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 **NATIONAL WASTE & RECYCLING ASSOCIATION'S INDEX OF EXHIBITS AND THIRD HEARING EXHIBITS**, copies of which are hereby served upon you.

Dated: December 6, 2022

By /s/ Claire A. Manning

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NATIONAL WASTE & RECYCLING ASSOCIATION INDEX OF EXHIBITS

Exhibit A

National Waste & Recycling Association℠
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NWRA'S CONCERNS WITH IEPA PROPOSED CHANGES TO PART 620

1. **<u>The IEPA'S proposal – and PFAS – is *a gamechanger:*</u>**
    1. Not your normal Part 620 rulemaking – PFAS constituents not like any other constituents now monitored: PFAS is *ubiquitous*, without source identifiers (Wide Public Use); *new unapproved analytical methodology required*.
    2. Part 620 GQSs are linked to other Board regulatory programs – so incumbent upon Board and regulated community to understand the resulting interplay between the proposed changes and the existing rules.
    3. Lack of Info on background GW concentration of PFAS but expected to be present.
2. **<u>The IEPA has not demonstrated that its proposal is technically feasible</u>**:
    1. Laboratory Analysis – Reliability and Achievability
    2. Interrelated Liability in the regulated community - Where will the PFAS go?
    3. No Background Levels Established – Significant portions of the State GW may exceed the proposed standard
3. **<u>The IEPA has not demonstrated that its proposal is economically reasonable</u>**:
    1. Since IEPA's approach and testimony ignores impacts to other programs, costs cannot be effectively addressed.
    2. Expectation: significant cost impacts associated with compliance and changes in business operations. These costs will be significant but remain undefined. Costs expected include new monitoring costs, new GW monitoring well equipment, leachate pretreatment/alternative disposal, and regulatory compliance.

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NWRA'S CONCERNS WITH IEPA PROPOSED CHANGES TO PART 620 (cont.)

4. <u>The IEPA has not addressed how it intends to implement these strict new standards across other regulatory programs, creating great uncertainty in the regulated community.</u>

1. New Background Calculations will need to be calculated, given expected presence of PFAS everywhere.
2. Detections in groundwater monitoring wells will be suspect (yet - enforcement/violations?).
3. Groundwater Impact Assessments – inputting these parameters will likely result in failed model – thereby delaying otherwise sound closure and development of landfills (GIA not required in other states).
4. Disposal Issues: Leachate and WWTP biosolids – issues will continue (and accelerate) so long as PFAS in products.
5. Expected Impacts on other regulatory programs: CERCLA; SRP; TACO; Construction Project Debris.

5. <u>NWRA urges the Board to not move forward with these rules at this time.</u>

1. NWRA fully supports drinking water MCL standard as significant first step – this is not that.
2. NWRA will participate in advancing workable strategies to address PFAS contamination.
3. IPCB should wait for federal and/or state-legislated approach or coordinated strategy.

Exhibit B

Electronic Filing: Received, Clerk's Office 09/15/2022

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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 **TESTIMONY OF THOMAS A. HILBERT ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION**, copies of which are hereby served upon you.

Dated: September 15, 2022

By /s/ Claire A. Manning

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TESTIMONY OF THOMAS A. HILBERT ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION

I. Introduction

I am providing this testimony on behalf of the National Waste and Recycling Association (NWRA) – Illinois Chapter. NWRA has created an Illinois workgroup, which I chair, to review and provide comments and testimony on behalf of the waste and recycling businesses in Illinois regarding the proposed updates to Title 35 IAC Part 620 groundwater regulations. The NWRA – Illinois Chapter represents companies that manage the waste products that are generated by businesses and residents in the State of Illinois. This testimony focuses on the proposed updates that add groundwater standards for PFAS (per and polyfluorinated alkyl substances), as well as other proposed revisions to the regulations. NWRA-Illinois Chapter prepared a power-point presentation for its members, which is summarized in our Pre-Filed Testimony. We would be happy to present this information to the Board at its hearings in December. See Attachment A.

My name is Thomas A. Hilbert. I am presently a Regional Engineering Manager for Waste Connections. Waste Connections is the third largest integrated waste services company in North America with a network of operations in 41 states and 6 Canadian provinces. We are full-service provider of solid waste collection, providing non-hazardous solid waste collection, recycling and landfill disposal services to commercial, industrial, municipal and residential customers. I have 30 years of experience in environmental management and hold a B.Sc. degree in Geophysics from

Western Washington University and a M. Sc. in Civil/Environmental Engineering from the University of Arizona. I hold Prior Conduct Certification and am a certified manager of landfill operations by the State of Illinois.

We appreciate the opportunity to present this information to the Illinois Pollution Control Board (IPCB) in this rulemaking and the continued opportunity to work with the Illinois Environmental Protection Agency (IEPA) to ensure that Illinois groundwater quality standards are protective of the health of citizens residing and conducting business in Illinois.

PFAS have properties that make them useful in an incredible variety of applications and have been in use since the 1950's. PFAS have been used in coatings for textiles, paper products, and cookware and to formulate some firefighting foams, and have a range of applications in the aerospace, photographic imaging, semiconductor, automotive, construction, electronics, and aviation industries. Therefore, they have become ubiquitous and widely distributed throughout society and subsequently in the environment. It is widely understood that PFAS have potential health risks and we support the IEPA's efforts to establish appropriate groundwater quality standards for certain PFAS chemicals. However, the current rule proposal is problematic in that it fails to consider or address the expected serious economic and disruptive impact that the proposed new standards for PFAS, at the levels proposed, will have on other regulatory frameworks under Title 35 of the Illinois Administrative Code: Environmental Protection.

II. The IEPA has not provided a comprehensive analysis of the feasibility or the economic impacts of the proposed changes to the Part 620 rules.

The addition of PFAS constituents at the levels in the proposed rule will have currently undefined impacts on multiple other regulatory programs. Without a structured review of the impacts the proposed changes have on other regulatory programs, individuals, businesses and units

of local government will be left without a practical or economic alternative to comply with the other regulatory programs.

The Part 811 municipal solid waste landfill regulatory framework currently has both a design standard and a performance standard. The performance standard requires a groundwater impact assessment ("GIA") which requires groundwater transport modeling of a hypothetical leak in the landfill containment system to assess whether there is a potential for a constituent of the landfill leachate to reach the landfill's groundwater compliance boundary. This is a standard that every landfill in the state must pass prior to the IEPA granting an operating permit – and this requirement is specific to Illinois. We know of no other state that requires this GIA analysis and the GIA regulations are not federally required or federally driven.

The GIA is highly sensitive to the concentration difference between the modeled leachate constituent and the applicable groundwater quality standard. It is also sensitive to the attenuation properties of the modeled constituent. Constituents with low attenuation, such as PFAS, will travel farther without any degradation in concentration. The groundwater standard concentrations proposed for PFOA and PFOS are at levels that are up to 1000 times higher than the typical leachate concentrations. Very few if any MSW landfills in Illinois will be able to pass a GIA model at the currently proposed PFAS groundwater quality standards without the implementation of extremely expensive and unnecessary design standards or the implementation of difficult to achieve contingent remediation plans with associated costly new financial assurance requirements. To be clear, the GIA is a modeling exercise. Our point here is that it will not be reflective of actual risks to the environment for a landfill that meets the Subtitle D design standards. Yet, as the regulations currently require, it must be performed prior to achieving a permit.

Further, every Illinois MSW landfill must review and update the GIA every 5 years when it applies for the renewal of its landfill operating permit. Without some change in the GIA regulatory process, we believe that to achieve the very conservative PFAS limits proposed every existing permitted landfill will be required to go through an overly expensive permitting process and added financial assurance costs, without any analysis or consideration of whether any environmental benefits will be achieved by such added burdens.

While we appreciate and support standards to protect public sources of drinking water, no evaluation has been made by the State of Illinois as to whether the costly and burdensome requirements that will flow from the proposed rule, given the current intertwined relationship between Part 620 and other regulatory programs, will achieve associated environmental benefits. The IEPA's justification simply assumes that all people will drink all groundwater and that all tested groundwater – regardless of how proximate it is to actual potable water sources or whether it will realistically impact such potable water sources – would be subject to the very conservative proposed potable water standards.

Additionally, NWRA Illinois is concerned that many false readings will occur during the monitoring process, since many of the components of MSW landfill groundwater monitoring system contain Teflon or similar PFAS containing plastics or other components. This will likely require every Illinois landfill to replace existing groundwater monitoring system components with non PFAS containing components to avoid the potential for exceeding the proposed groundwater quality standards for PFAS.

The proposed Part 620 rules also remove the definition of the "Practical Quantitation Limit" but it will remain as the referenced standard in Part 811, and the IEPA has not indicated when or how it intends to propose changes to Part 811. A review of the impacts of the proposed

Part 620 rules on other regulatory programs will eliminate conflicting definitions within the Title 35 of the Illinois Administrative Code, and consideration should be made to the workability of these new definitions in the context of those other regulatory programs prior to moving to adopt this proposed rule. We believe that the significant changes proposed here cannot be made in a vacuum and, to a large extent, that is what this rule proposal does.

The above is a simple review of the direct impacts that the proposed Part 620 regulations would have upon the Part 811 regulatory framework which were not adequately addressed with the proposed revisions. We understand that the 620 rules have been amended in the past without requiring a comprehensive review on the other regulatory programs. However, prior groundwater rulemakings have been relatively simple additions of constituents and not at the levels proposed for the six proposed PFAS standards and not with new and different analytical laboratory testing protocols also being proposed. The addition of new constituents at a standard that is 1000 lower than any existing standard adds complexities that must be given additional consideration. Similarly, although not as significant, the establishment of conflicting definitions with Title 35 of the Illinois Administrative code will cause confusion when those definitions are used as part of routine regulatory compliance.

Even more important is the fact that the interrelation between various regulatory frameworks under Title 35 of the Illinois Administrative Code creates significant challenges to regulatory compliance and reasonably achievable disposal options – each important to businesses and local government alike in Illinois. Most landfills rely on Publicly Owned Treatment Works ("POTW") facilities for leachate management. In turn, POTWs increasingly rely on landfills for biosolids management and disposal of PFAS-laden media. Efforts to address PFAS in groundwater must avoid disrupting this interdependence among essential public services to

communities. When POTWs refuse to accept landfill leachate, which is beginning to happen, there is a significant economic impact on the landfill which threatens the landfill's ability to maintain compliance with the leachate removal requirements of the Part 811 rules until they can find an alternative disposal option for the leachate or construct a pretreatment facility to comply with the POTW's influent standards. However, removing PFAS from landfill leachate requires advanced treatment techniques which are prohibitively expensive.

Estimated capital costs to implement leachate pretreatment at a moderate-sized landfill to the extent necessary to reduce PFAS to the levels proposed, should such reductions even be feasible, range from $2 million to $7 million. Multiplying this cost across all Illinois landfills would have an economic impact on the landfill industry alone, currently estimated at several hundred million dollars.

Further, the proposed PFAS standards in the Part 620 rules will create chaos in relation to the existing practice of application and disposal of biosolids from POTWs – and must be considered in the context of this rulemaking. There is significant potential that liability concerns will lead POTWs to stop the practice of land application. Disposal of biosolids at MSW landfills, which is currently a routine practice, could also be potentially affected by the proposed groundwater rules. If POTW's are already refusing acceptance of landfill leachate over concerns regarding the presence of low levels of PFAS in leachate it is logical that the landfill would refuse to accept biosolids to eliminate potential sources of PFAS in the waste stream accepted at the landfill to limit the liability and cost associated with managing PFAS containing waste streams. Even if a landfill decided they were willing to accept the added cost and liability of accepting biosolids with PFAS, there is the very likelihood that landfills will reach a limit on the ability to accept biosolids due to the higher moisture content of biosolids to MSW materials.

There are many other interrelated impacts, impacts which have not been investigated or analyzed, that will be driven by the proposed rules. Simply assuming, without understanding how, the impacts on other regulatory frameworks will get sorted out after the groundwater quality standards are established is not acceptable. The potential economic and legal liabilities will be disruptive and harmful to businesses and units of local governments across Illinois – and must be understood in the context of developing an appropriate groundwater protection standard.

III. There has not been a statewide assessment of the occurrence and concentration of PFAS in Illinois groundwater or other media.

Without understanding background levels of PFAS in groundwater there is uncertainty as to the impacts that the proposed rule will have on the regulated community. It is accepted that PFAS are ubiquitous and widely dispersed in the environment. As recently as 2018, greater than 90% of the US population had a mean blood serum concentration for PFOA and PFOS of 1.4 ug/l and 4.3 ug/l respectively which is nearly 1000 times greater than the proposed groundwater standards. It is clear that human exposure and presence in the environment is widespread. PFAS are found in agricultural products that are applied to farmland, they are transported by air and dispersed in rainfall. Therefore, without widespread background data there is no certainty that the proposed groundwater standards will not be exceeded in numerous locations throughout the state which has the potential to create a quagmire of compliance, liability, and legal concerns, since at the proposed concentration standards there will likely be no well-defined source. Thus, it is imperative that the proposed standard be workable in all contexts in which it will be applied, not just in the context of potable water safe for human consumption.

IEPA has performed a review of PFAS concentrations in municipal drinking water supplies. Drinking water samples were collected from 1,428 different community water supply locations throughout Illinois for 18 PFAS compounds. From that sample database there were 68

locations which exceeded the minimum reporting level of 2 ng/l (parts per trillion) in approximately 4.8% of the sampled locations. The vast majority of public exposure to PFAS from a water supply source will be through drinking water supplied in a community water supply system. Therefore, it would be more appropriate for the state to focus on establishing a maximum contaminant level ("MCL") for community water supplies under Part 611 - Primary Drinking Water Standards. The feasibility and economic impacts of establishing MCL's for PFAS are more easily defined since the state has already determined the number of community water supply systems that would be required to install a treatment system. Focusing on establishing an MCL under the primary drinking water standards is more protective of public health since it would eliminate the largest exposure pathway to the public.

IV. The only approved USEPA analytical method for non-drinking water media does not have a Lower Limit of Quantitation or Method Detection Limit that can meet the proposed groundwater quality standard for PFOA and PFOS.

The USEPA does not have an approved multi-lab validated analytical method that can detect PFOA and PFOS at the proposed groundwater quality standards. The USEPA has proposed a draft method 1633 specifically for PFAS compounds but it has not yet been finalized. The draft method 1633 does have a single lab verified that has a reported Method Detection Limit ("MDL") that is right at the 2 ng/l standard proposed for PFOA. There is no guarantee that once finalized through a multi-lab validated process that the MDL for method 1633 will be at or below the proposed groundwater standard for PFOA. Even if method 1633 is finalized with a MDL of 2 ng/l it will have been established by using controlled samples with rigorously controlled laboratory procedures. The variable nature of field samples and the real-world laboratory procedures in a high-volume analytical laboratory will likely result in a high number of sample analytical reports that will have a reporting limit that is above the MDL. Putting the regulated entities in a situation

in which there is a high probability that they will not be able to reliably provide an analytical report that can demonstrate compliance with the groundwater water quality standard will cause unnecessary compliance issues not related to actual environmental protection and is simply not reasonable.

V. Illinois is proposing the lowest standard for PFOA and PFOS of all the states that have established water quality standards for PFAS compounds.

Illinois is proposing the lowest groundwater quality standard for PFOA and PFOS than any other of the states that have established a groundwater quality or advisory standards for PFAS compounds. The wide variation in state standards for PFAS is largely due to the current lack of a well-defined and accepted toxicological profile for PFAS. Human epidemiological and toxicology studies are ongoing and as of the date of this filing the USEPA has not finalized its toxicity values to be used for determining MCL's for any of the proposed PFAS in this rulemaking. The lack of a defined standard for developing an MCL is clearly evident in the wide variation in state groundwater and drinking water quality standards. Proposing groundwater quality standards prior to the establishment of final toxicity assessments only creates confusion and uncertainty in the regulated community. The USEPA is in the process of developing federal MCL's for PFOA and PFOS and has indicated that an initial draft would be published in late 2022 with anticipated finalization in 2023. Illinois should wait for the USEPA's final determination of appropriate toxicity values for the proposed PFAS standards prior to establishing separate and potentially conflicting standards. Meanwhile, Illinois could be developing a more comprehensive and workable strategy to regulate and control PFAS.

2022 Summary of States with DW and/or GW PFAS Standards or Guidance

					PFAS Analyte Concentration (µg/L) and CAS RN					
	Year Last Updated	Standard / Guidance	Type	Promulgated Rule (Y/N/O)	PFOA	PFOS	PFNA	PFBS	PFHxS	HFPO-DA (Gen-X)
USEPA	2016	Health Advisory	DW	N	0.070	0.070				
	2019	Screening Level, CERCLA sites	GW	N	0.040	0.040				
Alaska	2016	CL	GW	Y	0.400	0.400				
California	2021	RL (CA)	DW	Y	0.010	0.040		5		
Colorado	2020	Translation Levels	GW/SW	Y	0.070	0.070	0.070	400	0.700	
Hawaii	2020	EAL	Protected GW	Y	0.040	0.040	0.0044	40	0.019	0.016
Illinois	2021	Health-based Guidance	DW	N	0.002	0.014	0.021	2.1	0.14	0.021
Illinois	**2022**	**Proposed Rulemaking**	**GW**	**Ongoing**	**0.002**	**0.0077**	**0.012**	**1.2**	**0.077**	**0.012**
Indiana	2019	SL (tap)	Protected GW	Y				400		
Iowa	2016	Statewide Standards	Protected GW	Y	0.070	0.070				
Maine	2021	RAG	GW	O	0.070	0.070	0.070	400	0.070	
Massachusetts	2020	MCL	DW	Y	0.020	0.020	0.020		0.020	
Michigan	2021	MCL/GCC	DW/GW	Y	0.008	0.016	0.006	0.420	0.051	0.370
Minnesota	2018	HRL - chronic	DW/GW	Y	0.035	0.300		7		
Montana	2019	Water Quality Standard	GW	Y	0.070	0.070				
New Hampshire	2019	AGQS	GW/DW	Y	0.012	0.015	0.011		0.018	
New Jersey	2022	MCL	GW/DW	Y, N	0.014	0.013	0.013			
New York	2020	MCL	DW	Y	0.010	0.010				
North Carolina	2006	IMAC	GW	Y	2					
Ohio	2022	Action Level	DW	O	0.070	0.070	0.021	2.1	0.140	0.002
Oregon	2011	IL	SW	Y	24	300	1			
Rhode Island	2017	GQS	DW/GW	Y	0.070	0.070				
Texas	2021	Tier 1 PCL	GW	Y	0.290	0.560	0.290	34	0.093	
Vermont	2020	MCL	DW/GW	Y	0.020	0.020	0.020		0.020	
Washington	2021	SAL	DW	Y	0.010	0.015	0.009	0.345	0.065	

VI. Concluding Statement.

We understand and support the States' efforts to establish appropriate standards for PFAS, and we appreciate the Board's responsibility to protect the public health and safety of Illinois citizens. However, we feel strongly that IEPA is acting prematurely in proposing such conservative PFAS groundwater quality standards as the State's first step – without addressing the significant ramifications that will result, and without considering whether the cost of those ramifications exceed the environmental benefit. The concerns regarding PFAS are extremely complicated since these compounds are contained in products that have been used for years and have become integrated into all aspects of our society and consequently into the environment. A recent University Wisconsin-Madison review showed that 70% of the rainwater sampling sites had detectable levels of PFOA at up to 3 ng/l (median < 1 ng/l) which is higher than the proposed standard in this rulemaking. It is simply not reasonable to develop a groundwater quality standard

that is potentially lower than what is found in rainfall concentrations. Further, prior to moving forward with this rule, the regulated community and the Board must be assured of its feasibility and have a clear understanding of its costs. To date, the IEPA has not addressed either. We need a much more thorough understanding of how the proposed standards will interact between the various regulatory programs under Title 35 of the Illinois Administrative Code prior to adopting PFAS into the Part 620 rules at the levels currently proposed. In conclusion, while we would wholly support the Board's adoption of an MCL for PFAS, we would ask that the Board stay this particular rule proposal until more information is available and presented.

This concludes my testimony.

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REFERENCES

Electronic Filing: Received, Clerk's Office 09/15/2022

CERTIFICATE OF SERVICE

I, the undersigned, certify that on this 15th day of September 2022, I electronically served the **TESTIMONY OF THOMAS A. HILBERT 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: September 15, 2022

By /s/ Claire A. Manning

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National Waste & Recycling Association℠
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ILLINOIS GROUNDWATER QUALITY REGULATORY CHANGES
Addition of PFAS – Review and Status

Discussion Outline

- **Per- and Polyfluoroalkyl Substances (PFAS) -** The Basics – What, Where, and Why Worry
- **Revisions to Title 35 IAC 620 -** What are the significant changes
- **Comparison to Other States and Federal Updates -** How does IL compare and What is the USEPA doing
- **Summary of Impacts to the Landfill Industry -** Operational Risks and Economic Impacts
- **Summary and Review of Rulemaking Process -** Outline of Rulemaking Process, Schedule, and Who is involved

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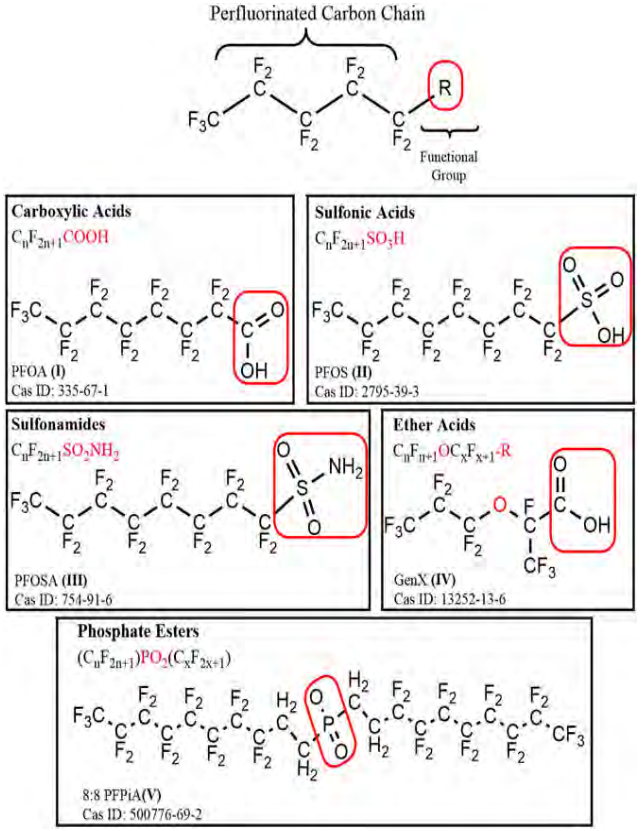
What and Where Are Per- and Polyfluoroalkyl Substances (PFAS)

PFAS	Source of PFAS
Long-Chains (C8)	
Perfluorooctanoic acid (PFOA)	Nonstick Surfaces
Perfluorooctane sulfonate (PFOS)	Fabric Protection, Firefighting Foam
Perfluorononanoic acid (PFNA)	Surfactant for Plastic Production
Short-Chains (C6)	
Perfluorohexane Sulfonic Acid (PFHxS)	Firefighting Foam
Perfluorohexanoic Acid (PFHxA)	Degradation Product of PFHxS
Perfluorobutyrate Acid (PFBA)	Photographic Film



- Polyfluoroakyl (PolyfluoroTelemers) - Pre-Cursor Compounds to Perfluoroalkyl Acids

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Why are PFAS a Concern?

- Environmentally Persistent – Half lives measured in decades
- Ubiquitous – clothing, food, paint, health care, manufacturing, etc. and not limited to a well regulated source
- Health Concern – See Below

Animal Studies

- ✓Cancer/tumors (testicular, liver, pancreatic)
- ✓Reproductive
- ✓Developmental
- ✓Immunological
- ✓Endocrine (thyroid)
- ✓Hematological
- ✓Neurobehavioral
- ✓Liver
- ✓Kidney

Human (potential associations)

- ✓Cancer (testicular, kidney)
- ✓Reproductive
- ✓Developmental (decreased birth weight)
- ✓Immunological (decreased immune/vaccine response)
- ✓Thyroid effects
- ✓Metabolic (increased cholesterol, uric acid)
- ✓Liver (liver enzymes)

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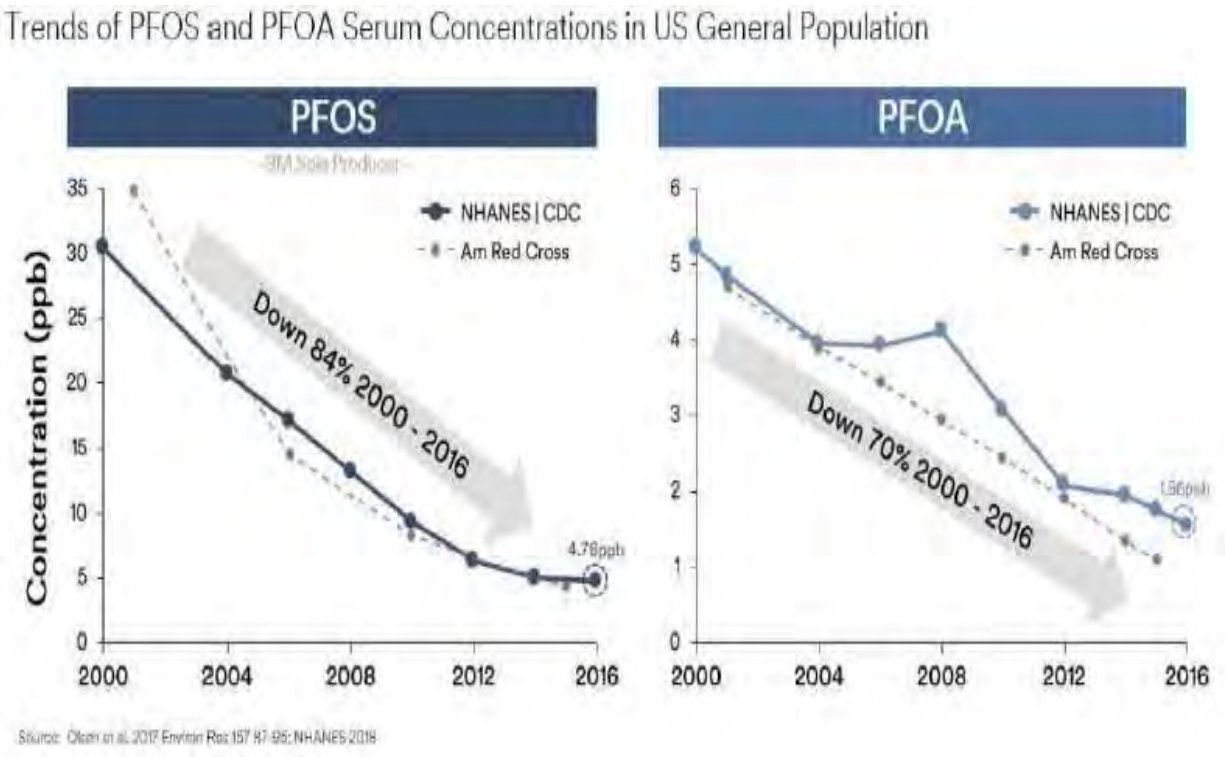
PFOA and PFOS Levels in the Blood of the General Population on Decline



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Title 35 IAC 620 Proposed New Constituents and MCLs

The amendments propose the addition of 10 chemicals:

CONSTITUENT	Class I (ug/L)	Class II (ug/L)
•Aluminum	1900	none
•Lithium	40	2500
•1-Methylnaphthalene	270	270
•Molybdenum	19	50
•Perfluorobutane Sulfonic Acid (PFBS)	1.2	1.2
•Perfluorohexane Sulfonic Acid (PFHxS)	0.077	0.077
•Perfluorononanoic Acid (PFNA)	0.012	0.012
•Perfluorooctanoic Acid (PFOA)	0.002	0.002
•Perfluorooctane Sulfonic Acid (PFOS)	0.0077	0.0077
•Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	0.012	0.012

- The Proposed Rule Also Eliminates the Definition of Practical Quantitation Limit (PQL)

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Major USEPA Actions

- **May 2016: Drinking Water Health Advisories Issued for PFOS and PFOA (70 ppt)**
- December 2019: Interim Groundwater Cleanup Levels for PFOS/PFOA for CERCLA and RCRA Corrective Action
- March 2020: SDWA Preliminary Regulatory Determination for PFOA/PFOS
- **May 2020: EPA Final Rule adding 172 PFAS compounds to Toxic Release Inventory**
- June 2020: TSCA Significant New Use Rule for PFAS
- **November 2020: Interim Strategy for PFAS in NPDES Permits**
- December 2020: Interim Guidance on Destroying and Disposing of Certain PFAS and PFAS Containing Materials That Are Not Consumer Products
- January 2021: ANPRM - Addressing PFOA and PFOS in the Environment: Potential Future Regulation Pursuant to CERCLA and RCRA (Advance notice of proposed rulemaking)
- January 2021: PFBS Toxicity Assessment (withdrawn February 9, 2021), re-issued April 8, 2021
- **June 2021: Began rule development for designating PFAS/PFOA as CERCLA hazardous substances**
- **October 2021: PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024**
- **October 2021: Initiate process to add 4 PFAS chemicals as RCRA hazardous constituents**
- December 2021: Expanded PFAS monitoring in drinking water 2023-2025 (UCMR 29 PFAS compounds)

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USEPA PFAS Strategic Roadmap 2021-2024

USEPA PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024 (Published on 10/18/2021)	2022				2023				2024			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
Office of Chemical Safety and Pollution Prevention												
Published national PFAS testing strategy												
Ensure a robust review process for new PFAS												
Review previous decisions on PFAS												
Close the door on abandoned PFAS and uses												
Enhance PFAS reporting under TRI												
Finalize new PFAS reporting under TSCA Section 8												
Office of Water												
Nationwide monitoring for PFAS in DW, final rule (Fall 2021), monitoring (2023-2025)												
Establish primary DW regulation for PFOS and PFOA			Proposed				Final					
Leverage NPDES permitting to reduce PFAS discharge to waterways												
Publish final tox assessment for Gen X and 5 additional PFAS												
Publish health advisories for GenX and PFBS												
Restrict PFAS discharges from industrial sources through effluent limitations guidelines program												
Publish multi-lab validated analytical method for 40 PFAS												
Publish updated PFAS analytical methods to monitor DW												
Publish final recommended ambient water quality criteria for PFAS												
Monitor fish tissue for PFAS from nation's lakes and evaluate human biomarkers for PFAS												
Finalize list of PFAS for use in fish advisory programs												
Finalize risk assessment for PFOS and PFOA in biosolids												
Office of Land and Emergency Management												
Propose to designate certain PFAS as CERCLA haz substances	Propose d					Final						
Issue advance notice of proposed rulemaking on various PFAS under CERCLA												
Issue updated guidance on destroying and disposing of certain PFAS and PFAS containing materials												
Office of Air and Radiation												
Build the technical foundation to address PFAS air emission												
Office of R&D												
Develop and validate methods to detect and measure PFAS in the environment												
Advance the science to assess human health and environmental risks from PFAS												
Evaluate and develop technologies for reducing PFAS in the environment												

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2022 Summary of States With DW and/or GW PFAS Standards or Guidance - 22

					PFAS Analyte Concentration (µg/L) and CAS RN					
	Year Last Updated	Standard / Guidance	Type	Promulgated Rule (Y/N/O)	PFOA	PFOS	PFNA	PFBS	PFHxS	HFPO-DA (Gen-X)
USEPA	2016	Health Advisory	DW	N	0.070	0.070				
	2019	Screening Level, CERCLA sites	GW	N	0.040	0.040				
Alaska	2016	CL	GW	Y	0.400	0.400				
California	2021	RL (CA)	DW	Y	0.010	0.040		5		
Colorado	2020	Translation Levels	GW/SW	Y	0.070	0.070	0.070	400	0.700	
Hawaii	2020	EAL	Protected GW	Y	0.040	0.040	0.0044	40	0.019	0.016
Illinois	2021	Health-based Guidance	DW	N	0.002	0.014	0.021	2.1	0.14	0.021
Illinois	**2022**	**Proposed Rulemaking**	**GW**	**Ongoing**	**0.002**	**0.0077**	**0.012**	**1.2**	**0.077**	**0.012**
Indiana	2019	SL (tap)	Protected GW	Y				400		
Iowa	2016	Statewide Standards	Protected GW	Y	0.070	0.070				
Maine	2021	RAG	GW	O	0.070	0.070	0.070	400	0.070	
Massachusetts	2020	MCL	DW	Y	0.020	0.020	0.020		0.020	
Michigan	2021	MCL/GCC	DW/GW	Y	0.008	0.016	0.006	0.420	0.051	0.370
Minnesota	2018	HRL - chronic	DW/GW	Y	0.035	0.300		7		
Montana	2019	Water Quality Standard	GW	Y	0.070	0.070				
New Hampshire	2019	AGQS	GW/DW	Y	0.012	0.015	0.011		0.018	
New Jersey	2022	MCL	GW/DW	Y, N	0.014	0.013	0.013			
New York	2020	MCL	DW	Y	0.010	0.010				
North Carolina	2006	IMAC	GW	Y	2					
Ohio	2022	Action Level	DW	O	0.070	0.070	0.021	2.1	0.140	0.002
Oregon	2011	IL	SW	Y	24	300	1			
Rhode Island	2017	GQS	DW/GW	Y	0.070	0.070				
Texas	2021	Tier 1 PCL	GW	Y	0.290	0.560	0.290	34	0.093	
Vermont	2020	MCL	DW/GW	Y	0.020	0.020	0.020		0.020	
Washington	2021	SAL	DW	Y	0.010	0.015	0.009	0.345	0.065	

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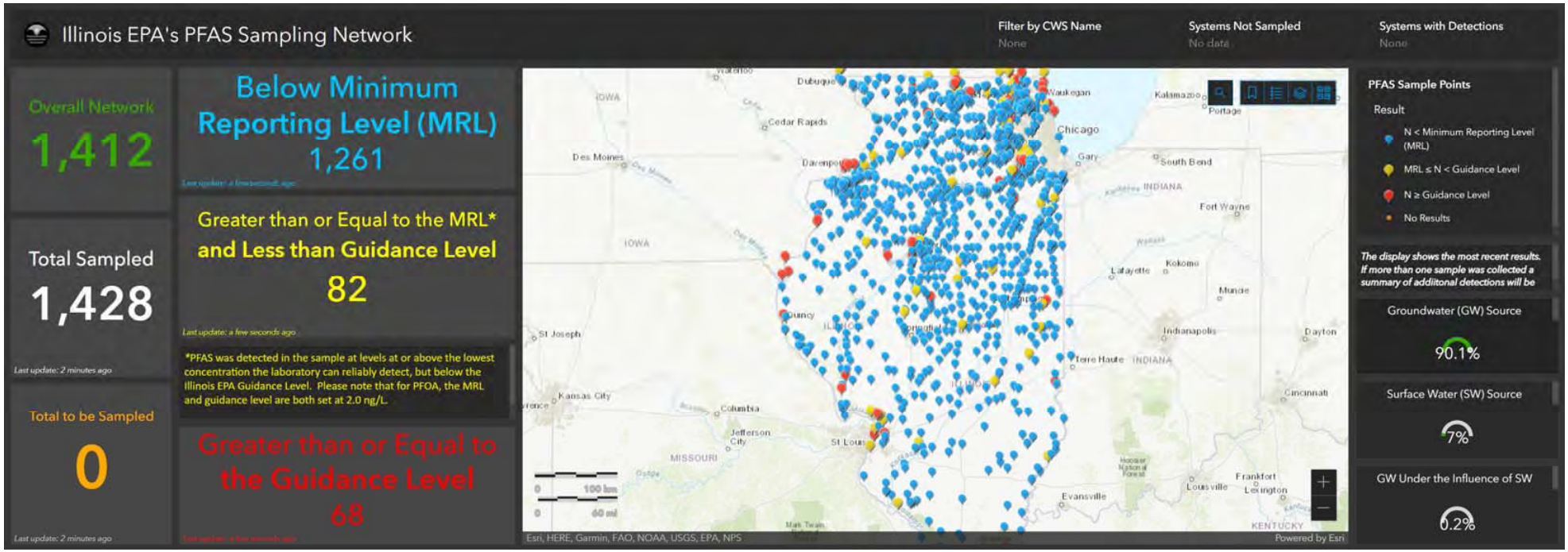
Illinois EPA PFAS Statewide Community Water Supply Sampling

- Sampled 1,428 systems for 18 PFAS compounds
- Issued statewide Health Advisories for six PFAS compounds based on results



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OPERATIONAL AND ECONOMIC IMPACTS TO LANDFILLS AND OTHER INDUSTRY

IMPLEMENTATION OF PFAS STANDARDS TO 35 IAC PART 620 WILL REQUIRE THE FOLLOWING:

1. **Determination of background concentrations or AGQSs/MAPCs**
   a. **Multiple sampling events for multiple upgradient wells**
   b. **Sampling of wells with intrawell values**
   c. **Appropriate laboratory methods**
   d. **Limited laboratories capable of appropriate testing methods**
2. **Validation of detections in background wells**
   a. **Cross contamination from well materials, pumps, tubing, other sampling equipment**
   b. **Potential resampling**
3. **Calculation of background concentrations/AGQSs/MAPCs**

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OPERATIONAL AND ECONOMIC IMPACTS TO LANDFILLS AND OTHER INDUSTRY

4. Leachate analyses

a. **Cross contamination**

b. **Matrix interferences**

c. **Validation issues**

d. **Other ramifications include source concentrations for the GIA**

5. Groundwater Impact Assessment

a. **To be evaluated during the first permit renewal after approval**

b. **Ultra conservative approach to model parameters not required by other states or environmentally justified**

6. Contingent remediation plan

a. **Predicted failure of Groundwater Impact Assessment**

b. **Must be designed with cost included in financial assurance**

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OPERATIONAL AND ECONOMIC IMPACTS TO LANDFILLS AND OTHER INDUSTRY

10. Leachate Disposal and Treatment

a. **POTWs refusal to receive leachate – THIS IS A SIGNIFICANT RISK – The USEPA is developing Effluent Limit Guidance**

b. **Landfills refusal to accept POTW sludge**

c. **Potential Need for onsite pre-treatment facilities**

d. **What will surface water discharge limits be?**

e. **How will antidegradation assessments be impacted (discharge process permitting process)**

11. Impacts to Other Regulations with Potential Impacts to Landfills

a. **Site Remediation Program (SRP)**

b. **Tiered Approach to Corrective Action Objectives (TACO)**

c. **Clean Construction or Demolition Debris Fill Operation (CCDD)**

d. **IDOT – significant influx of contaminated soils typically suitable for a CCDD site**

Characterization of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Landfill Leachate and Preliminary Evaluation of Leachate Treatment Processes

(FINAL)

Submitted October 31, 2019
(updated December 11, 2019)

Authors

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Report # 11960

PROJECT TITLE: Characterization of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Landfill Leachate and Preliminary Evaluation of Leachate Treatment Processes

PRINCIPAL INVESTIGATOR: Helena Solo-Gabriele, Professor
AFFILIATION: University of Miami, Dept. of Civil, Arch., & Environ. Engineering
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PROJECT WEBSITE: http://www.coe.miami.edu/hmsolo/?page_id=769.

PROJECT DURATION: September 1, 2017 to August 31, 2019

ABSTRACT: Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are fluorine-containing chemicals that are found in many products that are stick and stain resistant. The most studied of the PFAS are perfluorooctanoic acid (PFOA) which is used to make Teflon, and perfluorooctane sulfonate (PFOS), a breakdown product of a common water resistant chemical known as Scotchgard. Although used widely, only recently have their human health impacts been recognized. Studies have linked PFOA and PFOS to thyroid and liver diseases, diseases of the immune system, and cancer. Due to their wide ranging usage in consumer products, landfills represent a logical end-of-life reservoir for PFAS. The objectives of this study are to evaluate the concentrations of PFAS in leachates from Florida landfills and to assess the capacity of current treatments to remove PFAS from leachate. Leachate samples will be collected from landfills in the State of Florida and from the effluent of leachate treatment facilities. These samples are to be analyzed with LC-MS/MS for PFAS. Data on leachate volumes and treatment data will be consolidated for landfills in the State of Florida. From this literature information coupled with leachate measurements, a preliminary assessment will be made about the effectiveness of existing leachate treatment strategies in reducing PFOA and PFOS levels. In an effort to broadly assess the health risks associated with the PFAS, results from leachate measurements will be compared to the U.S. Environmental Protection Agency's PFAS health advisory of 0.07 parts per billion. Results can be used by regulators to assess whether treatment systems are needed to remove PFAS from landfill leachates in Florida.

