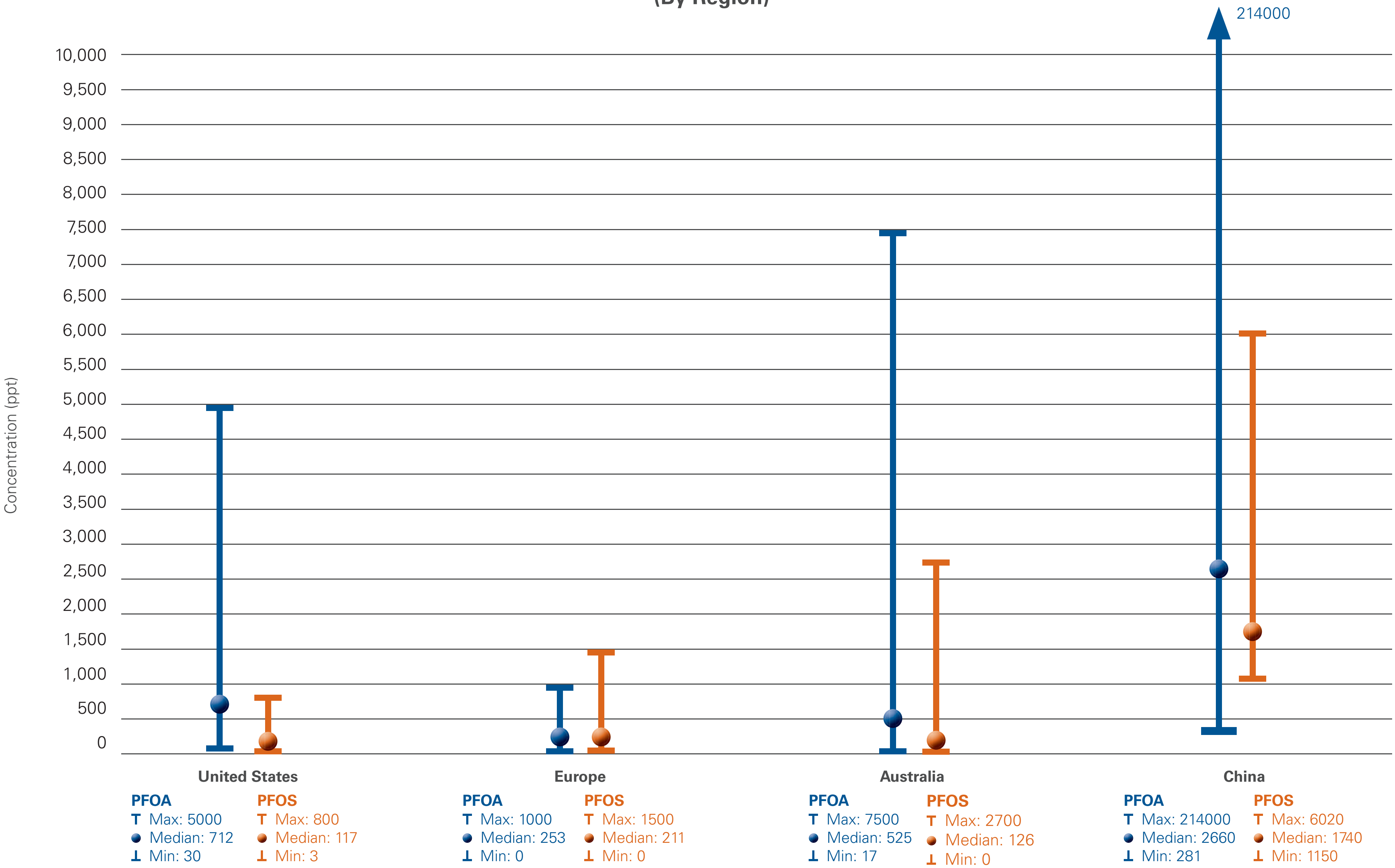


Figure 2-2

PFOA & PFOS Concentrations in Landfill Leachate (By Region)

3.0 LEACHATE SAMPLING PROGRAM

This section includes information regarding the statewide PFAS sampling program participants, along with sample collection methods and analytical techniques. The sampling program included 32 sites located in the Lower and Upper Peninsulas of Michigan, as shown on the attached Figure 3-1, Site Location Map. Each site is an active, Type II, municipal solid waste landfill. As explained later in this report, we included three additional landfills with leachate data available for comparison as part of our overall evaluation. The locations of these three disposal facilities (i.e., City of Riverview Landfill, South Kent County Landfill, and Smiths Creek Landfill) are also shown on Figure 3-1.

3.1 Field Methods

3.1.1 Site Sampling Planning & Coordination

NTH working with Test America Laboratories (TAL) sampled leachate at the 32 MWRA-member landfills over a period of 14 days, beginning on Monday, November 19, 2018, and concluding on Wednesday, December 12, 2018. NTH accompanied TA staff during the first 5 days of sampling to verify TAL followed MDEQ-recommended sampling methods and protocol in the guidance documents referenced below.

NTH contacted each of the 32 participating facilities and requested information including site contacts, leachate system discharge configuration, access limitations, specialized site requirements, pretreatment installations, leachate discharge volume, and receiving WRRF locations. The relevant information from the sites is summarized on Table 3-1, Landfill Leachate Discharge Information.

Additionally, NTH prepared and distributed a sampling schedule based on logistical groupings to maximize efficiency and coordinate acceptable sampling times at each site. NTH remained in contact with TAL to maintain the established schedule according to site-specific approvals. NTH provided TAL the compiled site information for use as a guide during the sampling to help streamline and prepare for the field work.

3.1.2 Sampling Collection Overview

Experienced TAL field staff completed leachate sampling with oversight by Mr. Michael McNamara (NTH) during the first 5 sampling days. Mr. McNamara previously completed PFAS sampling training conducted by the MDEQ in April 2018. The MDEQ training included field-sampling of leachate and groundwater along with the collection equipment blanks using laboratory-supplied PFAS-free water (LSPFW). MDEQ has issued a number of draft guidance documents for PFAS sample collection, including:

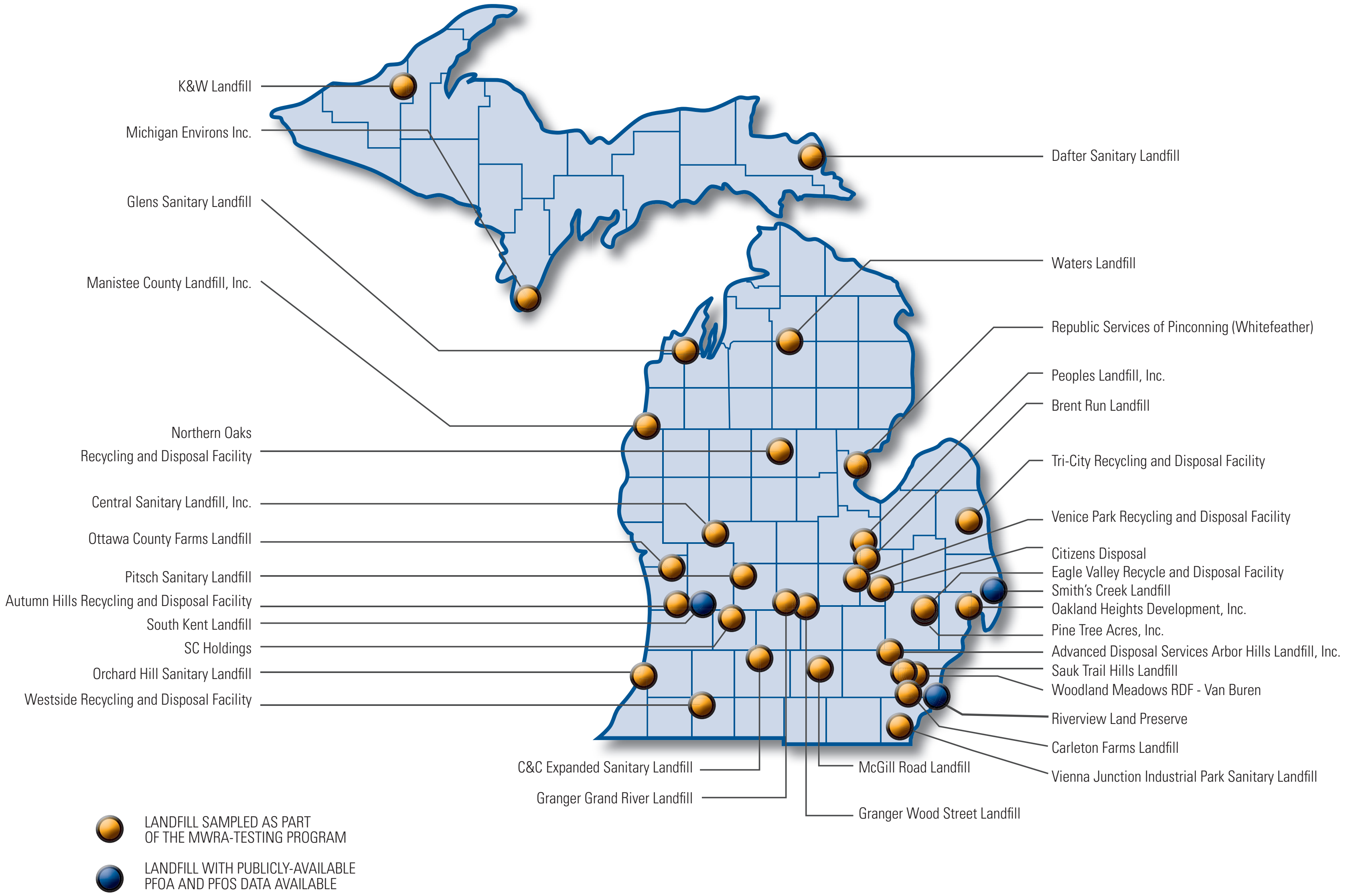
- "Standard Operating Procedure – Collection of Landfill Leachate Samples for Analysis of Polyfluorinated Alkyl Substances (draft)," dated April 2018,
- "Wastewater PFAS Sampling Guidance," dated October 2018, and
- "General PFAS Sampling Checklist," dated October 2018.

Both NTH and TAL reviewed and followed these documents during sampling activities. To maintain consistency and uniformity with the program sampling, TAL dedicated two experienced representatives (Gary Schafer and Zachary Nelson) to this project, who remained involved for the duration of the entire 32-site program, as indicated in Table 3-1. During the first five days of sampling, which included 14 of the 32 sites, NTH accompanied the designated TAL sampling crew and verified that TAL followed the MDEQ PFAS-sampling protocols. A summary of the sampling procedures is included in Appendix A, Sampling and Testing Methods.

3.1.3 Sample Analysis

Consistent with MWRA's agreement with MDEQ, the sample analysis for this study included PFOA and PFOS using EPA Method 537 (modified). This was done to focus the study on the two compounds with Michigan Part 201 and Rule 57 standards. TA analyzed the samples at their Sacramento laboratory following their US EPA Method 537 (modified) standard operating procedures (SOPs).

Figure 3-1



ATTACHMENT C

Table 3-1

Landfill Leachate Generation & Disposal Methods

		LEACHATE DISCHARGE INFORMATION		
MWRA-Member Landfill Designation	**Leachate Treatment Facility**	**Discharge Configuration**	**Pretreatment**	**Approximate Daily Disposal Volume at WRRF (Gallons)**
Discharge to Sanitary Sewer				
ADVANCED DISPOSAL SERVICES ARBOR HILLS LANDFILL INC	Ypsilanti Community Utilities Authority (YCUA) Pump and Haul to CWT eventually discharges to GLWA (~38,000 gpd)	Manhole to Sewer	N/A	60,400
BRENT RUN LANDFILL	Anthony Ragnone WWTP (Genesee County)	Manhole to Sewer	N/A	16,400
CITIZENS DISPOSAL	Anthony Ragnone WWTP (Genesee County)	Manhole to Sewer	N/A	32,900
EAGLE VALLEY RECYCLE & DISPOSAL FACILITY	Great Lakes Water Authroity WRRF (GLWA)	Forcemain to Sewer	N/A	32,900
GRANGER GRAND RIVER LANDFILL	Southern Clinton County Utilities Authority (SCCMUA)	Manhole to Sewer	N/A	64,400
GRANGER WOOD STREET LANDFILL	City of Lansing WWTP (Lansing)	Manhole to Sewer	N/A	19,200
OAKLAND HEIGHTS DEVELOPMENT INC	Clinton River Water Resource Recovery Facility in Pontiac (CRWRRF)	Manhole to Sewer	N/A	17,800
PINE TREE ACRES INC	Great Lakes Water Authroity WRRF (GLWA)	Manhole to Sewer	N/A	74,000
SAUK TRAIL HILLS LANDFILL	Ypsilanti Community Utilities Authority (YCUA)	Manhole to Sewer	N/A	20,500
SC HOLDINGS	City of Hastings WWTP (Hastings)	Direct Discharge	Ammonia Treatment	16,000
VENICE PARK RECYCLING & DISPOSAL FACILITY	Anthony Ragnone WWTP (Genesee County)	Two Manholes to Sewer	N/A	32,900
WESTSIDE RECYCLING & DISPOSAL FACILITY	City of Three Rivers WWTP (Three Rivers)	Direct Discharge	N/A	60,800
WOODLAND MEADOWS RDF-VAN BUREN	Great Lakes Water Authroity WRRF (GLWA)	Manhole to Sewer	N/A	54,800
Pump and Haul to WRRF				
AUTUMN HILLS RECYCLING AND DISPOSAL FACILITY	City of Grand Rapids WWTP (Grand Rapids)	Loadout Pad	N/A	54,800
DAFTER SANITARY LANDFILL	City of Sault Ste. Marie WWTP (Sault St. Marie)	Loadout Pad	N/A	16,500
GLENS SANITARY LANDFILL	Betsie Lake Utility Authority (BLUA)	Loadout Pad	Site Evaporator	3,800
K & W LANDFILL	Portage Lake Water and Sewage Authority's WWTF (Portage Lake) Iron-Gogebic Wastewater Authority's Treatment Facility (Ironwood)	Loadout Pad	N/A	17,500
MANISTEE COUNTY LANDFILL INC	City of Ludington WWTP (Ludington) (approx 4,700 gpd)	Loadout Pad	N/A	4,700
	Packaging Corporation of America (PCA) - approx 30,000 gpd	Loadout Pad	N/A	
MICHIGAN ENVIRONS INC	City of Menominee WWTF (Menominee)	Loadout Pad	N/A	13,100
PITSCH SANITARY LANDFILL	Belding WRRF (Belding), with Grand Rapids as a backup	Loadout Pad	N/A	15,000
TRI-CITY RECYCLING AND DISPOSAL FACILITY	City of Sandusky WWTP (Sandusky)	Loadout Pad	N/A	9,600
Pump and Haul to Centralized Waste Treatment				
ADVANCED DISPOSAL SERVICES ARBOR HILLS LANDFILL INC	YCUA (60,400 gpd) Pump and Haul to CWT eventually discharges to GLWA	Loadout Pad	N/A	38,000
C & C EXPANDED SANITARY LANDFILL	Dart/Clean Earth in Detroit (DART) - GLWA	Loadout Pad	N/A	42,000
CARLETON FARMS LANDFILL	Dart/Clean Earth in Detroit (DART) - GLWA	Loadout Pad	N/A	123,300
CENTRAL SANITARY LANDFILL INC	SET Environmental Inc - Grand Rapids	Loadout Pad	N/A	30,100
MCGILL ROAD LANDFILL	Usher Oil (Detroit) (Usher) - GLWA	Loadout Pad	N/A	13,700
NORTHERN OAKS RECYCLING AND DISPOSAL FACILITY	Plummer's Environmental Services - Wyoming, MI (Plummer's)	Loadout Pad	Site Evaporator	12,300
ORCHARD HILL SANITARY LANDFILL	Third Party Pretreatment Facility in Holland, MI - Holland WRRF"	Loadout Pad	Reverse Osmosis	12,500
OTTAWA COUNTY FARMS LANDFILL	SET Environmental Inc - Grand Rapids	Loadout Pad	N/A	82,200
PEOPLES LANDFILL INC	Usher - GLWA	Loadout Pad	N/A	21,900
VIENNA JUNCTION INDUSTRIAL PARK SANITARY LANDFILL	Half to City of Toledo - Toledo (Out of state so not included in total) Half to Usher in Romulus, MI - GLWA	Loadout Pad	N/A	13,700
Pump and Haul to Deep Injection Well for Disposal				
WHITEFEATHER LANDFILL	Deep Injection Well In Pinconning -approx 12,600 gpd	Loadout Pad	N/A	Deep Well Disposal - No offsite leachate disposal
WATERS LANDFILL	Northeastern Exploration (Deep Well) in Johannesburg, MI-approx 8,200 gpd	Loadout Pad	Site Evaporator	Deep Well Disposal - No offsite leachate disposal

ATTACHMENT C

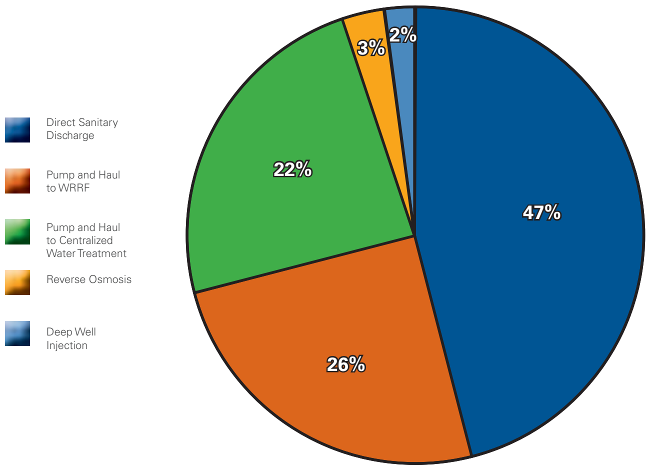
3.2 Leachate Disposal Methods, Daily Leachate Volume, & Receiving WRRFs

In this section, we present details regarding leachate disposal methods, annual leachate volumes, and the water resource recovery facilities (WRRFs) that treat leachate generated by the participating landfills, including relevant summary tables and graphics.

3.2.1 Disposal Methods

We obtained disposal information from a pre-sampling questionnaire completed by each facility owner representative. Based on the compiled data included in Table 3-1, the participating landfills manage leachate either by direct sanitary sewer discharge (DSD); pump-and-haul (PAH) for discharge; deep well injection (DWI); or a combination of these three methods. One site, Orchard Hill Landfill, primarily treats leachate for direct discharge to surface water using a reverse-osmosis (RO) system or whenever necessary, manages leachate by PAH. Figure 3-2, Statewide Leachate Disposal Methods illustrates the percentage by leachate volume of each disposal method utilized by the participating landfills.

Figure 3-2
Statewide Leachate Disposal Methods
(Percentage based on gallons treated)



3.2.2 Daily Leachate Volumes

Each site representative accessed their respective site Operating Records that include leachate flow measurements. The average daily leachate volumes by site, are included on Table 3-1. As indicated on Table 3-1 and graphed on Figure 3-3, Average Daily Leachate Volume Managed at Michigan WRRFs, the leachate volume discharged to WRRFs varies, ranging from approximately 3,800 gallons per day (gpd) at Glen's Sanitary Landfill to approximately 123,000 gpd at Carleton Farms Landfill. The daily flow from all 32 landfills is just over 1 million gallons. In general, the larger landfills produce more leachate than smaller ones, but other factors affect leachate generation including timing of cell closures, new cell development, leachate minimization practices, precipitation and recirculation.

3.2.3 Receiving WRRFs

As summarized on Table 3-1, with the exception of DWI, leachate from the original 32 MWRA-member landfills participating in this study are ultimately discharged to a WRRF, regardless of disposal/conveyance/pretreatment method employed. Statewide, the leachate from 18 facilities (more than half the participating sites) is managed at one of the five following, relatively large, regional WRRFs located in the southern half of Michigan's Lower Peninsula

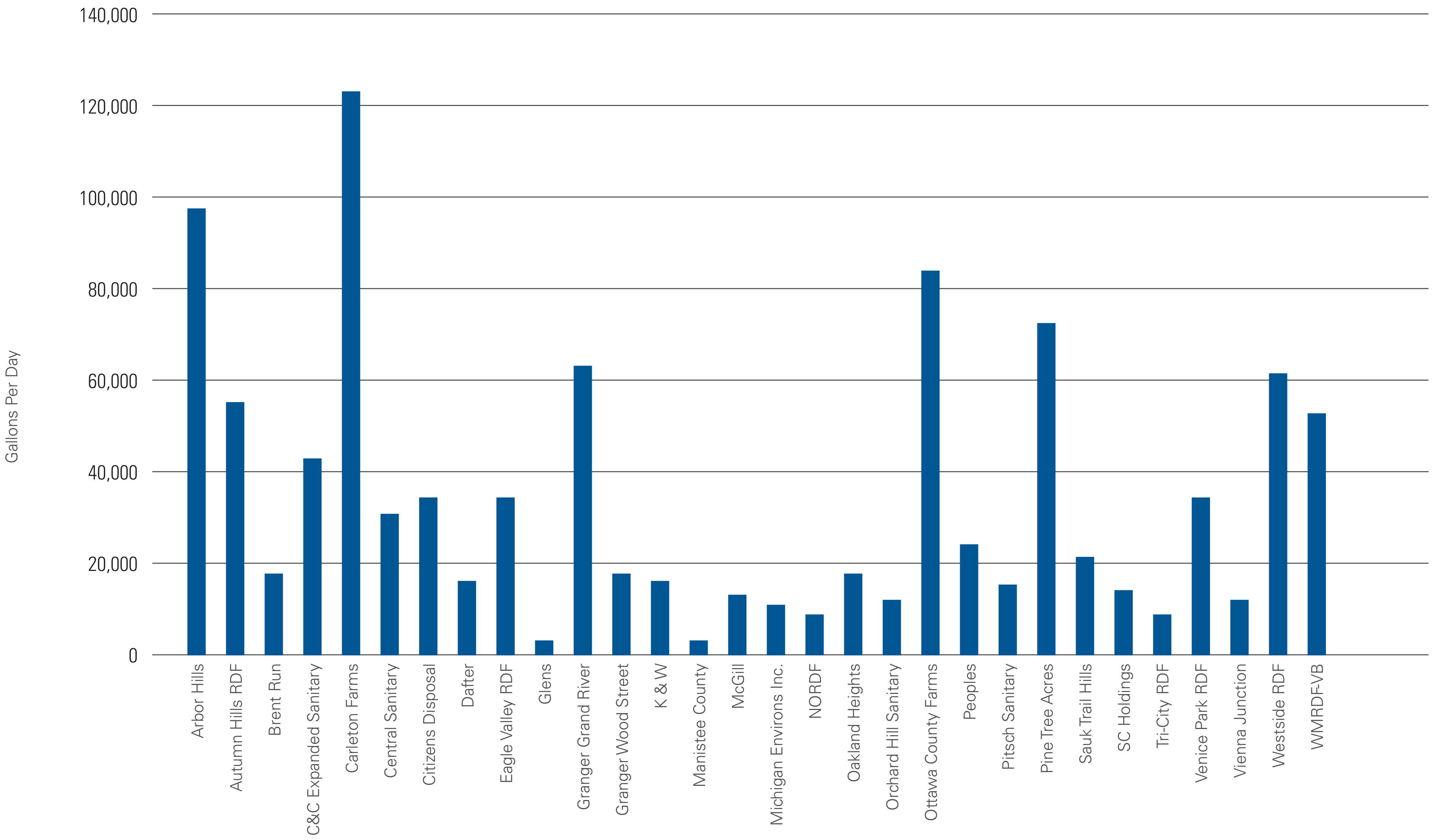
1. Great Lakes Water Authority in Detroit (GLWA), used by nine landfills,
2. Clinton River Water Resource Recovery in Pontiac (CRWRR), used by one landfill;
3. Grand Rapids Water Resource Recovery (GRWRR), used by four landfills
4. Anthony Ragnone Wastewater Treatment Plant near Flint (Ragnone), used by three landfills
5. Ypsilanti Community Utilities Authority (YUCA), used by two landfills (one of these landfills also PAH to GLWA).

Leachate from the remaining 12 participating landfills is managed at individual, local and generally smaller-scale WRRFs, primarily located in less-densely populated regions of the state (e.g., Mid-Michigan, SW-Michigan, Northern-Michigan, and various locations in the Upper Peninsula), as indicated in Table 3-1.

Figure 3-3

Average Daily Leachate Volume Managed at Michigan WRRFs.

Note: Leachate volumes provided by MWRA members



ATTACHMENT C

4.2 Statewide PFOA and PFOS Leachate Concentrations Ranges

Analytical data reports prepared by TAL, are contained in Appendix C, Analytical Data Reports. Table 4-2A, PFOA and PFOS Concentrations and Mass in Active Type II Landfills Leachate presents the concentrations of these PFAS compounds detected in 39 separate leachate samples collected from 35 active Type II landfills located in Michigan. We note three landfills included two or more leachate samples/locations (Venice Park, two samples; Riverview LF, three samples; and South Kent County LF, two samples).

As shown on Table 4-2A, PFOA concentrations for the MWRA participating landfills ranged from 240 ppt to 3,200 ppt. For all 35 Michigan active Type II landfills with data the PFOA concentration ranged from 16 ppt to 3,200 ppt with the lowest concentration in leachate detected in a Western-Michigan landfill and greatest concentration at a SE-Michigan landfill. The median PFOA leachate concentration was 1,000 ppt and the "average" concentration was approximately 1,187 ppt.

For PFOS, the leachate concentrations ranged from 100 to 710 ppt for the MWRA 32 participating landfills. For all 35 Michigan active Type II landfills with data the PFOS concentration ranged from 9 to 960 ppt, and the median value is 220 ppt. The lowest PFOS concentration was detected in leachate from a SE-Michigan landfill; the greatest from a Western-Michigan landfill. The average PFOS concentration was 287 ppt and the median concentration was 220 ppt.

4.3 MWRA Landfill Leachate PFOA & PFOS Concentrations Compared To Other Studies

Table 4-3, Michigan vs. Worldwide PFOA and PFOS Leachate Concentration Ranges compares ranges of PFOA and PFOS leachate concentrations observed as part of this study ("Michigan") to the ranges reported for other areas, based on the literature review discussed in Section 2.1. As shown, the worldwide leachate range for PFOA concentrations, is non-detect to 214,000 ppt and the corresponding PFOS range is non-detect to 6,020 ppt.

As indicated in Table 4-3, Michigan's PFOA and PFOS ranges are within those observed in the US based on available published literature. The Michigan PFOS concentration range is consistent with that reported in other Western world regions, but nearly an order-of-magnitude lower than what is reported for China. The apparent reason China's concentrations are greater is their continued use of PFAS compounds in consumer-goods manufacturing.

Table 4-3
Michigan vs. Worldwide PFOA and PFOS Leachate Concentrations Ranges

Region	PFOA (ppt)	PFOS (ppt)
Michigan*	16 to 3,200	9 to 960
United States	30 to 5,000	3 to 800
Europe	ND to 1,000	ND to 1,500
Australia	17 to7,500	13 to 2,700
China	281 to 214,000	1,150 to 6,020
Worldwide Range	**ND to 214,000**	**ND to 6,020**

* Based on leachate analyses from 32 MWRA-member landfills participating in this statewide study and leachate data obtained on MiWaters.com.

4.4 Leachate PFOA And PFOS Concentrations vs. MDEQ Criteria

As indicated in Section 2.1, Michigan has established both groundwater clean-up criteria and surface water quality standards (WQS) for PFOA and PFOS. The Michigan Part 201 groundwater cleanup criteria for PFOA and PFOS is 70 ppt, either individually or as a combined limit. This is not an enforceable standard for public drinking water supplies but has been used in Michigan as a protective guideline during site investigations.

The Rule 57 PFOA WQS is 420 ppt for surface water that may be used as a drinking water (DW) source and 12,000 ppt for non-drinking water (NDW) sources. For PFOS, the WQS for drinking and non-drinking water sources are 11 ppt and 12 ppt, respectively.

It is not appropriate regulatory policy to compare the leachate results to surface water quality standards (WQS) because leachate is not being discharged to surface water. Nevertheless, the WQS are used as a means of putting the leachate results in some context.

Individually, as shown on Table 4-2A, the concentration of PFOA in leachate collected from two landfills during this study are below the 420 ppt DW WQS as are the concentrations from two samples from two separate landfills with data obtained from MiWaters. The other samples are above the 420 ppt value. The concentration of PFOA in the leachate from all sites was considerably lower than the 12,000 ppt NDW WQS. The concentration of PFOS at all locations exceeded the DW and NDW WQS.

Table 4-2A

Concentrations and Mass of PFOA AND PFOS Michigan Active Type II Landfills' Leachate

MWRA Participating Landfill Designation	Average Leachate Volume GPD	PFOA (ppt)	PFOS (ppt)	"PFOA Daily Mass (lb/day)"	"PFOS Daily Mass (lb/day)"
Arbor Hills Landfill	98,400	3200	220	0.0026	0.00018
Autumn Hills RDF	54,800	1300	380	0.0006	0.00017
Brent Run Landfill	16,400	540	110	0.0001	0.00002
C&C Expanded Sanitary Landfill	42,000	1300	450	0.0004	0.00015
Carleton Farms Landfill	123,300	1800	250	0.0018	0.00026
Central Sanitary Landfill	30,100	2500	470	0.0006	0.00012
Citizen's Disposal Inc.	32,900	1100	180	0.0003	0.00005
Dafter Sanitary Landfill	16,500	680	130	0.0001	0.00002
Eagle Valley RDF	32,900	490	170	0.0001	0.00005
Glens Sanitary Landfill	3,800	770	210	0.00002	0.00001
Granger Grand River Landfill	64,400	240	160	0.0001	0.00009
Granger Wood Street Landfill	19,200	470	110	0.0001	0.00002
K&W Landfill	17,500	830	170	0.0001	0.00002
Manistee County Landfill	4,700	420	220	0.000016	0.000009
McGill Road Landfill	13,700	760	170	0.0001	0.00002
Michigan Environs Inc. (Menominee)	13,100	1400	100	0.0002	0.00001
Northern Oaks RDF	12,300	1000	220	0.0001	0.00002
Oakland Heights Development	17,800	780	230	0.0001	0.00003
Orchard Hill Sanitary Landfill	12,500	650	110	0.0001	0.00001
Ottawa County Farms Landfill	82,200	1800	530	0.0012	0.0004
People's Landfill	21,900	2500	710	0.0005	0.00013
Pine Tree Acres RDF	74,000	1800	430	0.001	0.0003
Pitsch Sanitary Landfill	15,000	1300	260	0.0002	0.00003
Sauk Trail Hills Landfill	20,500	2800	610	0.0005	0.00010
SC Holdings	16,000	960	410	0.0001	0.00005
Tri-City RDF	9,600	1200	160	0.0001	0.00001
Venice Park RDF MH#20*	32,900	910	190	0.0007	0.0002
Venice Park RDF MH#21*		1500	630		
Vienna Junction Industrial Park Sanitary Landfill	13,700	1300	130	0.0001	0.00001
Waters Landfill	NONE	930	230	NONE	NONE
Westside RDF	60,800	1300	160	0.0007	0.00008
Whitefeather Landfill	NONE	1700	550	NONE	NONE
Woodland Meadows RDF -Van Buren	54,800	2000	510	0.0009	0.00023
Other Active Type II Landfill Leachate Data Obtained from MIWaters		**PFOA (ppt)**	**PFOS (ppt)**	**PFOA Daily Mass (lb/day)**	**PFOS Daily Mass (lb/day)**
Riverview 003*		1900	270		
Riverview 004*		860	140		
Riverview 007*	37,400	38	8.5	0.0003	0.00004
South Kent Outfall*		725	960		
South Kent Hauled*	48,000	16	130	0.0001	0.0002
Smith's Creek Landfill*	32,900	510	120	0.0001	0.00003
	minimum	16	9	0.000016	0.000007
	maximum	3200	960	0.003	0.0004
	median	1000	220	0.0001	0.00005
	average	1186	287	0.0004	0.0001
	n	39	39	33	33

Notes:
1. There are a total 45 Active Type II Landfills in Michigan; 35 are represented in this table.
* - These facilities reported multiple laboratory results. In these cases, we calculated mass based on the averaged concentrations for PFOA and PFOS.
2. Riverview, South Kent, and Smith's Creek leachate are managed by the Downriver, Wyoming, and Port Huron WRRFs, respectively.

4.5: Statewide PFOA and PFOS WRRF Influent Concentrations

WRRFs serve all users within their respective service areas. Landfill leachate mixes with other wastewater from homes and workplaces, as well as public and private facilities (e.g., churches, restaurants and stores), that is delivered via municipal sanitary sewer networks. The WRRF treats the combined wastewater before adequately-treated water is discharged to a local surface water body or via infiltration beds.

Although very effective at removing bacteria, pathogens, and most undesirable chemicals present in wastewater, most WRRFs are not currently designed to significantly remove PFOA and PFOS.

Table 4-2B, WRRF Influent PFOA & PFOS Concentrations & Daily Mass, summarizes available data obtained from MiWaters organized by three groups. "Group A" includes the 14 (11 with available data) WRRFs that accept leachate from MWRA-member landfills; "Group B" nine (8 with data) that represent WRRF's that accept leachate from other active Type II landfills; and "Group C" 39 (20 with data) identify WRRFs that do not accept leachate from active Type II landfills.

Reviewing all three groups, PFOA influent concentrations ranged from non-detect (ND) at eight WRRFs to 64.6 ppt. The median PFOA influent concentration was 5.06 ppt and the average was 10.3 ppt, based on 31 sample with reported detections.

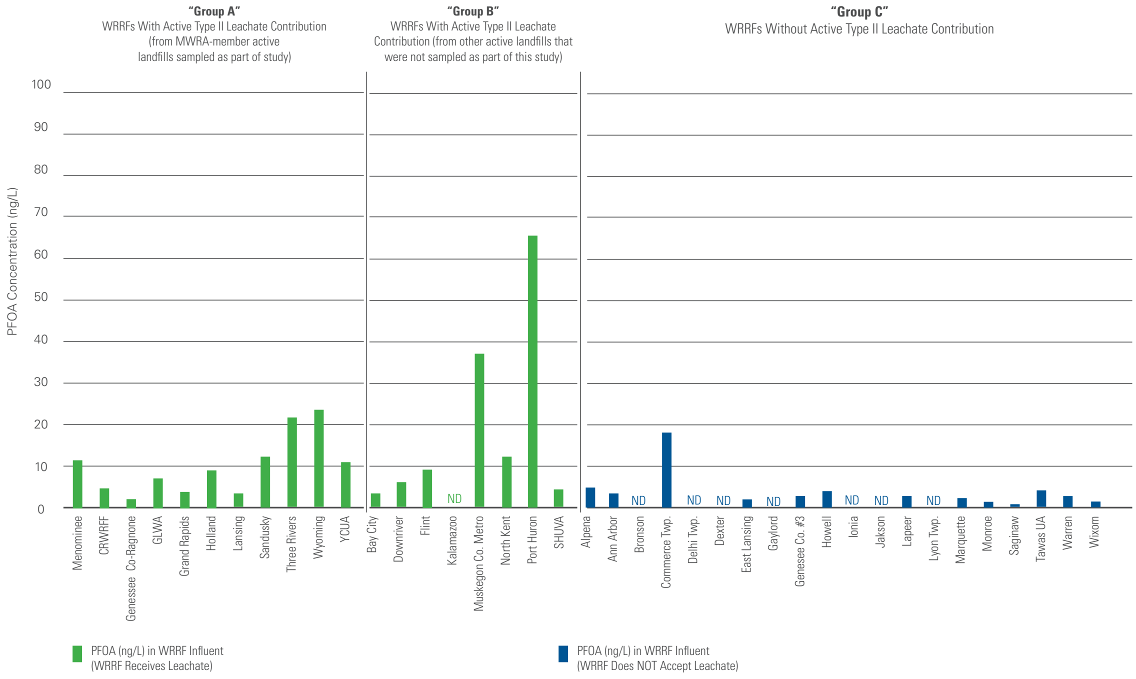
For PFOS in all groups, influent concentrations ranged from ND (at the same six WRRFs as before) to approximately 500 ppt. The median and average PFOS influent concentrations were 8.6 ppt and 34.5 ppt respectively, based on 29 samples with results above the method detection limit (MDL).

Figure 4-1A, WRRF Gross Influent PFOA Concentrations, graphically depicts available data for influent PFOA concentrations at WRRFs that accept leachate from active Type II landfills and those that do not, categorized by the groupings described above and on the graphic. Based on visual analyses of Figure 4-1A, we note that all influent values (Group A, Group B, and Group C) were below the most stringent 420 ppt PFOA WQS.

Figure 4-1B, WRRF Gross Influent PFOS Concentrations, depicts available data for influent PFOS concentrations at WRRFs that accept leachate from active Type II landfills and those that do not, categorized by the groupings described above and on the graphic. Based on visual analyses of Figure 4-1B, we note that more than half (12 of 19) of the WRRFs that accept landfill leachate (Group A and Group B) were below 11 ppt, the most stringent WQS for PFOS.

Figure 4-1A

WRRF Gross Influent PFOA Concentrations
At WRRFs that Accept and Do Not Accept Active Type II Leachate

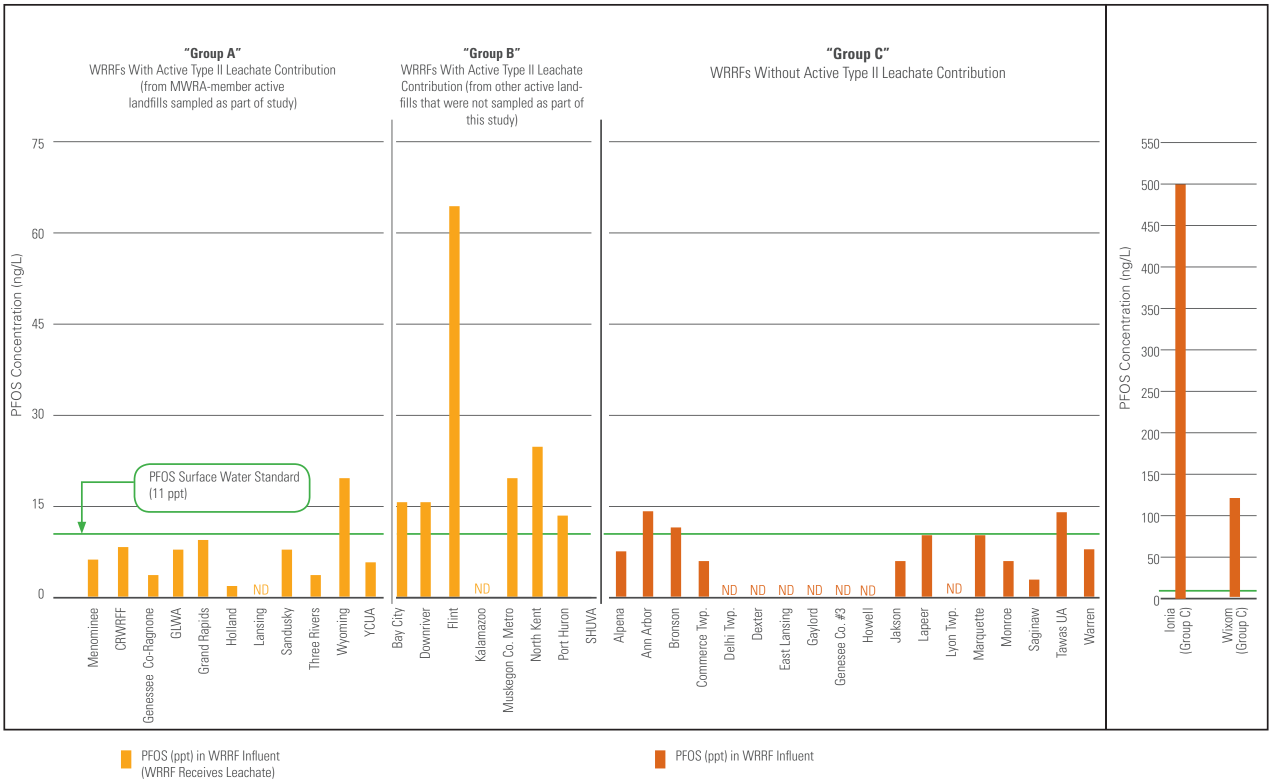


Notes
1. PFOS influent concentrations obtained from MIWaters.com.
2. ND = Not detected above laboratory reporting limit.
3. PFOA surface water standard is 420 ppt (not depicted on this chart).

Figure 4-1B

WRRF Gross Influent PFOS Concentrations

At WRRFs that Accept and Do Not Accept Active Type II Leachate



Notes
1. PFOS influent concentrations obtained from MIWaters.com
2. ND = Not detected above laboratory reporting limit

4.6 PFOA & PFOS Leachate and WRRF Mass Comparison

In order to estimate the mass contribution of PFOA and PFOS in landfill leachate to the total WRRFs influent mass that were evaluated in the study, we again relied on information available from MWRA-member landfills (combined with data available for other landfills) and data provided via MiWaters (for influent and WRRF design flows). This information was used to calculate an estimated mass contribution of PFOA and PFOS from each landfill to their associated WRRF. We also estimated the total mass contribution of PFOA and PFOS from all study landfills and other wastewater sources that contribute to WRRF influent.

4.6.1: Influent Leachate PFOA and PFOS Mass

Table 4-2A, summarizes the calculated daily mass of PFOA in leachate from 33 landfills (2 landfills do not discharge to WRRFs) included in this study. The total daily PFOA estimated mass from all 33 landfills' leachate was 0.014 lb. Daily mass for PFOA was from a low of 0.000016 lb. (Northern-Michigan landfill) to a high of 0.0026 lb. (SE-Michigan landfill). The median daily PFOA mass was 0.0001 lb. and the average daily PFOA mass was 0.0004 lb. These small mass values illustrate that although some of the concentration results appear high when viewed in parts per trillion values, the mass contributions are actually quite low.

The calculated daily mass of PFOS in leachate from the 33 landfills is also include on Table 4-2A. The total daily PFOS estimated mass in leachate from all 33 landfills' leachate was 0.0031 lb. The daily mass ranged from a low of 0.000007 lb. (Northern-Michigan landfill) to a high of 0.0004 lb. (Western Michigan Landfill). The median daily PFOS mass was 0.00005 lb. and the average daily mass for PFOS was 0.0001 lb.

4.6.2: WRRF PFOA and PFOS Mass

Table 4-2B, provides a summary of all WRRFs used in our analyses. We note that the influent flow calculation is based on the WRRF design flow capacity provided in each WRRF's NPDES permit. This design flow was used since actual flow information is not known or published via MiWaters. Further, we note that most of the WRRF influent mass calculations rely on a single or very limited number of samples. Based on these considerations, the calculated masses are provided as estimates and actual mass may fluctuate over time, depending on a number of inter-related factors (e.g., precipitation, seasonality, etc.)

From Table 4-2B, based on 27 results, estimated daily WRRF influent PFOA mass ranged from non-detect (at 10 facilities) to 0.03 lb., with a median of 0.0007 lb. and average of 0.003 lb. For PFOS, based on 25 results, estimated daily WRRF influent ranged from non-detect (at several locations) to 0.04 lb.; the associated median and average values were 0.0019 lb. and 0.005 lb., respectively.

Figure 4-2A, PFOA Mass: Influent Leachate vs. Overall WRRF Influent, depicts the total PFOA mass contribution from leachate versus overall estimated WRRF influent mass on a daily basis for the 13 facilities that receive leachate and have PFOA and/or PFOS data. Review of this graphic reveals the following:

- PFOA mass from leachate represents a relatively minor proportion of the individual WRRFs estimated influent mass at a majority of the WRRFs.
- GLWA's PFOA influent mass is at least twice that of any of the other 12 WRRFs, which is based on its permitted treatment capacity and large area served including many industrial facilities; and
- The influent PFOA mass for the other WRRFs that serve large, densely-populated metropolitan areas are generally greater than observed at smaller WRRFs that serve less-populated areas.

Figure 4-2B, PFOS Mass: Influent Leachate vs. Overall WRRF Influent, depicts the total PFOS mass contribution from leachate versus overall estimated WRRF influent mass on a daily basis for the 13 facilities that receive leachate and have PFOA and or PFOS data. Visual evaluation of this stacked bar chart graph reveals the following:

- PFOS mass from leachate represents a relatively minor proportion of most the individual WRRFs and overall;
- GLWA's PFOS influent mass is at least twice that of any of the other WRRFs, based on its large permitted treatment capacity and large area served including many industrial facilities; and
- Other than Lansing, which did not detect PFOS in their influent, the influent PFOS mass for the WRRFs that serve large, metropolitan areas are generally greater than smaller WRRFs that serve less populated areas.

Table 4-2B

WRRF Influent PFOA and PFOS Concentrations (Page 1 of 2)

Leachate Disposal/WRRF Facility	WRRF Permitted Capacity (MGD)*	Influent Concentration		Influent Mass	
		PFOA (ppt)	PFOS (ppt)	PFOA (lb/ day	PFOS (lb/day)
		Min to Max	Min to Max		
Group A: WRRFs Utilized by MWRA-member Active, Type II Landfills Participating in this Study					
Belding	3.07	NA	NA	NA	NA
Menominee	3.2	12	5.6	0.0003	0.0001
Clinton River	30.6	4.94	7.68	0.0013	0.0019
Genesee Co-Ragnone	25.9	4	5.22	0.0009	0.0012
GLWA	650	6.02	7.54	0.0324	0.0406
Grand Rapids	61.1	5.06	12.7	0.0026	0.0066
Hastings	2	NA	NA	NA	NA
Holland	12	8.93	3.79	0.0009	0.0004
Lansing	35	4.98	ND	0.0014	ND
Ludington	4.5	NA	NA	NA	NA
Sandusky	2.55	12.2	7.98	0.0003	0.0002
Three Rivers	2.75	21.44	7.39	0.0005	0.0002
Wyoming	22	5.08 to 25	6.2 to 26.4	0.0046	0.0048
YCUA	51.2	12	4.8 to 7.51	0.0051	0.0032
Group B: WRRFs Utilized to Dispose Leachate from Other Active, Type II Landfills					
Bay City	18	4.87	18.2	0.0007	0.0027
Downriver	125	7.2	22.2	0.0075	0.0230
Flint	50	10.3	62.4	0.0043	0.0258
Kalamazoo	53.5	ND	ND	ND	ND
KI Sawyer	0.65	NA	NA	NA	NA
Muskegon Co Metro	43	11.7 to 36.9	10.5 to 24.3	0.0131	0.0086
North Kent S A	8	11.2	31.1	0.0007	0.0021
Port Huron	20	64.6	19.5	0.0107	0.0032
S Huron Valley UA (SHUVA)	24	3.76	ND	0.0007	ND

* WRRF permitted daily flow and PFOA and PFOS data provided by MIWaters.com.

Influent mass calculated using the single sample or the maximum value where multiple data are available.

NA: data not available

ND : Not detected. Detection limit unknown. Excluded from average and median calculations.

Table 4-2B

WRRF Influent PFOA and PFOS Concentrations (Page 2 of 2)

Leachate Disposal/WRRF Facility	WRRF Permitted Capicity (MGD)*	Influent Concentration		Influent Mass	
		PFOA (ppt)	PFOS (ppt)	PFOA (lb/ day	PFOS (lb/day)
		Min to Max	Min to Max		
Group C: WRRFs that do not Treat Active Type II Leachate					
Adrian	7	NA	NA	NA	NA
Alpena	5.5	5.94	5.44	0.0003	0.0002
Ann Arbor	29.5	2.91 to 4.3	16.5 to 20	0.0011	0.0049
AuGres	0.221	NA	NA	NA	NA
Battle Creek	18	NA	NA	NA	NA
Benton Harbor - St. Joseph	15.3	NA	NA	NA	NA
Boyne City	0.9	NA	NA	NA	NA
Bronson	0.5	ND	12	ND	0.0001
Charlotte	1.8	NA	NA	NA	NA
Commerce Twp	8.5	17.9	6.38	0.0013	0.0004
Delhi Twp	4	ND	ND	ND	ND
Dexter	0.58	ND	ND	ND	ND
East Lansing	18.75	2.21	ND	0.0004	ND
Gaylord	2.2	ND	ND	ND	ND
Genesee Co #3	11	2.6	ND	0.0002	ND
Gladwin	0.65	NA	NA	NA	NA
Greenville	1.75	NA	NA	NA	NA
Holly	1.35	NA	NA	NA	NA
Howell	2.4	4.42	ND	0.0001	ND
Ionia	4	ND	499.36	ND	0.0165
Jackson	18	ND	5.98	ND	0.0009
Lapeer	1.5	4.2	8.6	0.0001	0.0001
Lyon Twp	1.095	ND	ND	ND	ND
Marquette	3.85	3.27	10.3	0.0001	0.0003
Marysville	2.4	NA	NA	NA	NA
Milan WWTP	2.5	NA	NA	NA	NA
Monroe	24	2.89	5.5	0.0006	0.0011
Mt Clemens	6	NA	NA	NA	NA
Petoskey	2.5	NA	NA	NA	NA
Saginaw Twp	4.8	NA	NA	NA	NA
Saginaw	32	2.56	4.19	0.0007	0.0011
Saline	1.81	NA	NA	NA	NA
South Lyon	2.5	NA	NA	NA	NA
Sturgis	2.8	NA	NA	NA	NA
Tawas Utility Authority	2.4	6.2	17	0.0001	0.0004
Warren	36	4.61	7.31	0.0014	0.0022
West Bay County Regional	10.28	NA	NA	NA	NA
Wixom	2.8	3.07	128	0.0001	0.0029
Zeeland	1.65	NA	NA	NA	NA
Summary Statistics - all Groups (A, B, C)	minimum maximum median average n	ND 64.6 5.06 10.3 31	ND 499.36 8.6 34.5 29	ND 0.03 0.0007 0.003 31	ND 0.04 0.0019 0.005 29

* WRRF permitted daily flow and PFOA and PFOS data provided by MIWaters.com

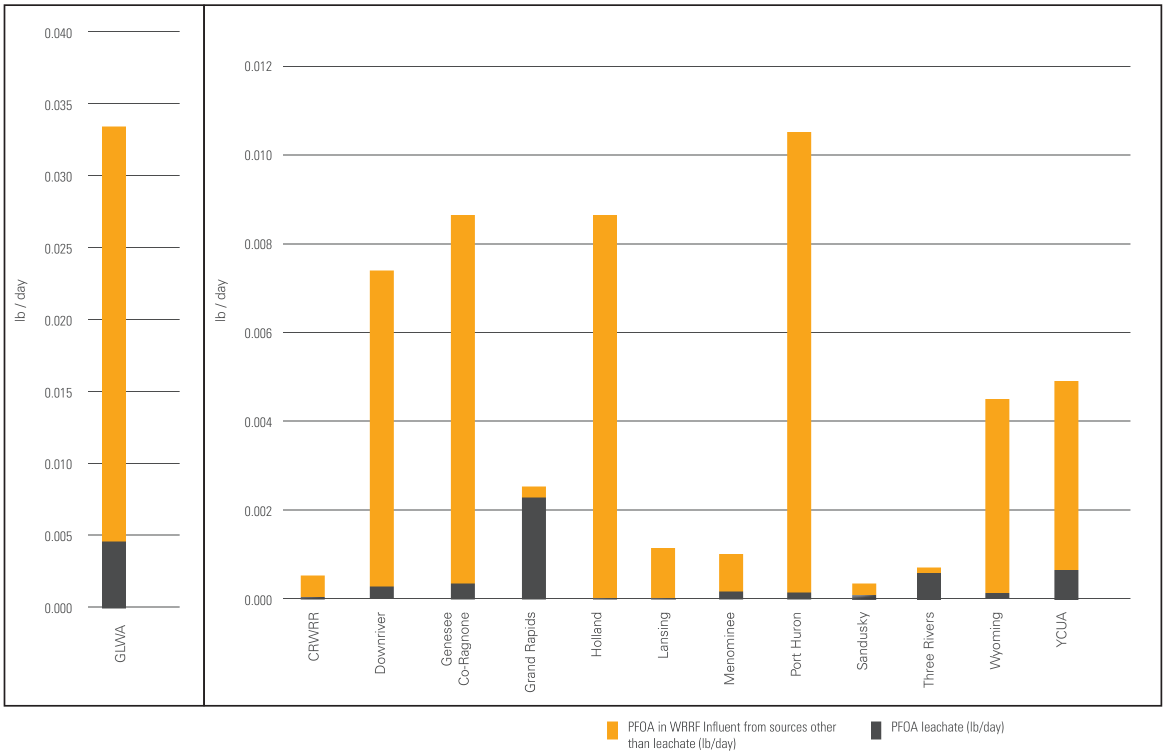
Influent mass calculated using the single sample or the maximum value where multiple data are available.

NA: data not available

ND : Not detected. Detection limit unknown. Excluded from average and median calculations.