Key words: Perfluoroalkyl and polyfluoroalkyl substances (PFAS), leachate, landfills, PFOS, PFOA.

METRICS REPORTING
This page will be omitted from the report when it is published.

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Metrics:

1. Research publications from this Hinkley Center Project.
   - Helena Solo-Gabriele, Athena Jones, Hekai Zhang, Johnsie Lang, 2019. Perfluoroalkyl substances in landfill leachates produced from different waste types. Abstracts from the American Chemical Society Spring 2019 National Meeting & Expo, Orlando, FL, April 2019. https://tpa.acs.org/abstract/acsnm257-3110261/perfluoroalkyl-substances-in-landfill-leachates-produced-from-different-waste-types
   - Solo-Gabriele, H.M., Jones, A.S., Lindstrom, A.B., Lang, J.R., 20XX. Per- and polyfluoroalkyl Substances in Landfill Leachates Produced from Different Waste Types. In review.

2. Research presentations resulting from this Hinkley Center Project.
   - "Characterization of Per- and Poly-fluoroalkyl Substances (PFAS) in Landfill Leachate and Preliminary Evaluation of Leachate Treatment Processes." Hinkley Center for Solid and Hazardous Waste Management Advisory Board Meeting, Orlando, Florida, September 28, 2018. (Speaker presentation by H. Solo-Gabriele)
   - "What are Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) and an Update of Studies Focused on Evaluating Landfill Leachate." Sponsored by the Florida Section of the American Water Works Association, Webinar, September 26, 2018 (Speaker presentation by H. Solo-Gabriele)
   - "Perfluoroalkyl substances in landfill leachates produced from different waste types." American Chemical Society Spring 2019 National Meeting & Expo, Orlando, FL, April 2019. (speaker presentation by H. Solo-Gabriele)

3. List who has referenced or cited your publications from this project. Drs. Solo-Gabriele and Townsend's research on treated wood is highly cited. Please see Google Scholar for citation details about their publications.
   For Solo-Gabriele: https://scholar.google.com/citations?hl=en&user=zvpDSPoAAAAJ

For Townsend: https://scholar.google.com/citations?hl=en&user=PqujfgkAAAAJ

4. How have the research results from this Hinkley Center project been leveraged to secure additional research funding?
   - The U.S. Environmental Protection Agency (EPA), Research Triangle Park (RTP) provided analytical support to this project by analyzing the samples free of charge. The analysis included the measurement of 11 PFAS species within 22 samples. The estimated in-kind contribution of this support was estimated at $6,000.

   - During the Fall of 2018 an RFP was issued entitled, "Practical Methods to Analyze and Treat Emerging Contaminants (PFAS) in Solid Waste, Landfills, Wastewater/Leachates, Soils, and Groundwater to Protect Human Health and the Environment." We (Townsend as PI) submitted a proposal to the U.S. EPA in response to this call and we heard back that the proposal will be funded. The title is: A Systems-Based Approach to Understand the Role of Waste Type, Management Strategies and Treatment Methods on the Occurrence, Source, and Fate of PFAS in Landfills. The duration is for three years. The start date is estimated at October 2019.

5. What new collaborations were initiated based on this Hinkley Center project?
   - We restarted our UM/UF collaboration. Drs. Solo-Gabriele and Townsend collaborated for decades on the CCA-treated wood research. This first year of PFAS funding helped to re-initiate that collaboration by providing the ability to apply for much larger grants. This current project resulted in background data that permitted for large collaborative proposals that could support faculty and students at both UM and UF.
   - As a result of this project we have developed strong relationships with both EPA-RTP and EPA-ORD. We are very grateful for the relationships with both groups. The relationship with EPA-RTP did facilitate the relationship with EPA-ORD as the data collected from this first Hinkley PFAS project was presented to the EPA which in turn transitioned into the second EPA relationship, this time with ORD.
   - We have established collaborations with landfill operators at the 5 landfills included in this study. Many more collaborations are being established with landfill operators as we prepare for the second Hinkley PFAS project.
   - We have established a collaboration with the FDEP through communications via the TAG. The FDEP has provided assistance in accessing their Solid Waste Universe and Oculus databases.
   - The TAG committee has been very supportive of this project participating in TAG meetings and assisting the research team in making connections to other groups and encouraging research exchange meetings.

6. How have the results from this Hinkley Center funded project been used by the FDEP or other stakeholders.
   - PFAS as a landfill contaminant is relatively new. At the national level the EPA is gathering background information for potential decision-making concerning PFAS in landfill leachates. The national initiatives have also facilitated awareness among the FDEP who, in turn, have exhibited a strong interest in the results.

- Landfill operators have been contacting the research group proactively asking about their individual landfill results. There is clearly a strong interest among landfill operators due to concerns about potential regulations at wastewater treatment plants.

ACKNOWLEDGEMENTS

- This project was funded by the Hinkley Center for Solid and Hazardous Waste Management. In-kind support has been provided by the EPA-RTP.
- We are thankful to all of the student researchers that worked on this project. They are all listed as authors on this report (Athena Jones, Hekai Zhang, Yutao Chen, and Matthew Roca).
- We thank all landfill operators that allowed us to collect samples at their site and also those who shared their knowledge of their landfill operations.
- We are thankful to the experts at EPA-RTP who shared their wealth of PFAS knowledge with the team. We are particularly thankful to Dr. Johnsie Lang who facilitated the sample analysis and took team members through the sample analysis process at the EPA-RTP laboratories during January and July 2018. We are thankful to Dr. Mark Strynar for the opportunity to utilize his laboratory for the pre-processing and analysis of samples. We are thankful to Dr. Andrew Lindstrom for sharing his knowledge about PFAS.
- We are grateful to all of the Technical Awareness Group (TAG) members listed in the following table, plus the individuals who took part in the TAG meetings who are listed in the table that follows for participating in meetings and for their input and feedback.

RESEARCH TEAM MEMBERS

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Hekai Zhang	Graduate Student University of Miami
Yutao Chen	Graduate Student University of Miami
Matthew Roca	Undergraduate Student University of Miami

HINKLEY CENTER

Name	Affiliation and Address
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Wester W. Henderson III	Research Coordinator III
Tim Vinson	Research Coordinator

TECHNICAL AWARENESS GROUP (TAG) MEMBERS. Note: Participation in the TAG group does not imply an endorsement of the research. The TAG group are individuals who are interested in the research and are capable and willing to provide input. This input is considered by the research team as the research project progresses.

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Ashley Danley-Thomson, Ph.D.	Assistant Professor at Florida Gulf Coast University with research that relates to PFAS
Weiland Uchdorf, Ph.D.	Facility Engineer, Resources Recovery Facility, Department of Solid Waste Management, Miami-Dade County 6990 NW 97th Ave, Miami, Fl 33178

TAG MEETING PARTICIPANTS. Note: Participation in the TAG meetings does not imply an endorsement of the research.	
Name	**Affiliation**
MEETING 1 (In Person)	
Athena Jones	University of Miami
Helena Solo-Gabriele	University of Miami
Madeline Keep	University of Miami
Wes Henderson	Hinkley Center for Solid and Hazardous Waste Management
Weiland Uchdorf	Department of Solid Waste Management, Miami-Dade County, Resources Recovery
MEETING 1 (On-Line)	
Cory Dilmore	Florida Dept. of Environmental Protection, Permitting and Compliance, Tallahassee, FL
Eric Charest	Indian River County Utilities, Environmental Compliance
Elizabeth Foeller	Waste Management Inc., Environmental Protection
Himanshu Mehta	Indian River County Utilities, Environmental Compliance
Hilary Thornton	U.S. EPA Region 4, Superfund Division
Joe Dertian	Florida Department of Environmental Protection, Solid Waste, Tallahassee, FL
Johnsie Lang	Orise Fellow stationed at Research Triangle Park, EPA
Joseph O'Neill	Hillsborough County, Solid Waste Management Division
Rula Deeb	Geosyntec Consultants
Ramana Kari	Solid Waste Authority of Palm Beach County
Richard Meyers	Broward County Solid Waste and Recycling
Thabet Tolaymant	U.S. EPA Emerging Materials and Sustainability, Chemical Safety for Sustainability
MEETING 2	
Dr. Meeroff	Florida Atlantic University
Amede Dimonnay	Broward County Environmental Engineering and Permitting Division
Amy Hightower	
Athena Jones	University of Miami
Ashley Danley-Thomson	Florida Gulf Coast University
Bishow Shaha	Florida Atlantic University
David Meyers	
Dave Phillips	Florida Dept. of Environmental Protection
Dan Schauer	Geosyntec Consultants
Elisabeth Hawley	Geosyntec Consultants
El Kromhout	Florida Dept. of Environmental Protection
Helena Solo-Gabriele	University of Miami
Hilary Thornton	EPA Project Manager in EPA Region 4

TAG MEETING PARTICIPANTS. (Cont'd) Note: Participation in the TAG meetings does not imply an endorsement of the research.	
Name	**Affiliation**
MEETING 2 (Cont'd)	
Johnsie Lang	Orise Fellow stationed at Research Triangle Park, EPA
John Merrill	Geosyntec Consultants
James Telson	Solid Waste Authority of Palm Beach County
Kavitha Dasu	Battelle
Laura Barrett	Florida Dept. of Environmental Protection
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Mark Eyeington	Solid Waste Authority of Palm Beach County
Md Fahim Salek	Florida Atlantic University
Manuel Hernandez	SCS Engineers
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Neil Coffman	Florida Atlantic University
Nate Mayer	Solid Waste Authority of Palm Beach County
Nicole Robey	University of Florida
Ramana Kari	Solid Waste Authority of Palm Beach County
Robert Sterner	
Rohan Sethi	Florida Atlantic University
Ram Tewari	Arcadis
Sharmily Rahman	
Wester Henderson	Hinkley Center for Solid and Hazardous Waste Management
MEETING 3 (In Person)	
Fangmei Zhang	Miami-Dade Department of Environmental Resources Management
Helena Solo-Gabriele	University of Miami
Hekai Zhang	University of Miami
John Schert	Hinkley Center for Solid and Hazardous Waste Management
Lee Casey	SCS Environmental Consultants and Contractors
Liz Foeller	Waste Management Inc.
Malak Anshassi	University of Florida
Mario Porcelli	Miami-Dade County, Department of Solid Waste Management
Timothy Townsend	University of Florida
Viraj da Silva	SCS Environmental Consultants and Contractors
Weiland Uchdorf	Miami-Dade County Department of Solid Waste Management
Yutao Chen	University of Miami
Yalan Liu	University of Florida
Yanett Rodriguez	Miami-Dade County Department of Solid Waste Management

TAG MEETING PARTICIPANTS. (Cont'd) Note: Participation in the TAG meetings does not imply an endorsement of the research.	
Name	**Affiliation**
MEETING 3 (On-Line)	
Amede Dimonnay	Broward County Environmental Engineering and Permitting Division
Ashley Danley-Thomson	Florida Gulf Coast University
Bob Curtis	SCS Engineers
Bryan White	Manatee County
Caroline Devitt	SCS Engineers
Cory Dilmore	Environmental Administrator, Florida DEP
David Broten	Solid Waste Authority of Palm Beach County
Eric Charest	Indian River County Department of Utility Services
Gail DeRuzzo	Battelle
Hilary Thornton	EPA Project Manager in EPA Region 4
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Kavitha Dasu	Battelle
Kevin Vann	CDM Smith
Linda Monroy	Lee County
Larry Ruiz	Hillsborough County Solid Waste
Lois Rose	Sarasota County Solid Waste
Lynn Zender	Zender Environmental Health and Research Group
Morton Barlaz	North Carolina State University
Mark Culbreth	Environmental Consulting & Technology
Nicole Robey	University of Florida
Page Jordan	Oak Ridge Institute for Science and Education
Robert Curtis	SCS Engineers
Robert Graessel	Miami Dade County Dept of Solid Waste Management
Richard Meyers	Davie and Broward County
Rebecca Rodriguez	Lee County
Sam Levin	s2li Consultants
Sean Peterson	Zender Environmental Health and Research Group
Shaopeng Xu	University of Florida
Teresa Booeshaghi	Florida Department of Environmental Protection
Tim Bahr	Florida Department of Environmental Protection
Terry Cerullo	Florida Department of Environmental Protection
Thomas Mulligan	Brevard County Solid Waste Management Department
Thomas Smallwood	University of Florida
Wes Henderson	Hinkley Center for Solid and Hazardous Waste Management

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LIST OF ABBREVIATIONS AND ACRONYMS

5:3 FTCA	5:3 Fluorotelomer Carboxylic Acid
AFFF	Aqueous Film Forming Foam
ASDWA	Association of State Drinking Water Administrators
ATSDR	Agency for Toxic Substances and Disease Registry
BOD	Biochemical Oxygen Demand
C&D	Construction and Demolition
C_2F_6	Hexafluoroethane
CCA	Chromated Copper Arsenate
C-F	Carbon-Fluorine Bond
CF_4	Tetrafluoromethane
COD	Chemical Oxygen Demand
CWB	California Water Boards
EFSA	European Food Safety Authority
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FPePA	3-Perfluoropentyl Propanoic Acid
FTA-MXA	Native Telomer Mix
FTOH	Fluorotelomer Alcohol
GC	Gas Condensate
HCSHWM	Hinkley Center for Solid and Hazardous Waste Management
HDPE	High-Density Polyethylene Resin
LC-MS/MS	Liquid Chromatography with Tandem Mass Spectrometry
MeOH	Methyl Alcohol
MSW	Municipal Solid Waste
MSWA	Municipal Solid Waste Ash
ND	Not Detected
OECD	Organization for Economic Co-operation and Development
ORD	Office of Research and Development
PFAC-MXA	Fluorinated Acid/Sulfonate Mix

PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
PFBA	Perfluorobutanoic Acid
PFBS	Perfluorobutanesulfonic Acid
PFDA	Perfluorodecanoci Acid
PFHpA	Perfluoroheptanoic Acid
PFHxA	Perfluorohexanoic Acid
PFHxS	Perfluorohexanesulfonic Acid
PFNA	Perfluorononanoic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate/ Perfluorooctanesulfonic Acid
PFPeA	Perfluoropentanoic Acid
PI	Project Investigator
RFP	Request for Proposal
RTP	Research Triangle Park
SPE	Solid Phase Extraction
TAG	Technical Awareness Group
TDS	Total Dissolve Solids
TOC	Total Organic Carbon
TOF-LC/MS	Time of Flight-Liquid Chromatograph/Mass Spectrometer
TS	Total Solids
UF	University of Florida
UM	University of Miami
UNEP	United Nations Environment Program
US EPA	U.S. Environmental Protection Agency
WWTP	Wastewater Treatment Plant

UNITS OF MEASURE

$	Dollars
%	Parts per hundred
^{o}C	Degrees Celsius
g	Grams
kg	Kilograms
kg/year	Kilograms per year
L	Liter
mg	Milligrams
mg/L	Milligrams per liter
mL	Milliliter
mM	Millimolar/ Millimole per liter
ng	Nanograms
ng/L	Nanograms per liter
pH	Measure of the hydrogen ion activity
ppb	Parts per billion
µL	Microliter
µl/min	Microliter per minute

EXECUTIVE SUMMARY

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) are found in many consumer products which will be ultimately disposed in landfills. Limiting exposures will require managing leachates from different types of landfills, each with different PFAS levels depending upon the source of the waste. This study evaluated 11 PFAS species (7 carboxylic acids, 3 sulfonic acids, and 5:3 FTCA) in different types of landfill leachates: municipal solid waste (MSW), construction and demolition (C&D), MSW ash (MSWA), and MSWA with landfill gas condensate (GC). Leachates were also analyzed before and after onsite treatment at two of these facilities. Results indicate that MSWA leachate had significantly lower PFAS levels relative to other leachate types. The correlation between total PFAS and incineration temperature for the ash leachates was significant, with lower total PFAS concentration associated with an increase in incineration temperature. The levels of PFASs in untreated C&D and untreated MSW leachate were similar suggesting that both waste sources are a significant source of PFAS. This is particularly relevant since some C&D landfills in Florida are not lined.

In this study, leachates at two treatment facilities were evaluated. The treatment systems were both designed for ammonia removal via aeration, one was a continuous flow through system and the other was a batch reactor. The continuous flow through system treated leachate that consisted primarily of MSWA. The batch reactor treated predominantly MSW leachate. Results show that the levels of targeted PFAS species in MSW leachate from the continuous flow through system did not change - with effluent concentrations similar to influent concentrations. For the batch reactor, the concentration of PFAS increased in the effluent (after treatment) presumably due to the conversion of PFAS precursors in the untreated leachate sample.

In summary results from this study serve as a starting point for assessing landfill leachates in the State of Florida. The fact that MSWA had lower total PFAS levels should be further evaluated to determine if the lower levels are due to destruction of PFAS as opposed to conversion to a PFAS form that was not measured. More samples should be collected to evaluate the influence of incineration temperature on PFAS species, as incineration may serve as one alternative for the removal of PFAS from the environment. Further study should be conducted to evaluate whether other leachate treatment strategies are effective at removing PFAS.

Overall, the results from this study can be useful to waste managers as well as legislators in the State of Florida when making decisions about the disposal and treatment of landfill leachate that may be contaminated with PFAS.

CHAPTER I

MOTIVATION, OBJECTIVES, AND BACKGROUND

CHAPTER I

MOTIVATION, OBJECTIVES, AND BACKGROUND

This chapter focuses on describing the motivation and objectives (Section I.1) and the project background (Section I.2) for this study.

I.1 MOTIVATION AND OBJECTIVES

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) are fluorine-containing chemicals that are found in many products that are stick and stain resistant. The most common of the PFASs are perfluorooctanoic acid (PFOA) which is used to make Teflon, and perfluorooctane sulfonate (PFOS), a breakdown product of a common water-resistant chemical known as Scotchgard. Although used widely, only recently have their human health impacts been recognized. Studies have linked PFOA and PFOS to thyroid and liver diseases, diseases of the immune system, and cancer. Due to their wide-ranging usage in consumer products, landfills represent a logical end-of-life reservoir for PFASs. The objectives of this study are to evaluate the concentrations of PFASs in leachates from Florida landfills and to assess the capacity of current treatments to remove PFASs from leachate. Leachate samples will be collected from landfills in the State of Florida and from the effluent of leachate treatment facilities. These samples are to be analyzed with LC-MS/MS for PFASs. Data on leachate volumes and treatment data will be consolidated for landfills in the State of Florida. From this literature information coupled with leachate measurements, a preliminary assessment will be made about the effectiveness of existing leachate treatment strategies in reducing PFOA and PFOS levels. In an effort to broadly assess the health risks associated with the PFASs, results from leachate measurements will be compared to the U.S. Environmental Protection Agency's PFASs health advisory of 0.07 parts per billion. Results can be used by regulators to assess whether treatment systems are needed to remove PFASs from landfill leachates in Florida.

The goal of this study is to assess the degree to which Florida landfills can inadvertently contribute towards the cycling of PFASs. To address this goal, this proposal has two objectives. The first objective will focus on documenting the levels of PFOA, PFOS, and their precursors in landfill leachates within the State of Florida. These measurements will be used to determine if, and by what factor, concentrations exceed the EPA health advisory levels. The second objective will focus on a preliminary assessment of the effectiveness of currently available treatment processes for PFOA and PFOS removal from landfill leachate.

I.2 BACKGROUND

I.2.1 Introductory Chemistry

Fluorine is the most electronegative element meaning that it has the strongest tendency to form a bonded pair of electrons when it forms a compound. The "shared electrons" or covalent bonds between carbon and fluorine are the strongest in organic chemistry making carbon-fluorine (C-F) compounds resistant to hydrolysis, photolysis, and biodegradation (US EPA 2014b). The class of fluorinated substances that are the topic of this proposal include a carbon chain (alkyl) with a functional group on one end. The carbon chain of each molecule is either partly or fully fluorinated. If less than 100% of the carbon is bonded with fluorine the prefix "**poly**fluorinated" is used. If 100% of the carbon in the chain is bonded with fluorine the prefix "**per**fluorinated" is used (Buck et al. 2011).

The two Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs) that are the primary focus of this research are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) (Figure I.1). The length of the carbon chain in both compounds is 8 carbon atoms. The PFOA has a carboxylic acid functional group attached to the carbon chain, whereas PFOS has a sulfonatic acid functional group attached to its carbon chain (Figure I.1),

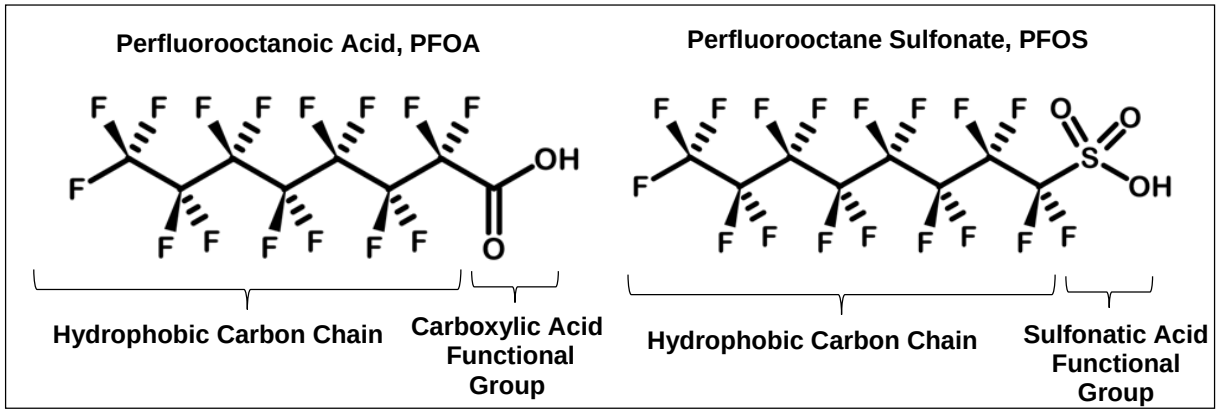


Figure I.1 Structure of PFOA and PFOS emphasizing the carbon chain and functional groups.

I.2.2 Persistence

One of the challenges of managing PFASs is their persistence in the environment. This persistence is largely due to their strong C-F bonds. PFOA and PFOS are particularly persistent due to their hydrophobic fluorinated carbon chain and a hydrophilic functional group which binds to surfaces (Figure I.1). The fluorinated chain is what makes these PFASs water resistant and an ideal chemical for use in products such as food packaging, non-stick pans, and rain protection gear. Studies have shown that PFASs do not degrade by typical environmental processes including hydrolysis, photolysis, and biodegradation (US EPA 2014b, Schultz et al. 2003, OECD 2002). The

half-life of PFOS in water is over 41 years at 25 °C and the half-life of PFOA in water of the same temperature is over 92 years (ATSDR 2009; Brooke et al. 2004; EFSA 2008; Environment Canada 2012; US EPA 2002b; OECD 2002; UNEP 2006). PFOA and PFOS have been manufactured since the late 1940s. Therefore PFOA and PFOS included in consumer products since this time are likely to still be in the environment, with landfills serving as a significant repository.

Moreover, PFOA can be formed from the degradation of other fluorinated compounds (US EPA, 2017a). One notable category is fluorotelomer-based polymers which are used in paper intended for contact with food (Figure I.2). Fluorotelomers are used in wrappers for fast food, pizza box liners, granola wrappers, and microwave popcorn bag liners. The fluorotelomer-based polymers persist for decades in the environment and are believed to represent a long-standing reservoir of PFOA (Washington et al. 2015a, b).

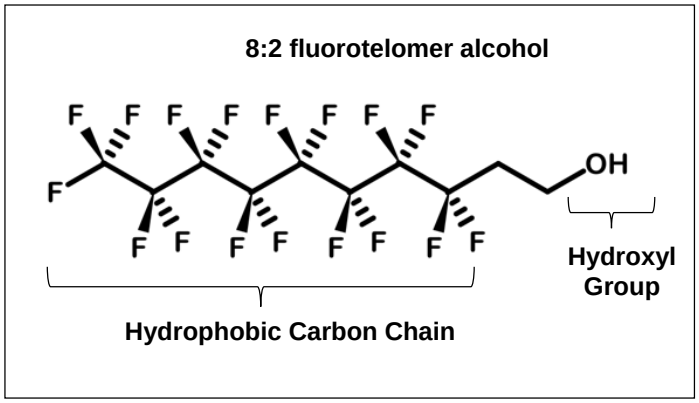


Figure I.2 Example of fluorotelomer polymer (8:2 fluorotelomer alcohol, 8:2 FTOH), a known precursor for PFOA – breaks down in the environment to PFOA.

I.2.3 Health Impacts

The U.S. EPA has currently classified PFOA and PFOS as emerging contaminants because new research suggests that they are linked to adverse human and environmental health impacts (US EPA 2014a). PFOAs can be ingested (Bao et al. 2017, Domingo and Nadal 2017) inhaled (Nilsson et al. 2010), or absorbed through the skin (Franko et al. 2012). Once the PFASs enter the human body, they remain for very long periods of time (half-life of 3 years, Bartell et al. 2010, Steenland et al. 2010). Studies have found that >99% of Americans' blood serum contains detectable levels of PFASs (Calafat et al. 2007). Since the recognition of PFOA accumulation in human blood serum, many animal and human epidemiologic studies have been conducted. Studies on rodents have shown that blood serum PFOA is associated with thyroid diseases, B-cell and T-cell immune responses, atrophy of spleen and thymus, enlarged liver, and liver cancer (Yang et al. 2002) Epidemiologic studies of human populations have found that PFOA in blood serum is associated with thyroid dysfunction (Li et al. 2017b), asthma and impaired lung function (Qin et al. 2017),

and kidney cancer (Li et al. 2017a). The U.S. EPA has identified PFOA to be a likely human carcinogen (US EPA 2014b).

In response to the suspected health impacts, the EPA has facilitated the phase out of PFOA from eight primary U.S. manufacturers as of 2015 and PFOS was phased out in 2002 from its single U.S. manufacturer (US EPA 2017). EPA has not yet established drinking water regulations for PFOA and PFOS. Given the large body of literature that speaks to the potential adverse health effects, PFOA and PFOS will likely be regulated to prevent exposure to the public and the environment. In the interim the EPA has issued, effective May 2016, a non-enforceable health advisory of 0.07 parts per billion for the sum of PFOA and PFOS (U.S. EPA 2016).

The EPA response above does not directly address the fluorotelomer-based polymer precursors which degrade to PFOA. At wastewater treatment plants it has been documented that levels of PFOA increase through the treatment system (Arvaniti and Stasinakis et al. 2015) due to the degradation of fluorinated precursors in wastewater (Xiao et al. 2012). The PFOA in the water generally accumulates in sewage-biosolids whose ultimate disposition is for use on agricultural fields and within landfills where it can be released over time into leachates. Although the direct production of PFOA and PFOS has been addressed through agreements between the EPA and chemical manufacturers, such agreements do not exist for the fluorinated precursors. As such the precursors for PFOA continue to be produced as components of consumer products thereby prolonging the long-term health impacts of PFOA through its circulation within the environment.

I.2.4 Detection of PFASs in the Environment

As far as the extent of recent contamination: PFOS and PFOA have been discovered in low concentrations in remote regions of the arctic ice cap and Antarctica (Lau et al. 2007, Martin et al. 2004, Young et al. 2007, Zhao et al. 2012). In river environments directly downstream of chemical production facilities, concentrations of PFOA are found at very high levels of up to 4534 ng/L in China (Wang et al. 2014) and 19,400 ng/L in Japan (Shiwaku et al. 2016). In rivers **not directly** impacted by industrial discharges, concentrations of PFOA were measured at 2.2 ng/L for rivers in northern Europe (Nguyen et al. 2017), and 46 ng/L for a river that serves as a drinking water source in North Carolina (Sun et al. 2016). In wastewater elevated levels of PFASs are also documented. Within wastewater treatment plants levels of PFOA increase with values from 1-10 ng/L in the influent and 10-100 ng/L in the effluent for a plant in the Netherlands (Bossi et al 2008). In Korean wastewaters levels are higher at 111 ng/L (Kwon et al. 2017). Overall the highest levels are observed in surface waters and sediments downstream of former fluorinated chemical production facilities as well as in wastewater effluent, wastewater biosolids, and landfill leachate (US EPA 2014a). A landfill known to have received waste from PFOA and PFOS industrial processes documented leachate levels as high as 82,000 ng/L and 31,000 ng/L, respectively (Oliaei et al. 2013).

I.2.5 Detection in Municipal Landfill Leachates

For six landfills in the U.S. the levels of PFOA and PFOS were on the order of 1,000 ng/L whereas levels of PFOS were on the order of 100 ng/L (Huset et al. 2011). The general vicinity of the U.S. landfills was identified in the Huset et al. (2011) study as: three from the Mid-Atlantic, one from the U.S. West Coast, one from the Pacific Northwest, and one from the Gulf Coast. All six landfills received biosolids and all but one recirculated leachate. The levels of PFOA and PFOS at the U.S. landfills were consistent with levels measured in leachates from 4 landfills in Spain (Fuertes et al. 2017) and a little higher than those measured at 22 landfills in Germany (Busch et al. 2010). The highest levels were measured in leachates collected from five landfills in China. The PFOA/PFOS concentrations in these leachates were highly variable with the upper limits being a few orders of magnitude higher than those measured in the U.S.

Table I.1 Concentrations (ng/L) of PFOA and PFOS in untreated landfill leachates

	U.S. (Huset et al. 2011)	Finland (Perkola and Sainio 2013)	Spain (Fuertes et al. 2017)	Germany (Busch et al. 2010)	China (Yan et al. 2015)
No. of Landfills	6	2	4	22	5
PFOA	660	170	600	150	280 to 214,000
PFOS	110	110	20	30	1100 to 6000

I.2.6 Conceptualized PFOA and PFOS Life Cycle

Landfills represent a significant reservoir of PFOA and PFOS accumulation from the direct accumulation of consumer products containing PFOA, PFOS, and their precursors and by receiving wastewater biosolids which have been documented to contain these compounds (Figure I.3). Carpet, stain resistant paper, clothing, and other textiles have been implicated as consumer products in landfills that can serve as a direct source of PFASs to landfill leachate (Lang et al. 2016). Bench top reactor studies have found that the release of PFASs from these products into landfill leachate occurs under methane producing conditions (Allred et al. 2015) thereby providing direct evidence that these compounds can be released through landfill leachate. In addition to direct leaching from consumer products, another source of PFASs to landfills is from disposed wastewater biosolids. A U.S. national inventory of biosolids collected in 2001 showed that of the 3000 kg/year of PFASs found in biosolids about 20% was ultimately disposed in landfills with the bulk of the remainder used for agricultural purposes (Venkatesan and Halden 2013).

Given the long persistence of PFOA and PFOS in the environment and what is currently known about its sources, a life cycle has been conceptualized as part of this proposal (Figure I.3). This life cycle identifies two the predominant sources of PFOA, PFOS, and their precursors to landfills as described above. The life cycle also illustrates how the leachates from landfills can be recirculated via wastewater treatment plants. The land applied biosolids at wastewater treatment plants can then impact the food and water supplies thereby impacting human populations through

ingestion. One way to break the cycle and prevent human health impacts is to treat releases from landfills, a reservoir at the heart of our conceptualized PFAS recirculation process.

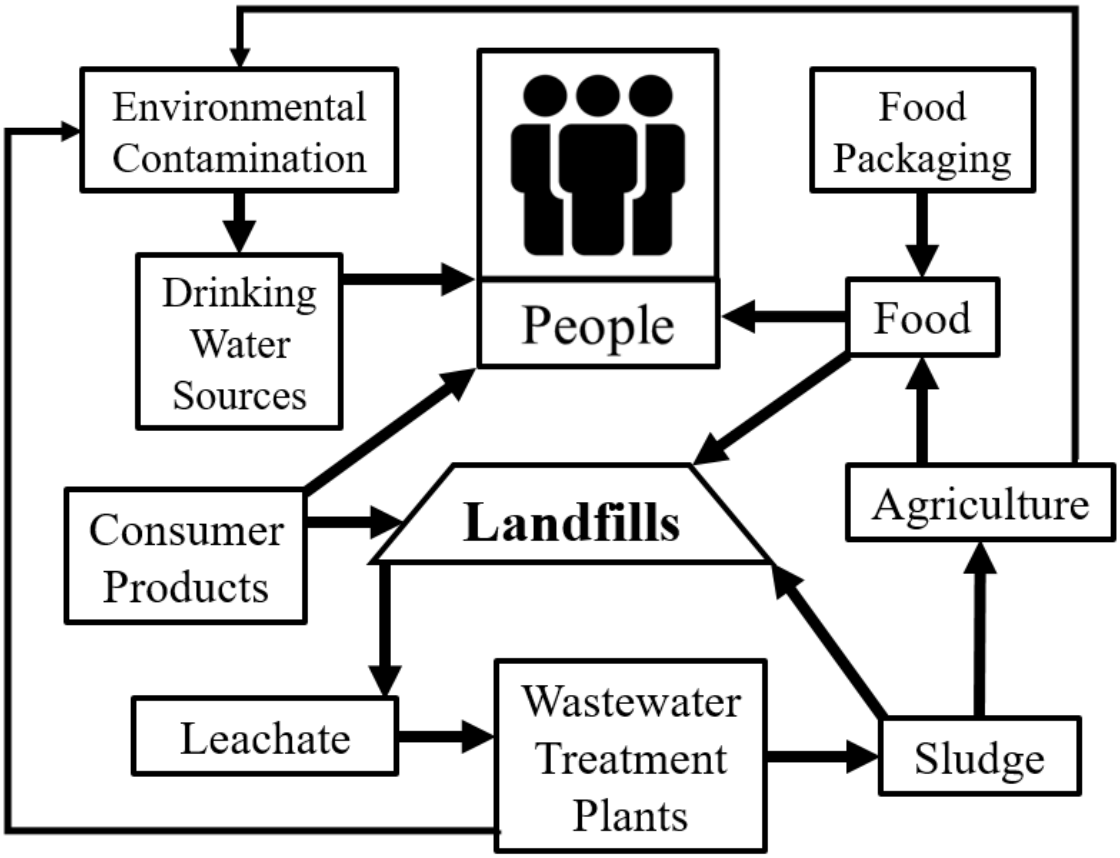


Figure I.3 Conceptualized Life Cycle of PFOA and PFOS and their precursors showing landfills as a significant reservoir and potential source to wastewater treatment plants. Depending upon the wastewater effluent discharge and ultimate use of the biosolids, the PFASs can potentially be inadvertently cycled back to the environment and ingested by humans.

CHAPTER II

PFAS IN LANDFILL LEACHATE AND PRELIINARY ASSESSMENT OF LEACHATE TREATMENT

CHAPTER II

PFAS IN LANDFILL LEACHATE AND PRELIINARY ASSESSMENT OF LEACHATE TREATMENT

II.1 INTRODUCTION

Landfill leachate presents a unique challenge for managing Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) from products that have reached the end of their service life. PFASs are used in many consumer products, including sealants (Favreau et al. 2017), sprays for textiles (Ye et al. 2015), Teflon parts (U.S. EPA 2018), clothing, carpet (Lang et al. 2016), ski waxes (Kotthoff et al. 2015), and in non-stick surfaces such as cookware (U.S. EPA 2018). They are also found in food packaging such as paper food wrappers and cups (Wang et al. 2017, Schaider et al. 2017). Aqueous film forming foam (AFFF) represent another source of PFAS release to the environment (Dauchy et al. 2017, Backe et al. 2013, Houtz et al. 2013). Widespread uses and their resistance to destruction make management of PFASs difficult at the end of their service lives.

The chain of carbon and fluorine bonds in PFASs are persistent due to the highly electronegative nature of fluorine, which results in the strongest bond that is possible with carbon (O'Hagan 2008). As a result of the strong bonds, the C-F chain portion of the molecule is resistant to degradation, including resistance to hydrolysis, photolysis, and biodegradation (U.S. EPA 2014, Schultz et al. 2003, OECD 2002). The half-life of PFOA in water is over 92 years at 25 °C and the half-life of PFOS in water of the same temperature is over 41 years (U.S. EPA 2014).

PFASs have been linked to human health effects. PFASs are found in the blood of over 98% of Americans (Calafat et al. 2007). In in-vivo studies with rodents, PFASs have been linked to thyroid diseases, diseases of the immune system, and have been associated with liver cancer (Yang et al. 2002, Lau et al. 2007). In exposed communities, PFASs have also been linked with thyroid disease (Li et al. 2017b), asthma, impaired lung function (Qin et al. 2017), and cancers of the kidney and bladder (Li et al. 2017a).

As a result of the public health concerns associated with PFASs, the U.S. Environmental Protection Agency (U.S. EPA) has issued effective May 2016 a drinking water health advisory of 70 ng/L for the sum of two PFAS species, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) (U.S. EPA 2016, Hamid et al. 2018). Some U.S. states have adopted stricter drinking water guidelines. For example, Vermont has adopted a guideline of 20 ng/L for the sum of PFOA and PFOS plus three additional species (PFNA, PFHxS, and PFHpA, defined in Figure II.1). Similarly, New Jersey and California have adopted a guideline of 14 ng/L for PFOA and 13 ng/L for PFOS (ASDWA 2019, CWB 2019).

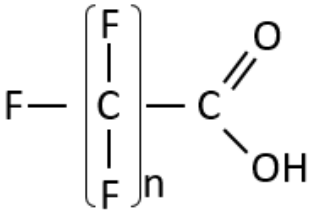
Municipal solid waste (MSW) leachates have been documented with PFOA on the order of 1,000's ng/L and PFOS on the order of 100's ng/L in the U.S. (Huset et al. 2011, Lang et al. 2017, Benskin et al. 2012) and Europe (Fuertes et al. 2017, Busch et al. 2010, Perkola and Sainio 2013). A landfill known to have received waste from PFOA and PFOS industrial processes documented leachate levels as high as 82,000 ng/L and 31,000 ng/L, respectively (Oliaei et al. 2013). The highest levels were measured in leachates collected from five landfills in China with PFOA levels up to 214,000 ng/L and PFOS levels up to 6,000 ng/L (Yan et al. 2015).

The types of landfills used for disposal of waste vary in terms of their composition. MSW landfills in the U.S. that were part of Lang et al. (2017) accepted household waste including organics, cardboard, glass, paper and plastics, whereas in an Austrian study (Gallen et al. 2017) MSW was predominantly organic waste. Gallen et al. (2017) also evaluated a second class of landfills containing cardboard, glass, paper and plastics plus construction and demolition (C&D) wastes (defined as concrete, soil, metals, timber, and plastics). The levels of PFASs observed in the C&D leachates of the Gallen et al. study were 1,400 ng/L for PFOA and 1,100 ng/L for PFOS, on average.

Landfill leachates are typically managed via transfer to a wastewater treatment plant (WWTP). In WWTPs, some PFASs tend to bioaccumulate in the sludge (typically PFAS with >8 carbon fluoroalkyl chains) (Venkatesan and Halden 2013) whereas others, such as the fluorotelomers, can be transformed from one PFAS species to another (e.g., alcohols to carboxylic acids, Xiao et al. 2012). Lang et al. (2017) and Busch (2010) found that while PFAS concentrations were high in leachate, the volume of leachate generated is low compared to WWTP outflows, resulting in a relatively small annual mass release.

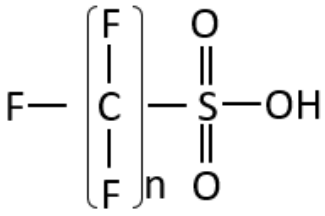
The objective of this study was to analyze the concentrations of 11 PFASs (Figure II.1) in leachate samples from landfills composed of different waste types. Two waste types have never been previously evaluated for PFAS content MSW ash (MSWA) and gas condensate (GC). In addition, we analyzed PFASs before and after treatment at on-site, full-scale leachate treatment facilities.

Perfluoroalkyl carboxylic acids



n+1= 4, perfluorobutanoic acid (PFBA)
= 5, perfluoropentanoic acid (PFPeA)
= 6, perfluorohexanoic acid (PFHxA)
= 7, Perfluoroheptanoic acid (PFHpA)
= 8, perfluorooctanoic acid (PFOA)
= 9, perfluorononanoic acid (PFNA)
=10, Perfluorodecanoic acid (PFDA)

Perfluoroalkyl sulfonic acids



n= 4, perfluorobutanesulfonic acid (PFBS)
= 6, perfluorohexanesulfonic acid (PFHxS)
= 8, perfluorooctanesulfonic acid (PFOS)

Fluorotelomer acids

n = 5, 5:3 fluorotelomer carboxylic acid (5:3 FTCA)

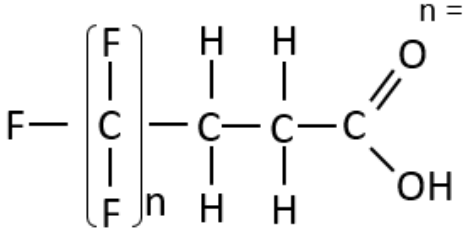


Figure II.1 Defined acronyms and structural configuration of a PFAS species analyzed during the current study.

II.2 METHODS

II.2.1 Landfill sites

Samples were collected at five different landfill facilities within Florida, USA (Table II.1). Pre-treatment and the ultimate disposal of leachate differed for each facility. Ultimate disposal at two landfill facilities consisted of on-site aeration with disposal to a WWTP. For two other landfill facilities, the leachate was discharged to a WWTP without pre-treatment. At one facility, the leachate was discharged to deep well injection without pre-treatment.

Some of the facilities had access to leachate flows from distinct waste types by cell. Leachate was obtained from cells containing predominantly MSW, predominantly C&D, predominantly MSWA, and combinations thereof. The characteristics of the incineration facilities producing the ash varied. These variations included differences in the boiler temperatures used to incinerate the waste. Although the cells accepted both bottom and fly ash, the pre-treatment of the fly ash also differed between facilities prior to its disposal within the landfill cell. A sample was also collected of GC from a landfill cell containing a mixture of predominantly MSWA and MSW leachates. The gas condensate originates from the gas emitted from the landfill that condenses in the landfill gas collection system and subsequently falls-out and is diverted to the landfill leachate collection system. Thus, the GC sample is a combination of the landfill gas condensate and leachate. C&D landfills are designed to accept wastes from construction and demolition activities. Historically the majority of these landfills do not have bottom liners designed to capture leachate. More recently, as of 2010, bottom liners were required within the State of Florida. These landfills, which are referred to as Class III in Florida, were included within the C&D category. Class III landfills accept waste (yard trash, C&D debris, processed tires, asbestos, carpet, cardboard, paper, glass, plastic, and furniture other than appliances) that are not expected to produce leachate that poses a threat to public health or the environment as per Florida statutes (FAC 2016). MSW ash landfills accept ash from incineration for either volume reduction or waste-to-energy purposes. These landfills are also required to maintain bottom liners. Although not all C&D (inclusive of Class III) landfills have bottom liners, the landfills targeted as part of this study had bottom liner systems.

Sample collection was initiated at the participating facilities after two interviews: a telephone interview and an interview in person with the facility managers. During these interviews questions were asked about the type of waste disposed and the possibility of collecting leachates that corresponded to a particular waste type. From these interviews, the sampling plan was devised to optimize the isolation of a particular leachate type (MSW, C&D, MSWA, GC) and of a particular age, if possible. Additionally, priority was given to evaluate landfill leachate treatment processes. At facilities where landfill leachates were treated, samples were collected immediately prior to and after treatment for comparison.

A total of 12 samples were collected across five facilities. They consisted of one GC sample from predominantly an ash cell (75% MSWA/25% MSW), two samples from C&D landfills, four samples from predominantly MSW (2 with 100% MSW and 2 with a mix of 75% MSW/25% C&D

and five samples from predominantly ash landfills (2 with 100% MSWA, 1 with 98% MSWA/2% MSW, and 2 with 65% MSWA/35% MSW) (Table II.1).

Table II.1 Types of waste producing leachate, age of landfill cell producing leachate at time of sample collection, pre-treatment of ash, and pre-treatment/ultimate disposition of the leachate for the five landfill facilities included as part of the current study.

Facility ID	Sample ID	Waste Type	Age of cell (years)
A	C&D (100%)	Untreated C&D (Class III) only	26
	C&D (100%)	Untreated C&D (Class III) only	25
	GC	Gas condensate mixed with leachate from several cells composed of approx. 75% MSWA & 25% MSW.	20
	MSWA (98%)	MSW ash from cell containing 98% ash and 2% MSW.	8
B	MSW (75%)/ C&D(25%)	Overall the landfill contains 75% MSW & 25% C&D. Landfill is separated into old (27 year old) versus new (6 year) cells. The leachate from the first sampling point is a combination from old and new cells (averaged). Leachate from the second sampling point came from the old cell only.	17
	MSW (75%)/ C&D(25%)		27
C	MSWA(65%)/ MSW(35%)_U	Waste at this landfill facility consists of MSWA mixed with MSW at an approximate proportion of 65:35. The first sample corresponds to leachate entering the on-site pretreatment system and the second sample corresponds to leachate after on-site pretreatment.	34
	MSWA(65%)/ MSW(35%)_T		34
D	MSWA(100%)	Ash monofill. Samples came from two different manholes at the site.	18
	MSWA(100%)		18
E	MSW(100%)_U	The vast majority of the waste is MSW. The first sample corresponds to leachate entering the on-site treatment system and the second sample corresponds to leachate after on-site pretreatment.	39
	MSW(100%)_T		39

II.2.2 Sample Collection Methods

Leachate was collected in two half-liter HDPE bottles per sampling location. One collection bottle was used for subsequent PFAS analysis and the other was used for measures pH and chemical oxygen demand (COD).

Samples were poured directly into the collection bottles if spigots were available. A new primary collection bottle, also made of HDPE, was used when samples were to be collected from manholes or pump stations. The primary collection bottle was attached to a stainless-steel hose clamp which in turn was attached to a zinc-coated chain. The primary collection bottle was then lowered into the manhole/well using the chain and bottle attachment. This allowed for the collection of leachate samples in wells up to 10 meters deep and containing leachate that was only a few centimeters deep at the bottom. The lower end of the chain was detachable allowing for replacement of the primary sample collection bottle and lowest chain portion between sampling stations to avoid cross-contamination.

One trip blank was processed per facility visited. The trip blank consisted of an HDPE bottle that contained deionized water and was closed throughout sample collection, storage, and shipment. In addition, for each leachate sample a sample blank was also collected by opening the bottle containing deionized water during the time of sampling and then closing it after the sample was collected. Upon collection, samples were placed in a cooler with ice.

II.2.3 Laboratory Analysis

After collecting samples at each facility, sample bottles were immediately transported to the University of Miami (UM) laboratory (Coral Gables, FL). An aliquot was removed for the basic physical-chemical parameters of pH and COD at UM. The remaining sample (earmarked for PFAS analysis) was frozen. The aliquot was analyzed for pH using a meter calibrated to 4, 7, and 10 pH units (Orion Star A211) and for COD using pre-dispensed ampules (Bioscience Inc.) to which 1 ml of 1:10 diluted sample was added and analyzed spectrophotometrically (Milton Roy, Spec 20 with calibration standards from 0 to 4,500 mg/L of COD).

The frozen samples were batched into two sets for PFAS analysis at the U.S. EPA Research Triangle Park (RTP) laboratory (Raleigh, NC), with one set shipped for analysis during January 2018 and the second set shipped for analysis during July 2018. Samples at EPA-RTP were placed in a -5°C freezer upon receipt. Samples were thawed in the refrigerator overnight prior to analysis of PFAS concentrations.

The pre-processing of the samples after shipment included the addition of internal standards that were isotopically labeled (Wellington Laboratories, MPFAC-MXA and MFTA-MXA), a filtration step, followed by a solid phase extraction (SPE) process using Oasis WAX cartridges (Huset et al. 2011, Backe and Field 2012). For the first batch only, the sample extracts were filtered using Envi-carb cartridges (Sigma Aldrich). Eluates from the Oasis WAX/Envi-Carb cartridge (batch 1) and

Oasis WAX (batch 2) were concentrated to 2 ml by evaporation using nitrogen gas. One-hundred microliter sample aliquots were prepared for analyses with the addition of 300 µL of 2.5 mM ammonium acetate. For the first batch a calibration curve was prepared using the purchased standards (Wellington Laboratories, PFAC-MXA: fluorinated acid/sulfonate mix, FTA-MXA: native telomer mix, FPePA: 3-perfluoropentyl propanoic acid) with an analytical range of 300 to 1200 ng/L.

The second batch of samples were diluted 1:2 with deionized water. For the second analysis date, the calibration curve prepared at EPA-RTP consisted of a wider range of concentrations (10 to 2000 ng/L for FTA-MXA, 50 to 5000 ng/L 5:3 FTCA: fluorotelomer carboxylic acid, PFAC-MXA 10 to 2000 ng/L). The solid phase extraction for this batch was pH-adjusted with 2.5 mL of nitric acid on the WAX cartridge to optimize the recovery of short chain PFASs

Samples were analyzed on a Time of Flight-Liquid Chromatograph/Mass Spectrometer TOF-LC/MS (Agilent, 1100 Series). The column consisted of a Poroshell 120 EC-C8 (2.1 x 50 mm, 2.7 µm). The flow rate was 300 µl/min with a gradient consisting of an aqueous phase (A: 95% deionized water and 5% MeOH in 0.4 mM ammonium formate) and an organic phase (B: 95% methanol and 5% of deionized water in 0.4 mM ammonium formate). The initial gradient (75% A, 25% B) was ramped to 80% B over 5 minutes and held for 5 minutes. This was followed by a second ramp to 100% B for 2 minutes and held for 3 minutes. For both analysis batches, analytical blanks were also added to the process (300 µL of 2.5 mM ammonium acetate + 100 µL of MeOH) as a check for contamination during analysis.

II.2.4 Statistical Analysis

Statistical differences in the mean values were evaluated through t-tests assuming two sample unequal variances with alpha at 0.05. A 90% degree of confidence was selected for this study. Correlations were assessed through the coefficient of determination, R^2, and were considered strong for R^2 greater than 0.7 and significant for *p* values less than 0.05.

II.3 RESULTS AND DISCUSSION

II.3.1 Leachate Characterization

The physical-chemical parameters of pH and COD depended upon leachate type. The pH of the leachates varied from 6.2 to 8.1, with MSWA leachate at the lowest pH and MSW leachate with the highest pH (Table II.2). The low pH range is consistent with landfills undergoing the younger acidic phase whereas the higher range is consistent with landfills undergoing the methanogenic phase (Kjeldsen et al. 2002). A weak but significant correlation was observed between landfill age and pH (R^2=0.54, *p*=0.01), with higher pH generally associated with older landfills. The COD of the samples ranged from 700 mg/L corresponding to the treated MSWA/MSW leachate, up to 14,000 mg/L for the GC leachate (Table II.2). The COD values tended to be low in comparison to landfills undergoing acidic phase decomposition. These values were more consistent with the

typical values observed during methanogenic phases (3,000 COD mg/L on average) (Kjeldsen et al. 2002). The association between landfill age and COD was weak and insignificant (R^2=0.18, *p*=0.17).

Table II.2 Landfill cell composition, age, leachate pH, leachate COD and individual PFAS concentrations for the five facilities visited. Eleven PFAS species were measured in the leachate samples collected as part of this study.

Facility ID	Waste Type	Waste Proportions	Age (years)	pH	COD (mg/L)	PFAS (ng/L)‡											
						PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFBS	PFHxS	PFOS	5:3 FTCA	Total
A	C&D	100%	26	7.6	2,700	1,170	1,620	2,190	1,160	1,720	59	40	781	4,130	875	1,930	15,670
						1,150	1,790	2,250	1,120	1,740	56	40	828	4,230	874	1,900	15,960
A	C&D	100%	25	7.6	2,000	1,250	1,720	2,200	1,260	1,750	58	51	529	4,630	965	1,650	16,060
						1,200	322	2,130	1,160	1,680	66	51	560	4,530	1,000	1,760	14,450
B	MSW and C&D	75:25	17	7.7	3,800	1,460	ND[e]	3,560	1,060	2,200	104	121	3,150	2,250	557	2,540	17,010
						688	ND	1,830	1,090	2,290	116	104	3,220	2,330	600	2,540	14,800
B	MSW and C&D	75:25	27	7.7	3,800	ND	ND	4,270	1,310	2,860	144	121	ND	3,560	770	2,990	16,030
						2,200	ND	4,240	1,320	2,860	116	167	ND	3,580	736	3,050	18,270
E	MSW untreated	100%	39	8.1	4,600	1,410	ND	3,570	1,180	2,620	119	169	3,420	651	875	1,590	15,610
						1,659[c]	ND	3,590	1,182	2,643	125	189	3,351	635	870	1,600	15,840
E	***MSW treated[d]***	***100%***	39	***8.0***	***4,100***	***2,708***	***2,951***	***4,290***	***1,767***	***2,990***	***146***	***256***	***2,671***	***643***	***1,230***	***314***	19,970
						2,562	***31,36***	***4,295***	***1,764***	***2,962***	***154***	***318***	***2,625***	***612***	***1,180***	***306***	19,920
C	MSWA/MSW untreated	65:35	34	7.5	1,800	1,380	990	1,691	695	1,177	108	ND	331	994	330	748	8,450
						1,450	1,150	1,720	722	1,166	101	ND	363	992	319	736	8,730
C	***MSWA/MSW treated[d]***	***65:35***	34	***8.1***	***700***	***1,290***	***1,050***	***1,610***	***819***	***1,610***	***106***	***ND***	***388***	***1,400***	***296***	***ND***	8,570
						1,380	***1,040***	***1,630***	***791***	***1,596***	***99***	***ND***	***386***	***1,390***	***305***	***ND***	8,600
A	GC (MSWA/MSW)	75:25	21	7.3	14,000	ND[a]	ND[a]	1,140	299	609	159	81	3,800[b]	313	720	2,710	9,830
A	MSWA/MSW	98:2	12	6.9	8,800	1040	1,360	1,770	546	1,010	160	105	5,510	606	342	1,000	13,450
						917	1,230	1,680	485	964	136	99	4,900	540	347	954	12,260
D	Ash	100	18	6.2	4,200	421	652	742	328	360	ND	ND	508	182	166	ND	3,360
						512	567	726	292	387	ND	ND	547	184	158	ND	3,370
D	Ash	100	18	6.4	4,300	450	437	589	256	259	ND	ND	534	179	120	ND	2,820
						470	477	637	255	269	ND	ND	552	176	124	ND	2,960

‡Results correspond to the second batch of analyses which were done in duplicate. The only exception was the sample containing the gas condensate mixed with MSWA/MSW, which was analyzed with the first batch of samples and only one analysis is available.

[a]In the first analyses, the extraction was not optimized to measure the low carbon PFAS (PFBA and PFPeA) and so these measured as non-detects for the gas condensate.

[b]The PFBS concentration for the gas condensate sample was above the limit of the calibration curve so the value listed is an estimate.

[c]The internal control sample for this sample was in error and so the value listed corresponds to the value without the correction for the internal control.

[d]Leachates that were treated on-site are shown in itallics.

[e] Not Detected.

II.3.2 Total PFAS Levels

Quality control samples showed that all trip blanks, field blanks, and analytical blanks were below the limits of detection, except for PFHxA, which was detected in the analytical blank at a factor of 10 below the limit of quantification. All calibration curves (ranges listed in methods section) were characterized by correlation coefficients (R^2 values) of 0.99 with the exception of the calibration curve for PFDA for which the R^2 value was 0.98 and for 5:3 FTCA for which the R^2 value was 0.91. Duplicate analyses of the standards were characterized by excellent precision with coefficients of variation of 2.4% on average.

Among the factors evaluated, landfill type appears to have the most significant impact on leachate total PFAS levels (sum of the 11 PFAS measured in the current study) (Figure II.2). To begin with, the ash leachate from facility D had the lowest levels of total PFASs (<3,400 ng/L) relative to other landfills that also contained predominantly ash ($p<0.001$). This landfill is a pure ash monofill with no integration of other waste types. Additionally, the incinerator temperature (930 to 980 °C) that produced the ash for this monofill was the highest among all the landfills that accepted ash. The MSWA landfills that received ash incinerated at intermediate temperatures (facility C, 815 to 870 °C) had intermediate levels of total PFASs, at 8,400 to 8,700 ng/L. The MSWA landfill that received ash incinerated at the lowest temperatures (facility A, 760 to 870 °C) had the highest total PFAS levels among the MSWA leachates, at 12,300 to 13,500 ng/L. The correlation between total PFAS and incineration temperature for the ash leachates was significant ($R^2=0.92$, $p<0.001$), with lower total PFAS concentration associated with an increase in incineration temperature (Figure II.3).

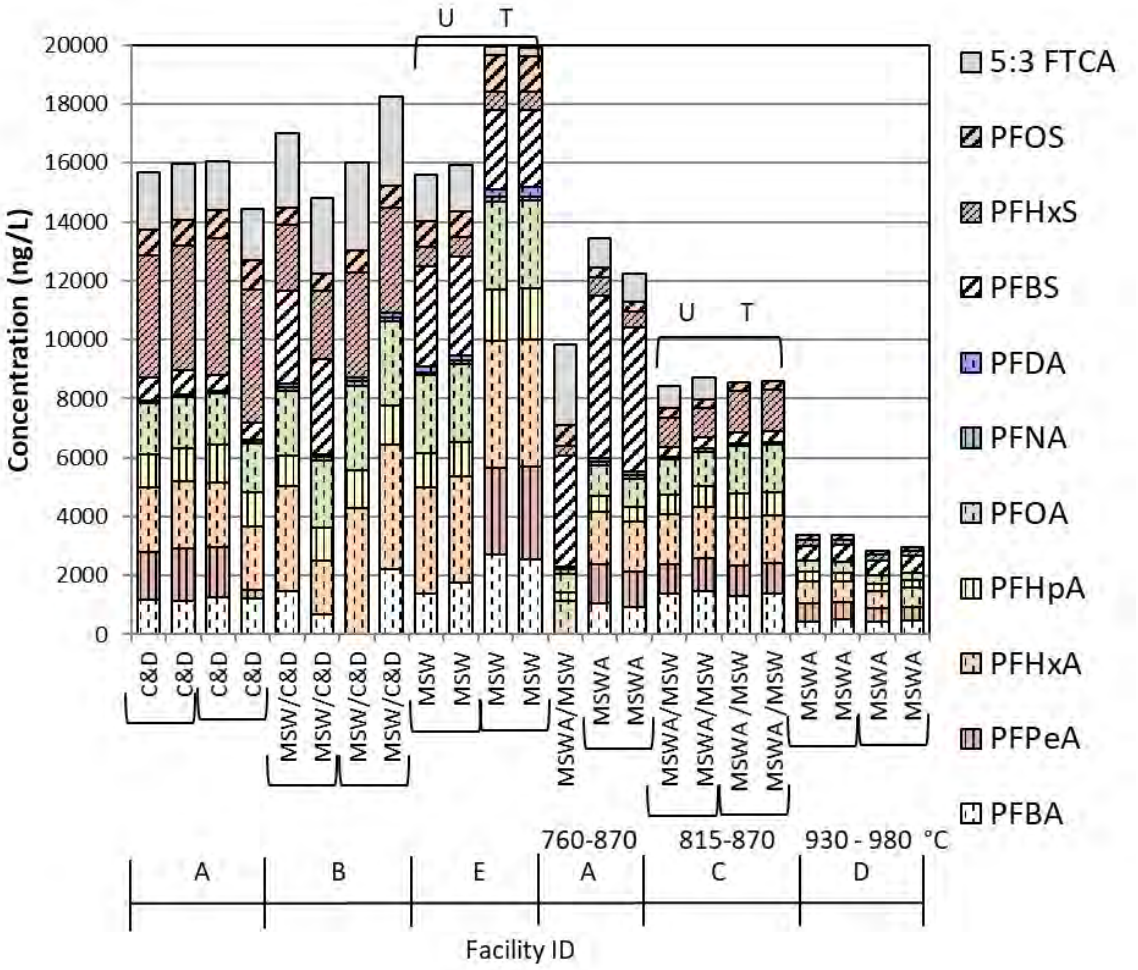


Figure II.2 Overall PFAS results for leachates collected from five facilities. All results provided in duplicate with the exception of the gas condensate sample. Brackets of 2 samples correspond to duplicates of the same leachate sample. The "U" and "T" set of samples correspond to untreated (U) leachates and the corresponding treated (T) effluents. The temperatures indicate the average operating temperature of the facility where the ash was generated.

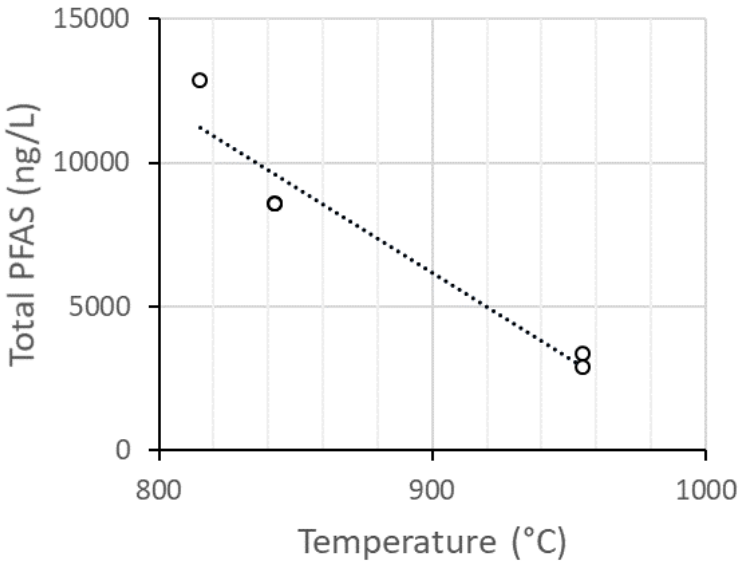


Figure II.3 Total PFAS in ash leachates versus incineration temperatures ($R^2 = 0.92$, $p < 0.001$)

This trend with incineration temperature is consistent with laboratory studies that have shown that PFASs are transformed within the 500 to 1000 °C range (Krusic et al. 2005, Yamada et al. 2005, Taylor et al. 2014, Merino et al. 2016). For example, Ellis et al. (2001) found that fluoropolymers at 500 °C decompose and rearrange to form halogenated organic acids and produce polyfluoro-(C3-C14) carboxylic acids. Garcia et al. (2007) found that at 850°C, C_2F_6 and CF_4 are formed. Feng et al. (2015) described a thermolysis mechanism for a perfluorosulfonic acid membrane that involved cleavage of both the polymer backbone and its side chains to produce perfluorocarboxylic acids. As such, the results observed in Figure II.2 are consistent with the transformation of PFASs to other species or to the partial destruction of PFASs during the waste incineration process. Further evidence of transformation is provided by evaluating the ratios of PFBA/PFOA and PFPeA/PFOA. These ratios were greater than one for all ash leachate samples (1.25 and 1.20, respectively) and less than one for MSW and C&D leachate samples (0.87 and 0.68, respectively) in the current study. It is possible that the higher incineration temperature resulted in more PFAS transformation towards shorter C-F chain species relative to the lower incineration temperature causing this shift in the proportions. Given the evidence from laboratory-based studies concerning the transformation of PFAS species, direct measurement of the exhaust gases from the waste-to-energy incinerators is warranted to confirm that PFASs in fact are being destroyed as opposed to being transformed or volatilized and lost to the atmosphere. This should be a priority for future studies.

Results also show that the GC sample also had unique characteristics. The GC sample originated from a leachate stream that was receiving predominantly MSWA (75%). This sample was the only one from the set that was analyzed during the first analysis round (January 2018) which did not capture the lower carbon chain alkylated PFASs (PFBA and PFPeA), suggesting that the total PFAS levels could have been higher than those shown in Figure II.2. Overall, the levels for the GC sample are consistent with the levels observed in the samples from facility A (MSWA, 98%) with the exception of the shorter chain PFASs. The intermediate total PFAS levels for the GC sample are consistent with the intermediate temperatures for the ash used for this particular site (right hand side of Figure II.2). With respect to PFAS species, the sample with the lowest total levels of measured PFASs (ash monofill leachates for facility D) had the lowest levels of all 11 individual PFAS species (<3,400 ng/L for the sum of all 11 species). Individual PFAS species for the ash leachates from facility A (two MSWA(98%) samples plus the GC sample) were also low with the exception of PFBS. PFBS were elevated for these three samples.

For the landfill cells that contained predominantly MSW or C&D, total PFAS concentrations were higher in comparison to the cells dominated by ash. The total PFAS concentration for the non-ash cells varied between 14,000 to 20,000 ng/L. The total PFAS levels between C&D (mean of 15,530 ng/L) and MSW landfill (mean of 15,730 ng/L) types were not statistically different (p=0.65). However, C&D and MSW leachates were statistically different from MSWA leachate (mean for MSWA of 7,490 ng/L) (p<0.001).

The finding that total PFASs levels in C&D and MSW leachates were similar is in contrast to studies by Gallen et al. (2016, 2017) who found that C&D leachates had higher levels of PFASs

by about a factor of 3. In the current study the differences in total PFAS concentrations were not statistically different between the two landfill types. Similar leachate concentrations for C&D and MSW landfill cells indicates that C&D waste is releasing PFAS to leachate and could be a source of PFAS release to the environment.

With respect to leachate treatment, one treatment system resulted in an increase in PFAS concentrations (MSW(100%) at facility E, p=0.02) whereas the other (MSWA(65%)/MSW(35%) at facility C) did not result in total PFAS levels that were statistically different (p=0.99) between before and after treatment. The mean concentrations for facility E were 15,730 ng/L and 19,940 ng/L, before and after treatment, respectively. These results are consistent with studies at WWTPs (Arvaniti and Stasinakis 2015). For example, Bossi et al. (2008) found that levels of PFOA increased from values of 1-10 ng/L in the influent to 10-100 ng/L in the treated effluent. This increase has been attributed to the degradation of fluorinated precursors such as 8:2 FTOHs to form PFOA and 6:2 FTOH to form PFHxA (Xiao et al. 2012).

The treatment systems for facilities E and C were similar between the two landfills, both were dominated by aeration processes for ammonia removal, but the treatment process resulted in different outcomes. The difference in the efficacy of treatment could have been associated with waste type. Facility E treated 100% MSW leachate which resulted in an increase in PFAS levels. Facility C treated predominantly MSWA, the chemistry of which could have responded differently to the aeration process. The lower concentrations in the treated leachate from Facility C suggests that ash contains fewer precursors.

Given the conversion of PFASs within WWTP systems, more work is needed to track the fate of PFASs in leachates currently discharged from landfills. Four facilities included in the current study discharge their leachates to WWTPs, two after pretreatment and two without pretreatment. The practice of disposing leachates to WWTPs results in the increase in PFASs due to the conversion of precursors. The PFAS in the aqueous phase at WWTPs have been found to partition towards the solids phase or sludge which in turn can be land applied on agricultural areas (Washington et al. 2010). The disposal of leachate to WWTP can result in its distribution within the environment through sludge application or ultimate WWTP effluent disposal.

When evaluating correlations between total PFASs and physical-chemical parameters, different results were observed depending upon the parameter evaluated (Table II.2). The relationship between total PFASs and COD was not significant (R^2=0.004, p=0.83). However, a weak but significant relationship was observed between total PFASs and pH (R^2=0.55, p=0.006).

When evaluating the carboxylated PFAS species, the treated MSW leachate had the highest levels of each of the carboxylated PFAS from the shortest chain (PFBA, mean concentration of 2640 ng/L) to the longest chain (PFDA, mean concentration of 290 ng/L) measured. The only exception was PFNA where the treated MSW leachate (150 ng/L) was still elevated but not the highest level observed (159 ng/L) which corresponded to the GC leachate for facility A).

When comparing the levels of individual PFAS species to the national average (Lang et al. 2017), PFHxS was noticeably high (by over an order of magnitude, national average at about 350 ng/L) for the leachates observed in the current study. All C&D leachates measured in the current study had PFHxS concentrations that were above the national average (mean of 4,380 ng/L). Even for landfills with C&D mixed with MSW, the PFHxS concentrations were noticeably high (>2,200 ng/L) overall (Figure II.4), suggesting that the source may be associated with C&D types of waste. The elevated levels of PFHxS in C&D leachates are consistent with the use of PFHxS as a surfactant coating for carpets and other building materials (Jin et al. 2011). Such materials are commonly found in C&D waste and can serve as a possible source for the elevated PFHxS levels. An additional source of PFHxS has included AFFF. PFHxS has been found at fire-fighting facilities that use these materials during training activities (Bräunig et al. 2019).

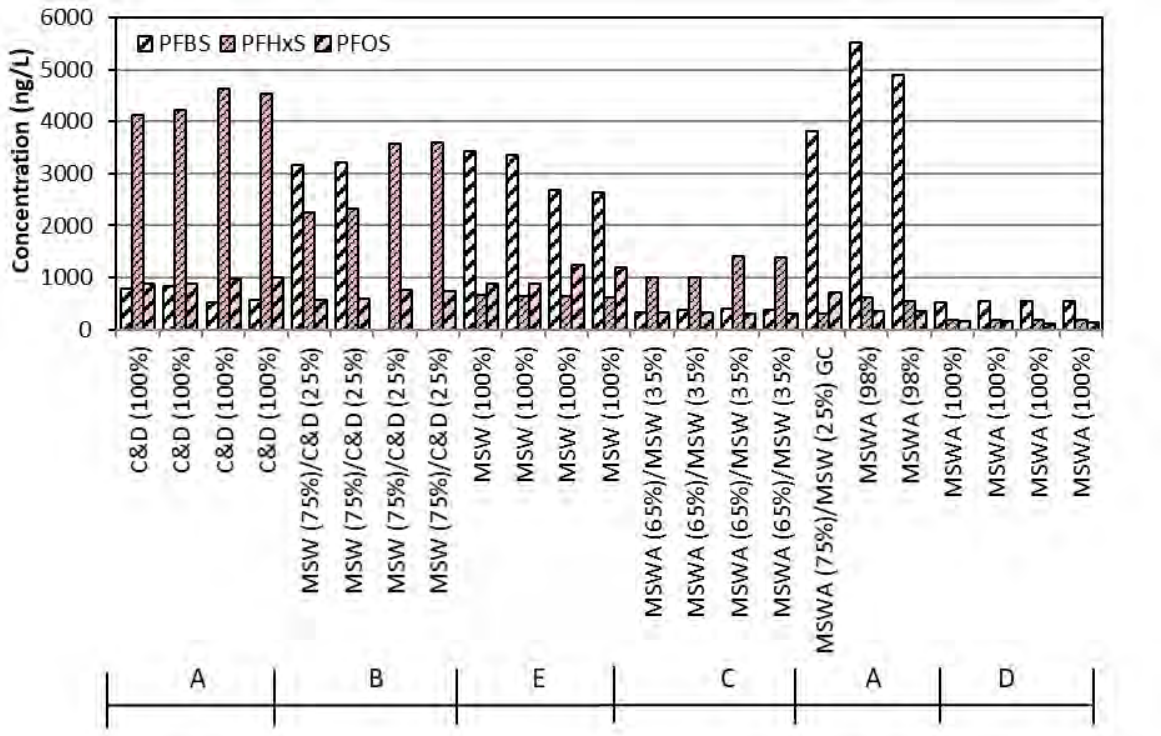


Figure II.4 Concentrations of sulfonic PFAS in different landfill types.

EXHIBIT 1

Consistent with the findings in other studies (Lang et al. 2017, Allred et al. 2015), 5:3 FTCA was found to represent a major component of PFASs in untreated landfill leachate (400 to 1,500 ng/L in Lang et al.). Among the different leachate types, MSW in the current study had the highest levels of 5:3 FTCA (maximum of 3050 ng/L for facility B). Ash leachates had no measurable levels of 5:3 FTCA and treated leachates had lower 5:3 FTCA levels relative to untreated leachates ($p<0.001$). This difference is particularly evident for the MSW (100%) leachate where concentrations of 5:3 FTCA decreased by a factor of 5 (from 1600 to 310 ng/L, Figure II.5) after treatment. The lower values of 5:3 FTCA after treatment suggest a number of possibilities. The lower values can be due to volatilization, differential sorption, or the conversion of FTCA during the treatment process to other PFAS species, in particular to possibly PFAS species with the same five carbon chain backbone, PFPeA. For PFPeA (Figure II.5, bottom panel), a marked increase in this species was observed between untreated and treated C&D leachate. These results are consistent with studies that focused on transformation pathways in activated sludge WWTP processes (Wang et al. 2012, Xiao et al. 2012) that showed a conversion of PFASs from 5:3 FTCA to PFPeA during the treatment process. Similarly, studies specifically using landfill leachates have observed the loss of 5:3 FTCA during aeration in constructed wetland systems (Yin et al. 2017). Given the evidence of this conversion, of interest would be to evaluate the influence of aeration conditions (temperature, time, air flow rates) on the transformation of PFAS species. Future studies should include an evaluation of additional PFAS precursors and the possibility of their conversion to PFAS species.

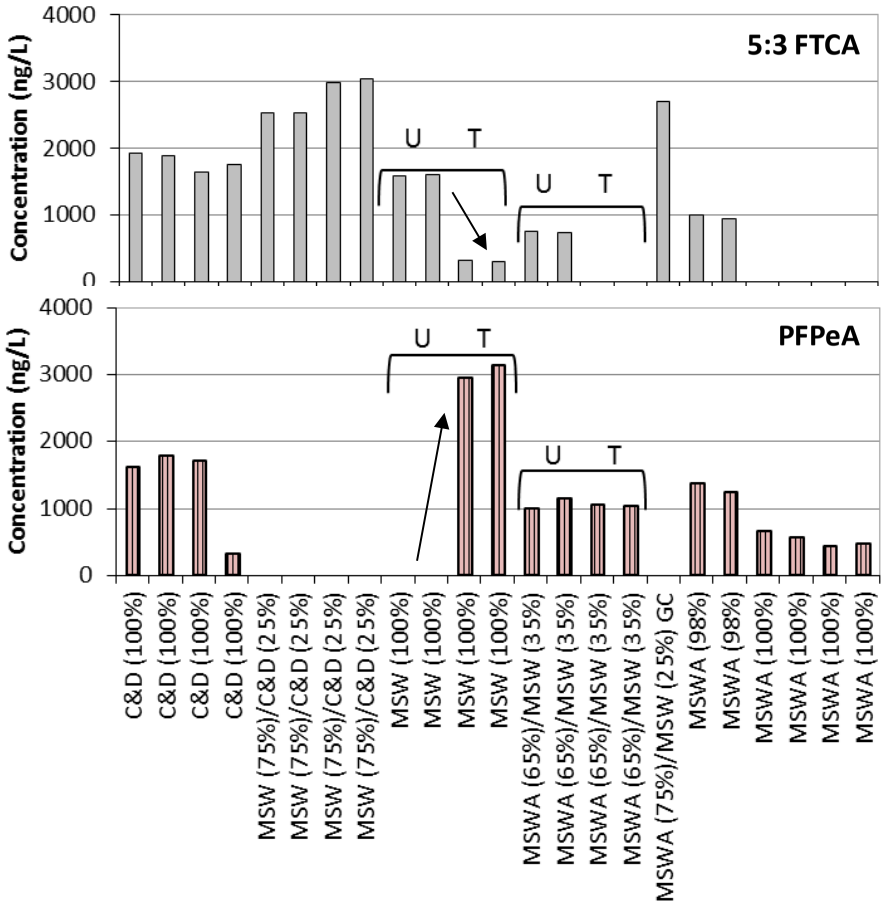


Figure II.5 Levels of 5:3 FTCA (top panel) and PFPeA (bottom panel) in different types of landfill leachate. A significant increase in PFPeA is observed between untreated and treated C&D leachate suggesting a transformation of 5:3 FTCA to this species during landfill leachate treatment.

However, the increase in PFPeA was not observed for the untreated and treated MSWA(65%)/MSW(35%) leachate. Among the MSWA leachates, the GC sample had particularly high levels of 5:3 FTCA especially when compared to the MSWA from the same facility (outlier at 90% confidence limit). The notable difference between this sample and the other MSWA samples is the presence of gas condensate, suggesting that perhaps the condensate may

serve as reservoir for this species of PFAS. This is especially notable given that other studies have found that fluorotelomer alcohols tend to be semi-volatile (Hamid et al. 2018).

Among the PFASs for which U.S. EPA health advisories have been issued (PFOS and PFOA), levels were 2 to 9 times higher in the current study in comparison to other studies conducted at MSW landfills in the U.S. (Huset et al. 2011, Lang et al. 2017) and in European countries (Fuertes et al. 2017, Busch et al. 2010). However, the concentrations were lower in comparison to landfill leachates measured in China (Yan et al. 2015). The treated MSW leachate samples were observed to have the highest PFOA level (~3000 ng/L) and the highest PFOS level (~1200 ng/L) (Figure II.6). These results are consistent with the predominance of PFOA and PFOS in treated wastewaters (Kwon et al. 2017) which showed a total PFAS concentration of 111 ng/L which is over an order of magnitude more dilute than the PFAS levels observed in leachates. Notably these PFAS species were observed in all leachates even for the oldest landfill (39 years) suggesting that PFOA and PFOS are still in the environment, with landfills serving as a significant concentrated sources to aqueous systems.

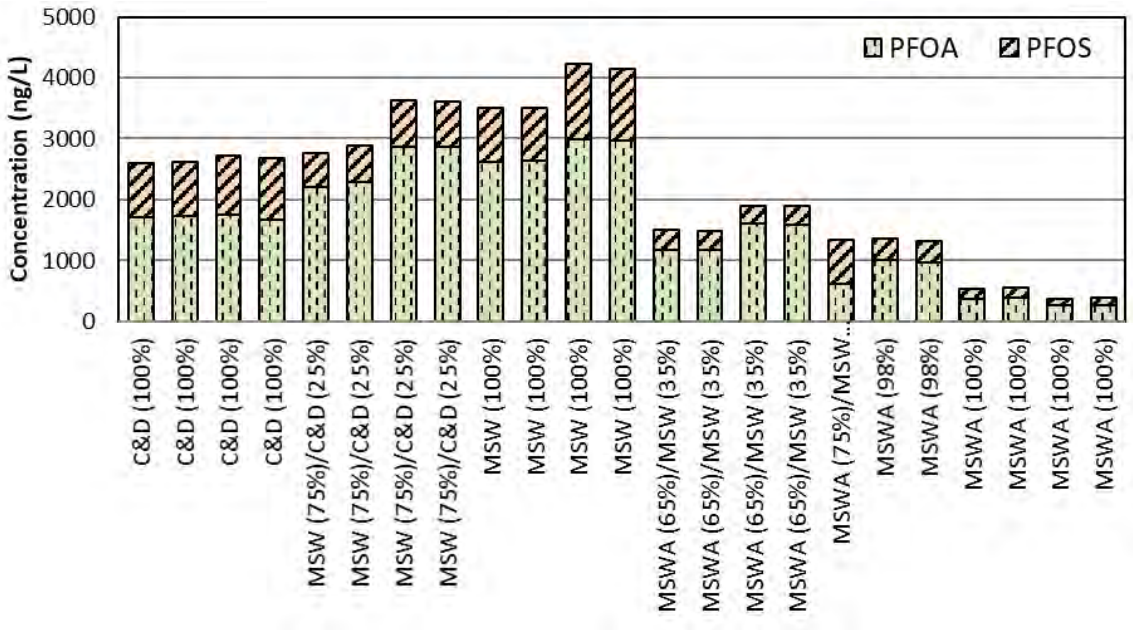


Figure II.6 Levels of PFOS and PFOA in different types of landfill leachate.

Interestingly overall, the 8 carbon species (PFOA and PFOS) were not the most abundant species (Figure II.7). The 6 carbon species in both the carboxylated (PFHxA) and sulfonic (PFHxS) species were the most abundant. Of interest would be to evaluate health-based regulatory guidelines for PFHxA and PFHxS given their higher abundance.