Figure 4-2A

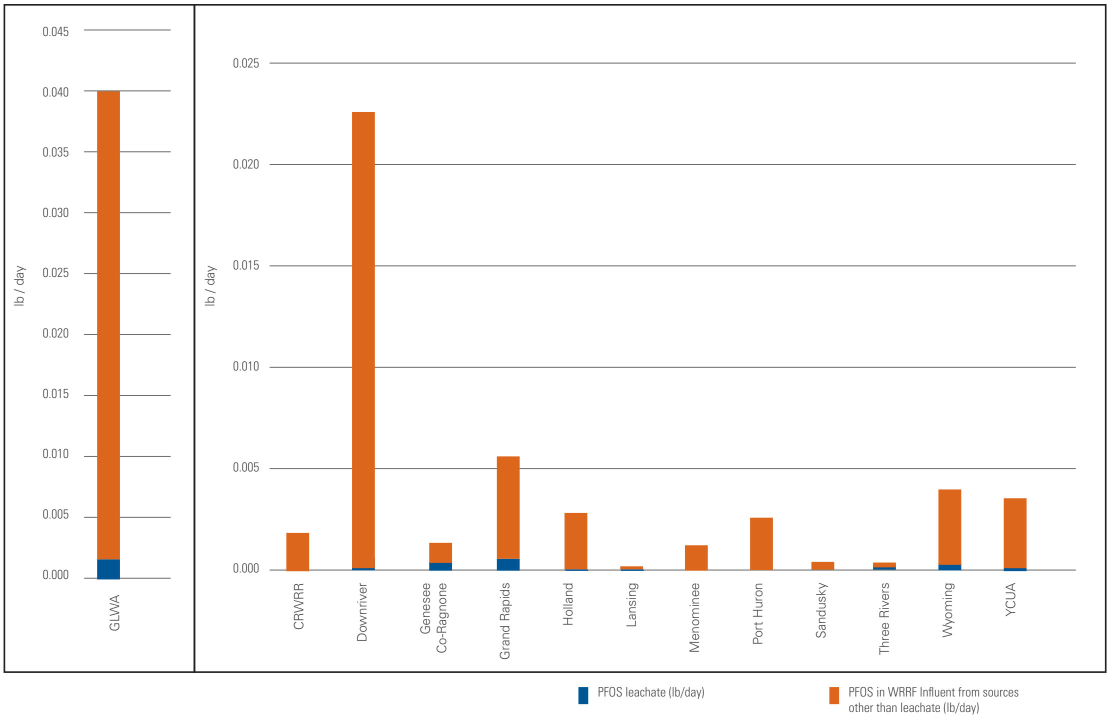
PFOA Mass: Influent Leachate vs. Overall WRRF Influent



Note: Gray shading indicates active Type II landfill leachate loading to WWRF for PFOA mass. This graph includes a total of 13 WRRFs utilized by 26 landfills. Eleven of the WRRFs treat 24 active landfills (23 which were sampled as part of this study and South Kent landfill). Two of the WRRFs are utilized by two additional active landfills that were not sampled as part of this study. PFOA and PFOS influent concentrations were unavailable from the WRRFs that treat other active Type II landfills. The mass represents a calculated value on a single sample, permitted discharge volume, and average daily leachate discharge.

Figure 4-2B

PFOS Mass: Influent Leachate vs. Overall WRRF Influent



Note : Blue shading represents active Type II landfill leachate loading for PFOS mass at each WRRF. This graph includes a total of 13 WRRFs utilized by 26 landfills. Eleven of the WRRFs treat 24 active landfills (23 which were sampled as part of this study and South Kent landfill). Two of the WRRFs are utilized by two additional active landfills that were not sampled as part of this study. PFOS influent concentrations were unavailable for the WRRFs that treat other active Type II landfills. The mass represents a calculated value on a single sample, permitted discharge volume, and average daily leachate discharge.

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5.0: OTHER CONSIDERATIONS

In this section, we discuss other concerns related to the current understanding of PFOA and PFOS in the environment that need to be addressed to help guide future regulatory, toxicological, and best-management practices (BMPs).

5.1: WRRF Influent, Effluent, and Biosolids

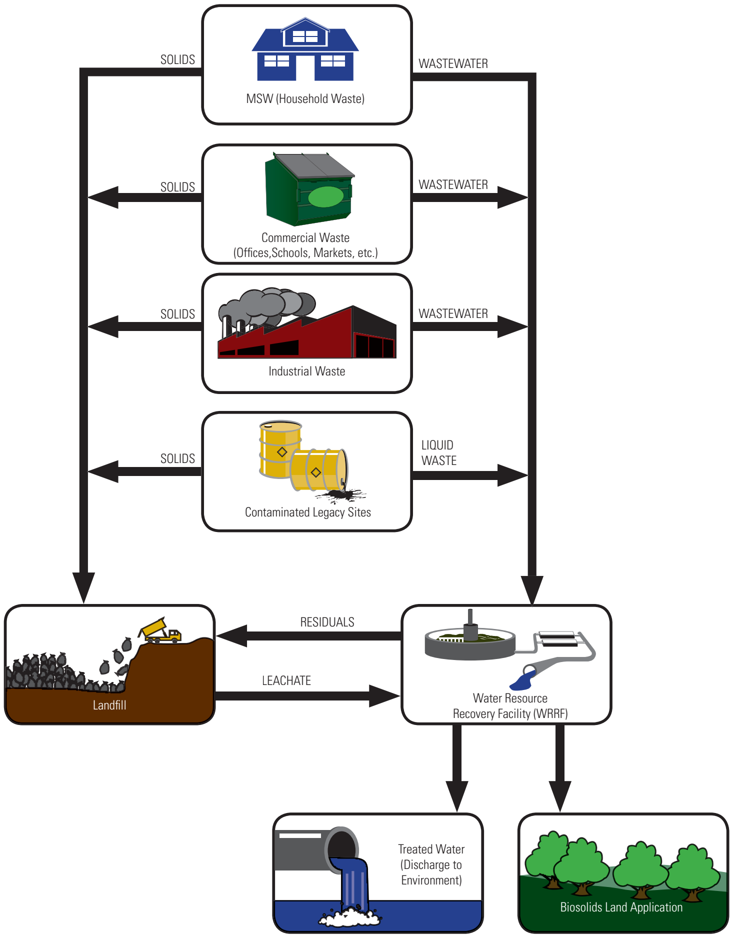
It is documented that WRRF biosolids typically contain PFAS (NEBRA, 2018). A recent comprehensive study was completed for the North East Biosolids and Residuals Association (NEBRA) that examined PFOA and PFOS concentrations in WRRF biosolids. Although the biosolids data are reported for solid/sludge samples and leachate samples are liquids, based on our review, the biosolids concentrations were typically two orders-of-magnitude greater than observed in active, Type II landfill leachate on a ppt basis.

Related specifically to PFOA and PFOS mass in leachate and WRRF biosolids, there are complexities between these two media that need evaluation to optimize future management of these two waste streams:

- the role of biochemical processes in WRRFs;
- fate and transport of PFOA/PFOS contained in biosolids
- temporal and spatial variation effects;
- waste age and state of decomposition in landfills;
- impact of equipment and infrastructure residual contamination; and
- appropriate and effective current BMPs.

While beyond the scope of this study to assess these factors, recent and ongoing research by others may provide direction. For example, work by Hamid (2018) and Lang (2017) indicate some PFAS compounds typically increase in WRRF effluent as compared to influent from biochemical degradation of related PFAS chemicals within the waste stream. Other factors could include residual PFAS from WRRF processing equipment.

For landfills, the existing literature (Lang, et al, and related references) indicates that PFOA+PFOA leachate mass decreases over time with more rapid declines observed in temperate, humid climates. This observation is significant with respect to long-term PFAS leachate management and reduction.



5.2: Proper PFAS Waste Management: Interdependence between Landfills, WRRFs, and General Public

Our study and previous investigations confirm PFAS presence in LF leachate – it comes from many sources that cannot be easily identified or eliminated including various consumer products disposed in landfills. As indicated throughout this report, PFAS have been used for over 50 years in household products. Managing PFAS-containing waste is a challenge that touches all sectors of the economy, including the solid waste industry, manufacturing and commercial sectors, and the general public. It is a societal concern that we need to work together to effectively address.

The leachate is effectively managed at landfills through active leachate collection via engineered liner systems. In Michigan, the most viable method for leachate management is its discharge to a local WRRF where it is handled with other household, commercial, and various industrial wastewaters. In this way, leachate is managed in a closed system where there is no direct exposure to the public. WRRFs treat wastewater to meet certain regulatory criteria prior to discharge of the treated water.

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Considering data collected and evaluated during this study, the impact that PFOA and PFOS in landfill leachate has on WRRFs influent concentrations is presented on Figures 4-2A and 4-2B. These data indicate that:
:

a. leachate provides a relatively minor contribution to the overall PFOA and PFOS concentration/mass in most WRRF influent because of the relatively low leachate discharge volumes;

b. non-leachate sources of PFOA and PFOS significantly contribute to WRRF influent and at higher volumes. It is noteworthy that the WRRF influent that have no landfill leachate contribution show a similar concentration range for PFOA and PFOS as WRRF influent that has leachate contribution; and

c. although reduction of landfill leachate concentrations of PFOA and PFOS to the WRRF influent could be beneficial to meeting WQS in the WRRF effluent, the impact may be minor in most cases since leachate typically contributes a relatively small volume to the overall WRRF influent.

As discussed above, WRRFs also produce biosolids (i.e., "sewage sludge") with elevated concentrations of PFAS. These biosolids are normally either land applied as fertilizer or incinerated (which potentially create separate environmental exposures), or are disposed at landfills (which likely contributes to higher PFAS concentrations in leachate at those landfills).

Each of these WRRF biosolids management methods have potential unintended adverse consequences. Incineration emissions may contribute to airborne PFAS, although this is largely un-studied. Similar cross-media impacts may be related to land application. Disposing of biosolids in landfills likely increases the concentrations of PFAS in leachate discharged to WRRFs. However, of the three disposal methods, landfilling in properly built and managed landfills appears to pose the least risk because landfills have engineering controls and environmental monitoring systems.

Accordingly, landfills and WRRFs have an important and mutually-beneficial relationship: landfills need to dispose of leachate and WRRFs need to safely manage society's biosolids. Together, these two critical environmental infrastructure components would benefit from enhanced cooperation to manage PFAS to serve the needs of both industries and protect the environment.

6.0: CONCLUSIONS

PFOA and PFOS were detected in all of the leachate samples taken in the study. The concentration ranges were similar to previous leachate studies conducted elsewhere in the US. The variability from landfill to landfill may reflect variations in waste-types, waste age, size of landfills in the study, and the relative state of decomposition. In summary:

- In leachate sampled from MWRA member landfills that participated in this study, PFOA ranged from 240 to 3,200 ppt and PFOS ranged from 100 to 710 ppt.
- In published studies of landfill leachate in the United States, PFOA ranged from 30 to 5,000 ppt and PFOS ranged from 3 to 800 ppt.
- Michigan leachate concentrations were substantially lower than some other countries, such as China, where published studies show PFOA ranged from 281 to 214,000 ppt and PFOS ranged from 1,150 to 6,020 ppt.

Comparing leachate volume and mass contribution from the 35 landfills examined to the total influent mass at the 39 WRRFs shows that the contribution of PFOA and PFOS is mostly from non-landfill sources.

- On a statewide basis, available data indicates that the 35 landfills contribute approximately one million gallons of leachate to WRRF influent, with approximately 0.01 lbs / day of PFOA and 0.003 lbs / day of PFOS.
- On a statewide basis, available data indicates that the 34 WRRFs that have influent data receive approximately 1.4 billion gallons of influent daily (based on design capacity), with approximately 0.09 lbs / day of PFOA and 0.15 lbs / day of PFOS.

The ranges of PFOA and PFOS concentrations in WRRF influent that do not accept leachate show overlap with those that do accept leachate.

- In WRRFs that do not accept landfill leachate, influent levels of PFOA range from non-detect to 17.9 ppt while PFOS ranges from non-detect to 499 ppt (next highest value is 128 ppt).
- In WRRFs that accept landfill leachate, influent levels of PFOA range from non-detect to 64.6 ppt while PFOS ranges from non-detect to 62.4 ppt.
- Available data show that PFOA levels in WRRF influent are well below Michigan's most conservative surface water criteria (420 ppt) at all WRRFs examined, and that PFOS levels in WRRF influent are below Michigan's most conservative surface water criteria (11 ppt) at approximately two-thirds of the WRRFs examined.
- The data collected during this study indicate that leachate provides a relatively minor contribution to the overall PFOA and PFOS concentration in most WRRF influent; non-leachate sources of PFOA and PFOS contribute greater mass to WRRF influent than leachate.

7.0: RECOMMENDATIONS

Based on the results of this study, we present the following recommendations:

- The solid waste industry in Michigan (and nationally) must continue working to understand the significance of the contribution of leachate to PFOA and PFOS received by WRRFs and work towards reduction solutions.

- The conclusions of this study are based mainly on a single leachate sample from each landfill and limited available data for WRRFs. Therefore, calculated mass values are estimates and more data and information are needed. This should include additional leachate data, WRRF influent data, and biosolids data.

- Facilities will need to present and discuss their individual results with the WRRF receiving their leachate to help evaluate any appropriate solutions on a local basis.

The information gathered during this study and other research can be used to develop, where needed, improved practices for management of waste that contains PFAS within and between landfills and WRRFs. Future collaboration should involve forming a workgroup consisting of MWRA members, MDEQ, MPART, and WRRFs. Discussions should take into consideration the unique aspects of landfills as a component of PFAS management and their interdependence with WRRFs in providing an important function to society. Further, the stakeholder parties need to work with toxicologists and other environmental scientists to better understand the potential impacts of PFOA and PFOS on human health in the context of landfill leachate and in general.

MWRA is committed to continue playing an active role in this process, as demonstrated by its funding of this statewide leachate report and ongoing participation with state and federal technical and scientific committees working toward solutions that follows sound scientific principles and implements best management practices where needed.

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North Carolina
Collective Study Report

Collective Study of PFAS and 1,4-Dioxane in Landfill Leachate and Estimated Influence on Wastewater Treatment Plant Facility Influent

National Waste & Recycling Association - Carolinas Chapter

H&H Job No. NWA-001
March 10, 2020

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ATTACHMENT D

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1.0 Introduction

Hart & Hickman, PC (H&H) has prepared this North Carolina Collective Study Report on behalf of the Carolinas Chapter of the National Waste & Recycling Association (NWRA) and certain member companies. This report documents the results of a study of perfluoroalkyl and polyfluoroalkyl substances (PFAS) and 1,4-dioxane in municipal solid waste landfill (MSWLF) leachate and its possible influence on wastewater treatment plant (WWTP) facility influent.

In February 2019, the North Carolina Department of Environmental Quality (NCDEQ) met with representatives of the landfill industry to discuss the potential presence of PFAS and 1,4-dioxane in leachate as part of a statewide effort to better understand the presence of these emerging chemicals in the environment. During the meeting, NCDEQ inquired about sampling landfill leachate to begin to understand PFAS and 1,4-dioxane content and its influence on leachate treatment/disposal practices, including publicly owned WWTPs that receive leachate for treatment. Rather than participating landfills sampling and reporting individually, representatives of the landfill industry agreed to participate in a collective study involving active MSWLFs in North Carolina. From these discussions with NCDEQ, the Carolinas Chapter of the NWRA committed to collect leachate samples from nine privately-owned or operated MSWLFs, including four landfills that transport leachate to WWTPs located within the Cape Fear River Basin and five landfills that transport leachate to WWTPs located across the remainder of the State. This report documents the scope and results of the sampling program. Where available, the results of the sampling were evaluated in conjunction with WWTP influent volumes and published sampling data in order to estimate the relative contribution of landfill leachate to overall WWTP influent mass of PFAS and 1,4-dioxane. The goals and objectives of the sampling program were presented to NCDEQ in a Scoping Document, dated August 8, 2019. NCDEQ issued a letter, dated August 14, 2019, concurring with the plan outlined in the Scoping Document.

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This North Carolina Collective Study Report is organized into sections to include the following:

- General overview of PFAS and 1,4-dioxane in landfill leachate, including background information, waste management system considerations, a summary of previous studies, and North Carolina regulatory status;
- Description of sampling activities and results; and
- Discussion of the WWTPs receiving the landfill leachate and calculations related to estimating the contribution of landfill leachate to overall WWTP influent mass.

2.0 General Overview

2.1 Background Information

PFAS are a group of man-made chemicals that have been manufactured and used in a variety of industries worldwide since the 1940s. The most extensively produced and studied PFAS compounds are perfluorooctanoic acid (PFOA) and perfluorooctanesulfonate (PFOS). Another notable PFAS compound is 2,3,3,3-tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (PFPrOPrA), which has the trade name GenX and is used in manufacturing nonstick coatings (United States Environmental Protection Agency [EPA], 2019a).

PFAS have been used to make a variety of consumer products that are resistant to water, grease, or stains. PFAS have also been used in firefighting foams and various industrial processes (Interstate Technology and Regulatory Council [ITRC], 2017). PFAS do not occur naturally, but are widespread in the environment and have been found in people, wildlife, and fish all over the world. Certain PFAS can accumulate in the human body for long periods of time and do not break down easily in the environment (Agency for Toxic Substances and Disease Registry [ATSDR], 2020).

PFOS and PFOA have been largely phased out by industry in the United States, with this phase-out beginning in the early 2000s. However, PFOS and PFOA are still being produced internationally and imported into the United States in consumer goods. Landfills receive a large variety of residential and industrial waste containing PFAS compounds (see inset) (ITRC, 2017).

Products/Wastes with Potential PFAS

- Consumer products
  - Paper and packaging
  - Clothing and carpets
  - Outdoor textiles and sporting equipment
  - Ski and snowboard waxes
  - Non-stick cookware
  - Cleaning agents and fabric softeners
  - Polishes and waxes
  - Pesticides and herbicides
  - Hydraulic fluids
  - Windshield wipers
  - Paints, varnishes, dyes, and inks
  - Adhesives
  - Medical products
  - Personal care products (for example, shampoo, hair conditioners, sunscreen, cosmetics, toothpaste, dental floss)
- Sewage sludge
- Industrial wastes
- Auto shredder residue
- Debris from fire cleanup
- Discarded AFFF
- Other sources

PFAS are considered to be contaminants of emerging concern (CECs). CECs are chemicals that present known or potential human health effects or environmental risks, but either do not have regulatory cleanup standards or regulatory standards are evolving due to new science, detection capabilities or pathways, or both (ITRC, 2017). PFAS were the primary focus of the North Carolina Collective Study; however, at the request of the NCDEQ, another CEC, 1,4-dioxane, was also included in the sampling and analytical program. 1,4-Dioxane has been used as a solvent in the manufacture of other chemicals, as a stabilizer for chlorinated solvents, and as a laboratory reagent. It can also be found as a by-product in many consumer and industrial products (EPA, 2017a, ATSDR, 2011, and ATSDR, 2012) (see inset). Disposal of these products in landfills can result in 1,4-dioxane in landfill leachate (Maine Department of Environmental Protection [MDEP], 2020).

Products/Wastes with Potential 1,4-Dioxane

- Consumer products
  - Household cleaners
  - Detergents
  - Shampoos
  - Deodorants
  - Cosmetics
  - Food supplements
- Paint
- Paint strippers
- Dyes
- Greases
- Antifreeze
- Aircraft deicing fluids
- Adhesives
- Pesticides
- Industrial wastes
- Laboratory wastes

2.2 Waste Management System Considerations

Landfills and WWTPs play an important role in managing wastes for our communities. It is important to note that landfills and WWTPs are receivers of PFAS and 1,4-dioxane and are not the producers or original sources. Rather, consumer products and other wastes disposed of in these facilities represent the source. Modern landfills are well-engineered and managed facilities designed to protect the environment from contaminants that may be present in the waste stream. MSWLFs must meet stringent regulatory requirements (see inset) (EPA, 2017b). North Carolina Administrative Code (NCAC) Title 15A Subchapter 13B requires that MSWLF liner systems include either 1) a geomembrane liner installed above and in direct and uniform contact with a compacted clay liner with a minimum thickness of 24 inches and a permeability

MSWLF Regulatory Requirements

- Location restrictions
- Composite liner requirements
- Leachate collection and removal systems
- Operating practices
- Federal, state, and local environmental monitoring requirements (groundwater, surface water, stormwater, air, leachate)
- Closure and post-closure care requirements
- Corrective action provisions
- Financial assurance
- Others

of no more than 1.0 x 10^{-7} cm/sec or 2) a geomembrane liner installed above and in direct and uniform contact with a geosynthetic clay liner (GCL) overlying a compacted clay liner with a minimum thickness of 18 inches and a permeability of no more than 1.0 x 10^{-5} cm/sec. Landfill leachate is generated from rainfall travelling through landfill waste or liquids within the waste itself. The leachate is effectively captured through liner and leachate collection systems. A common method of leachate disposal is discharge to a local publicly-owned WWTP where it is handled with other household, commercial, and various industrial wastewaters. Management of leachate in this way provides for a closed system where there is no direct exposure to the public (NTH Consultants, Ltd. [NTH], 2019).

Because PFAS and 1,4-dioxane are so ubiquitous, publicly-owned WWTPs receive wastewater from multiple sources that may contain PFAS and 1,4-dioxane. In addition to landfill leachate, other potential sources containing PFAS and/or 1,4-dioxane include wastewater from industrial, commercial, and agricultural operations and domestic sewage generated from homes, workplaces, and other public and private facilities. Biosolids (sewage sludge) from WWTPs may contain PFAS compounds (EPA, 2018; MDEP, 2020a; Michigan Department of Environment, Great Lakes, and Energy, 2020). Biosolids are commonly disposed of via land application, incineration, or landfilling. Because MSWLFs are strictly regulated and include liners and leachate collection systems engineered to prevent releases of pollutants to the environment, disposal of biosolids in MSWLFs may represent the preferred management option.

2.3 Other Related Studies

NTH, on behalf of the Michigan Waste & Recycling Association (MWRA), recently performed a statewide study of landfill leachate PFAS impacts on WWTP influent in the State of Michigan (herein referred to as the Michigan Study). This effort represented one of the largest studies conducted on active landfill leachate to date. The results of the study were documented in a Technical Report dated March 1, 2019 (NTH, 2019). Testing performed as part of the Michigan Study included collection of leachate samples from 32 active MSWLFs located in the State of Michigan and analysis of the samples for PFOS and PFOA. Data related to leachate disposal methods and volumes were gathered for each of the MSWLFs tested. The results were evaluated with respect to publicly available sampling data for WWTPs located across the State of Michigan. The North Carolina Collective Study presented in this report was performed using an approach similar to the Michigan Study. The results of the Michigan Study are discussed in conjunction with the results of the North Carolina Collective Study in Sections 3.4 and 4.0 of this report.

The Michigan Study also included a review of literature related to PFAS in landfill leachate. The literature review identified two key publications: National Estimate of Per- and Polyfluoroalkyl Substances (PFAS) Release to U.S. Municipal Landfill Leachate (Lang et al, 2017) and Review of the Fate and Transformation of Per- and Polyfluoroalkyl Substances (PFASs) in Landfills (Hamid et al, 2018). Lang et al (2017) evaluated the concentrations of PFAS compounds in 95 samples of leachate from landfills of varying climates and waste ages in the United States. According to the summary presented in the Michigan Study report, Lang et al demonstrated that PFOA and PFOS concentrations in leachate generally have been decreasing over time, with greater rates of decline in humid regions. Hamid et al (2018) compiled data from 11 literature sources that document PFAS leachate concentrations from dozens of landfills and more than 162 leachate samples from across the globe. The data show that PFOS and PFOA concentrations vary widely in different regions of the world, and are likely reflective of the consumer products and industrial materials used, produced, and disposed in each country. Reported concentrations for landfills in China were notably higher than elsewhere, which is likely due to the continued production of consumer goods containing PFAS and associated industrial waste from the manufacturing processes. Note that PFAS-containing products manufactured in China and other countries are often imported into the United States for purchase and eventually disposed of in United States landfills. PFOS and PFOA concentration data based on the literature review performed during the Michigan Study are summarized in **Table 1** and depicted in **Figure 1**.

Additional studies of PFAS in landfill leachate are underway since the date of the Michigan Study. Locally, the North Carolina Policy Collaboratory (NC Collaboratory) has funded research being performed by the NC PFAS Testing (PFAST) Network. The NC Collaboratory was established by the North Carolina General Assembly in 2016 to facilitate and fund research and make recommendations to the General Assembly. The PFAST Network consists of investigators from various NC universities performing multiple studies related to PFAS. One of these studies is being led by Dr. Morton Barlaz at North Carolina State University and focuses on PFAS in landfill leachate. The purpose of the study is to assess the relative importance of MSWLFs and domestic wastewater as contributors of PFAS to WWTPs and potentially to surface water (PFAST Network, 2019). The results of the PFAST Network study have not yet been published and therefore could not be incorporated into the North Carolina Collective Study documented in this report.

No comprehensive studies have been identified regarding 1,4-dioxane concentrations in landfill leachate. More data are available regarding 1,4-dioxane concentrations in public water systems (PWS). Monitoring of 1,4-dioxane in PWS was required by the EPA Third Unregulated Contaminant Monitoring Rule (UCMR 3). Adamson et al (2017) documents an evaluation of 1,4-dioxane concentrations in PWS located across the United States based on data collected under the UCMR 3. The results of the study identified detectable concentrations of 1,4-dioxane in 21% of 4,864 PWS. The study concluded that the data indicated a decreasing trend in concentrations and detection frequency over time. The study also concluded that detections of 1,4-dioxane were highly associated with detections of other chlorinated solvent compounds, which is attributed to the use of 1,4-dioxane as a solvent stabilizer.

2.4 Regulatory Status

The regulatory status of PFAS and 1,4-dioxane are currently evolving as additional studies are completed regarding human health risks and ecological effects. No regulatory standards or screening levels have been developed by EPA or the State of North Carolina that are applicable to landfill leachate. Levels that have been established for drinking water are summarized below, but it should be noted that these levels do not apply to landfill leachate.

PFAS

EPA has not adopted Federal regulatory standards or Maximum Contaminant Levels (MCLs) for PFAS compounds to date. EPA has established a Health Advisory Level for combined or individual PFOS and PFOA of 70 nanograms per liter (ng/L, equivalent to parts per trillion). EPA's health advisories are non-enforceable and non-regulatory but provide technical information to state agencies and other public health officials on health effects, analytical methodologies, and treatment technologies associated with drinking water contamination (EPA, 2019b).

North Carolina also has not adopted regulatory standards for PFAS compounds to date. North Carolina has established a Drinking Water Health Goal for PFPrOPrA (GenX) of 140 ng/L. According to the North Carolina Department of Health and Human Services (NCDHHS), the PFPrOPrA Drinking Water Health Goal is not a regulatory level and is not a boundary line between a "safe" or "dangerous" level, but can be used to provide information to affected communities and residents about potential risks from exposure to GenX through drinking water (NCDHHS, 2020).

1,4-Dioxane

EPA has not adopted Federal regulatory standards or MCLs for 1,4-dioxane to date. EPA has established a Drinking Water Health Advisory Level of 35 micrograms per liter (µg/L, equivalent to parts per billion). As referenced above, EPA's health advisories are non-enforceable and non-regulatory but provide technical information to state agencies and other public health officials (EPA, 2019b).

North Carolina has established a 2L Groundwater Standard under Title 15A NCAC 2L .0202 of 3 µg/L for 1,4-dioxane. The 2L Standards are the maximum allowable concentrations resulting from any discharge of contaminants that may be tolerated without creating a threat to human health or would otherwise render the groundwater unsuitable for it intended best usage. Although a 2L Groundwater Standard has been established, NCDEQ has relied on the EPA Drinking Water Health Advisory Level of 35 µg/L when evaluating the potential for impacts to public water supplies (NCDEQ, 2020).

3.0 Sampling Activities

3.1 Locations Sampled

In accordance with the August 2019 Scoping Document, leachate samples were collected from the following nine active MSWLF facilities located across the State of North Carolina:

1. Great Oak Landfill (7607-MSWLF-2015)
2. Sampson County Disposal, LLC (8202-MSWLF-2000)
3. South Wake MSW Landfill (9222-MSWLF-2008)
4. Upper Piedmont Regional Landfill (7304-MSWLF-1997)
5. BFI-Charlotte Motor Speedway Landfill V (1304-MSWLF-1992)
6. Uwharrie Environmental Regional Landfill (6204-MSWLF-1995)
7. East Carolina Regional Landfill (0803-MSWLF-1993)
8. Chambers Development MSW Landfill (0403-MSWLF-2010)
9. Foothills Environmental Landfill (1403-MSWLF-1998)

Prior to sampling, H&H contacted each landfill and requested information regarding site contacts, leachate collection and disposal systems, access limitations, typical leachate sampling locations, leachate volumes, and leachate disposal methods. This information is summarized in **Table 2**. The landfill locations are shown on **Figure 2**.

3.2 Sampling Methodology

Sampling was performed by H&H staff with experience sampling for PFAS and other constituents of concern. Sampling procedures were in accordance with the guidance document "PFC Sampling Procedures, January 2019" issued by the NCDEQ Division of Waste Management (DWM) Solid Waste Section (herein referred to as NC DWM Sampling Guidance). Prior to sampling, a Health & Safety Plan was prepared to cover safety concerns associated with the proposed field activities. Sampling bottles, bottle coolers, and PFAS-free water for blanks and decontamination were obtained from the laboratory, GEL Laboratories, LLC (GEL) located in Charleston, South Carolina.

Because PFAS are present in many commonly used materials, the PFCs Sampling Checklist form included with the NC DWM Sampling Guidance was followed by field personnel to reduce the potential for cross-contamination of samples with PFAS from external sources. Each sampler washed their hands before sampling and utilized a minimum of three layers of nitrile gloves at each sampling location to maintain a "clean hands" approach after encountering various surfaces. Sampling supplies were placed on new high-density polyethylene (HDPE) sheeting in close proximity to the sampling location.

Sampling was performed September 16 through 19, 2019. Leachate collection/management systems vary by landfill facility; therefore, samples were collected under three general scenarios as described below. The sampling scenario for each facility is indicated on **Table 2**.

Valve at Bottom of Holding Tank/Discharge Line

- At locations where a sample port was located at the bottom of the holding tank and/or the discharge line (all locations except BFI-Charlotte Motor Speedway Landfill V and Great Oak Landfill), the valve was opened to clear any potential sediment and to adjust the flow to an appropriate rate for sample collection. Using fresh nitrile gloves, the sampler then removed the lid of the sample container and collected the sample keeping the sample container lid in the opposite hand. Upon completion of sampling, bottles were capped, placed in Zip-lock bags, and placed into laboratory-supplied coolers filled with ice. Because samples were collected directly into laboratory-supplied sampling containers and no separate sampling apparatus was used, no equipment blanks were collected for these locations.

Direct From Lagoon

- At the BFI-Charlotte Motor Speedway Landfill V, the sampling team mobilized to the leachate lagoon and set up a sampling station on the edge of the lagoon utilizing new HDPE sheeting. Samples were collected by submerging a new unpreserved laboratory-supplied sample container approximately 1-foot below the surface of the lagoon, then transferring the contents into the laboratory-supplied sample containers to be submitted for analysis. Upon completion of sampling, bottles were capped, placed in Zip-lock bags, and placed into laboratory-supplied coolers filled with ice. Because samples were collected using laboratory-supplied sampling containers and no separate sampling apparatus was used, no equipment blanks were collected for this location.

Direct From Holding Tank

- At the Great Oak Landfill, the level of leachate in the holding tank was insufficient to collect a sample from the discharge port; therefore, samples were collected directly from the manhole hatch located at the top of the leachate holding tank. On September 17, 2019, samples were collected using a new properly decontaminated HDPE bucket and cotton string for analysis of both PFAS and 1,4-dioxane. H&H returned to the site on September 30, 2019, to resample for 1,4-dioxane due to issues with damage to sample containers during transport to the laboratory. During the sampling on September 30, 2019, samples were collected using a new HDPE bailer and cotton string for analysis of 1,4-dioxane. To complete the sampling, leachate was extracted from the holding tank using the bucket or bailer and transferred into the sample containers. The sampling station at the platform on top of the holding tank was covered with new HDPE sheeting. In addition, the “windmill” technique was utilized while bailing to prevent the bailer or string from contacting potential PFAS containing surfaces. Upon completion of sampling, bottles were capped, placed in Zip-lock bags, and placed into laboratory-supplied coolers filled with ice. For quality assurance/quality control (QA/QC), an equipment blank was collected during each sampling event from the bucket or bailer using PFAS-free water provided by the laboratory.

Each sample was assigned a unique identification number beginning with the first four digits of the NCDEQ permit number. Samples collected for analysis of PFAS were placed in coolers separate from samples collected for analysis of 1,4-dioxane. The sample coolers were shipped to GEL under chain-of-custody protocol for analysis as described in Section 3.3.

3.3 Laboratory Analyses

The samples from each facility were analyzed for PFAS by modified EPA Method 537.1 using Method PFAS by LCMSMS Compliant with Table B-15 of Department of Defense Quality Systems Manual (QSM) Version 5.3 and 1,4-dioxane by EPA Method 8270 Selective Ion Monitoring. The list of PFAS compounds included in the analyses was based on prior discussions between NWRA member companies and NCDEQ staff. At the request of NCDEQ, samples from Sampson County Disposal, LLC were also analyzed for PFPrOPrA by modified EPA Method 537.1.

Three items were identified during review of the laboratory QA/QC data which are discussed below:

- For sample 0403-1 (Chambers Development MSWLF), the surrogate recovery for the 1,4-dioxane sample analysis was below acceptable limits. The analytical results indicated 60% surrogate recovery with an estimated sample concentration of 9.22 µg/L. If this concentration is adjusted upward based on 100% recovery instead of 60%, the estimated 1,4-dioxane concentration in the sample would be 15.4 µg/L ([9.22 µg/L x 100%] / 60% = 15.4 µg/L). Following the initial analysis, GEL re-analyzed a second portion of the sample. However, the re-analysis was performed outside the method-recommended holding time. The results of the second analysis indicated a concentration of 14.8 µg/L. Based on the adjusted initial sample analysis result and the re-analysis result, H&H concludes that there is sufficient data to conclude the concentration in the sample is reasonably on the order of approximately 15 µg/L.
- For sample 1304-1 (BFI-Charlotte Motor Speedway Landfill V), GEL inadvertently did not analyze the 1,4-dioxane sample collected on September 16, 2019. A second sample (ID 1,1A,2,2A) was collected by landfill facility personnel on December 4, 2019 and analyzed for 1,4-dioxane.

- The equipment blank sample collected from Great Oak Landfill (sample 7607-EB) contained perfluorobutyric acid (PFBA) at a laboratory estimated concentration of 1.12 ng/L. The concentration detected was J-flagged, which means the concentration is estimated above the laboratory method detection limit but below the quantification/reporting limit. PFBA was also detected in the primary leachate sample collected from Great Oak Landfill (sample 7607). Based on these data, there is less confidence in PFBA concentrations reported for the Great Oak Landfill.

Laboratory analytical reports are included in **Appendix A**.

3.4 Discussion of Sampling Results and Comparison to Other Studies

The results of the laboratory analyses indicated detectable concentrations of PFOS, PFOA, and other PFAS compounds in each of the collected samples. 1,4-Dioxane was also detected in each of the samples. A summary of laboratory analytical data for the full set of constituents of concern is provided in **Table 3**.

Concentrations of PFOS and PFOA detected in the samples were compared to concentrations detected in leachate samples collected during the Michigan Study. The comparison data are summarized in **Table 4**. The results of the comparison indicated mean concentrations detected during the North Carolina Collective Study were generally similar to those detected during the Michigan Study (see inset). Variations in minimum and maximum concentrations between the North Carolina and Michigan studies are likely a result of differing sample sizes. Comparison to published literature references (as referenced in Section 2.2) indicates that concentrations detected during the North Carolina Collective Study are also within

PFOS and PFOA Concentrations in Leachate

Parameter		Min	Max	Mean
PFOS (ng/L)	NC	82	402	199
	MI	9	960	222
PFOA (ng/L)	NC	108	3,690	1,005
	MI	16	3,200	881

the range of values reported during other studies in the United States and other Western world regions, but more than an order of magnitude lower than maximum values reported for China.

Similar to the procedure followed during the Michigan Study, the analytical data and estimated annual leachate volumes provided by each MSWLF facility were used to calculate the daily mass of PFOS and PFOA contained within landfill leachate for each facility. The calculations based on the North Carolina Collective Study data indicate a mean daily mass of less than 0.001 lbs/day of PFOS or PFOA (see inset). Comparison of estimated daily mass values for the North Carolina Collective Study to those calculated during the Michigan Study indicate generally similar values. Daily mass calculations for PFOS and PFOA are summarized in **Table 4** and depicted on **Figure 3**.

PFOS and PFOA Daily Mass in Leachate

Parameter		Min	Max	Mean
PFOS Daily Mass (lbs/day)	NC	0.00001	0.00014	0.00004
	MI	0.00001	0.00040	0.00005
PFOA Daily Mass (lbs/day)	NC	0.00001	0.00098	0.00013
	MI	0.00002	0.00260	0.00022

Daily mass calculations were also performed for 1,4-dioxane based on data collected during the North Carolina Collective Study. The results of the calculations indicated a mean daily mass of less than 0.1 lbs/day of 1,4-dioxane (see inset). The Michigan Study did not include analysis for 1,4-dioxane, nor were comprehensive published references identified for typical 1,4-dioxane concentrations in landfill leachate. As such, no additional data are available for comparison. However, based on the general similarity in PFAS concentrations reported in the North Carolina Collective Study, Michigan Study, and United States published literature, the 1,4-dioxane concentrations detected during the North Carolina Collective Study are expected to be similar to those for other MSWLFs across the United States. Daily mass calculations for 1,4-dioxane are summarized in **Table 5** and depicted on **Figure 7**.

1,4-Dioxane Concentration and Daily Mass in Leachate

Parameter	Min	Max	Mean
1,4-Dioxane Concentration (µg/L)	14.8	469	120
1,4-Dioxane Daily Mass (lbs/day)	0.0022	0.0944	0.0255

4.0 Influence on WWTP Influent

4.1 Description of Receiving WWTPs

The MSWLFs covered under the North Carolina Collective Study each dispose of leachate via one or more publicly-owned WWTPs. H&H compiled locations for the receiving WWTPs based on information provided by each landfill. A summary of the receiving WWTP names, addresses, and National Pollutant Discharge Elimination System (NPDES) permit numbers is provided in **Table 2**. H&H determined the permitted flow for each WWTP based on information obtained from permit applications on the NCDEQ on-line Laserfiche document repository. Permitted flows are used rather than actual flows to be consistent with the approach used by NCDEQ during evaluation of the WWTP sampling data referenced below.

4.2 WWTP Sampling Data Source

In 2019, the NCDEQ DWR issued letters to publicly owned utilities with pretreatment programs and industrial dischargers in the Cape Fear River Basin requiring influent sampling for 1,4-dioxane and PFAS for three consecutive months beginning in July 2019. The sampling was performed in July, August, and September 2019. H&H retrieved the results of the sampling from the NCDEQ website (NCDEQ, 2020). Discussions in this report are based on average concentrations detected during the three monthly sampling events between July and September 2019.

The NCDEQ website contains PFAS and 1,4-dioxane data for the following WWTPs which receive leachate from landfills in the North Carolina Collective Study, including:

- City of Asheboro WWTP
- East Burlington WWTP
- Utley Creek Water Reclamation Facility
- Harnett County Lillington Plant

4.3 Discussion of WWTP Influent Sampling Results and Comparison to Other Studies

The WWTP sampling data are summarized on **Table 6**. For the WWTPs that receive leachate from facilities in the North Carolina Collective Study, the concentrations of PFOS and PFOA in the influent range from 8.86 to 49.5 ng/L (based on the average of the samples collected at each WWTP). Based on documentation provided on the NCDEQ website, NCDEQ concluded that the PFOS and PFOA concentrations for these facilities would not cause levels at downstream PWS intakes that exceed the EPA Drinking Water Health Advisory Level of 70 ng/L.

For 1,4-dioxane, the average concentrations of WWTP influent range from 5.95 to 18.5 μg/L, with the exception of one outlier which indicated a significantly higher average concentration of 163 μg/L. Based on documentation provided on the NCDEQ website, the elevated outlier concentration is primarily attributed to an industrial discharger rather than a landfill leachate source. Overall, for the WWTPs that receive leachate from facilities in the North Carolina Collective Study, NCDEQ concluded that the 1,4-dioxane concentrations for these WWTPs are not anticipated to cause levels that exceed the EPA Drinking Water Health Advisory Level of 35 μg/L at downstream PWS intakes.

The WWTP sampling and flow data were used to calculate the estimated daily mass of PFOS, PFOA, and 1,4-dioxane for each facility with available data. For PFOS and PFOA, the calculated daily mass values were then compared to WWTP daily mass values calculated during the Michigan Study. The results of this comparison indicated that the daily PFOS and PFOA mass for the North Carolina WWTPs are generally similar to or lower than the corresponding daily mass for the Michigan WWTPs. Daily WWTP mass calculations summarized in **Tables 6** and **7**, and depicted on **Figures 4** and **8**.

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4.4 Leachate Contribution to WWTP Daily Mass

Percent Contribution to WWTP Influent Daily Mass		
Constituent	Leachate Sources	Non-Leachate Sources
PFOS	0.7 to 2.9%	97.1 to 99.3%
PFOA	0.6 to 10.2%	89.8 to 99.4%
1,4-Dioxane	0.3 to 3.6%	96.4 to 99.7%

In order to evaluate the relative contribution of landfill leachate to WWTP daily mass, the daily mass values calculated for leachate were compared to the daily mass values calculated for WWTP influent. The results of these calculations for the North Carolina Collective Study facilities are summarized in **Table 8**. The PFOS and PFOA data are depicted along with similar data from the Michigan Study on **Figures 5** and **6**, respectively. The 1,4-dioxane data are depicted on **Figure 8**. **Review of the graphical depiction demonstrates that the mass of PFOS, PFOA, and 1,4-dioxane from landfill leachate represents a minor contribution to overall WWTP influent mass**. The estimated percent contribution of landfill leachate to overall WWTP mass for the sites in the North Carolina Collective Study ranges from only 0.3 to 10.2% for PFOS, PFOA, and 1,4-dioxane (see inset), with an average of 3.3%. The PFOS and PFOA results are corroborated by the larger data set included in the Michigan Study, **which also confirms that landfill leachate represents a minor contribution to overall WWTP influent mass and non-leachate sources represent a much larger contribution.**

Review of the graphical depictions on Figures 5, 6, and 8 demonstrates that the mass of PFOS, PFOA, and 1,4-dioxane from landfill leachate represents a minor contribution to overall WWTP influent mass.

5.0 Conclusions and Recommendations

The North Carolina Collective Study included collection of leachate samples from nine MSWLF facilities located across the State of North Carolina for analysis of PFAS constituents and 1,4-dioxane. Where available, the results of the sampling were evaluated in conjunction with WWTP influent volumes and published sampling data in order to estimate the relative contribution of landfill leachate to overall WWTP influent mass of PFAS and 1,4-dioxane. The data were also evaluated with respect to the results of a larger study performed in Michigan using similar methodology.

The results of the North Carolina Collective Study clearly show that **landfill leachate represents a minor contribution of PFOS, PFOA, and 1,4-dioxane mass to overall WWTP influent mass for these compounds. Non-leachate sources contribute significantly more mass to WWTP influent than leachate.** These conclusions are supported by both the North Carolina Collective Study and the Michigan Study. Importantly, NCDEQ concluded that WWTP influent sampling data for facilities in the Cape Fear River Basin that receive leachate from landfills in the Collective Study indicate that **PFOS, PFOA, and 1,4-dioxane concentrations do not pose a threat to downstream PWS intakes**.

MSWLFs and WWTPs generally have an interdependent relationship for waste management (WWTPs accept leachate from MSWLFs and MSWLFs accept biosolids from WWTPs). **Landfills and WWTPs are not producers of the original sources of PFAS and 1,4-dioxane. Rather, they both receive and manage PFAS contaminated waste and wastewater from households, business, and industry.** MSWLFs and WWTPs are designed to manage waste in ways that are protective of human health and the environment. If long term reductions of CECs in the environment are to be achieved, then manufacturing and product utilization in society need to be addressed. The evidence provided by this report that landfill leachate represents only a small percentage of total influent mass of PFAS and 1,4-dioxane into WWTPs indicates the ubiquitous nature of these compounds in society. In spite of this ubiquitous nature, it is encouraging to note that in the Cape Fear River basin, NCDEQ concluded that WWTP discharges do not represent a threat to drinking water supplies in most cases.

Based on the findings of both the North Carolina Collective Study and the Michigan Study, continued work towards PFAS and 1,4-dioxane source reduction solutions, such as the United States' phase-out of PFOS and PFOA in manufacturing, is recommended. We also recommend collaboration between the solid waste and WWTP industries, NCDEQ, and the scientific community in order to identify best management practices and other solutions for safe management of wastes generated by our communities.

6.0 References

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TABLES

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SMARTER ENVIRONMENTAL SOLUTIONS

Table 1
Literature Summary of PFOS and PFOA in Landfill Leachate
North Carolina Collective Study
H&H Job No. NWA-001

Source Cited	Location/ Region	Sample Size	PFOA[1]			PFOS[2]		
			Detection Frequency (%)	Concentration Range (ng/l)[3]	Median (ng/l)	Detection Frequency (%)	Concentration Range (ng/l)	Median (ng/l)
Huset, et al (2011)	USA	5	100	380 - 1,000	490	100	56 -160	97
Allred, et al (2015)	USA	6	100	150 - 5,000	1,055	100	25 - 590	155
Lang, et al (2017)	USA	87	100	30 - 5,000	590	96	3 - 800	99
Benskin, et al (2012)	Canada	5	100	210 - 1,500	520	100	80 - 4,400	390
Kallenborn, et al (2004)	Nordic Countries	NA	NA	90 - 501	230	NA	30 - 190	80
Bossi, et al (2008)	Denmark	NA	NA	0 - 6	3	NA	0 - 4	NA
Woldegiorgis, et al (2008)	Sweden	NA	NA	40 - 1,000	540	NA	30 - 1,500	550
Busch, et al (2010)	Germany	20	95	0 - 926	57	100	0 - 235	3
Fuertes, et al (2017)	Spain	6	100	200 - 585	437	17	0 - 44	NA
Gullen, et al (2016)	Australia	17	100	19 - 2,100	450	89	0 - 100	31
Gullen, et al (2017)	Australia	97	64	17 - 7,500	600	65	13 - 2,700	220
Yan, et al (2015)	China	6	100	281 - 214,000	2,260	100	1,150 - 6,020	1,740

Notes:

1. PFOA = Perfluorooctanoic acid
2. PFOS = Perfluorooctanesulfonate
3. ng/L = nanograms per liter

Data Source: Michigan Waste & Recycling Association Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent (March 2019).

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Table 2
Landfill and WWTP Facility Information
North Carolina Collective Study
H&H Job No. NWA-001

Landfill Name	NCDEQ Permit Number	Landfill Address	Estimated Annual Leachate Volume (gallons/day)	Description of Sampling Location	Receiving WWTP[1] Name	WWTP NPDES[2] Permit Number	WWTP Permitted Flow Limit (gallons/day)*	Receiving WWTP Address	Receiving WWTP River Basin
Foothills Environmental Landfill	1403-MSWLF-1998	2800 Cheraw Road Lenoir, NC 28645	24,364	Valve at Bottom of Holding Tank	Henry Fork WWTP	NC0040797	9,000,000	4014 River Road Hickory, NC	Catawba
BFI-Charlotte Motor Speedway Landfill V	1304-MSWLF-1992	5105 Morehead Road Concord, NC 28027	40,027	Direct from Lagoon	Rocky River Regional WWTP	NC0036269	26,500,000	6400 Breezy Lane Concord, NC	Yadkin Pee Dee
Chambers Development MSWLF	0403-MSWLF-2010	375 Dozer Drive Polkton, NC 28135	17,452	Valve at Bottom of Holding Tank	Anson County WWTP	NC0041408	3,500,000	1306 Hollywood Road Wadesboro, NC	Yadkin Pee Dee
Uwharrie Environmental Regional Landfill	6204-MSWLF-1995	500 Landfill Road Mt Gilead, NC 27306	31,649	Valve at Bottom of Holding Tank	Town of Troy WWTP	NC0028916	1,200,000	Troy, NC	Yadkin Pee Dee
Great Oak Landfill	7607-MSWLF-2015	3597 Old Cedar Falls Road Randleman, NC 27317	9,589	Direct from Holding Tank	City of Asheboro WWTP	NC0026123	9,000,000	1032 Bonkemeyer Dr Asheboro, NC	Cape Fear
Upper Piedmont Regional Landfill	7304-MSWLF-1997	9650 Oxford Road Rougemont, NC 27572	31,830	Valve at Bottom of Holding Tank	East Burlington WWTP	NC0023868	12,000,000	225 Stone Quarry Road Haw River, NC	Cape Fear
Wake County South Wake MSWLF	9222-MSWLF-2008	6124 Old Smithfield Road Apex, NC 27502	5,260	Valve on Discharge Line	Utley Creek Water Reclamation Facility	NC0063096	6,000,000**	150 Treatment Plant Road Holly Springs, NC	Cape Fear
			3,890		City of Lumberton WWTP	NC0024571	20,000,000	700 Lafayette Street Lumberton, NC	Lumber
Sampson County Disposal, LLC	8202-MSWLF-2000	7434 Roseboro Highway Roseboro, NC 28382	8,658	Valve on Discharge Line	Harnett County Lillington Plant	NC0021636	7,500,000	175 Bain Street Lillington, NC	Cape Fear
			16,219		Harnett County South Plant	NC0088366	15,000,000	3224 Shady Grove Road Spring Lake, NC	Cape Fear
			20,411		City of Lumberton WWTP	NC0024571	20,000,000	700 Lafayette Street Lumberton, NC	Lumber
			22,137		Not applicable - Evaporation	Not applicable	Not applicable	Not applicable	Not applicable
East Carolina Regional Landfill	0803-MSWLF-1993	1922 Republican Road Aulander, NC 27805	41,044	Valve at Bottom of Holding Tank	Tar River Regional WWTP	NC0030317	21,000,000	3031 Treatment Plant Road Rocky Mount, NC	Tar-Pamlico

Notes:
1. WWTP = wastewater treatment plant
2. NPDES = National Pollutant Discharge Elimination System
* = Permitted flow obtained from Section A.6 of latest NPDES permit application retrieved from North Carolina Department of Environmental Quality on-line Laserfiche document repository in December 2019.
** = After receiving an Authorization to Construct, the treatment capacity will increase to 8 millions of gallons per day.