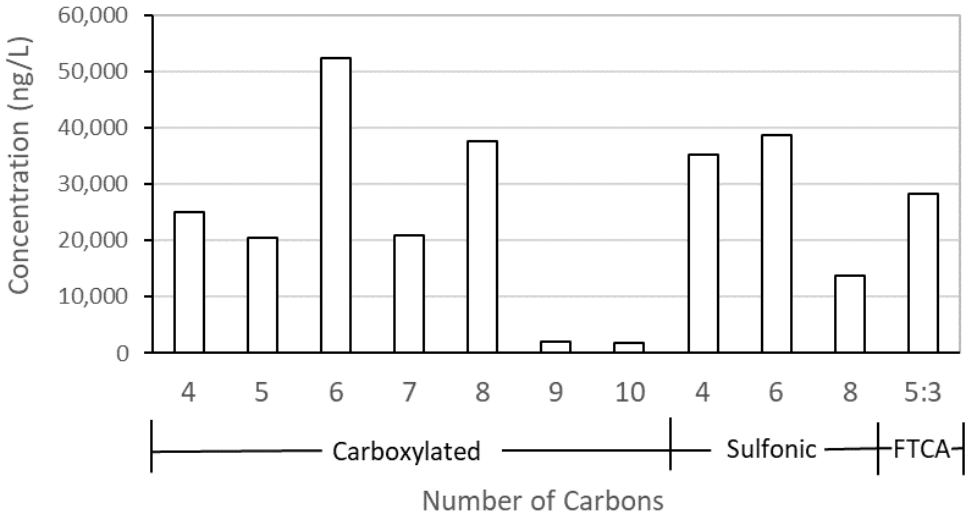


Figure II.7 Sum of PFAS species for all samples collected, organized by functional groups of carboxylated, sulfonic and FTCA and by number of carbon in the carbon-fluorine chain.

One facility included in the current study disposed its leachate to deep well injection. The fate of PFASs through deep well injection is not known, as is the overall long-term impact of this practice. The impacts of deep well injection of landfill leachates on PFASs environmental distributions should also be evaluated further.

CHAPTER III

SUMMARY AND CONCLUSIONS

CHAPTER III

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III.1 SUMMARY AND CONCLUSIONS

Overall this study showed that leachates from ash landfills had lower levels of PFAS relative to leachates from MSW and C&D landfills. The degree to which the PFAS levels decreased was correlated with incineration temperatures used to generate the ash. This is the first time that MSWA was measured from field-scale landfills and also the first time that the leachates from field-scale MSWA leachates were correlated with the incineration temperature of the waste. Total PFAS levels in C&D and MSW leachates were observed to be at similar concentrations, indicating that wastes in C&D landfills could also serve as a source of PFAS release to the environment. Additionally, C&D leachates exhibited unusually high levels of PFHxS, consistent with their use as sealants and water repellants in building materials, emphasizing the need to evaluate leachates from all waste types. As observed in other studies, treatment using aeration processes increased PFAS levels. Additional work is needed to confirm trends and to establish a mass balance analysis to determine removals of PFAS from the environment through leachate treatment.

III.2 IMPLICATIONS FOR SOLID WASTE INDUSTRY

The levels of PFOA plus PFOS in MSW and C&D leachates is on the order of 3,000 ng/L which is significant when compared to the EPA regulatory guideline level of 70 ng/L for drinking water. Given the high values in landfill leachates, efforts should focus on protecting drinking water supplies from potential leachate impacts via processes that treat for PFAS.

The finding that lower levels of total PFAS in MSWA is significant. If the PFAS are destroyed in the incineration process, one “treatment” option would be to increase the temperature of existing incineration facilities to facilitate the destruction of PFAS. But first, it must be shown the PFAS are destroyed instead of being converted from one form to another in the incineration process.

Results also suggest that aeration treatment for ammonia removal is not effective at removing PFAS from landfill leachate. In this study, leachates at two treatment facilities were evaluated. The treatment systems were both designed for ammonia removal via aeration, one was a continuous flow through system and the other was a batch reactor. The continuous flow through system treated leachate that consisted primarily of MSWA. The batch reactor treated predominantly MSW leachate. Results show that the levels of targeted PFAS species in MSW leachate from the continuous flow through system did not change with effluent concentrations similar to influent concentrations. For the batch reactor, the concentration of PFAS increased in

the effluent (after treatment) presumably due to the conversion of PFAS precursors in the untreated leachate sample.

III.3 RECOMMENDATIONS

Results from this study serve as a starting point for assessing landfill leachates in the State of Florida. The finding that MSWA had lower total PFAS levels should be further evaluated to determine if the lower levels are due to destruction of PFAS as opposed to conversion to a PFAS form that was not measured. More samples should be collected to evaluate the influence of incineration temperature on PFAS species, as incineration may serve as one alternative for the removal of PFAS from the environment. Research on "incineration" treatment should also include a study of the quality of emissions from the incineration facility to assure that PFAS are not being spread through atmospheric routes.

Further study should be conducted to evaluate whether other leachate treatment strategies are effective at removing PFAS. In this study aeration was found to not be effective at decreasing PFAS levels in leachate. Other potential landfill treatment strategies should be evaluated including the potential for granular activated carbon and reverse osmosis to remove PFAS from landfill leachate.

III.4 PRACTICAL BENEFITS FOR END USERS

This study will be useful to waste managers as well as legislators in the State of Florida when making decisions about the disposal and treatment of landfill leachate that may be contaminated with PFAS. Of significance is that C&D leachates have similar levels of total PFAS as MSW leachates. MSWA had the lowest levels of total PFAS. This information can be used to identify strategies to minimize the impacts from PFAS products found in landfills.

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RE: S.1507 - PFAS Release Disclosure Act

Dear Ms. Ledezma,

The American Water Works Association has compiled the following information in response to your information request. The following is preliminary, reflecting the need to gather information quickly so as to be timely and useful to the Congressional Budget Office's work.

AWWA focused on responding to the following questions:

1. How would bill S. 1507 affect private and public water systems, state, local and tribal governments?
    a. setting new monitoring and testing processes (if needed)
        i. testing, monitoring, and reporting new requirements to the Safe Drinking Water Act including collecting samples, training personnel, reporting.
    b. remediation costs, including
        i. new treatment technology to remove substances
        ii. new personnel
        iii. training personnel
    c. coordination with nearby industries that may release the contaminants

2. Where is there a recent report estimating testing and data collection costs relevant to S. 1507?

The questions posed do not address the public health benefits associated with the control of per- and polyfluoroalkyl substances (PFAS). We would refer you to the Office of Groundwater and Drinking Water at the U.S. Environmental Protection Agency for assistance estimating the benefits of S. 1507 requirements.

As you will see in the attached several EPA documents can be referenced in estimating the administrative burden and monitoring and reporting requirements associated with the S.1507. There are a number of data gaps associated with estimating the cost of drinking water treatment associated with the legislation. The attached includes a discussion of the information sources and considerations for such an analysis. AWWA also prepared a preliminary estimate to illustrate the analysis that is feasible with available information, particularly recognizing the limited time available to your office to prepare an estimate.

- Depending on how the legislation is finalized we found the potential capital costs associated with implementing drinking water treatment to remove perfluorooctanoic acid (PFOA); and perfluorooctane sulfonic acid (PFOS) in drinking water to quickly exceed $3 billion and, if federal implementation were to mirror the direction of state-level efforts, capital costs would exceed $38 billion.
- In addition to debt service, recurring annual operation and maintenance (O&M) costs reach $150 million, and could reach $1.3 billion for a drinking water maximum contaminant level (MCL) for PFOA and PFOS.
- There is the potential, given the limited understanding of PFAS removal that a treatment standard would be based on reverse osmosis and entail more than $530 billion in capital investment and over $16 billion in annual O&M costs.

In preparing this analysis we were not able to adequate represent all consequences of the legislative text, e.g.,

- Community-level response, including the addition of water treatment, in response to health advisories for PFAS as described in S.1507
- Loss of water supply and associated water system resiliency
- Implications for state revolving loan fund allocation
- Availability of funds for other infrastructure investments like implementation of the Long-Term Lead and Copper Rule.

Please see the attached responses to the questions posed in the attached. An extract of the relevant S.1507 legislative text is also included for reference.

If you have any questions regarding the attached, please contact Steve Via or Chris Moody at (202) 628-8303.

Best regards,

G. Tracy Mehan, III
Executive Director for Government Affairs
American Water Works Association

cc: Jennifer McLain, EPA/OW/OGWDW
Andrew Hanson, EPA/IGA

Who is AWWA

The American Water Works Association (AWWA) is an international, nonprofit, scientific and educational society dedicated to providing total water solutions assuring the effective management of water. Founded in 1881, the Association is the largest organization of water supply professionals in the world. Our membership includes more than 4,000 utilities that supply roughly 80 percent of the nation's drinking water and treat almost half of the nation's wastewater. Our 50,000-plus total membership represents the full spectrum of the water community: public water and wastewater systems, environmental advocates, scientists, academicians, and others who hold a genuine interest in water, our most important resource. AWWA unites the diverse water community to advance public health, safety, the economy, and the environment.

ATACHMENT 1. RESPONSES TO QUESTIONS POSED

How would bill S. 1507affect private and public water systems, state, local and tribal governments?

Under the Safe Drinking Water Act (SDWA), there is no distinction between private and public water systems. All are treated the same. In either instance, the cost of implementing federal requirements are passed on directly to ratepayers. Relevant SDWA definitions (42 U.S. Code § 300f. Definitions) include:

> Public Water System -- "The term "public water system" means a system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals. …"
>
> Community water system (CWS)– "means a public water system that—(A) serves at least 15 service connections used by year-round residents of the area served by the system; or (B) regularly serves at least 25 year-round residents."
>
> Noncommunity water system (NCWS)– "a public water system that is not a community water system."

Note that standards set under SDWA do not apply to individual, household wells.

CWSs may be operated by local government (e.g., a village, town, city, county), a creature of local government (e.g., a public service authority), or a creature of the state (e.g., Massachusetts Water Resource Authority). Local government may also contract or sell the operation of water infrastructure to a private utility (e.g., a for-profit company, non-profit cooperative, etc.). In any of these instances, local government is directly or indirectly engaged in oversight of the CWS.

Based on data from the Safe Drinking Water Information System (SDWIS), 46% of CWSs are privately owned. Importantly the majority of those CWSs that are privately owned serve less than 500 persons. These CWSs may be subdivisions, manufactured home communities, public housing developments or apartment buildings that have their own water system. These CWSs would, like municipally-based systems, pass the cost of regulatory implementation on to the year-round residents, if not through rates, through other fee / cost mechanisms.

Seventy percent of Non-transient NCWSs (NTNCWSs) are privately owned reflecting the nature of NTNCWSs (e.g., schools, factories, office buildings, and hospitals which have their own water systems). These NTCWSs would incorporate the cost of compliance into their operating budgets, passing those costs on as necessary. For example, in the case of public schools these costs come back to local government budget processes.

While states may own / operate water systems that are regulated under SDWA, the primary burden on states is the oversight of rule implementation. Implementation of SDWA is delegated to states and some

tribes also implement SDWA. EPA provides direct implementation in the District of Columbia, Wyoming, and U.S. territories. Oversight entails:

1. Changing appropriate state regulations to incorporate and implement the new federal requirements (such changes can require state legislative action)
2. Modifying existing data systems in collaboration with EPA to track compliance
3. Informing systems of compliance obligations
4. Supervising system compliance strategies including construction of capital facilities
5. Processing of compliance monitoring data and PWS reports (e.g., monthly operating reports)
6. Modification and execution of sanitary surveys and other mechanisms used to ensure compliance (beyond monitoring compliance data)
7. Modification of operator certification testing
8. Ensuring that training is available to support operator certification
9. Directing state capacity assistance programs and associate support programs to assist systems (typically small systems) with compliance challenges

The Association of State Drinking Water Administrators has prepared a recent analysis of state oversight program costs for potential revisions to the Lead and Copper Rule. While that analysis does not directly address the cost of implementing a new MCL it does illustrate the nature of rule implementation. The study, Costs of States' Transactions Study (CoSTS) For Potential Long-Term Revisions to the Lead and Copper Rule (LT-LCR) (April, 2018) is available at https://www.asdwa.org/wp-content/uploads/2018/05/CoSTS-Report-Final-2018.pdf.

Section 5 of EPA's Health Risk Reduction and Cost Analysis of the Proposed Perchlorate National Primary Drinking Water Regulation illustrates the burden of rule implementation (May 2019, EPA 816-R-19-004, (EPA-HQ-OW-2018-0780-0124), Available at https://www.regulations.gov/document?D=EPA-HQ-OW-2018-0780-0124). In referencing this material, note that perchlorate in an inorganic contaminant within the SDWA Standard Monitoring Framework and consequently less frequent monitoring requirements apply.

Number of Systems to Consider in Evaluating Treatment and Monitoring Costs

The number of impacted systems is based on data available from SDWIS. If previous rules offer insight into implementation of S. 1507 requirements, then provisions are likely applicable to both CWSs and NTNCWSs. There are 49,678 CWSs and 17,558 NTNCWSs that are currently identified as active in SDWIS, which would likely be required to comply with regulatory requirements under S.1507 provisions and thus undertake monitoring and potentially incur the cost of additional drinking water treatment.

Number of CWS and NTNCWS by System Size

Size Category	Population Range	System Count		
		CWS	NTNCWS	Total
1	0–100	11,788	8,456	20,244
2	101–500	15,207	6,465	21,672
3	501–1,000	5,342	1,569	6,911
4	1,001–3,300	7,999	874	8873
5	3,301–10,000	4,994	154	5148
6	10,001–50,000	3,343	38	3381
7	50,001–100,000	567	1	568
8	100,001–1,000,000	414	1	415
9	> 1,000,001	24	0	24
	Total	49,678	17,558	67,236

More detailed population category breakdowns are available through SDWIS.

Roughly 15% of CWS and NTNCWS are consecutive systems. That is, they purchase water from another water system. This is an important distinction for estimating the impacts of legislative action in that:

1. All water systems must comply with SDWA provisions independently (every PWS stands alone when it comes to compliance).
2. All water systems subject to a rule must conduct the associated monitoring.
3. When a new requirement takes effect, water systems must evaluate how best to comply, it may be that:
    a. The wholesale water system supplying water to a consecutive system does not have elevated contaminant levels warranting treatment.
    b. The wholesale system must install treatment and pass that cost on to its own customers and it wholesale accounts.
    c. The combination of supplies available to the consecutive system are such that it must install treatment itself, build / utilize an intertie with an alternative wholesale system, or develop a new source of supply.
    d. The consecutive system's customers are best served by consolidating with another water system in order to comply.

Regardless of whether a wholesale system or the consecutive system constructs additional treatment facilities to comply with requirements, additional treatment capacity is required to meet the water supply demand of all of impact system's service population.

Number of CWS and NTNCWS by Source of Supply

Size Category	Population Range	Ground Water	Surface Water	Purchased
1	0–100	18,656	555	1,015
2	101–500	18,268	745	2,648
3	501–1,000	5,214	368	1,325
4	1,001–3,300	5,796	931	2,143
5	3,301–10,000	2,716	977	1,454
6	10,001–50,000	1,321	978	1,082
7	50,001–100,000	157	221	190
8	100,001–1,000,000	72	246	97
9	> 1,000,001	2	21	1
	Total	52,202	5,042	9,955

Note – Incomplete information in SDWIS leads to discrepancies in totals.

Where is there a recent report estimating testing and data collection costs relevant to S. 1507?

S. 1507 includes two different sampling requirements:

1. Expansion of Unregulated Contaminant Monitoring to include all PFAS for which there is an analytical method and
2. Monitoring to support implementation of the required primary drinking water standard for PFAS.

There are a number reference documents CBO should be aware of with respect to estimating the federal, state and system level costs associated with monitoring. Those references include:

1. Information Collection Request Summaries for the Unregulated Contaminant Monitoring Rule
    a. Statistical Design and Sample Selection for the Unregulated Contaminant Monitoring Regulation (1999), August 2001, EPA 815-R-01-004 (EPA-HQ-OW-2009-0090-0131), (Available at https://www.regulations.gov/document?D=EPA-HQ-OW-2009-0090-0131)
    b. Information Collection Request Renewal for the Unregulated Contaminant Monitoring Rule (UCMR 3), March 2012, (EPA-HQ-OW-2009-0090-0143) (Available at https://www.regulations.gov/document?D=EPA-HQ-OW-2009-0090-0143)

c. Information Collection Request Renewal for the Unregulated Contaminant Monitoring Rule (UCMR 4), EPA 815-B-15-003, November 2015. (EPA-HQ-OW-2015-0218-0056) Available at (file:///C:/Users/svia/Downloads/EPA-HQ-OW-2015-0218-0056%20(1).pdf)

2. Information Collection Request Summaries for the SDWA Inorganic Contaminant Rule

   a. Information Collection Request (ICR): Disinfectants/Disinfection Byproducts, Chemical, and Radionuclides Information Collection Request, April 2004 (EPA-HQ-OW-2004-0009-0002) Available at file:///C:/Users/svia/Downloads/EPA-HQ-OW-2004-0009-0002.pdf

   b. ICR History is available at https://www.reginfo.gov/public/Forward?SearchTarget=PRA&textfield=+2040-0204

Unregulated Contaminant Monitoring Rule Monitoring

Section 2021 of the America's Water Infrastructure Act of 2018 (P.L. 115-270, Available at https://www.congress.gov/bill/115th-congress/senate-bill/3021?q=%7B%22search%22%3A%5B%22Public+Law+115%5Cu2013270%22%5D%7D&s=7&r=1) requires EPA, if funds are available, to collect data from all public water systems serving more than 3,300 persons and a statistically valid sample of smaller systems in future UCMR cycles. There is parallel text with respect to UCMR monitoring in S. 1507 for the required PFAS monitoring. EPA-HQ-OW-2009-0090-0131 provides an explanation of the statistical basis for the UCMR sampling. All public water systems (PWS) serving more than 10,000 persons incur all UCMR monitoring costs while EPA is to fund sampling, analysis, and related shipping (e.g., bear the cost of monitoring). If implemented as drafted, the cost of this provision would be in addition to monitoring costs for the fifth round of UCMR monitoring rather than a component of UCMR5.

The implication of this guidance as discussed by EPA at its July 16, 2019, UCMR5 stakeholder meeting is that future UCMRs will involve sampling from all public water systems serving more than 3,300 persons (9,512 systems) and a sample of more than 800 systems serving less than 3,300 persons.[1] Whether additional federal funding will be available to extend monitoring to include these 5,147 water systems is unknown. Past UCMR implementation costs are captured in a few specific tables in the EPA information collection request justifications:

- EPA-HQ-OW-2009-0090-0143 illustrates the cost burdens associated with UCMR monitoring for PFAS under UCMR3. EPA-HQ-OW-2015-0218-0056 illustrates cost burdens for the current UCMR4 cycle but does not specifically include monitoring for PFAS compounds.
- Exhibit 7 and 8 in EPA-HQ-OW-2004-0009-0002 summarize the burden of ongoing monitoring under SDWA including the Volatile Organic Compound and Synthetic Organic Contaminants monitoring which would be models for monitoring to support PFAS MCLs.

[1] The presentation materials are not yet posted to the EPA UCMR website but are anticipated in the near future (https://www.epa.gov/dwucmr/unregulated-contaminant-monitoring-rule-ucmr-meetings-and-materials).

During the UCMR5 stakeholder meeting in July EPA indicated that it would have two PFAS analytical methods available (EPA Method 537.1 and 533). Method 537.1 is currently available for use; Method 533 is still in development, consequently cost and performance information is incomplete at this time.

The cost of implementing UCMR at the federal, state, and water system level is a five-year endeavor. While the direct costs associated with monitoring occur over a three-year window, there is a year of pre-monitoring preparation, and for EPA, states, and some systems a final year of data quality control and report generation. It is likely that the costs of expanding the current program to the larger sample as directed in AWIA / S.1507 will require additional investment in federal and state personnel, contractor support, and improvement of data systems, above and beyond extrapolation of the current implementation costs to 5,147 more systems.

Compliance Monitoring

Currently, requirements for monitoring regulated VOCs and SOCs adhere to the SDWA "Standard Monitoring Framework." The monitoring framework is summarized in two documents:

1. Standard Monitoring Framework, February 1991. (EPA 570/F-91-045) (Available at https://nepis.epa.gov/Exe/ZyPDF.cgi/10003I17.PDF?Dockey=10003I17.PDF)
2. The Standardized Monitoring Framework: A Quick Reference Guide, March 2004, (EPA 816-F-04-010) (Available at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=3000667K.txt)

Important elements to reflect in costing compliance monitoring for PFAS include:

1. Costs are likely to be borne by all CWS and NTNCWS (i.e., approximately 67,236 systems).
2. The cost of monitoring of analytical methods like EPA Method 537.1 is as much as $500 per sample (EPA Method 537.1 would be adequate to support PFOA an PFOS monitoring; it could also support monitoring other PFAS for which EPA is preparing risk assessments).
3. Sample costs are by entry-point-to-the distribution system, not water system. Most water systems have multiple EPTDSs. EPA has a standard table of EPTDS/system as a function of system size based on the Community Water System Survey (last published in 2009, Available at https://www.epa.gov/dwstandardsregulations/community-water-system-survey). See following table.

Number of EPTDS and Associated Design Flows as a Function of System Size

Size Category	Population Range	Entry Points/ System	Design Flow from each Entry Point (gpm)
1	0–100	2.4	5
2	101–500	2.0	35
3	501–1,000	2.1	82
4	1,001–3,300	1.9	252
5	3,301–10,000	2.2	657
6	10,001–50,000	3.1	2,027
7	50,001–100,000	4.1	3,767
8	100,001–1,000,000	6.6	16,283
9	> 1,000,001	14.5	19,906

4. As described in EPA 816-F-04-010 it is possible for systems to be allowed to take smaller numbers of samples over time, but at a minimum sampling is quarterly for the initial three years of sampling. At which time the system may be eligible for reduced monitoring at the primacy agency's discretion. In current practice, detection of a contaminant means that sampling will be ongoing on at least an annual basis and observation at levels closer to the MCL warrant more regular monitoring. There is variability in burden as a function of system size and whether the supply is groundwater or surface water. Groundwater is generally judged to be less variable over time than surface water, so reduced monitoring is available more rapidly.
5. The EPA summary of current compliance monitoring costs reflect ongoing mature monitoring costs, where there are monitoring waivers or reduced monitoring in place, rather than reflecting start-up monitoring.
6. The fact sheet, Per- and Polyfluoroalkyl Substances (PFASs) Monitoring, Sampling, and Analysis (July 2019, Available at https://www.awwa.org/LinkClick.aspx?fileticket=ufb-Vl3VrVY%3d&portalid=0) provides a brief overview of PFAS analytical methods.

New Treatment Technology to Remove Substances

S. 1507 directs EPA to regulate perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). It also directs EPA to evaluate a regulatory option where a measure of total PFAS is employed.

The national cost of a regulation for PFAS will vary significantly based on two regulatory decisions: (1) the specific PFAS that are included in the regulation and (2) the maximum contaminant levels (MCLs). These two factors will determine the number of systems that are impacted as well as the treatment objectives of the facilities, which may require different, or multiple, types of treatment technology for compliance.

Should EPA finalize risk assessments for additional PFAS, six such assessments are underway, then these too would lead to addition of drinking water treatment in some communities. There is not enough information from these risk assessment processes, treatment studies, and occurrence data to adequately

inform the current effort. Several of these PFAS are less amenable to drinking water treatment than PFOA and PFOS.

Approach to Preparing Preliminary Cost Estimation

AWWA prepared an illustrative national cost analysis using available information to demonstrate both the challenges of developing such an analysis and the policy relevance of an estimate. The following cost estimate is based on:

1. Data from Safe Drinking Water Information System (SDWIS) to determine the number of systems in each size category.
2. Water Treatment Plant design flows and numbers of treatment facilities per water system size category as utilized by EPA in its cost analyses. (see above table).
3. Initial capital cost and recurring annual operation and maintenance (O&M) costs from representative projects with similar treatment technologies and/or with the objective of PFAS removal. Data was used to develop cost models to project these costs based on the water system size. Cost data was collected for treatment processes relevant to PFAS including activated carbon, ion exchange and reverse osmosis. These processes were considered since they are the most studied, and most effective, processes for removing PFOA and PFOS. It is important to note that these treatment processes have more limited research on removal of other PFAS and typically have varying degrees of removal success based on the individual PFAS in the drinking water.
4. PFAS monitoring data from the Third Unregulated Contaminant Monitoring Rule, which was used along with SDWIS data to determine the number of water systems in each size category that would be impacted by potential PFAS regulations of 20 ppt, 40 ppt, and 70 ppt. Importantly, these estimates are based on occurrence data for PFOA and PFOS, not all PFAS, in public water systems.

In the rulemaking process, EPA will prepare a more detailed cost analysis. When EPA conducts its analysis, its practice is to estimate the number of systems that are likely to be triggered to install treatment and to forecast the distribution of treatment technologies that will be applied (e.g., x percent will utilize granular activated carbon, y percent will utilize ion exchange). Because such forecasts require more information than is currently available the best option for a planning level national cost estimate is to represent the national cost assuming all systems used a particular technology (e.g., all systems used GAC, all systems used IX, all systems used reverse osmosis). EPA will also be better positioned to take into account the impact of individual state regulations on the number of water systems that will make treatment changes to comply with requirements resulting from S.1507.

While the treatment technologies used for this estimate are well known, their applicability on PFAS is still a topic of active research. The choice of a particular technology, or combination of technologies, is not only dependent on treatment objectives for PFAS but also the system's existing facilities, other treatment objectives or requirements, and the characteristics of the water they are trying to treat. As noted above, the costs reflected here are for treatment based on PFOA and PFOS occurrence, not the level of treatment required. Some PFAS are not as readily removed as others leading to more rapid breakthrough of GAC and IX media, consequently some systems may have more expensive treatment processes based on the need to replace media more often. Setting individual compound treatment goals at lower

concentrations or summing more compounds within a single numeric limit has a similar effect – necessitating more frequent replacement of the media.

National Capital Cost to Install Treatment

Treatment Objective	Capital Costs ($ millions)		
	Granular Activated Carbon	Ion Exchange	Reverse Osmosis
< 70 ng/L	$2,100 - $4,400	$1,900 - $4,100	$5,700 - $12,000
< 40 ng/L	$5,600 - $12,000	$5,400 - $12,000	$15,000 - $33,000
< 20 ng/L	$23,000- $50,000	$22,000 - $48,000	$63,000 - $140,000
Treatment Technique	$140,000 - $290,000	$130,000 - $280,000	$370,000 - $800,000

National Annual Operating and Maintenance Cost for Installed Treatment

Treatment Objective	**Annual Recurring Costs ($ millions)**		
	Granular Activated Carbon	Ion Exchange	Reverse Osmosis
≤ 70 ng/L	$44 - $90	$210 -$460	$190 - $410
≤ 40 ng/L	$110 - $240	$540 - $1,200	$480 -$1,000
≤ 20 ng/L	$460 - $980	$2,200 - $4,800	$2,000 - $4,200
Treatment Technique	$2,700 - $5,800	$13,000 - $28,000	$12,000 - $25,000

In describing treatment costs, it is important to consider both capital and O&M costs. When making site-specific treatment decisions water systems will try to achieve reliable treatment while managing project life-cycle costs, and do so with a margin of safety. Consequently, in some scenarios what in general looks like the least cost option will not be the most effective investment for a given water system. Because investments in advanced treatment are long-term investments, uncertainty in treatment objectives leads to conservatism beyond simply assuring reliable compliance with an MCL; this too leads actual system improvements toward consideration of more conservative treatment goal, use of multiple unit operations and selection of more expensive treatment technologies.

As noted above, the treatment objective is a significant determinant of cost. The above tables illustrate four different regulations. These national estimates are a function of the number of systems estimated to require additional treatment based on combined PFOA and PFOS levels exceeding the regulatory limits. While we have information from UCMR 3 and state level efforts, which can be used estimate the occurrence of PFOA and PFOS, there is not an analysis of the occurrence of PFAS as a class, or a surrogate measure of PFAS. The above estimates based on treatment objectives of 70, 40, and 20 ng/L reflect reported UCMR occurrence data and subsequent re-analysis of UCMR data. The final row in the table reflects a duty by all CWS and NTNCWS to meet a treatment standard. This is a regulatory approach that is used when an adequate analytical method is not available for a contaminant.

As noted above, EPA has a duty under SDWA to prepare a sound benefit-cost estimate for a rulemaking, that estimate will need to overcome significant limitations in the above analytical approach by:

1. Being based on demonstrated removal efficiencies for all of the target contaminants.
2. Forecasting the distribution of treatment technologies taking the actual target contaminants and water matrix effects into account.
3. Incorporating the additional SDWA treatment requirements associated with adding advanced treatment to what are now small groundwater systems without treatment.

EPA will also be better able to take into account consequences of this and other legislative actions. To the extent that state or federal legislation action impacts (1) stack emissions from GAC regeneration (e.g., controls on stack emissions), (2) requires disposal of GAC or IX media as hazardous waste, or (3) restricts the release of PFAS through NPDES permits, those costs will need to be incorporated into the cost of drinking water treatment. The costs associated with residual stream management can be quite significant. While data is not available for PFAS, analyses conducted to inform the California Hexavalent Chromium MCL process demonstrate the impact of residuals management on treatment option selection and implementation costs.[2] To the extent that compliance is reliant on technologies like reverse osmosis, in the absence of significant technological advances, brine disposal for many communities relies on disposal in Underground Injection Control program wells.

Note that as the CBO request included a specific query on administration and monitoring costs, the above treatment costs do not include either – they are simply a planning level estimate (i.e., -30% /+50% estimate for the cost of implementing necessary treatment facilities to address PFAS in drinking water systems. A cost estimate should also consider the following financial implications due to the new regulations with respect to system resiliency, e.g.,

- If, and how, the investment in treatment might increase, or decrease, protection against other likely water quality risks?
- To what degree will available water supplies be reduced (e.g., water supply wells taken off-line, impacts on ongoing aquifer storage and recovery programs, creation of brine streams, etc.)?
- How will the treatment investment impact funding availability for other infrastructure investments like implementation of the Long-Term Lead and Copper Rule?

[2] Arcadis. Final Report – Hexavalent Chromium Treatment Residuals Management, March 27, 2012, (Prepared for the Association of California Water Agencies and the City of Glendale Water and Power.
Chad J. Seidel, Issam N. Najm, Nicole K. Blute, Christopher J. Corwin, XueyiNg Wu, National and California treatment costs to comply with potential hexavalent chromium MCLs, Journal AWWA, First published: 01 June 2013 https://doi.org/10.5942/jawwa.2013.105.0080.

ATTACHMENT 2. REFERENCES FOR TREATMENT COST ESTIMATE

PFAS Treatment Project References for Treatment Cost Estimate

Facility	Treatment Capacity	Treatment Option	Capital Cost Estimate	Annual O&M Estimate
Cape Fear Public Utility Authority[1]	44 MGD	GAC	$46M	$2.7M
		IX	$46M	$2.1M
		RO	$150M	$4.7M
Brunswick County Public Utilities[2]	36 MGD	RO	$99M	$2.9M
		Ozone w/Biofiltration and GAC	$99M	$4.7M
		GAC w/IX and UV-AOP	$84M	$4.7M
Merrimack Village District (MVD)[3]	2.88 MGD	GAC	$3.6M to $4.3M	$0.13M to $0.27M
		IX	$4.4M to $5.1M	$0.12M to $0.19M
	1.44 MGD	GAC	$6.9M	$0.12M to $0.19M
		IX	$7.4M	$0.25M to $0.61M
	4.32 MGD	GAC	$10.9M	$0.24M to $0.43M
		IX	$12.2M	$0.52M to $1.4M
City of Portsmouth (Pease)[4]	1.67 MGD	GAC	$13M	$0.16M
West Morgan East Lawrence Water Authority[5]	8 MGD	GAC	$4M	$0.6M
		RO	$40M to $80M	N/A
Ann Arbor, MI[6]	22 MGD	GAC	N/A	$0.35M
Issaquah, WA[7,8]	0.36 MGD	GAC	$1M	N/A

1. https://www.cfpua.org/DocumentCenter/View/11386/BlackVeatch_FinalReport
2. https://www.brunswickcountync.gov/wp-content/uploads/2018/04/CDM-Smith-Brunswick-Final-Report-April-2018.pdf
3. http://www.mvdwater.org/wp-content/uploads/2018/12/PFAS-Treatment-Feasibility-Report-237-8-Final.pdf
4. http://files.cityofportsmouth.com/publicworks/Pease%20Well%20Treatment%20Cost%20Alternative%20Report%20-%20June%202017%20(Final).pdf
5. https://www.waaytv.com/content/news/WAAY-31-I-Team-Investigation-Cleaning-contaminated-water-483249661.html
6. https://energycommerce.house.gov/sites/democrats.energycommerce.house.gov/files/documents/05.15.19 Witness Testimony_Steglitz.pdf
7. https://pfasproject.com/issaquah-washington/
8. https://www.issaquahwa.gov/DocumentCenter/View/2810

Similar Treatment Process Project References for Treatment Cost Estimate

Facility	Treatment Capacity	Treatment Option	Capital Cost Estimate	Annual O&M Estimate
Aurora, CO[1]	10 MGD	Brackish RO	$33M	N/A
Multiple Systems, TX[2]	1.2 to 27.5 MGD	Brackish RO	$2.75M to $118M[4]	$0.5M to $6.5M[4]
Multiple Systems, FL[4]	2.0 to 10 MGD	IX	$0.85M to $4M	N/A
State of Industry Model[5]	2.7 to 27 MGD	Brackish RO	$9.5M to $60M[4]	N/A
	0.1 to 10 MGD	Brackish RO	N/A	$0.06 to $2M[4]

1. https://awwa.onlinelibrary.wiley.com/doi/pdf/10.5942/jawwa.2017.109.0020
2. http://www.twdb.texas.gov/innovativewater/desal/doc/Cost_of_Desalination_in_Texas_rev.pdf
3. In some cases, reported cost estimates are greater than 5 years old and have been updated to reflect inflation.
4. https://scholarcommons.usf.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=7837&context=etd
5. https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/programs/conf2011/pdf/Lozier.pdf

ATTACHMENT 3. EXCERPT OF RELEVANT TEXT FROM S.1507 - PFAS RELEASE DISCLOSURE ACT

TITLE II—DRINKING WATER

SEC. 201. NATIONAL PRIMARY DRINKING WATER REGULATIONS FOR PFAS.

Section 1412(b)(2) of the Safe Drinking Water Act (42 U.S.C. 300g–1(b)(2)) is amended by adding at the end the following:

"(D) PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES.—

"(i) IN GENERAL.—Not later than 2 years after the date of enactment of this subparagraph, the Administrator shall promulgate a national primary drinking water regulation for perfluoroalkyl and polyfluoroalkyl substances, which shall, at a minimum, include standards for—

"(I) perfluorooctanoic acid (commonly referred to as 'PFOA'); and

"(II) perfluorooctane sulfonic acid (commonly referred to as 'PFOS').

"(ii) ALTERNATIVE PROCEDURES.—

"(I) IN GENERAL.—Not later than 1 year after the validation by the Administrator of an equally effective quality control and testing procedure to ensure compliance with that national primary drinking water regulation to measure the levels described in subclause (II) or other methods to detect and monitor perfluoroalkyl and polyfluoroalkyl substances in drinking water, the Administrator shall add the procedure or method as an alternative to the quality control and testing procedure described in that national primary drinking water regulation by publishing the procedure or method in the Federal Register.

"(II) LEVELS DESCRIBED.—The levels referred to in subclause (I) are—

"(aa) the level of a perfluoroalkyl or polyfluoroalkyl substance;

"(bb) the total levels of perfluoroalkyl and polyfluoroalkyl substances; and

"(cc) the total levels of organic fluorine.

"(iii) INCLUSIONS.—The Administrator may include a perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances on—

"(I) the list of contaminants for consideration of regulation under paragraph (1)(B)(i); and

"(II) the list of unregulated contaminants to be monitored under section 1445(a)(2)(B)(i).

"(iv) MONITORING.—When establishing monitoring requirements for public water systems as part of a national primary drinking water regulation under clause (i) or clause (vi)(II), the Administrator shall tailor the monitoring requirements for public water systems that do not detect or are reliably and consistently below the maximum contaminant level (as defined in section 1418(b)(2)(B)) for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances subject to the national primary drinking water regulation.

"(v) HEALTH RISK REDUCTION AND COST ANALYSIS.—In meeting the requirements of paragraph (3)(C), the Administrator may rely on information available to the Administrator with respect to 1 or more specific perfluoroalkyl or polyfluoroalkyl substances to extrapolate reasoned conclusions regarding the health risks and effects of a class of perfluoroalkyl or polyfluoroalkyl substances of which the specific perfluoroalkyl or polyfluoroalkyl substances are a part.

"(vi) REGULATION OF ADDITIONAL SUBSTANCES.—

"(I) DETERMINATION.—The Administrator shall make a determination under paragraph (1)(A), using the criteria described in clauses (i) through (iii) of that paragraph, whether to include a perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances in the national primary drinking water regulation under clause (i) not later than 18 months after the later of—

"(aa) the date on which the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances is listed on the list of contaminants for consideration of regulation under paragraph (1)(B)(i); and

"(bb) the date on which—

"(AA) the Administrator has received the results of monitoring under section 1445(a)(2)(B) for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substance; or

"(BB) the Administrator has received finished water data or finished water monitoring surveys for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances from a Federal or State agency that the Administrator determines to be sufficient to make a determination under paragraph (1)(A).

"(II) PRIMARY DRINKING WATER REGULATIONS.—

"(aa) IN GENERAL.—For each perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances that the Administrator determines to regulate under subclause (I), the Administrator—

"(AA) not later than 18 months after the date on which the Administrator makes the determination, shall propose a national primary drinking water regulation for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances; and

"(BB) may publish the proposed national primary drinking water regulation described in subitem (AA) concurrently with the publication of the determination to regulate the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances.

"(bb) DEADLINE.—

"(AA) IN GENERAL.—Not later than 1 year after the date on which the Administrator publishes a proposed national primary drinking water regulation under item (aa)(AA) and subject to subitem (BB), the Administrator shall take final action on the proposed national primary drinking water regulation.

"(BB) EXTENSION.—The Administrator, on publication of notice in the Federal Register, may extend the deadline under subitem (AA) by not more than 6 months.

"(vii) LIFETIME DRINKING WATER HEALTH ADVISORY.—

"(I) IN GENERAL.—Subject to subclause (II), the Administrator shall publish a health advisory under paragraph (1)(F) for a perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances not later than 1 year after the later of—

"(aa) the date on which the Administrator finalizes a toxicity value for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances; and

"(bb) the date on which the Administrator validates an effective quality control and testing procedure for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substance, if such a procedure did not exist on the date on which the toxicity value described in item (aa) was finalized.

"(II) WAIVER.—The Administrator may waive the requirements of subclause (I) with respect to a perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl and polyfluoroalkyl substances if the Administrator determines that there is a substantial likelihood that the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances will not occur in drinking water.".

SEC. 202. MONITORING AND DETECTION.

(a) MONITORING PROGRAM FOR UNREGULATED CONTAMINANTS.—

(1) IN GENERAL.—The Administrator shall include each substance described in paragraph (2) in the fifth publication of the list of unregulated contaminants to be monitored under section 1445(a)(2)(B)(i) of the Safe Drinking Water Act (42 U.S.C. 300j–4(a)(2)(B)(i)).

(2) SUBSTANCES DESCRIBED.—The substances referred to in paragraph (1) are perfluoroalkyl and polyfluoroalkyl substances and classes of perfluoroalkyl and polyfluoroalkyl substances—

(A) for which a method to measure the level in drinking water has been validated by the Administrator; and

(B) that are not subject to a national primary drinking water regulation under clause (i) or (vi)(II) of subparagraph (D) of section 1412(b)(2) of the Safe Drinking Water Act (42 U.S.C. 300g–1(b)(2)).

(3) EXCEPTION.—The perfluoroalkyl and polyfluoroalkyl substances and classes of perfluoroalkyl and polyfluoroalkyl substances included in the list of unregulated contaminants to be monitored under section 1445(a)(2)(B)(i) of the Safe Drinking Water Act (42 U.S.C. 300j–4(a)(2)(B)(i)) under paragraph (1) shall not count towards the limit of 30 unregulated contaminants to be monitored by public water systems under that section.

(b) APPLICABILITY.—

(1) IN GENERAL.—The Administrator shall—

(A) require public water systems serving more than 10,000 persons to monitor for the substances described in subsection (a)(2);

(B) subject to paragraph (2) and the availability of appropriations, require public water systems serving not fewer than 3,300 and not more than 10,000 persons to monitor for the substances described in subsection (a)(2); and

(C) subject to paragraph (2) and the availability of appropriations, ensure that only a representative sample of public water systems serving fewer than 3,300 persons are required to monitor for the substances described in subsection (a)(2).

(2) REQUIREMENT.—If the Administrator determines that there is not sufficient laboratory capacity to carry out the monitoring required under subparagraphs (B) and (C) of paragraph (1), the Administrator may waive the monitoring requirements in those subparagraphs.

(3) FUNDS.—The Administrator shall pay the reasonable cost of such testing and laboratory analysis as is necessary to carry out the monitoring required under paragraph (1) from—

(A) funds made available under subsection (a)(2)(H) or (j)(5) of section 1445 of the Safe Drinking Water Act (42 U.S.C. 300j–4); or

(B) any other funds made available for that purpose.

SEC. 203. ENFORCEMENT.

Notwithstanding any other provision of law, the Administrator may not impose financial penalties for the violation of a national primary drinking water regulation (as defined in section 1401 of the Safe Drinking Water Act (42 U.S.C. 300f)) with respect to a perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances for which a national primary drinking water regulation has been promulgated under clause (i) or (vi) of subparagraph (D) of section 1412(b)(2) of the Safe Drinking Water Act (42 U.S.C. 300g–1(b)(2)) earlier than the date that is 5 years after the date on which the Administrator promulgates the national primary drinking water regulation.

SEC. 204. DRINKING WATER STATE REVOLVING FUNDS.

Section 1452 of the Safe Drinking Water Act (42 U.S.C. 300j–12) is amended—

(1) in subsection (a)(2), by adding at the end the following:

"(G) EMERGING CONTAMINANTS.—

"(i) IN GENERAL.—Subject to clause (ii), amounts deposited under subsection (t) in a State loan fund established under this section may be used to provide grants for the purpose of addressing emerging contaminants, with a focus on perfluoroalkyl and polyfluoroalkyl substances.

"(ii) REQUIREMENTS.—

"(I) SMALL AND DISADVANTAGED COMMUNITIES.—Not less than 25 percent of the amounts described in clause (i) shall be used to provide grants to—

"(aa) disadvantaged communities (as defined in subsection (d)(3)); or

"(bb) public water systems serving fewer than 25,000 persons.

"(II) PRIORITIES.—In selecting the recipient of a grant using amounts described in clause (i), a State shall use the priorities described in subsection (b)(3)(A).";

(2) in subsection (m)(1), in the matter preceding subparagraph (A), by striking "this section" and inserting "this section, except for subsections (a)(2)(G) and (t)"; and

(3) by adding at the end the following:

"(t) EMERGING CONTAMINANTS.—

"(1) IN GENERAL.—Amounts made available under this subsection shall be allotted to a State as if allotted under subsection (a)(1)(D) as a capitalization grant, for deposit into the State loan fund of the State, for the purposes described in subsection (a)(2)(G).

"(2) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to carry out this subsection $100,000,000 for each of fiscal years 2020 through 2024, to remain available until expended."

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

SWANA
SOLID WASTE ASSOCIATION OF NORTH AMERICA

May 10, 2022

Re: Relief for Municipal Solid Waste Landfills from CERCLA Liability for PFAS

Dear Chairman Carper, Ranking Member Capito, Chairman DeFazio, Ranking Member Graves, Chairman Pallone, and Ranking Member McMorris Rodgers:

The municipal solid waste (MSW) management sector strongly supports the goal of addressing per- and poly-fluoroalkyl substances (PFAS) contamination and holding accountable manufacturers and heavy users of these compounds. We are concerned, however, that regulation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) instead would assign environmental cleanup liability to essential public services and their customers. We therefore request that Congress provide MSW landfills and other passive receivers with a narrow exemption from liability if certain PFAS are designated as hazardous substances under CERCLA. Doing so would keep CERCLA liability on the industries that created the pollution in the first place.

Context

- Landfills neither manufacture nor use PFAS; instead, they receive discarded materials containing PFAS that are ubiquitous in residential and commercial waste streams. MSW landfills and the communities they serve should not be held financially liable under CERCLA for PFAS contamination, as landfills are part of the long-term solution to managing these compounds.
- Landfills are essential public services that are subject to extensive federal, state, and local environmental, health, and safety requirements. Further, MSW landfills are important to managing and limiting PFAS in the environment, as recognized by the Environmental Protection Agency (EPA) in its December 2020 draft Interim Guidance on the Destruction and Disposal of [PFAS] and Materials Containing [PFAS].
- **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.**
- Most landfills rely on wastewater treatment facilities for leachate management. Wastewater and drinking water facilities increasingly rely on landfills for biosolids management and disposal of PFAS-laden filters. Efforts to address PFAS at MSW landfills and drinking water and wastewater facilities must avoid disrupting this interdependence among essential public services to communities.
- Landfill leachate typically represents a minor proportion of the total quantity of PFAS received at wastewater treatment facilities from all sources. PFAS manufacturers or users, by comparison, contribute PFAS at levels that can be orders of magnitude higher than landfills.

Significant Economic Impacts

- Removing PFAS from landfill leachate requires advanced treatment techniques which are prohibitively expensive. Estimated capital costs to implement leachate pretreatment at a moderate-sized landfill to the extent necessary to significantly reduce PFAS range from $2 million to $7 million, **with nationwide costs totaling $966 million to $6.279 billion per year** for the solid waste sector. Trace concentrations of PFAS nevertheless would remain in leachate following pretreatment, exposing landfills to CERCLA liability.
- Absent relief from CERCLA liability, manufacturers and heavy users of PFAS compounds will bring claims for contribution against landfills and other passive receivers, generating significant litigation costs. EPA's exercise of enforcement discretion will not insulate landfills from this litigation.

- These costs will be passed along to communities, water and wastewater treatment facilities, and biosolids management, all of which rely on the services of MSW landfills.

Broad Unintended Consequences

- **CERCLA regulation will impel landfills to restrict inbound wastes and/or increase disposal costs for media with elevated levels of PFAS, including filters, biosolids, and impacted soils at Department of Defense facilities.** The mere prospect of regulation in this area is already disrupting the interdependence of the drinking water, wastewater, and solid waste sectors.
- 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.
- Cost increases likely will have a significant disproportionate impact on low-income households that rely on the affordability of services that the solid waste sector provides.

Recommendation

Although our sector is simultaneously pursuing "no action assurance" from EPA, the agency historically has been very hesitant to provide this relief given its policy that assurances should be given only "in extremely unusual cases." As such, and acknowledging that EPA may have limited authority to act on our request, we recommend providing the following narrow exemption from CERCLA liability that affords relief to landfills and other passive receivers of PFAS[1]:

(a) IN GENERAL.—No publicly owned or operated community water system (as defined at 42 U.S.C. 300f), publicly owned treatment works (as defined at 33 U.S.C. 1292), or municipal solid waste landfill (as defined at 40 C.F.R. 258.2) shall be liable under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601 et seq.) for the costs of responding to, or damages resulting from, a release to the environment of a perfluoroalkyl or polyfluoroalkyl substance designated as a hazardous substance under section 102(a) of such Act that resulted from the discharge of effluent, the disposal or management of biosolids, the disposal of filtration media resin, or the discharge of leachate where such actions are in compliance with Federal or State law and all applicable permits.

(b) EXCEPTION.—Subsection (a) shall not apply with respect to any discharge described in such subsection that results from any gross negligence, willful misconduct, or noncompliance with any Federal or State law or permit governing the discharge of effluent, disposal or management of biosolids, disposal of filtration media resin, or waste disposal.

Thank you for your consideration of our request, and we look forward to continuing to partner with the federal government to ensure the safe and effective management of waste streams containing PFAS.

Sincerely,

National Waste & Recycling Association
Solid Waste Association of North America

cc: Senate EPW Committee Members
House T&I and E&C Committee Members

[1] The exemption would not extend to underlying soil and groundwater contamination from a MSW landfill or to facilities other than MSW landfills that accept waste streams with elevated concentrations of PFAS.

wasterecycling.org

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February 8, 2022

Ms. Ariana Sutton-Grier
Office of Management and Budget
Office of Information & Regulatory Affairs
1100 G Street, NW
Washington, DC 20005

Re: PFAS Management Costs for Municipal Solid Waste Landfills

Dear Ms. Sutton-Grier:

Thank you for the opportunity to meet with your office on February 7, 2022, to discuss the potential impacts on the solid waste sector of EPA's proposed rule designating PFOA and PFOS as CERCLA hazardous substances (RIN: 2050-AH09). The National Waste & Recycling Association (NWRA) is a trade association representing the private sector waste and recycling industry. Our members operate in all fifty states and the District of Columbia. Also present during the meeting were some of our members and representatives from the Solid Waste Association of North America (SWANA). SWANA is a not-for-profit professional association in the solid waste field with more than 10,000 members in both the private and public sectors across North America.

In response to your request for information on the economic impact of the rule to our sector, we have provided the following cost estimates and information. As we discussed at our meeting, the designation of PFOA and PFOS as hazardous substances under CERCLA will likely have unintended consequences that undercut the Administration's broader environmental goals. We ask that OIRA account for these realities, as well as the significant economic impact of the rule on innocent essential public services and their customers, as it considers the draft proposed rule. The municipal solid waste industry continues to strongly support the goals of addressing PFAS contamination and holding accountable those entities that are responsible for the compounds through their manufacture and/or use.

The municipal solid waste industry is unaware of any full-scale commercially proven PFAS treatment destruction technologies for landfill leachate. Existing technologies have been deployed to remove, but not destroy, PFAS, including reverse osmosis and granular activated carbon. These technologies currently are available to landfills and wastewater treatment facilities but require significant wastewater pretreatment before PFAS removal can be achieved. It is also important to highlight that there are notable differences in the use of treatment technologies for PFAS removal at landfills versus wastewater treatment facilities.

Since most landfills do not employ leachate pretreatment, PFAS removal requires the development of a multi-step process including (1) pretreatment to address non-PFAS constituents, (2) subsequent PFAS removal technology, and (3) PFAS residuals treatment/management. From an economic perspective, leachate pretreatment and PFAS residuals management will add significantly to the costs of landfill operation.

The municipal solid waste industry is unaware of any full-scale commercially proven PFAS treatment destruction technologies for landfill leachate. Existing technologies have been deployed to remove, but not destroy, PFAS, including reverse osmosis and granular activated carbon. These technologies currently are available to landfills and wastewater treatment facilities but require significant wastewater pretreatment before PFAS removal can be achieved. It is also important to highlight that there are notable differences in the use of treatment technologies for PFAS removal at landfills versus wastewater treatment facilities.

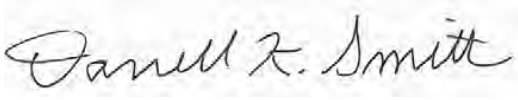
Since most landfills do not employ leachate pretreatment, PFAS removal requires the development of a multi-step process including (1) pretreatment to address non-PFAS constituents, (2) subsequent PFAS removal technology, and (3) PFAS residuals treatment/management. From an economic perspective, leachate pretreatment and PFAS residuals management will add significantly to the costs of landfill operation.

The estimated capital cost to implement leachate pretreatment to the extent necessary to remove PFAS is approximately $2 to $7 million to provide complete, multi-step biological treatment of 30,000 to 40,000 gallons per day of leachate, representing a moderate sized landfill. Included in this cost estimate is approximately $0.5 to $1.5 million for PFAS removal technology, with additional costs anticipated for landfills where more stringent effluent levels are desired/mandated.

Moreover, since these technologies are unable to destroy PFAS, further management of the residual PFAS waste streams is needed 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, the municipal solid waste industry anticipates 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%) (see Appendix). Based on an estimated 16.1 billion gallons of leachate per year generated in the United States (see pg. 68 of EPA's *Interim Guidance on the Destruction and Disposal of PFAS and PFAS-Containing Materials*), **increased costs associated with PFAS management could total approximately $966 million to $6.279 billion per year for municipal solid waste landfills.**

We appreciate the opportunity to provide these additional comments, and we look forward to working with you as you continue to review the proposed rule. If you have any questions, please feel free to contact Anne Germain at agermain@wasterecycling.org or 302-270-5483.

Very truly yours,



Darrell K. Smith
President & CEO

Appendix. Cost Summary of Review of Conceptual Leachate Treatment Scoping Study New England Waste Services of Vermont (NEWSVT) Coventry, Vermont

The State of Vermont requested Civil & Environmental Consultants, Inc. (CEC), to prepare an independent evaluation of several alternative management and technology approaches for managing PFAS in the landfill leachate at the NEWSVT landfill in Coventry, Vermont. This is the only currently operating disposal facility in the state. CEC based its review on previous project experience and vendor quotes. The approaches in these alternatives included hauling to municipal wastewater resource recovery facilities (WWRFs), pretreatment to reduce the PFAS load in the hauled leachate, and various treatment options for surface water disposal. The treatment and disposal cost opinions at the WWRFs did not include the costs to the WWRFs for managing the PFAS in their effluent. These treatment costs do not include residuals management.

The overall alternative cost opinions presented below (based on CY 2020 costs) to be anticipated for a landfill generating 50,000 gallons per day (GPD) for a present worth cost range, including capital and life cycle operation and maintenance, ranged from $26 million to $95 million. The recommended alternative (Alternative 1A-2) involved a capital cost expenditure of $15.5 million and an annual cost of almost $1 million. The opinion of total annual cost for PFAS management for operation and maintenance and capital recovery over a 20-year bond repayment is $2.3 million for the 50,000 GPD leachate flow.

Alternative 1A-2 represents the lowest cost of the options reviewed. Costs for other options ranged as high as $8.3 million. In addition, these costs don't reflect other potential risks associated with managing leachate if POTWs cut off acceptance post-CERCLA regulation.

Option	Annualized costs (millions)
1a	$2.4
1a-2	$2.3
1a-3	$2.9
3a	$8.3
2a	$3.2
2d	$3.8
4a	$2.7
4b	$3.1

The life cycle cost opinions for the alternatives evaluated, including capital and annual operation and maintenance costs, ranged from $0.07 per gallon for hauling and disposal at WWRFs to over $0.41 per gallon for advanced multistage leachate treatment. The alternative recommended (Alternative 1A-2) included reverse osmosis treatment followed by a residuals evaporator to reduce the volume in the reverse osmosis reject flow from 15% to 3% of the leachate flow. Other related costs were not included, as the technology was not sufficiently developed at the report date.

Although this evaluation was based on a specific flow with specific site conditions, smaller plans may experience a higher cost per gallon, while larger plants may experience a smaller cost per gallon. The full text of the report is located at: https://anrweb.vt.gov/PubDocs/DEC/PFAS/Studies/Report-CEC-Review-of-BC-Conceptual-Study-6-15-2021.pdf

Table 3. Cost Opinions

NEWSVT PFAS Landfill Leachate Treatment System - Cost Summary

Technology	CAPEX Range			OPEX	Treatment System Life Cycle Cost - Present Worth	Mid opinion annual Capital Recovery Factor (CRF) = 0.087185	Combined Annualized Cost, CRF + OPEX	Treatment Cost/Gal	Annual Transport & Disposal (T&D)	Total Annual Treatment and Hauling/Disposal Cost	Present Worth Treatment System and T&D	Overall Cost/Gallon
	Low CAPEX Less 20%	Mid - Opinion	High CAPEX Plus 100%									
No Action	0	0	0	$0	0	0	0	0	$1,572,000	$1,572,000.00	$18,030,840	$0.07
Option 1a On-Site: Discharge to Surface Water	$13,163,000	$16,454,000	$32,908,000	$961,000	$27,500,000	$1,435,000	$2,396,000	$0.1313	$0	$2,396,000	$27,482,120	$0.1313
Option 1a-2 CEC Revision On-Site: Discharge to Surface Water	$12,354,000	$15,443,000	$30,886,000	$921,000	$26,000,000	$1,346,000	$2,267,000	$0.1242	$0	$2,267,000	$26,002,490	$0.1242
Option 1a-3 HTX CEC Revision On-Site: Discharge to Surface Water	$2,152,000	$2,690,000	$5,380,000	$2,640,000	$33,000,000	$235,000	$2,875,000	$0.1575	$0	$2,875,000	$32,976,250	$0.1575
Option 3a On-Site: Zero Liquid Discharge (ZLD)	$10,927,000	$13,659,000	$27,318,000	$7,142,000	$95,600,000	$1,191,000	$8,333,000	$0.4566	$0	$8,333,000	$95,579,510	$0.4566
Option 2a Off-Site: Pretreatment at POTW (50% Reduction)	$7,140,000	$8,925,000	$17,850,000	$835,000	$18,500,000	$778,000	$1,613,000	$0.0884	$1,572,000	$3,185,000	$36,531,950	$0.1745
Option 2d: Offsite HTX Pretreatment at POTW/NEWSVT (50% Reduction)	$2,381,000	$2,976,000	$5,952,000	$2,001,000	$25,900,000	$259,000	$2,260,000	$0.1238	$1,572,001	$3,832,001	$43,953,051	$0.2100
Option 4a –Off-Site: POTW Enhancements Newport	$5,031,000	$6,289,000	$12,578,000	$954,000	$17,200,000	$548,000	$1,502,000	$0.0823	$1,154,000	$2,656,000	$30,464,820	$0.1455
Option 4b - Off-Site: POTW Enhancements Montpelier	$4,645,000	$5,806,000	$11,612,000	$1,085,000	$18,300,000	$506,000	$1,591,000	$0.0872	$1,572,000	$3,163,000	$36,279,610	$0.1733

From *Review of Conceptual Leachate Treatment Scoping Study New England Waste Services of Vermont (NEWSVT) Coventry, Vermont* (p. 19)

PFAS Deposition in Precipitation: Efficacy of the NADP-NTN & Initial Findings

WisPAC Meeting, January 16, 2020

Martin Shafer, Mark Olson, Camille Danielson and Kirsten Widmayer

State Laboratory of Hygiene, School of Medicine & Public Health, University of Wisconsin-Madison

NADP

PFAS Dispersal & Atmospheric Processing

Atmospheric Transport, Processing and Deposition is Under-appreciated and Under-Studied

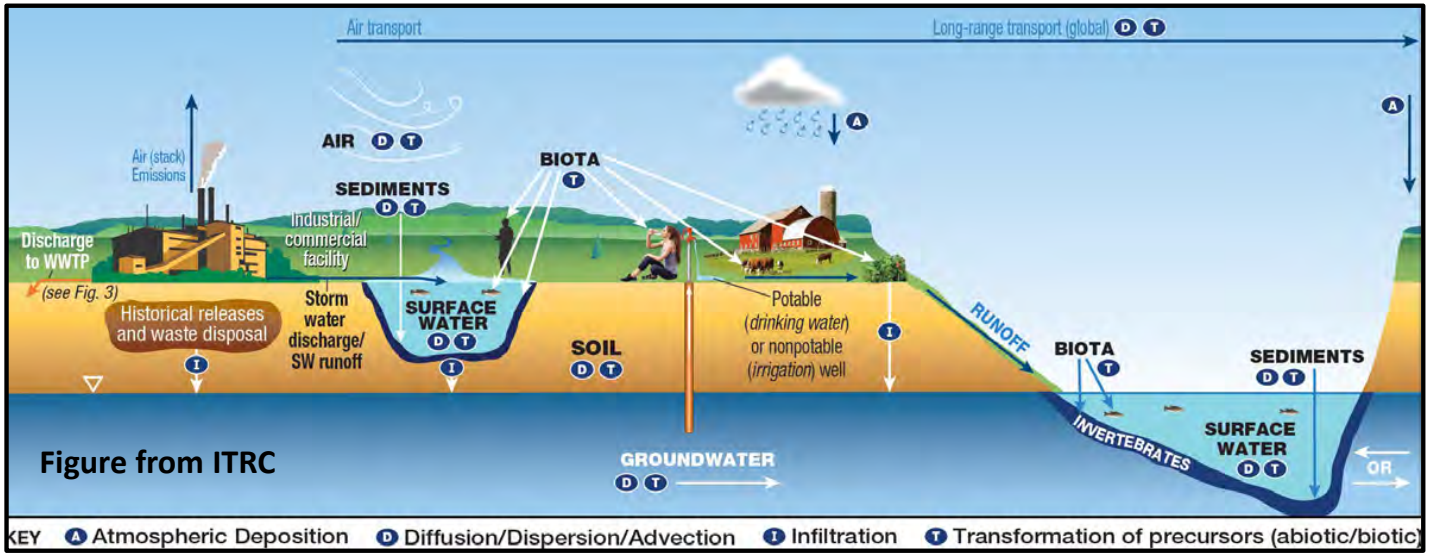


Figure from ITRC

PFAS found in remote environments (aquatic, atmosphere and terrestrial) far from any known sources)

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1. **Direct Industrial Emissions (1° & 2°)**
2. **Precursor Emissions**
3. **Particle Injection**
4. **POTW/Land-Spreading**
5. **Foam Use**

PFAS Dispersal & Atmospheric Processing

Short & Long-Range Transport in the Atmosphere

1. Vapor phase (e.g. neutral (more) volatile precursors)
2. Aerosol phase (e.g. ionic compounds & long-chain)

Transformations in the Atmosphere

1. Perfluoroalkanesulfonamides → carboxylic acids
2. Perfluorotelomeralcohols → carboxylic acids

Removal (Deposition) from the Atmosphere

1. Wet Deposition (precipitation/rain)
2. Dry Deposition

Atmospheric fate and transport of PFAS strongly dependent upon the specific PFAS compound

Hg analogy

NADP

Atmospheric Cycling Important in Dispersal of PFAS

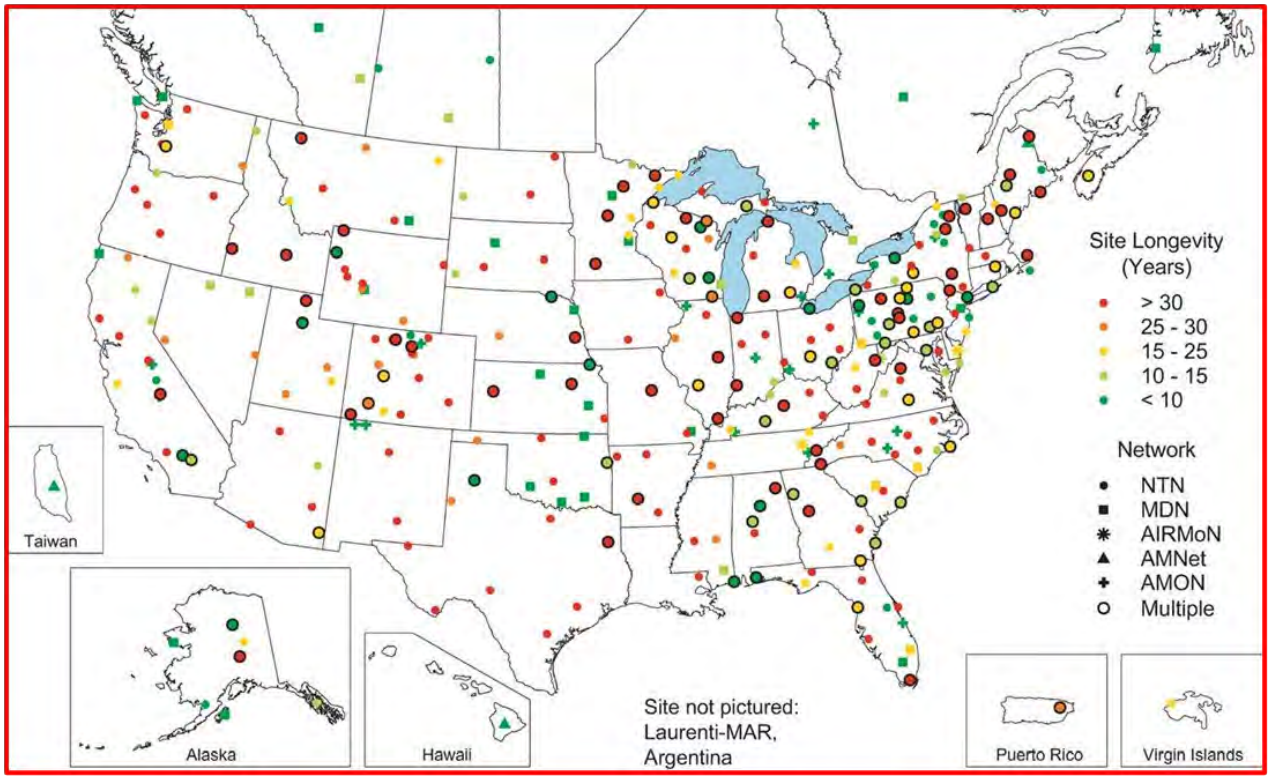
Goals & Approach: Wet Deposition

The NADP-NTN currently comprises 263 sites across the US and Canada, collecting 7-day wet-only precipitation samples. The Wisconsin State Laboratory of Hygiene at the UW-Madison operates all of the NADP networks and is home to the analytical laboratories that support these networks.

- Design and implement **field and laboratory experiments** to determine whether the NADP/NTN sampling network as currently configured (or with certain modifications) **would support robust PFAS concentration and deposition monitoring**
- Apply **ISO method 21675** (36 PFAS compound) to the NTN network evaluation studies and precipitation monitoring
- Perform **PFAS measurements** on geographically diverse **precipitation samples** from the NADP National Trends Network (NTN) to assess PFAS levels and **deposition fluxes**.

National Atmospheric Deposition Program
NADP

NADP Monitoring Sites



Synoptic Overview of PFAS Deposition and/or More Targeted Collections

Wisconsin NTN and MDN NADP Sites

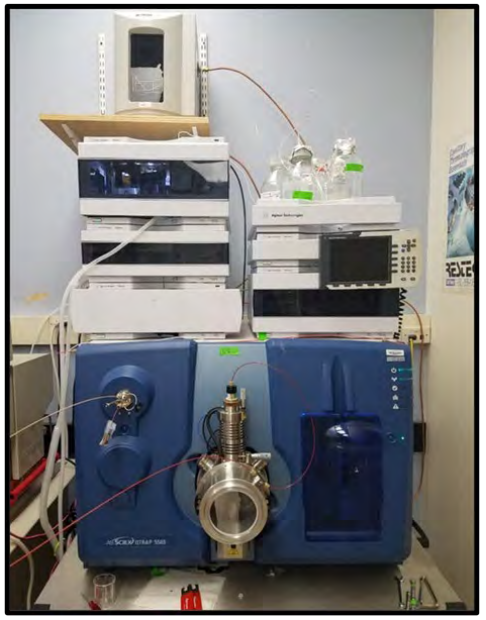
- WI06, UW Arboretum, Dane County
- WI08, Brule River, Douglas County
- WI10, Potawatomi, Forest County
- WI31, Devil's Lake, Sauk County
- WI35, Perkinstown, Taylor County
- WI36, Trout Lake, Vilas County
- WI37, Spooner, Washburn County

Red = NTN & MDN
7 NTN & 5 MDN Sites

1. Super-site in development at Eagle Heights (UW-Madison)
2. Ability to deploy "temporary" and/or mobile NTN collectors

PFAS Analytical Methods

- **Analytical methods**:
  - ✓ ISO Method 21675 (PFAS in Water by LC-MS/MS). 36 PFAS compounds. 26 isotopically-labeled internal-standards
  - ✓ 500 or 250 mL sample volume; entire sample extracted
  - ✓ Automated SPE (Oasis-WAX; 8-station Promochrom Tech.)
  - ✓ Sciex QTRAP 5500 LC/MS/MS, Waters Acquity UPLC
- **Contamination Control**:
  - ✓ QC'd polypropylene collection bottles
  - ✓ Gloves worn during sampling
  - ✓ NO Teflon or related materials



National Atmospheric Deposition Program

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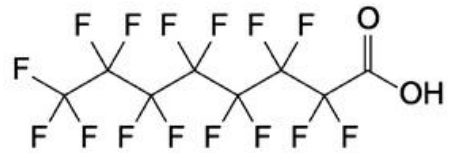
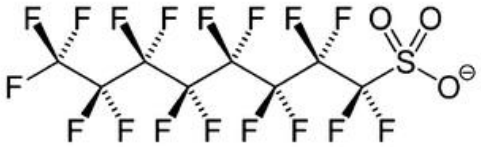
PFAS Compounds



Perfluorooctanoic acid (PFOA)

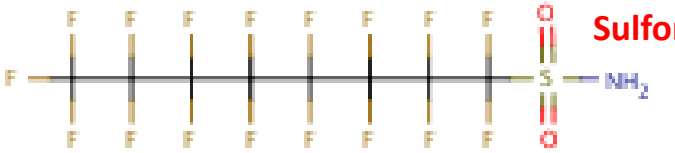
Carboxylic Acids



Perfluorooctanesulfonate (PFOS)

Sulfonates

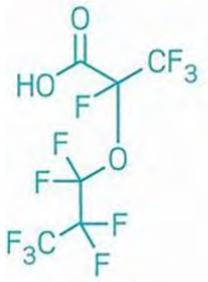
Fluorotelomers



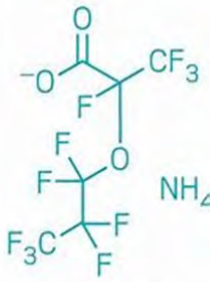
Sulfonamides

>4500 compounds known/suspected
220 with authentic standards
50 with "routine" robust methods
18 in EPA 537.1 (drinking water)
3-5 with regulatory limits (States)

1. **-C_nF_{2n}-head →**
2. **Repel oil and water**
3. **Chemical and Thermal stability**
4. **Reduce friction**
5. **High surface activity**



HFPO-DA

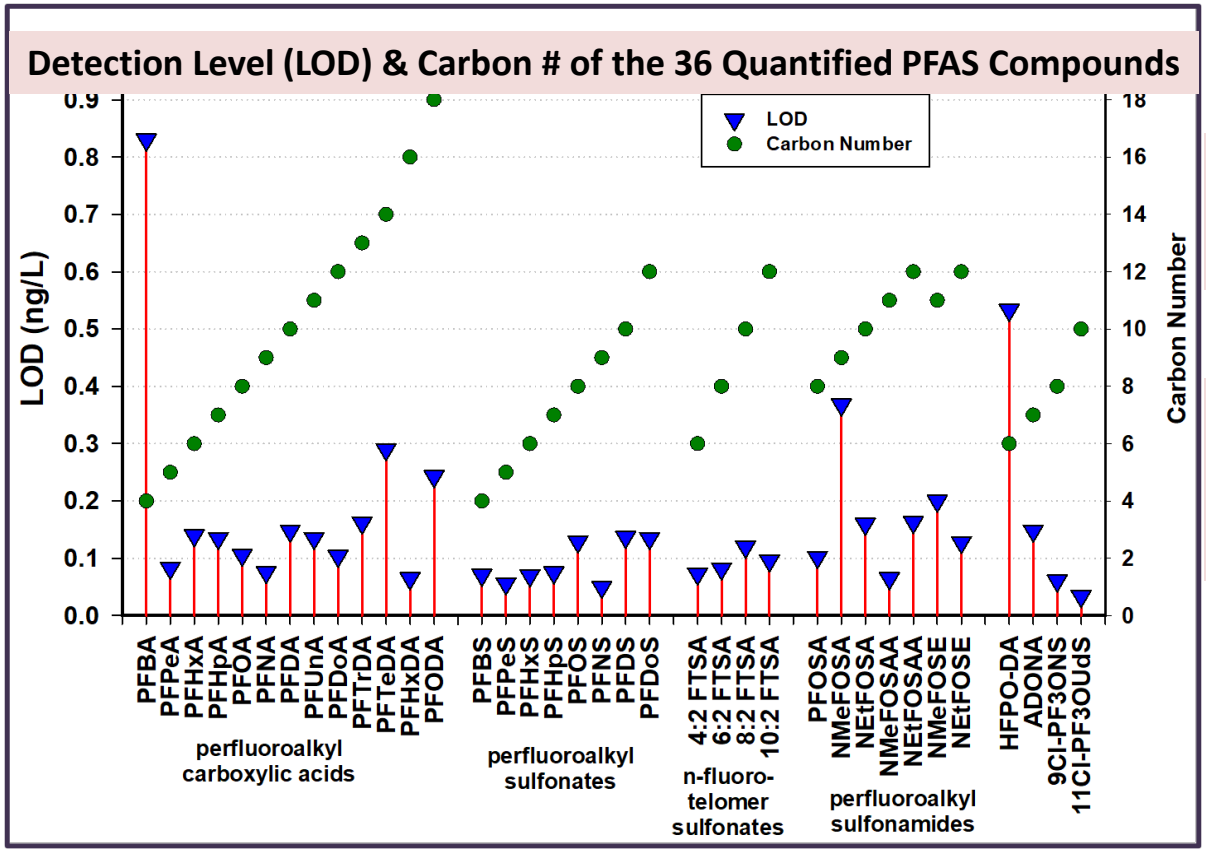


GenX

Buck et al. 2011

NADP **National Atmospheric Deposition Program**

PFAS Method Performance Outcomes in Precipitation



LODs
Typically in Range of 0.15 to 0.2 ng/L

Spike Recoveries
Typically in Range of 90 to 110% (4 ng/L spike)

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NTN Network Efficacy for PFAS Measurement

A. System Blanks: Bucket & Bag Collectors

- ✓ High-purity water → collectors

B. PFAS Retention/Loss Studies

- ✓ Water, spiked with 36 PFAS compounds at low ng/L levels → collectors

Retention/Loss Study Experimental Matrix

Sample Matrix	Incubation Location	Collector Type	Day 0	Day 1	Day 3	Day 7
MQ	Lab	Bag	1	2	2	2
MQ	Lab	Bucket	1	2	2	2
Precip	Lab	Bag	1	2	2	2
Precip	Lab	Bucket		2	2	2
Precip	Field	Bag		2	2	2
Precip	Field	Bucket	1	2	2	2

System blank trials run in triplicate.
Values in table are number of replicates for retention/loss studies.

Network Efficacy: Field Method Blank Outcomes

I. High Purity Water (7-day field conditions)

I. **Bags:** no detects for 36 species (except PFOA at 0.23 ng/L in 1 sample)
II. **Buckets:** no detects for 36 species (except PFOA at 0.44 ng/L in 1 sample)
III. **NTN Bottle:** no detects for 36 species

II. Methanol Rinses

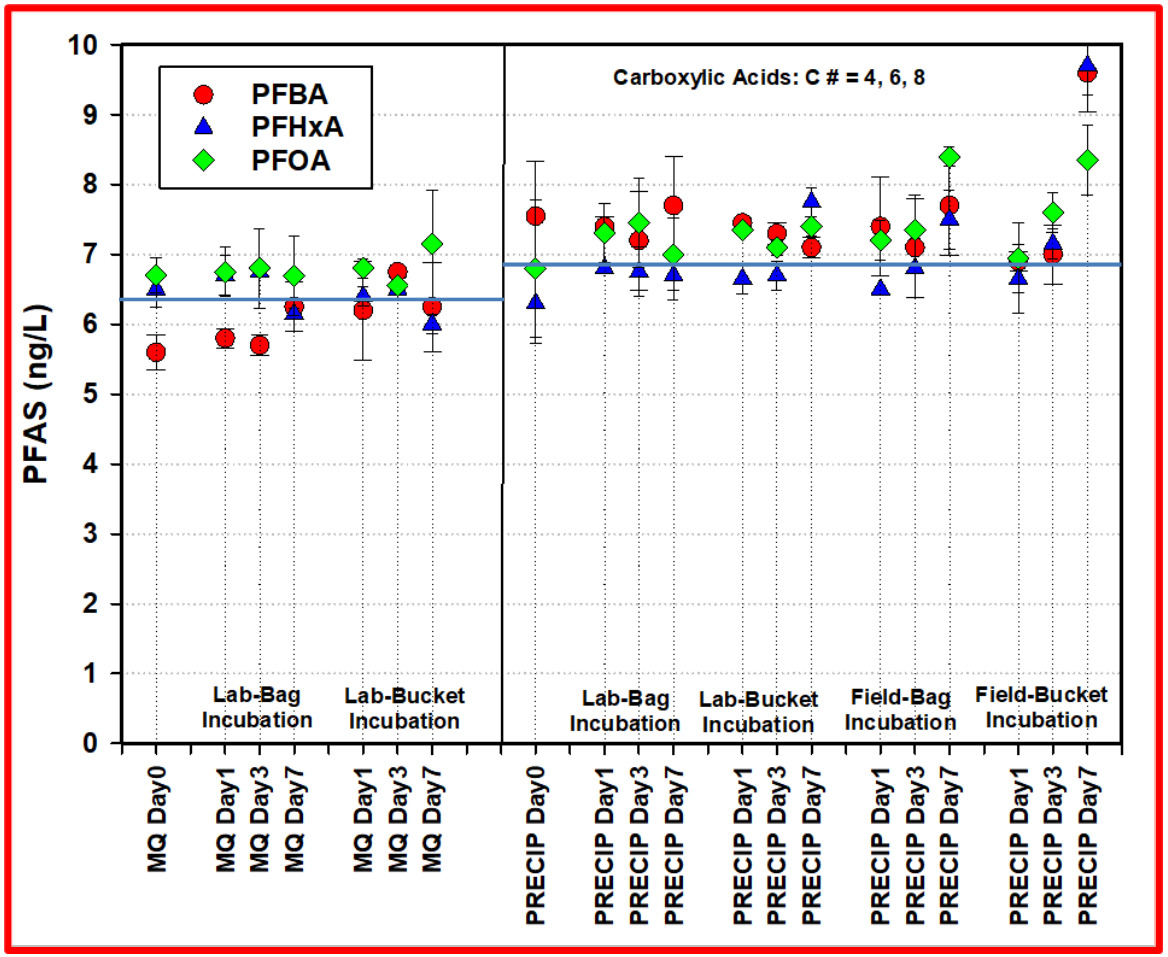
I. **Buckets:** no detects for 36 species

Bucket Washers

Buckets

PFAS Retention/Loss Study

Carboxylic Acids
C# = 4, 6, 8



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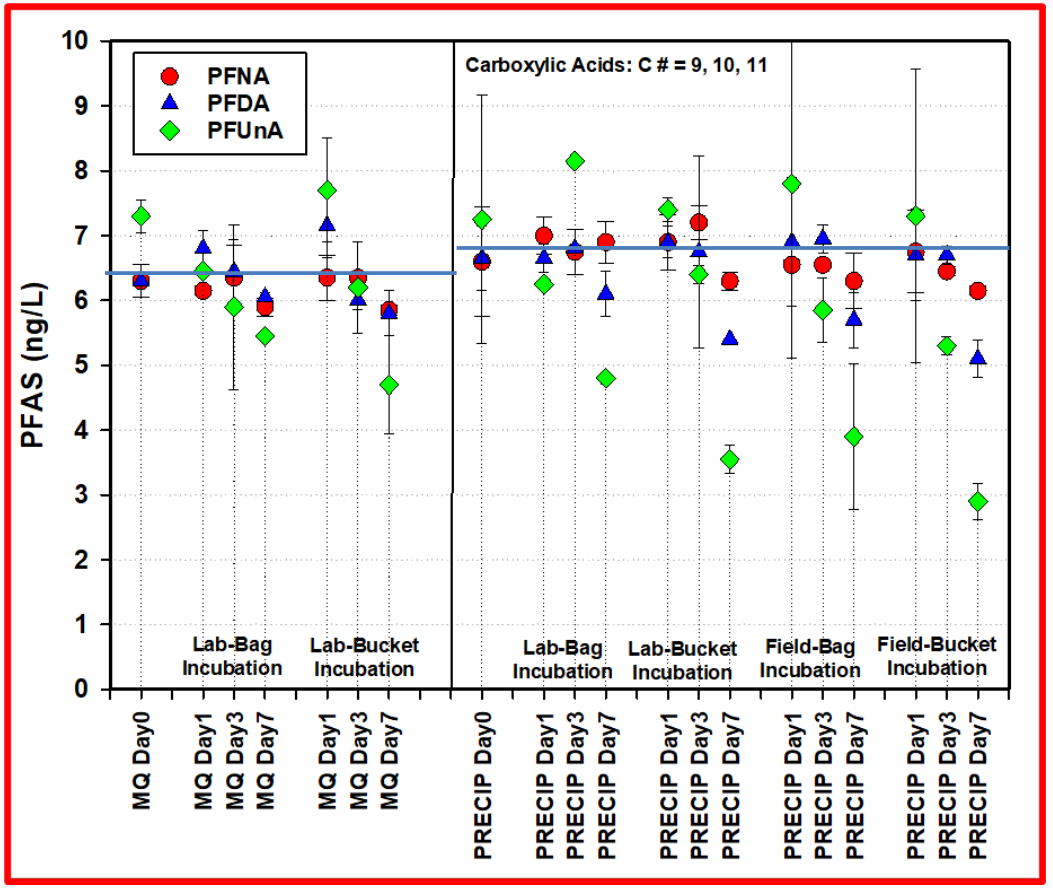
PFAS Retention/Loss Study