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Table 3
Leachate Analytical Data
North Carolina Collective Study
H&H Job No. NWA-001

Parameter	Sample ID		9222-1	1403-1	1304-1	0403-1	6204-1	7607-1	0803-1	7304-1	8202-1
	Sampling Date		09/18/19	09/16/19	09/16/19*	09/16/19	09/17/19	09/17/19**	09/19/19	09/17/19	09/18/19
	Landfill Name		Wake County South Wake MSWLF[1]	Foothills Environmental Landfill	BFI-Charlotte Motor Speedway Landfill V	Chambers Development MSWLF	Uwharrie Environmental Regional Landfill	Great Oak Landfill	East Carolina Regional Landfill	Upper Piedmont Regional Landfill	Sampson County Disposal, LLC
	Laboratory Method	Units[2]									
Fluorotelomer sulfonate 4:2 (4:2 FTS)	EPA 537.1 Mod	ng/L	ND[3]	ND	ND	ND	ND	ND	ND	ND	ND
Fluorotelomer sulfonate 6:2 (6:2 FTS)	EPA 537.1 Mod	ng/L	ND	ND	ND	180J[4]	ND	ND	ND	ND	ND
Fluorotelomer sulfonate 8:2 (8:2 FTS)	EPA 537.1 Mod	ng/L	ND	ND	39.7	ND	35.8J	ND	ND	ND	ND
N-ethylperfluoro-1-octanesulfonamidoacetic acid (NEtFOSAA)	EPA 537.1 Mod	ng/L	ND	101	87.2	14.9J	68.0	15.6J	237	48.7	43.8
N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)	EPA 537.1 Mod	ng/L	35.8J	257	258	50.5	180	42.4	230	106	104
Perfluorobutyric acid (PFBA)	EPA 537.1 Mod	ng/L	600	744	1920	831	2400	303EB[5]	650	743	4770
Perfluorobutanesulfonate (PFBS)	EPA 537.1 Mod	ng/L	1420	4400	5260	6290	2870	72.2	3850	1420	7530
Perfluorotetradecanoic acid (PFTeDA)	EPA 537.1 Mod	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluorotridecanoic acid (PFTrDA)	EPA 537.1 Mod	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluorodecanesulfonate (PFDS)	EPA 537.1 Mod	ng/L	ND	ND	6.87J	ND	ND	7.10J	ND	14.9J	ND
Perfluorodecanoic acid (PFDA)	EPA 537.1 Mod	ng/L	17.3J	82.6	590	23.6	632	18.5J	90.8	48.0	90.9
Perfluorododecanoic acid (PFDoA)	EPA 537.1 Mod	ng/L	7.40J	ND	63.3	ND	184	ND	ND	ND	9.17J
Perfluoroheptanesulfonate (PFHpS)	EPA 537.1 Mod	ng/L	ND	6.82J	8.17J	ND	9.40J	ND	9.39J	ND	ND
Perfluoroheptanoic acid (PFHpA)	EPA 537.1 Mod	ng/L	241	571	983	249	1560	68.4	689	344	5520
Perfluorohexanesulfonate (PFHxS)	EPA 537.1 Mod	ng/L	237	794	925	218	640	59.1	536	190	424
Perfluorohexanoic acid (PFHxA)	EPA 537.1 Mod	ng/L	2940	3920	3470	2200	5540	449	3610	2350	6730
Perfluorononanesulfonate (PFNS)	EPA 537.1 Mod	ng/L	20.7	ND	ND	ND	ND	ND	ND	13.4J	ND
Perfluorononanoic acid (PFNA)	EPA 537.1 Mod	ng/L	28.8	71.4	269	15.5J	326	32.8	89.0	44.1	128
Perfluorooctanesulfonamide (PFOSA)	EPA 537.1 Mod	ng/L	ND	7.08J	11.5J	ND	ND	8.75J	17.3J	ND	ND
Perfluorooctanesulfonate (PFOS)	EPA 537.1 Mod	ng/L	82.3	296	356	84.2	356	83.9	402	254	222
Perfluorooctanoic acid (PFOA)	EPA 537.1 Mod	ng/L	803	1650	2210	345	3690	108	1640	884	1790
Perfluoropentanesulfonate (PFPeS)	EPA 537.1 Mod	ng/L	32.3	50.6	73.2	19.6	41.4	10.3J	54.7	28.1	61.0
Perfluoropentanoic acid (PFPeA)	EPA 537.1 Mod	ng/L	577	1070	2160	780	2150	159	1220	621	86400
Perfluoroundecanoic acid (PFUdA)	EPA 537.1 Mod	ng/L	ND	7.04J	30.8	ND	33.0	7.44J	ND	ND	10.2J
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (PFPrOPrA)[6]	EPA 537.1 Mod	ng/L	NA[7]	NA	NA	NA	NA	NA	NA	NA	10800
1,4-Dioxane	EPA 8270 SIM	µg/L	30.0	99.7	214	14.8Q[8]	357	469	157	177	184

Notes:
1. MSWLF = municipal solid waste landfill
2. ng/L = nanograms per liter; µg/L = micrograms per liter
3. ND = Not detected above laboratory method detection limt
4. J = Estimated concentration between method detection limit and reporting limit
5. EB = Constituent was also detected in associated equipment blank sample
6. PFPrOPrA also known by trade name GenX
7. NA = Not analyzed
8. Q = Value indicates results of reanalysis outside laboratory holding time

* = BFI-Charlotte Motor Speedway Landfill V was resampled for 1,4-dioxane (new sample ID 1,1A,2,2A) on 12/4/19

** = Great Oak Landfill (sample ID 7607-1) was resampled for 1,4-dioxane analysis on 9/30/19

ATTACHMENT D

Table 4
PFOS and PFOA Daily Leachate Mass Calculations
North Carolina Collective Study
H&H Job No. NWA-001

Sampling Reference	Average Leachate Volume (gallons/day)	PFOS[1] (ng/L)[3]	PFOA[2] (ng/L)	PFOS Daily Mass (lbs/day)[4]	PFOA Daily Mass (lbs/day)
North Carolina Collective Study					
Wake County South Wake MSWLF[5]	9,151	82.3	803	0.00001	0.00001
Foothills Environmental Landfill	24,364	296	1,650	0.00006	0.00006
BFI-Charlotte Motor Speedway Landfill V	40,027	356	2,210	0.00012	0.00074
Chambers Development MSWLF	17,452	84	345	0.00001	0.00005
Uwharrie Environmental Regional Landfill	31,649	356	3,690	0.00009	0.00098
Great Oak Landfill	9,589	84	108	0.00001	0.00001
East Carolina Regional Landfill	41,044	402	1,640	0.00014	0.00056
Upper Piedmont Regional Landfill	31,830	254	884	0.00007	0.00024
Sampson County Disposal, LLC*	45,288	222	1,790	0.00008	0.00068
Minimum	9,151	82	108	0.00001	0.00001
Maximum	45,288	402	3,690	0.00014	0.00098
Geometric Mean	24,152	199	1,005	0.00004	0.00013
Michigan Study[6]					
Arbor Hills Landfill	98,400	220	3,200	0.00018	0.0026
Autumn Hills RDF[7]	54,800	380	1,300	0.00017	0.0006
Brent Run Landfill	16,400	110	540	0.00002	0.0001
C&C Expanded Sanitary Landfill	42,000	450	1,300	0.00015	0.0004
Carleton Farms Landfill	123,300	250	1,800	0.00026	0.0018
Central Sanitary Landfill	30,100	470	2,500	0.00012	0.0006
Citizen's Disposal Inc.	32,900	180	1,100	0.00005	0.0003
Dafter Sanitary Landfill	16,500	130	680	0.00002	0.0001
Eagle Valley RDF	32,900	170	490	0.00005	0.0001
Glens Sanitary Landfill	3,800	210	770	0.00001	0.00002
Granger Grand River Landfill	64,400	160	240	0.00009	0.0001
Granger Wood Street Landfill	19,200	110	470	0.00002	0.0001
K&W Landfill	17,500	170	830	0.00002	0.0001
Manistee County Landfill	4,700	220	420	0.000009	0.000016
McGill Road Landfill	13,700	170	760	0.00002	0.0001
Michigan Environs Inc. (Menominee)	13,100	100	1,400	0.00001	0.0002
Northern Oaks RDF	12,300	220	1,000	0.00002	0.0001
Oakland Heights Development	17,800	230	780	0.00003	0.0001
Orchard Hill Sanitary Landfill	12,500	110	650	0.00001	0.0001
Ottawa County Farms Landfill	82,200	530	1,800	0.0004	0.0012
People's Landfill	21,900	710	2,500	0.00013	0.0005
Pine Tree Acres RDF	74,000	430	1,800	0.0003	0.001
Pitsch Sanitary Landfill	15,000	260	1,300	0.00003	0.0002
Sauk Trail Hills Landfill	20,500	610	2,800	0.00010	0.0005
SC Holdings	16,000	410	960	0.00005	0.0001
Tri-City RDF	9,600	160	1,200	0.00001	0.0001
Venice Park RDF MH#20/Venice Park RDF MH#21**	32,900	190	910	0.0002	0.0007
		630	1,500		
Vienna Junction Industrial Park Sanitary Landfill	13,700	130	1,300	0.00001	0.0001
Waters Landfill	NONE	230	930	NONE	NONE
Westside RDF	60,800	160	1,300	0.00008	0.0007
Whitefeather Landfill	NONE	550	1,700	NONE	NONE
Woodland Meadows RDF -Van Buren	54,800	510	2,000	0.00023	0.0009
Riverview 003/Riverview 004/Riverview 007**	37,400	270	1,900	0.00004	0.0003
		140	860		
		8.5	38		
South Kent Outfall/South Kent Hauled**	48,000	960	725	0.0002	0.0001
		130	16		
Smith's Creek Landfill**	32,900	120	510	0.00003	0.0001
Minimum	3,800	9	16	0.00001	0.00002
Maximum	123,300	960	3,200	0.00040	0.00260
Geometric Mean	25,501	222	881	0.00005	0.00022

Notes:
1. PFOS = Perfluorooctanesulfonate
2. PFOA = Perfluorooctanoic acid
3. ng/L = nanograms per liter
4. lbs/day = pounds per day
5. MSWLF = municipal solid waste landfill
6. Michigan Study = Michigan Waste & Recycling Association Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent (March 2019)
7. RDF = recycling and disposal facility

* = Leachate volume does not include volume disposed of via evaporation.

** = Multiple laboratory results reported, average used for daily mass calculations.

ATTACHMENT D

Table 5
1,4-Dioxane Daily Leachate Mass Calculations
North Carolina Collective Study
H&H Job No. NWA-001

Sampling Reference	Average Leachate Volume (gallons/day)	1,4-Dioxane (µg/L)[1]	1,4-Dioxane Daily Mass (lbs/day)[2]
North Carolina Collective Study			
Wake County South Wake MSWLF[3]	9,151	30.0	0.0023
Foothills Environmental Landfill	24,364	99.7	0.0203
BFI-Charlotte Motor Speedway Landfill V	40,027	214	0.0716
Chambers Development MSWLF	17,452	14.8Q[4]	0.0022
Uwharrie Environmental Regional Landfill	31,649	357	0.0944
Great Oak Landfill	9,589	469	0.0376
East Carolina Regional Landfill	41,044	157	0.0538
Upper Piedmont Regional Landfill	31,830	177	0.0471
Sampson County Disposal, LLC*	45,288	184	0.0696
Minimum	9,151	14.8	0.0022
Maximum	45,288	469	0.0944
Geometric Mean	24,152	120	0.0255

Notes:
1. µg/L = micrograms per liter
2. lbs/day = pounds per day
3. MSWLF = municipal solid waste landfill
4. Q = value indicates results of reanalysis outside laboratory holding time
* = Leachate volume is representative of volume disposed at WWTPs.

ATTACHMENT D

Table 6
PFOS and PFOA Daily WWTP Mass Calculations
North Carolina Collective Study
H&H Job No. NWA-001

Facility	WWTP[1] Permitted Flow Limit (gallons/day)*	PFOS[2] Concentration (ng/l)[4]	PFOA[3] Concentration (ng/l)	PFOS Daily Mass (lbs/day)[5]	PFOA Daily Mass (lbs/day)
WWTPs that receive leachate from landfills in North Carolina Collective Study					
City of Asheboro WWTP	9,000,000	10.6	19.3	0.0008	0.0014
East Burlington WWTP	12,000,000	49.5	39.6	0.0050	0.0040
Utley Creek Water Reclamation Facility	6,000,000**	10	9.8	0.0005	0.0005
Harnett County Lillington Plant	7,500,000	8.86	20.2	0.0006	0.0013
Michigan Study[6] WWTPs that receive leachate from landfills included in Study					
Menominee	3,200,000	5.6	12	0.0001	0.0003
Clinton River	30,600,000	7.68	4.94	0.0019	0.0013
Genesee Co-Ragnone	25,900,000	5.22	4	0.0012	0.0009
GLWA	650,000,000	7.54	6.02	0.0406	0.0324
Grand Rapids	61,100,000	12.7	5.06	0.0066	0.0026
Holland	12,000,000	3.79	8.93	0.0004	0.0009
Lansing	35,000,000	ND[7]	4.98	ND	0.0014
Sandusky	2,550,000	7.98	12.2	0.0002	0.0003
Three Rivers	2,750,000	7.39	21.44	0.0002	0.0005
Wyoming	22,000,000	6.2 to 26.4	5.08 to 25	0.0048	0.0046
YCUA	51,200,000	4.8 to 7.51	12	0.0032	0.0051
Michigan Study WWTPs that receive leachate from landfills not included in Study					
Bay City	18,000,000	18.2	4.87	0.0027	0.0007
Downriver	125,000,000	22.2	7.2	0.0230	0.0075
Flint	50,000,000	62.4	10.3	0.0258	0.0043
Kalamazoo	53,500,000	ND	ND	ND	ND
Muskegon Co Metro	43,000,000	10.5 to 24.3	11.7 to 36.9	0.0086	0.0131
North Kent S A	8,000,000	31.1	11.2	0.0021	0.0007
Port Huron	20,000,000	19.5	64.6	0.0032	0.0107
S Huron Valley UA (SHUVA)	24,000,000	ND	3.76	ND	0.0007

Notes:
1. WWTP = wastewater treatment plant
2. PFOS = Perfluorooctanesulfonate
3. PFOA = Perfluorooctanoic acid
4. ng/L = nanograms per liter
5. lbs/day = pounds per day
6. Michigan Study = Michigan Waste & Recycling Association Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent (March 2019)
7. ND = not detected

* = Permitted flow obtained from Section A.6 of latest National Pollutant Discharge Elimination System permit application retrieved from North Carolina Department of Environmental Quality on-line Laserfiche document repository in December 2019.
** = After receiving an Authorization to Construct, the treatment capacity will increase to 8 millions of gallons per day. The lower value of 6 millions of gallons per day was conservatively used for concentration calculations.
Table only shows facilities for which sampling data are available.

For Michigan sites, daily mass calculations performed using maximum value where multiple data are available. For North Carolina sites, concentrations shown and associated daily mass calculations are based on average values for three sampling events performed between July and September 2019.

ATTACHMENT D

Table 7
1,4-Dioxane Daily WWTP Mass Calculations
North Carolina Collective Study
H&H Job No. NWA-001

Facility	WWTP[1] Permitted Flow Limit (gallons/day)*	1,4-Dioxane Concentration (µg/l)[2]	1,4-Dioxane Daily Mass (lbs/day)[3]
WWTPs that receive leachate from landfills in North Carolina Collective Study			
City of Asheboro WWTP	9,000,000	163	12.2927
East Burlington WWTP	12,000,000	18.5	1.8583
Utley Creek Water Reclamation Facility	6,000,000**	7.3	0.3635
Harnett County Lillington Plant	7,500,000	5.95	0.3729

Notes:
1. WWTP = wastewater treatment plant
2. µg/L = micrograms per liter
3. lbs/day = pounds per day

* = Permitted flow obtained from Section A.6 of latest National Pollutant Discharge Elimination System permit application retrieved from North Carolina Department of Environmental Quality on-line Laserfiche document repository in December 2019.
** = After receiving an Authorization to Construct, the treatment capacity will increase to 8 millions of gallons per day. The lower value of 6 millions of gallons per day was conservatively used for concentration calculations.
Concentrations shown and associated daily mass calculations are based on average values for three sampling events performed between July and September 2019.

ATTACHMENT D

Table 8
Percent of WWTP Daily Mass Contributed by Landfill Leachate
North Carolina Collective Study
H&H Job No. NWA-001

Landfill Name	Average Leachate Volume (gallons/day)	Receiving WWTP[1] Name	WWTP Permitted Flow Limit (gallons per day)*	Constituent	Concentration Data			Daily Mass Data		Percentage of WWTP Influent Daily Mass Associated with Landfill Leachate***
					Concentration Units[2]	Landfill Leachate Concentration	WWTP Influent Concentration	Landfill Leachate Daily Mass (lbs/day)[3]	WWTP Influent Daily Mass (lbs/day)	
Wake County South Wake MSWLF[4]	5,260	Utley Creek Water Reclamation Facility	6,000,000**	PFOS[5]	ng/L	82.3	10	0.00000	0.0005	0.7%
				PFOA[6]	ng/L	803	9.8	0.00004	0.0005	7.2%
				PFOS+PFOA	ng/L	885	20	0.00004	0.0010	3.9%
				1,4-Dioxane	µg/L	30	7.3	0.00132	0.3635	0.4%
	3,890	City of Lumberton WWTP	20,000,000	PFOS	ng/L	82.3	NS[7]	0.00000	NS	NS
				PFOA	ng/L	803	NS	0.00003	NS	NS
				PFOS+PFOA	ng/L	885	NS	0.00003	NS	NS
				1,4-Dioxane	µg/L	30	NS	0.00098	NS	NS
Foothills Environmental Landfill	24,364	Henry Fork WWTP	9,000,000	PFOS	ng/L	296	NS	0.00006	NS	NS
				PFOA	ng/L	1650	NS	0.00034	NS	NS
				PFOS+PFOA	ng/L	1946	NS	0.00040	NS	NS
				1,4-Dioxane	µg/L	99.7	NS	0.02030	NS	NS
BFI-Charlotte Motor Speedway Landfill V	40,027	Rocky River Regional WWTP	26,500,000	PFOS	ng/L	356	NS	0.00012	NS	NS
				PFOA	ng/L	2210	NS	0.00074	NS	NS
				PFOS+PFOA	ng/L	2566	NS	0.00086	NS	NS
				1,4-Dioxane	µg/L	214	NS	0.07157	NS	NS
Chambers Development MSWLF	17,452	Anson County WWTP	3,500,000	PFOS	ng/L	84.2	NS	0.00001	NS	NS
				PFOA	ng/L	345	NS	0.00005	NS	NS
				PFOS+PFOA	ng/L	429	NS	0.00006	NS	NS
				1,4-Dioxane	µg/L	14.8Q[8]	NS	0.00216	NS	NS
Uwharrie Environmental Regional Landfill	31,649	Town of Troy WWTP	1,200,000	PFOS	ng/L	356	NS	0.00009	NS	NS
				PFOA	ng/L	3690	NS	0.00098	NS	NS
				PFOS+PFOA	ng/L	4046	NS	0.00107	NS	NS
				1,4-Dioxane	µg/L	357	NS	0.09441	NS	NS
Great Oak Landfill	9,589	City of Asheboro WWTP	9,000,000	PFOS	ng/L	83.9	10.6	0.00001	0.0008	0.8%
				PFOA	ng/L	108	19.3	0.00001	0.0014	0.6%
				PFOS+PFOA	ng/L	192	29.9	0.00002	0.0022	0.7%
				1,4-Dioxane	µg/L	469	163	0.03758	12.2927	0.3%
East Carolina Regional Landfill	41,044	Tar River Regional WWTP	21,000,000	PFOS	ng/L	402	NS	0.00014	NS	NS
				PFOA	ng/L	1640	NS	0.00056	NS	NS
				PFOS+PFOA	ng/L	2042	NS	0.00070	NS	NS
				1,4-Dioxane	µg/L	157	NS	0.05384	NS	NS
Upper Piedmont Regional Landfill	31,830	East Burlington WWTP	12,000,000	PFOS	ng/L	254	49.5	0.00007	0.0050	1.4%
				PFOA	ng/L	884	39.6	0.00024	0.0040	5.9%
				PFOS+PFOA	ng/L	1138	89.0	0.00030	0.0089	3.4%
				1,4-Dioxane	µg/L	177	18.5	0.04707	1.8583	2.5%
Sampson County Disposal, LLC	8,658	Harnett County Lillington Plant	7,500,000	PFOS	ng/L	222	8.86	0.00002	0.0006	2.9%
				PFOA	ng/L	1790	20.2	0.00013	0.0013	10.2%
				PFOS+PFOA	ng/L	2012	29.0	0.00015	0.0018	8.0%
				1,4-Dioxane	µg/L	184	5.95	0.01331	0.3729	3.6%
				PFPrOPrA[9]	ng/L	10800	NS	0.00078	NS	NS
	16,219	Harnett County South Plant	15,000,000	PFOS	ng/L	222	NS	0.00003	NS	NS
				PFOA	ng/L	1790	NS	0.00024	NS	NS
				PFOS+PFOA	ng/L	2012	NS	0.00027	NS	NS
				1,4-Dioxane	µg/L	184	NS	0.02494	NS	NS
				PFPrOPrA	ng/L	10800	NS	0.00146	NS	NS
	20,411	City of Lumberton WWTP	20,000,000	PFOS	ng/L	222	NS	0.00004	NS	NS
				PFOA	ng/L	1790	NS	0.00031	NS	NS
				PFOS+PFOA	ng/L	2012	NS	0.00034	NS	NS
				1,4-Dioxane	µg/L	184	NS	0.03138	NS	NS
				PFPrOPrA	ng/L	10800	NS	0.00184	NS	NS
	22,137	Evaporation	Not applicable	PFOS	ng/L	222	NA[10]	NA	NA	NA
				PFOA	ng/L	1790	NA	NA	NA	NA
				PFOS+PFOA	ng/L	2012	NA	NA	NA	NA
				1,4-Dioxane	µg/L	184	NA	NA	NA	NA
				PFPrOPrA	ng/L	10800	NA	NA	NA	NA

Notes:
1. WWTP = wastewater treatment plant
2. ng/L = nanograms per liter; µg/L = micrograms per liter
3. lbs/day = pounds per day
4. MSWLF = municipal solid waste landfill
5. PFOS = perfluorooctanesulfonate
6. PFOA = perfluorooctanoic acid
7. NS = no sampling data available
8. Q = value indicates results of reanalysis outside laboratory holding time
9. PFPrOPrA = 2,3,3,3-tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (trade name GenX)
10. NA = not applicable

* = Permitted flow obtained from Section A.6 of latest National Pollutant Discharge Elimination System permit application retrieved from North Carolina Department of Environmental Quality on-line Laserfiche document repository in December 2019.

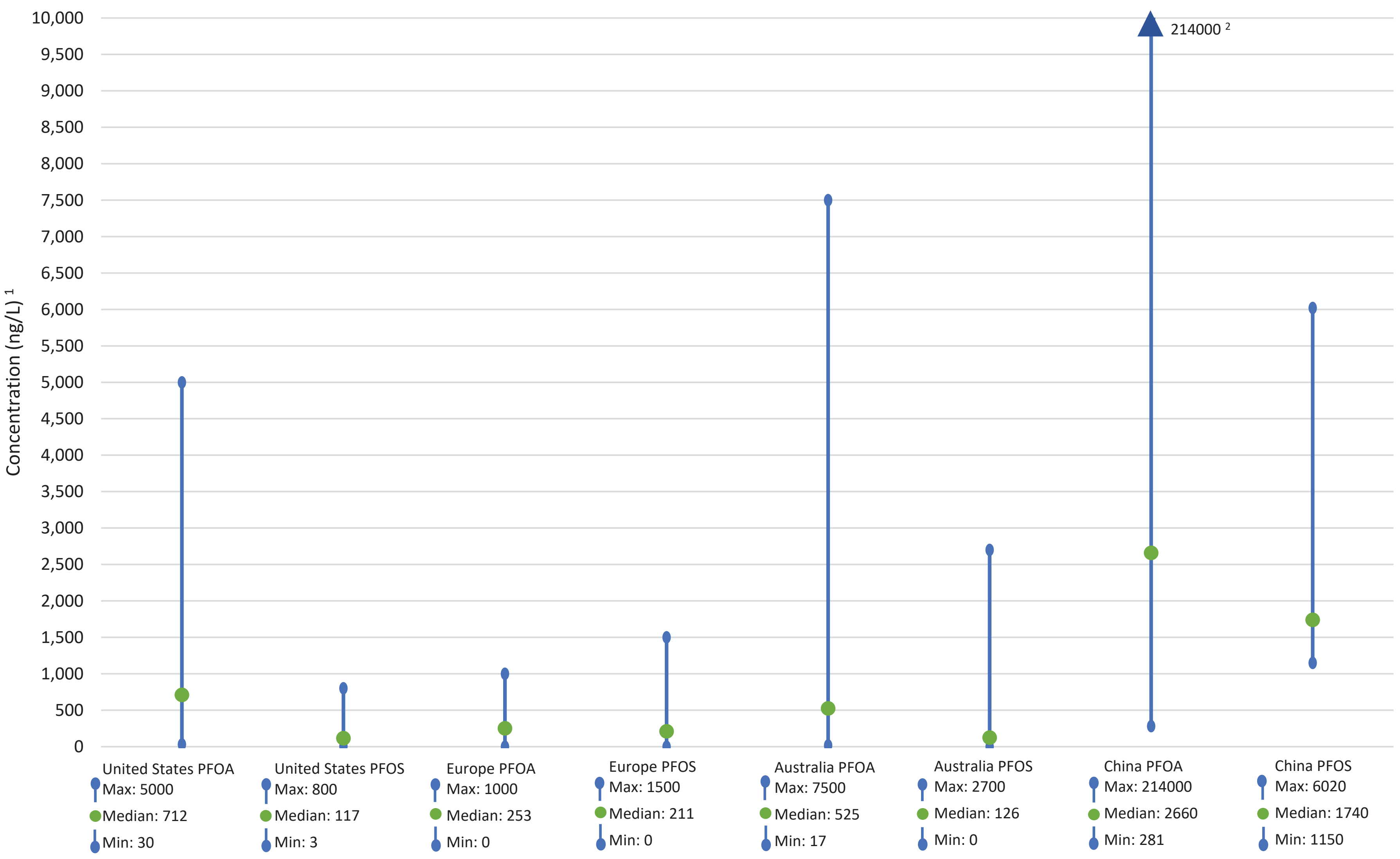
** = After receiving an Authorization to Construct, the treatment capacity will increase to 8 millions of gallons per day. The lower value of 6 millions of gallons per day was conservatively used for concentration calculations.

*** = WWTP mass attributed to landfill leachate only includes contributions from landfills covered under the North Carolina Collective Study.

ATTACHMENT D

FIGURES

Figure 1
PFOA & PFOS Concentrations in Landfill Leachate Based on Literature Summary



Notes:
1. ng/L = nanograms per liter
2. Concentration is beyond the scale of the graph (>20 times scale of graph)

Source: Michigan Waste & Recycling Association Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent (March 2019)

ATTACHMENT D

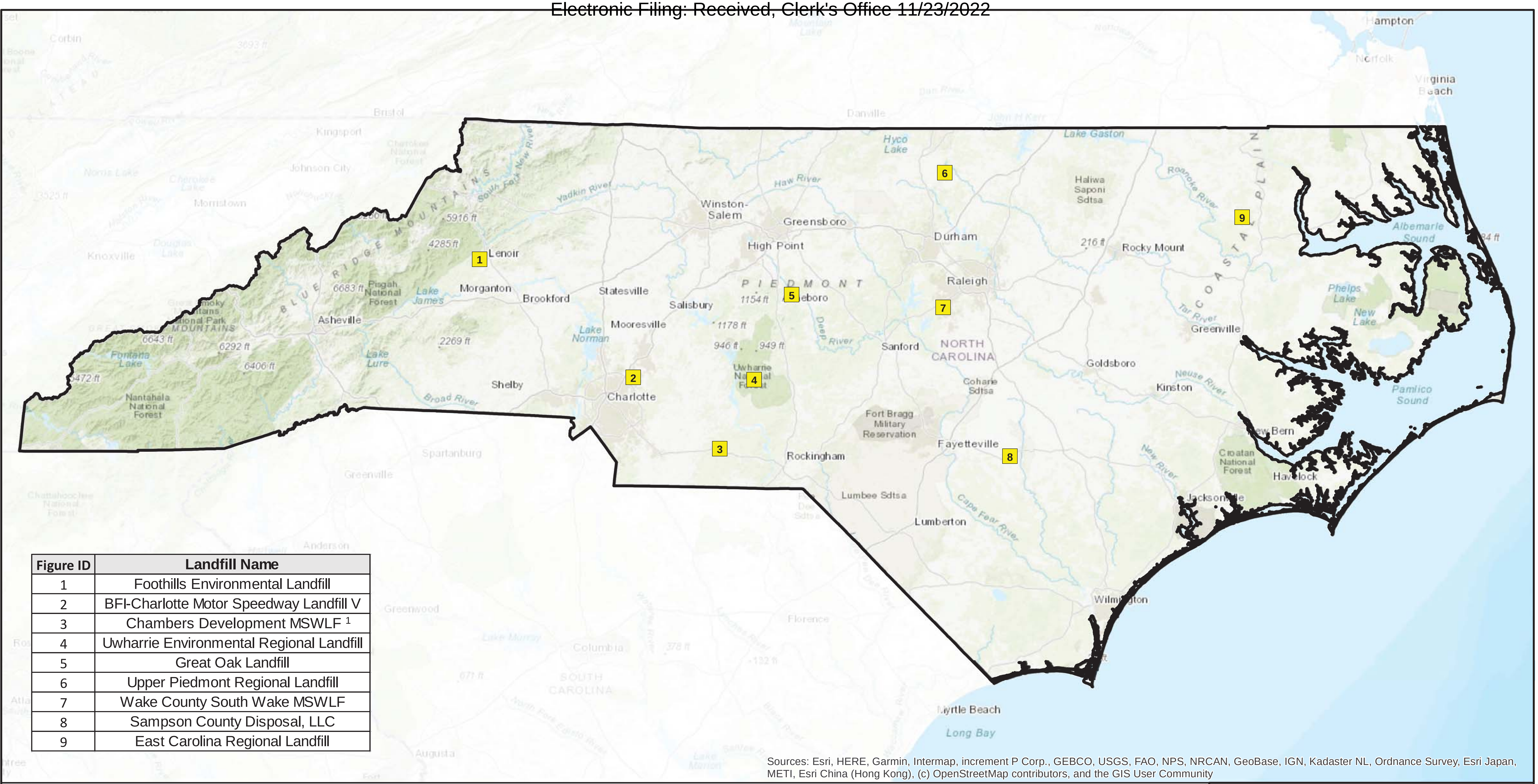


Figure ID	Landfill Name
1	Foothills Environmental Landfill
2	BFI-Charlotte Motor Speedway Landfill V
3	Chambers Development MSWLF ¹
4	Uwharrie Environmental Regional Landfill
5	Great Oak Landfill
6	Upper Piedmont Regional Landfill
7	Wake County South Wake MSWLF
8	Sampson County Disposal, LLC
9	East Carolina Regional Landfill

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

LEGEND

🟨 LANDFILL LOCATION

NOTE:

1. MSWLF = MUNICIPAL SOLID WASTE LANDFILL

LANDFILL LOCATION NUMBERS ARE CODED TO THE TABLE AS SHOWN.

N

0 40 80
Miles

TITLE
FACILITY LOCATION MAP

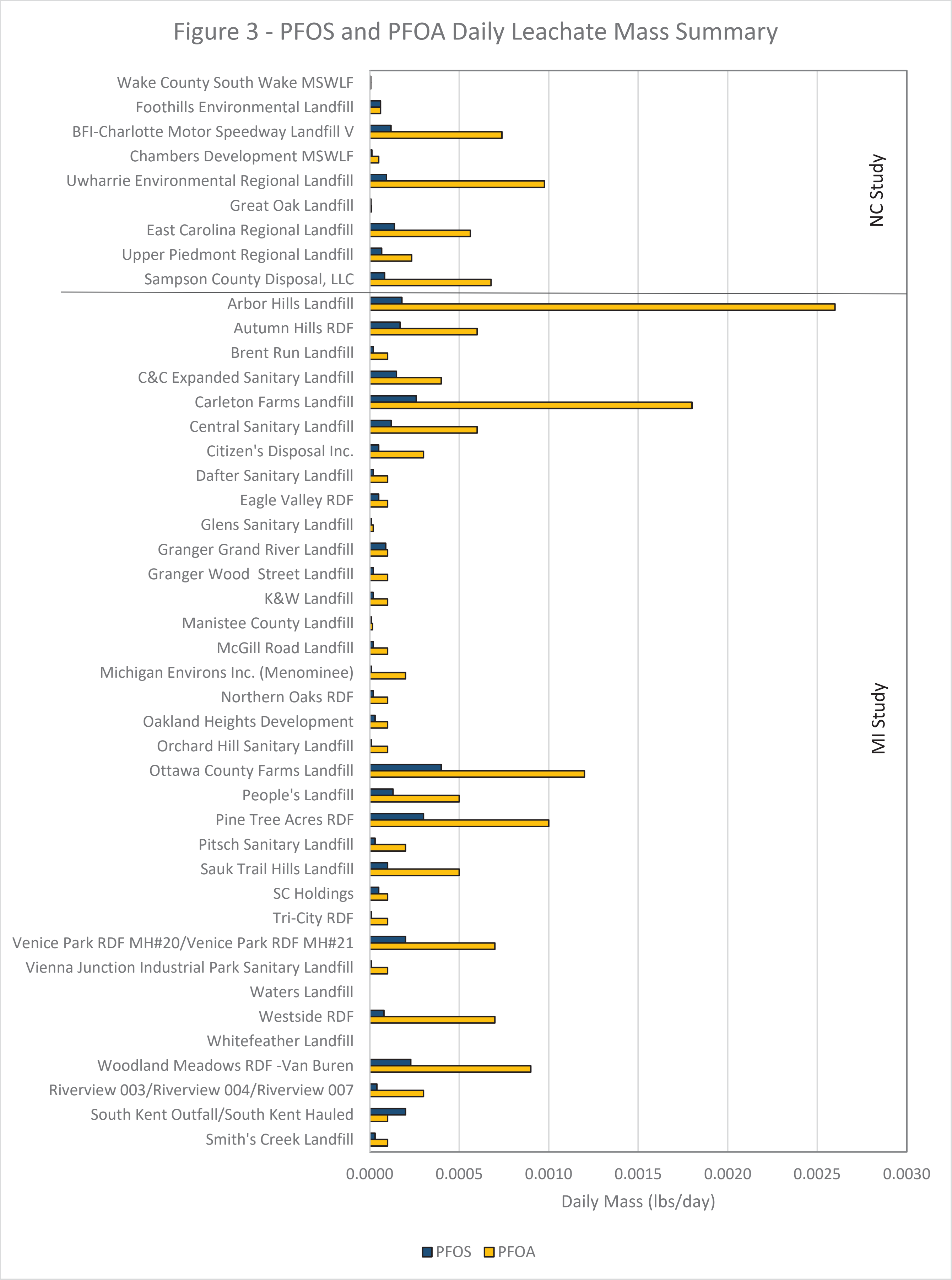
PROJECT
NORTH CAROLINA COLLECTIVE STUDY

hart hickman
SMARTER ENVIRONMENTAL SOLUTIONS

2923 South Tryon Street - Suite 100
Charlotte, North Carolina 28203
704-586-0007 (p) 704-586-0373 (f)
License # C-1269 / # C-245 Geology

DATE: 2-14-20	REVISION NO: 0
JOB NO: NWA-001	FIGURE NO: 2

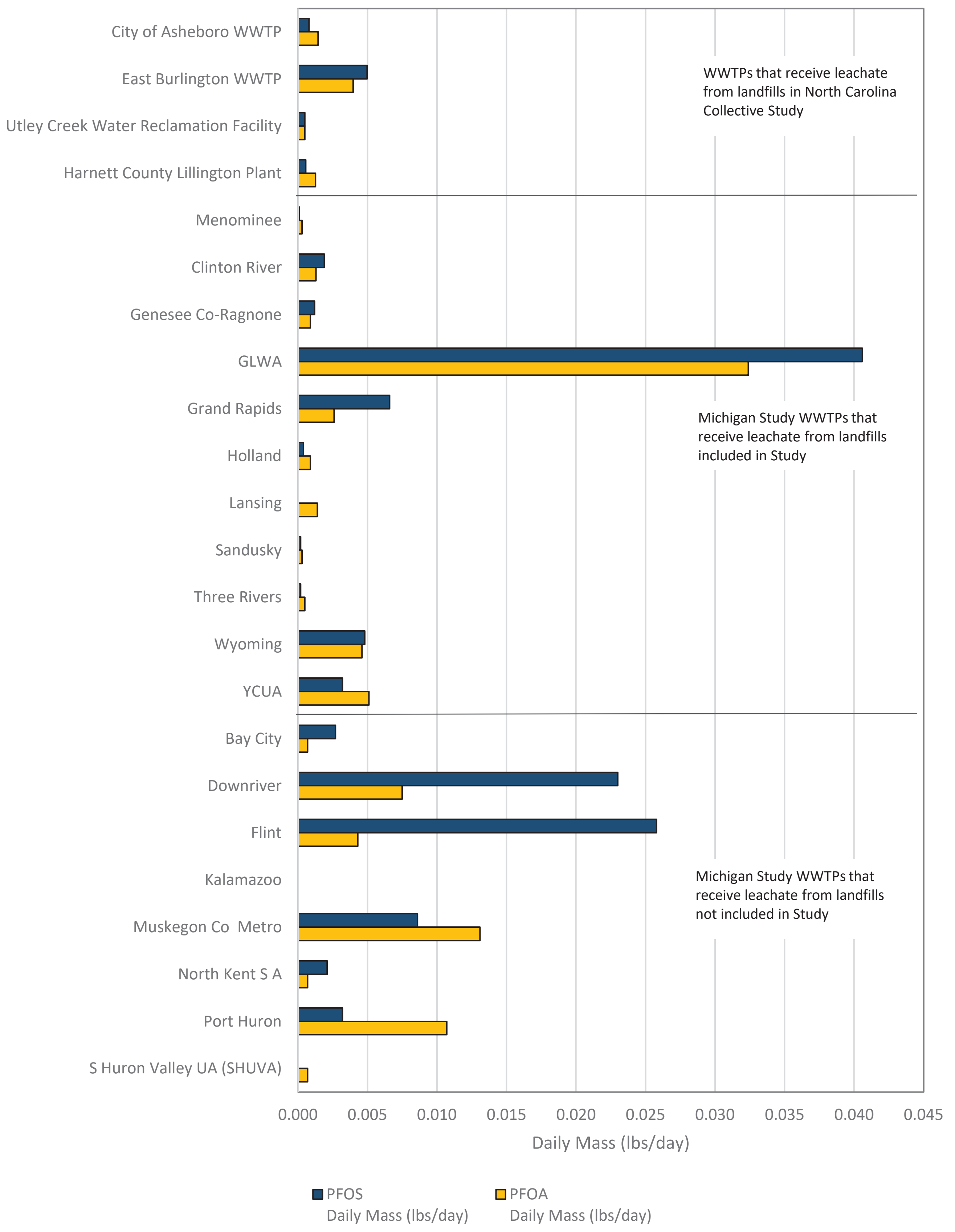
Path: \\HHFS01\Redirectedfolders\sperry\My Documents\ArcGIS\PROJECTS\NWA-001\SITE_MAP.mxd



Notes:
1. MI Study = Michigan Waste & Recycling Association Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent (March 2019)
2. lbs/day = pounds per day

ATTACHMENT D

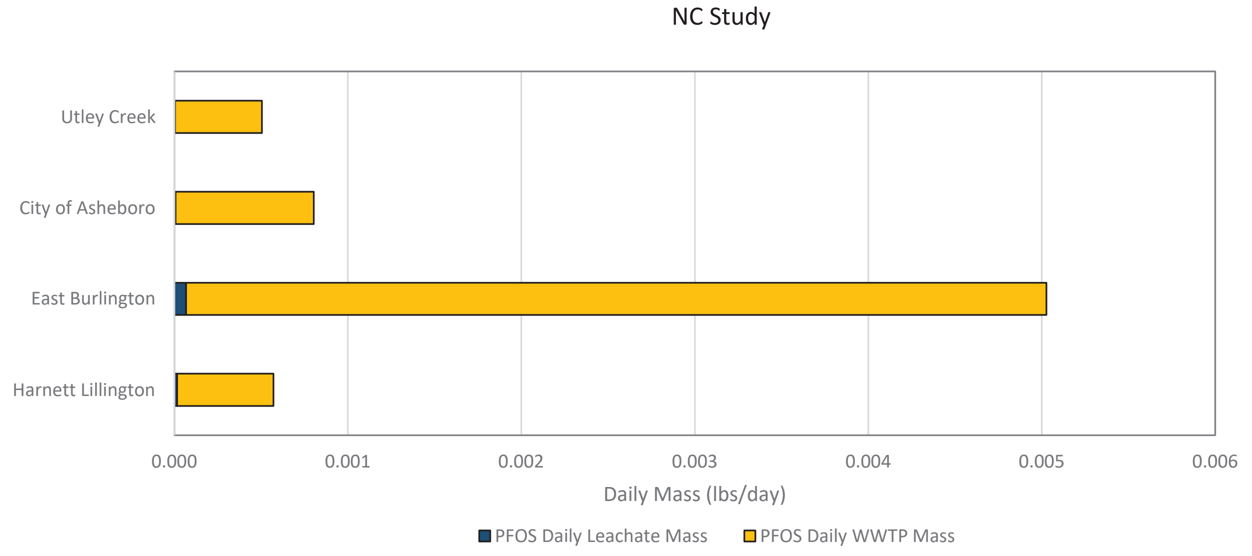
Figure 4 - PFOS and PFOA Daily WWTP Mass Summary

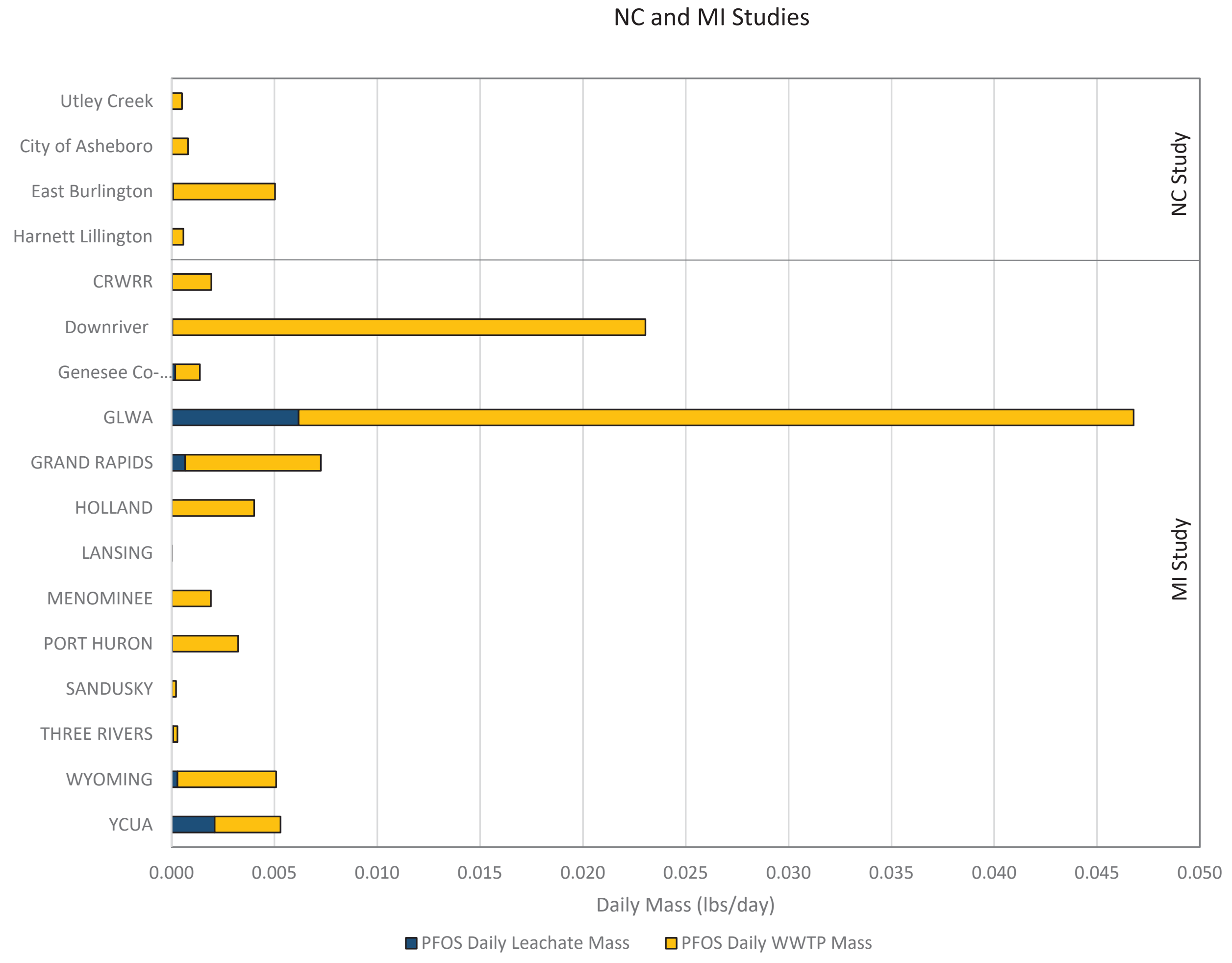


Notes:
1. MI Study = Michigan Waste & Recycling Association Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent (March 2019)
2. lbs/day = pounds per day

ATTACHMENT D

Figure 5 - PFOS Landfill Leachate Contribution to WWTP Daily Mass



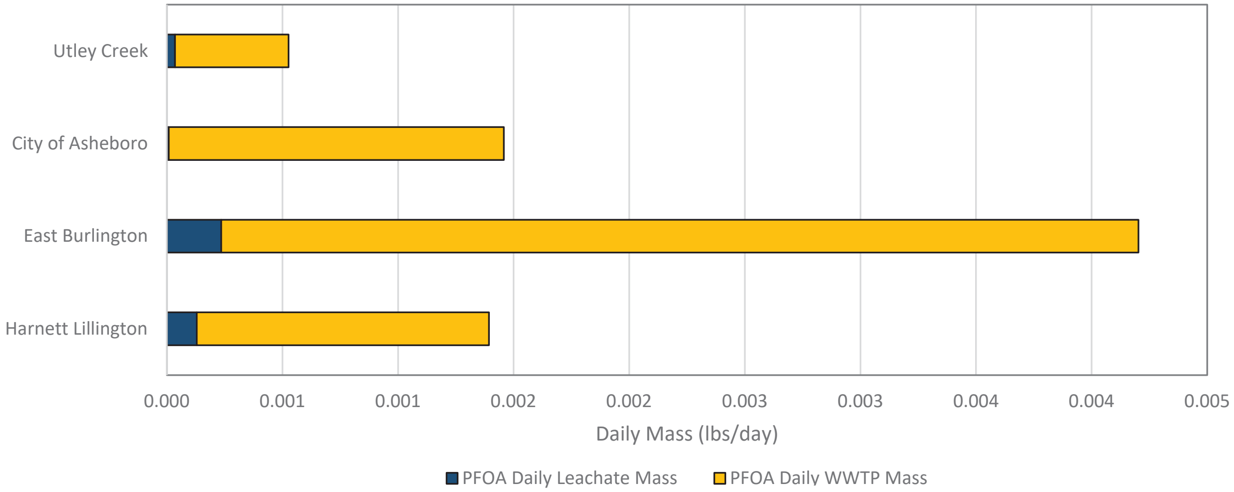


Notes:
1. MI Study = Michigan Waste & Recycling Association Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent (March 2019)
2. lbs/day = pounds per day

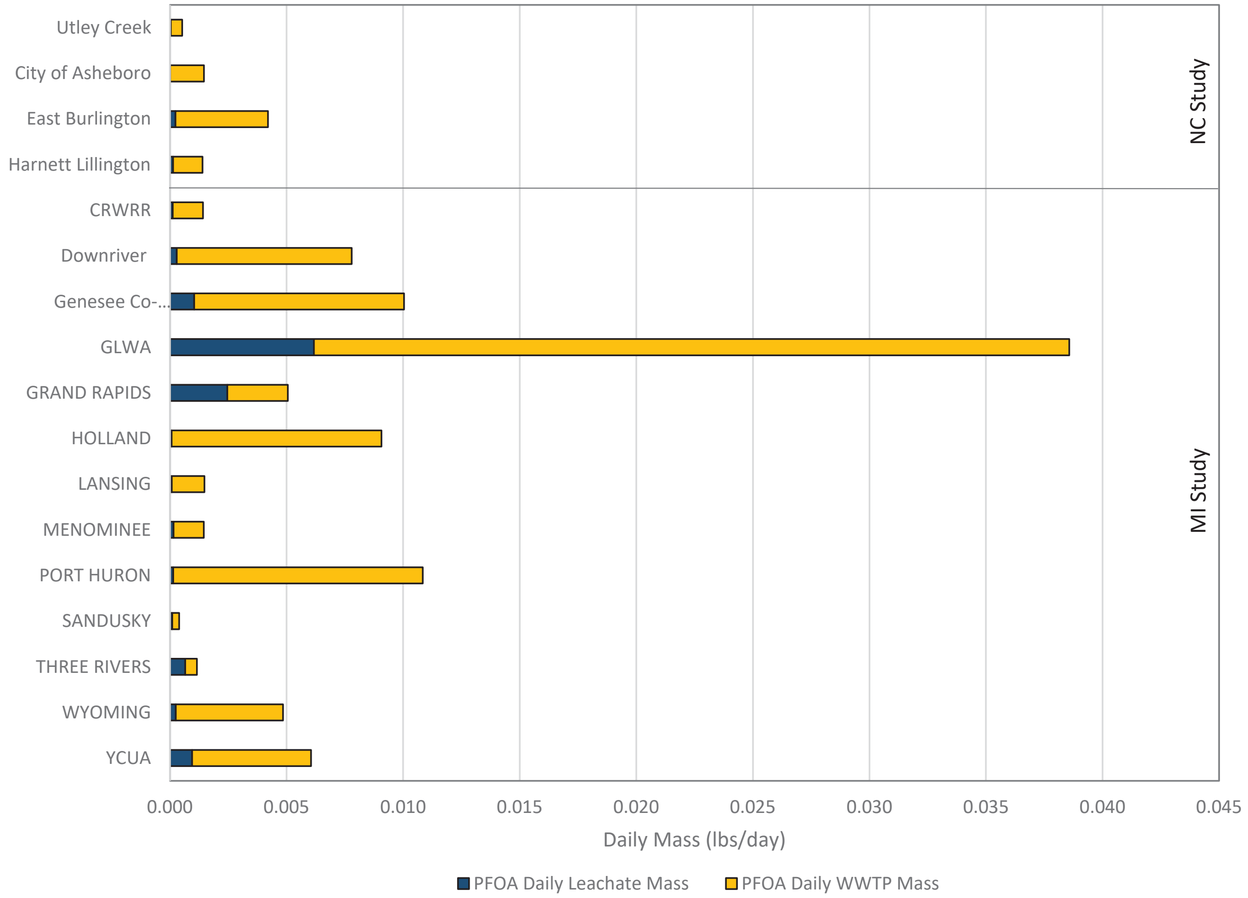
ATTACHMENT D

Figure 6 - PFOA Landfill Leachate Contribution to WWTP Daily Mass

NC Study

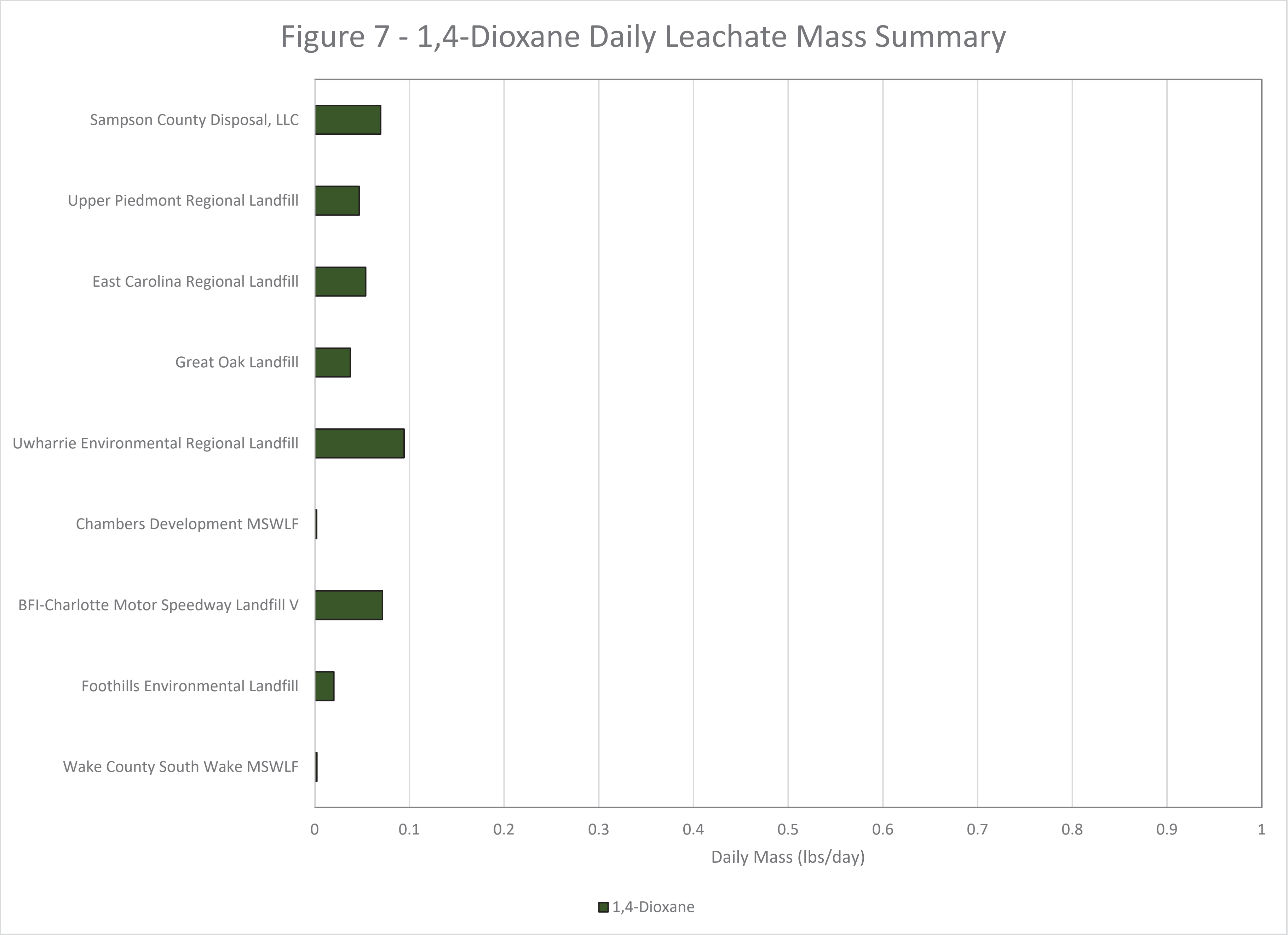


NC and MI Studies



Notes:
1. MI Study = Michigan Waste & Recycling Association Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent (March 2019)
2. lbs/day = pounds per day

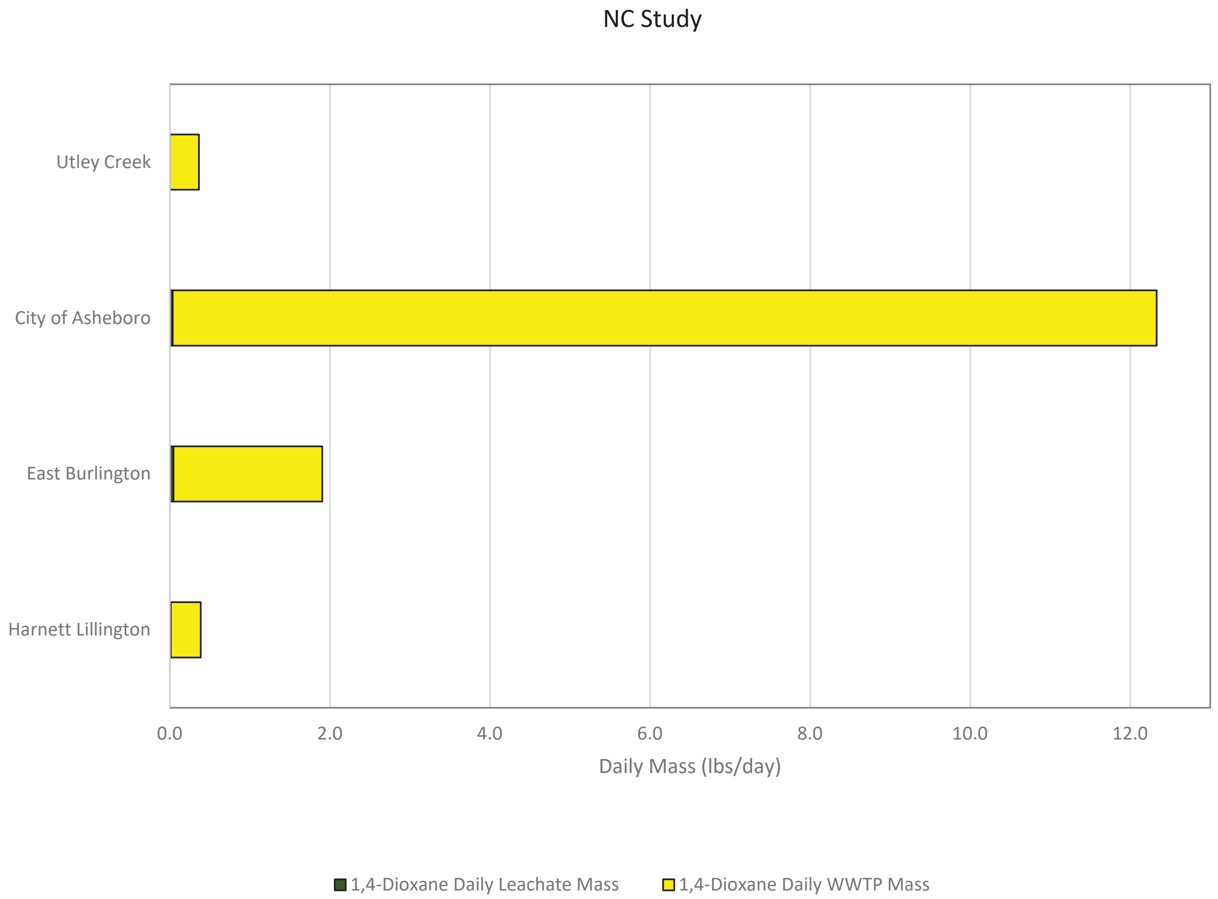
ATTACHMENT D



Note:
1. lbs/day = pounds per day

ATTACHMENT D

Figure 8 - 1,4-Dioxane Landfill Leachate Contribution to WWTP Daily Mass



Notes:
1. lbs/day = pounds per day
2. Maximum 1,4-dioxane daily leachate mass is 0.1 lbs/day.