Carboxylic Acids
C# = 9, 10, 11



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PFAS Retention/Loss Study

Sulfonic Acids
C# = 4, 6, 8

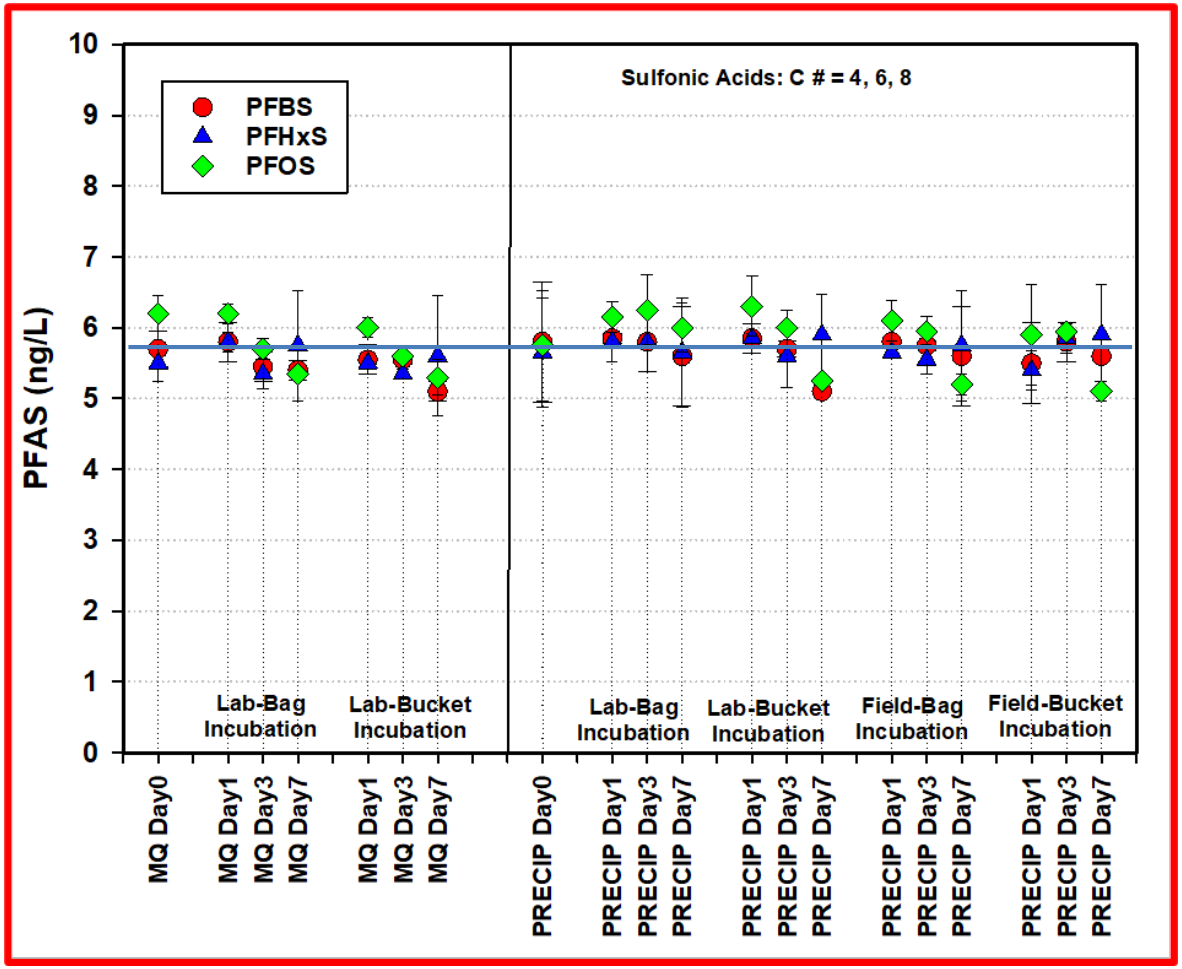

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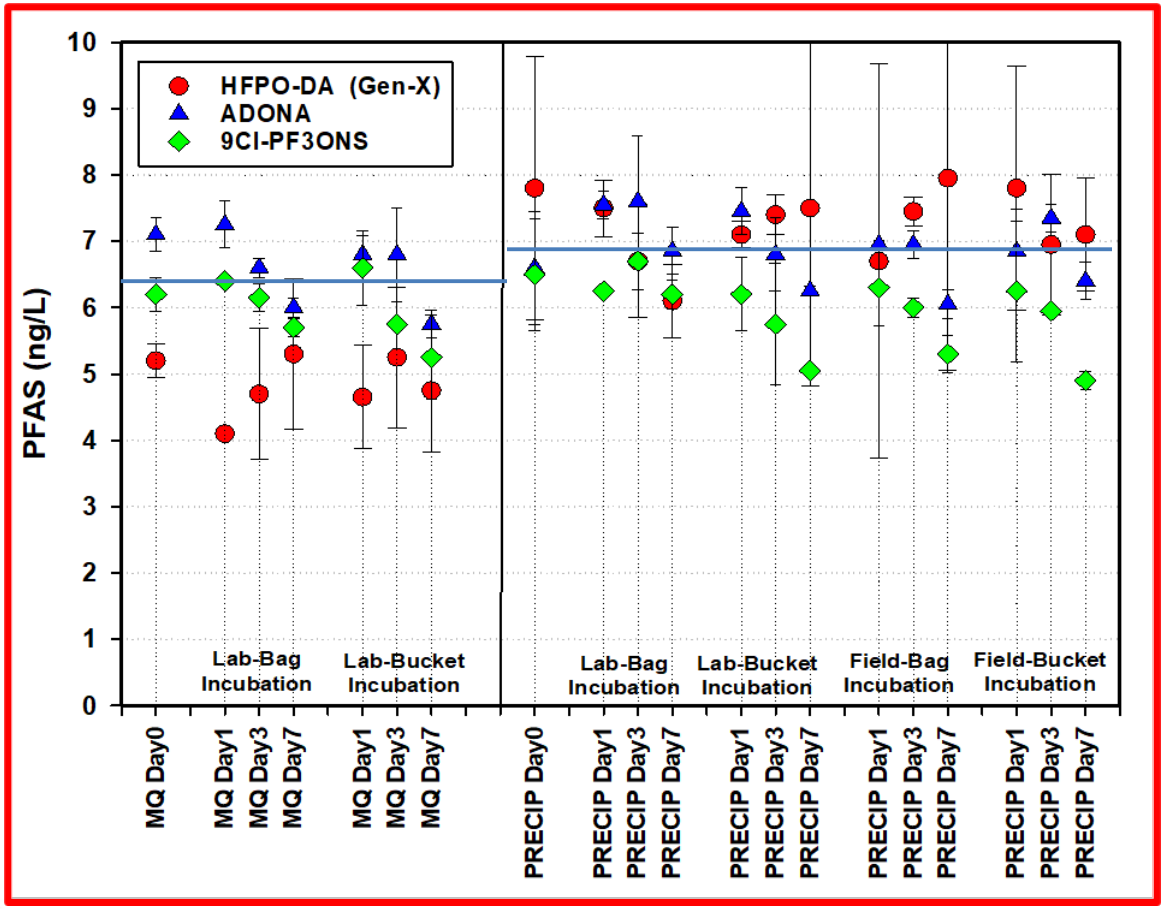
EXHIBIT 5

PFAS Retention/Loss Study

Gen-X & Related



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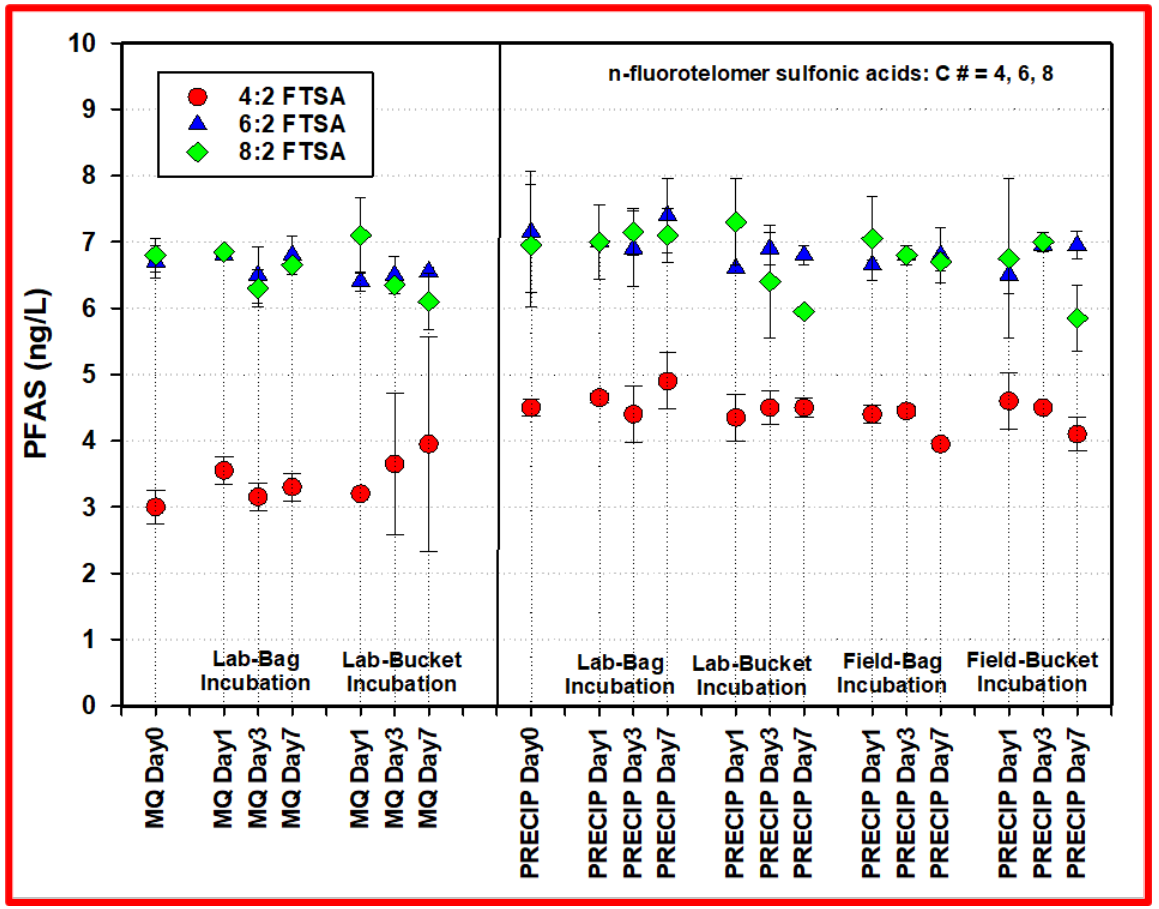
PFAS Retention/Loss Study

FTSA



National Atmospheric Deposition Program

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PFAS Retention/Loss Study

- Loss of PFAS in the NTN collector is minimal for compounds of carbon number <10 under current (and planned) NTN protocols.
- Losses are observed for longer-chain (>10 carbon) PFAS compounds.
  - ✓Where did the PFAS go?
  - ✓Are they recoverable?

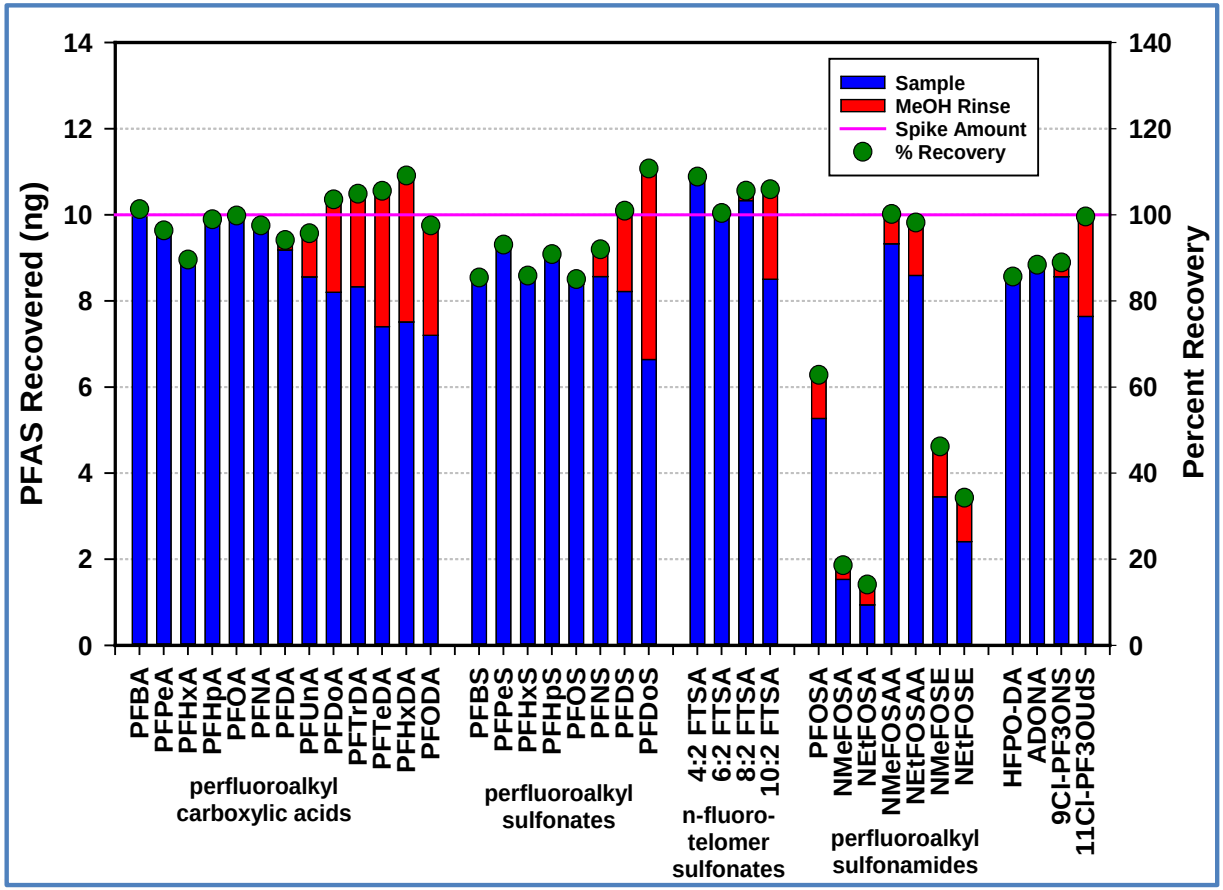
PFAS Retention/Loss: Methanol Bucket Rinse

10 ng Spike in 2L of MQ

7-Day Exposure

50 mL MeOH Bucket Rinse

Average of Triplicate Buckets



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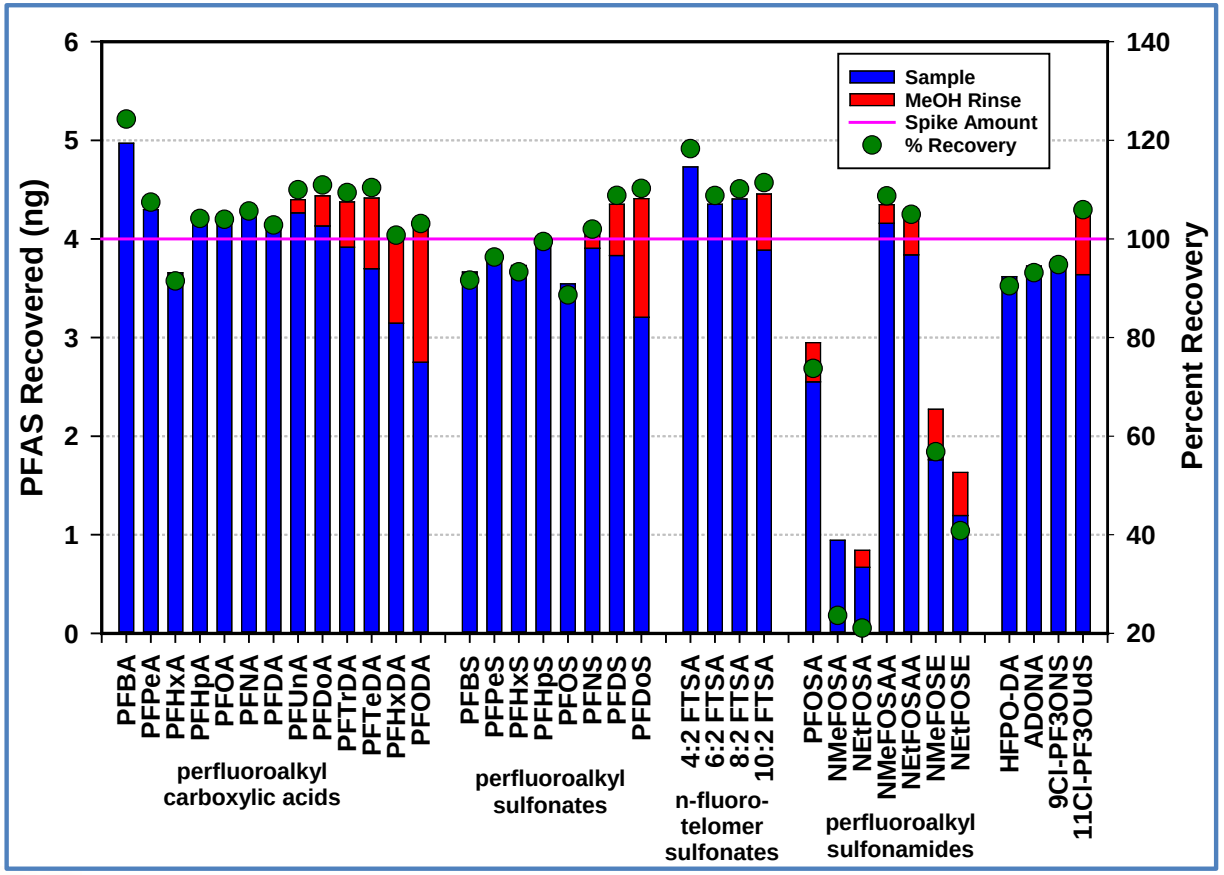
PFAS Retention/Loss: Methanol Bucket Rinse

4 ng Spike in 2L of MQ

7-Day Exposure

50 mL MeOH Bucket Rinse

Average of Triplicate Buckets



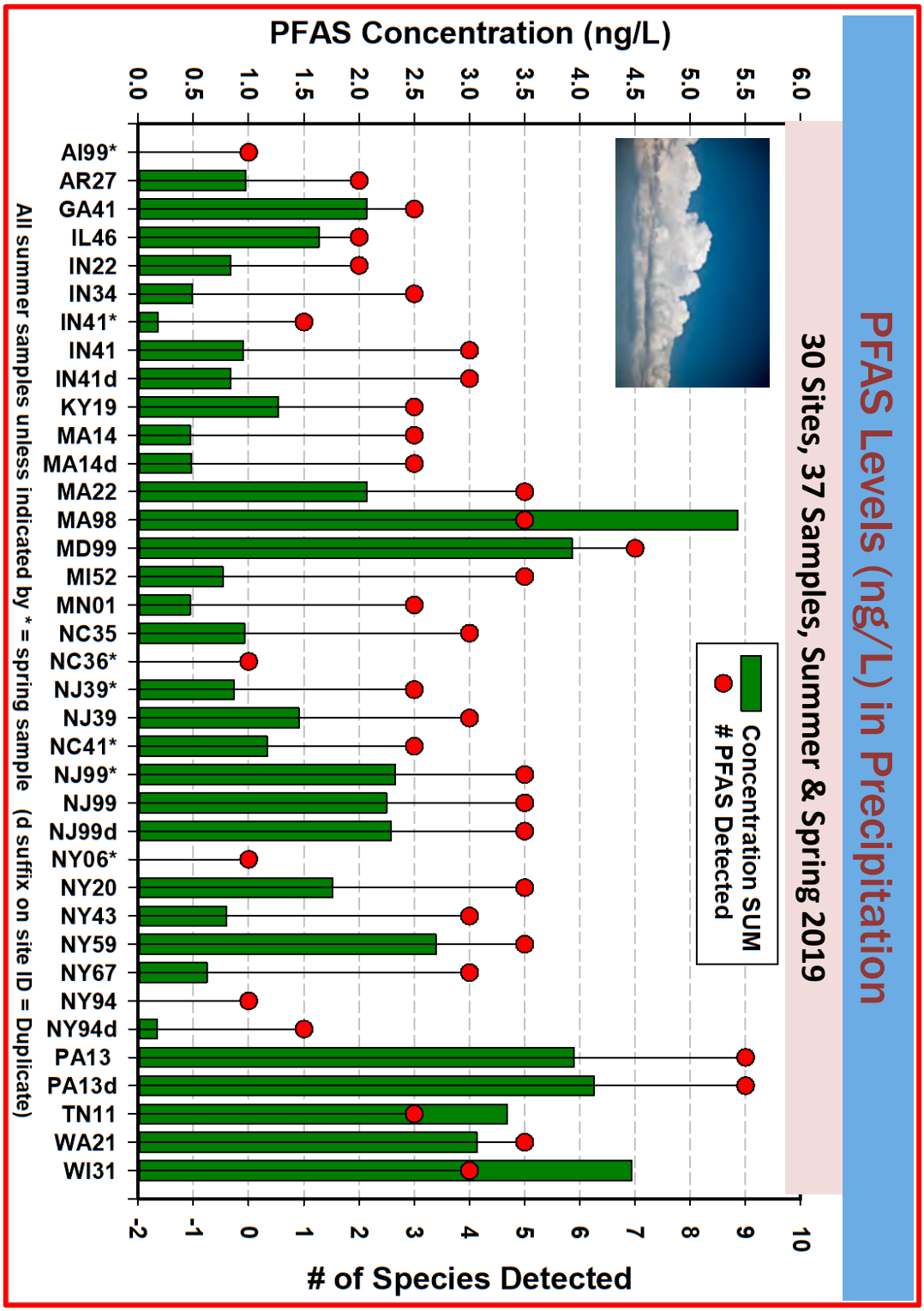


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EXHIBIT 5

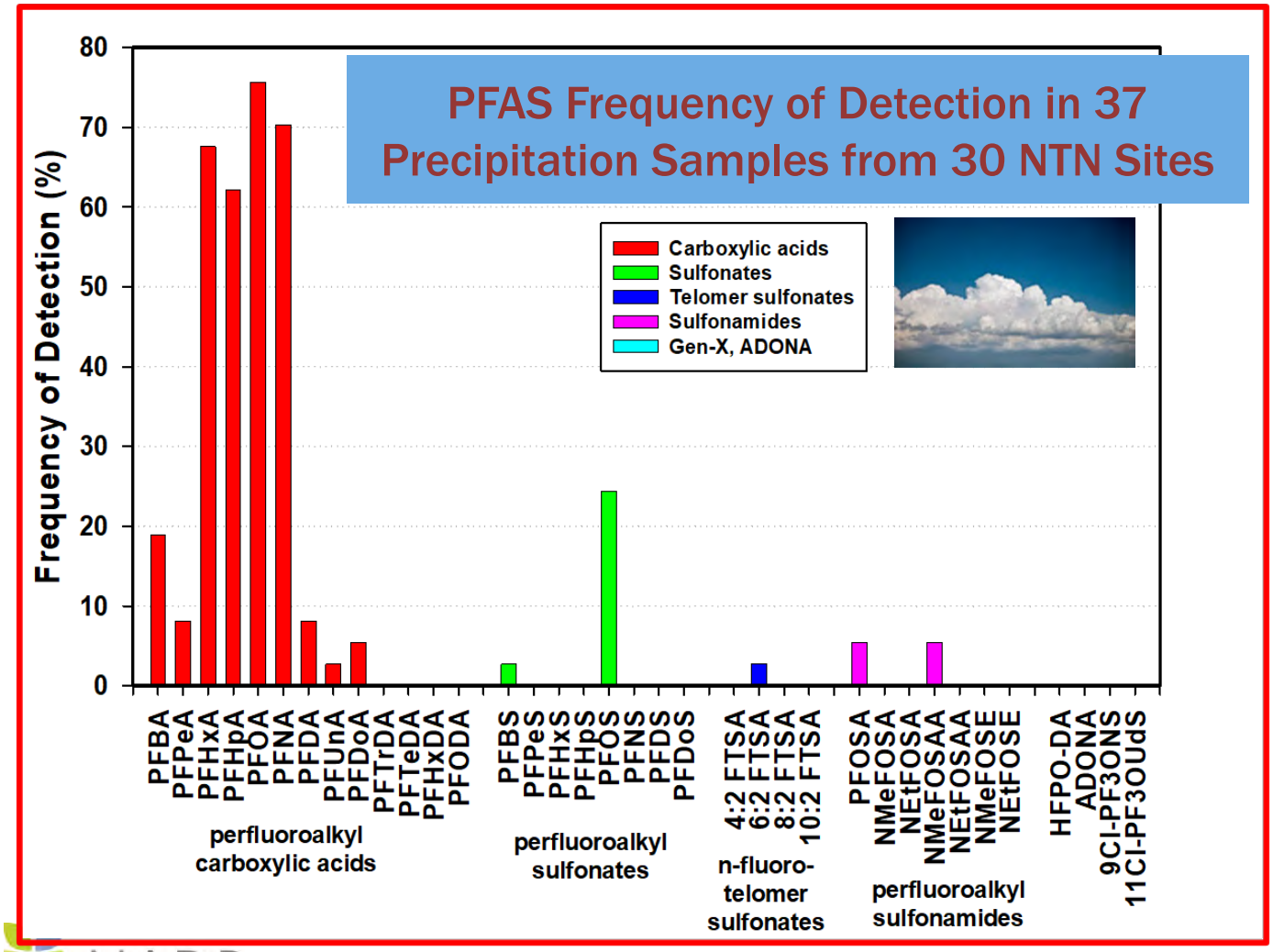
PFAS Frequency of Detection in 37 Precipitation Samples from 30 NTN Sites
Frequency of Detection (%)
0
10
20
30
40
50
60
70
80
Carboxylic acids
Sulfonates
Telomer sulfonates
Sulfonamides
Gen-X, ADONA
PFBA
PFPeA
PFHxA
PFHpA
PFOA
PFNA
PFDA
PFUnA
PFDoA
PFTrDA
PFTeDA
PFHxDA
PFODA
perfluoroalkyl carboxylic acids
PFBS
PFPeS
PFHxS
PFHpS
PFOS
PFNS
PFDS
PFDoS
perfluoroalkyl sulfonates
4:2 FTSA
6:2 FTSA
8:2 FTSA
10:2 FTSA
n-fluoro-telomer sulfonates
PFOSA
NMeFOSA
NEtFOSA
NMeFOSAA
NEtFOSAA
NMeFOSE
NEtFOSE
perfluoroalkyl sulfonamides
HFPO-DA
ADONA
9Cl-PF3ONS
11Cl-PF3OUdS

EXHIBIT 5

PFAS Levels (ng/L) in Precipitation

Median and Maximum @ 30 NTN Sites

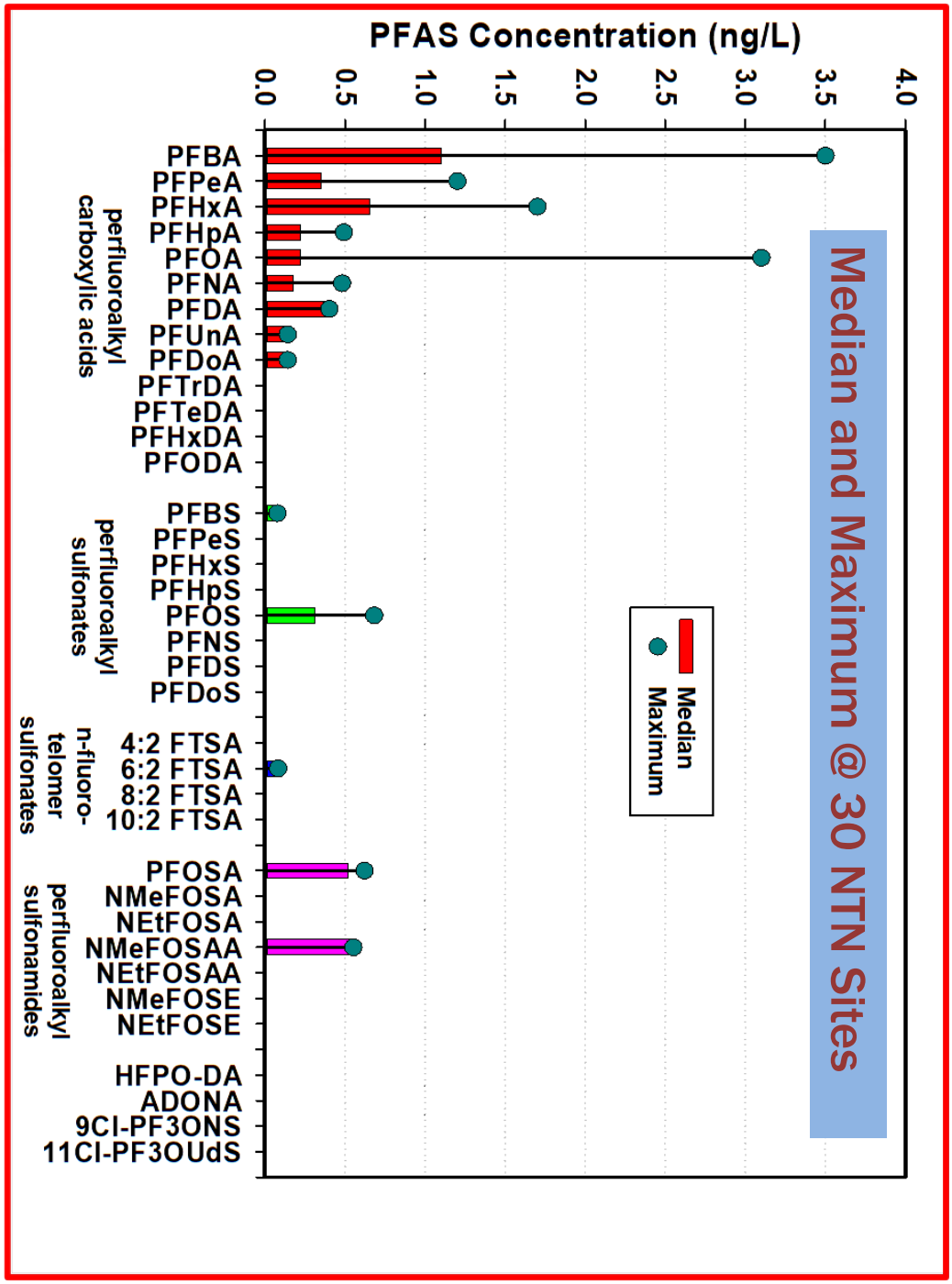

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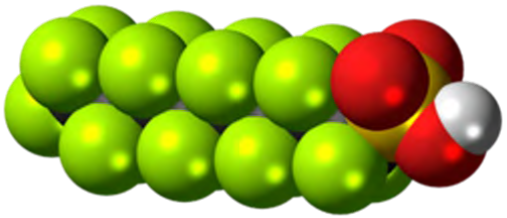
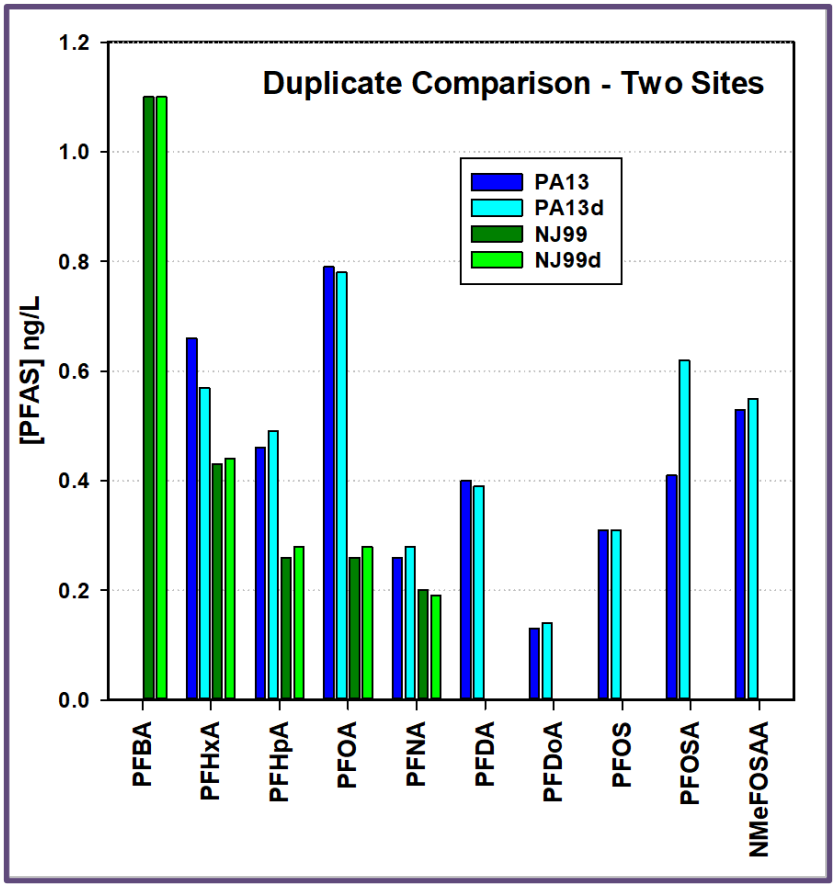
EXHIBIT 5

PFAS Method Performance Outcomes in Precipitation

PFAS Method Precision

Two Precipitation Sample Duplicates





PFAS Occurrence Summary

- **Concentrations of most PFAS compounds were low, generally < 1 ng/L, though the sum of the quantified species exceeded 4 ng/L at several sites.**
  - **The carboxylic acid compounds were by far the most frequently detected.**
  - **PFHxA, PFHpA, PFOA and PFNA were each present in nearly 70% of all samples.**
  - **Shorter-chain PFAS compounds dominated.**
- **Precipitation from sites in the mid-Atlantic states generally had the greatest number of detectable PFAS species and the highest concentrations.**

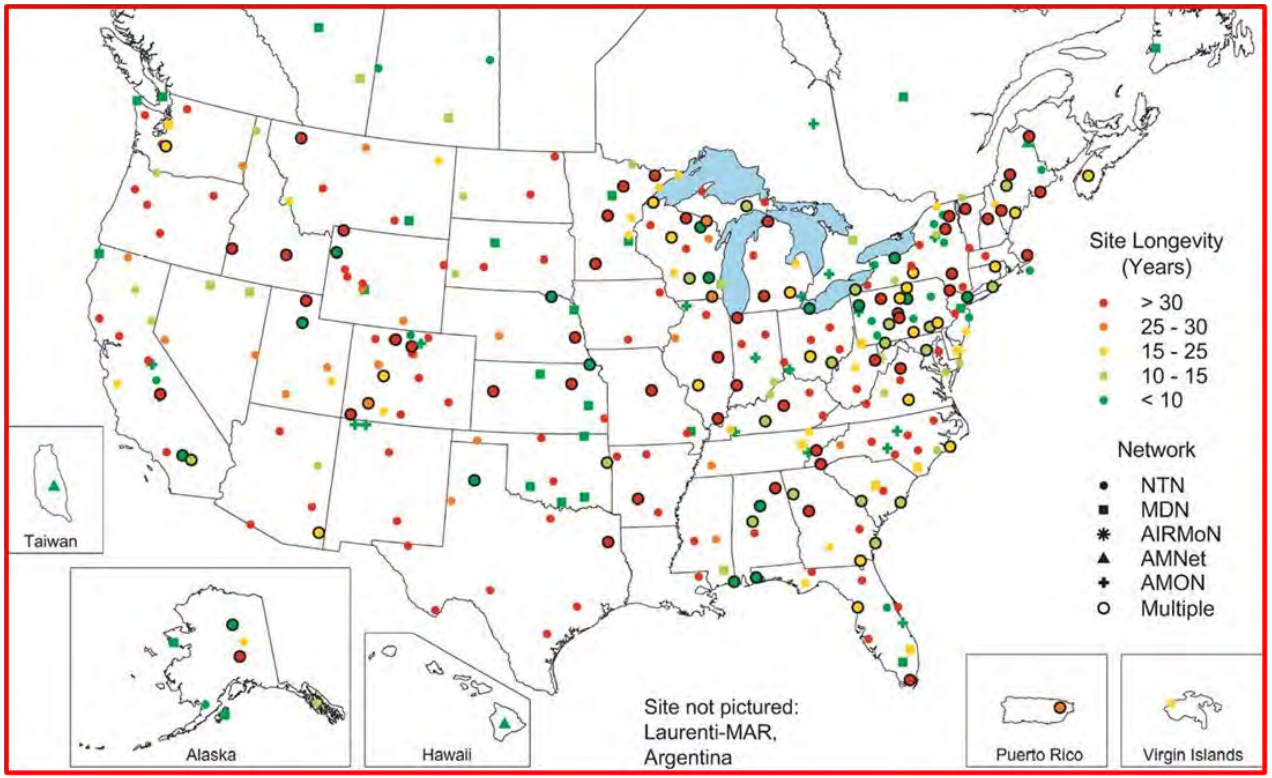
Regulatory Limits and Reference Concentrations

- **EPA Reference Concentration: 70 ng/L (PFOA+PFOS)**
- **State Drinking Water Limits: 5 – 70 ng/L**
- **WI proposed 20 ng/L WQL, 2 ng/L action level**
- **Research suggests biological impacts at < 1 ng/L**

PFAS Deposition Fluxes

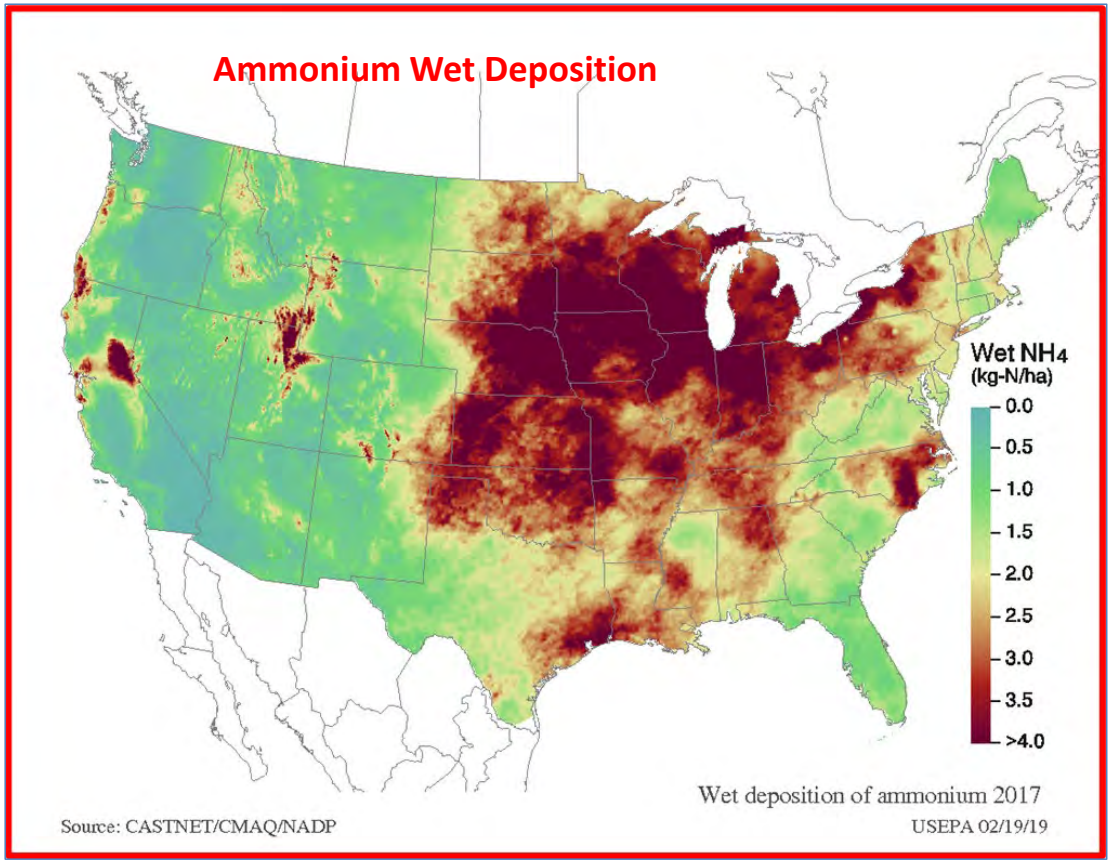
- Concentrations of **0.2 to 6.0 ng/L** equate to a wet deposition PFAS flux of **0.7 to 21 ng/m^2/day** (at an annual precipitation volume of 125 cm/year).
- This flux is significant for many environments (e.g. large lakes with long residence times – for Lake Michigan → annual flux of 4.4x10^{14} ng/year → 0.1 ng/L/year PFAS accumulation throughout the water column)

NADP Monitoring Sites



Synoptic Overview of PFAS Deposition and/or More Targeted Collections

Potential for PFAS Deposition Maps



- **a. Synoptic Overview**
- **b. Seasonality**
- **c. Regional Trends**
- **d. "Hot-Spots"**
- **e. Species Trends**
- **f. Transformations**

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Summary and Where Next?