ATTACHMENT D

APPENDIX A

LABORATORY ANALYTICAL REPORTS

GEL Laboratories LLC
a member of The GEL Group INC

PO Box 30712 Charleston, SC 29417
2040 Savage Road Charleston, SC 29407
P 843.556.8171
F 843.766.1178

gel.com

November 08, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for South Wake MSWLF
Work Order: 490673

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on September 19, 2019. This revised data report has been prepared and reviewed in accordance with GEL's standard operating procedures. This package was revised to include PFPeA and PFOA.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 490673 GEL Work Order: 490673

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
J	See case narrative for an explanation
J	Value is estimated
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the 'U' qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

ATTACHMENT D

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forSouth Wake MSWLF

Client Sample ID:	9222-1	Project:	NWRA00119
Sample ID:	490673001	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	18-SEP-19 10:00		
Receive Date:	19-SEP-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	U	ND	13.2	40.0	ng/L	0.200	1	JLS	10/04/19	1109	1921240	1
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	J	35.8	13.2	40.0	ng/L	0.200	1					
Perfluorobutanesulfonic acid (PFBS)		1420	6.60	17.8	ng/L	0.200	1					
Perfluorodecanesulfonic acid (PFDS)	U	ND	6.60	19.4	ng/L	0.200	1					
Perfluorodecanoic acid (PFDA)	J	17.3	7.80	20.0	ng/L	0.200	1					
Perfluorododecanoic acid (PFDoA)	J	7.40	6.60	20.0	ng/L	0.200	1					
Perfluoroheptanesulfonic acid (PFHpS)	U	ND	6.60	19.0	ng/L	0.200	1					
Perfluoroheptanoic acid (PFHpA)		241	6.60	20.0	ng/L	0.200	1					
Perfluorohexanesulfonic acid (PFHxS)		237	6.60	18.2	ng/L	0.200	1					
Perfluorohexanoic acid (PFHxA)		2940	6.60	20.0	ng/L	0.200	1					
Perfluorononanesulfonic acid (PFNS)		20.7	7.00	19.2	ng/L	0.200	1					
Perfluorononanoic acid (PFNA)		28.8	6.60	20.0	ng/L	0.200	1					
Perfluorooctanesulfonamide (PFOSA)	U	ND	6.60	18.6	ng/L	0.200	1					
Perfluorooctanesulfonic acid (PFOS)		82.3	8.00	20.0	ng/L	0.200	1					
Perfluorooctanoic acid (PFOA)		803	7.00	20.0	ng/L	0.200	1					
Perfluoropentanesulfonic acid (PFPeS)		32.3	6.60	18.8	ng/L	0.200	1					
Perfluoropentanoic acid (PFPeA)		577	6.60	20.0	ng/L	0.200	1					
Perfluoroundecanoic acid (PFUdA)	U	ND	6.60	20.0	ng/L	0.200	1					
Fluorotelomer sulfonate 8:2 (8:2 FTS)	U	ND	132	384	ng/L	0.200	10	JLS	10/02/19	0622	1921240	2
Perfluorobutyric acid (PFBA)		600	66.0	200	ng/L	0.200	10					
Perfluorotetradecanoic acid (PFTeDA)	U	ND	66.0	200	ng/L	0.200	10					
Perfluorotridecanoic acid (PFTrDA)	U	ND	66.0	200	ng/L	0.200	10					
Fluorotelomer sulfonate 4:2 (4:2 FTS)	U	ND	1320	3760	ng/L	0.200	100	JLS	10/02/19	1016	1921240	3
Fluorotelomer sulfonate 6:2 (6:2 FTS)	U	ND	1320	3800	ng/L	0.200	100					
Semi-Volatile-GC/MS												

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forSouth Wake MSWLF

Client Sample ID: 9222-1
Sample ID: 490673001
Project: NWRA00119
Client ID: NWRA001

Semi-Volatile-GC/MS

SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
1,4-Dioxane		30.0	10.0	20.0	ug/L	0.200	10	JMB3	09/24/19	1314	1919444	4

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
EPA 537.1 Mod, PFAS, Compl	PFCs Extraction in Liquid	LM1	09/27/19	0830	1921239
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJW1	09/23/19	1200	1919441

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
2	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
3	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
4	SW846 3535A/8270E SIM	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	26.2 ug/L	40.0	66*	(70%-130%)

Notes:

Column headers are defined as follows:
DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration
Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

ATTACHMENT D

GEL LABORATORIES LLC
2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: November 8, 2019

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia
Contact: **Mr. Jim Riley**

Workorder: **490673**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
QC1204391614 LCS										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	18.2			15.7	ng/L		86	(60%-145%)	JLS	10/02/19 06:05
Fluorotelomer sulfonate 6:2 (6:2 FTS)	18.5			20.4	ng/L		110	(56%-143%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.7			17.5	ng/L		94	(57%-138%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	19.5			19.3	ng/L		99	(63%-131%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	19.5			21.5	ng/L		111	(62%-133%)		
Perfluorobutanesulfonic acid (PFBS)	17.2			16.6	ng/L		96	(68%-136%)		
Perfluorobutyric acid (PFBA)	19.5			19.7	ng/L		101	(70%-133%)		
Perfluorodecanesulfonic acid (PFDS)	18.8			16.8	ng/L		89	(53%-142%)		
Perfluorodecanoic acid (PFDA)	19.5			18.0	ng/L		93	(62%-135%)		
Perfluorododecanoic acid (PFDoA)	19.5			19.5	ng/L		100	(66%-131%)		
Perfluoroheptanesulfonic acid (PFHpS)	18.5			18.1	ng/L		98	(66%-138%)		
Perfluoroheptanoic acid (PFHpA)	19.5			17.9	ng/L		92	(67%-135%)		
Perfluorohexanesulfonic acid (PFHxS)	17.7			14.5	ng/L		82	(64%-137%)		
Perfluorohexanoic acid (PFHxA)	19.5			18.9	ng/L		97	(67%-133%)		

GEL LABORATORIES LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Workorder: 490673

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorononanesulfonic acid (PFNS)	18.7			17.5	ng/L		93	(66%-130%)	JLS	10/02/19 06:05
Perfluorononanoic acid (PFNA)	19.5			21.1	ng/L		108	(66%-134%)		
Perfluorooctanesulfonamide (PFOSA)	19.5			21.5	ng/L		111	(68%-137%)		
Perfluorooctanesulfonic acid (PFOS)	19.5			19.8	ng/L		102	(61%-131%)		
Perfluorooctanoic acid (PFOA)	19.5			18.8	ng/L		97	(63%-145%)		
Perfluoropentanesulfonic acid (PFPeS)	18.3			16.5	ng/L		90	(62%-139%)		
Perfluoropentanoic acid (PFPeA)	19.5			19.3	ng/L		99	(69%-132%)		
Perfluorotetradecanoic acid (PFTeDA)	19.5			22.5	ng/L		115	(65%-143%)		
Perfluorotridecanoic acid (PFTrDA)	19.5			19.9	ng/L		102	(57%-149%)		
Perfluoroundecanoic acid (PFUdA)	19.5			19.1	ng/L		98	(65%-134%)		
QC1204391615 LCSD										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	17.6			20.5	ng/L	26	116	(0%-35%)		10/02/19 06:14
Fluorotelomer sulfonate 6:2 (6:2 FTS)	17.9			17.6	ng/L	14	98	(0%-36%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.1			19.9	ng/L	13	110	(0%-39%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	18.8			20.1	ng/L	4	107	(0%-25%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	18.8			21.9	ng/L	2	116	(0%-26%)		

QC Summary

Workorder: **490673**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorobutanesulfonic acid (PFBS)	16.7			17.2	ng/L	4	103	(0%-30%)	JLS	10/02/19 06:14
Perfluorobutyric acid (PFBA)	18.8			19.3	ng/L	2	102	(0%-30%)		
Perfluorodecanesulfonic acid (PFDS)	18.2			17.2	ng/L	3	95	(0%-28%)		
Perfluorodecanoic acid (PFDA)	18.8			21.1	ng/L	16	112	(0%-29%)		
Perfluorododecanoic acid (PFDoA)	18.8			19.0	ng/L	3	101	(0%-30%)		
Perfluoroheptanesulfonic acid (PFHpS)	17.9			17.7	ng/L	2	99	(0%-30%)		
Perfluoroheptanoic acid (PFHpA)	18.8			19.6	ng/L	9	104	(0%-30%)		
Perfluorohexanesulfonic acid (PFHxS)	17.2			16.8	ng/L	15	98	(0%-30%)		
Perfluorohexanoic acid (PFHxA)	18.8			20.9	ng/L	10	111	(0%-23%)		
Perfluorononanesulfonic acid (PFNS)	18.1			18.2	ng/L	4	101	(0%-27%)		
Perfluorononanoic acid (PFNA)	18.8			18.7	ng/L	12	99	(0%-27%)		
Perfluorooctanesulfonamide (PFOSA)	18.8			20.2	ng/L	6	107	(0%-30%)		
Perfluorooctanesulfonic acid (PFOS)	18.8			19.9	ng/L	1	106	(0%-27%)		
Perfluorooctanoic acid (PFOA)	18.8			18.9	ng/L	0	100	(0%-30%)		
Perfluoropentanesulfonic acid (PFPeS)	17.7			17.3	ng/L	4	98	(0%-29%)		

QC Summary

Workorder: **490673**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoropentanoic acid (PFPeA)	18.8			20.0	ng/L	3	106	(0%-30%)	JLS	10/02/19 06:14
Perfluorotetradecanoic acid (PFTeDA)	18.8			20.6	ng/L	9	109	(0%-30%)		
Perfluorotridecanoic acid (PFTrDA)	18.8			17.7	ng/L	11	94	(0%-35%)		
Perfluoroundecanoic acid (PFUdA)	18.8			21.2	ng/L	10	112	(0%-28%)		
QC1204391613 MB										
Fluorotelomer sulfonate 4:2 (4:2 FTS)			U	ND	ng/L					10/02/19 05:56
Fluorotelomer sulfonate 6:2 (6:2 FTS)			U	ND	ng/L					
Fluorotelomer sulfonate 8:2 (8:2 FTS)			U	ND	ng/L					
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)			U	ND	ng/L					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)			U	ND	ng/L					
Perfluorobutanesulfonic acid (PFBS)			U	ND	ng/L					
Perfluorobutyric acid (PFBA)			U	ND	ng/L					
Perfluorodecanesulfonic acid (PFDS)			U	ND	ng/L					
Perfluorodecanoic acid (PFDA)			U	ND	ng/L					
Perfluorododecanoic acid (PFDoA)			U	ND	ng/L					
Perfluoroheptanesulfonic acid (PFHpS)			U	ND	ng/L					

GEL LABORATORIES LLC
2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Workorder: 490673

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoroheptanoic acid (PFHpA)			U	ND	ng/L				JLS	10/02/19 05:56
Perfluorohexanesulfonic acid (PFHxS)			U	ND	ng/L					
Perfluorohexanoic acid (PFHxA)			U	ND	ng/L					
Perfluorononanesulfonic acid (PFNS)			U	ND	ng/L					
Perfluorononanoic acid (PFNA)			U	ND	ng/L					
Perfluorooctanesulfonamide (PFOSA)			U	ND	ng/L					
Perfluorooctanesulfonic acid (PFOS)			U	ND	ng/L					
Perfluorooctanoic acid (PFOA)			U	ND	ng/L					
Perfluoropentanesulfonic acid (PFPeS)			U	ND	ng/L					
Perfluoropentanoic acid (PFPeA)			U	ND	ng/L					
Perfluorotetradecanoic acid (PFTeDA)			U	ND	ng/L					
Perfluorotridecanoic acid (PFTrDA)			U	ND	ng/L					
Perfluoroundecanoic acid (PFUdA)			U	ND	ng/L					
Semi-Volatile-GC/MS										
Batch 1919444										
QC1204387349 LCS										
**1,4-Dioxane-d8	4.00			3.55	ug/L		89	(70%-130%)	JMB3	09/24/19 12:24

GEL LABORATORIES LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Workorder: **490673**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS										
Batch 1919444										
QC1204387350 LCSD										
**1,4-Dioxane-d8	4.00			3.18	ug/L		79	(70%-130%)	JMB3	09/24/19 12:49
QC1204387348 MB										
1,4-Dioxane			U	ND	ug/L					09/24/19 11:59
**1,4-Dioxane-d8	4.00			3.05	ug/L		76	(70%-130%)		

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported
A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound
N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted

ATTACHMENT D

QC Summary

Workorder: **490673**

Parmname	**NOM**	**Sample**	**Qual**	**QC**	**Units**	**RPD/D%**	**REC%**	**Range**	**Anlst**	**Date**	**Time**

X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 490673

GC/MS Semivolatile

Product: **Analysis of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry**
Analytical Method: SW846 3535A/8270E SIM
Analytical Procedure: GL-OA-E-073 REV# 2
Analytical Batch: 1919444

Preparation Method: SW846 3535A
Preparation Procedure: GL-OA-E-073 REV# 2
Preparation Batch: 1919441

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490673001	9222-1
1204387348	Method Blank (MB)
1204387349	Laboratory Control Sample (LCS)
1204387350	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Quality Control (QC) Information

Surrogate Recoveries
Sample (See Below) did not meet surrogate recovery acceptance criteria. The sample was analyzed at a dilution. As a result, one or more surrogates were diluted out of the acceptance limits.

Sample	Analyte	Value
490673001 (9222-1)	1, 4-Dioxane-d8	66* (70%-130%)

Laboratory Control Sample Duplicate (LCSD)
An LCSD was used in place of matrix QC due to limited sample volume.

Technical Information

Sample Dilutions
Sample 490673001 (9222-1) was diluted due to the presence of non-target analytes. The data from the dilution are reported.

LCMSMS-Misc

Product: The Extraction and Analysis of Per and Polyfluroalkyl Substances Using LCMSMS
Analytical Method: EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15
Analytical Procedure: GL-OA-E-076 REV# 7
Analytical Batches: 1921240 and 1921239

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490673001	9222-1
1204391613	Method Blank (MB)
1204391614	Laboratory Control Sample (LCS)
1204391615	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Sample Dilutions

The following samples were diluted to bring the over range concentrations within the calibration range and/or due to matrix interference that caused internal standards recoveries to fall outside the acceptance range. 490673001 (9222-1).

Analyte	490673
	001
Fluorotelomer sulfonate 4:2 (4:2 FTS)	100X
Fluorotelomer sulfonate 6:2 (6:2 FTS)	100X
Fluorotelomer sulfonate 8:2 (8:2 FTS)	10X
Perfluorobutyric acid (PFBA)	10X
Perfluorotetradecanoic acid (PFTeDA)	10X
Perfluorotridecanoic acid (PFTrDA)	10X

Miscellaneous Information

Additional Comments

Additional sample volume was not provided for matrix QC. Also, reduced sample volumes were used for all samples except 490876002 (7607-EB) due to elevated concentrations of target analytes.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Page: 1 of 1
Project # NWA-001
GEL Quote #: NWRA Quote
COC Number (1): NA
PO Number: NA

490673
~~490887~~ hq 9/23

GEL Laboratories LLC
Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics
gel.com

Chain of Custody and Analytical Request

GEL Work Order Number:
GEL Project Manager:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: NWRA c/o Hart & Hickman, PC
Phone # 919-847-4241
Project/Site Name: South Wake MSWLF
Fax # 704-586-0007
Address: Apex, NC
Collected By: Patrick Stevens
Send Results To: Genna Olson golson@harthickman.com

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive *Please supply isotopic info.*	(7) Known or possible hazards	Total number of containers	PFAS 21 cmpd list by EPA 537 mod	1,4-Dioxane by EPA 8270SIM	Comments Note: extra sample is required for sample specific QC
9222-1	09-18-19	1000	N	N	ML			4	X	X	

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	Patrick H. Stevens	09-18-19	1630	1		9/19/19	0850
2				2			
3				3			

TAT Requested: Normal: X Rush: ____ Specify: ________ **(Subject to Surcharge)**
Fax Results: [ ] Yes [X] No
Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4
Additional Remarks:
For Lab Receiving Use Only: Custody Seal Intact? [ ] Yes [ ] No *Cooler Temp:* 1 °C

> For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)

Sample Collection Time Zone: [X] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ________

1.) Chain of Custody Number = Client Determined

2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite

3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.

4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, ML=Misc Liquid, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).

6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) *Are there any known or possible hazards associated with these samples?*

RCRA Metals
As = Arsenic
Ba = Barium
Cd = Cadmium
Cr = Chromium
Pb = Lead
Hg= Mercury
Se= Selenium
Ag= Silver
MR= Miscellaneous RCRA metals

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. (i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)

ATTACHMENT D

GEL Laboratories LLC

Client: NWRA	JR **SAMPLE RECEIPT & REVIEW FORM** 6
Received By:	SDG/AR/COC/Work Order: 490673
	Date Received: 9/19/19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 7762 7563 2308 -1°, 7762 7563 3418-1° 7762 7563 2764 -1°, 7762 7563 3290-1°

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A) Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓			Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius
4	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: IR4-16 TEMP: 1° Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?			✓	Circle Applicable: Seals broken [✓ Damaged container] Leaking container Other (describe) 6204-1 (1 bottle) cap received cracked
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?			✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials VG Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

List of current GEL Certifications as of 08 November 2019

State	Certification
Alaska	17−018
Alaska Drinking Water	SC00012
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−28
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

GEL Laboratories LLC
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PO Box 30712 Charleston, SC 29417
2040 Savage Road Charleston, SC 29407
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gel.com

November 08, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for Foothills Environmental Landfill
Work Order: 490860

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on September 19, 2019. This revised data report has been prepared and reviewed in accordance with GEL's standard operating procedures. This package was revised to include PFPeA and PFOA.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 490860 GEL Work Order: 490860

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
J	See case narrative for an explanation
J	Value is estimated
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the 'U' qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

ATTACHMENT D

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forFoothills Environmental Landfill

Client Sample ID: 1403-1
Sample ID: 490860001
Matrix: Misc Liquid
Collect Date: 16-SEP-19 09:20
Receive Date: 19-SEP-19
Collector: Client

Project: NWRA00119
Client ID: NWRA001

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
Fluorotelomer sulfonate 4:2 (4:2 FTS)	U	ND	13.2	37.6	ng/L	0.200	1	JLS	10/02/19	0849	1921240	1
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)		101	13.2	40.0	ng/L	0.200	1					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)		257	13.2	40.0	ng/L	0.200	1					
Perfluorodecanesulfonic acid (PFDS)	U	ND	6.60	19.4	ng/L	0.200	1					
Perfluorodecanoic acid (PFDA)		82.6	7.80	20.0	ng/L	0.200	1					
Perfluorododecanoic acid (PFDoA)	U	ND	6.60	20.0	ng/L	0.200	1					
Perfluoroheptanesulfonic acid (PFHpS)	J	6.82	6.60	19.0	ng/L	0.200	1					
Perfluoroheptanoic acid (PFHpA)		571	6.60	20.0	ng/L	0.200	1					
Perfluorohexanesulfonic acid (PFHxS)		794	6.60	18.2	ng/L	0.200	1					
Perfluorononanesulfonic acid (PFNS)	U	ND	7.00	19.2	ng/L	0.200	1					
Perfluorononanoic acid (PFNA)		71.4	6.60	20.0	ng/L	0.200	1					
Perfluorooctanesulfonamide (PFOSA)	J	7.08	6.60	18.6	ng/L	0.200	1					
Perfluorooctanesulfonic acid (PFOS)		296	8.00	20.0	ng/L	0.200	1					
Perfluoropentanesulfonic acid (PFPeS)		50.6	6.60	18.8	ng/L	0.200	1					
Perfluoropentanoic acid (PFPeA)		1070	6.60	20.0	ng/L	0.200	1					
Perfluoroundecanoic acid (PFUdA)	J	7.04	6.60	20.0	ng/L	0.200	1					
Fluorotelomer sulfonate 8:2 (8:2 FTS)	U	ND	132	384	ng/L	0.200	10	JLS	10/02/19	0657	1921240	2
Perfluorobutanesulfonic acid (PFBS)		4400	66.0	178	ng/L	0.200	10					
Perfluorobutyric acid (PFBA)		744	66.0	200	ng/L	0.200	10					
Perfluorohexanoic acid (PFHxA)		3920	66.0	200	ng/L	0.200	10					
Perfluorooctanoic acid (PFOA)		1650	70.0	200	ng/L	0.200	10					
Perfluorotetradecanoic acid (PFTeDA)	U	ND	66.0	200	ng/L	0.200	10					
Perfluorotridecanoic acid (PFTrDA)	U	ND	66.0	200	ng/L	0.200	10					
Fluorotelomer sulfonate 6:2 (6:2 FTS)	U	ND	1320	3800	ng/L	0.200	100	JLS	10/02/19	1059	1921240	3
Semi-Volatile-GC/MS												

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forFoothills Environmental Landfill

Client Sample ID: 1403-1
Sample ID: 490860001
Project: NWRA00119
Client ID: NWRA001

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Semi-Volatile-GC/MS												
SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"												
1,4-Dioxane		99.7	2.00	4.00	ug/L	0.200	2	JMB3	09/24/19	1829	1919444	4

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
EPA 537.1 Mod, PFAS, Compl	PFCs Extraction in Liquid	LM1	09/27/19	0830	1921239
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJW1	09/23/19	1200	1919441

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
2	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
3	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
4	SW846 3535A/8270E SIM	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	30.0 ug/L	40.0	75	(70%-130%)

Notes:

Column headers are defined as follows:
DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration
Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

GEL LABORATORIES LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: November 8, 2019

Page 1 of 7

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia

Contact: **Mr. Jim Riley**

Workorder: **490860**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
QC1204391614 LCS										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	18.2			15.7	ng/L		86	(60%-145%)	JLS	10/02/19 06:05
Fluorotelomer sulfonate 6:2 (6:2 FTS)	18.5			20.4	ng/L		110	(56%-143%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.7			17.5	ng/L		94	(57%-138%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	19.5			19.3	ng/L		99	(63%-131%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	19.5			21.5	ng/L		111	(62%-133%)		
Perfluorobutanesulfonic acid (PFBS)	17.2			16.6	ng/L		96	(68%-136%)		
Perfluorobutyric acid (PFBA)	19.5			19.7	ng/L		101	(70%-133%)		
Perfluorodecanesulfonic acid (PFDS)	18.8			16.8	ng/L		89	(53%-142%)		
Perfluorodecanoic acid (PFDA)	19.5			18.0	ng/L		93	(62%-135%)		
Perfluorododecanoic acid (PFDoA)	19.5			19.5	ng/L		100	(66%-131%)		
Perfluoroheptanesulfonic acid (PFHpS)	18.5			18.1	ng/L		98	(66%-138%)		
Perfluoroheptanoic acid (PFHpA)	19.5			17.9	ng/L		92	(67%-135%)		
Perfluorohexanesulfonic acid (PFHxS)	17.7			14.5	ng/L		82	(64%-137%)		
Perfluorohexanoic acid (PFHxA)	19.5			18.9	ng/L		97	(67%-133%)		

QC Summary

Workorder: 490860

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorononanesulfonic acid (PFNS)	18.7			17.5	ng/L		93	(66%-130%)	JLS	10/02/19 06:05
Perfluorononanoic acid (PFNA)	19.5			21.1	ng/L		108	(66%-134%)		
Perfluorooctanesulfonamide (PFOSA)	19.5			21.5	ng/L		111	(68%-137%)		
Perfluorooctanesulfonic acid (PFOS)	19.5			19.8	ng/L		102	(61%-131%)		
Perfluorooctanoic acid (PFOA)	19.5			18.8	ng/L		97	(63%-145%)		
Perfluoropentanesulfonic acid (PFPeS)	18.3			16.5	ng/L		90	(62%-139%)		
Perfluoropentanoic acid (PFPeA)	19.5			19.3	ng/L		99	(69%-132%)		
Perfluorotetradecanoic acid (PFTeDA)	19.5			22.5	ng/L		115	(65%-143%)		
Perfluorotridecanoic acid (PFTrDA)	19.5			19.9	ng/L		102	(57%-149%)		
Perfluoroundecanoic acid (PFUdA)	19.5			19.1	ng/L		98	(65%-134%)		
QC1204391615 LCSD										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	17.6			20.5	ng/L	26	116	(0%-35%)		10/02/19 06:14
Fluorotelomer sulfonate 6:2 (6:2 FTS)	17.9			17.6	ng/L	14	98	(0%-36%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.1			19.9	ng/L	13	110	(0%-39%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	18.8			20.1	ng/L	4	107	(0%-25%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	18.8			21.9	ng/L	2	116	(0%-26%)		

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QC Summary

Workorder: **490860**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorobutanesulfonic acid (PFBS)	16.7			17.2	ng/L	4	103	(0%-30%)	JLS	10/02/19 06:14
Perfluorobutyric acid (PFBA)	18.8			19.3	ng/L	2	102	(0%-30%)		
Perfluorodecanesulfonic acid (PFDS)	18.2			17.2	ng/L	3	95	(0%-28%)		
Perfluorodecanoic acid (PFDA)	18.8			21.1	ng/L	16	112	(0%-29%)		
Perfluorododecanoic acid (PFDoA)	18.8			19.0	ng/L	3	101	(0%-30%)		
Perfluoroheptanesulfonic acid (PFHpS)	17.9			17.7	ng/L	2	99	(0%-30%)		
Perfluoroheptanoic acid (PFHpA)	18.8			19.6	ng/L	9	104	(0%-30%)		
Perfluorohexanesulfonic acid (PFHxS)	17.2			16.8	ng/L	15	98	(0%-30%)		
Perfluorohexanoic acid (PFHxA)	18.8			20.9	ng/L	10	111	(0%-23%)		
Perfluorononanesulfonic acid (PFNS)	18.1			18.2	ng/L	4	101	(0%-27%)		
Perfluorononanoic acid (PFNA)	18.8			18.7	ng/L	12	99	(0%-27%)		
Perfluorooctanesulfonamide (PFOSA)	18.8			20.2	ng/L	6	107	(0%-30%)		
Perfluorooctanesulfonic acid (PFOS)	18.8			19.9	ng/L	1	106	(0%-27%)		
Perfluorooctanoic acid (PFOA)	18.8			18.9	ng/L	0	100	(0%-30%)		
Perfluoropentanesulfonic acid (PFPeS)	17.7			17.3	ng/L	4	98	(0%-29%)		

QC Summary

Workorder: 490860

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoropentanoic acid (PFPeA)	18.8			20.0	ng/L	3	106	(0%-30%)	JLS	10/02/19 06:14
Perfluorotetradecanoic acid (PFTeDA)	18.8			20.6	ng/L	9	109	(0%-30%)		
Perfluorotridecanoic acid (PFTrDA)	18.8			17.7	ng/L	11	94	(0%-35%)		
Perfluoroundecanoic acid (PFUdA)	18.8			21.2	ng/L	10	112	(0%-28%)		
QC1204391613 MB										
Fluorotelomer sulfonate 4:2 (4:2 FTS)			U	ND	ng/L					10/02/19 05:56
Fluorotelomer sulfonate 6:2 (6:2 FTS)			U	ND	ng/L					
Fluorotelomer sulfonate 8:2 (8:2 FTS)			U	ND	ng/L					
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)			U	ND	ng/L					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)			U	ND	ng/L					
Perfluorobutanesulfonic acid (PFBS)			U	ND	ng/L					
Perfluorobutyric acid (PFBA)			U	ND	ng/L					
Perfluorodecanesulfonic acid (PFDS)			U	ND	ng/L					
Perfluorodecanoic acid (PFDA)			U	ND	ng/L					
Perfluorododecanoic acid (PFDoA)			U	ND	ng/L					
Perfluoroheptanesulfonic acid (PFHpS)			U	ND	ng/L					

QC Summary

Workorder: **490860**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoroheptanoic acid (PFHpA)			U	ND	ng/L				JLS	10/02/19 05:56
Perfluorohexanesulfonic acid (PFHxS)			U	ND	ng/L					
Perfluorohexanoic acid (PFHxA)			U	ND	ng/L					
Perfluorononanesulfonic acid (PFNS)			U	ND	ng/L					
Perfluorononanoic acid (PFNA)			U	ND	ng/L					
Perfluorooctanesulfonamide (PFOSA)			U	ND	ng/L					
Perfluorooctanesulfonic acid (PFOS)			U	ND	ng/L					
Perfluorooctanoic acid (PFOA)			U	ND	ng/L					
Perfluoropentanesulfonic acid (PFPeS)			U	ND	ng/L					
Perfluoropentanoic acid (PFPeA)			U	ND	ng/L					
Perfluorotetradecanoic acid (PFTeDA)			U	ND	ng/L					
Perfluorotridecanoic acid (PFTrDA)			U	ND	ng/L					
Perfluoroundecanoic acid (PFUdA)			U	ND	ng/L					
Semi-Volatile-GC/MS										
Batch 1919444										
QC1204387349 LCS										
**1,4-Dioxane-d8	4.00			3.55	ug/L		89	(70%-130%)	JMB3	09/24/19 12:24

ATTACHMENT D

QC Summary

Workorder: **490860**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time
Semi-Volatile-GC/MS											
Batch 1919444											
QC1204387350 LCSD											
**1,4-Dioxane-d8	4.00			3.18	ug/L		79	(70%-130%)	JMB3	09/24/19	12:49
QC1204387348 MB											
1,4-Dioxane			U	ND	ug/L					09/24/19	11:59
**1,4-Dioxane-d8	4.00			3.05	ug/L		76	(70%-130%)			

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported
A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound
N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted

ATTACHMENT D

QC Summary

Workorder: **490860**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time

X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 490860

GC/MS Semivolatile

Product: Analysis of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry
Analytical Method: SW846 3535A/8270E SIM
Analytical Procedure: GL-OA-E-073 REV# 2
Analytical Batch: 1919444

Preparation Method: SW846 3535A
Preparation Procedure: GL-OA-E-073 REV# 2
Preparation Batch: 1919441

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490860001	1403-1
1204387348	Method Blank (MB)
1204387349	Laboratory Control Sample (LCS)
1204387350	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Quality Control (QC) Information

Laboratory Control Sample Duplicate (LCSD)
An LCSD was used in place of matrix QC due to limited sample volume.

Technical Information

Sample Dilutions
Sample 490860001 (1403-1) was diluted due to the presence of one or more over-range target analytes.

LCMSMS-Misc

Product: The Extraction and Analysis of Per and Polyfluroalkyl Substances Using LCMSMS
Analytical Method: EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15
Analytical Procedure: GL-OA-E-076 REV# 7
Analytical Batches: 1921240 and 1921239

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490860001	1403-1
1204391613	Method Blank (MB)
1204391614	Laboratory Control Sample (LCS)
1204391615	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Sample Dilutions

The following samples were diluted to bring the over range concentrations within the calibration range and/or due to matrix interference that caused internal standards recoveries to fall outside the acceptance range. 490860001 (1403-1).

Analyte	490860 001
Fluorotelomer sulfonate 6:2 (6:2 FTS)	100X
Fluorotelomer sulfonate 8:2 (8:2 FTS)	10X
Perfluorobutanesulfonate (PFBS)	10X
Perfluorobutyric acid (PFBA)	10X
Perfluorohexanoic acid (PFHxA)	10X
Perfluorooctanoic acid (PFOA)	10X
Perfluorotetradecanoic acid (PFTeDA)	10X
Perfluorotridecanoic acid (PFTrDA)	10X

Miscellaneous Information

Additional Comments

Additional sample volume was not provided for matrix QC. Also, reduced sample volumes were used for all samples except 490876002 (7607-EB) due to elevated concentrations of target analytes.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

ATTACHMENT D

Page: 1 of 1
Project # NWA-001
GEL Quote #: NWRA Quote
COC Number (1): NA
PO Number: NA

490860

GEL Laboratories LLC
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Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

Chain of Custody and Analytical Request

GEL Work Order Number:
GEL Project Manager:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: NWRA c/o Hart & Hickman, PC
Phone # 919-847-4241
Project/Site Name: Foothills Environmental Landfill
Fax # 704-586-0007
Address: Lenoir, NC
Collected By: Patrick Stevens
Send Results To: Genna Olson golson@harthickman.com

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Comments
Note: extra sample is required for sample specific QC

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive *Please supply isotopic info.*	(7) Known or possible hazards	Total number of containers	PFAS 21 cmpd list by EPA 537 mod	1,4-Dioxane by EPA 8270SIM									
1403-1	09-16-19	0920	N	N	ML			4	X	X									

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	Patrick H. Stevens	09-18-19	1630	1		9/19/19	0850
2				2			
3				3			

TAT Requested: Normal: X Rush: ____ Specify: ________ (Subject to Surcharge)

Fax Results: [ ] Yes [X] No

Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4

Additional Remarks:

For Lab Receiving Use Only: *Custody Seal Intact?* [ ] Yes [ ] No *Cooler Temp:* 1 °C

> For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)

Sample Collection Time Zone: [X] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ________

1.) Chain of Custody Number = Client Determined

2.) QC Codes: **N** = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite

3.) Field Filtered: For liquid matrices, indicate with a - **Y** - for yes the sample was field filtered or - **N** - for sample was not field filtered.

4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **ML**=Misc Liquid, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B* - **3**, *6010B/7470A* - **1**).

6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) *Are there any known or possible hazards associated with these samples?*

RCRA Metals
As = Arsenic
Ba = Barium
Cd = Cadmium
Cr = Chromium
Pb = Lead
Hg= Mercury
Se= Selenium
Ag= Silver
MR= Miscellaneous RCRA metals

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA Jh	SDG/AR/COC/Work Order: 490860
Received By: AjA	Date Received: 9/19/19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 7762 7563 2308 -1°, 7762 7563 3418-1° 7762 7563 2764 -1°, 7762 7563 3290-1°

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓			Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius TEMP: 1°
4	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: IR4-16 Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?			✓	Circle Applicable: Seals broken [✓ Damaged container] Leaking container Other (describe) 6204-1 (1bottle) cap received cracked
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?			✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials VQ Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

List of current GEL Certifications as of 08 November 2019

State	Certification
Alaska	17−018
Alaska Drinking Water	SC00012
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−28
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

GEL Laboratories LLC
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November 08, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for BFI-Charlotte motor Speedway Landfill V
Work Order: 490866

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on September 19, 2019. This revised data report has been prepared and reviewed in accordance with GEL's standard operating procedures. This package was revised to include PFPeA and PFOA.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 490866 GEL Work Order: 490866

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
J	See case narrative for an explanation
J	Value is estimated
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the 'U' qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

ATTACHMENT D

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forBFI-Charlotte motor Speedway Landfill V

Client Sample ID: 1304-1
Project: NWRA00119
Sample ID: 490866001
Client ID: NWRA001
Matrix: Misc Liquid
Collect Date: 16-SEP-19 12:55
Receive Date: 19-SEP-19
Collector: Client

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
Fluorotelomer sulfonate 8:2 (8:2 FTS)		39.7	13.2	38.4	ng/L	0.200	1	JLS	10/02/19	0907	1921240	1
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)		87.2	13.2	40.0	ng/L	0.200	1					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)		258	13.2	40.0	ng/L	0.200	1					
Perfluorodecanesulfonic acid (PFDS)	J	6.87	6.60	19.4	ng/L	0.200	1					
Perfluorodecanoic acid (PFDA)		590	7.80	20.0	ng/L	0.200	1					
Perfluorododecanoic acid (PFDoA)		63.3	6.60	20.0	ng/L	0.200	1					
Perfluoroheptanesulfonic acid (PFHpS)	J	8.17	6.60	19.0	ng/L	0.200	1					
Perfluoroheptanoic acid (PFHpA)		983	6.60	20.0	ng/L	0.200	1					
Perfluorohexanesulfonic acid (PFHxS)		925	6.60	18.2	ng/L	0.200	1					
Perfluorononanesulfonic acid (PFNS)	U	ND	7.00	19.2	ng/L	0.200	1					
Perfluorononanoic acid (PFNA)		269	6.60	20.0	ng/L	0.200	1					
Perfluorooctanesulfonamide (PFOSA)	J	11.5	6.60	18.6	ng/L	0.200	1					
Perfluorooctanesulfonic acid (PFOS)		356	8.00	20.0	ng/L	0.200	1					
Perfluoropentanesulfonic acid (PFPeS)		73.2	6.60	18.8	ng/L	0.200	1					
Perfluoroundecanoic acid (PFUdA)		30.8	6.60	20.0	ng/L	0.200	1					
Perfluorobutanesulfonic acid (PFBS)		5260	66.0	178	ng/L	0.200	10	JLS	10/02/19	0706	1921240	2
Perfluorobutyric acid (PFBA)		1920	66.0	200	ng/L	0.200	10					
Perfluorohexanoic acid (PFHxA)		3470	66.0	200	ng/L	0.200	10					
Perfluorooctanoic acid (PFOA)		2210	70.0	200	ng/L	0.200	10					
Perfluoropentanoic acid (PFPeA)		2160	66.0	200	ng/L	0.200	10					
Perfluorotetradecanoic acid (PFTeDA)	U	ND	66.0	200	ng/L	0.200	10					
Perfluorotridecanoic acid (PFTrDA)	U	ND	66.0	200	ng/L	0.200	10					
Fluorotelomer sulfonate 4:2 (4:2 FTS)	U	ND	1320	3760	ng/L	0.200	100	JLS	10/02/19	1117	1921240	3
Fluorotelomer sulfonate 6:2 (6:2 FTS)	U	ND	1320	3800	ng/L	0.200	100					

The following Prep Methods were performed:

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forBFI-Charlotte motor Speedway Landfill V

Client Sample ID:	1304-1	Project:	NWRA00119
Sample ID:	490866001	Client ID:	NWRA001

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
EPA 537.1 Mod, PFAS, Compl	PFCs Extraction in Liquid	LM1	09/27/19	0830	1921239

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
2	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
3	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	

Notes:

Column headers are defined as follows:

DF: Dilution Factor	Lc/LC: Critical Level
DL: Detection Limit	PF: Prep Factor
MDA: Minimum Detectable Activity	RL: Reporting Limit
MDC: Minimum Detectable Concentration	SQL: Sample Quantitation Limit

GEL LABORATORIES LLC
2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: November 8, 2019

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia

Contact: **Mr. Jim Riley**

Workorder: **490866**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time
Perfluorinated Compounds											
Batch 1921240											
QC1204391614 LCS											
Fluorotelomer sulfonate 4:2 (4:2 FTS)	18.2			15.7	ng/L		86	(60%-145%)	JLS	10/02/19	06:05
Fluorotelomer sulfonate 6:2 (6:2 FTS)	18.5			20.4	ng/L		110	(56%-143%)			
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.7			17.5	ng/L		94	(57%-138%)			
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	19.5			19.3	ng/L		99	(63%-131%)			
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	19.5			21.5	ng/L		111	(62%-133%)			
Perfluorobutanesulfonic acid (PFBS)	17.2			16.6	ng/L		96	(68%-136%)			
Perfluorobutyric acid (PFBA)	19.5			19.7	ng/L		101	(70%-133%)			
Perfluorodecanesulfonic acid (PFDS)	18.8			16.8	ng/L		89	(53%-142%)			
Perfluorodecanoic acid (PFDA)	19.5			18.0	ng/L		93	(62%-135%)			
Perfluorododecanoic acid (PFDoA)	19.5			19.5	ng/L		100	(66%-131%)			
Perfluoroheptanesulfonic acid (PFHpS)	18.5			18.1	ng/L		98	(66%-138%)			
Perfluoroheptanoic acid (PFHpA)	19.5			17.9	ng/L		92	(67%-135%)			
Perfluorohexanesulfonic acid (PFHxS)	17.7			14.5	ng/L		82	(64%-137%)			
Perfluorohexanoic acid (PFHxA)	19.5			18.9	ng/L		97	(67%-133%)			

QC Summary

Workorder: **490866**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorononanesulfonic acid (PFNS)	18.7			17.5	ng/L		93	(66%-130%)	JLS	10/02/19 06:05
Perfluorononanoic acid (PFNA)	19.5			21.1	ng/L		108	(66%-134%)		
Perfluorooctanesulfonamide (PFOSA)	19.5			21.5	ng/L		111	(68%-137%)		
Perfluorooctanesulfonic acid (PFOS)	19.5			19.8	ng/L		102	(61%-131%)		
Perfluorooctanoic acid (PFOA)	19.5			18.8	ng/L		97	(63%-145%)		
Perfluoropentanesulfonic acid (PFPeS)	18.3			16.5	ng/L		90	(62%-139%)		
Perfluoropentanoic acid (PFPeA)	19.5			19.3	ng/L		99	(69%-132%)		
Perfluorotetradecanoic acid (PFTeDA)	19.5			22.5	ng/L		115	(65%-143%)		
Perfluorotridecanoic acid (PFTrDA)	19.5			19.9	ng/L		102	(57%-149%)		
Perfluoroundecanoic acid (PFUdA)	19.5			19.1	ng/L		98	(65%-134%)		
QC1204391615 LCSD										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	17.6			20.5	ng/L	26	116	(0%-35%)		10/02/19 06:14
Fluorotelomer sulfonate 6:2 (6:2 FTS)	17.9			17.6	ng/L	14	98	(0%-36%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.1			19.9	ng/L	13	110	(0%-39%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	18.8			20.1	ng/L	4	107	(0%-25%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	18.8			21.9	ng/L	2	116	(0%-26%)		

QC Summary

Workorder: **490866**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time
Perfluorinated Compounds											
Batch 1921240											
Perfluorobutanesulfonic acid (PFBS)	16.7			17.2	ng/L	4	103	(0%-30%)	JLS	10/02/19	06:14
Perfluorobutyric acid (PFBA)	18.8			19.3	ng/L	2	102	(0%-30%)			
Perfluorodecanesulfonic acid (PFDS)	18.2			17.2	ng/L	3	95	(0%-28%)			
Perfluorodecanoic acid (PFDA)	18.8			21.1	ng/L	16	112	(0%-29%)			
Perfluorododecanoic acid (PFDoA)	18.8			19.0	ng/L	3	101	(0%-30%)			
Perfluoroheptanesulfonic acid (PFHpS)	17.9			17.7	ng/L	2	99	(0%-30%)			
Perfluoroheptanoic acid (PFHpA)	18.8			19.6	ng/L	9	104	(0%-30%)			
Perfluorohexanesulfonic acid (PFHxS)	17.2			16.8	ng/L	15	98	(0%-30%)			
Perfluorohexanoic acid (PFHxA)	18.8			20.9	ng/L	10	111	(0%-23%)			
Perfluorononanesulfonic acid (PFNS)	18.1			18.2	ng/L	4	101	(0%-27%)			
Perfluorononanoic acid (PFNA)	18.8			18.7	ng/L	12	99	(0%-27%)			
Perfluorooctanesulfonamide (PFOSA)	18.8			20.2	ng/L	6	107	(0%-30%)			
Perfluorooctanesulfonic acid (PFOS)	18.8			19.9	ng/L	1	106	(0%-27%)			
Perfluorooctanoic acid (PFOA)	18.8			18.9	ng/L	0	100	(0%-30%)			
Perfluoropentanesulfonic acid (PFPeS)	17.7			17.3	ng/L	4	98	(0%-29%)			

QC Summary

Workorder: **490866**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoropentanoic acid (PFPeA)	18.8			20.0	ng/L	3	106	(0%-30%)	JLS	10/02/19 06:14
Perfluorotetradecanoic acid (PFTeDA)	18.8			20.6	ng/L	9	109	(0%-30%)		
Perfluorotridecanoic acid (PFTrDA)	18.8			17.7	ng/L	11	94	(0%-35%)		
Perfluoroundecanoic acid (PFUdA)	18.8			21.2	ng/L	10	112	(0%-28%)		
QC1204391613 MB										
Fluorotelomer sulfonate 4:2 (4:2 FTS)			U	ND	ng/L					10/02/19 05:56
Fluorotelomer sulfonate 6:2 (6:2 FTS)			U	ND	ng/L					
Fluorotelomer sulfonate 8:2 (8:2 FTS)			U	ND	ng/L					
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)			U	ND	ng/L					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)			U	ND	ng/L					
Perfluorobutanesulfonic acid (PFBS)			U	ND	ng/L					
Perfluorobutyric acid (PFBA)			U	ND	ng/L					
Perfluorodecanesulfonic acid (PFDS)			U	ND	ng/L					
Perfluorodecanoic acid (PFDA)			U	ND	ng/L					
Perfluorododecanoic acid (PFDoA)			U	ND	ng/L					
Perfluoroheptanesulfonic acid (PFHpS)			U	ND	ng/L					

QC Summary

Workorder: **490866**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoroheptanoic acid (PFHpA)			U	ND	ng/L				JLS	10/02/19 05:56
Perfluorohexanesulfonic acid (PFHxS)			U	ND	ng/L					
Perfluorohexanoic acid (PFHxA)			U	ND	ng/L					
Perfluorononanesulfonic acid (PFNS)			U	ND	ng/L					
Perfluorononanoic acid (PFNA)			U	ND	ng/L					
Perfluorooctanesulfonamide (PFOSA)			U	ND	ng/L					
Perfluorooctanesulfonic acid (PFOS)			U	ND	ng/L					
Perfluorooctanoic acid (PFOA)			U	ND	ng/L					
Perfluoropentanesulfonic acid (PFPeS)			U	ND	ng/L					
Perfluoropentanoic acid (PFPeA)			U	ND	ng/L					
Perfluorotetradecanoic acid (PFTeDA)			U	ND	ng/L					
Perfluorotridecanoic acid (PFTrDA)			U	ND	ng/L					
Perfluoroundecanoic acid (PFUdA)			U	ND	ng/L					

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported

QC Summary

Workorder: **490866**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time

A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound
N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted
X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

LCMSMS-Misc
Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 490866

Product: **The Extraction and Analysis of Per and Polyfluroalkyl Substances Using LCMSMS**
Analytical Method: EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15
Analytical Procedure: GL-OA-E-076 REV# 7
Analytical Batches: 1921240 and 1921239

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490866001	1304-1
1204391613	Method Blank (MB)
1204391614	Laboratory Control Sample (LCS)
1204391615	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Sample Dilutions

The following samples were diluted to bring the over range concentrations within the calibration range and/or due to matrix interference that caused internal standards recoveries to fall outside the acceptance range. 490866001 (1304-1).

Analyte	490866
	001
Fluorotelomer sulfonate 4:2 (4:2 FTS)	100X
Fluorotelomer sulfonate 6:2 (6:2 FTS)	100X
Perfluorobutanesulfonate (PFBS)	10X
Perfluorobutyric acid (PFBA)	10X
Perfluorohexanoic acid (PFHxA)	10X
Perfluorooctanoic acid (PFOA)	10X
Perfluoropentanoic acid (PFPeA)	10X
Perfluorotetradecanoic acid (PFTeDA)	10X
Perfluorotridecanoic acid (PFTrDA)	10X

Miscellaneous Information

Additional Comments

Additional sample volume was not provided for matrix QC. Also, reduced sample volumes were used for all samples except 490876002 (7607-EB) due to elevated concentrations of target analytes.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

ATTACHMENT D

Page: 1 of 1
Project # NWA-001
GEL Quote #: NWRA Quote
COC Number [1]: NA
PO Number: NA

490866

GEL Laboratories LLC
gel.com Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

Chain of Custody and Analytical Request

GEL Work Order Number:
GEL Project Manager:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: NWRA c/o Hart & Hickman, PC
Phone # 919-847-4241
Project/Site Name: BFI-Charlotte Motor Speedway Landfill V
Fax # 704-586-0007
Address: Concord, NC
Collected By: Patrick Stevens
Send Results To: Genna Olson golson@harthickman.com

Sample Analysis Requested [5] (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive Please supply isotopic info.	(7) Known or possible hazards	Total number of containers	PFAS 21 cmpd list by EPA 537 mod	1,4-Dioxane by EPA 8270SIM	Comments Note: extra sample is required for sample specific QC
1304-1	09-16-19	1255	N	N	ML			4	X	X	

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 Patrick H. Stevens	09-18-19	1630	1	9/19/19	0850
2			2		
3			3		

TAT Requested: Normal: X Rush: ___ Specify: ___ (Subject to Surcharge)

Fax Results: [ ] Yes [X] No

Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4

Additional Remarks:

For Lab Receiving Use Only: Custody Seal Intact? [ ] *Yes* [ ] *No* *Cooler Temp:* 1 °C

> For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)

Sample Collection Time Zone: [X] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ______

1.) Chain of Custody Number = Client Determined

2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite

3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.

4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, ML=Misc Liquid, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B* - 3, *6010B/7470A* - 1).

6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) *Are there any known or possible hazards associated with these samples?*

RCRA Metals
As = Arsenic
Ba = Barium
Cd = Cadmium
Cr = Chromium
Pb = Lead
Hg= Mercury
Se= Selenium
Ag= Silver
MR= Miscellaneous RCRA metals

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

GEL | Laboratories LLC

Th

SAMPLE RECEIPT & REVIEW FORM 6

Client: NWRA	SDG/AR/COC/Work Order: 490866
Received By: AjA	Date Received: 9/19/19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 7762 7563 2308 -1°, 7762 7563 3418-1° 7762 7563 2764 -1°, 7762 7563 3290-1°

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓			Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius
4	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: IR4-16 TEMP: 1° Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?			✓	Circle Applicable: Seals broken [✓ Damaged container] Leaking container Other (describe) 6204-1 (1bottle) cap received cracked
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?			✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials VG Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

List of current GEL Certifications as of 08 November 2019

State	Certification
Alaska	17−018
Alaska Drinking Water	SC00012
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−28
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

GEL Laboratories LLC
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PO Box 30712 Charleston, SC 29417
2040 Savage Road Charleston, SC 29407
P 843.556.8171
F 843.766.1178

gel.com

November 08, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for Chambers Development MSWLF
Work Order: 490872

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on September 19, 2019. This revised data report has been prepared and reviewed in accordance with GEL's standard operating procedures. This package was revised to include PFPeA and PFOA.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 490872 GEL Work Order: 490872

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
J	See case narrative for an explanation
J	Value is estimated
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
h	Preparation or preservation holding time was exceeded

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the ’U’ qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

ATTACHMENT D

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forChambers Development MSWLF

Client Sample ID:	0403-1	Project:	NWRA00119
Sample ID:	490872001	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	16-SEP-19 15:30		
Receive Date:	19-SEP-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
Fluorotelomer sulfonate 8:2 (8:2 FTS)	U	ND	13.2	38.4	ng/L	0.200	1	JLS	10/02/19	0915	1921240	1
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	J	14.9	13.2	40.0	ng/L	0.200	1					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)		50.5	13.2	40.0	ng/L	0.200	1					
Perfluorodecanesulfonic acid (PFDS)	U	ND	6.60	19.4	ng/L	0.200	1					
Perfluorodecanoic acid (PFDA)		23.6	7.80	20.0	ng/L	0.200	1					
Perfluorododecanoic acid (PFDoA)	U	ND	6.60	20.0	ng/L	0.200	1					
Perfluoroheptanesulfonic acid (PFHpS)	U	ND	6.60	19.0	ng/L	0.200	1					
Perfluoroheptanoic acid (PFHpA)		249	6.60	20.0	ng/L	0.200	1					
Perfluorohexanesulfonic acid (PFHxS)		218	6.60	18.2	ng/L	0.200	1					
Perfluorononanesulfonic acid (PFNS)	U	ND	7.00	19.2	ng/L	0.200	1					
Perfluorononanoic acid (PFNA)	J	15.5	6.60	20.0	ng/L	0.200	1					
Perfluorooctanesulfonamide (PFOSA)	U	ND	6.60	18.6	ng/L	0.200	1					
Perfluorooctanesulfonic acid (PFOS)		84.2	8.00	20.0	ng/L	0.200	1					
Perfluorooctanoic acid (PFOA)		345	7.00	20.0	ng/L	0.200	1					
Perfluoropentanesulfonic acid (PFPeS)		19.6	6.60	18.8	ng/L	0.200	1					
Perfluoropentanoic acid (PFPeA)		780	6.60	20.0	ng/L	0.200	1					
Perfluoroundecanoic acid (PFUdA)	U	ND	6.60	20.0	ng/L	0.200	1					
Fluorotelomer sulfonate 6:2 (6:2 FTS)	J	180	132	380	ng/L	0.200	10	JLS	10/02/19	0714	1921240	2
Perfluorobutanesulfonic acid (PFBS)		6290	66.0	178	ng/L	0.200	10					
Perfluorobutyric acid (PFBA)		831	66.0	200	ng/L	0.200	10					
Perfluorohexanoic acid (PFHxA)		2200	66.0	200	ng/L	0.200	10					
Perfluorotetradecanoic acid (PFTeDA)	U	ND	66.0	200	ng/L	0.200	10					
Perfluorotridecanoic acid (PFTrDA)	U	ND	66.0	200	ng/L	0.200	10					
Fluorotelomer sulfonate 4:2 (4:2 FTS)	U	ND	1320	3760	ng/L	0.200	100	JLS	10/02/19	1125	1921240	3
Semi-Volatile-GC/MS												

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forChambers Development MSWLF

Client Sample ID:	0403-1	Project:	NWRA00119
Sample ID:	490872001	Client ID:	NWRA001

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Semi-Volatile-GC/MS												
SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"												
1,4-Dioxane	Q	9.22	1.00	2.00	ug/L	0.200	1	JMB3	09/24/19	1854	1919444	4
1,4-Dioxane	h	14.8	1.00	2.00	ug/L	0.200	1	JMB3	10/02/19	1652	1922216	5

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
EPA 537.1 Mod, PFAS, Compl	PFCs Extraction in Liquid	LM1	09/27/19	0830	1921239
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJ	10/02/19	1000	1922215
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJW1	09/23/19	1200	1919441

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
2	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
3	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
4	SW846 3535A/8270E SIM	
5	SW846 3535A/8270E SIM	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	24.2 ug/L	40.0	60*	(70%-130%)
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	37.7 ug/L	40.0	94	(70%-130%)

Notes:

Column headers are defined as follows:
DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration
Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

GEL LABORATORIES LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: November 8, 2019

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia

Contact: **Mr. Jim Riley**

Workorder: **490872**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
QC1204391614 LCS										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	18.2			15.7	ng/L		86	(60%-145%)	JLS	10/02/19 06:05
Fluorotelomer sulfonate 6:2 (6:2 FTS)	18.5			20.4	ng/L		110	(56%-143%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.7			17.5	ng/L		94	(57%-138%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	19.5			19.3	ng/L		99	(63%-131%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	19.5			21.5	ng/L		111	(62%-133%)		
Perfluorobutanesulfonic acid (PFBS)	17.2			16.6	ng/L		96	(68%-136%)		
Perfluorobutyric acid (PFBA)	19.5			19.7	ng/L		101	(70%-133%)		
Perfluorodecanesulfonic acid (PFDS)	18.8			16.8	ng/L		89	(53%-142%)		
Perfluorodecanoic acid (PFDA)	19.5			18.0	ng/L		93	(62%-135%)		
Perfluorododecanoic acid (PFDoA)	19.5			19.5	ng/L		100	(66%-131%)		
Perfluoroheptanesulfonic acid (PFHpS)	18.5			18.1	ng/L		98	(66%-138%)		
Perfluoroheptanoic acid (PFHpA)	19.5			17.9	ng/L		92	(67%-135%)		
Perfluorohexanesulfonic acid (PFHxS)	17.7			14.5	ng/L		82	(64%-137%)		
Perfluorohexanoic acid (PFHxA)	19.5			18.9	ng/L		97	(67%-133%)		

QC Summary

Workorder: 490872

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorononanesulfonic acid (PFNS)	18.7			17.5	ng/L		93	(66%-130%)	JLS	10/02/19 06:05
Perfluorononanoic acid (PFNA)	19.5			21.1	ng/L		108	(66%-134%)		
Perfluorooctanesulfonamide (PFOSA)	19.5			21.5	ng/L		111	(68%-137%)		
Perfluorooctanesulfonic acid (PFOS)	19.5			19.8	ng/L		102	(61%-131%)		
Perfluorooctanoic acid (PFOA)	19.5			18.8	ng/L		97	(63%-145%)		
Perfluoropentanesulfonic acid (PFPeS)	18.3			16.5	ng/L		90	(62%-139%)		
Perfluoropentanoic acid (PFPeA)	19.5			19.3	ng/L		99	(69%-132%)		
Perfluorotetradecanoic acid (PFTeDA)	19.5			22.5	ng/L		115	(65%-143%)		
Perfluorotridecanoic acid (PFTrDA)	19.5			19.9	ng/L		102	(57%-149%)		
Perfluoroundecanoic acid (PFUdA)	19.5			19.1	ng/L		98	(65%-134%)		
QC1204391615 LCSD										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	17.6			20.5	ng/L	26	116	(0%-35%)		10/02/19 06:14
Fluorotelomer sulfonate 6:2 (6:2 FTS)	17.9			17.6	ng/L	14	98	(0%-36%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.1			19.9	ng/L	13	110	(0%-39%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	18.8			20.1	ng/L	4	107	(0%-25%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	18.8			21.9	ng/L	2	116	(0%-26%)		

QC Summary

Workorder: **490872**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorobutanesulfonic acid (PFBS)	16.7			17.2	ng/L	4	103	(0%-30%)	JLS	10/02/19 06:14
Perfluorobutyric acid (PFBA)	18.8			19.3	ng/L	2	102	(0%-30%)		
Perfluorodecanesulfonic acid (PFDS)	18.2			17.2	ng/L	3	95	(0%-28%)		
Perfluorodecanoic acid (PFDA)	18.8			21.1	ng/L	16	112	(0%-29%)		
Perfluorododecanoic acid (PFDoA)	18.8			19.0	ng/L	3	101	(0%-30%)		
Perfluoroheptanesulfonic acid (PFHpS)	17.9			17.7	ng/L	2	99	(0%-30%)		
Perfluoroheptanoic acid (PFHpA)	18.8			19.6	ng/L	9	104	(0%-30%)		
Perfluorohexanesulfonic acid (PFHxS)	17.2			16.8	ng/L	15	98	(0%-30%)		
Perfluorohexanoic acid (PFHxA)	18.8			20.9	ng/L	10	111	(0%-23%)		
Perfluorononanesulfonic acid (PFNS)	18.1			18.2	ng/L	4	101	(0%-27%)		
Perfluorononanoic acid (PFNA)	18.8			18.7	ng/L	12	99	(0%-27%)		
Perfluorooctanesulfonamide (PFOSA)	18.8			20.2	ng/L	6	107	(0%-30%)		
Perfluorooctanesulfonic acid (PFOS)	18.8			19.9	ng/L	1	106	(0%-27%)		
Perfluorooctanoic acid (PFOA)	18.8			18.9	ng/L	0	100	(0%-30%)		
Perfluoropentanesulfonic acid (PFPeS)	17.7			17.3	ng/L	4	98	(0%-29%)		

QC Summary

Workorder: **490872**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoropentanoic acid (PFPeA)	18.8			20.0	ng/L	3	106	(0%-30%)	JLS	10/02/19 06:14
Perfluorotetradecanoic acid (PFTeDA)	18.8			20.6	ng/L	9	109	(0%-30%)		
Perfluorotridecanoic acid (PFTrDA)	18.8			17.7	ng/L	11	94	(0%-35%)		
Perfluoroundecanoic acid (PFUdA)	18.8			21.2	ng/L	10	112	(0%-28%)		
QC1204391613 MB										
Fluorotelomer sulfonate 4:2 (4:2 FTS)			U	ND	ng/L					10/02/19 05:56
Fluorotelomer sulfonate 6:2 (6:2 FTS)			U	ND	ng/L					
Fluorotelomer sulfonate 8:2 (8:2 FTS)			U	ND	ng/L					
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)			U	ND	ng/L					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)			U	ND	ng/L					
Perfluorobutanesulfonic acid (PFBS)			U	ND	ng/L					
Perfluorobutyric acid (PFBA)			U	ND	ng/L					
Perfluorodecanesulfonic acid (PFDS)			U	ND	ng/L					
Perfluorodecanoic acid (PFDA)			U	ND	ng/L					
Perfluorododecanoic acid (PFDoA)			U	ND	ng/L					
Perfluoroheptanesulfonic acid (PFHpS)			U	ND	ng/L					

QC Summary

Workorder: **490872**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time
Perfluorinated Compounds											
Batch 1921240											
Perfluoroheptanoic acid (PFHpA)			U	ND	ng/L				JLS	10/02/19	05:56
Perfluorohexanesulfonic acid (PFHxS)			U	ND	ng/L						
Perfluorohexanoic acid (PFHxA)			U	ND	ng/L						
Perfluorononanesulfonic acid (PFNS)			U	ND	ng/L						
Perfluorononanoic acid (PFNA)			U	ND	ng/L						
Perfluorooctanesulfonamide (PFOSA)			U	ND	ng/L						
Perfluorooctanesulfonic acid (PFOS)			U	ND	ng/L						
Perfluorooctanoic acid (PFOA)			U	ND	ng/L						
Perfluoropentanesulfonic acid (PFPeS)			U	ND	ng/L						
Perfluoropentanoic acid (PFPeA)			U	ND	ng/L						
Perfluorotetradecanoic acid (PFTeDA)			U	ND	ng/L						
Perfluorotridecanoic acid (PFTrDA)			U	ND	ng/L						
Perfluoroundecanoic acid (PFUdA)			U	ND	ng/L						
Semi-Volatile-GC/MS											
Batch 1919444											
QC1204387349 LCS											
**1,4-Dioxane-d8	4.00			3.55	ug/L		89	(70%-130%)	JMB3	09/24/19	12:24

QC Summary

Workorder: **490872**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS										
Batch 1919444										
QC1204387350 LCSD										
**1,4-Dioxane-d8	4.00			3.18	ug/L		79	(70%-130%)	JMB3	09/24/19 12:49
QC1204387348 MB										
1,4-Dioxane			U	ND	ug/L					09/24/19 11:59
**1,4-Dioxane-d8	4.00			3.05	ug/L		76	(70%-130%)		
Batch 1922216										
QC1204393997 LCS										
**1,4-Dioxane-d8	4.00			4.08	ug/L		102	(70%-130%)	JMB3	10/02/19 15:34
QC1204393998 LCSD										
**1,4-Dioxane-d8	4.00			3.76	ug/L		94	(70%-130%)		10/02/19 16:02
QC1204393996 MB										
1,4-Dioxane			U	ND	ug/L					10/02/19 15:07
**1,4-Dioxane-d8	4.00			3.87	ug/L		97	(70%-130%)		

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported
A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound

QC Summary

Workorder: **490872**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time

N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted
X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 490872

GC/MS Semivolatile

Product: Analysis of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry
Analytical Method: SW846 3535A/8270E SIM
Analytical Procedure: GL-OA-E-073 REV# 2
Analytical Batch: 1919444

Preparation Method: SW846 3535A
Preparation Procedure: GL-OA-E-073 REV# 2
Preparation Batch: 1919441

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490872001	0403-1
1204387348	Method Blank (MB)
1204387349	Laboratory Control Sample (LCS)
1204387350	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Quality Control (QC) Information

Surrogate Recoveries
Sample (See Below) did not meet surrogate recovery acceptance criteria. The sample was re-extracted out of holding and met acceptance criteria for all surrogates. Both sets of data results have been reported.

Sample	Analyte	Value
490872001 (0403-1)	1, 4-Dioxane-d8	60* (70%-130%)

Laboratory Control Sample Duplicate (LCSD)
An LCSD was used in place of matrix QC due to limited sample volume.

Product: Analysis of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry
Analytical Method: SW846 3535A/8270E SIM
Analytical Procedure: GL-OA-E-073 REV# 2

Analytical Batch: 1922216

Preparation Method: SW846 3535A
Preparation Procedure: GL-OA-E-073 REV# 2
Preparation Batch: 1922215

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490872001	0403-1
1204393996	Method Blank (MB)
1204393997	Laboratory Control Sample (LCS)
1204393998	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Quality Control (QC) Information

Laboratory Control Sample Duplicate (LCSD)
An LCSD was used in place of matrix QC due to limited sample volume.

Technical Information

Holding Time Specifications
Sample (See Below) was re-extracted out of holding due to QC failure. The failure did not confirm, so both sets of results are reported and have been qualified accordingly.

Sample	Value
490872001 (0403-1)	Received 19-SEP-19, within holding, prepped 02-OCT-19, out of holding 23-SEP-19

Miscellaneous Information

Manual Integrations
Sample (See Below) required manual integration in order to properly identify one or more peaks and/or to correctly position the baseline as set in the calibration standard injections.

Sample	Analyte	Value
490872001 (0403-1)	Tetrahydrofuran-d8	Result 100ug/L

LCMSMS-Misc

Product: **The Extraction and Analysis of Per and Polyfluroalkyl Substances Using LCMSMS**
Analytical Method: EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15

ATTACHMENT D

Analytical Procedure: GL-OA-E-076 REV# 7
Analytical Batches: 1921240 and 1921239

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490872001	0403-1
1204391613	Method Blank (MB)
1204391614	Laboratory Control Sample (LCS)
1204391615	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Sample Dilutions

The following samples were diluted to bring the over range concentrations within the calibration range and/or due to matrix interference that caused internal standards recoveries to fall outside the acceptance range. 490872001 (0403-1).

Analyte	490872
	001
Fluorotelomer sulfonate 4:2 (4:2 FTS)	100X
Fluorotelomer sulfonate 6:2 (6:2 FTS)	10X
Perfluorobutanesulfonate (PFBS)	10X
Perfluorobutyric acid (PFBA)	10X
Perfluorohexanoic acid (PFHxA)	10X
Perfluorotetradecanoic acid (PFTeDA)	10X
Perfluorotridecanoic acid (PFTrDA)	10X

Miscellaneous Information

Additional Comments

Additional sample volume was not provided for matrix QC. Also, reduced sample volumes were used for all samples except 490876002 (7607-EB) due to elevated concentrations of target analytes.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Page: 1 of 1
Project # NWA-001
GEL Quote #: NWRA Quote
COC Number [1]: NA
PO Number: NA

490872

GEL Laboratories LLC
gel.com
Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

Chain of Custody and Analytical Request

GEL Work Order Number: ***GEL Project Manager:***

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: NWRA c/o Hart & Hickman, PC Phone # 919-847-4241
Project/Site Name: Chambers Development MSWLF Fax # 704-586-0007
Address: Polkton, NC
Collected By: Patrick Stevens Send Results To: Genna Olson golson@harthickman.com

Sample Analysis Requested [5] (Fill in the number of containers for each test)

<-- Preservative Type (6)

Comments
Note: extra sample is required for sample specific QC

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive *Please supply isotopic info.*	(7) Known or possible hazards	Total number of containers	PFAS 21 cmpd list by EPA 537 mod	1,4-Dioxane by EPA 8270SIM									Comments
0403-1	09-16-19	1530	N	N	ML			4	X	X									

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	Patrick H. Stevens	09-18-19	1630	1		9/19/19	0850
2				2			
3				3			

TAT Requested: **Normal:** X **Rush:** ____ **Specify:** ________ **(Subject to Surcharge)**
Fax Results: [ ] Yes [X] No
Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4
Additional Remarks:
For Lab Receiving Use Only: *Custody Seal Intact?* [ ] *Yes* [ ] *No* ***Cooler Temp:*** 1 °C

> For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)
Sample Collection Time Zone: [X] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ________

1.) Chain of Custody Number = Client Determined

2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite

3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.

4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, ML=Misc Liquid, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B* - 3, *6010B/7470A* - 1).

6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) *Are there any known or possible hazards associated with these samples?*

RCRA Metals
As = Arsenic
Ba = Barium
Cd = Cadmium
Cr = Chromium
Pb = Lead
Hg= Mercury
Se= Selenium
Ag= Silver
MR= Miscellaneous RCRA metals

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

ATTACHMENT D

GEL Laboratories LLC

Jh

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA

SDG/AR/COC/Work Order: 490872

Received By: AJA

Date Received: 9/19/19

Carrier and Tracking Number

Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other

7762 7563 2308 -1°, 7762 7563 3418-1°
7762 7563 2764 -1°, 7762 7563 3290-1°

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓	▨		Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓	▨		Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius
4	Daily check performed and passed on IR temperature gun?	✓	▨		Temperature Device Serial #: IR4-16 TEMP: 1° Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?		▨	✓	Circle Applicable: Seals broken [✓ Damaged container] Leaking container Other (describe) 6204-1 (1 bottle) cap received cracked
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?		▨	✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓	▨		ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓	▨		ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓	▨		Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓	▨		
13	COC form is properly signed in relinquished/received sections?		▨	✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials VDJ Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

List of current GEL Certifications as of 08 November 2019

State	Certification
Alaska	17−018
Alaska Drinking Water	SC00012
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−28
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

GEL Laboratories LLC
a member of The GEL Group INC

PO Box 30712 Charleston, SC 29417
2040 Savage Road Charleston, SC 29407
P 843.556.8171
F 843.766.1178

gel.com

November 08, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for Uwharrie Environmental Regional Landfill
Work Order: 490875

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on September 19, 2019. This revised data report has been prepared and reviewed in accordance with GEL's standard operating procedures. This package was revised to include PFPeA and PFOA.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 490875 GEL Work Order: 490875

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
J	See case narrative for an explanation
J	Value is estimated
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the ’U’ qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

ATTACHMENT D

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forUwharrie Environmental Regional Landfill

Client Sample ID:	6204-1	Project:	NWRA00119
Sample ID:	490875001	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	17-SEP-19 08:55		
Receive Date:	19-SEP-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
Fluorotelomer sulfonate 8:2 (8:2 FTS)	J	35.8	13.2	38.4	ng/L	0.200	1	JLS	10/02/19	0924	1921240	1
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)		68.0	13.2	40.0	ng/L	0.200	1					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)		180	13.2	40.0	ng/L	0.200	1					
Perfluorodecanesulfonic acid (PFDS)	U	ND	6.60	19.4	ng/L	0.200	1					
Perfluorodecanoic acid (PFDA)		632	7.80	20.0	ng/L	0.200	1					
Perfluorododecanoic acid (PFDoA)		184	6.60	20.0	ng/L	0.200	1					
Perfluoroheptanesulfonic acid (PFHpS)	J	9.40	6.60	19.0	ng/L	0.200	1					
Perfluoroheptanoic acid (PFHpA)		1560	6.60	20.0	ng/L	0.200	1					
Perfluorohexanesulfonic acid (PFHxS)		640	6.60	18.2	ng/L	0.200	1					
Perfluorononanesulfonic acid (PFNS)	U	ND	7.00	19.2	ng/L	0.200	1					
Perfluorononanoic acid (PFNA)		326	6.60	20.0	ng/L	0.200	1					
Perfluorooctanesulfonamide (PFOSA)	U	ND	6.60	18.6	ng/L	0.200	1					
Perfluorooctanesulfonic acid (PFOS)		356	8.00	20.0	ng/L	0.200	1					
Perfluoropentanesulfonic acid (PFPeS)		41.4	6.60	18.8	ng/L	0.200	1					
Perfluoroundecanoic acid (PFUdA)		33.0	6.60	20.0	ng/L	0.200	1					
Perfluorobutanesulfonic acid (PFBS)		2870	66.0	178	ng/L	0.200	10	JLS	10/02/19	0731	1921240	2
Perfluorobutyric acid (PFBA)		2400	66.0	200	ng/L	0.200	10					
Perfluorohexanoic acid (PFHxA)		5540	66.0	200	ng/L	0.200	10					
Perfluorooctanoic acid (PFOA)		3690	70.0	200	ng/L	0.200	10					
Perfluoropentanoic acid (PFPeA)		2150	66.0	200	ng/L	0.200	10					
Perfluorotetradecanoic acid (PFTeDA)	U	ND	66.0	200	ng/L	0.200	10					
Perfluorotridecanoic acid (PFTrDA)	U	ND	66.0	200	ng/L	0.200	10					
Fluorotelomer sulfonate 4:2 (4:2 FTS)	U	ND	1320	3760	ng/L	0.200	100	JLS	10/02/19	1134	1921240	3
Fluorotelomer sulfonate 6:2 (6:2 FTS)	U	ND	1320	3800	ng/L	0.200	100					
Semi-Volatile-GC/MS												

ATTACHMENT D

GEL LABORATORIES LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forUwharrie Environmental Regional Landfill

Client Sample ID:	6204-1	Project:	NWRA00119
Sample ID:	490875001	Client ID:	NWRA001

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Semi-Volatile-GC/MS												
SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"												
1,4-Dioxane		357	10.0	20.0	ug/L	0.200	10	JMB3	09/24/19	1528	1919444	4

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
EPA 537.1 Mod, PFAS, Compl	PFCs Extraction in Liquid	LM1	09/27/19	0830	1921239
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJW1	09/23/19	1200	1919441

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
2	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
3	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
4	SW846 3535A/8270E SIM	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	40.4 ug/L	40.0	101	(70%-130%)

Notes:

Column headers are defined as follows:

DF: Dilution Factor	Lc/LC: Critical Level
DL: Detection Limit	PF: Prep Factor
MDA: Minimum Detectable Activity	RL: Reporting Limit
MDC: Minimum Detectable Concentration	SQL: Sample Quantitation Limit

ATTACHMENT D

QC Summary

Report Date: November 8, 2019

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia

Contact: **Mr. Jim Riley**

Workorder: **490875**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
QC1204391614 LCS										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	18.2			15.7	ng/L		86	(60%-145%)	JLS	10/02/19 06:05
Fluorotelomer sulfonate 6:2 (6:2 FTS)	18.5			20.4	ng/L		110	(56%-143%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.7			17.5	ng/L		94	(57%-138%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	19.5			19.3	ng/L		99	(63%-131%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	19.5			21.5	ng/L		111	(62%-133%)		
Perfluorobutanesulfonic acid (PFBS)	17.2			16.6	ng/L		96	(68%-136%)		
Perfluorobutyric acid (PFBA)	19.5			19.7	ng/L		101	(70%-133%)		
Perfluorodecanesulfonic acid (PFDS)	18.8			16.8	ng/L		89	(53%-142%)		
Perfluorodecanoic acid (PFDA)	19.5			18.0	ng/L		93	(62%-135%)		
Perfluorododecanoic acid (PFDoA)	19.5			19.5	ng/L		100	(66%-131%)		
Perfluoroheptanesulfonic acid (PFHpS)	18.5			18.1	ng/L		98	(66%-138%)		
Perfluoroheptanoic acid (PFHpA)	19.5			17.9	ng/L		92	(67%-135%)		
Perfluorohexanesulfonic acid (PFHxS)	17.7			14.5	ng/L		82	(64%-137%)		
Perfluorohexanoic acid (PFHxA)	19.5			18.9	ng/L		97	(67%-133%)		

QC Summary

Workorder: **490875**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorononanesulfonic acid (PFNS)	18.7			17.5	ng/L		93	(66%-130%)	JLS	10/02/19 06:05
Perfluorononanoic acid (PFNA)	19.5			21.1	ng/L		108	(66%-134%)		
Perfluorooctanesulfonamide (PFOSA)	19.5			21.5	ng/L		111	(68%-137%)		
Perfluorooctanesulfonic acid (PFOS)	19.5			19.8	ng/L		102	(61%-131%)		
Perfluorooctanoic acid (PFOA)	19.5			18.8	ng/L		97	(63%-145%)		
Perfluoropentanesulfonic acid (PFPeS)	18.3			16.5	ng/L		90	(62%-139%)		
Perfluoropentanoic acid (PFPeA)	19.5			19.3	ng/L		99	(69%-132%)		
Perfluorotetradecanoic acid (PFTeDA)	19.5			22.5	ng/L		115	(65%-143%)		
Perfluorotridecanoic acid (PFTrDA)	19.5			19.9	ng/L		102	(57%-149%)		
Perfluoroundecanoic acid (PFUdA)	19.5			19.1	ng/L		98	(65%-134%)		
QC1204391615 LCSD										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	17.6			20.5	ng/L	26	116	(0%-35%)		10/02/19 06:14
Fluorotelomer sulfonate 6:2 (6:2 FTS)	17.9			17.6	ng/L	14	98	(0%-36%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.1			19.9	ng/L	13	110	(0%-39%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	18.8			20.1	ng/L	4	107	(0%-25%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	18.8			21.9	ng/L	2	116	(0%-26%)		

QC Summary

Workorder: 490875

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorobutanesulfonic acid (PFBS)	16.7			17.2	ng/L	4	103	(0%-30%)	JLS	10/02/19 06:14
Perfluorobutyric acid (PFBA)	18.8			19.3	ng/L	2	102	(0%-30%)		
Perfluorodecanesulfonic acid (PFDS)	18.2			17.2	ng/L	3	95	(0%-28%)		
Perfluorodecanoic acid (PFDA)	18.8			21.1	ng/L	16	112	(0%-29%)		
Perfluorododecanoic acid (PFDoA)	18.8			19.0	ng/L	3	101	(0%-30%)		
Perfluoroheptanesulfonic acid (PFHpS)	17.9			17.7	ng/L	2	99	(0%-30%)		
Perfluoroheptanoic acid (PFHpA)	18.8			19.6	ng/L	9	104	(0%-30%)		
Perfluorohexanesulfonic acid (PFHxS)	17.2			16.8	ng/L	15	98	(0%-30%)		
Perfluorohexanoic acid (PFHxA)	18.8			20.9	ng/L	10	111	(0%-23%)		
Perfluorononanesulfonic acid (PFNS)	18.1			18.2	ng/L	4	101	(0%-27%)		
Perfluorononanoic acid (PFNA)	18.8			18.7	ng/L	12	99	(0%-27%)		
Perfluorooctanesulfonamide (PFOSA)	18.8			20.2	ng/L	6	107	(0%-30%)		
Perfluorooctanesulfonic acid (PFOS)	18.8			19.9	ng/L	1	106	(0%-27%)		
Perfluorooctanoic acid (PFOA)	18.8			18.9	ng/L	0	100	(0%-30%)		
Perfluoropentanesulfonic acid (PFPeS)	17.7			17.3	ng/L	4	98	(0%-29%)		

GEL LABORATORIES LLC

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QC Summary

Workorder: 490875

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoropentanoic acid (PFPeA)	18.8			20.0	ng/L	3	106	(0%-30%)	JLS	10/02/19 06:14
Perfluorotetradecanoic acid (PFTeDA)	18.8			20.6	ng/L	9	109	(0%-30%)		
Perfluorotridecanoic acid (PFTrDA)	18.8			17.7	ng/L	11	94	(0%-35%)		
Perfluoroundecanoic acid (PFUdA)	18.8			21.2	ng/L	10	112	(0%-28%)		
QC1204391613 MB										
Fluorotelomer sulfonate 4:2 (4:2 FTS)			U	ND	ng/L					10/02/19 05:56
Fluorotelomer sulfonate 6:2 (6:2 FTS)			U	ND	ng/L					
Fluorotelomer sulfonate 8:2 (8:2 FTS)			U	ND	ng/L					
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)			U	ND	ng/L					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)			U	ND	ng/L					
Perfluorobutanesulfonic acid (PFBS)			U	ND	ng/L					
Perfluorobutyric acid (PFBA)			U	ND	ng/L					
Perfluorodecanesulfonic acid (PFDS)			U	ND	ng/L					
Perfluorodecanoic acid (PFDA)			U	ND	ng/L					
Perfluorododecanoic acid (PFDoA)			U	ND	ng/L					
Perfluoroheptanesulfonic acid (PFHpS)			U	ND	ng/L					

QC Summary

Workorder: **490875**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoroheptanoic acid (PFHpA)			U	ND	ng/L				JLS	10/02/19 05:56
Perfluorohexanesulfonic acid (PFHxS)			U	ND	ng/L					
Perfluorohexanoic acid (PFHxA)			U	ND	ng/L					
Perfluorononanesulfonic acid (PFNS)			U	ND	ng/L					
Perfluorononanoic acid (PFNA)			U	ND	ng/L					
Perfluorooctanesulfonamide (PFOSA)			U	ND	ng/L					
Perfluorooctanesulfonic acid (PFOS)			U	ND	ng/L					
Perfluorooctanoic acid (PFOA)			U	ND	ng/L					
Perfluoropentanesulfonic acid (PFPeS)			U	ND	ng/L					
Perfluoropentanoic acid (PFPeA)			U	ND	ng/L					
Perfluorotetradecanoic acid (PFTeDA)			U	ND	ng/L					
Perfluorotridecanoic acid (PFTrDA)			U	ND	ng/L					
Perfluoroundecanoic acid (PFUdA)			U	ND	ng/L					
Semi-Volatile-GC/MS										
Batch 1919444										
QC1204387349 LCS										
**1,4-Dioxane-d8	4.00			3.55	ug/L		89	(70%-130%)	JMB3	09/24/19 12:24

ATTACHMENT D

QC Summary

Workorder: **490875**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time
Semi-Volatile-GC/MS											
Batch 1919444											
QC1204387350 LCSD											
**1,4-Dioxane-d8	4.00			3.18	ug/L		79	(70%-130%)	JMB3	09/24/19	12:49
QC1204387348 MB											
1,4-Dioxane			U	ND	ug/L					09/24/19	11:59
**1,4-Dioxane-d8	4.00			3.05	ug/L		76	(70%-130%)			

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported
A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound
N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted

QC Summary

Workorder: **490875**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time

X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 490875

GC/MS Semivolatile

Product: Analysis of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry
Analytical Method: SW846 3535A/8270E SIM
Analytical Procedure: GL-OA-E-073 REV# 2
Analytical Batch: 1919444

Preparation Method: SW846 3535A
Preparation Procedure: GL-OA-E-073 REV# 2
Preparation Batch: 1919441

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490875001	6204-1
1204387348	Method Blank (MB)
1204387349	Laboratory Control Sample (LCS)
1204387350	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Quality Control (QC) Information

Laboratory Control Sample Duplicate (LCSD)
An LCSD was used in place of matrix QC due to limited sample volume.

Technical Information

Sample Dilutions
Sample 490875001 (6204-1) was diluted due to the presence of one or more over-range target analytes.

LCMSMS-Misc

Product: The Extraction and Analysis of Per and Polyfluroalkyl Substances Using LCMSMS
Analytical Method: EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15
Analytical Procedure: GL-OA-E-076 REV# 7
Analytical Batches: 1921240 and 1921239

ATTACHMENT D

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	**Client Sample Identification**
490875001	6204-1
1204391613	Method Blank (MB)
1204391614	Laboratory Control Sample (LCS)
1204391615	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Sample Dilutions

The following samples were diluted to bring the over range concentrations within the calibration range and/or due to matrix interference that caused internal standards recoveries to fall outside the acceptance range. 490875001 (6204-1).

Analyte	**490875**
	001
Fluorotelomer sulfonate 4:2 (4:2 FTS)	100X
Fluorotelomer sulfonate 6:2 (6:2 FTS)	100X
Perfluorobutanesulfonate (PFBS)	10X
Perfluorobutyric acid (PFBA)	10X
Perfluorohexanoic acid (PFHxA)	10X
Perfluorooctanoic acid (PFOA)	10X
Perfluoropentanoic acid (PFPeA)	10X
Perfluorotetradecanoic acid (PFTeDA)	10X
Perfluorotridecanoic acid (PFTrDA)	10X

Miscellaneous Information

Additional Comments

Additional sample volume was not provided for matrix QC. Also, reduced sample volumes were used for all samples except 490876002 (7607-EB) due to elevated concentrations of target analytes.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Page: 1 of 1
Project # NWA-001
GEL Quote #: NWRA Quote
COC Number [1]: NA
PO Number: NA

490875

GEL Laboratories LLC
gel.com Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

Chain of Custody and Analytical Request

GEL Work Order Number:
GEL Project Manager:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: NWRA c/o Hart & Hickman, PC Phone # 919-847-4241
Project/Site Name: Uwharrie Environmental Regional Landfill Fax # 704-586-0007
Address: Mt Gilead, NC
Collected By: Patrick Stevens Send Results To: Genna Olson golson@harthickman.com

Sample Analysis Requested [5] (Fill in the number of containers for each test)

<-- Preservative Type (6)

Comments
Note: extra sample is required for sample specific QC

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive *Please supply isotopic info.*	Should this sample be considered: (7) Known or possible hazards	Total number of containers	PFAS 21 cmpd list by EPA 537 mod	1,4-Dioxane by EPA 8270SIM									Comments
6204-1	09-17-19	0855	N	N	ML			4	X	X									

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 Patrick H. Stevens	09-18-19	1630	1	9/19/19	0850
2			2		
3			3		

TAT Requested: Normal: X Rush: ____ Specify: ________ **(Subject to Surcharge)**
Fax Results: [ ] Yes [X] No
Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4
Additional Remarks:
For Lab Receiving Use Only: Custody Seal Intact? [ ] *Yes* [ ] *No* *Cooler Temp:* 1 °C

> *For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)*

Sample Collection Time Zone: [X] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ________

1.) Chain of Custody Number = Client Determined

2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite

3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.

4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, ML=Misc Liquid, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B* - 3, *6010B/7470A* - 1).

6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) *Are there any known or possible hazards associated with these samples?*

RCRA Metals
As = Arsenic Hg= Mercury
Ba = Barium Se= Selenium
Cd = Cadmium Ag= Silver
Cr = Chromium MR= Miscellaneous RCRA metals
Pb = Lead

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

ATTACHMENT D

GEL | Laboratories LLC

Jh

SAMPLE RECEIPT & REVIEW FORM 6

Client: NWRA

Received By: AjA

SDG/AR/COC/Work Order: 490875

Date Received: 9/19/19

Carrier and Tracking Number

Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other

7762 7563 2308 -1°, 7762 7563 3418-1°
7762 7563 2764-1°, 7762 7563 3290-1°

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓			Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius
4	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: IR4-16 TEMP: 1° Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?			✓	Circle Applicable: Seals broken [✓ Damaged container] Leaking container Other (describe) 6204-1 (1 bottle) cap received cracked
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?			✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials VQ Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

List of current GEL Certifications as of 08 November 2019

State	Certification
Alaska	17−018
Alaska Drinking Water	SC00012
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−28
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

Electronic Filing: Received, Clerk's Office 11/23/2022

GEL Laboratories LLC
a member of The GEL Group INC

PO Box 30712 Charleston, SC 29417
2040 Savage Road Charleston, SC 29407
P 843.556.8171
F 843.766.1178

gel.com

November 08, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for Great Oak Landfill
Work Order: 490876

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on September 19, 2019. This revised data report has been prepared and reviewed in accordance with GEL's standard operating procedures. This package was revised to include PFPeA and PFOA.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 490876 GEL Work Order: 490876

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
J	See case narrative for an explanation
J	Value is estimated
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the 'U' qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

ATTACHMENT D

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forGreat Oak Landfill

Client Sample ID:	7607-1	Project:	NWRA00119
Sample ID:	490876001	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	17-SEP-19 13:10		
Receive Date:	19-SEP-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	J	15.6	13.2	40.0	ng/L	0.200	1	JLS	10/04/19	1052	1921240	1
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)		42.4	13.2	40.0	ng/L	0.200	1					
Perfluorobutanesulfonic acid (PFBS)		72.2	6.60	17.8	ng/L	0.200	1					
Perfluorobutyric acid (PFBA)		303	6.60	20.0	ng/L	0.200	1					
Perfluorodecanesulfonic acid (PFDS)	J	7.10	6.60	19.4	ng/L	0.200	1					
Perfluorodecanoic acid (PFDA)	J	18.5	7.80	20.0	ng/L	0.200	1					
Perfluorododecanoic acid (PFDoA)	U	ND	6.60	20.0	ng/L	0.200	1					
Perfluoroheptanesulfonic acid (PFHpS)	U	ND	6.60	19.0	ng/L	0.200	1					
Perfluoroheptanoic acid (PFHpA)		68.4	6.60	20.0	ng/L	0.200	1					
Perfluorohexanesulfonic acid (PFHxS)		59.1	6.60	18.2	ng/L	0.200	1					
Perfluorohexanoic acid (PFHxA)		449	6.60	20.0	ng/L	0.200	1					
Perfluorononanesulfonic acid (PFNS)	U	ND	7.00	19.2	ng/L	0.200	1					
Perfluorononanoic acid (PFNA)		32.8	6.60	20.0	ng/L	0.200	1					
Perfluorooctanesulfonamide (PFOSA)	J	8.75	6.60	18.6	ng/L	0.200	1					
Perfluorooctanesulfonic acid (PFOS)		83.9	8.00	20.0	ng/L	0.200	1					
Perfluorooctanoic acid (PFOA)		108	7.00	20.0	ng/L	0.200	1					
Perfluoropentanesulfonic acid (PFPeS)	J	10.3	6.60	18.8	ng/L	0.200	1					
Perfluoropentanoic acid (PFPeA)		159	6.60	20.0	ng/L	0.200	1					
Perfluoroundecanoic acid (PFUdA)	J	7.44	6.60	20.0	ng/L	0.200	1					
Fluorotelomer sulfonate 8:2 (8:2 FTS)	U	ND	132	384	ng/L	0.200	10	JLS	10/02/19	0740	1921240	2
Perfluorotetradecanoic acid (PFTeDA)	U	ND	66.0	200	ng/L	0.200	10					
Perfluorotridecanoic acid (PFTrDA)	U	ND	66.0	200	ng/L	0.200	10					
Fluorotelomer sulfonate 4:2 (4:2 FTS)	U	ND	1320	3760	ng/L	0.200	100	JLS	10/02/19	1143	1921240	3
Fluorotelomer sulfonate 6:2 (6:2 FTS)	U	ND	1320	3800	ng/L	0.200	100					

The following Prep Methods were performed:

GEL LABORATORIES LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forGreat Oak Landfill

Client Sample ID:	7607-1	Project:	NWRA00119
Sample ID:	490876001	Client ID:	NWRA001

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
EPA 537.1 Mod, PFAS, Compl	PFCs Extraction in Liquid	LM1	09/27/19	0830	1921239

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
2	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
3	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	

Notes:

Column headers are defined as follows:

DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration

Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forGreat Oak Landfill

Client Sample ID:	7607-EB	Project:	NWRA00119
Sample ID:	490876002	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	17-SEP-19 12:40		
Receive Date:	19-SEP-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
Fluorotelomer sulfonate 4:2 (4:2 FTS)	U	ND	1.15	3.29	ng/L	0.0175	1	JLS	10/02/19	0941	1921240	1
Fluorotelomer sulfonate 6:2 (6:2 FTS)	U	ND	1.15	3.32	ng/L	0.0175	1					
Fluorotelomer sulfonate 8:2 (8:2 FTS)	U	ND	1.15	3.36	ng/L	0.0175	1					
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	U	ND	1.15	3.50	ng/L	0.0175	1					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	U	ND	1.15	3.50	ng/L	0.0175	1					
Perfluorobutanesulfonic acid (PFBS)	U	ND	0.577	1.56	ng/L	0.0175	1					
Perfluorobutyric acid (PFBA)	J	1.12	0.577	1.75	ng/L	0.0175	1					
Perfluorodecanesulfonic acid (PFDS)	U	ND	0.577	1.70	ng/L	0.0175	1					
Perfluorodecanoic acid (PFDA)	U	ND	0.682	1.75	ng/L	0.0175	1					
Perfluorododecanoic acid (PFDoA)	U	ND	0.577	1.75	ng/L	0.0175	1					
Perfluoroheptanesulfonic acid (PFHpS)	U	ND	0.577	1.66	ng/L	0.0175	1					
Perfluoroheptanoic acid (PFHpA)	U	ND	0.577	1.75	ng/L	0.0175	1					
Perfluorohexanesulfonic acid (PFHxS)	U	ND	0.577	1.59	ng/L	0.0175	1					
Perfluorohexanoic acid (PFHxA)	U	ND	0.577	1.75	ng/L	0.0175	1					
Perfluorononanesulfonic acid (PFNS)	U	ND	0.612	1.68	ng/L	0.0175	1					
Perfluorononanoic acid (PFNA)	U	ND	0.577	1.75	ng/L	0.0175	1					
Perfluorooctanesulfonamide (PFOSA)	U	ND	0.577	1.63	ng/L	0.0175	1					
Perfluorooctanesulfonic acid (PFOS)	U	ND	0.699	1.75	ng/L	0.0175	1					
Perfluorooctanoic acid (PFOA)	U	ND	0.612	1.75	ng/L	0.0175	1					
Perfluoropentanesulfonic acid (PFPeS)	U	ND	0.577	1.64	ng/L	0.0175	1					
Perfluoropentanoic acid (PFPeA)	U	ND	0.577	1.75	ng/L	0.0175	1					
Perfluorotetradecanoic acid (PFTeDA)	U	ND	0.577	1.75	ng/L	0.0175	1					
Perfluorotridecanoic acid (PFTrDA)	U	ND	0.577	1.75	ng/L	0.0175	1					
Perfluoroundecanoic acid (PFUdA)	U	ND	0.577	1.75	ng/L	0.0175	1					

The following Prep Methods were performed:

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forGreat Oak Landfill

Client Sample ID: 7607-EB
Sample ID: 490876002

Project: NWRA00119
Client ID: NWRA001

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
EPA 537.1 Mod, PFAS, Compl	PFCs Extraction in Liquid	LM1	09/27/19	0830	1921239

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	

Notes:

Column headers are defined as follows:
DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration
Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

QC Summary

Report Date: November 8, 2019

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia

Contact: **Mr. Jim Riley**

Workorder: **490876**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
QC1204391614 LCS										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	18.2			15.7	ng/L		86	(60%-145%)	JLS	10/02/19 06:05
Fluorotelomer sulfonate 6:2 (6:2 FTS)	18.5			20.4	ng/L		110	(56%-143%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.7			17.5	ng/L		94	(57%-138%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	19.5			19.3	ng/L		99	(63%-131%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	19.5			21.5	ng/L		111	(62%-133%)		
Perfluorobutanesulfonic acid (PFBS)	17.2			16.6	ng/L		96	(68%-136%)		
Perfluorobutyric acid (PFBA)	19.5			19.7	ng/L		101	(70%-133%)		
Perfluorodecanesulfonic acid (PFDS)	18.8			16.8	ng/L		89	(53%-142%)		
Perfluorodecanoic acid (PFDA)	19.5			18.0	ng/L		93	(62%-135%)		
Perfluorododecanoic acid (PFDoA)	19.5			19.5	ng/L		100	(66%-131%)		
Perfluoroheptanesulfonic acid (PFHpS)	18.5			18.1	ng/L		98	(66%-138%)		
Perfluoroheptanoic acid (PFHpA)	19.5			17.9	ng/L		92	(67%-135%)		
Perfluorohexanesulfonic acid (PFHxS)	17.7			14.5	ng/L		82	(64%-137%)		
Perfluorohexanoic acid (PFHxA)	19.5			18.9	ng/L		97	(67%-133%)		

QC Summary

Workorder: 490876

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorononanesulfonic acid (PFNS)	18.7			17.5	ng/L		93	(66%-130%)	JLS	10/02/19 06:05
Perfluorononanoic acid (PFNA)	19.5			21.1	ng/L		108	(66%-134%)		
Perfluorooctanesulfonamide (PFOSA)	19.5			21.5	ng/L		111	(68%-137%)		
Perfluorooctanesulfonic acid (PFOS)	19.5			19.8	ng/L		102	(61%-131%)		
Perfluorooctanoic acid (PFOA)	19.5			18.8	ng/L		97	(63%-145%)		
Perfluoropentanesulfonic acid (PFPeS)	18.3			16.5	ng/L		90	(62%-139%)		
Perfluoropentanoic acid (PFPeA)	19.5			19.3	ng/L		99	(69%-132%)		
Perfluorotetradecanoic acid (PFTeDA)	19.5			22.5	ng/L		115	(65%-143%)		
Perfluorotridecanoic acid (PFTrDA)	19.5			19.9	ng/L		102	(57%-149%)		
Perfluoroundecanoic acid (PFUdA)	19.5			19.1	ng/L		98	(65%-134%)		
QC1204391615 LCSD										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	17.6			20.5	ng/L	26	116	(0%-35%)		10/02/19 06:14
Fluorotelomer sulfonate 6:2 (6:2 FTS)	17.9			17.6	ng/L	14	98	(0%-36%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.1			19.9	ng/L	13	110	(0%-39%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	18.8			20.1	ng/L	4	107	(0%-25%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	18.8			21.9	ng/L	2	116	(0%-26%)		

GEL LABORATORIES LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Workorder: 490876

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorobutanesulfonic acid (PFBS)	16.7			17.2	ng/L	4	103	(0%-30%)	JLS	10/02/19 06:14
Perfluorobutyric acid (PFBA)	18.8			19.3	ng/L	2	102	(0%-30%)		
Perfluorodecanesulfonic acid (PFDS)	18.2			17.2	ng/L	3	95	(0%-28%)		
Perfluorodecanoic acid (PFDA)	18.8			21.1	ng/L	16	112	(0%-29%)		
Perfluorododecanoic acid (PFDoA)	18.8			19.0	ng/L	3	101	(0%-30%)		
Perfluoroheptanesulfonic acid (PFHpS)	17.9			17.7	ng/L	2	99	(0%-30%)		
Perfluoroheptanoic acid (PFHpA)	18.8			19.6	ng/L	9	104	(0%-30%)		
Perfluorohexanesulfonic acid (PFHxS)	17.2			16.8	ng/L	15	98	(0%-30%)		
Perfluorohexanoic acid (PFHxA)	18.8			20.9	ng/L	10	111	(0%-23%)		
Perfluorononanesulfonic acid (PFNS)	18.1			18.2	ng/L	4	101	(0%-27%)		
Perfluorononanoic acid (PFNA)	18.8			18.7	ng/L	12	99	(0%-27%)		
Perfluorooctanesulfonamide (PFOSA)	18.8			20.2	ng/L	6	107	(0%-30%)		
Perfluorooctanesulfonic acid (PFOS)	18.8			19.9	ng/L	1	106	(0%-27%)		
Perfluorooctanoic acid (PFOA)	18.8			18.9	ng/L	0	100	(0%-30%)		
Perfluoropentanesulfonic acid (PFPeS)	17.7			17.3	ng/L	4	98	(0%-29%)		

QC Summary

Workorder: 490876

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoropentanoic acid (PFPeA)	18.8			20.0	ng/L	3	106	(0%-30%)	JLS	10/02/19 06:14
Perfluorotetradecanoic acid (PFTeDA)	18.8			20.6	ng/L	9	109	(0%-30%)		
Perfluorotridecanoic acid (PFTrDA)	18.8			17.7	ng/L	11	94	(0%-35%)		
Perfluoroundecanoic acid (PFUdA)	18.8			21.2	ng/L	10	112	(0%-28%)		
QC1204391613 MB										
Fluorotelomer sulfonate 4:2 (4:2 FTS)			U	ND	ng/L					10/02/19 05:56
Fluorotelomer sulfonate 6:2 (6:2 FTS)			U	ND	ng/L					
Fluorotelomer sulfonate 8:2 (8:2 FTS)			U	ND	ng/L					
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)			U	ND	ng/L					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)			U	ND	ng/L					
Perfluorobutanesulfonic acid (PFBS)			U	ND	ng/L					
Perfluorobutyric acid (PFBA)			U	ND	ng/L					
Perfluorodecanesulfonic acid (PFDS)			U	ND	ng/L					
Perfluorodecanoic acid (PFDA)			U	ND	ng/L					
Perfluorododecanoic acid (PFDoA)			U	ND	ng/L					
Perfluoroheptanesulfonic acid (PFHpS)			U	ND	ng/L					

QC Summary

Workorder: 490876

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoroheptanoic acid (PFHpA)			U	ND	ng/L				JLS	10/02/19 05:56
Perfluorohexanesulfonic acid (PFHxS)			U	ND	ng/L					
Perfluorohexanoic acid (PFHxA)			U	ND	ng/L					
Perfluorononanesulfonic acid (PFNS)			U	ND	ng/L					
Perfluorononanoic acid (PFNA)			U	ND	ng/L					
Perfluorooctanesulfonamide (PFOSA)			U	ND	ng/L					
Perfluorooctanesulfonic acid (PFOS)			U	ND	ng/L					
Perfluorooctanoic acid (PFOA)			U	ND	ng/L					
Perfluoropentanesulfonic acid (PFPeS)			U	ND	ng/L					
Perfluoropentanoic acid (PFPeA)			U	ND	ng/L					
Perfluorotetradecanoic acid (PFTeDA)			U	ND	ng/L					
Perfluorotridecanoic acid (PFTrDA)			U	ND	ng/L					
Perfluoroundecanoic acid (PFUdA)			U	ND	ng/L					

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported

QC Summary

Workorder: **490876**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time

A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound
N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted
X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

LCMSMS-Misc
Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 490876

Product: The Extraction and Analysis of Per and Polyfluroalkyl Substances Using LCMSMS
Analytical Method: EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15
Analytical Procedure: GL-OA-E-076 REV# 7
Analytical Batches: 1921240 and 1921239

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490876001	7607-1
490876002	7607-EB
1204391613	Method Blank (MB)
1204391614	Laboratory Control Sample (LCS)
1204391615	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Sample Dilutions

The following samples were diluted to bring the over range concentrations within the calibration range and/or due to matrix interference that caused internal standards recoveries to fall outside the acceptance range. 490876001 (7607-1).

Analyte	**490876**
	001
Fluorotelomer sulfonate 4:2 (4:2 FTS)	100X
Fluorotelomer sulfonate 6:2 (6:2 FTS)	100X
Fluorotelomer sulfonate 8:2 (8:2 FTS)	10X
Perfluorotetradecanoic acid (PFTeDA)	10X
Perfluorotridecanoic acid (PFTrDA)	10X

Miscellaneous Information

Additional Comments

Additional sample volume was not provided for matrix QC. Also, reduced sample volumes were used for all samples except 490876002(7607-EB) (7607-EB) due to elevated concentrations of target analytes. PFBA was detected in the following samples above the MDL but less than LOQ. The sample is identified as Field Reagent Blanks (FRB). All samples associated with these blanks contained PFBA concentrations greater than 10 times that found in the blank. 490876002 (7607-EB).

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Page: 1 of 1
Project # NWA-001
GEL Quote #: NWRA Quote
COC Number [1]: NA
PO Number: NA

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Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

Chain of Custody and Analytical Request

490876
GEL Work Order Number:
GEL Project Manager:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: NWRA c/o Hart & Hickman, PC   Phone # 919-847-4241
Project/Site Name: Great Oak Landfill   Fax # 704-586-0007
Address: Randleman, NC
Collected By: Patrick Stevens   Send Results To: Genna Olson golson@harthickman.com

Sample Analysis Requested [5] (Fill in the number of containers for each test)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive Please supply isotopic info.	(7) Known or possible hazards	Total number of containers	PFAS 21 cmpd list by EPA 537 mod	1,4-Dioxane by EPA 8270SIM	Comments Note: extra sample is required for sample specific QC
									<-- Preservative Type (6)		
7607-1	09-17-19	1310	N	N	ML			4	X	X	
7607-EB	09-17-19	1240	EB	N	ML			4	X	X	

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 Patrick H. Stevens	09-18-19	1630	1	9/19/19	0850
2			2		
3			3		

TAT Requested: Normal: X Rush: ____ Specify: ________ (Subject to Surcharge)
Fax Results: [ ] Yes [X] No
Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4
Additional Remarks:
For Lab Receiving Use Only: Custody Seal Intact? [ ] Yes [ ] No *Cooler Temp:* 1 °C

> *For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)*
Sample Collection Time Zone: [X] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ________

1.) Chain of Custody Number = Client Determined

2.) QC Codes: **N** = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite

3.) Field Filtered: For liquid matrices, indicate with a - **Y** - for yes the sample was field filtered or - **N** - for sample was not field filtered.