- The current NTN protocols are “CLEAN” for a broad range of PFAS compounds.
- Loss of PFAS during collection is minimal for compounds of carbon # <10 under current protocols.
- Advance alternate handling/collection protocols to address losses of longer-chain compounds (rinsing, resin collection).
- Determine the phase distribution (particle-partitioning) of PFAS in precipitation and in air samples (dry-deposition).
- Robust Network sampling program (spatial/temporal)

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Wisconsin State Laboratory of Hygiene
UNIVERSITY OF WISCONSIN–MADISON

School of Medicine and Public Health
UNIVERSITY OF WISCONSIN–MADISON

QUESTIONS

Thank You

National Atmospheric Deposition Program
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Sources & Exposure

Product Sources

1. Coated textiles
2. Treated paper
3. Non-stick coatings
4. Food Packaging
5. Foams (AFFF)
6. Personal care products
7. Paints, varnishes

Industrial Sources

1. Paper mills
2. Metal finishers
3. Textile mills
4. Foam factories
5. PFAS factories
6. (manufacturing aids)

We are all burdened with PFAS
NHANES (serum)
1-8 micrograms/L
Median = 4 micrograms/L

Major Exposure Routes

1. Food
2. Drinking Water
3. Consumer Products
4. Hand-Mouth

Atmospheric Cycling Important in Dispersal

Major Entry Points

1. Fire fighting training
2. Industrial sites
3. Landfills
4. WWTP

PFAS Measurement Approaches

- **Total**
  - PIGE
  - XRF
  - TOF/CIC
  - EOF/CIC
- **Non-targeted**

- **Total Oxidizable Precursor (TOP)**

- **Targeted**
  - 12-50 species
  - Quantitative
  - Tox relevant
  - Small fraction of total

Advanced Search

Per- and Polyfluoroalkyl Substances (PFAS) and Your Health

PFAS in the US Population

Most people in the United States have been exposed to PFAS and have PFAS in their blood, especially perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA).

The National Health and Nutrition Examination Survey (NHANES) has measured blood PFAS in the U.S. population since 1999-2000. NHANES is a program of studies designed by the Centers for Disease Control and Prevention (CDC) to evaluate the health and nutrition of adults and children in the United States. NHANES data are publicly released in 2-year cycles.

Since 2002, production and use of PFOS and PFOA in the United States have declined. As the use of some PFAS has declined, some blood PFAS levels have gone down as well.

EXHIBIT 6

From 1999-2000 to 2017-2018, blood PFOA levels declined by more than 70%.

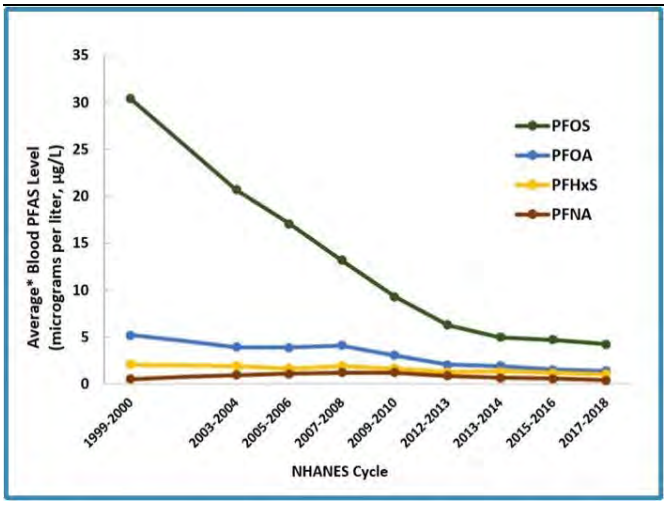
However, as PFOS and PFOA are phased out and replaced, people may be exposed to other PFAS.

Biomonitoring Studies

Biomonitoring studies have measured PFAS levels in other groups:

- Workers in PFAS manufacturing facilities
- Communities with contaminated drinking water
- The general U.S. population

Blood Levels of the Most Common PFAS in People in the United States Over Time



* Average = geometric mean

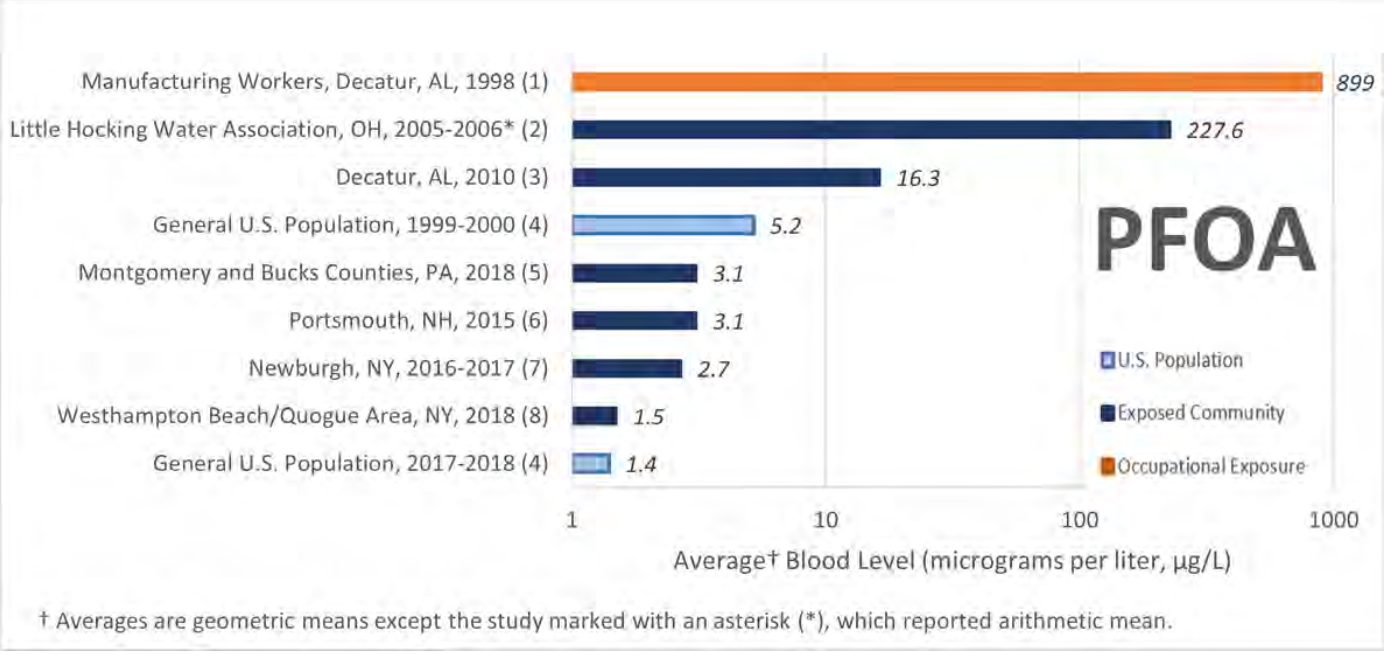
Data Source

Centers for Disease Control and Prevention. National Report on Human Exposure to Environmental Chemicals, Biomonitoring Data Tables for Environmental Chemicals. Atlanta, GA: U.S. Department of Health and Human

EXHIBIT 6

Service, Centers for Disease Control and Prevention.

The figures below show PFOA, PFOS, and PFHxS blood levels measured in different exposed populations, compared to levels CDC measured in the general U.S. population in 1999-2000, 2015-2016, and 2017-2018. ATSDR biomonitoring information is also available through PFAS exposure assessments.



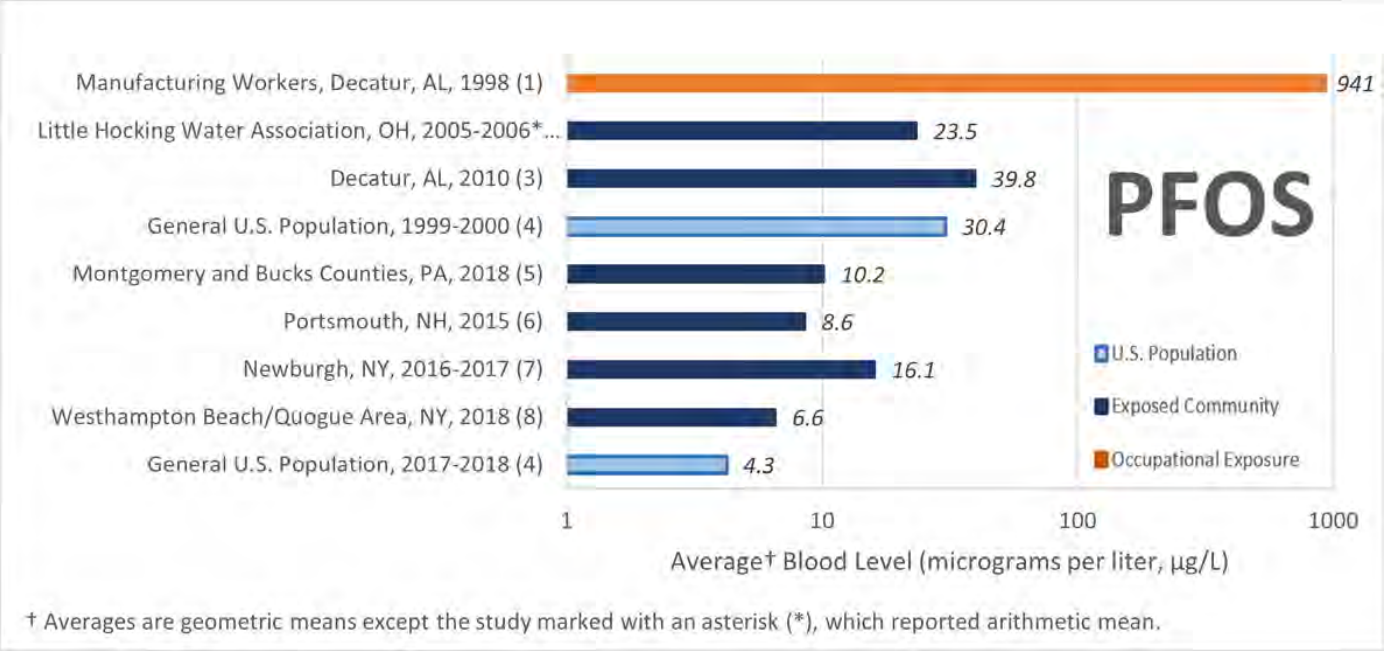
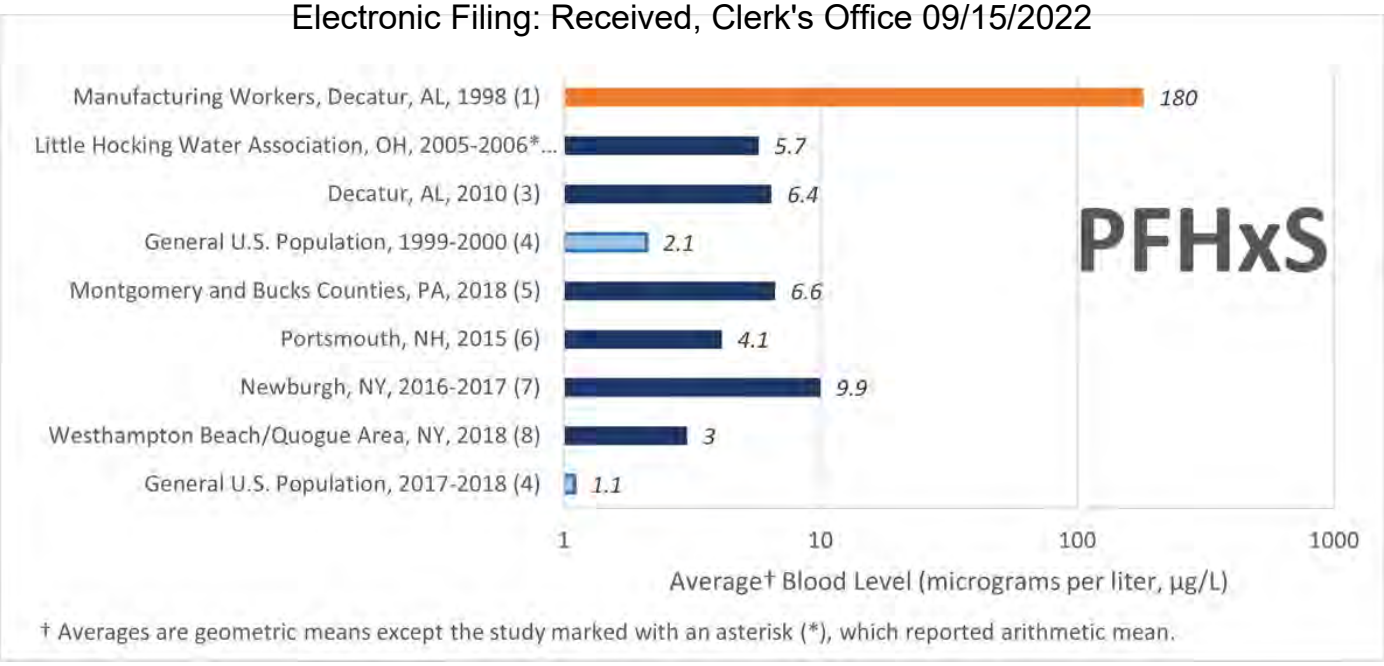


EXHIBIT 6



References and Data Sources

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8. New York Department of Health, 2018. https://www.health.ny.gov/environmental/investigations/drinkingwaterresponse/docs/westhampton_quogue_group_level_blood_testing

EXHIBIT 6

Page last reviewed: July 6, 2022

CONTACT ATSDR
Contact Information

CONTACT CDC-INFO

Have questions? We have answers.
1-800-CDC-INFO (800-232-4636)
TTY: 888-232-6348

Email CDC-INFO

EXHIBIT 6

Exhibit C

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

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 THOMAS A. HILBERT 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

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

PRE-FILED ANSWERS OF THOMAS A. HILBERT ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION

QUESTIONS FROM THE ILLINOIS POLLUTION CONTROL BOARD

32. *On page 3, regarding performing groundwater impact Assessment (GIA) for PFAS constituents, you state that GIA is highly sensitive to the concentration difference between the modeled leachate constituent and the applicable groundwater quality standard.*

    a. *Please clarify whether the applicable PFAS groundwater quality standards for landfills under 35 Ill Adm Code 811.320 would be based on Part 620 PFAS standards, or the site-specific background concentrations of the PFAS constituents*.

    ANSWER: Typically for most operating sites that meet the design standards of 35 Ill Adm Code 811, it is anticipated the PFAS standards would be based on the Class I concentration. However, at the groundwater levels proposed and absent any comprehensive study on PFAS concentrations in the groundwater around the state, it is not known if the groundwater quality would already exceed the proposed standards. If the groundwater in the upgradient area of the landfill contained PFAS above the proposed standards and it could be shown that it was not associated with the landfill, the applicable groundwater quality standard would be the statistically derived background value.

    b. *Please comment on whether a landfill in Illinois could be required to monitor PFAS constituents and establish background-based groundwater quality standards under Part 811 if PFAS constituents are detected in the landfill leachate*.

    ANSWER: Based on existing information from landfill facilities, PFAS constituents are expected in leachate. It is unclear whether the presence of PFAS in leachate would automatically trigger groundwater monitoring based on the presence of PFAS in the leachate. 35 Ill Adm Code 811.319(a)(2)(A) is the regulatory reference linking groundwater monitoring to the presence of a constituent in leachate but that reference only applies to inorganic constituents. 35 Ill Adm Code 811.319(a)(3)(A) requires organics monitoring to include the constituents listed in 40 CFR 141.40 which does include the PFAS constituents proposed to be added to the Part 620 standards. Yet, 40 CFR 141.40 is, by its terms, only applicable to owners and operators of public water systems.

33. *On page 3, you state, "The groundwater standard concentrations proposed for PFOA and PFOS are at levels that are up to 1000 times higher than the typical leachate concentrations." Please clarify whether you meant the proposed standards are 1000 times lower than typical leachate concentrations. If not, comment on why compliance with the proposed PFAS standards a significant issue for landfills.*

    ANSWER: That was a typographical error. The groundwater standard is up to 1,000 time lower than the typical leachate concentration.

34. *On page 4, you state that "every Illinois MSW landfill must review and update the GIA every 5 years when it applies for the renewal of its landfill operating permit."*

    a. *Please comment on whether any Illinois-based NWRA members have performed GIA for their landfills using the proposed PFAS standards or standards based on PFAS background concentrations that support your concerns.*

    ANSWER: Since Illinois does not currently have groundwater standards for PFAS constituents, inclusion of the subject constituents in the GIA update (35 IAC 813.304) submitted to the Agency is not necessary. The testimony is expressing the concern that upon adding PFAS to the Illinois Part 620 groundwater quality standards at the levels proposed, it will be required to be addressed in GIA updates for landfills pursuant to Sections 811.317(b) and 813.304(a)(5).

    b. *Also comment on whether NWRA has considered proposing any changes to the landfill GIA regulations to address the concerns regarding PFAS constituents.*

    ANSWER: The NWRA has discussed with the Illinois EPA the NWRA concerns regarding the addition of PFAS in landfill GIA regulations. The NWRA has expressed a desire to work with the Illinois EPA on changes to the Part 811 rules specifically related to the GIA requirements but the conversations have been general and the Illinois EPA has not indicated that it would support changes to the GIA regulations. Further, the Illinois EPA has not indicated when or whether it will seek revisions to the Board's solid waste regulations to address the waste industry's concerns related to implementation of the PFAS groundwater standard it seeks in this rulemaking.

35. *On page 5, you state that "when POTWs refuse to accept landfill leachate, which is beginning to happen, there is a significant economic impact on the landfill which threatens the landfill's ability to maintain compliance with the leachate removal requirements of the Part 811 rules...". Please clarify whether any POTW in Illinois has adopted pretreatment standards under 35 Ill Adm Code 310 that prohibit acceptance of landfill leachate because of PFAS presence. If so, submit any relevant pretreatment program information into the record.*

    ANSWER: I am currently unaware of any Illinois POTW that has adopted pretreatment standards for PFAS. However, there are POTW's in Illinois that have indicated that they will

refuse to accept landfill leachate after January 1, 2023 due to the concerns associated with PFAS regulations.

36. *Also on page 5, you state that the "estimated capital costs to implement leachate pretreatment at a moderate-sized landfill to the extent necessary to reduce PFAS to the levels proposed, should such reductions even be feasible, range from $2 million to $7 million. Please explain how you determined the estimated range of capital costs.*

ANSWER: The cost reference was a direct quote from an NWRA letter submitted to the federal Office of Information and Regulatory Affairs. The cost information which was included with the NWRA letter was based on cost study that was recently completed for a facility in Vermont. That information is detailed in Exhibit 4 of my testimony. After further review, the NWRA letter and my initial testimony ($2 million to $7 million) was too low. The Vermont study capital cost estimates ranged from $2.15 million to $16.45 million and did not include the annual operating expenses. The actual economic impact of the addition of PFAS to the groundwater quality standards will clearly be significant but are not well defined, leaving the regulated community unprepared to understand the economic and operational impacts of the proposed rules.

QUESTIONS FROM THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

1) *Does Method 1633 analyze for potable resource groundwater?*

ANSWER: EPA method 1633 which does analyze for PFAS in groundwater is still draft and therefore is still an unaccredited method. In addition, at the concentration levels in the proposed rules there may still be problems even if the method is approved with an MDL of 2 ng/l. Please also see Section IV (page 8) of provided testimony:

"There is no guarantee that once finalized through a multi-lab validated process that the MDL for method 1633 will be at or below the proposed groundwater standard for PFOA. Even if method 1633 is finalized with a MDL of 2 ng/l it will have been established by using controlled samples with rigorously controlled laboratory procedures. The variable nature of field samples and the real world laboratory procedures in a high volume analytical laboratory will likely result in a high number of sample analytical reports that will have a reporting limit that is above the MDL."

2) *Are there methods available for analyzing potable resource groundwater?*

ANSWER: See above answer response to question 1 and USEPA's response below to modified "drinking water" methods, taken directly from the USEPA website:

What are "modified EPA PFAS methods" (e.g., "Modified Method 537") and can they be used effectively for analysis of drinking water samples?

EPA is aware of some laboratories that are offering analysis for PFAS by techniques described as "modified" (e.g., "Modified Method 537"). These modified methods are

sometimes offered by laboratories to assess samples of drinking water and other environmental media (e.g., soils, ambient water) and to address PFAS analytes not currently addressed by EPA's methods. EPA is not aware of a standardized description of the modified methods, nor is the Agency aware of studies that have validated the performance of these modified methods across multiple laboratories. Therefore, EPA cannot address the performance of "modified methods" in a general manner. If you are considering using a modified method to analyze a sample, EPA recommends that you evaluate its appropriateness relative to your goals for the data and data quality objectives. ***https://www.epa.gov/pfas/epa-pfas-drinking-water-laboratory-methods***

3) *Do other methods have MRLs that meet the proposed 620 standard for PFOA?*

ANSWER: See responses to questions 1 and 2.

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CERTIFICATE OF SERVICE

I, the undersigned, certify that on this 23rd day of November 2022, I electronically served the **PRE-FILED ANSWERS OF THOMAS A. HILBERT 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

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Exhibit D

Electronic Filing: Received, Clerk's Office 09/15/2022

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 **TESTIMONY OF ERIC BALLENGER ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION**, copies of which are hereby served upon you.

Dated: September 15, 2022

By /s/ Claire A. Manning

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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)	)	

TESTIMONY OF ERIC BALLENGER ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION

My name is Eric Ballenger. I am employed by Republic Services. I have been employed with Republic Services (previously Allied Waste) since January of 1996. Republic Services is an American waste disposal company whose services include non-hazardous solid waste collection, waste transfer, waste disposal, recycling, and energy services. We are the second largest provider of waste disposal in the United States.

Prior to joining Republic Services, I was employed by EMCON, an environmental consulting firm. I am a Senior Manager of Hydrogeology for Republic Services. I assist in the management of environmental compliance at operating and closed landfills as well as manage multiple Superfund sites. Other duties include management of third-party environmental consultants and analytical laboratories, landfill greenfield and expansion hydrogeologic review, remedial design and implementation, and superfund management. My management area consists of the States of MN, WI, IL, IN, MO, OK, AR, NE and TX.

On behalf of Republic, I participate in a committee of the Illinois Chapter of the National Waste and Recycling Association ("NWRA") that has been evaluating the IEPA's proposed rule and this rulemaking. I am providing this testimony on NWRA's behalf and appreciate the Board allowing me the opportunity to do so. Collectively, the NWRA committee prepared a slide presentation that is attached to Tom Hilbert's testimony as Attachment A. My testimony today

focuses on the industry's concerns with the proposed PFAS new standards and how the IEPA's proposed changes to Part 620 will affect our 807 and 811 sites and their monitoring programs both operationally and financially.

It should be noted that we understand the concern over PFAS and that landfills are a potential source of PFAS impacts to groundwater if releases occur. But it should also be understood by the regulating agencies and the Board that landfills are receivers of PFAS, not users or producers. Landfills provide a vital function of managing society's PFAS-containing waste and treatment/remedial waste. The reliance on landfills is expected to increase in the short term as other protective destruction and disposal management options are being developed.

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. The presence of PFAS in leachate is due to disposal of many different PFAS-containing products. Once the testing of PFAS is added to our leachate monitoring program this will immediately add substantially more monitoring and associated costs that we believe have not been thoroughly researched by the IEPA – either as to the reasonableness of such costs in relation to environmental benefit or as to the feasibility of monitoring or remediating to such conservative values. This will affect 807 sites as well as "greenfield" sites all the way through post closure of currently active facilities. This is also expected to potentially affect the continual disposal and treatment of leachate by wastewater treatment plants (WWTP), especially if WWTPs have their own concerns about PFAS (discussed below).

Here are some of our concerns once PFAS is detected in leachate with a focus on current active 811 facilities:

New statistical background concentrations (AGQSs/MAPCs) will need to be calculated. PFAS are ubiquitous in the environment included in rainfall and there are many sources. This makes some detection of PFAS likely due to background conditions. This will require multiple sampling events of upgradient wells and potentially all wells if intrawell statistical values are permitted. Most site wells have expensive dedicated sampling systems which may include materials with PFAS that have nothing to do with impacts from the facility. How will that data be incorporated? Will all sampling systems have to be replaced? Will current analytical laboratories be able to meet the detection limits being suggested?

Validation of detections in background wells. Given the nature of PFAS, issues will arise related to leachate analysis. Leachate analysis may also have many cross-contamination issues that will not be associated with landfills but may be associated with lab or sampling equipment. This has the potential to produce a lot of flagged data that is not accurate. Therefore, using detection of PFAS in leachate to decide if groundwater monitoring is required is technically suspect.

Groundwater Impact Assessment. The current Groundwater Impact Assessment ("GIA") modeling requirements have the potential to be substantially affected and become unreasonably complicated. All 811 sites are required to run a GIA and if they do not pass the GIA additional remedial measures need to be either implemented or financially assured for. It is expected that because PFAS will most likely be detected in leachate and generally does not readily attenuate through distance in groundwater, many models will now fail. This will add substantial costs to site's financial assurance requirements and may even restrict sites from future expansions. These extremely conservative models are built into the 811 regulations even though they are not reliable indicators of environmental risk. It should be noted that other states do not require such

modeling and the federal Subtitle D rules, upon which the 811 rules are based, presume that the sufficiency of the engineer's landfill does not need additional modeling.

Disposal Issues: Leachate and Wastewater Treatment Plant (WWTP) biosolids. One of NWRA's primary concerns with the IEPA's proposed rule is that it fails to consider and address the cost and feasibility of treating leachate or biosolids to achieve the PFAS levels proposed, presuming such may be required to achieve those levels. Specifically, as to both 807 and 811 sites, we are concerned with how the proposed standards will affect our need to remove and dispose of leachate at local WWTPs. It must be understood that many landfills and WWTPs have a symbiotic relationship. POTWs receive our leachate and many landfills receive their biosolids. There is a significant risk that POTWs will begin to refuse leachate due to concerns about PFAS. Studies to date have shown that some PFAS passes through current WWTP treatment methods and accumulates in sludge. When WWTP biosolids are disposed of in landfills it is being "looped" back to the sites. If WWTPs start reducing the acceptance of landfill leachate due to concerns related to PFAS, many landfills may also stop accepting biosolids to reduce PFAS from entering sites and leachate.

To further complicate the potential issues, some states are beginning to restrict or eliminate the land application of biosolids as fertilizer on crop lands due to PFAS. If this also occurs in Illinois, more pressure will be placed on landfills to accept WWTP biosolids. Landfill capacity is already limited, and landfills may not be able to facilitate disposal of all the additional biosolids. Also, due to its wet nature, sludge has the potential to significantly add to the landfill's leachate volume and cause an increase in the landfill's carbon footprint. WWTPs may be required to add treatment systems to address PFAS. If this occurs, they will add surcharge costs to landfills which will most likely be passed on to the general consumer. This will also occur if landfills have to

pretreat leachate prior to WWTP disposal. Pretreatment of leachate for PFAS removal is largely unproven, technically challenging, and quite costly.

As you can see there are many concerns for our industry related to adding PFAS to the Board's groundwater rules, especially at such conversative values. We believe that this rulemaking is premature, given that federal limits are not yet established. It should also be noted 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. We urge the IEPA to reconsider the need to set these limits prior to fully understanding the implications to the industry and society.

This concludes my testimony.

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CERTIFICATE OF SERVICE

I, the undersigned, certify that on this 15th day of September 2022, I electronically served the **TESTIMONY 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: September 15, 2022

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Exhibit E

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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)	)	

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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

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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)	)	

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.

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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

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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.

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, CAE
Chief Executive Officer
American Public Works Association

David Biderman
Executive Director & Chief Executive Officer
Solid Waste Association of North America

Matthew D. Chase
Chief Executive Officer & Executive Director
National Association of County Officials

Frank Franciosi
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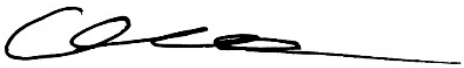

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Re: Docket ID No. EPA-HQ-OLEM-2019-0341; Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances

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.

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

[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

[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%). Increased costs associated with PFAS management thus could total approximately $966 million to $8.187 billion per year for municipal solid waste landfills alone. 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 frustrate EPA and DOD cleanup activities around military installations 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.

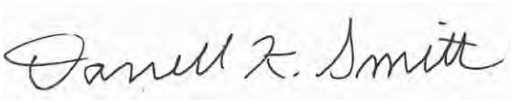
V. Recommendations

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
President & CEO
National Waste & Recycling Association

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

[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.

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)

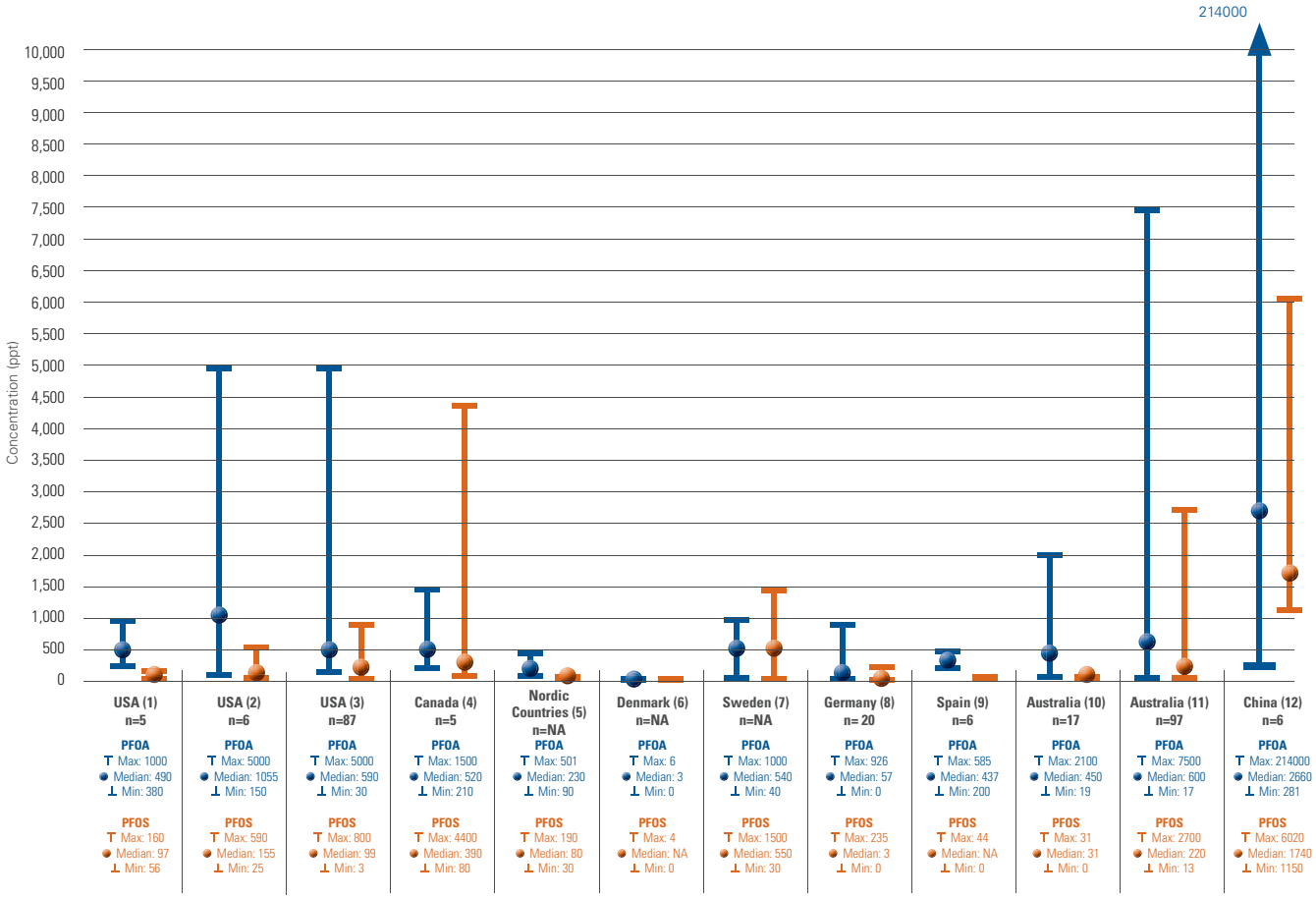
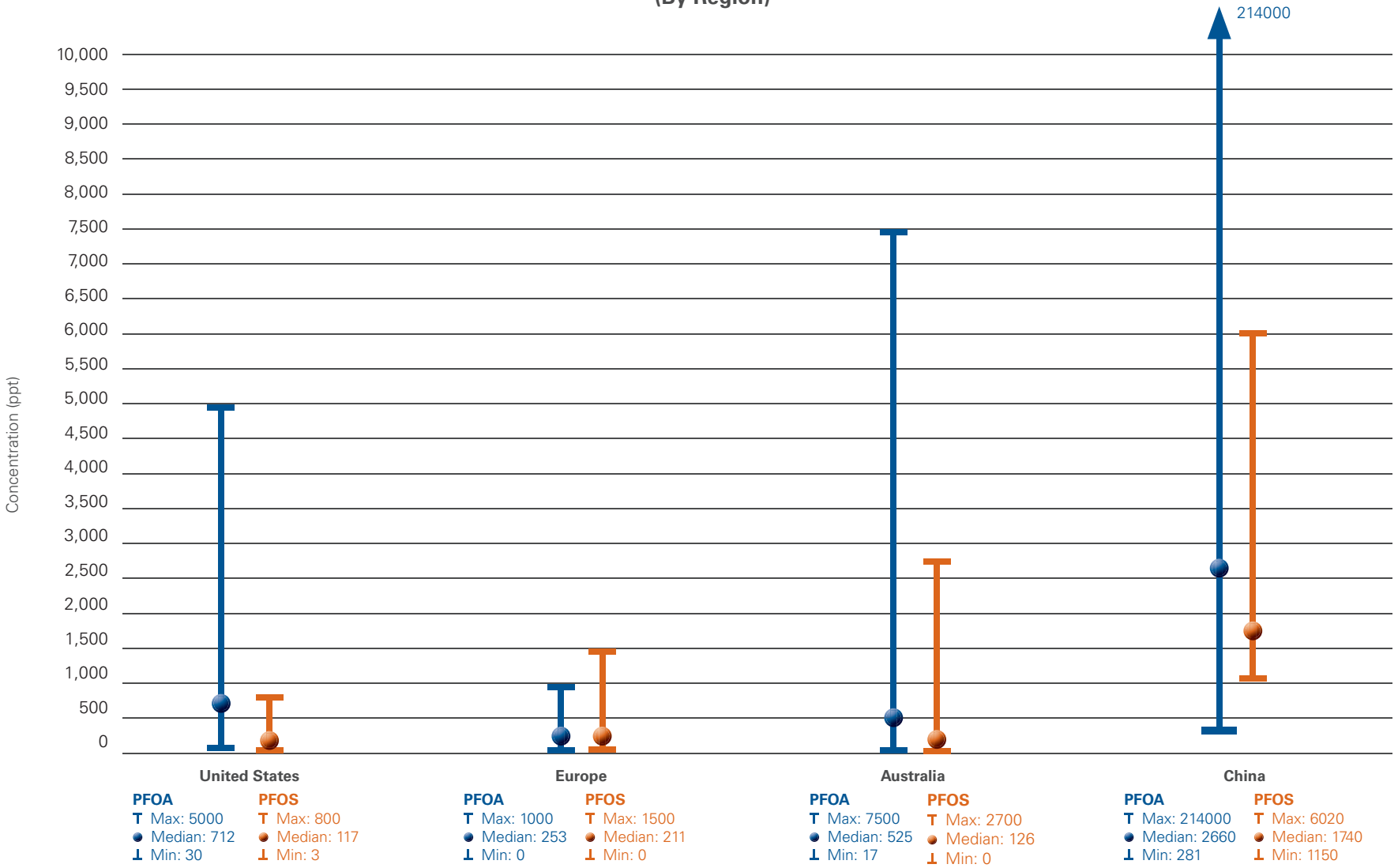


Table 2.2: Summary of Literature Study - PFOA & PFOS Concentrations in Landfill Leachate

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

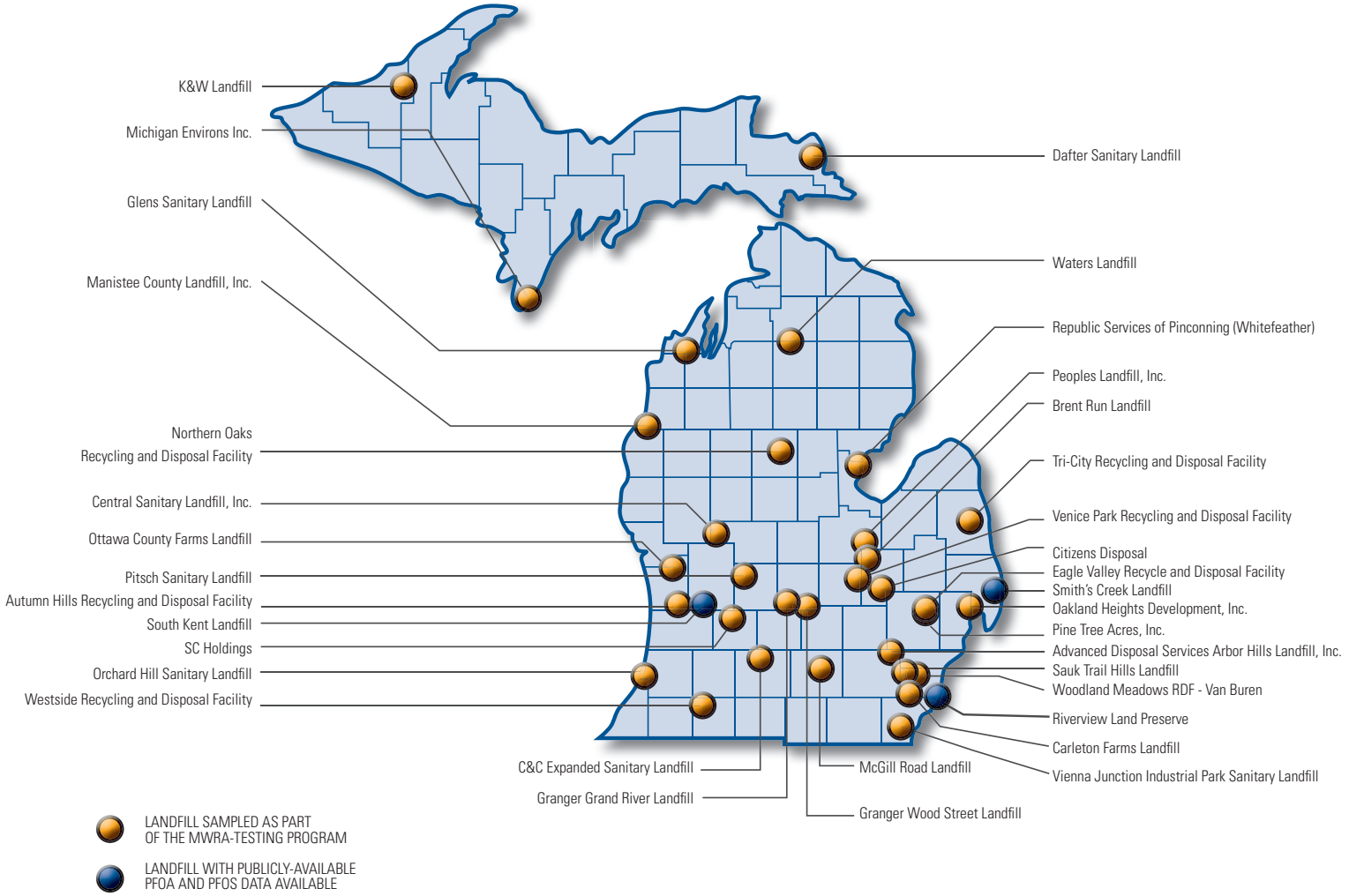

K&W Landfill
Michigan Environs Inc.
Glens Sanitary Landfill
Manistee County Landfill, Inc.
Northern Oaks
Recycling and Disposal Facility
Central Sanitary Landfill, Inc.
Ottawa County Farms Landfill
Pitsch Sanitary Landfill
Autumn Hills Recycling and Disposal Facility
South Kent Landfill
SC Holdings
Orchard Hill Sanitary Landfill
Westside Recycling and Disposal Facility
Dafter Sanitary Landfill
Waters Landfill
Republic Services of Pinconning (Whitefeather)
Peoples Landfill, Inc.
Brent Run Landfill
Tri-City Recycling and Disposal Facility
Venice Park Recycling and Disposal Facility
Citizens Disposal
Eagle Valley Recycle and Disposal Facility
Smith's Creek Landfill
Oakland Heights Development, Inc.
Pine Tree Acres, Inc.
Advanced Disposal Services Arbor Hills Landfill, Inc.
Sauk Trail Hills Landfill
Woodland Meadows RDF - Van Buren
Riverview Land Preserve
Carleton Farms Landfill
Vienna Junction Industrial Park Sanitary Landfill
C&C Expanded Sanitary Landfill
Granger Grand River Landfill
McGill Road Landfill
Granger Wood Street Landfill
LANDFILL SAMPLED AS PART OF THE MWRA-TESTING PROGRAM
LANDFILL WITH PUBLICLY-AVAILABLE PFOA AND PFOS DATA AVAILABLE