4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **ML**=Misc Liquid, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B**, **6010B/7470A**) and number of containers provided for each (i.e. *8260B* - 3, *6010B/7470A* - 1).

6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate. If no preservative is added = leave field blank

7.) *Are there any known or possible hazards associated with these samples?*

RCRA Metals
As = Arsenic   **Hg**= Mercury
Ba = Barium   **Se**= Selenium
Cd = Cadmium   **Ag**= Silver
Cr = Chromium   **MR**= Miscellaneous RCRA metals
Pb = Lead

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

***Please provide any additional details below regarding handling and/or disposal concerns.** (i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

ATTACHMENT D

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

JH

Client: NWRA	SDG/AR/COC/Work Order: 490876
Received By: AJA	Date Received: 9/19/19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 7762 7563 2308 -1°, 7762 7563 3418-1° 7762 7563 2764 -1°, 7762 7563 3290-1°

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓			Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius
4	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: IR4-16 TEMP: 1° Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?			✓	Circle Applicable: Seals broken [✓ Damaged container] Leaking container Other (describe) 6204-1 (1bottle) cap received cracked
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?			✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials VQ Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

List of current GEL Certifications as of 08 November 2019

State	Certification
Alaska	17−018
Alaska Drinking Water	SC00012
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−28
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

GEL Laboratories LLC
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PO Box 30712 Charleston, SC 29417
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November 08, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for East Carolina Reginal Landfill
Work Order: 490877

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on September 20, 2019. This revised data report has been prepared and reviewed in accordance with GEL's standard operating procedures. This package was revised to include PFPeA and PFOA.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 490877 GEL Work Order: 490877

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
J	See case narrative for an explanation
J	Value is estimated
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the ’U’ qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

ATTACHMENT D

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forEast Carolina Reginal Landfill

Client Sample ID:	0803-1	Project:	NWRA00119
Sample ID:	490877001	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	19-SEP-19 10:35		
Receive Date:	20-SEP-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
Fluorotelomer sulfonate 4:2 (4:2 FTS)	U	ND	13.2	37.6	ng/L	0.200	1	JLS	10/02/19	0950	1921240	1
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)		237	13.2	40.0	ng/L	0.200	1					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)		230	13.2	40.0	ng/L	0.200	1					
Perfluorodecanesulfonic acid (PFDS)	U	ND	6.60	19.4	ng/L	0.200	1					
Perfluorodecanoic acid (PFDA)		90.8	7.80	20.0	ng/L	0.200	1					
Perfluorododecanoic acid (PFDoA)	U	ND	6.60	20.0	ng/L	0.200	1					
Perfluoroheptanesulfonic acid (PFHpS)	J	9.39	6.60	19.0	ng/L	0.200	1					
Perfluoroheptanoic acid (PFHpA)		689	6.60	20.0	ng/L	0.200	1					
Perfluorohexanesulfonic acid (PFHxS)		536	6.60	18.2	ng/L	0.200	1					
Perfluorononanesulfonic acid (PFNS)	U	ND	7.00	19.2	ng/L	0.200	1					
Perfluorononanoic acid (PFNA)		89.0	6.60	20.0	ng/L	0.200	1					
Perfluorooctanesulfonamide (PFOSA)	J	17.3	6.60	18.6	ng/L	0.200	1					
Perfluorooctanesulfonic acid (PFOS)		402	8.00	20.0	ng/L	0.200	1					
Perfluorooctanoic acid (PFOA)		1640	7.00	20.0	ng/L	0.200	1					
Perfluoropentanesulfonic acid (PFPeS)		54.7	6.60	18.8	ng/L	0.200	1					
Perfluoropentanoic acid (PFPeA)		1220	6.60	20.0	ng/L	0.200	1					
Perfluoroundecanoic acid (PFUdA)	U	ND	6.60	20.0	ng/L	0.200	1					
Perfluorobutanesulfonic acid (PFBS)		3850	66.0	178	ng/L	0.200	10	JLS	10/02/19	0749	1921240	2
Perfluorobutyric acid (PFBA)		650	66.0	200	ng/L	0.200	10					
Perfluorohexanoic acid (PFHxA)		3610	66.0	200	ng/L	0.200	10					
Perfluorotetradecanoic acid (PFTeDA)	U	ND	66.0	200	ng/L	0.200	10					
Perfluorotridecanoic acid (PFTrDA)	U	ND	66.0	200	ng/L	0.200	10					
Fluorotelomer sulfonate 6:2 (6:2 FTS)	U	ND	1320	3800	ng/L	0.200	100	JLS	10/02/19	1151	1921240	3
Fluorotelomer sulfonate 8:2 (8:2 FTS)	U	ND	1320	3840	ng/L	0.200	100					
Semi-Volatile-GC/MS												

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forEast Carolina Reginal Landfill

Client Sample ID:	0803-1	Project:	NWRA00119
Sample ID:	490877001	Client ID:	NWRA001

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Semi-Volatile-GC/MS												
SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"												
1,4-Dioxane		157	4.00	8.00	ug/L	0.200	4	JMB3	09/24/19	1919	1919444	4

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
EPA 537.1 Mod, PFAS, Compl	PFCs Extraction in Liquid	LM1	09/27/19	0830	1921239
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJW1	09/23/19	1200	1919441

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
2	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
3	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
4	SW846 3535A/8270E SIM	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	27.3 ug/L	40.0	68*	(70%-130%)

Notes:

Column headers are defined as follows:

DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration
Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

GEL LABORATORIES LLC
2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: November 8, 2019

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia
Contact: **Mr. Jim Riley**

Workorder: **490877**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
QC1204391614 LCS										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	18.2			15.7	ng/L		86	(60%-145%)	JLS	10/02/19 06:05
Fluorotelomer sulfonate 6:2 (6:2 FTS)	18.5			20.4	ng/L		110	(56%-143%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.7			17.5	ng/L		94	(57%-138%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	19.5			19.3	ng/L		99	(63%-131%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	19.5			21.5	ng/L		111	(62%-133%)		
Perfluorobutanesulfonic acid (PFBS)	17.2			16.6	ng/L		96	(68%-136%)		
Perfluorobutyric acid (PFBA)	19.5			19.7	ng/L		101	(70%-133%)		
Perfluorodecanesulfonic acid (PFDS)	18.8			16.8	ng/L		89	(53%-142%)		
Perfluorodecanoic acid (PFDA)	19.5			18.0	ng/L		93	(62%-135%)		
Perfluorododecanoic acid (PFDoA)	19.5			19.5	ng/L		100	(66%-131%)		
Perfluoroheptanesulfonic acid (PFHpS)	18.5			18.1	ng/L		98	(66%-138%)		
Perfluoroheptanoic acid (PFHpA)	19.5			17.9	ng/L		92	(67%-135%)		
Perfluorohexanesulfonic acid (PFHxS)	17.7			14.5	ng/L		82	(64%-137%)		
Perfluorohexanoic acid (PFHxA)	19.5			18.9	ng/L		97	(67%-133%)		

GEL LABORATORIES LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Workorder: 490877

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorononanesulfonic acid (PFNS)	18.7			17.5	ng/L		93	(66%-130%)	JLS	10/02/19 06:05
Perfluorononanoic acid (PFNA)	19.5			21.1	ng/L		108	(66%-134%)		
Perfluorooctanesulfonamide (PFOSA)	19.5			21.5	ng/L		111	(68%-137%)		
Perfluorooctanesulfonic acid (PFOS)	19.5			19.8	ng/L		102	(61%-131%)		
Perfluorooctanoic acid (PFOA)	19.5			18.8	ng/L		97	(63%-145%)		
Perfluoropentanesulfonic acid (PFPeS)	18.3			16.5	ng/L		90	(62%-139%)		
Perfluoropentanoic acid (PFPeA)	19.5			19.3	ng/L		99	(69%-132%)		
Perfluorotetradecanoic acid (PFTeDA)	19.5			22.5	ng/L		115	(65%-143%)		
Perfluorotridecanoic acid (PFTrDA)	19.5			19.9	ng/L		102	(57%-149%)		
Perfluoroundecanoic acid (PFUdA)	19.5			19.1	ng/L		98	(65%-134%)		
QC1204391615 LCSD										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	17.6			20.5	ng/L	26	116	(0%-35%)		10/02/19 06:14
Fluorotelomer sulfonate 6:2 (6:2 FTS)	17.9			17.6	ng/L	14	98	(0%-36%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.1			19.9	ng/L	13	110	(0%-39%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	18.8			20.1	ng/L	4	107	(0%-25%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	18.8			21.9	ng/L	2	116	(0%-26%)		

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QC Summary

Workorder: 490877

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorobutanesulfonic acid (PFBS)	16.7			17.2	ng/L	4	103	(0%-30%)	JLS	10/02/19 06:14
Perfluorobutyric acid (PFBA)	18.8			19.3	ng/L	2	102	(0%-30%)		
Perfluorodecanesulfonic acid (PFDS)	18.2			17.2	ng/L	3	95	(0%-28%)		
Perfluorodecanoic acid (PFDA)	18.8			21.1	ng/L	16	112	(0%-29%)		
Perfluorododecanoic acid (PFDoA)	18.8			19.0	ng/L	3	101	(0%-30%)		
Perfluoroheptanesulfonic acid (PFHpS)	17.9			17.7	ng/L	2	99	(0%-30%)		
Perfluoroheptanoic acid (PFHpA)	18.8			19.6	ng/L	9	104	(0%-30%)		
Perfluorohexanesulfonic acid (PFHxS)	17.2			16.8	ng/L	15	98	(0%-30%)		
Perfluorohexanoic acid (PFHxA)	18.8			20.9	ng/L	10	111	(0%-23%)		
Perfluorononanesulfonic acid (PFNS)	18.1			18.2	ng/L	4	101	(0%-27%)		
Perfluorononanoic acid (PFNA)	18.8			18.7	ng/L	12	99	(0%-27%)		
Perfluorooctanesulfonamide (PFOSA)	18.8			20.2	ng/L	6	107	(0%-30%)		
Perfluorooctanesulfonic acid (PFOS)	18.8			19.9	ng/L	1	106	(0%-27%)		
Perfluorooctanoic acid (PFOA)	18.8			18.9	ng/L	0	100	(0%-30%)		
Perfluoropentanesulfonic acid (PFPeS)	17.7			17.3	ng/L	4	98	(0%-29%)		

QC Summary

Workorder: **490877**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoropentanoic acid (PFPeA)	18.8			20.0	ng/L	3	106	(0%-30%)	JLS	10/02/19 06:14
Perfluorotetradecanoic acid (PFTeDA)	18.8			20.6	ng/L	9	109	(0%-30%)		
Perfluorotridecanoic acid (PFTrDA)	18.8			17.7	ng/L	11	94	(0%-35%)		
Perfluoroundecanoic acid (PFUdA)	18.8			21.2	ng/L	10	112	(0%-28%)		
QC1204391613 MB										
Fluorotelomer sulfonate 4:2 (4:2 FTS)			U	ND	ng/L					10/02/19 05:56
Fluorotelomer sulfonate 6:2 (6:2 FTS)			U	ND	ng/L					
Fluorotelomer sulfonate 8:2 (8:2 FTS)			U	ND	ng/L					
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)			U	ND	ng/L					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)			U	ND	ng/L					
Perfluorobutanesulfonic acid (PFBS)			U	ND	ng/L					
Perfluorobutyric acid (PFBA)			U	ND	ng/L					
Perfluorodecanesulfonic acid (PFDS)			U	ND	ng/L					
Perfluorodecanoic acid (PFDA)			U	ND	ng/L					
Perfluorododecanoic acid (PFDoA)			U	ND	ng/L					
Perfluoroheptanesulfonic acid (PFHpS)			U	ND	ng/L					

QC Summary

Workorder: 490877

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoroheptanoic acid (PFHpA)			U	ND	ng/L				JLS	10/02/19 05:56
Perfluorohexanesulfonic acid (PFHxS)			U	ND	ng/L					
Perfluorohexanoic acid (PFHxA)			U	ND	ng/L					
Perfluorononanesulfonic acid (PFNS)			U	ND	ng/L					
Perfluorononanoic acid (PFNA)			U	ND	ng/L					
Perfluorooctanesulfonamide (PFOSA)			U	ND	ng/L					
Perfluorooctanesulfonic acid (PFOS)			U	ND	ng/L					
Perfluorooctanoic acid (PFOA)			U	ND	ng/L					
Perfluoropentanesulfonic acid (PFPeS)			U	ND	ng/L					
Perfluoropentanoic acid (PFPeA)			U	ND	ng/L					
Perfluorotetradecanoic acid (PFTeDA)			U	ND	ng/L					
Perfluorotridecanoic acid (PFTrDA)			U	ND	ng/L					
Perfluoroundecanoic acid (PFUdA)			U	ND	ng/L					
Semi-Volatile-GC/MS										
Batch 1919444										
QC1204387349 LCS										
**1,4-Dioxane-d8	4.00			3.55	ug/L		89	(70%-130%)	JMB3	09/24/19 12:24

QC Summary

Workorder: **490877**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS										
Batch 1919444										
QC1204387350 LCSD										
**1,4-Dioxane-d8	4.00			3.18	ug/L		79	(70%-130%)	JMB3	09/24/19 12:49
QC1204387348 MB										
1,4-Dioxane			U	ND	ug/L					09/24/19 11:59
**1,4-Dioxane-d8	4.00			3.05	ug/L		76	(70%-130%)		

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported
A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound
N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted

QC Summary

Workorder: **490877**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time

X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 490877

GC/MS Semivolatile

Product: **Analysis of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry**
Analytical Method: SW846 3535A/8270E SIM
Analytical Procedure: GL-OA-E-073 REV# 2
Analytical Batch: 1919444

Preparation Method: SW846 3535A
Preparation Procedure: GL-OA-E-073 REV# 2
Preparation Batch: 1919441

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490877001	0803-1
1204387348	Method Blank (MB)
1204387349	Laboratory Control Sample (LCS)
1204387350	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Quality Control (QC) Information

Surrogate Recoveries
Sample (See Below) did not meet surrogate recovery acceptance criteria. The sample was analyzed at a dilution. As a result, one or more surrogates were diluted out of the acceptance limits.

Sample	Analyte	Value
490877001 (0803-1)	1, 4-Dioxane-d8	68* (70%-130%)

Laboratory Control Sample Duplicate (LCSD)
An LCSD was used in place of matrix QC due to limited sample volume.

Technical Information

Sample Dilutions
Sample 490877001 (0803-1) was diluted due to the presence of one or more over-range target analytes.

LCMSMS-Misc

Product: The Extraction and Analysis of Per and Polyfluroalkyl Substances Using LCMSMS
Analytical Method: EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15
Analytical Procedure: GL-OA-E-076 REV# 7
Analytical Batches: 1921240 and 1921239

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490877001	0803-1
1204391613	Method Blank (MB)
1204391614	Laboratory Control Sample (LCS)
1204391615	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Sample Dilutions

The following samples were diluted to bring the over range concentrations within the calibration range and/or due to matrix interference that caused internal standards recoveries to fall outside the acceptance range. 490877001 (0803-1).

Analyte	490877
	001
Fluorotelomer sulfonate 6:2 (6:2 FTS)	100X
Fluorotelomer sulfonate 8:2 (8:2 FTS)	100X
Perfluorobutanesulfonate (PFBS)	10X
Perfluorobutyric acid (PFBA)	10X
Perfluorohexanoic acid (PFHxA)	10X
Perfluorotetradecanoic acid (PFTeDA)	10X
Perfluorotridecanoic acid (PFTrDA)	10X

Miscellaneous Information

Additional Comments

Additional sample volume was not provided for matrix QC. Also, reduced sample volumes were used for all samples except 490876002 (7607-EB) due to elevated concentrations of target analytes.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Page: 1 of 1
Project #: 190772 NWRA0019
GEL Quote #: NWRA Quote
COC Number (1): N/A
PO Number: Bill to NWRA

490877

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Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics
Chain of Custody and Analytical Request

GEL Work Order Number:
GEL Project Manager: Julie Robinson

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: NWRA c/o Hart & Hickman, P.C. Phone # 919-847-4241
Project/Site Name: East Carolina Regional Landfill Fax #
Address: 1922 Republican Road, Aulander, NC 27805
Collected By: P. Stevens Send Results To: Gemma Olson JDksn@harthickman.com

Sample Analysis Requested (5) (Fill in the number of containers for each test)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive Please supply isotopic info	Should this sample be considered: (7) Known or possible hazards	Total number of containers	N 1,4-Dioxane by 8270 SIM										<-- Preservative Type (6) Comments Note: extra sample is required for sample specific QC
0803-1	09-19-19	1035	G	N	WL			2	X										

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 Pellett	9-19-19	1700	1 Fedex	9-19-19	1700
2			2 A. Almer	9/20/19	8:55
3			3		

TAT Requested: **Normal:** X **Rush:** ____ **Specify:** ____ **(Subject to Surcharge)**
Fax Results: [ ] Yes [X] No
Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4
Additional Remarks:
For Lab Receiving Use Only: *Custody Seal Intact?* [ ] *Yes* [ ] *No* ***Cooler Temp:*** 1 *°C*

> For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)
Sample Collection Time Zone: [ ] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ____

1.) Chain of Custody Number = Client Determined

2.) QC Codes: N = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite

3.) Field Filtered: For liquid matrices, indicate with a - **Y** - for yes the sample was field filtered or - **N** - for sample was not field filtered.

4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **ML**=Misc Liquid, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B* - 3, *6010B/7470A* - 1).

6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) Are there any known or possible hazards associated with these samples?

RCRA Metals
As = Arsenic **Hg**= Mercury
Ba = Barium **Se**= Selenium
Cd = Cadmium **Ag**= Silver
Cr = Chromium **MR**= Miscellaneous
Pb = Lead RCRA metals

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

ATTACHMENT D

ATTACHMENT D

Page: 1 of 1
Project # 190772 NWRA0019
GEL Quote #: NWRA Quote
COC Number (1): NA
PO Number: Bill to NWRA

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Chain of Custody and Analytical Request

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

GEL Work Order Number:
GEL Project Manager: Julie Robinson

Client Name: NWRA c/o Hart Hickman, P.C. Phone # 919-847-4241
Project/Site Name: East Carolina Regional Landfill Fax #
Address: 1922 Republican Road, Aulander, NC 27805
Collected By: P. Stevens Send Results To: Genna Olson golson@harthickman.com

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive *Please supply isotopic info*	(7) Known or possible hazards	Total number of containers	Sample Analysis Requested (5) (Fill in the number of containers for each test) PFAS (21-compound) modified EPA 537										Comments Note: extra sample is required for sample specific QC
									<-- Preservative Type (6): N										
0803-1	09-19-19	1035	G	N	ML			2	X										

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1		9-19-19	1700	1	Fedex	9-19-19	1700
2				2	A. Almen	9/20/19	8:55
3				3			

TAT Requested: Normal: [✓ X] Rush: ____ Specify: ______ (Subject to Surcharge)
Fax Results: [ ] Yes [✓ X] No
Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4
Additional Remarks:
For Lab Receiving Use Only: *Custody Seal Intact?* [ ] *Yes* [ ] *No* ***Cooler Temp:*** 1 *°C*

> For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)

Sample Collection Time Zone: [ ] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ____

1.) Chain of Custody Number = Client Determined

2.) QC Codes: N = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite

3.) Field Filtered: For liquid matrices, indicate with a - **Y** - for yes the sample was field filtered or - **N** - for sample was not field filtered.

4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **ML**=Misc Liquid, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B* - 3, *6010B/7470A* - 1).

6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) Are there any known or possible hazards associated with these samples?

RCRA Metals
As = Arsenic Hg= Mercury
Ba = Barium Se= Selenium
Cd = Cadmium Ag= Silver
Cr = Chromium MR= Miscellaneous RCRA metals
Pb = Lead

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

GEL Laboratories LLC

JR

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: 490877
Received By: AA	Date Received: 9/20/19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 7762 8638 8788 7762 8638 8034

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓			Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius TEMP: 1°
4	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: IR4-16 Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections? AA 9/20	~~✓~~		✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials KG Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

List of current GEL Certifications as of 08 November 2019

State	Certification
Alaska	17−018
Alaska Drinking Water	SC00012
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−28
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

GEL Laboratories LLC
a member of The GEL Group INC

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2040 Savage Road Charleston, SC 29407
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gel.com

November 08, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for Upper Piedmont Regional Landfill
Work Order: 490879

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on September 19, 2019 and September 20, 2019. This revised data report has been prepared and reviewed in accordance with GEL's standard operating procedures. This package was revised to include PFPeA and PFOA.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 490879 GEL Work Order: 490879

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
J	See case narrative for an explanation
J	Value is estimated
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the 'U' qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forUpper Piedmont Regional Landfill

Client Sample ID:	7304-1	Project:	NWRA00119
Sample ID:	490879001	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	17-SEP-19 15:25		
Receive Date:	19-SEP-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)		48.7	13.2	40.0	ng/L	0.200	1	JLS	10/04/19	1100	1921240	1
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)		106	13.2	40.0	ng/L	0.200	1					
Perfluorobutanesulfonic acid (PFBS)		1420	6.60	17.8	ng/L	0.200	1					
Perfluorodecanesulfonic acid (PFDS)	J	14.9	6.60	19.4	ng/L	0.200	1					
Perfluorodecanoic acid (PFDA)		48.0	7.80	20.0	ng/L	0.200	1					
Perfluorododecanoic acid (PFDoA)	U	ND	6.60	20.0	ng/L	0.200	1					
Perfluoroheptanesulfonic acid (PFHpS)	U	ND	6.60	19.0	ng/L	0.200	1					
Perfluoroheptanoic acid (PFHpA)		344	6.60	20.0	ng/L	0.200	1					
Perfluorohexanesulfonic acid (PFHxS)		190	6.60	18.2	ng/L	0.200	1					
Perfluorononanesulfonic acid (PFNS)	J	13.4	7.00	19.2	ng/L	0.200	1					
Perfluorononanoic acid (PFNA)		44.1	6.60	20.0	ng/L	0.200	1					
Perfluorooctanesulfonamide (PFOSA)	U	ND	6.60	18.6	ng/L	0.200	1					
Perfluorooctanesulfonic acid (PFOS)		254	8.00	20.0	ng/L	0.200	1					
Perfluorooctanoic acid (PFOA)		884	7.00	20.0	ng/L	0.200	1					
Perfluoropentanesulfonic acid (PFPeS)		28.1	6.60	18.8	ng/L	0.200	1					
Perfluoropentanoic acid (PFPeA)		621	6.60	20.0	ng/L	0.200	1					
Perfluoroundecanoic acid (PFUdA)	U	ND	6.60	20.0	ng/L	0.200	1					
Fluorotelomer sulfonate 8:2 (8:2 FTS)	U	ND	132	384	ng/L	0.200	10	JLS	10/02/19	0757	1921240	2
Perfluorobutyric acid (PFBA)		743	66.0	200	ng/L	0.200	10					
Perfluorohexanoic acid (PFHxA)		2350	66.0	200	ng/L	0.200	10					
Perfluorotetradecanoic acid (PFTeDA)	U	ND	66.0	200	ng/L	0.200	10					
Perfluorotridecanoic acid (PFTrDA)	U	ND	66.0	200	ng/L	0.200	10					
Fluorotelomer sulfonate 4:2 (4:2 FTS)	U	ND	1320	3760	ng/L	0.200	100	JLS	10/02/19	1200	1921240	3
Fluorotelomer sulfonate 6:2 (6:2 FTS)	U	ND	1320	3800	ng/L	0.200	100					

The following Prep Methods were performed:

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forUpper Piedmont Regional Landfill

Client Sample ID:	7304-1	Project:	NWRA00119
Sample ID:	490879001	Client ID:	NWRA001

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
EPA 537.1 Mod, PFAS, Compl	PFCs Extraction in Liquid	LM1	09/27/19	0830	1921239

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
2	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
3	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	

Notes:

Column headers are defined as follows:

DF: Dilution Factor	Lc/LC: Critical Level
DL: Detection Limit	PF: Prep Factor
MDA: Minimum Detectable Activity	RL: Reporting Limit
MDC: Minimum Detectable Concentration	SQL: Sample Quantitation Limit

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forUpper Piedmont Regional Landfill

Client Sample ID:	7304-1	Project:	NWRA00119
Sample ID:	490879002	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	17-SEP-19 15:25		
Receive Date:	20-SEP-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Semi-Volatile-GC/MS												
SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"												
1,4-Dioxane		177	5.00	10.0	ug/L	0.200	5	JMB3	09/24/19	1945	1919444	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJW1	09/23/19	1200	1919441

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	SW846 3535A/8270E SIM	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	24.2 ug/L	40.0	61*	(70%-130%)

Notes:

Column headers are defined as follows:

DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration
Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

GEL LABORATORIES LLC
2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: November 8, 2019

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia
Contact: **Mr. Jim Riley**

Workorder: **490879**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
QC1204391614 LCS										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	18.2			15.7	ng/L		86	(60%-145%)	JLS	10/02/19 06:05
Fluorotelomer sulfonate 6:2 (6:2 FTS)	18.5			20.4	ng/L		110	(56%-143%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.7			17.5	ng/L		94	(57%-138%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	19.5			19.3	ng/L		99	(63%-131%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	19.5			21.5	ng/L		111	(62%-133%)		
Perfluorobutanesulfonic acid (PFBS)	17.2			16.6	ng/L		96	(68%-136%)		
Perfluorobutyric acid (PFBA)	19.5			19.7	ng/L		101	(70%-133%)		
Perfluorodecanesulfonic acid (PFDS)	18.8			16.8	ng/L		89	(53%-142%)		
Perfluorodecanoic acid (PFDA)	19.5			18.0	ng/L		93	(62%-135%)		
Perfluorododecanoic acid (PFDoA)	19.5			19.5	ng/L		100	(66%-131%)		
Perfluoroheptanesulfonic acid (PFHpS)	18.5			18.1	ng/L		98	(66%-138%)		
Perfluoroheptanoic acid (PFHpA)	19.5			17.9	ng/L		92	(67%-135%)		
Perfluorohexanesulfonic acid (PFHxS)	17.7			14.5	ng/L		82	(64%-137%)		
Perfluorohexanoic acid (PFHxA)	19.5			18.9	ng/L		97	(67%-133%)		

QC Summary

Workorder: **490879**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorononanesulfonic acid (PFNS)	18.7			17.5	ng/L		93	(66%-130%)	JLS	10/02/19 06:05
Perfluorononanoic acid (PFNA)	19.5			21.1	ng/L		108	(66%-134%)		
Perfluorooctanesulfonamide (PFOSA)	19.5			21.5	ng/L		111	(68%-137%)		
Perfluorooctanesulfonic acid (PFOS)	19.5			19.8	ng/L		102	(61%-131%)		
Perfluorooctanoic acid (PFOA)	19.5			18.8	ng/L		97	(63%-145%)		
Perfluoropentanesulfonic acid (PFPeS)	18.3			16.5	ng/L		90	(62%-139%)		
Perfluoropentanoic acid (PFPeA)	19.5			19.3	ng/L		99	(69%-132%)		
Perfluorotetradecanoic acid (PFTeDA)	19.5			22.5	ng/L		115	(65%-143%)		
Perfluorotridecanoic acid (PFTrDA)	19.5			19.9	ng/L		102	(57%-149%)		
Perfluoroundecanoic acid (PFUdA)	19.5			19.1	ng/L		98	(65%-134%)		
QC1204391615 LCSD										
Fluorotelomer sulfonate 4:2 (4:2 FTS)	17.6			20.5	ng/L	26	116	(0%-35%)		10/02/19 06:14
Fluorotelomer sulfonate 6:2 (6:2 FTS)	17.9			17.6	ng/L	14	98	(0%-36%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.1			19.9	ng/L	13	110	(0%-39%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	18.8			20.1	ng/L	4	107	(0%-25%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	18.8			21.9	ng/L	2	116	(0%-26%)		

GEL LABORATORIES LLC
2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Workorder: 490879

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorobutanesulfonic acid (PFBS)	16.7			17.2	ng/L	4	103	(0%-30%)	JLS	10/02/19 06:14
Perfluorobutyric acid (PFBA)	18.8			19.3	ng/L	2	102	(0%-30%)		
Perfluorodecanesulfonic acid (PFDS)	18.2			17.2	ng/L	3	95	(0%-28%)		
Perfluorodecanoic acid (PFDA)	18.8			21.1	ng/L	16	112	(0%-29%)		
Perfluorododecanoic acid (PFDoA)	18.8			19.0	ng/L	3	101	(0%-30%)		
Perfluoroheptanesulfonic acid (PFHpS)	17.9			17.7	ng/L	2	99	(0%-30%)		
Perfluoroheptanoic acid (PFHpA)	18.8			19.6	ng/L	9	104	(0%-30%)		
Perfluorohexanesulfonic acid (PFHxS)	17.2			16.8	ng/L	15	98	(0%-30%)		
Perfluorohexanoic acid (PFHxA)	18.8			20.9	ng/L	10	111	(0%-23%)		
Perfluorononanesulfonic acid (PFNS)	18.1			18.2	ng/L	4	101	(0%-27%)		
Perfluorononanoic acid (PFNA)	18.8			18.7	ng/L	12	99	(0%-27%)		
Perfluorooctanesulfonamide (PFOSA)	18.8			20.2	ng/L	6	107	(0%-30%)		
Perfluorooctanesulfonic acid (PFOS)	18.8			19.9	ng/L	1	106	(0%-27%)		
Perfluorooctanoic acid (PFOA)	18.8			18.9	ng/L	0	100	(0%-30%)		
Perfluoropentanesulfonic acid (PFPeS)	17.7			17.3	ng/L	4	98	(0%-29%)		

QC Summary

Workorder: 490879

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoropentanoic acid (PFPeA)	18.8			20.0	ng/L	3	106	(0%-30%)	JLS	10/02/19 06:14
Perfluorotetradecanoic acid (PFTeDA)	18.8			20.6	ng/L	9	109	(0%-30%)		
Perfluorotridecanoic acid (PFTrDA)	18.8			17.7	ng/L	11	94	(0%-35%)		
Perfluoroundecanoic acid (PFUdA)	18.8			21.2	ng/L	10	112	(0%-28%)		
QC1204391613 MB										
Fluorotelomer sulfonate 4:2 (4:2 FTS)			U	ND	ng/L					10/02/19 05:56
Fluorotelomer sulfonate 6:2 (6:2 FTS)			U	ND	ng/L					
Fluorotelomer sulfonate 8:2 (8:2 FTS)			U	ND	ng/L					
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)			U	ND	ng/L					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)			U	ND	ng/L					
Perfluorobutanesulfonic acid (PFBS)			U	ND	ng/L					
Perfluorobutyric acid (PFBA)			U	ND	ng/L					
Perfluorodecanesulfonic acid (PFDS)			U	ND	ng/L					
Perfluorodecanoic acid (PFDA)			U	ND	ng/L					
Perfluorododecanoic acid (PFDoA)			U	ND	ng/L					
Perfluoroheptanesulfonic acid (PFHpS)			U	ND	ng/L					

QC Summary

Workorder: 490879

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluoroheptanoic acid (PFHpA)			U	ND	ng/L				JLS	10/02/19 05:56
Perfluorohexanesulfonic acid (PFHxS)			U	ND	ng/L					
Perfluorohexanoic acid (PFHxA)			U	ND	ng/L					
Perfluorononanesulfonic acid (PFNS)			U	ND	ng/L					
Perfluorononanoic acid (PFNA)			U	ND	ng/L					
Perfluorooctanesulfonamide (PFOSA)			U	ND	ng/L					
Perfluorooctanesulfonic acid (PFOS)			U	ND	ng/L					
Perfluorooctanoic acid (PFOA)			U	ND	ng/L					
Perfluoropentanesulfonic acid (PFPeS)			U	ND	ng/L					
Perfluoropentanoic acid (PFPeA)			U	ND	ng/L					
Perfluorotetradecanoic acid (PFTeDA)			U	ND	ng/L					
Perfluorotridecanoic acid (PFTrDA)			U	ND	ng/L					
Perfluoroundecanoic acid (PFUdA)			U	ND	ng/L					
Semi-Volatile-GC/MS										
Batch 1919444										
QC1204387349 LCS										
**1,4-Dioxane-d8	4.00			3.55	ug/L		89	(70%-130%)	JMB3	09/24/19 12:24

QC Summary

Workorder: **490879**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS										
Batch 1919444										
QC1204387350 LCSD										
**1,4-Dioxane-d8	4.00			3.18	ug/L		79	(70%-130%)	JMB3	09/24/19 12:49
QC1204387348 MB										
1,4-Dioxane			U	ND	ug/L					09/24/19 11:59
**1,4-Dioxane-d8	4.00			3.05	ug/L		76	(70%-130%)		

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported
A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound
N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted

QC Summary

Workorder: **490879**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time

X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 490879

GC/MS Semivolatile

Product: **Analysis of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry**
Analytical Method: SW846 3535A/8270E SIM
Analytical Procedure: GL-OA-E-073 REV# 2
Analytical Batch: 1919444

Preparation Method: SW846 3535A
Preparation Procedure: GL-OA-E-073 REV# 2
Preparation Batch: 1919441

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490879002	7304-1
1204387348	Method Blank (MB)
1204387349	Laboratory Control Sample (LCS)
1204387350	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Quality Control (QC) Information

Surrogate Recoveries
Sample (See Below) did not meet surrogate recovery acceptance criteria. The sample was analyzed at a dilution. As a result, one or more surrogates were diluted out of the acceptance limits.

Sample	Analyte	Value
490879002 (7304-1)	1, 4-Dioxane-d8	61* (70%-130%)

Laboratory Control Sample Duplicate (LCSD)
An LCSD was used in place of matrix QC due to limited sample volume.

Technical Information

Sample Dilutions
Sample 490879002 (7304-1) was diluted due to the presence of one or more over-range target analytes.

ATTACHMENT D

LCMSMS-Misc

Product: The Extraction and Analysis of Per and Polyfluroalkyl Substances Using LCMSMS
Analytical Method: EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15
Analytical Procedure: GL-OA-E-076 REV# 7
Analytical Batches: 1921240 and 1921239

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490879001	7304-1
1204391613	Method Blank (MB)
1204391614	Laboratory Control Sample (LCS)
1204391615	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Sample Dilutions

The following samples were diluted to bring the over range concentrations within the calibration range and/or due to matrix interference that caused internal standards recoveries to fall outside the acceptance range. 490879001 (7304-1).

Analyte	490879
	001
Fluorotelomer sulfonate 4:2 (4:2 FTS)	100X
Fluorotelomer sulfonate 6:2 (6:2 FTS)	100X
Fluorotelomer sulfonate 8:2 (8:2 FTS)	10X
Perfluorobutyric acid (PFBA)	10X
Perfluorohexanoic acid (PFHxA)	10X
Perfluorotetradecanoic acid (PFTeDA)	10X
Perfluorotridecanoic acid (PFTrDA)	10X

Miscellaneous Information

Additional Comments

Additional sample volume was not provided for matrix QC. Also, reduced sample volumes were used for all samples except 490876002 (7607-EB) due to elevated concentrations of target analytes.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Page: 1 of 1
Project # NWA-001
GEL Quote #: NWRA Quote
COC Number [1]: NA
PO Number: NA

490879

GEL Laboratories LLC
gel.com
Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

Chain of Custody and Analytical Request

GEL Work Order Number:
GEL Project Manager:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: NWRA c/o Hart & Hickman, PC
Phone # 919-847-4241
Project/Site Name: Upper Piedmont Regional Landfill
Fax # 704-586-0007
Address: Rougemont, NC
Collected By: Patrick Stevens
Send Results To: Genna Olson golson@harthickman.com

Sample Analysis Requested [5] (Fill in the number of containers for each test)

<-- Preservative Type (6)

PFAS 21 cmpd list by EPA 537 mod

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive *Please supply isotopic info.*	(7) Known or possible hazards	Total number of containers	PFAS 21 cmpd list by EPA 537 mod										Comments Note: extra sample is required for sample specific QC
7304-1	09-17-19	1525	N	N	ML			2	X										

Note that you will receive a separate cooler 9/20/19 with bottles for 1,4-dioxane analysis for this site. It is OK to include those in the same lab report as these samples.

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	Patrick H. Stevens	09-18-19	1630	1		9/19/19	0850
2				2			
3				3			

TAT Requested: Normal: X Rush: ____ Specify: ________ (Subject to Surcharge)
Fax Results: [ ] Yes [X] No
Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4
Additional Remarks:
For Lab Receiving Use Only: *Custody Seal Intact?* [ ] *Yes* [ ] *No* *Cooler Temp:* 1 °C

> *For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)*

Sample Collection Time Zone: [X] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ________

1.) Chain of Custody Number = Client Determined

2.) QC Codes: **N** = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite

3.) Field Filtered: For liquid matrices, indicate with a - **Y** - for yes the sample was field filtered or - **N** - for sample was not field filtered.

4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **ML**=Misc Liquid, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B* - **3**, *6010B/7470A* - **1**).

6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) *Are there any known or possible hazards associated with these samples?*

RCRA Metals
As = Arsenic
Ba = Barium
Cd = Cadmium
Cr = Chromium
Pb = Lead
Hg= Mercury
Se= Selenium
Ag= Silver
MR= Miscellaneous RCRA metals

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

ATTACHMENT D

Page: 1 of 1
Project #: 190772 NWRA00119
GEL Quote #: NWRA Quote
COC Number (1): N/A
PO Number: Bill to NWRA

GEL Laboratories LLC
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Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

Chain of Custody and Analytical Request

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

GEL Work Order Number:
GEL Project Manager: Julie Robinson

Client Name: NWRA c/o Hart & Hickman, P.C. Phone # 919-847-4241
Project/Site Name: Upper Piedmont Regional Landfill Fax #
Address: 9650 Oxford Road, Rougemont, NC 27572
Collected By: P. Stevens Send Results To: Gorm Olsen golsen@harthickman.com

Sample Analysis Requested (5) (Fill in the number of containers for each test)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive Please supply isotopic info.	(7) Known or possible hazards	Total number of containers	1,4-Dioxane by EPA 8270 SIM										<-- Preservative Type (6) Comments Note: extra sample is required for sample specific QC
7304-1	09-17-19	1525	G	N	ML			2	X										

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	P. Stevens	9-19-19	1700	1	Fedex	9-19-19	1700
2				2	A. Almer	9/20/19	8:55
3				3			

TAT Requested: **Normal:** [✓] **Rush:** ____ **Specify:** ________ **(Subject to Surcharge)**

Fax Results: [ ] Yes [✓ No]

Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4

Additional Remarks:

For Lab Receiving Use Only: *Custody Seal Intact?* [ ] *Yes* [ ] *No* ***Cooler Temp:*** ____ °C

> For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)

Sample Collection Time Zone: [ ] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ________

1.) Chain of Custody Number = Client Determined

2.) QC Codes: N = Normal Sample, TB = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite

3.) Field Filtered: For liquid matrices, indicate with a - **Y** - for yes the sample was field filtered or - **N** - for sample was not field filtered.

4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **ML**=Misc Liquid, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B* - **3**, *6010B/7470A* - 1).

6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) *Are there any known or possible hazards associated with these samples?*

RCRA Metals
As = Arsenic **Hg**= Mercury
Ba = Barium **Se**= Selenium
Cd = Cadmium **Ag**= Silver
Cr = Chromium **MR**= Miscellaneous RCRA metals
Pb = Lead

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

ATTACHMENT D

GEL Laboratories LLC

Jh

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: ~~490859~~ 490879
Received By: AJA	Date Received: 9/19/19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 7762 7563 2308 -1°, 7762 7563 3418-1° 7762 7563 2764 -1°, 7762 7563 3290 -1°

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes__ No__
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓			Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius TEMP: 1°
4	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: IR4-16 Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?			✓	Circle Applicable: Seals broken [✓ Damaged container] Leaking container Other (describe) 6204-1 (1bottle) cap received cracked
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, are Encores or Soil Kits present for solids? Yes__ No__ NA__(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes__ No__ NA__(If unknown, select No) Are liquid VOA vials free of headspace? Yes__ No__ NA__ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?			✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials VOF Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

GEL Laboratories LLC

JR

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: 490879
Received By: AJA	**Date Received:** 9/20/19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 7762 8638 8788 7762 8638 8034

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓			Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius TEMP: 1°
4	Daily check performed and passed on IR temperature gun?	✓			**Temperature Device Serial #:** IR4-16 Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?	~~✓~~ AJA 9/20		✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials KG Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

List of current GEL Certifications as of 08 November 2019

State	Certification
Alaska	17−018
Alaska Drinking Water	SC00012
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−28
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

Electronic Filing: Received, Clerk's Office 11/23/2022

GEL Laboratories LLC
a member of The GEL Group INC

PO Box 30712 Charleston, SC 29417
2040 Savage Road Charleston, SC 29407
P 843.556.8171
F 843.766.1178

gel.com

November 08, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for Sampson County Disposal, LLC
Work Order: 490881

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on September 19, 2019 and September 20, 2019. This revised data report has been prepared and reviewed in accordance with GEL's standard operating procedures. This package was revised to include PFPeA and PFOA.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 490881 GEL Work Order: 490881

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
J	See case narrative for an explanation
J	Value is estimated
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the ’U’ qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

ATTACHMENT D

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forSampson County Disposal, LLC

Client Sample ID:	8202-1	Project:	NWRA00119
Sample ID:	490881001	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	18-SEP-19 12:20		
Receive Date:	19-SEP-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
Fluorotelomer sulfonate 4:2 (4:2 FTS)	U	ND	13.2	37.6	ng/L	0.200	1	JLS	10/02/19	1007	1921240	1
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)		43.8	13.2	40.0	ng/L	0.200	1					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)		104	13.2	40.0	ng/L	0.200	1					
Perfluorodecanesulfonic acid (PFDS)	U	ND	6.60	19.4	ng/L	0.200	1					
Perfluorodecanoic acid (PFDA)		90.9	7.80	20.0	ng/L	0.200	1					
Perfluorododecanoic acid (PFDoA)	J	9.17	6.60	20.0	ng/L	0.200	1					
Perfluoroheptanesulfonic acid (PFHpS)	U	ND	6.60	19.0	ng/L	0.200	1					
Perfluorohexanesulfonic acid (PFHxS)		424	6.60	18.2	ng/L	0.200	1					
Perfluorononanesulfonic acid (PFNS)	U	ND	7.00	19.2	ng/L	0.200	1					
Perfluorononanoic acid (PFNA)		128	6.60	20.0	ng/L	0.200	1					
Perfluorooctanesulfonamide (PFOSA)	U	ND	6.60	18.6	ng/L	0.200	1					
Perfluorooctanesulfonic acid (PFOS)		222	8.00	20.0	ng/L	0.200	1					
Perfluorooctanoic acid (PFOA)		1790	7.00	20.0	ng/L	0.200	1					
Perfluoropentanesulfonic acid (PFPeS)		61.0	6.60	18.8	ng/L	0.200	1					
Perfluoroundecanoic acid (PFUdA)	J	10.2	6.60	20.0	ng/L	0.200	1					
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (PFPrOPrA)		10800	330	1000	ng/L	0.200	50	JLS	10/02/19	0806	1921240	2
Fluorotelomer sulfonate 8:2 (8:2 FTS)	U	ND	660	1920	ng/L	0.200	50					
Perfluorobutanesulfonic acid (PFBS)		7530	330	890	ng/L	0.200	50					
Perfluorobutyric acid (PFBA)		4770	330	1000	ng/L	0.200	50					
Perfluoroheptanoic acid (PFHpA)		5520	330	1000	ng/L	0.200	50					
Perfluorohexanoic acid (PFHxA)		6730	330	1000	ng/L	0.200	50					
Perfluorotetradecanoic acid (PFTeDA)	U	ND	330	1000	ng/L	0.200	50					
Perfluorotridecanoic acid (PFTrDA)	U	ND	330	1000	ng/L	0.200	50					
Fluorotelomer sulfonate 6:2 (6:2 FTS)	U	ND	1320	3800	ng/L	0.200	100	JLS	10/02/19	1209	1921240	3

Certificate of Analysis

Report Date: November 8, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forSampson County Disposal, LLC

Client Sample ID: 8202-1
Sample ID: 490881001

Project: NWRA00119
Client ID: NWRA001

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
LCMSMS PFCs												
EPA 537Mod PFCs by LC-MS/MS "As Received"												
Perfluoropentanoic acid (PFPeA)		86400	660	2000	ng/L	0.200	100					

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
EPA 537.1 Mod, PFAS, Compl	PFCs Extraction in Liquid	LM1	09/27/19	0830	1921239

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
2	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	
3	EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15	

Notes:

Column headers are defined as follows:
DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration
Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

Certificate of Analysis

Report Date: November 8, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forSampson County Disposal, LLC

Client Sample ID:	8202-1	Project:	NWRA00119
Sample ID:	490881002	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	18-SEP-19 12:20		
Receive Date:	20-SEP-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Semi-Volatile-GC/MS												
SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"												
1,4-Dioxane		184	5.00	10.0	ug/L	0.200	5	JMB3	09/24/19	2011	1919444	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJW1	09/23/19	1200	1919441

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	SW846 3535A/8270E SIM	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	27.7 ug/L	40.0	69*	(70%-130%)

Notes:

Column headers are defined as follows:
DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration
Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

GEL LABORATORIES LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: November 8, 2019

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia

Contact: **Mr. Jim Riley**

Workorder: **490881**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
QC1204391614 LCS										
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (PFPrOPrA)	19.5			17.1	ng/L		88	(70%-137%)	JLS	10/02/19 06:05
Fluorotelomer sulfonate 4:2 (4:2 FTS)	18.2			15.7	ng/L		86	(60%-145%)		
Fluorotelomer sulfonate 6:2 (6:2 FTS)	18.5			20.4	ng/L		110	(56%-143%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.7			17.5	ng/L		94	(57%-138%)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	19.5			19.3	ng/L		99	(63%-131%)		
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	19.5			21.5	ng/L		111	(62%-133%)		
Perfluorobutanesulfonic acid (PFBS)	17.2			16.6	ng/L		96	(68%-136%)		
Perfluorobutyric acid (PFBA)	19.5			19.7	ng/L		101	(70%-133%)		
Perfluorodecanesulfonic acid (PFDS)	18.8			16.8	ng/L		89	(53%-142%)		
Perfluorodecanoic acid (PFDA)	19.5			18.0	ng/L		93	(62%-135%)		
Perfluorododecanoic acid (PFDoA)	19.5			19.5	ng/L		100	(66%-131%)		
Perfluoroheptanesulfonic acid (PFHpS)	18.5			18.1	ng/L		98	(66%-138%)		
Perfluoroheptanoic acid (PFHpA)	19.5			17.9	ng/L		92	(67%-135%)		

QC Summary

Workorder: **490881**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorohexanesulfonic acid (PFHxS)	17.7			14.5	ng/L		82	(64%-137%)	JLS	10/02/19 06:05
Perfluorohexanoic acid (PFHxA)	19.5			18.9	ng/L		97	(67%-133%)		
Perfluorononanesulfonic acid (PFNS)	18.7			17.5	ng/L		93	(66%-130%)		
Perfluorononanoic acid (PFNA)	19.5			21.1	ng/L		108	(66%-134%)		
Perfluorooctanesulfonamide (PFOSA)	19.5			21.5	ng/L		111	(68%-137%)		
Perfluorooctanesulfonic acid (PFOS)	19.5			19.8	ng/L		102	(61%-131%)		
Perfluorooctanoic acid (PFOA)	19.5			18.8	ng/L		97	(63%-145%)		
Perfluoropentanesulfonic acid (PFPeS)	18.3			16.5	ng/L		90	(62%-139%)		
Perfluoropentanoic acid (PFPeA)	19.5			19.3	ng/L		99	(69%-132%)		
Perfluorotetradecanoic acid (PFTeDA)	19.5			22.5	ng/L		115	(65%-143%)		
Perfluoroundecanoic acid (PFUdA)	19.5			19.1	ng/L		98	(65%-134%)		
QC1204391615 LCSD										
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (PFPrOPrA)	18.8			18.1	ng/L	5	96	(0%-30%)		10/02/19 06:14
Fluorotelomer sulfonate 4:2 (4:2 FTS)	17.6			20.5	ng/L	26	116	(0%-35%)		
Fluorotelomer sulfonate 6:2 (6:2 FTS)	17.9			17.6	ng/L	14	98	(0%-36%)		
Fluorotelomer sulfonate 8:2 (8:2 FTS)	18.1			19.9	ng/L	13	110	(0%-39%)		

QC Summary

Workorder: 490881

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	18.8			20.1	ng/L	4	107	(0%-25%)	JLS	10/02/19 06:14
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	18.8			21.9	ng/L	2	116	(0%-26%)		
Perfluorobutanesulfonic acid (PFBS)	16.7			17.2	ng/L	4	103	(0%-30%)		
Perfluorobutyric acid (PFBA)	18.8			19.3	ng/L	2	102	(0%-30%)		
Perfluorodecanesulfonic acid (PFDS)	18.2			17.2	ng/L	3	95	(0%-28%)		
Perfluorodecanoic acid (PFDA)	18.8			21.1	ng/L	16	112	(0%-29%)		
Perfluorododecanoic acid (PFDoA)	18.8			19.0	ng/L	3	101	(0%-30%)		
Perfluoroheptanesulfonic acid (PFHpS)	17.9			17.7	ng/L	2	99	(0%-30%)		
Perfluoroheptanoic acid (PFHpA)	18.8			19.6	ng/L	9	104	(0%-30%)		
Perfluorohexanesulfonic acid (PFHxS)	17.2			16.8	ng/L	15	98	(0%-30%)		
Perfluorohexanoic acid (PFHxA)	18.8			20.9	ng/L	10	111	(0%-23%)		
Perfluorononanesulfonic acid (PFNS)	18.1			18.2	ng/L	4	101	(0%-27%)		
Perfluorononanoic acid (PFNA)	18.8			18.7	ng/L	12	99	(0%-27%)		
Perfluorooctanesulfonamide (PFOSA)	18.8			20.2	ng/L	6	107	(0%-30%)		
Perfluorooctanesulfonic acid (PFOS)	18.8			19.9	ng/L	1	106	(0%-27%)		

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QC Summary

Workorder: 490881

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorooctanoic acid (PFOA)	18.8			18.9	ng/L	0	100	(0%-30%)	JLS	10/02/19 06:14
Perfluoropentanesulfonic acid (PFPeS)	17.7			17.3	ng/L	4	98	(0%-29%)		
Perfluoropentanoic acid (PFPeA)	18.8			20.0	ng/L	3	106	(0%-30%)		
Perfluorotetradecanoic acid (PFTeDA)	18.8			20.6	ng/L	9	109	(0%-30%)		
Perfluoroundecanoic acid (PFUdA)	18.8			21.2	ng/L	10	112	(0%-28%)		
QC1204391613 MB										
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (PFPrOPrA)			U	ND	ng/L					10/02/19 05:56
Fluorotelomer sulfonate 4:2 (4:2 FTS)			U	ND	ng/L					
Fluorotelomer sulfonate 6:2 (6:2 FTS)			U	ND	ng/L					
Fluorotelomer sulfonate 8:2 (8:2 FTS)			U	ND	ng/L					
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)			U	ND	ng/L					
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)			U	ND	ng/L					
Perfluorobutanesulfonic acid (PFBS)			U	ND	ng/L					
Perfluorobutyric acid (PFBA)			U	ND	ng/L					
Perfluorodecanesulfonic acid (PFDS)			U	ND	ng/L					
Perfluorodecanoic acid (PFDA)			U	ND	ng/L					

QC Summary

Workorder: 490881

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Perfluorinated Compounds										
Batch 1921240										
Perfluorododecanoic acid (PFDoA)			U	ND	ng/L				JLS	10/02/19 05:56
Perfluoroheptanesulfonic acid (PFHpS)			U	ND	ng/L					
Perfluoroheptanoic acid (PFHpA)			U	ND	ng/L					
Perfluorohexanesulfonic acid (PFHxS)			U	ND	ng/L					
Perfluorohexanoic acid (PFHxA)			U	ND	ng/L					
Perfluorononanesulfonic acid (PFNS)			U	ND	ng/L					
Perfluorononanoic acid (PFNA)			U	ND	ng/L					
Perfluorooctanesulfonamide (PFOSA)			U	ND	ng/L					
Perfluorooctanesulfonic acid (PFOS)			U	ND	ng/L					
Perfluorooctanoic acid (PFOA)			U	ND	ng/L					
Perfluoropentanesulfonic acid (PFPeS)			U	ND	ng/L					
Perfluoropentanoic acid (PFPeA)			U	ND	ng/L					
Perfluorotetradecanoic acid (PFTeDA)			U	ND	ng/L					
Perfluoroundecanoic acid (PFUdA)			U	ND	ng/L					

QC Summary

Workorder: **490881**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS										
Batch 1919444										
QC1204387349 LCS										
**1,4-Dioxane-d8	4.00			3.55	ug/L		89	(70%-130%)	JMB3	09/24/19 12:24
QC1204387350 LCSD										
**1,4-Dioxane-d8	4.00			3.18	ug/L		79	(70%-130%)		09/24/19 12:49
QC1204387348 MB										
1,4-Dioxane			U	ND	ug/L					09/24/19 11:59
**1,4-Dioxane-d8	4.00			3.05	ug/L		76	(70%-130%)		

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported
A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound
N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.

QC Summary

Workorder: **490881**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time

R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted
X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 490881

GC/MS Semivolatile

Product: **Analysis of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry**
Analytical Method: SW846 3535A/8270E SIM
Analytical Procedure: GL-OA-E-073 REV# 2
Analytical Batch: 1919444

Preparation Method: SW846 3535A
Preparation Procedure: GL-OA-E-073 REV# 2
Preparation Batch: 1919441

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
490881002	8202-1
1204387348	Method Blank (MB)
1204387349	Laboratory Control Sample (LCS)
1204387350	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Quality Control (QC) Information

Surrogate Recoveries
Sample (See Below) did not meet surrogate recovery acceptance criteria. The sample was analyzed at a dilution. As a result, one or more surrogates were diluted out of the acceptance limits.

Sample	Analyte	Value
490881002 (8202-1)	1, 4-Dioxane-d8	69* (70%-130%)

Laboratory Control Sample Duplicate (LCSD)
An LCSD was used in place of matrix QC due to limited sample volume.

Technical Information

Sample Dilutions
Sample 490881002 (8202-1) was diluted due to the presence of one or more over-range target analytes.

ATTACHMENT D

LCMSMS-Misc

Product: The Extraction and Analysis of Per and Polyfluroalkyl Substances Using LCMSMS
Analytical Method: EPA 537.1 Mod, PFAS, Compliant with QSM Table B-15
Analytical Procedure: GL-OA-E-076 REV# 7
Analytical Batches: 1921240 and 1921239

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	**Client Sample Identification**
490881001	8202-1
1204391613	Method Blank (MB)
1204391614	Laboratory Control Sample (LCS)
1204391615	Laboratory Control Sample Duplicate (LCSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Sample Dilutions

The following samples were diluted to bring the over range concentrations within the calibration range and/or due to matrix interference that caused internal standards recoveries to fall outside the acceptance range. 490881001 (8202-1).

Analyte	**490881**
	001
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (PFPrOPrA)	50X
Fluorotelomer sulfonate 6:2 (6:2 FTS)	100X
Fluorotelomer sulfonate 8:2 (8:2 FTS)	50X
Perfluorobutanesulfonate (PFBS)	50X
Perfluorobutyric acid (PFBA)	50X
Perfluoroheptanoic acid (PFHpA)	50X
Perfluorohexanoic acid (PFHxA)	50X
Perfluoropentanoic acid (PFPeA)	100X
Perfluorotetradecanoic acid (PFTeDA)	50X
Perfluorotridecanoic acid (PFTrDA)	50X

Miscellaneous Information

Additional Comments

Additional sample volume was not provided for matrix QC. Also, reduced sample volumes were used for all samples except 490876002 (7607-EB) due to elevated concentrations of target analytes.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Page: 1 of 1
Project #: NWA-001
GEL Quote #: NWRA Quote
COC Number [1]: NA
PO Number: NA

490881

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Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

Chain of Custody and Analytical Request

GEL Work Order Number:
GEL Project Manager:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: NWRA c/o Hart & Hickman, PC Phone # 919-847-4241
Project/Site Name: Sampson County Disposal, LLC Fax # 704-586-0007
Address: Roseboro, NC
Collected By: Patrick Stevens Send Results To: Genna Olson golson@harthickman.com

Sample Analysis Requested [5] (Fill in the number of containers for each test)

<-- Preservative Type (6)

PFAS 21 cmpd list by EPA 537 mod

GenX by EPA 537 mod

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive Please supply isotopic info.	(7) Known or possible hazards	Total number of containers	PFAS 21 cmpd list by EPA 537 mod	GenX by EPA 537 mod	Comments
8202-1	09-18-19	1220	N	N	ML			2	X	X	Note: extra sample is required for sample specific QC

Note that you will receive a separate cooler 9/20/19 with bottles for 1,4-dioxane analysis for this site. It is OK to include those in the same lab report as these samples.

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 Patrick H.	09-18-19	1630	1	9/19/19	0850
2			2		
3			3		

TAT Requested: **Normal:** X **Rush:** ____ **Specify:** ________ **(Subject to Surcharge)**

Fax Results: [ ] Yes [X] No

Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4

Additional Remarks:

For Lab Receiving Use Only: *Custody Seal Intact?* [ ] *Yes* [ ] *No* ***Cooler Temp:*** ____ °C

> For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)

Sample Collection Time Zone: [X] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ________

1.) Chain of Custody Number = Client Determined

2.) QC Codes: **N** = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite

3.) Field Filtered: For liquid matrices, indicate with a **- Y -** for yes the sample was field filtered or **- N -** for sample was not field filtered.

4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **ML**=Misc Liquid, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).

6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) *Are there any known or possible hazards associated with these samples?*

RCRA Metals
As = Arsenic **Hg**= Mercury
Ba = Barium **Se**= Selenium
Cd = Cadmium **Ag**= Silver
Cr = Chromium **MR**= Miscellaneous RCRA metals
Pb = Lead

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

ATTACHMENT D

Page: 1 of 1
Project # 190772 NWRA 00119
GEL Quote #: NWRA Quote
COC Number (1): N/A
PO Number: Bill to NWRA

490881

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Chain of Custody and Analytical Request

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

GEL Work Order Number:
GEL Project Manager: Julie Robinson

Client Name: NWRA c/o Hart Hickman, P.C.
Phone # 919-802-2784
Project/Site Name: Sampson County Disposal, LLC
Fax #
Address: 7434 Roseboro Hwy, Roseboro, NC 28382
Collected By: P. Stevens
Send Results To: Genna Olson jolson@hathickman.com

Sample Analysis Requested (5) (Fill in the number of containers for each test)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive Please supply isotopic info	Should this sample be considered: (7) Known or possible hazards	Total number of containers	1,4-Dioxane by EPA 8270 SIM										Comments Note: extra sample is required for sample specific QC
									N										<-- Preservative Type (6)
8202-1	09-18-19	1220	G	N	ML			2	X										

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1	9-19-19	1700	1 Fedex	9-19-19	1700
2			2 A. Alman	9/20/19	8:55
3			3		

TAT Requested: **Normal:** X **Rush:** ____ **Specify:** ________ **(Subject to Surcharge)**

Fax Results: [ ] Yes [✓ No]

Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4

Additional Remarks:

For Lab Receiving Use Only: *Custody Seal Intact?* [ ] *Yes* [ ] *No* ***Cooler Temp:*** 1 *°C*

> For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)

Sample Collection Time Zone: [ ] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ________

1.) Chain of Custody Number = Client Determined

2.) QC Codes: N = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite

3.) Field Filtered: For liquid matrices, indicate with a - **Y** - for yes the sample was field filtered or - **N** - for sample was not field filtered.

4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **ML**=Misc Liquid, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B* - **3**, *6010B/7470A* - **1**).

6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) Are there any known or possible hazards associated with these samples?

RCRA Metals
As = Arsenic
Hg= Mercury
Ba = Barium
Se= Selenium
Cd = Cadmium
Ag= Silver
Cr = Chromium
MR= Miscellaneous RCRA metals
Pb = Lead

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

ATTACHMENT D

GEL | Laboratories LLC

Jh

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: ~~490859~~ 490881
Received By: AJA	Date Received: 9/19/19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 7762 7563 2308 -1°, 7762 7563 3418-1° 7762 7563 2764-1°, 7762 7563 3290-1°

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓			Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius TEMP: 1°
4	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: IR4-16 Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?			✓	Circle Applicable: Seals broken [✓ Damaged container] Leaking container Other (describe) 6204-1 (1bottle) cap received cracked
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?			✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials VG Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

GEL | Laboratories LLC

JR

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: 490881
Received By: AJA	Date Received: 9/20/19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 7762 8638 8788 7762 8638 8034

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓	▨		Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓	▨		Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius TEMP: 1°
4	Daily check performed and passed on IR temperature gun?	✓	▨		Temperature Device Serial #: IR4-16 Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?	✓	▨		Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?		▨	✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓	▨		ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓	▨		ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓	▨		Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓	▨		
13	COC form is properly signed in relinquished/received sections? AA 9/20	X	▨	✓	Circle Applicable: [✓ Not relinquished] Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials KG Date 9/23/19 Page 1 of 1

GL-CHL-SR-001 Rev 6

ATTACHMENT D

List of current GEL Certifications as of 08 November 2019

State	Certification
Alaska	17−018
Alaska Drinking Water	SC00012
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−28
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

Electronic Filing: Received, Clerk's Office 11/23/2022

GEL Laboratories LLC
a member of The GEL Group INC

PO Box 30712 Charleston, SC 29417
2040 Savage Road Charleston, SC 29407
P 843.556.8171
F 843.766.1178

gel.com

October 14, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for Great Oak Landfill
Work Order: 491597

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on October 01, 2019. This original data report has been prepared and reviewed in accordance with GEL's standard operating procedures.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 491597 GEL Work Order: 491597

The Qualifiers in this report are defined as follows:

*   A quality control analyte recovery is outside of specified acceptance criteria

**   Analyte is a Tracer compound

**   Analyte is a surrogate compound

U   Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the 'U' qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

ATTACHMENT D

Certificate of Analysis

Report Date: October 14, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forGreat Oak Landfill

Client Sample ID:	7607-EB	Project:	NWRA00119
Sample ID:	491597001	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	30-SEP-19 09:55		
Receive Date:	01-OCT-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Semi-Volatile-GC/MS												
SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"												
1,4-Dioxane	U	ND	0.100	0.400	ug/L	0.020	1	JMB3	10/08/19	1130	1924252	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJ	10/07/19	1230	1924251

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	SW846 3535A/8270E SIM	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	3.43 ug/L	4.00	86	(70%-130%)

Notes:

Column headers are defined as follows:

DF: Dilution Factor	Lc/LC: Critical Level
DL: Detection Limit	PF: Prep Factor
MDA: Minimum Detectable Activity	RL: Reporting Limit
MDC: Minimum Detectable Concentration	SQL: Sample Quantitation Limit

ATTACHMENT D

Certificate of Analysis

Report Date: October 14, 2019

Company :	NWRA - Carolinas Chapter
Address :	1550 Crystal Drive, Suite 804 Arlington, Virginia 22202
Contact:	Mr. Jim Riley
Project:	Analytical forGreat Oak Landfill

Client Sample ID:	7607-2	Project:	NWRA00119
Sample ID:	491597002	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	30-SEP-19 10:35		
Receive Date:	01-OCT-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Semi-Volatile-GC/MS												
SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"												
1,4-Dioxane		469	20.0	40.0	ug/L	0.200	20	JMB3	10/08/19	1154	1924252	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJ	10/07/19	1230	1924251

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	SW846 3535A/8270E SIM	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	47.1 ug/L	40.0	118	(70%-130%)

Notes:

Column headers are defined as follows:

DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration
Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: October 14, 2019

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia

Contact: **Mr. Jim Riley**

Workorder: **491597**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS										
Batch 1924252										
QC1204398479 LCS										
**1,4-Dioxane-d8	4.00			3.61	ug/L		90	(70%-130%)	JMB3	10/08/19 11:05
QC1204398478 MB										
1,4-Dioxane			U	ND	ug/L					10/08/19 10:40
**1,4-Dioxane-d8	4.00			4.22	ug/L		105	(70%-130%)		
QC1204398483 491597002 MS										
**1,4-Dioxane-d8	40.0	47.1		42.2	ug/L		106	(70%-130%)		10/08/19 12:19
QC1204398484 491597002 MSD										
**1,4-Dioxane-d8	40.0	47.1		35.1	ug/L		88	(70%-130%)		10/08/19 12:44

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported
A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound
N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor

QC Summary

Workorder: **491597**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time

N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted
X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

GC/MS Semivolatile
Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 491597

Product: **Analysis of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry**
Analytical Method: SW846 3535A/8270E SIM
Analytical Procedure: GL-OA-E-073 REV# 2
Analytical Batch: 1924252

Preparation Method: SW846 3535A
Preparation Procedure: GL-OA-E-073 REV# 2
Preparation Batch: 1924251

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
491597001	7607-EB
491597002	7607-2
1204398478	Method Blank (MB)
1204398479	Laboratory Control Sample (LCS)
1204398483	491597002(7607-2) Matrix Spike (MS)
1204398484	491597002(7607-2) Matrix Spike Duplicate (MSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Quality Control (QC) Information

Spike Recovery Statement

The MS and MSD (See Below) spike recoveries were not within the acceptance limits. There was a detected presence of 1,4-Dioxane above the reporting limits in the un-spike parent sample that caused a biased calculated spike recovery result in the MS and MSD. The data results have been reported.

Sample	Analyte	Value
1204398483 (7607-2MS)	1, 4-Dioxane	0* (70%-130%)
1204398484 (7607-2MSD)	1, 4-Dioxane	0* (70%-130%)

Technical Information

Sample Dilutions

Samples 1204398483 (7607-2MS), 1204398484 (7607-2MSD) and 491597002 (7607-2) were diluted due to the presence of non-target analytes. The data from the dilutions are reported. Samples 1204398483 (7607-2MS), 1204398484 (7607-2MSD) and 491597002 (7607-2) were diluted due to the presence of one or more over-range target analytes.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

ATTACHMENT D

age: 1 of 1
roject # NWA-001
EL Quote #: NWRA Quote
OC Number (1): N/A
O Number: N/A

491597

GEL Laboratories LLC
gel.com
Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

Chain of Custody and Analytical Request

GEL Work Order Number:
GEL Project Manager: Julie Robinson

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

lient Name: NWRA c/o Hart & Hickman, PC Phone # 919-847-4241
roject/Site Name: Great Oak Landfill Fax #
ddress: 3597 Old Cedar Falls Rd, Randleman NC 27317
ollected By: P. Stevens Send Results To: gokon@harthickman.com

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive Please supply isotopic info.	(7) Known or possible hazards	Total number of containers	Sample Analysis Requested (5) (Fill in the number of containers for each test)										Comments Note: extra sample is required for sample specific QC
								<-- Preservative Type (6)	N										
									1,4-Dioxane by 8270 SIM										
7607-EB	09-30-19	955	EB	N	ML			2	X										
7607-2	↓	1035	G	N	ML			2	X										

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
	9/30/19	1600	1	10/01/19	850
			2		
			3		

TAT Requested: Normal: X Rush: ____ Specify: ________ (Subject to Surcharge)

Fax Results: [ ] Yes [☒ No]

Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4

Additional Remarks:

For Lab Receiving Use Only: *Custody Seal Intact?* [ ] *Yes* [ ] *No* ***Cooler Temp:*** ____ °C

For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)

Sample Collection Time Zone: [ ] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: ____

) Chain of Custody Number = Client Determined

) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite

) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.

) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, ML=Misc Liquid, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal

) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B* - 3, *6010B/7470A* - 1).

) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

) Are there any known or possible hazards associated with these samples?

CRA Metals
s = Arsenic Hg= Mercury
a = Barium Se= Selenium
d = Cadmium Ag= Silver
r = Chromium MR= Miscellaneous
b = Lead RCRA metals

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

GEL Laboratories

491 597

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: J.R.
Received By:	Date Received: 10-1-19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 7763 8929 7266

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓	▨		Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓	▨		Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius TEMP: 1°C
4	Daily check performed and passed on IR temperature gun?	✓	▨		Temperature Device Serial #: IR1-18 Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?	✓	▨		Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?		▨	✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓	▨		ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓	▨		ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓	▨		Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?		▨	✓	
13	COC form is properly signed in relinquished/received sections?	✓	▨		Circle Applicable: Not relinquished Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials SH Date 10/2/19 Page 1 of 1

ATTACHMENT D

List of current GEL Certifications as of 14 October 2019

State	Certification
Alaska	17−018
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−28
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

GEL Laboratories LLC
a member of The GEL Group INC

PO Box 30712 Charleston, SC 29417
2040 Savage Road Charleston, SC 29407
P 843.556.8171
F 843.766.1178

gel.com

December 19, 2019

Mr. Jim Riley
NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia 22202

Re: Analytical for CMS Landfill
Work Order: 498420

Dear Mr. Riley:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on December 05, 2019. This original data report has been prepared and reviewed in accordance with GEL's standard operating procedures.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at www.gel.com.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Julie Robinson

Julie Robinson
Project Manager

Purchase Order: GELP19-0905
Enclosures

ATTACHMENT D

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

NWRA001 NWRA − Carolinas Chapter

Client SDG: 498420 GEL Work Order: 498420

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the ’U’ qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Julie Robinson.

Reviewed by Julie Robinson

ATTACHMENT D

Certificate of Analysis

Report Date: December 19, 2019

Company : NWRA - Carolinas Chapter
Address : 1550 Crystal Drive, Suite 804

Arlington, Virginia 22202
Contact: Mr. Jim Riley
Project: Analytical forCMS Landfill

Client Sample ID:	1, 1A, 2, 2A	Project:	NWRA00119
Sample ID:	498420001	Client ID:	NWRA001
Matrix:	Water		
Collect Date:	04-DEC-19 13:30		
Receive Date:	05-DEC-19		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Semi-Volatile-GC/MS												
SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"												
1,4-Dioxane		214	4.00	8.00	ug/L	0.200	4	JMB3	12/11/19	0925	1947214	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3535A	SW8270E SIM Prep 1,4-Dioxane	SJ	12/10/19	0800	1947213

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	SW846 3535A/8270E SIM	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
1,4-Dioxane-d8	SW846 8270 SIM 1,4-Dioxane in Liquid "As Received"	25.3 ug/L	40.0	63*	(70%-130%)

Notes:

Column headers are defined as follows:
DF: Dilution Factor
DL: Detection Limit
MDA: Minimum Detectable Activity
MDC: Minimum Detectable Concentration
Lc/LC: Critical Level
PF: Prep Factor
RL: Reporting Limit
SQL: Sample Quantitation Limit

GEL LABORATORIES LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: December 19, 2019

NWRA - Carolinas Chapter
1550 Crystal Drive, Suite 804
Arlington, Virginia

Contact: **Mr. Jim Riley**

Workorder: **498420**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS										
Batch 1947214										
QC1204451621 LCS										
**1,4-Dioxane-d8	4.00			3.18	ug/L		79	(70%-130%)	JMB3	12/10/19 15:57
QC1204451620 MB										
1,4-Dioxane			U	ND	ug/L					12/10/19 15:33
**1,4-Dioxane-d8	4.00			3.48	ug/L		87	(70%-130%)		
QC1204451622 498420001 MS										
**1,4-Dioxane-d8	40.0	25.3		25.0	ug/L		63*	(70%-130%)		12/11/19 09:50
QC1204451623 498420001 MSD										
**1,4-Dioxane-d8	40.0	25.3		28.0	ug/L		70	(70%-130%)		12/11/19 10:13

Notes:

The Qualifiers in this report are defined as follows:

**	Analyte is a surrogate compound
<	Result is less than value reported
>	Result is greater than value reported
A	The TIC is a suspected aldol-condensation product
B	The target analyte was detected in the associated blank.
C	Analyte has been confirmed by GC/MS analysis
D	Results are reported from a diluted aliquot of the sample
E	Concentration of the target analyte exceeds the instrument calibration range
H	Analytical holding time was exceeded
J	See case narrative for an explanation
J	Value is estimated
JNX	Non Calibrated Compound
N	Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
N	Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor

QC Summary

Workorder: **498420**

Parmname	NOM	Sample	Qual	QC	Units	RPD/D%	REC%	Range	Anlst	Date	Time

N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted
X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

ATTACHMENT D

GC/MS Semivolatile
Technical Case Narrative
NWRA - Carolinas Chapter
SDG #: 498420

Product: Analysis of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry
Analytical Method: SW846 3535A/8270E SIM
Analytical Procedure: GL-OA-E-073 REV# 2
Analytical Batch: 1947214

Preparation Method: SW846 3535A
Preparation Procedure: GL-OA-E-073 REV# 2
Preparation Batch: 1947213

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
498420001	1, 1A, 2, 2A
1204451620	Method Blank (MB)
1204451621	Laboratory Control Sample (LCS)
1204451622	498420001(1, 1A, 2, 2A) Matrix Spike (MS)
1204451623	498420001(1, 1A, 2, 2A) Matrix Spike Duplicate (MSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Quality Control (QC) Information

Surrogate Recoveries
Samples (See Below) did not meet surrogate recovery acceptance criteria. Since the parent sample and associated MS/MSD pair displayed similar recoveries, the failures were attributed to matrix interference and the data results are reported.

Sample	Analyte	Value
1204451622 (1, 1A, 2, 2AMS)	1, 4-Dioxane-d8	63* (70%-130%)
498420001 (1, 1A, 2, 2A)	1, 4-Dioxane-d8	63* (70%-130%)

Spike Recovery Statement
The MS or MSD (See Below) recovered spiked analytes outside of the established acceptance limits. As similar recoveries were displayed in the MS and MSD, the failures were attributed to sample matrix interference and the data were reported.

Sample	Analyte	Value

1204451622 (1, 1A, 2, 2AMS)	1, 4-Dioxane	0* (70%-130%)
1204451623 (1, 1A, 2, 2AMSD)	1, 4-Dioxane	30* (70%-130%)

Technical Information

Sample Dilutions

Samples 1204451622 (1, 1A, 2, 2AMS), 1204451623 (1, 1A, 2, 2AMSD) and 498420001 (1, 1A, 2, 2A) were diluted due to the presence of one or more over-range target analytes.

Miscellaneous Information

Manual Integrations

Sample (See Below) required manual integration in order to properly identify one or more peaks and/or to correctly position the baseline as set in the calibration standard injections.

Sample	Analyte	Value
498420001 (1, 1A, 2, 2A)	Tetrahydrofuran-d8	Result 400ug/L

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Page: ________ of ________
Project # NWRA00119
GEL Quote #:
COC Number (1):
PO Number:

GEL | Laboratories LLC
gel.com
Chemistry | Radiochemistry | Radiobioassay | Specialty Analytics

Chain of Custody and Analytical Request

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

GEL Work Order Number: *GEL Project Manager:* 498420

Client Name: Phone #
Project/Site Name: Fax #
Address:
Collected By: Send Results To:

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive Please supply isotopic info	(7) Known or possible hazards	Total number of containers	Sample Analysis Requested (5) (Fill in the number of containers for each test): 14Dioxane(8270)										Comments Note: extra sample is required for sample specific QC
<-- Preservative Type (6)																			
1	12-04-19	13:30						1											
1A								1											
2								1											
2A								1											

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1			1 R. Almen	12/5/19	8:50
2			2		
3			3		

TAT Requested: Normal: _____ Rush: _____ Specify: _________ (Subject to Surcharge)

Fax Results: [ ] Yes [ ] No

Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4

Additional Remarks:

For Lab Receiving Use Only: *Custody Seal Intact?* [ ] Yes [ ] No ***Cooler Temp:*** _____ °C

> For sample shipping and delivery details, see Sample Receipt & Review form (SRR.)

Sample Collection Time Zone: [ ] Eastern [ ] Pacific [ ] Central [ ] Mountain [ ] Other: __________

1.) Chain of Custody Number = Client Determined

2.) QC Codes: N = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite

3.) Field Filtered: For liquid matrices, indicate with a **- Y -** for yes the sample was field filtered or **- N -** for sample was not field filtered.

4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **ML**=Misc Liquid, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal

5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B* - **3**, *6010B/7470A* - 1).

6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

7.) Are there any known or possible hazards associated with these samples?

RCRA Metals
As = Arsenic
Hg= Mercury
Ba = Barium
Se= Selenium
Cd = Cadmium
Ag= Silver
Cr = Chromium
MR= Miscellaneous RCRA metals
Pb = Lead

Characteristic Hazards
FL = Flammable/Ignitable
CO = Corrosive
RE = Reactive

TSCA Regulated
PCB = Polychlorinated biphenyls

Listed Waste
LW= Listed Waste
(F,K,P and U-listed wastes.)
Waste code(s):

Other
OT= Other / Unknown
(i.e.: High/low pH, asbestos, beryllium, irritants, other misc. health hazards, etc.)
Description:

Please provide any additional details below regarding handling and/or disposal concerns. *(i.e.: Origin of sample(s), type of site collected from, odd matrices, etc.)*

ATTACHMENT D

GEL Laboratories LLC

JR

SAMPLE RECEIPT & REVIEW FORM 494 420

Client: NWhA	SDG/AR/COC/Work Order:
Received By: AJA	**Date Received:** 12/5/19
Carrier and Tracking Number	Circle Applicable: [✓ FedEx Express] FedEx Ground UPS Field Services Courier Other 1223 6338 6060

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		✓	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		✓	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		✓	If D or E is yes, select Hazards below. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	**Comments/Qualifiers (Required for Non-Conforming Items)**
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?			✓	Circle Applicable: Client contacted and provided COC [✓ COC created upon receipt]
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: [✓ Wet Ice] Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius TEMP: 5°
4	Daily check performed and passed on IR temperature gun?	✓			**Temperature Device Serial #:** IR4-16 Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Circle Applicable: No dates on containers No times on containers COC missing info Other (describe)
11	Number of containers received match number indicated on COC?	✓			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?	✓			Circle Applicable: Not relinquished Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials SH Date 12/6/19 Page 1 of 1

ATTACHMENT D

List of current GEL Certifications as of 19 December 2019

State	Certification
Alaska	17−018
Alaska Drinking Water	SC00012
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M−SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122020−1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	2019−165
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−19−15
Utah NELAP	SC000122019−29
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

ATTACHMENT D

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News ▸ Landfills

Leachate is the Driving Force for PFAS Sequestration in Landfills

Posted
November 2, 2020

Potential for sequestering PFAS shown through mass balance approach.

By Arie Kremen, PhD

Landfill leachate is the major pathway by which per- and polyfluoroalkyl substances (PFAS) exit the containment of modern Subtitle D municipal solid waste landfills. PFAS concentrations in leachate vary over time and can be much greater than those found in sanitary wastewaters. The leachate-borne PFAS contribution to the mass loading of publicly owned treatment works (POTW) that accept leachate can equal that contributed by sanitary and industrial wastewaters. This observation contributes to the perception that landfills are PFAS sources.

However, the wastewater treatment centered perception does not correctly reflect the overall role landfills play in the PFAS cycle. To properly determine this role, we have conducted a mass balance

ATTACHMENT E

analysis, quantitatively accounting for inputs to and outputs from landfills that convey PFAS. The goal is to determine whether landfills are PFAS sources—as generally perceived—or if they are sequestering PFAS. The high-level analysis is a nationwide mass balance using published research and studies. The results show that the bulk of the landfilled PFAS is sequestered and effectively removed from the environment. The data does have limitations and more work is needed to validate and refine the findings. However, this work serves as a starting point for establishing data-driven PFAS policies and practices. While landfills are shown to sequester PFAS, leachate is the predominant pathway for PFAS out of landfills. Reducing leachate generation is expected to lower the output while reducing operating costs.

PFAS in Landfills Becomes Mobile

PFAS are a group of about 4,000 synthetic chemicals used to make fluoropolymer coatings and products that are resilient to physical, chemical and biological degradation. Products are treated with PFAS to imbue heat, stain, grease and water repellency properties to a wide variety of consumer products, including clothing, furniture, adhesives, food packaging, non-stick cooking surfaces and personal care products. In the environment, PFAS are highly mobile and can bioaccumulate in flora and fauna.

Products at the end of their useful life are discarded in landfills, where mechanical breakdown causes PFAS to detach and become mobile. Mobilized PFAS, together with other constituents, can be carried by landfill liquids and landfill gas (LFG). Modern landfills are designed and operated to remove liquids and landfill gas to ensure stability, minimize nuisances, and avoid the creation of safety hazards and adverse environmental conditions. Liquids are generally treated to remove contaminants, while landfill gas is either flared, used for energy generation, or converted to renewable natural gas.

PFAS are generally resilient to biological and chemical processes and are typically unaffected by conventional leachate and wastewater treatment. Data shows that PFAS from leachate and sanitary wastewaters accumulate in biosolids generated in biological wastewater treatment. Some jurisdictions allow the land application of biosolids for soil conditioning purposes. Others are restricting land application in favor of other disposal alternatives, including incineration and landfilling. Among other constituents, landfilled biosolids introduce PFAS into the landfill from leachate and other sources.

The mass balance approach evaluates changes over time in the amount of a constituent within a system and can provide insight into the relative strengths of inputs and outputs. When applied to landfills, the main inputs include waste, cover material and precipitation, while the outputs are mostly landfill gas and leachate.

We applied the mass balance approach to evaluate if landfills sequester PFAS. In other words, do landfills retain more PFAS than they release to the environment? The estimate is performed on a national level for municipal solid waste landfills. Figure 1 shows a map of landfilled waste by counties in the U.S.

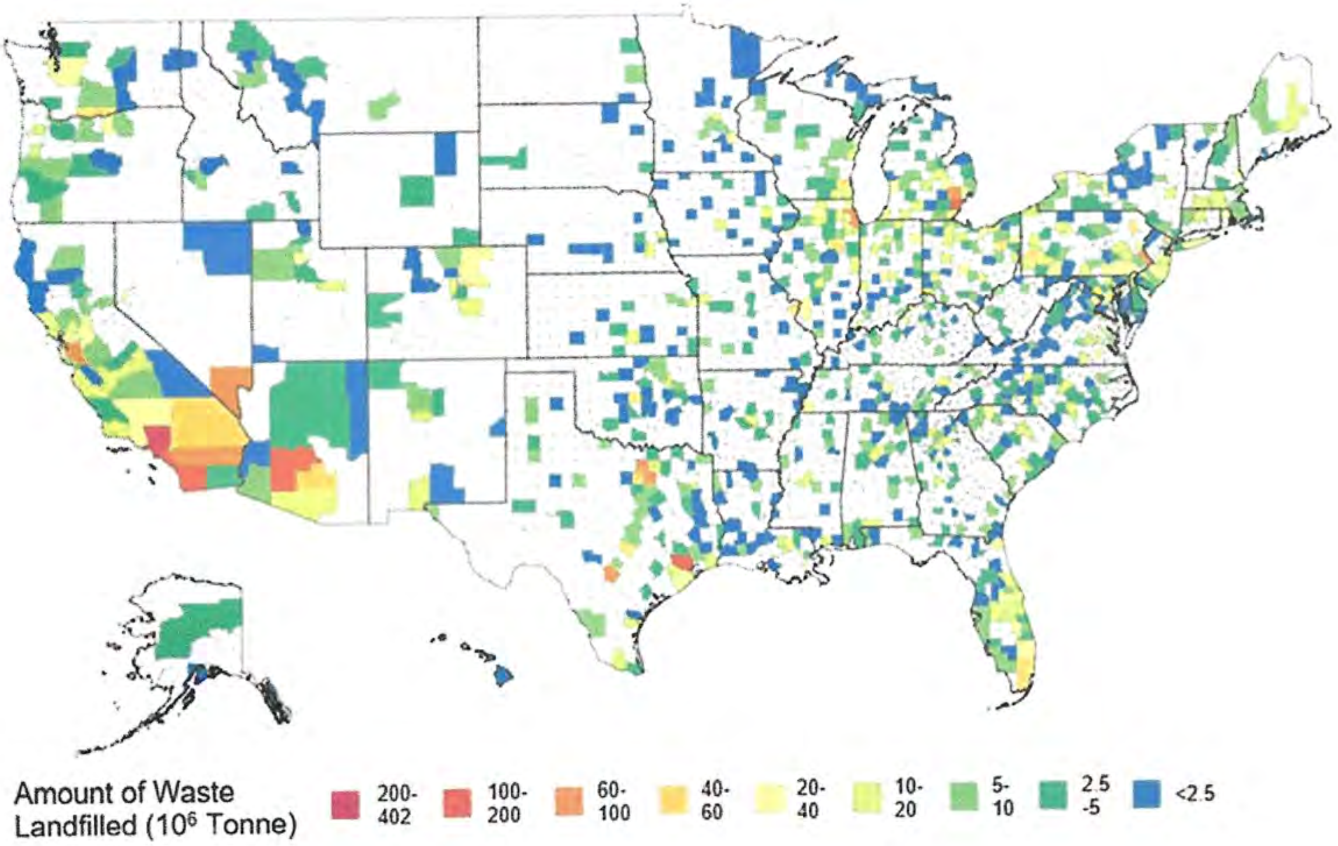


Figure 1

Map of landfilled waste by counties in the U.S. Credit: Waste Informatics: Establishing Characteristics of Contemporary U.S. Landfill Quantities and Practices, September 2016, Environmental Science & Technology, by Jon Powell, José Carlos Pons, and Marian Ruth Chertow, Yale

ATTACHMENT E

Mass balance relies on the laws of conservation, one of the most basic tools in scientific investigation. It is routinely applied to a range of static, dynamic, electric, nuclear and chemical systems. Financial budgeting is the application of the law to the world of finance. Mass conservation is generally applied to a well-defined domain (known as the control volume), and accounts for mass entering, leaving or accumulating in the control volume. Mass balance analyses may also consider the production or consumption of a constituent within the control volume in chemical or biological processes. Mass conservation can be expressed as:

$$\mathbf{M0 + (min - mout + Rnet)\Delta t = M0{+}\Delta t,}$$

where M0 and M0+Δt is the mass contained within the control volume at the start and end of the calculation period, respectively. The terms min and mout are the mass transfer fluxes into and out of the control volume during the investigated time period, and Rnet is the net rate of production and consumption within the domain. If Rnet is positive, mass is generated at a greater pace than it is being consumed. The terms can be quantified using physical, chemical or biological models or data derived from measurements. Figure 2 shows a generalized schematic of the mass balance approach.

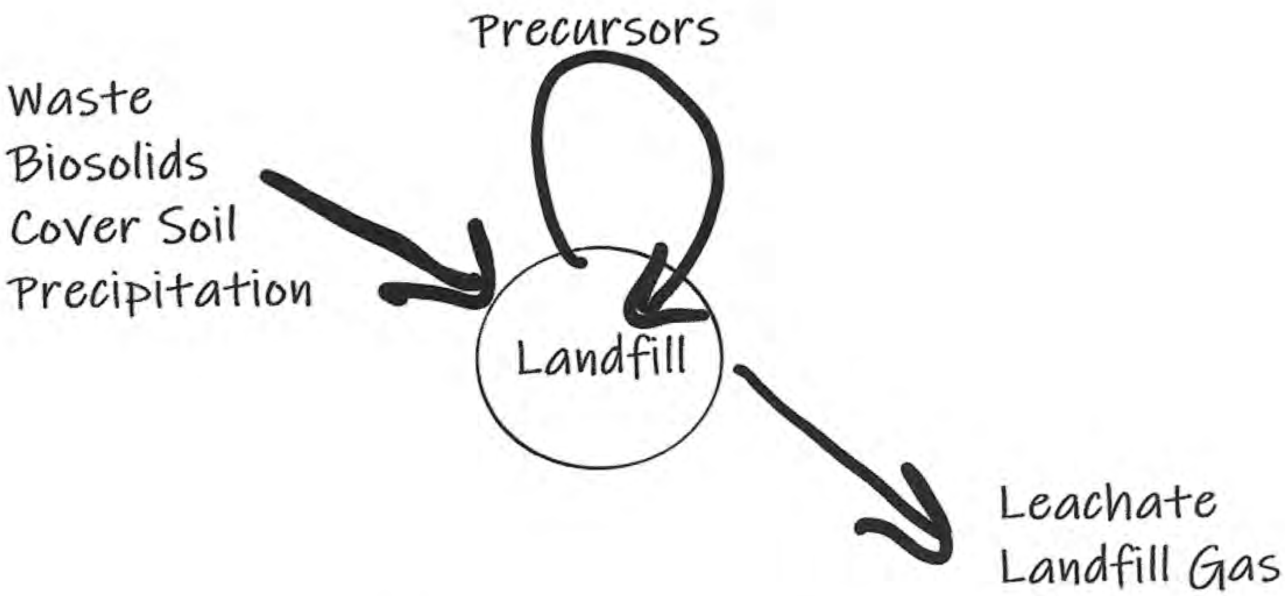


Figure 2: Schematic of mass balance approach.
Image courtesy of Tetra Tech, Inc.

Inputs to and Outputs from a Typical Landfill

Municipal Solid Waste

PFAS content of municipal solid waste (MSW) varies widely. There is no standard methodology for obtaining representative MSW samples and establishing their PFAS content. Values for individual fractions range from 0 to more than 1,000 nanogram PFAS per gram of sample (ng/g). A value of 10 ng/g is considered a representative figure characterizing the overall MSW PFAS content. According to the EPA, about 52.1 percent (2017) of municipal solid waste is landfilled, representing about 137.7 million tons per year. Based on these figures, the annual PFAS disposal rate is calculated to be 2,755 pounds (lbs) per year (1,250 kilograms (kg)/year).

Biosolids

EPA estimated that biosolid production from wastewater treatment is 7.18 million tons per year (6.51 million kg/year). About 60 percent is land-applied, with 20 percent each being landfilled and incinerated. Landfilling biosolids contributes between 1,030 and 1,295 lbs of PFAS per year (470 to 590 kg/year) (Venkatesan and Halden, 2013).

ATTACHMENT E

Cover Soils

Many facilities use offsite materials for daily and intermediate soil cover. Soils used may contain contaminants that make the soils unsuitable for off-landfill applications. Little information is documented on PFAS content in such soils. However, Sepulvado et al. (2011) have evaluated the PFAS content, specifically PFOA and PFOS, in agricultural soils to which biosolids were land-applied. Data from this research is used for a conservative estimate of PFAS input with cover soils. PFAS leached from cover soils is assumed to be accounted for in leachate (see below).

Cover soil use is estimated to be 20 percent of the landfilled waste mass, of which land-applied agricultural soils are assumed to be 1 percent. Based on Sepulvado et al., biosolid land-application can result in PFOS and PFOA concentrations of 200 ng/g and 25 ng/g in agricultural soils, respectively. This results in a total of 225 ng PFAS per gram of soil. From these data, the PFAS input with cover soils is calculated to be 123.9 lbs. per year (56.2 kg/year). Work done by McLachlan et al. (2019) on soil/water partitioning of PFAS found that the majority of leaching occurred within 49 to 120 days, with a partitioning coefficient of approximately 0.5. In other words, PFAS are split 50/50 between soil and water, which means cover soils add about 62.0 lbs. per year to the PFAS mass balance.

Precursors

In addition to the inputs discussed previously, landfilled waste contains precursor compounds that are converted to perfluoroalkyl acids (PFAA). These are considered PFAS. Unfortunately, a lack of analytical standards limits the quantification of PFAA. In the proprietary total oxidizable precursor assay (TOPA), chemical oxidation is applied to a sample converting precursor compounds to terminal PFAA. When applied to landfill leachate, results indicate that precursor compounds can amount to approximately 50 percent.

Precipitation

In the past, rainwater was not considered to be a PFAS transport route. However, research conducted at the National Atmospheric Deposition Program at the University of Wisconsin-Madison detected PFAS in all 37 samples collected. Most samples contain less than 1 ng PFAS per liter (ng/l). The highest concentration was nearly 5.5 ng/l, with a mode concentration of less than 1 ng/l. A separate study by the North Carolina Department of Environmental Quality, Division of Air Quality, found 500 ng/l in samples near a PFAS-producing facility.

ATTACHMENT E

Precipitation is the dominant source for leachate generation. For estimation purposes, the annual rainwater infiltration rate equals the leachate generation rate. Lang el al. (2019) provide an estimate of 16,180 million gallons of leachate per year. Conservatively, the rainwater PFAS concentration is assumed to be 10 ng/l. The PFAS input from rainwater is calculated to be 1.35 lbs. per year (0.61 kg/year).

Outputs

Leachate

Lang et al. (2017) developed an estimate for the PFAS mass in leachate, across three climatic regions of the U.S. The model estimates the annual leachate volume and extrapolates PFAS mass from a limited number of samples using a Monte-Carlo analysis. Results indicate that the 90th percentile range for PFAS carried by leachate ranges from 1,240 to 1405 lbs per year (563 to 638 kg/year). The leachate generation rate is estimated to be 16,140 million gallons per year (61.1 million m3/year).

Landfill Gas

Monitoring data indicates that PFAS are dry-deposited in areas downwind of landfills, indicating that fugitive and point-source emissions could be sources. Flaring of landfill gas (LFG) is believed to incompletely destroy PFAS. Tian (2018) directly measured PFAS content in landfill gas and found that concentrations ranged from 650 to 850 pg/m3 of LFG. This mass balance analysis uses a value of 1,000 pg/m3 for a conservative estimate.

Applying the EPA LandGEM model to estimate LFG generation from landfilled MSW with a methane generation rate of k=0.05 1/year and a specific methane generation capacity of L0=100 m3/Mg, the LFG generation in 2020 is estimated to be 771,900 million scfm per year (21,858 m3/year). Based on these estimates, the PFAS content of the annual LFG generation is calculated to be 0.05 lbs. per year (0.02 kg/year). In comparison to the other sources, this amount is negligible. For purposes of this analysis, PFAS contained in fugitive emissions or in flared landfill gas are not considered.

Summing it Up: Most Landfilled PFAS is Sequestered

Table 1 summarizes the PFAS mass loadings of the inputs and outputs considered. Annual PFAS inputs are

ATTACHMENT E

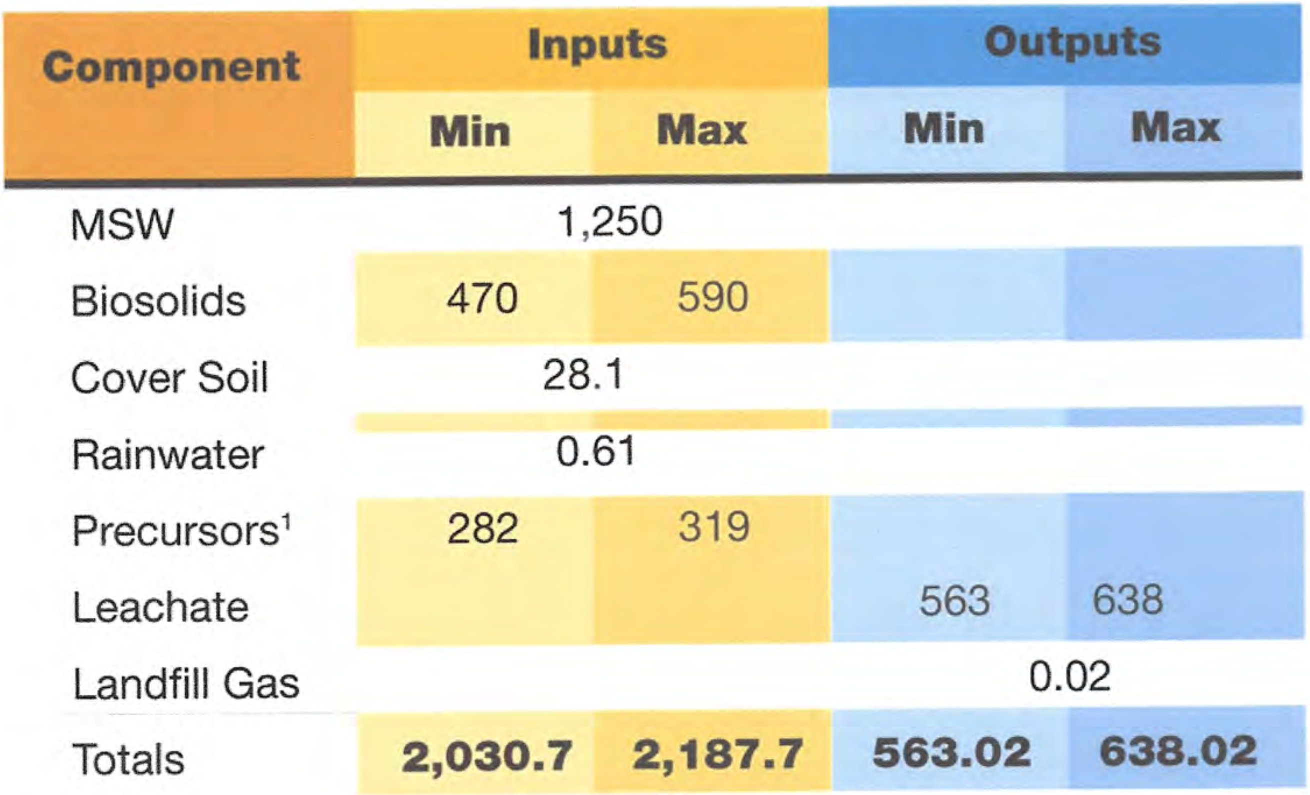
approximately 2.2 tons, of which MSW contributes about 60 percent. Biosolids and precursors represent 25 percent and 15 percent, respectively. Agricultural cover soils contribute approximately 1 percent. Nationally, the contribution from rainwater is negligible. This is also true for landfills situated in areas with high concentrations in rainwater.

These results show that the majority of the PFAS output is associated with leachate—the amount in landfill gas is negligible. The results also show that less than one third (27.7 percent to 29.2 percent) of PFAS landfilled is collected with leachate. In other words, the bulk of the landfilled PFAS is sequestered and effectively removed from the environment. This amounts to about 3,234 lbs. to 3,415 lbs. per year (1,467 kg to 1,549 kg/year).

More Work Needed to Build on High Level Mass Balance Data

It should be no surprise that landfills retain more PFAS than they are releasing. Modern landfills are designed, constructed, and operated to eliminate uncontrolled discharges and reduce leachate generation. It is also not surprising that leachate is the major pathway for PFAS leaving the landfill environment as they are substantially non-volatile, which means only very low quantities are present in LFG. Landfilled biosolids account for between 83 percent and 93 percent of the PFAS discharged with leachate, indicating that PFAS mass exchange between wastewater treatment and landfill is nearly balanced (see Figure 3).

Figure 3: Leachate truck. Photo courtesy of Getty Images.



Component	**Inputs**		**Outputs**	
	Min	**Max**	**Min**	**Max**
MSW	1,250			
Biosolids	470	590		
Cover Soil	28.1			
Rainwater	0.61			
Precursors[1]	282	319		
Leachate			563	638
Landfill Gas			0.02	
Totals	**2,030.7**	**2,187.7**	**563.02**	**638.02**

Table 1: PFAS Mass Balance Summary Table (kg/year).
Table courtesy of Tetra Tech, Inc.

While this approach can identify overall trends and provide estimates for the average PFAS mass cycle, it does not account for regional variation, nor does is provide site-specific guidance. Two major factors affect the accuracy/usefulness of the evaluation:

- The mass balance is a meta-analysis built upon research conducted by other multi-disciplinary groups. It uses data covering approximately two decades, from the early 2000s to 2019, and there have been delays in data gathering, analysis and publication. Year-over-year changes are likely to be small and their effect on the overall outcome are not expected to change the outcome significantly. Of note is the EPA PFOA Stewardship Program, under which eight major companies agreed to a 95 percent reduction in the manufacture and use of PFOA and its precursors. While the program took effect during the period considered in this research, its effects are offset by the time until such products are landfilled and the import of products from regions that have not joined the program.

- The variety of analytical methods, definitions and decisions by scientists in the PFAS research relied upon in this analysis increases the uncertainty of the data presented. For example, Lang et al. considered 19 substances while Venkatesan and Halden accounted for 13. However, these datasets and others agree that perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) account for the majority of the considered PFAS.

The mass balance also relies upon landfilling practice assumptions to estimate certain components. These assumptions are appropriate for this type of high-level analysis, and efforts were made to err on the side of caution.

With these limitations in mind, the mass balance indicates a few areas that will have an impact on future PFAS cycle policies and practices. We may expect that landfilling rates for biosolids will increase, as a reaction of jurisdictions to limit land-application. This is likely to reduce the introduction of PFAS to groundwater sources but increase PFAS disposal at landfills. On a local level, PFAS discharged with leachate to a POTW has been shown to exceed the headworks mass loading from sanitary wastewater in some cases. As effluent from POTW is discharged to streams it can enter the potable water supply. Leachate treatment for PFAS is challenging, due to the nature of leachate and PFAS. Until technological solutions are developed and economically feasible, a larger amount of PFAS can be sequestered by landfilling biosolids. | WA

***Arie Kremen**, PhD, is a civil and environmental engineer at Tetra Tech, Inc. (Pasadena, CA) with more than 25 years of experience in solid waste engineering and water resources, with a professional specialization on leachate management and disposal. His academic background is in beneficial reuse of reclaimed wastewater, including biological nutrient recovery. He has worked abroad and in the U.S. on wastewater and leachate treatment; landfill design and construction; and landfill remediation/closure projects. Dr. Kremen is the vice-Chair of the SWANA technical committee on landfill liquids, where he is leading the organization's effort into building a PFAS wiki for the solid waste industry. He can be reached at Arie.Kremen@tetratech.com.*

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- Venkatesan AK and Halden RU, 2013, National inventory of perfluoroalkyl substances in archived US biosolids from the 2001 EPA National Sewage Sludge Survey, Journal of Hazardous Materials, May 15, 2013, Volumes 252-253, pp 413.

Note

1. Estimated as 50 percent of the leachate PFAS mass loading.

Related News

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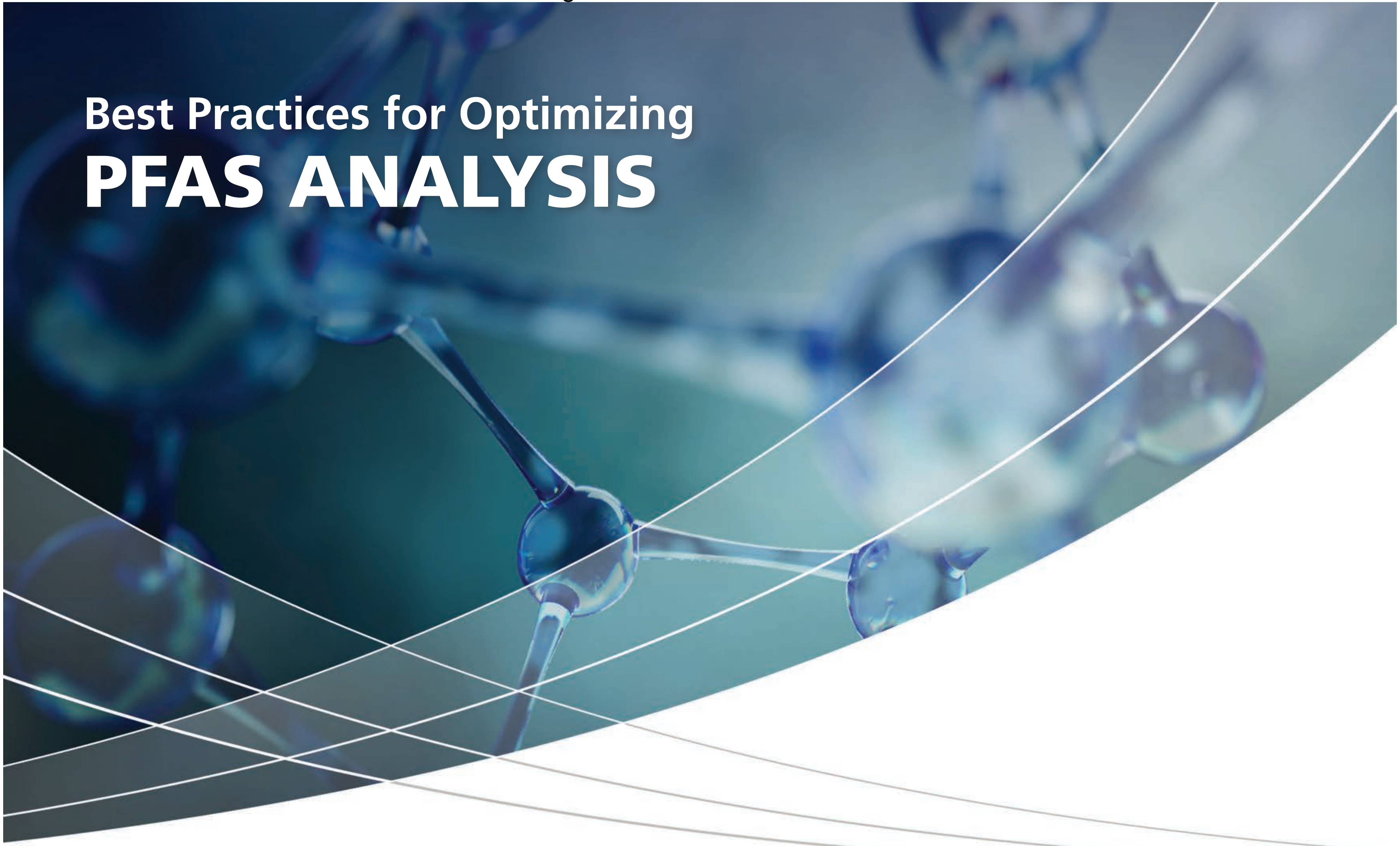

Best Practices for Optimizing
PFAS ANALYSIS

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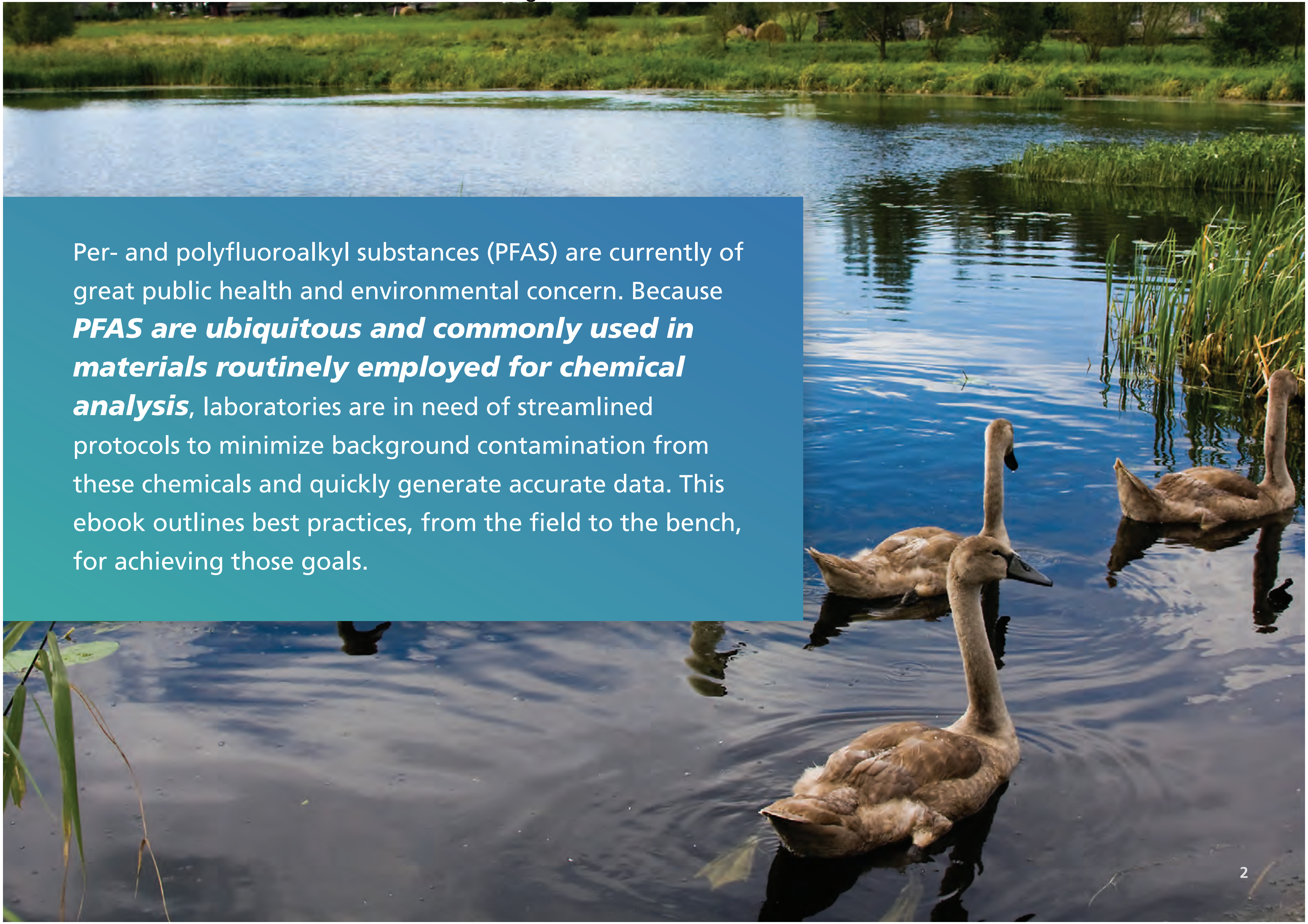

Per- and polyfluoroalkyl substances (PFAS) are currently of great public health and environmental concern. Because ***PFAS are ubiquitous and commonly used in materials routinely employed for chemical analysis***, laboratories are in need of streamlined protocols to minimize background contamination from these chemicals and quickly generate accurate data. This ebook outlines best practices, from the field to the bench, for achieving those goals.

ATTACHMENT F

Collecting Samples

Personal Gear

Sampling for PFAS without contaminating the samples can be challenging due to the prevalence of these chemicals in many consumer products and standard sampling equipment. To avoid the possibility of cross-contamination, lab and field personnel should select field clothing and personal protective equipment (PPE) carefully when collecting or preparing samples for PFAS analysis.

Items to AVOID During Sampling	Items **RECOMMENDED** During Sampling
Water-resistant, waterproof or stain-treated clothing, boots and/or rain gear made from materials containing PFAS.	Rain gear made from polyurethane or wax-coated materials. Boots made with polyurethane and polyvinylchloride (PVC).
Clothing with fabric softener or suspected of containing PFAS. Some items labeled as "PFOA-free" contain replacement PFAS.	Cotton clothing is recommended and should be well washed before use due to possible contamination from PFAS-related treatments.
Sunscreens, moisturizers, hand cream or other related products.	Avoid using any personal care products.

During collection, well-washed cotton clothing and outer gear made from polyurethane or wax-coated materials is recommended.

Field Equipment and Sampling Bottles

Potential sources for PFAS cross-contamination include many items commonly found in the sampling equipment, such as items directly involved in the sample collection (e.g., automatic samplers, dippers and tubing) and other accessories. To ensure an accurate assessment of PFAS, sampling personnel should take precautions when collecting samples.

Due to potential adsorption of analytes onto glass, lab and field personnel should use polypropylene containers for all standard, sample and extraction preparations. Polypropylene bottles fitted with polypropylene screw caps allow for PFAS sampling without the risk of cross-contamination. Sample bottles must be discarded after use to prevent contamination from previous sampling procedures.

Items to **AVOID** During Sampling	Items **RECOMMENDED** During Sampling
Any items with a non-stick coating containing PFAS, including containers, tubing or any other waterproofed items (e.g., notebooks).	High-density polyethylene (HDPE) or polypropylene containers with HDPE or polypropylene caps.
Plastic materials potentially containing PFAS.	HDPE or silicone tubing materials.

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Background Contamination

In order to check for residual PFAS on sampling equipment and overall contribution from different sources during the sampling event, equipment and field blanks should be collected prior to and during sampling. When collecting samples, personnel should use new nitrile gloves and replace them frequently to avoid cross-contamination.

Standard precautions for sample collection (e.g., bottle cap should not be placed on any other surface, avoid contact with inside of cap or bottle) should be strictly followed. After the sample is collected and capped, the sample bottle(s) should be placed in a resealable plastic bag separate from all other sample bottles.

Avoid reusing sampling equipment as previous uses may have involved PFAS-containing materials. Maintain separate supplies for PFAS sampling and for other contaminants. Before using new equipment, test for the presence of PFAS.

When reuse of materials and sampling equipment is necessary, lab and field personnel should follow standard decontamination procedures (as described later in this ebook) and confirm the absence of PFAS before reusing the equipment. It is also recommended to avoid the use of any materials listed on pages 3 and 4.

Lab Equipment Cleaning & Decontamination

PFAS can be present in the water and/or cleaning agents used in decontamination processes. When cleaning sampling equipment, lab personnel should avoid using decontamination soaps containing fluorosurfactants such as Decon 90. Water from an on-site well is also a potential source of contamination.

Alconox® and/or Liquinox® are recommended for decontamination processes as well as potable water from a municipal drinking water supply. Sampling equipment should be scrubbed using a polyethylene or PVC brush and flushed with water before the next use. Water should be always verified as “PFAS-free” before it is used for field and decontamination blanks and decontamination processes.

Food & Beverages

Standard safety protocols do not allow the presence of food and drinks in laboratories and areas where sampling is occurring. During the PFAS analysis, this safety protocol is even more relevant as food packaging, wrappers and containers may contain PFAS and can cause cross-contamination. Drinks and food should be kept nearby (e.g., staging area for sampling) to ensure personnel’s safety.

ATTACHMENT F

Preparing Samples

LABORATORY MATERIALS

Preparation and Storage of Stock Solutions and Standards

Stock solutions should be prepared and stored in PFAS-free high-density polyethylene (HDPE) or polypropylene (PP) containers with lined or unlined HDPE or polypropylene caps. Do not store samples in containers made of glass or low-density polyethylene (LDPE) materials. PFAS can adsorb to glass, especially when the chemicals are stored in a glass container for long periods of time.

Stability of the standards solutions for a predetermined interval of time when stored under recommended conditions is a relevant parameter for ensuring the quality of the analysis. As shown in Figure 1 (see next page), 50% methanol in water (same mixture as that used in ASTM D7979) is the optimal solution for dissolving PFAS and maintaining them in solution.

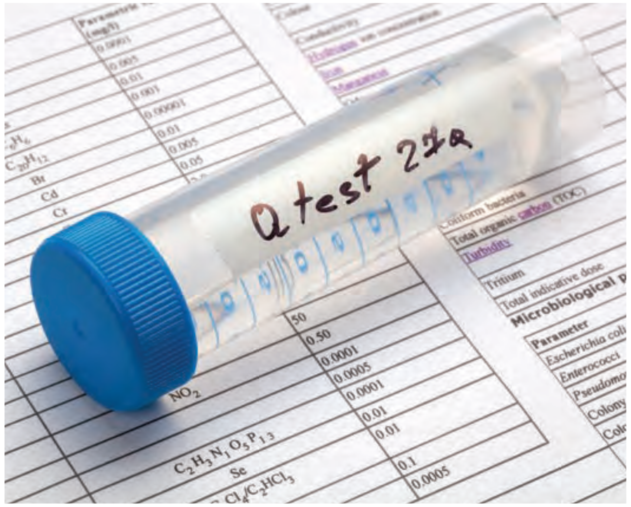
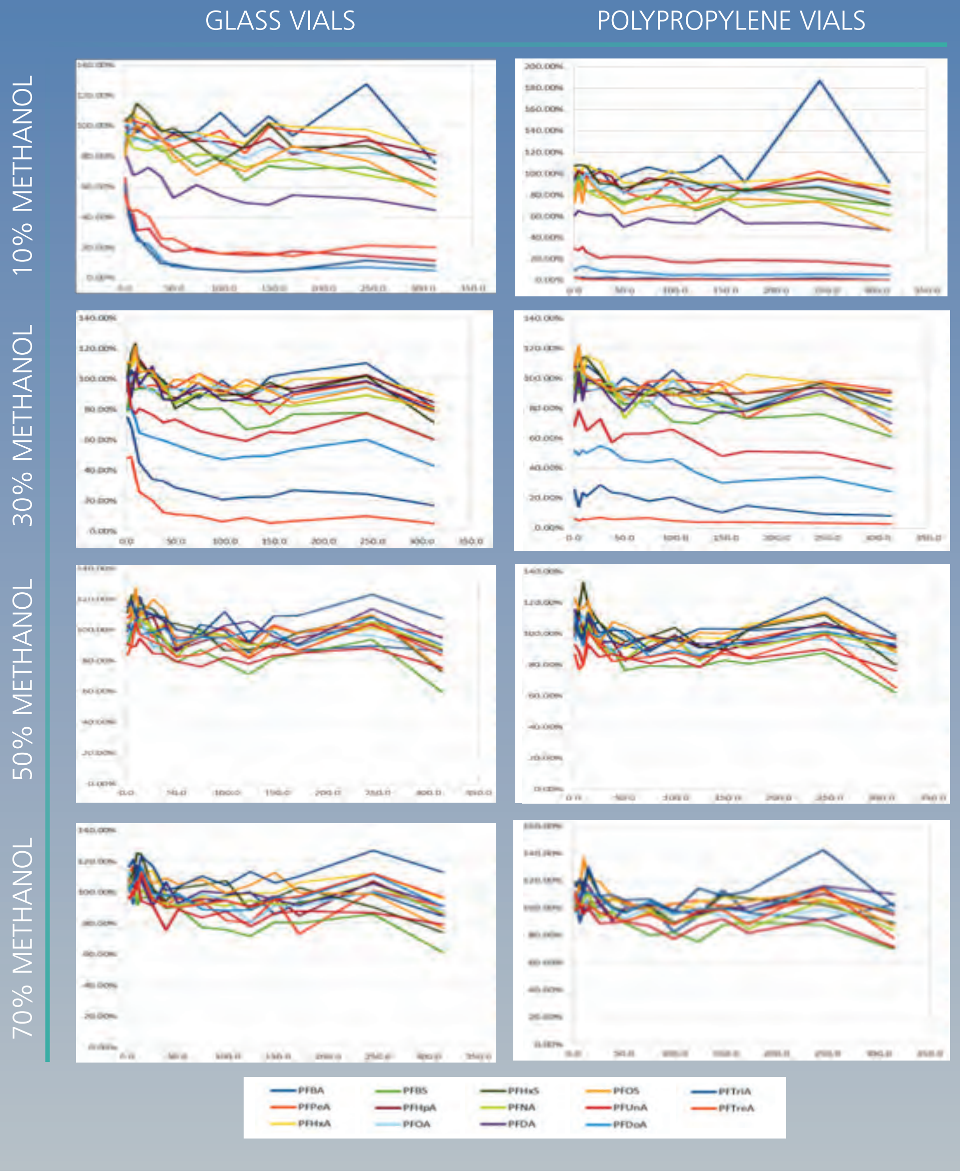


Figure 1: Potential adsorption of PFAS on the vial surface

*Plots of PFAS recovery against shelf life (time/hour)
for the various solvents in glass and polypropylene LC vials.*



Mixtures with lower concentrations of methanol (10% and 30%) show larger losses of PFAS due to the insolubility of PFAS in the solvent used. The recovery results for 90% methanol are similar to that of 70% methanol. However, the ***higher methanol content evaporates faster and causes changes in the sample volume***.

The PFAS concentration in the vial may change after the vial cap is pierced as the organic solvent (e.g., methanol:water solution) and/or PFAS compound can be lost through the puncture. If calibration standards are to be used multiple times, it is recommended to use an amber glass vial with sealed replaceable caps. Sealing the vials immediately after injection may reduce the loss of PFAS.

The use of LC propylene vials is commonly recommended for the analysis of PFAS. Shimadzu scientists compared LC propylene vials to amber glass vials (used in the majority of general applications and more easily resealed) to determine the potential adsorption of PFAS on the vial surface. Similar recovery and quantitation were observed for both types of materials, as shown in Figure 1.

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Sample Preparation and Injection

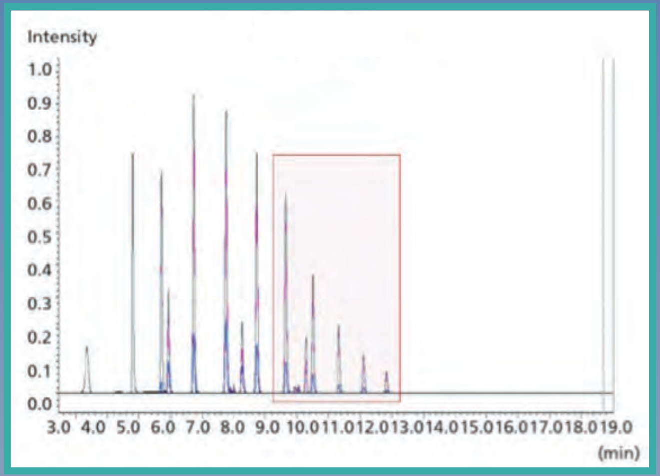
Some currently published methods (EPA 537, EPA 537.1) require a step of sample pre-concentration by solid phase extraction (SPE). Materials used in the manufacturing of supplies for preparing the samples by SPE may also contain PFAS. To avoid pre-concentrating the background PFAS during this step of the analysis, all new SPE cartridges, solvents and vials for collecting samples must be tested for PFAS prior to the first use.

PFAS-free tubing should be used for loading samples into the cartridges. If automatic sample extractors are employed for this step of the analysis, checking with the manufacturer is strongly recommended to identify all components made of PFTE and replace them when feasible.

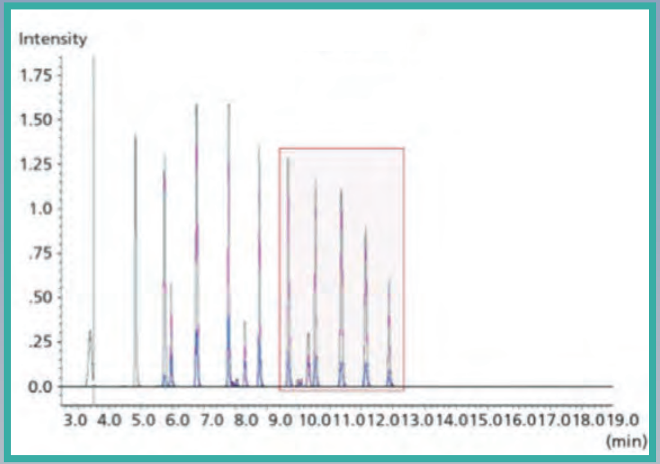
Once samples are pre-concentrated and ready for injection in the LC-MS/MS or samples are prepared accordingly to methods that allow for large volume injection (ASTM D7979), they may sit in the autosampler tray for extended periods of time. In these situations, some PFAS compounds may settle, precipitate or adsorb on the surface. It is important to remember to mix the extract/sample before (re)injection. Vortexing the solution before injection ensures a homogenous solution and optimum results. Figure 2 shows the chromatogram of the PFAS compounds before and after vortexing a 50 ng/L standard allowed to sit for 24 hours. The recovery of the long-chain PFAS is considerably lower before vortex.

Figure 2: PFAS compounds before and after vortexing a 50 ng/L standard allowed to sit for 24 hours

BEFORE VORTEX



AFTER VORTEX



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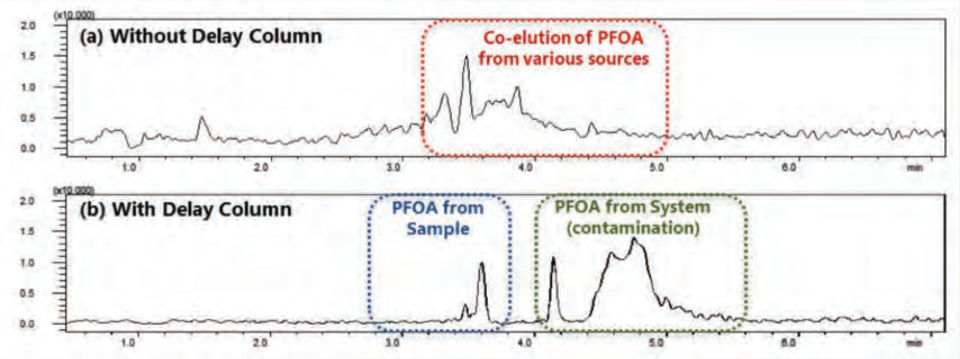
Instrumentation

It is recommended to use a solvent delay column (installed after the mixer and before the autosampler) to delay the elution of PFAS originating from solvent bottles and other parts of the liquid chromatography system (e.g., pumps and tubing). As shown in Figure 3 below, using the delay column enables the detection of PFOA originating solely from the sample.

Additionally, bypassing the degasser when possible is recommended as well as replacing any PTFE-containing tubing and parts in the LC.

Figure 3: Chromatogram of PFOA:
(a) without delay column and (b) with delay column



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Shimadzu's team of service engineers can help you set up the exact LC configuration (including solvent lines, tubing, bypassing of solvent lines and more) that is proven to deliver contamination-free results. For more information, please contact a Shimadzu expert at ***800-477-1227*** or visit ***www.OneLabOneEarth.com***.

In collaboration with EPA and ASTM International, Shimadzu is working to advance research and technical knowledge related to PFAS exposure and contamination. Using Shimadzu LC-MS/MS instruments, they have vetted standardized methods for analyzing PFAS compounds in a diverse type of samples. Designed with proprietary ultrafast technologies and patented ion focusing technology, Shimadzu's LC-MS/MS systems deliver fast, high-quality results for PFAS analysis.

To learn more about Shimadzu's solutions for PFAS analysis, visit
www.OneLabOneEarth.com

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An Equipment Manufacturer's Perspective on Regulatory Guidance and Ambiguity on PFAS in Groundwater Sampling

Sandy Britt, PG, CHG

QED Environmental Systems Inc.

sbritt@qedenv.com

ATTACHMENT G

Why do we use Teflon®?

- Groundwater sampling equipment, including pumps, bailers, tubing and other components, have historically been manufactured using Teflon* and other fluoropolymers due to its many advantageous properties:
  - Chemically inert
  - Non-reactive
  - Highly resistant to sorption and leaching of common groundwater contaminants
  - No leachable matrix components (well, okay, PFAS, but no VOCs, SVOCs, etc.)
  - Very low gas permeability
  - Very high temperature resistance
  - Very high working pressures (tubing, bladders, seals)
  - Extremely good flex properties for moving parts (e.g., bladders, seals)

**Teflon® is a registered trademark of the Chemours company (formerly DuPont) and refers to a range of fluoropolymers, the best known of which is polytetrafluoroethylene (PTFE)*

ATTACHMENT G

What about PFAS?
Addressing the materials issues

- There is concern that sampling for PFAS using sampling equipment manufactured from fluoropolymers (e.g., Teflon, PTFE, ETFE, FEP) could result in sample contamination
- Recommendations or requirements in regulatory guidance documents, SOPs and “fact sheets” from industry organizations to avoid the use of all fluoropolymers have been based on an abundance of caution, and research continues to determine which materials can be safely used
- Manufacturers of sampling equipment and components such as plastic tubing are challenged with finding alternate materials that can meet performance requirements while meeting needs for both PFAS sampling and other organic compounds

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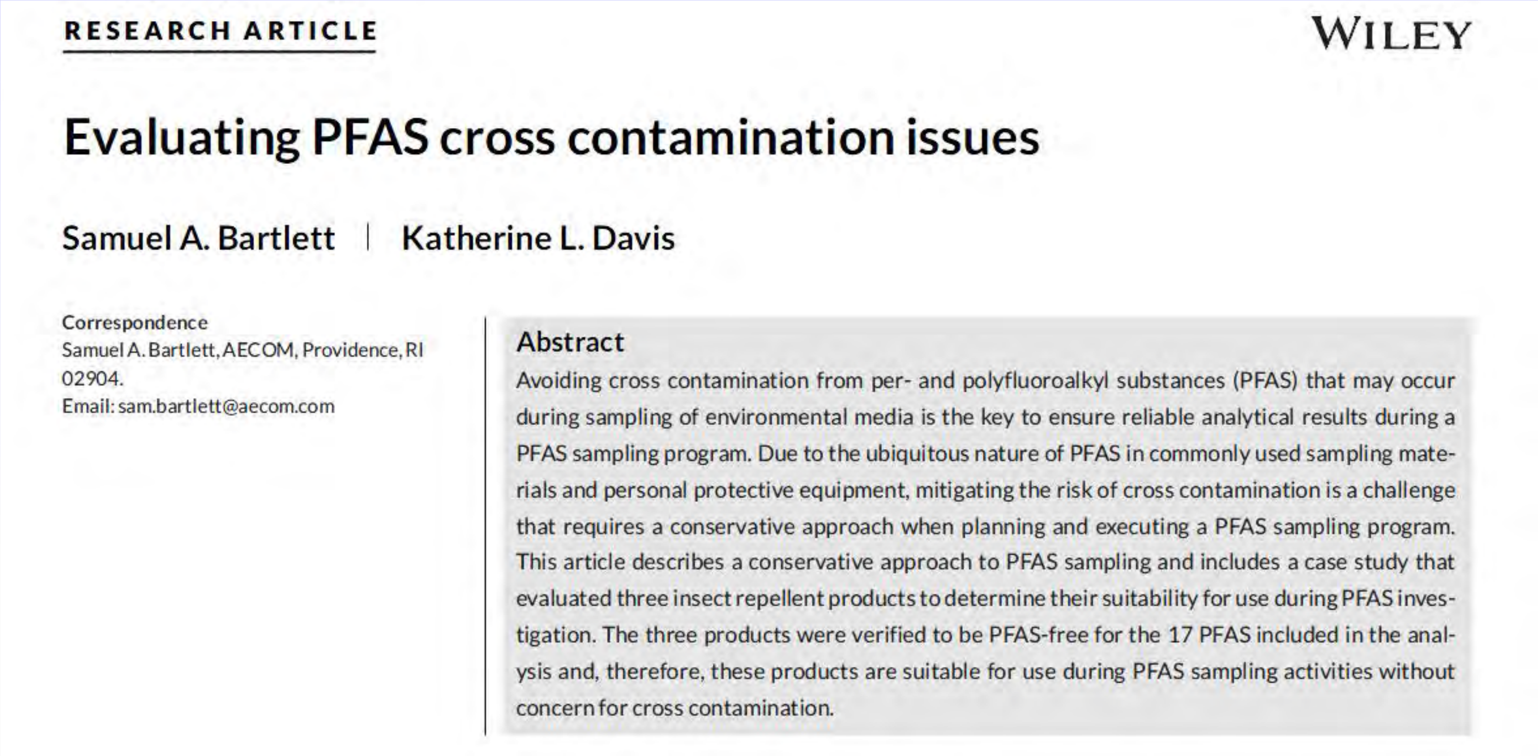
Some examples…



RESEARCH ARTICLE

WILEY

Evaluating PFAS cross contamination issues

Samuel A. Bartlett | Katherine L. Davis

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02904.
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Abstract

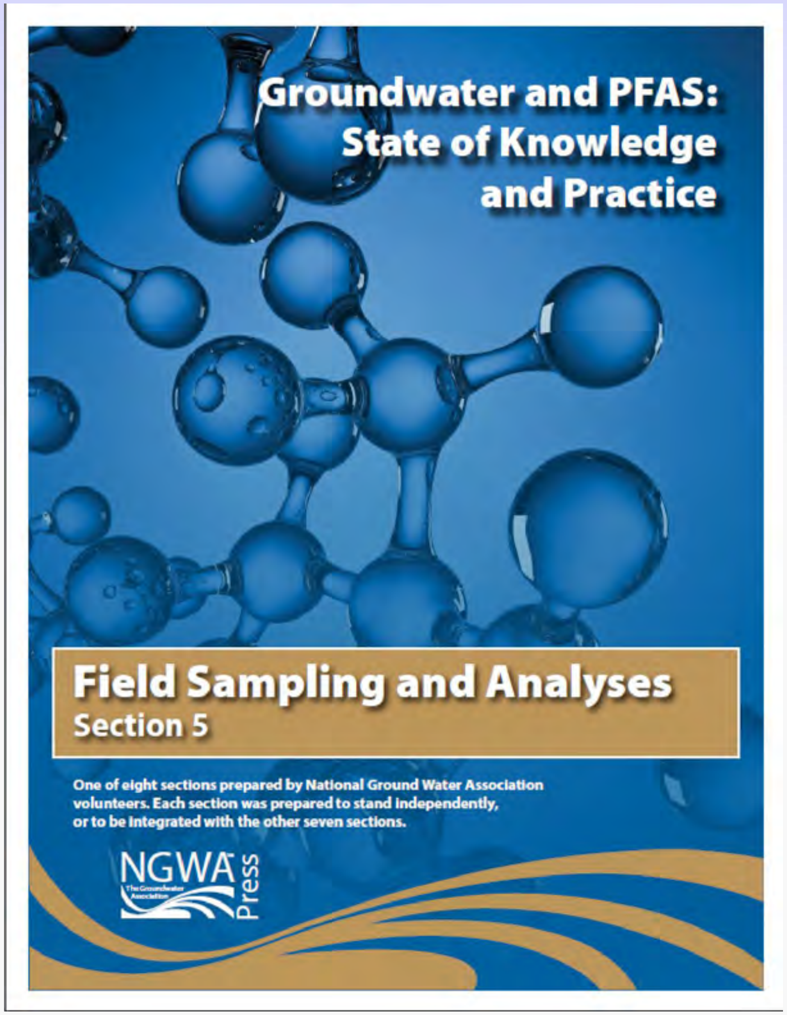
Avoiding cross contamination from per- and polyfluoroalkyl substances (PFAS) that may occur during sampling of environmental media is the key to ensure reliable analytical results during a PFAS sampling program. Due to the ubiquitous nature of PFAS in commonly used sampling materials and personal protective equipment, mitigating the risk of cross contamination is a challenge that requires a conservative approach when planning and executing a PFAS sampling program. This article describes a conservative approach to PFAS sampling and includes a case study that evaluated three insect repellent products to determine their suitability for use during PFAS investigation. The three products were verified to be PFAS-free for the 17 PFAS included in the analysis and, therefore, these products are suitable for use during PFAS sampling activities without concern for cross contamination.

“A common trend in many PFAS sampling documents is to completely prohibit the use or even the presence of suspected items on a project site undergoing PFAS sampling.”

“A conservative PFAS sampling guidance should include testing procedures to evaluate whether a material suspected of containing PFAS presents a risk of cross contamination.”

Some examples, continued

"The materials of construction…. <u>should be free from polytetrafluorethylene (PTFE) or ethylene tetrafluoroethylene</u> (ETFE) to the maximum extent practicable.



Groundwater and PFAS: State of Knowledge and Practice

Field Sampling and Analyses
Section 5

One of eight sections prepared by National Ground Water Association volunteers. Each section was prepared to stand independently, or to be integrated with the other seven sections.

From NGWA, March 2018

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Per- and Polyfluoroalkyl Substances (PFAS) Sampling Guidelines

CALIFORNIA STATE WATER QUALITY CONTROL BOARD

DIVISION OF WATER QUALITY

March 20, 2019

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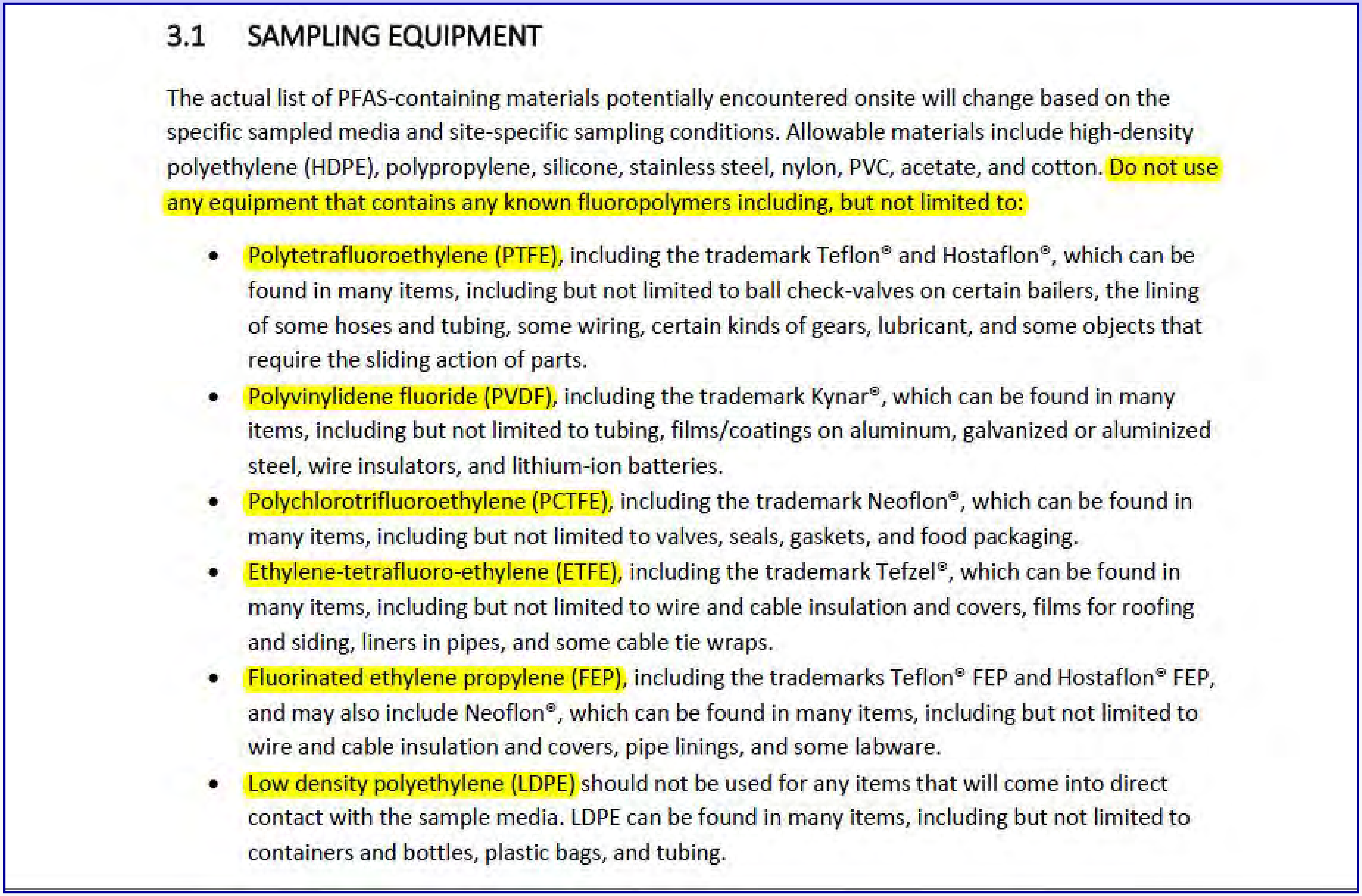

3.1 SAMPLING EQUIPMENT

The actual list of PFAS-containing materials potentially encountered onsite will change based on the specific sampled media and site-specific sampling conditions. Allowable materials include high-density polyethylene (HDPE), polypropylene, silicone, stainless steel, nylon, PVC, acetate, and cotton. Do not use any equipment that contains any known fluoropolymers including, but not limited to:

- Polytetrafluoroethylene (PTFE), including the trademark Teflon® and Hostaflon®, which can be found in many items, including but not limited to ball check-valves on certain bailers, the lining of some hoses and tubing, some wiring, certain kinds of gears, lubricant, and some objects that require the sliding action of parts.
- Polyvinylidene fluoride (PVDF), including the trademark Kynar®, which can be found in many items, including but not limited to tubing, films/coatings on aluminum, galvanized or aluminized steel, wire insulators, and lithium-ion batteries.
- Polychlorotrifluoroethylene (PCTFE), including the trademark Neoflon®, which can be found in many items, including but not limited to valves, seals, gaskets, and food packaging.
- Ethylene-tetrafluoro-ethylene (ETFE), including the trademark Tefzel®, which can be found in many items, including but not limited to wire and cable insulation and covers, films for roofing and siding, liners in pipes, and some cable tie wraps.
- Fluorinated ethylene propylene (FEP), including the trademarks Teflon® FEP and Hostaflon® FEP, and may also include Neoflon®, which can be found in many items, including but not limited to wire and cable insulation and covers, pipe linings, and some labware.
- Low density polyethylene (LDPE) should not be used for any items that will come into direct contact with the sample media. LDPE can be found in many items, including but not limited to containers and bottles, plastic bags, and tubing.

From Per- and Polyfluoroalkyl Substances (PFAS) Sampling Guidelines, CALIFORNIA STATE WATER QUALITY CONTROL BOARD, March 2019. https://www.waterboards.ca.gov/water_issues/programs/pfas/

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What are my options?

- Examples of alternate materials offered in guidance documents all have some limitations:
  - HDPE isn’t as strong and flexible as PTFE and FEP – cycle life testing on HDPE bladders showed 1,500 – 3,000 cycles to failure, equal to 1-2 years of use for dedicated pumps (PTFE = 200K cycles, 100-200 years use)
  - Polypropylene is rather inflexible and tends to take a set when used for materials such as tubing, making it difficult to impossible uncoil, especially in cold weather
  - Silicone rubber is flexible but has a high capacity for sorption of organics
  - Vinyl (Tygon or flexible polyvinyl chloride) is made flexible through the use of phthalate plasticizers that will leach into samples, also absorbs organics
  - Alternatives to Viton (FKM), such as nitrile rubber, often leach other organic compounds - QED testing of nitrile showed up to 10,000 µg/l carbon disulfide

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Is there actually PFAS in my Teflon?

- Not all fluoropolymers will leach PFAS into groundwater samples
- The only way to be certain that sampling equipment is PFAS-free is through material testing and analysis
- QED testing has shown that PTFE pump bladders and seals and FEP tubing have tested to be free of PFAS based on the lowest available laboratory reporting limits
- Manufacturers of sampling equipment and components such as plastic tubing are challenged with finding alternate PFAS-free materials that can meet engineering performance requirements while also meeting sampling program needs for other organic compounds such as fuels and solvents (VOCs and SVOCs) without sample bias or contamination
- Portable and dedicated sampling pumps and passive sampling systems are available that are entirely PFAS-free and Teflon-free

QED

Some early research studies of common commercial and consumer products show PTFE thread tape and "pipe dope" as likely sources of PFAS

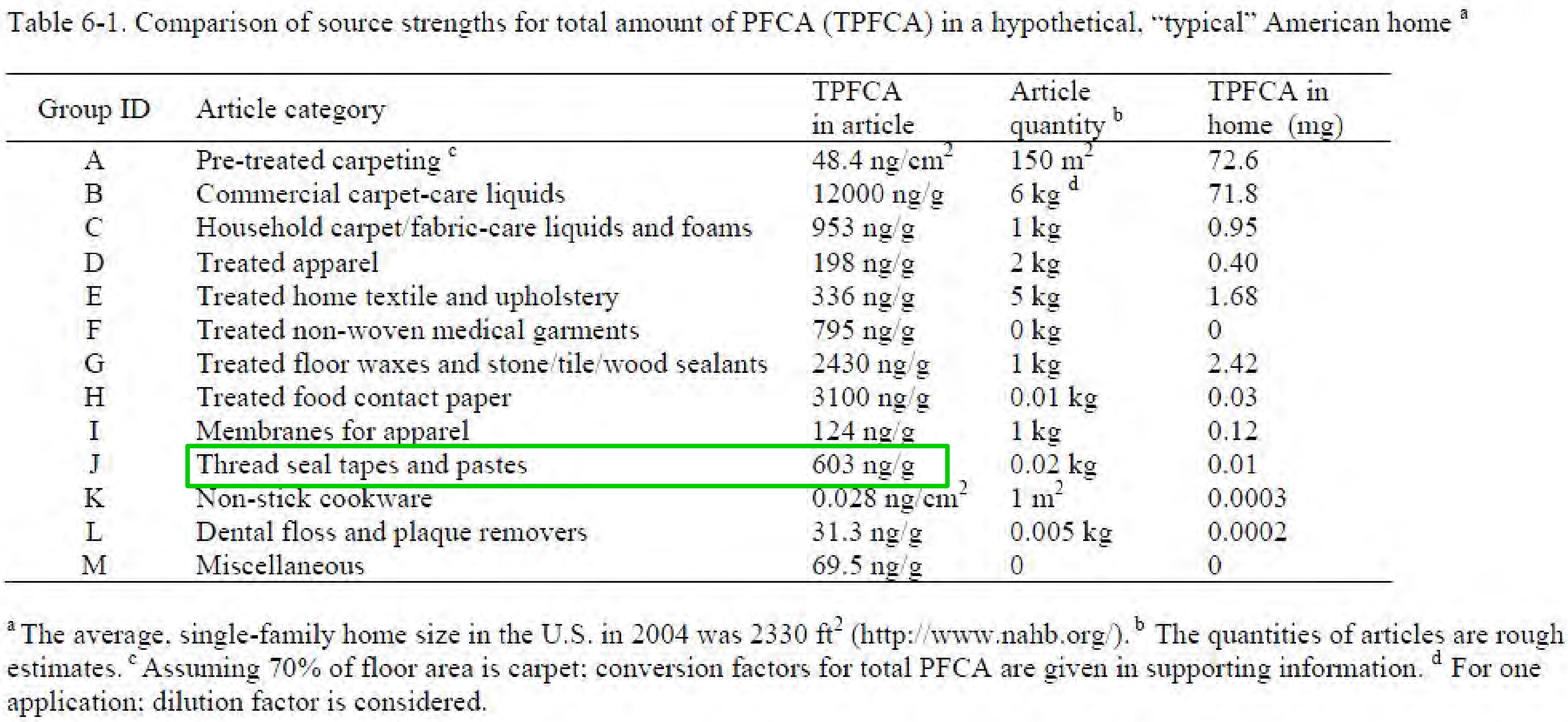


Table 6-1. Comparison of source strengths for total amount of PFCA (TPFCA) in a hypothetical, "typical" American home [a]

Group ID	Article category	TPFCA in article	Article quantity [b]	TPFCA in home (mg)
A	Pre-treated carpeting [c]	48.4 ng/cm^2	150 m^2	72.6
B	Commercial carpet-care liquids	12000 ng/g	6 kg [d]	71.8
C	Household carpet/fabric-care liquids and foams	953 ng/g	1 kg	0.95
D	Treated apparel	198 ng/g	2 kg	0.40
E	Treated home textile and upholstery	336 ng/g	5 kg	1.68
F	Treated non-woven medical garments	795 ng/g	0 kg	0
G	Treated floor waxes and stone/tile/wood sealants	2430 ng/g	1 kg	2.42
H	Treated food contact paper	3100 ng/g	0.01 kg	0.03
I	Membranes for apparel	124 ng/g	1 kg	0.12
J	Thread seal tapes and pastes	603 ng/g	0.02 kg	0.01
K	Non-stick cookware	0.028 ng/cm^2	1 m^2	0.0003
L	Dental floss and plaque removers	31.3 ng/g	0.005 kg	0.0002
M	Miscellaneous	69.5 ng/g	0	0

[a] The average, single-family home size in the U.S. in 2004 was 2330 ft^2 (http://www.nahb.org/). [b] The quantities of articles are rough estimates. [c] Assuming 70% of floor area is carpet; conversion factors for total PFCA are given in supporting information. [d] For one application; dilution factor is considered.

From Perfluorocarboxylic Acid Content in 116 Articles of Commerce, EPA/600/R-09/033, March 2009

ATTACHMENT G

Peristaltic Pumps

- Fits any well diameter, including small direct-push wells and multi-level systems
- Suction lift limited to 20 - 26 (6 – 8m) feet water depth, including drawdown
- Flexible elastomeric tubing, such as silicone, is required at pump head but can be attached to other non-fluoropolymer tubing materials such as HDPE & LDPE
- While peristaltic pumps are often cited as less accurate for gas sensitive parameters (e.g., VOCs, metals), PFAS are not volatile and quite stable in water, so no sample bias is expected

Battery-powered peristaltic pump

AC-powered peristaltic pump

QED

Electric Submersible Pumps

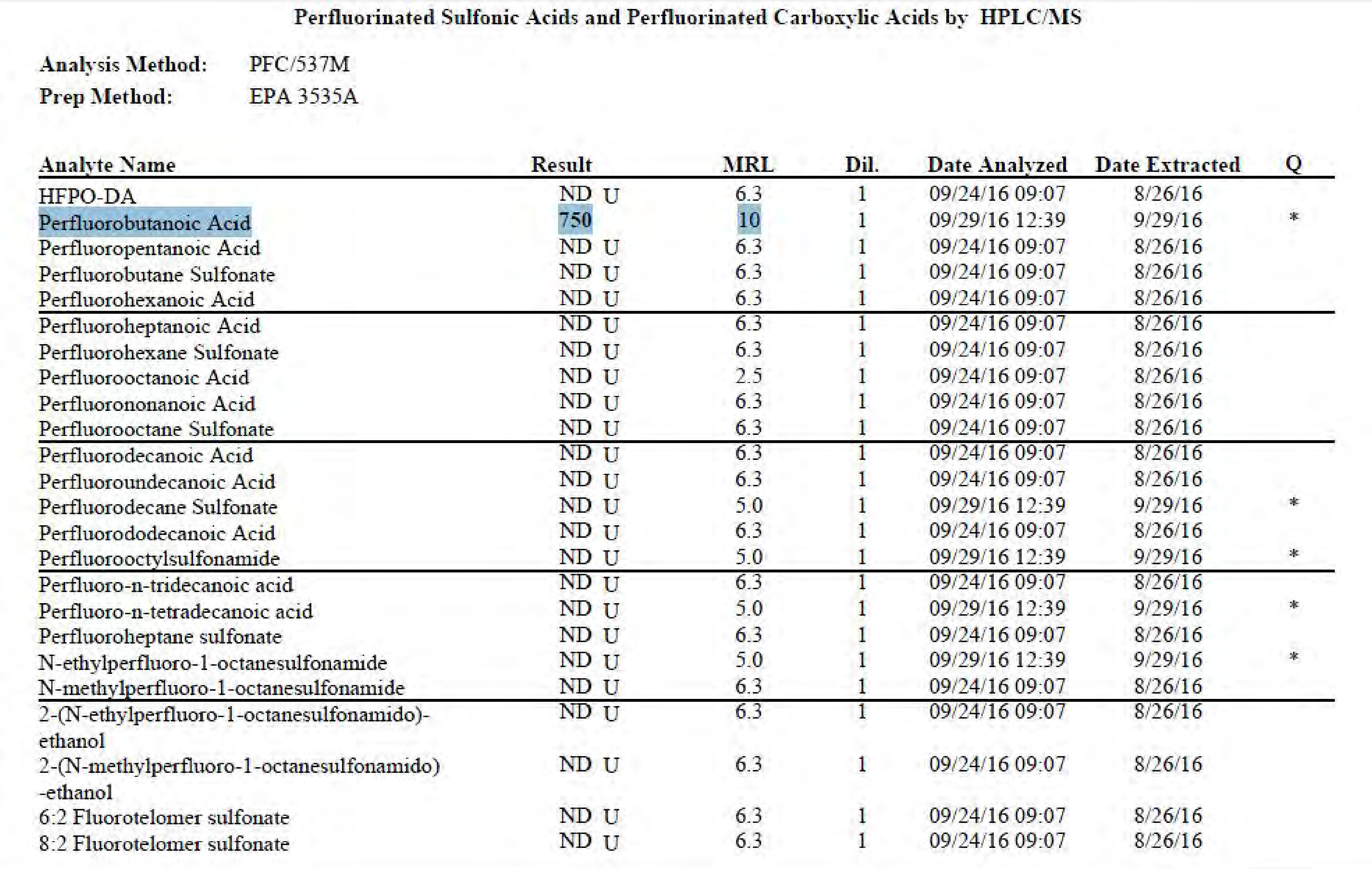
- Fit into 2-inch (50mm) well casings
- Sampling depths up to 275 feet (84m) for AC-voltage pumps and 50 – 200 feet (15m - 60m) for DC-voltage pumps
- Greater depths for DC pumps using drop tube inlet where water depth <150'
- May not work where guidance or GWSAP for PFAS sampling prohibit use of Teflon (fluoropolymers) - many electric pumps have PTFE motor seals, PTFE wear parts and ETFE-coated motor cable
- Testing for PFAS in Grundfos Redi-Flo2 (DiGuiseppi, et al., 2014) showed PFBA detection (>100 ng/L) – most likely source is ETFE (Tefzel®) wire insulation. QED testing of ETFE tubing detected PFBA at 750 ng/L

AC-voltage pump, control box and generator

DC-voltage pump and control box

ATTACHMENT G

ETFE Tubing, 24 hour minimum soak test



Perfluorinated Sulfonic Acids and Perfluorinated Carboxylic Acids by HPLC/MS

Analysis Method: PFC/537M
Prep Method: EPA 3535A

Analyte Name	Result		MRL	Dil.	Date Analyzed	Date Extracted	Q
HFPO-DA	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluorobutanoic Acid	750		10	1	09/29/16 12:39	9/29/16	*
Perfluoropentanoic Acid	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluorobutane Sulfonate	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluorohexanoic Acid	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluoroheptanoic Acid	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluorohexane Sulfonate	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluorooctanoic Acid	ND	U	2.5	1	09/24/16 09:07	8/26/16	
Perfluorononanoic Acid	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluorooctane Sulfonate	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluorodecanoic Acid	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluoroundecanoic Acid	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluorodecane Sulfonate	ND	U	5.0	1	09/29/16 12:39	9/29/16	*
Perfluorododecanoic Acid	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluorooctylsulfonamide	ND	U	5.0	1	09/29/16 12:39	9/29/16	*
Perfluoro-n-tridecanoic acid	ND	U	6.3	1	09/24/16 09:07	8/26/16	
Perfluoro-n-tetradecanoic acid	ND	U	5.0	1	09/29/16 12:39	9/29/16	*
Perfluoroheptane sulfonate	ND	U	6.3	1	09/24/16 09:07	8/26/16	
N-ethylperfluoro-1-octanesulfonamide	ND	U	5.0	1	09/29/16 12:39	9/29/16	*
N-methylperfluoro-1-octanesulfonamide	ND	U	6.3	1	09/24/16 09:07	8/26/16	
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	ND	U	6.3	1	09/24/16 09:07	8/26/16	
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	ND	U	6.3	1	09/24/16 09:07	8/26/16	
6:2 Fluorotelomer sulfonate	ND	U	6.3	1	09/24/16 09:07	8/26/16	
8:2 Fluorotelomer sulfonate	ND	U	6.3	1	09/24/16 09:07	8/26/16	

Air-Powered Bladder Pumps

- Designs are available to fit well as small as 0.5” well casing and multilevel tubing wells
- Sampling depths to 1,000’ (300 m) lift, even greater depths with drop tube inlets
- Wide range of material choices (PVC, stainless steel, poly) to match contaminant chemistry and background water quality – BUT – dedicated pumps historically use PTFE bladders, which can’t be used under some sampling plans
- Portable and dedicated pumps are available with HDPE & LDPE bladders, but these often don’t have the long bladder life typical of PTFE bladders and are designed to be replaced frequently, which defeats the purpose of a dedicated system

Dedicated Bladder Pumps

Portable Bladder Pumps

QED Sample Pro® PFAS-Free/Teflon-free Portable Bladder Pump Sampling Systems

PORTABLE GROUNDWATER SAMPLING PUMP

The most reliable portable sampling pump is PFAS-Free

Sample Pro®

The Original PFC-Free Bladder Pump

The Sample Pro pump and Tubing are and have Always Been PFAS-Free

ATTACHMENT G

WELL WIZARD ®

Zero™ and Clear™

- Well Wizard Zero models are constructed entirely from non-fluoropolymer plastics that have been tested and certified to be PFAS-free
- Well Wizard Clear models will use the same components but retain the PTFE bladder for very low level organic testing - also tested PFAS-free
- QED's industry-first HDPE twin bonded tubing meets all PFAS sampling program requirements and has been tested for PFAS, VOCs and SVOCs
- Models available to sample to 600 feet depth (300 PSI pressure) and can sample to nearly unlimited depths using drop tube inlet systems
- **Available November – December 2019**

ATTACHMENT G

Passive and No-Purge Samplers

- Much simpler to design without any fluoropolymers - few to no moving parts
- Polyethylene Diffusion Bag (PDB) won't work for PFAS – will not equilibrate
- Whole water samplers can work if sample volume requirements are met
- Some available without any fluoropolymers, but testing is still recommended to ensure that no PFAS can leach from materials used

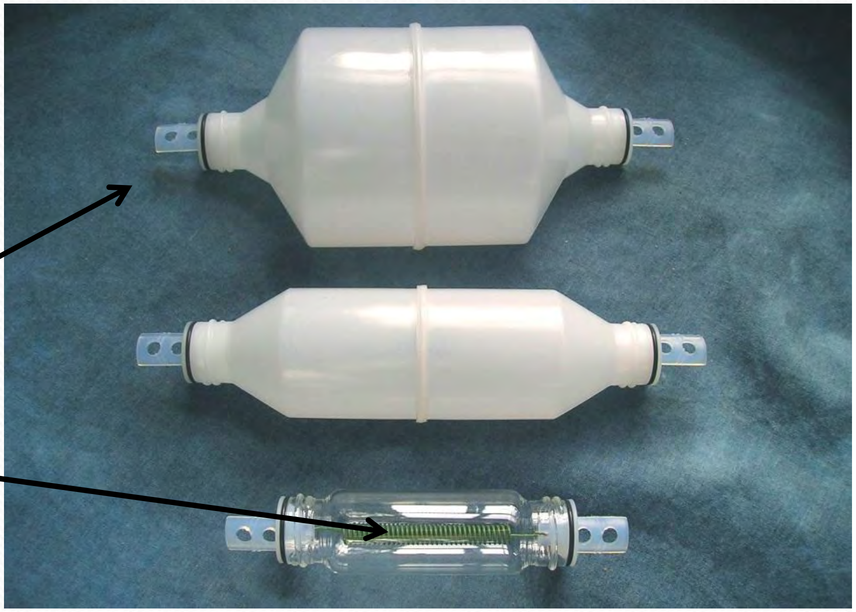
PDB Sampler

Snap Sampler®

ATTACHMENT G

SNAP SAMPLER Zero™

PFAS FREE
QED
TRUSTED PROVEN QUALITY
TESTED FOR PURITY



- All components tested for PFAS
- Molded acetal "snap caps" with EPDM O-ring seals
- Passivated stainless steel center springs
- Distinctive white HDPE liner bottle caps for 125 mL and 350 mL poly bottles and white/blue septa caps for 40 mL VOA vials sealed in separate packaging
- **Available November - December 2019**

QED

ATTACHMENT G

Sampling Equipment Recommendations

- Follow a common sense approach to the use of any materials and supplies – look for studies on PFAS content in materials and, when in doubt, either test your system or eliminate suspect materials
- For new dedicated pump systems, portable pump systems and passive samplers, equipment blank testing can determine if they're PFAS-free, or obtain certification from the manufacturer that the equipment and tubing has been tested and is PFAS-free
- For existing dedicated sampling systems, test in place for absence or presence of PFAS in samples before replacing any components
    - Where results are ND in all wells, systems can be used (unless GWSAP or regulatory restrictions on existing materials exist)
    - Where PFAS is detected in some or all wells, those wells can be sampled again using a known PFAS-free system to determine if source is the sampling system or if PFAS existing in the water
    - When a sampling system shows PFAS, look for sources such as PTFE thread tape, gaskets or seals that could be eliminated or replaced with alternate materials

Questions?

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ATTACHMENT G