Table 3-1

Landfill Leachate Generation & Disposal Methods

MWRA-Member Landfill Designation	Leachate Treatment Facility	LEACHATE DISCHARGE INFORMATION		
		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

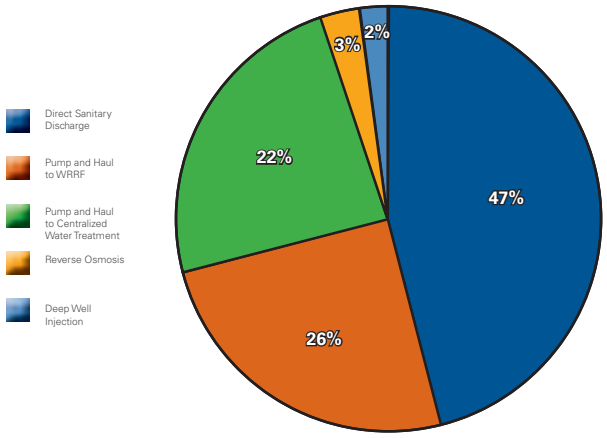
3.2 Leachate Disposal Methods, Daily Leachate Volume, & Receiving WRRFs

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

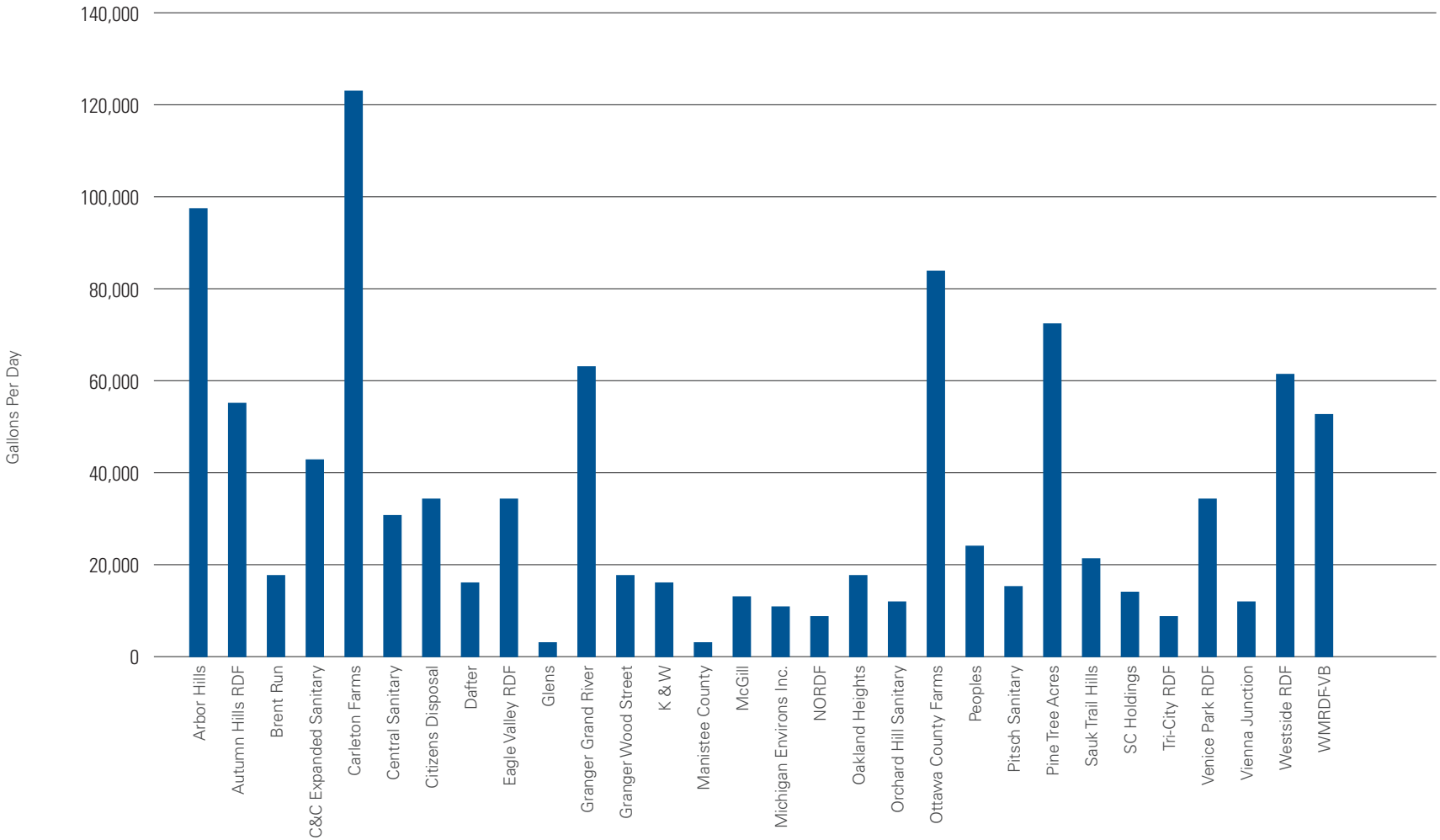
1. Great Lakes Water Authority in Detroit (GLWA), used by nine landfills,
2. Clinton River Water Resource Recovery in Pontiac (CRWRR), used by one landfill;
3. Grand Rapids Water Resource Recovery (GRWRR), used by four landfills
4. Anthony Ragnone Wastewater Treatment Plant near Flint (Ragnone), used 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



4.2 Statewide PFOA and PFOS Leachate Concentrations

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* Riverview 004* Riverview 007*	37,400	1900 860 38	270 140 8.5	0.0003	0.00004
South Kent Outfall* South Kent Hauled*	48,000	725 16	960 130	0.0001	0.0002
Smith's Creek Landfill*	32,900	510	120	0.0001	0.00003
	minimum maximum median average n	16 3200 1000 1186 39	9 960 220 287 39	0.000016 0.003 0.0001 0.0004 33	0.000007 0.0004 0.00005 0.0001 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.

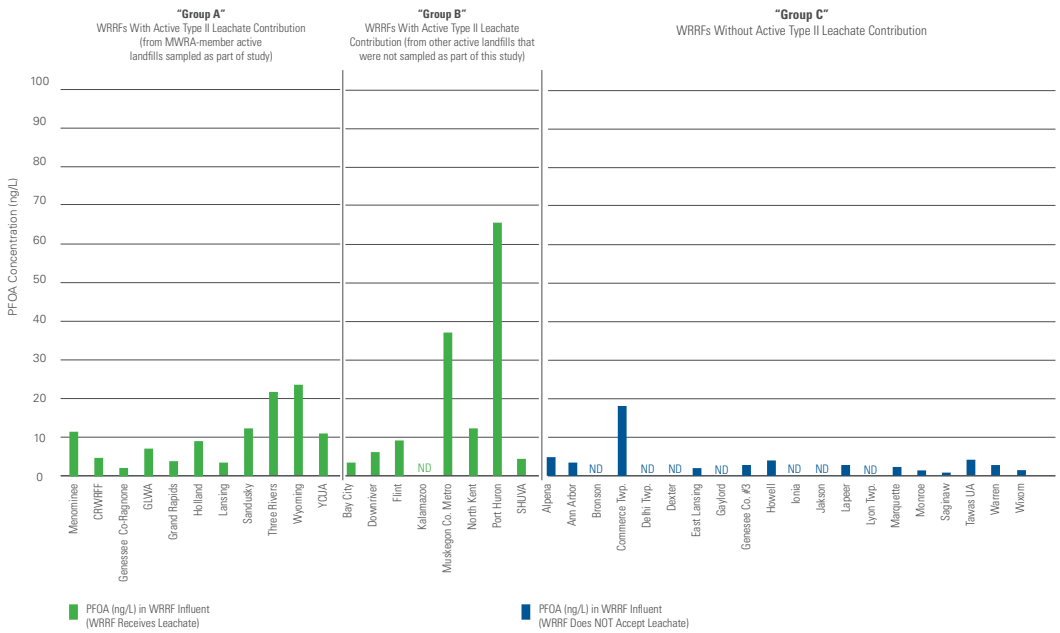
Reviewing all three groups, PFOA influent concentrations ranged from non-detect (ND) at eight WRRFs to 64.6 ppt. The median PFOA influent concentration was 5.06 ppt and the average was 10.3 ppt, based on 31 sample with reported detections.

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.

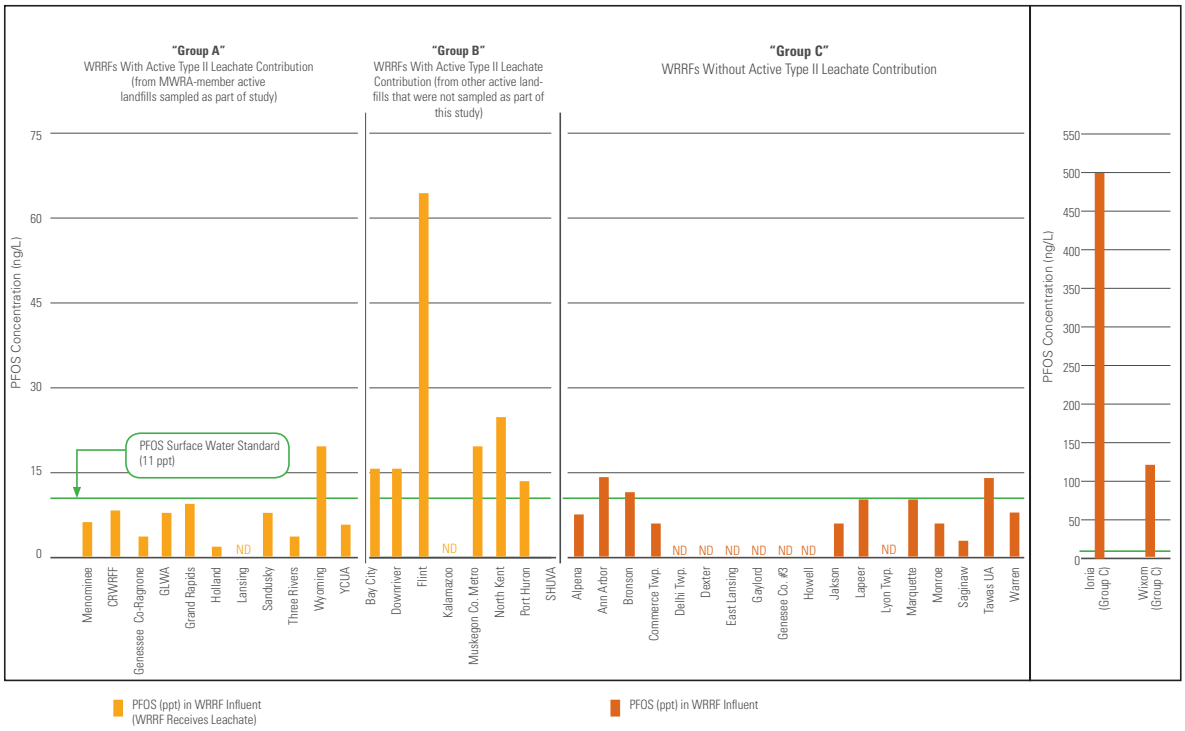
Figure 4-1B, WRRF Gross Influent PFOS Concentrations, depicts available data for influent PFOS concentrations at WRRFs that accept leachate from active Type II landfills and those that do not, categorized by the groupings described above and on the graphic. Based on visual analyses of Figure 4-1B, we 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 Capicity (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.

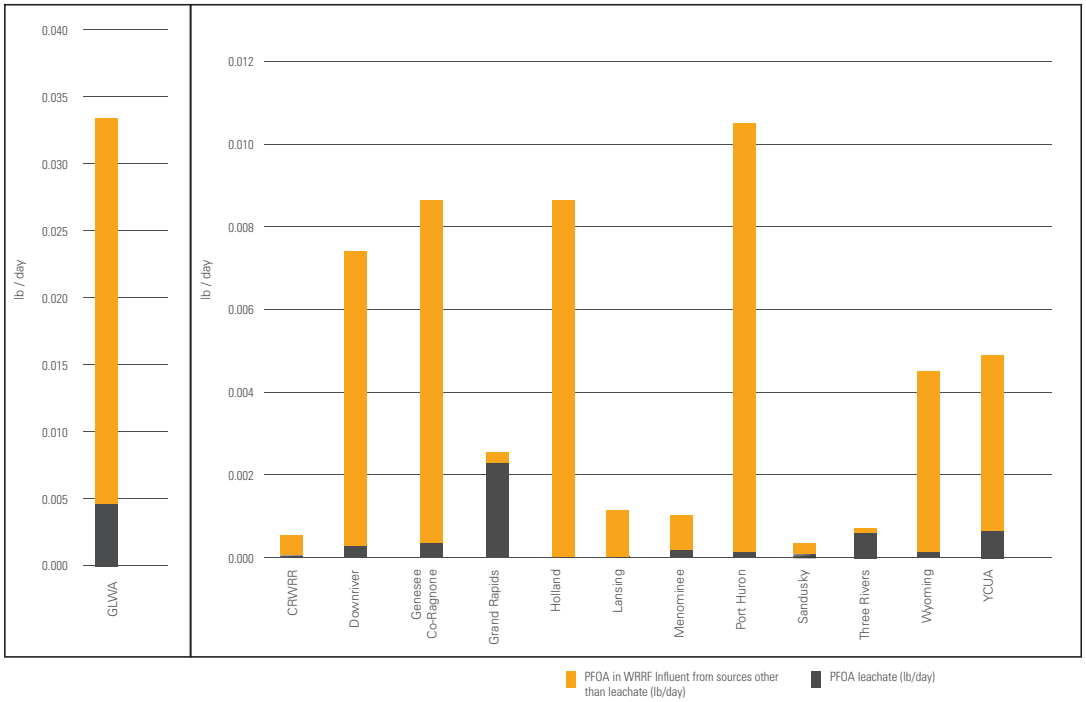
Table 4-2B

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

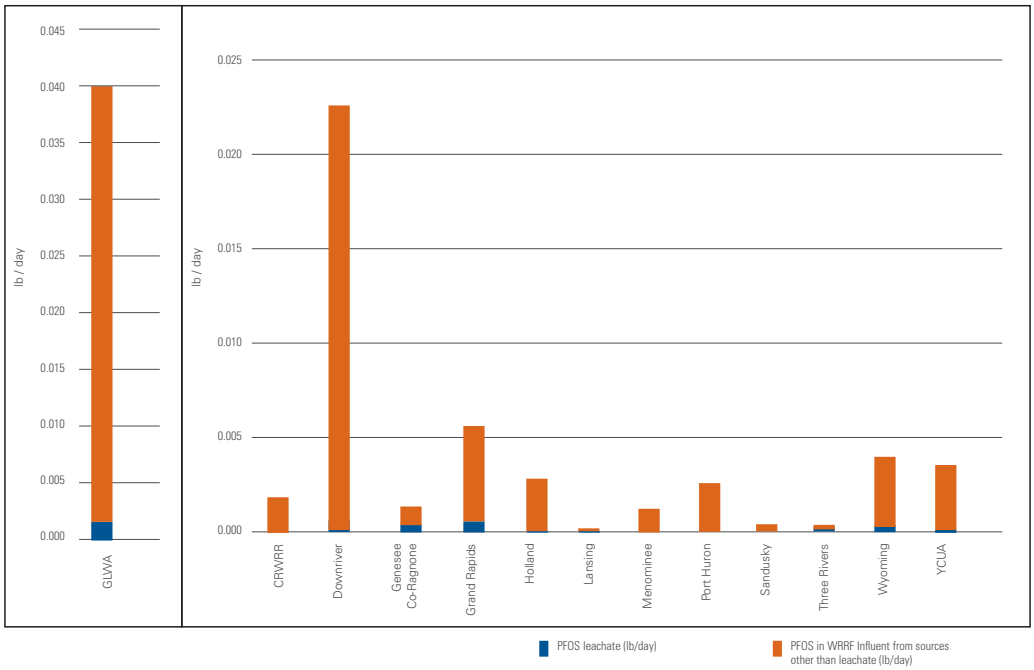
* WRRF permitted daily flow and PFOA and PFOS data provided by MIWaters.com
Influent mass calculated using the single sample or the maximum value where multiple data are available.
NA: data not available
ND - Not detected. Detection limit unknown. Excluded from average and median calculations

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.

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

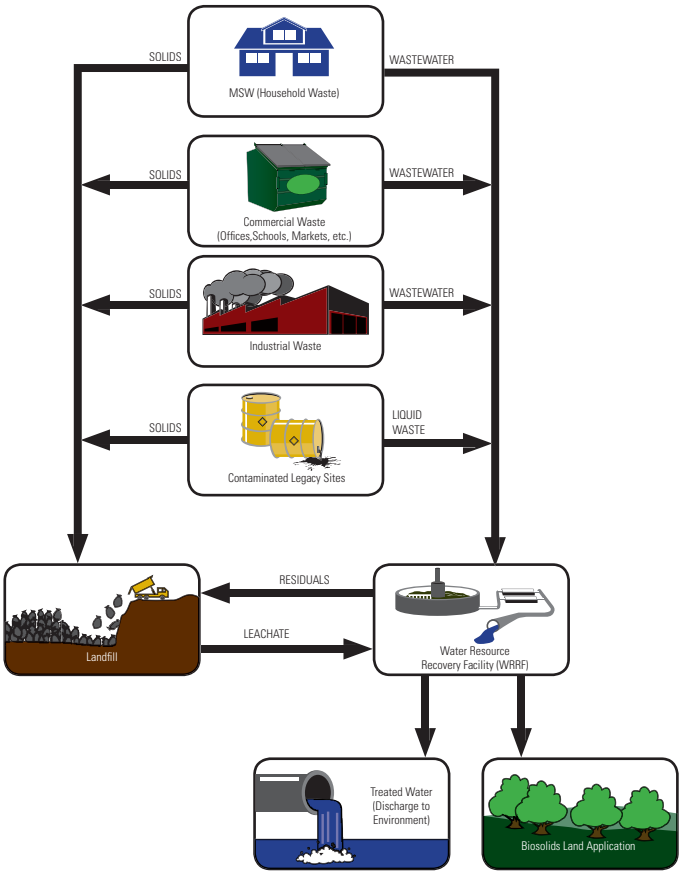
It is documented that WRRF biosolids typically contain PFAS (NEBRA, 2018). A recent comprehensive study was completed for the North East Biosolids and Residuals Association (NEBRA) that examined PFOA and PFOS concentrations in WRRF biosolids. Although the biosolids data are reported for solid/sludge 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.

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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North Carolina Collective Study Report
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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.

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**.

4.4 Leachate Contribution to WWTP Daily Mass

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.**

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%**

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

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).

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.

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

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.

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.

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.

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.

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

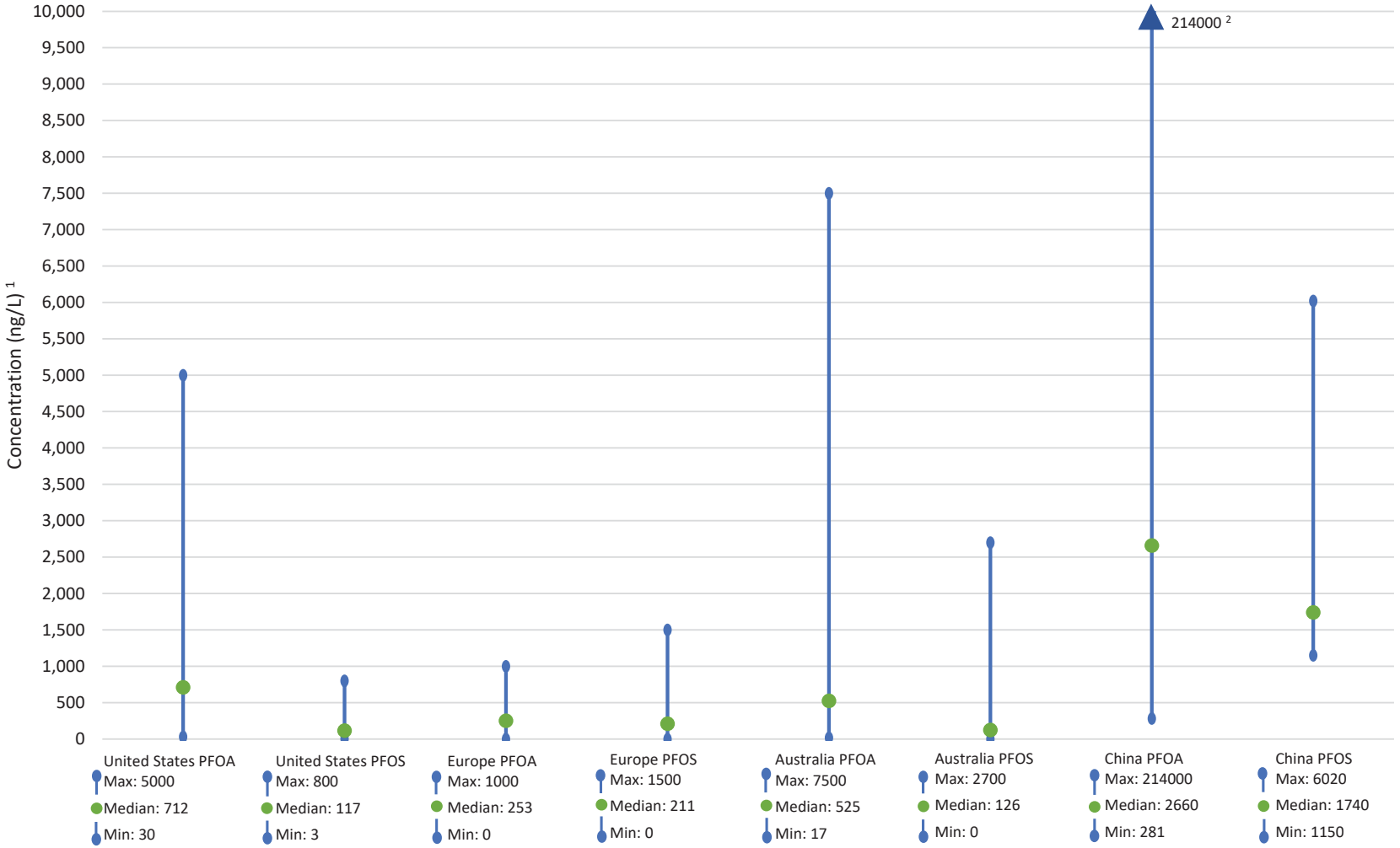
Landfill Name	Average Leachate Volume (gallons/day)	Receiving WWTP[1] Name	WWTP Permitted Flow Limit (gallons per day)*	Constituent	Concentration Data			Daily Mass Data		Percentage of WWTP Influent Daily Mass Associated with Landfill Leachate***
					Concentration Units[2]	Landfill Leachate Concentration	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.

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 Impacts on Water Resource Recovery Facility Influent (March 2019)

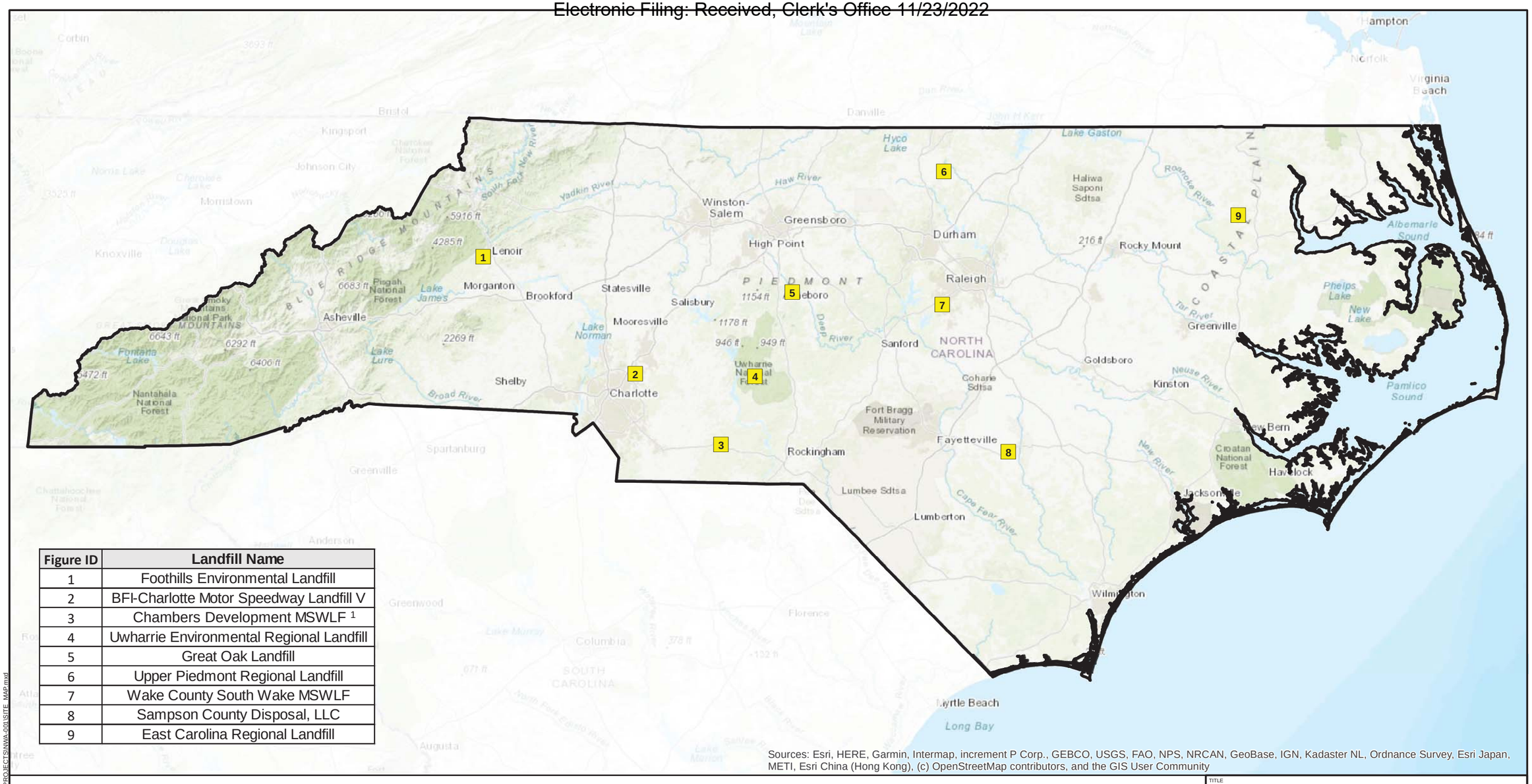


Figure ID	Landfill Name
1	Foothills Environmental Landfill
2	BFI-Charlotte Motor Speedway Landfill V
3	Chambers Development MSWLF [1]
4	Uwharrie Environmental Regional Landfill
5	Great Oak Landfill
6	Upper Piedmont Regional Landfill
7	Wake County South Wake MSWLF
8	Sampson County Disposal, LLC
9	East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

0 40 80
Miles

TITLE: FACILITY LOCATION MAP

PROJECT: NORTH CAROLINA COLLECTIVE STUDY

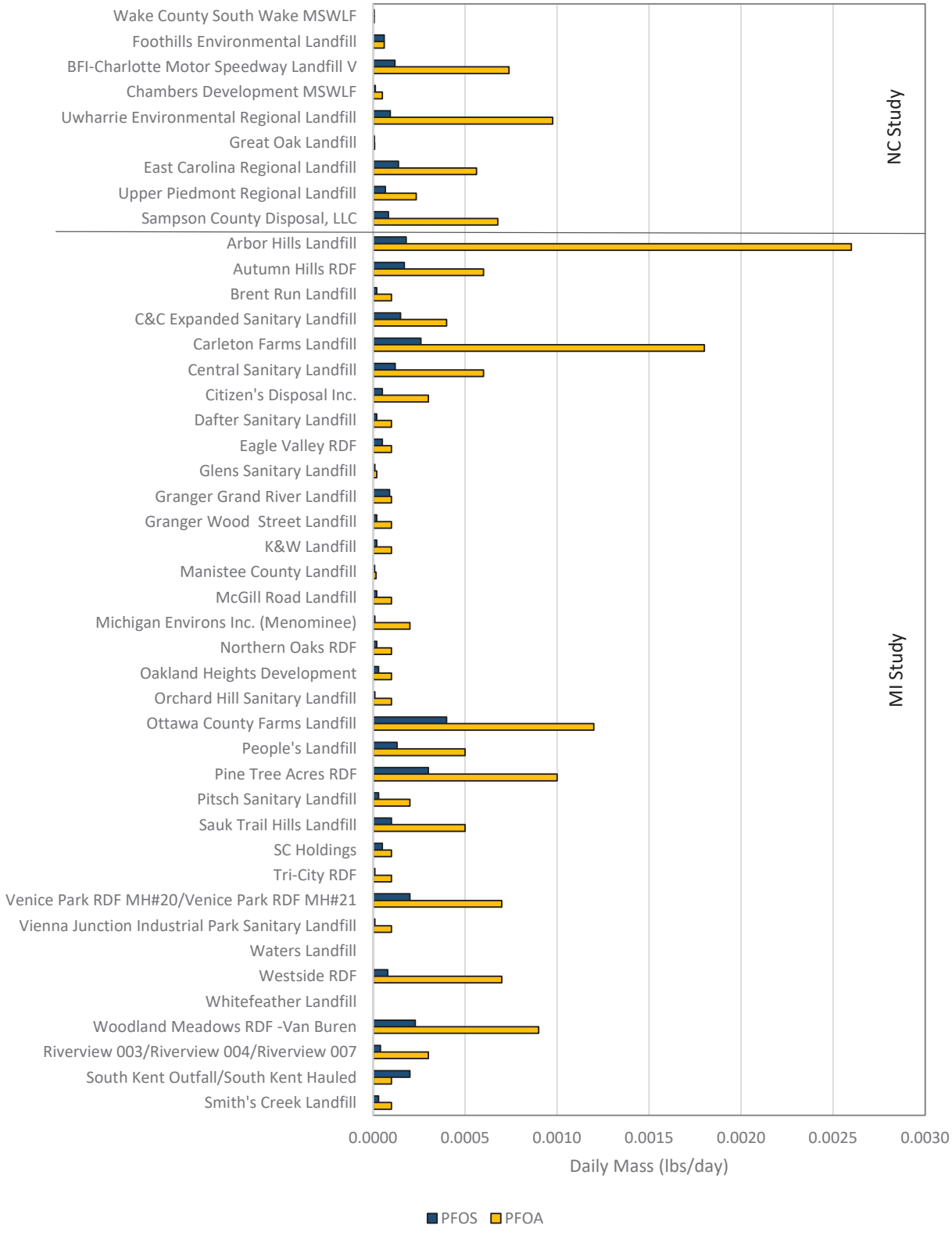
hart hickman
SMARTER ENVIRONMENTAL SOLUTIONS
2923 South Tryon Street - Suite 100
Charlotte, North Carolina 28203
704-586-0007 (p) 704-586-0373 (f)
License # C-1269 / # C-245 Geology

DATE: 2-14-20 | REVISION NO: 0

JOB NO: NWA-001 | FIGURE NO: 2

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

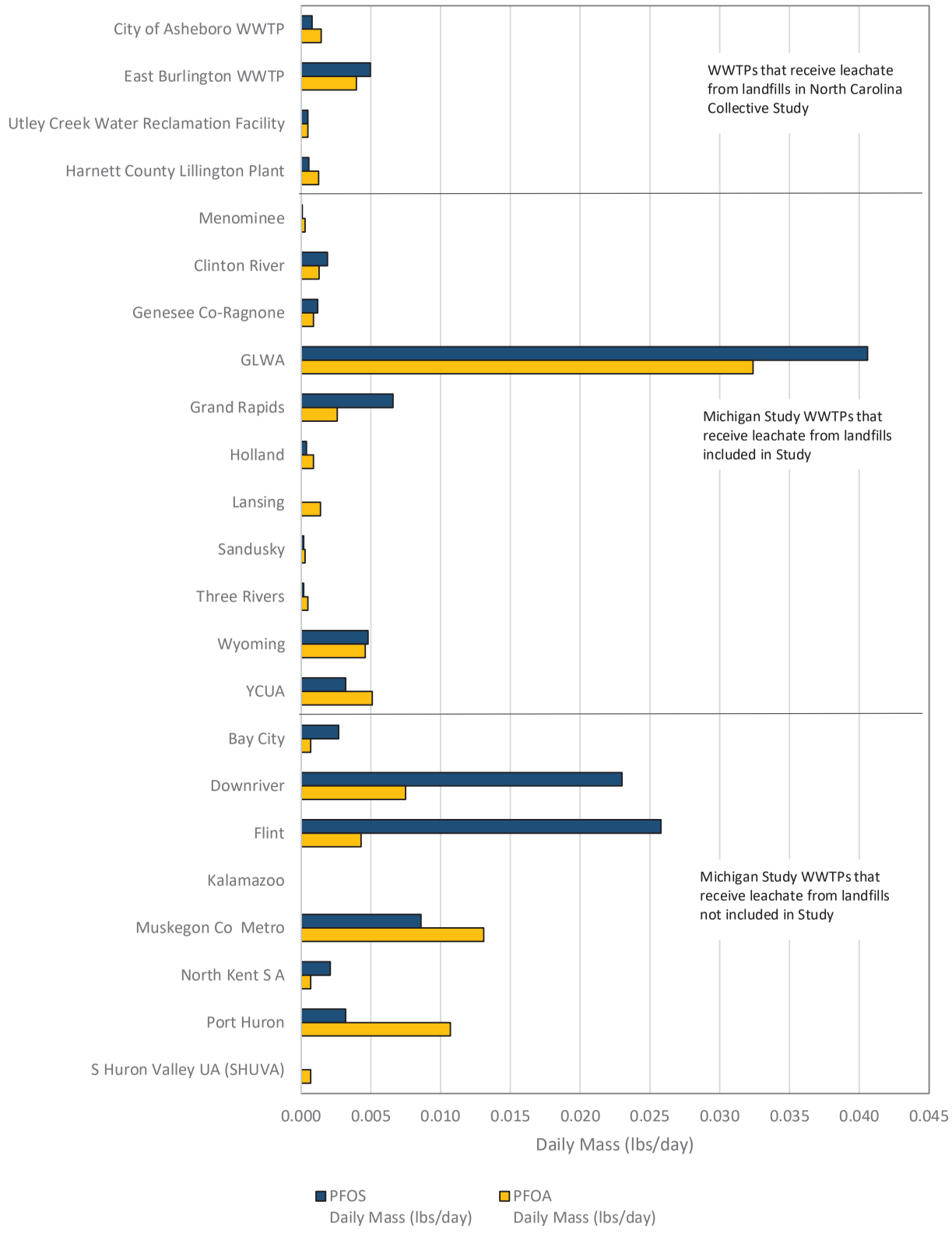
Figure 3 - PFOS and PFOA Daily Leachate Mass Summary



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

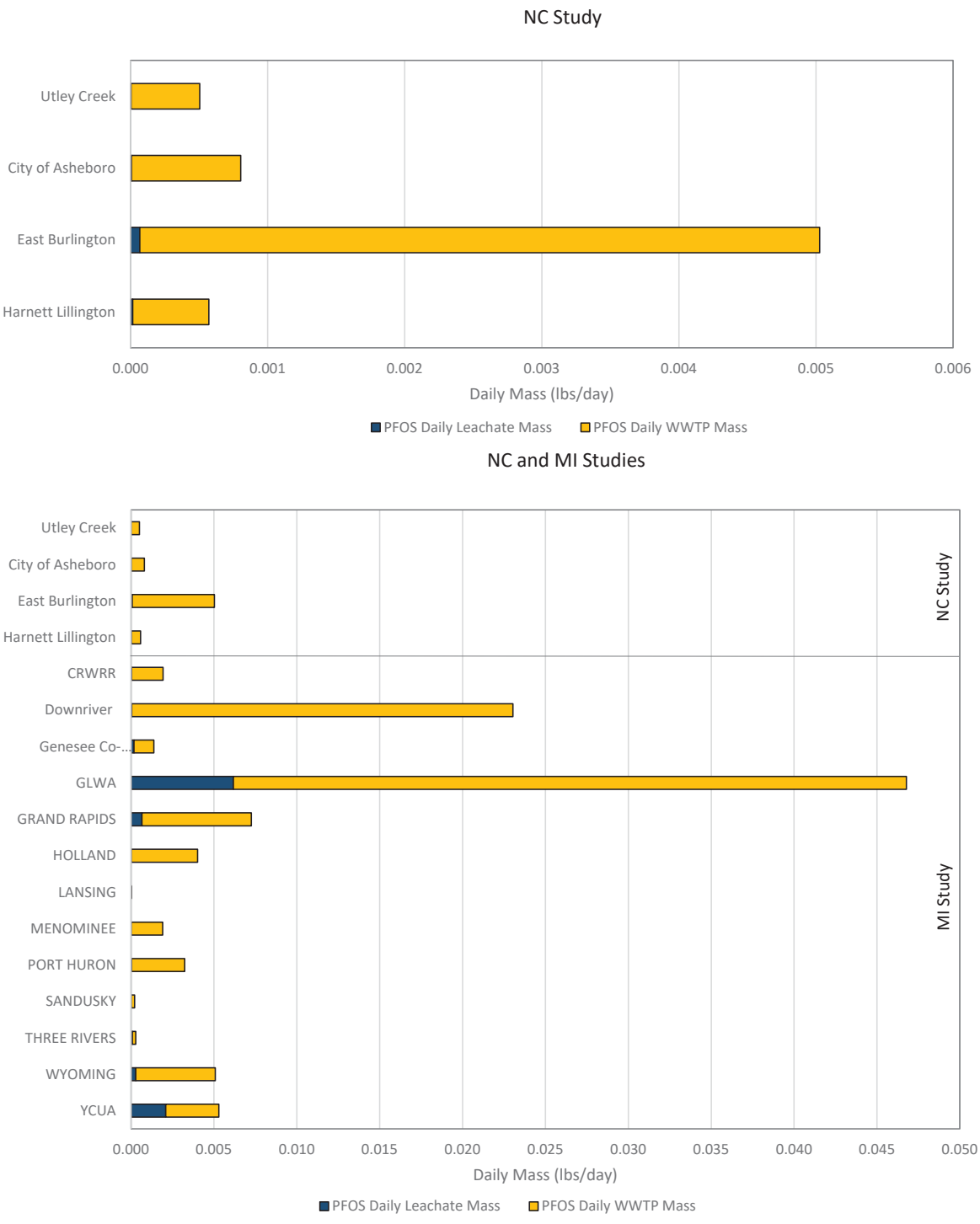
Figure 4 - PFOS and PFOA Daily WWTP Mass Summary



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

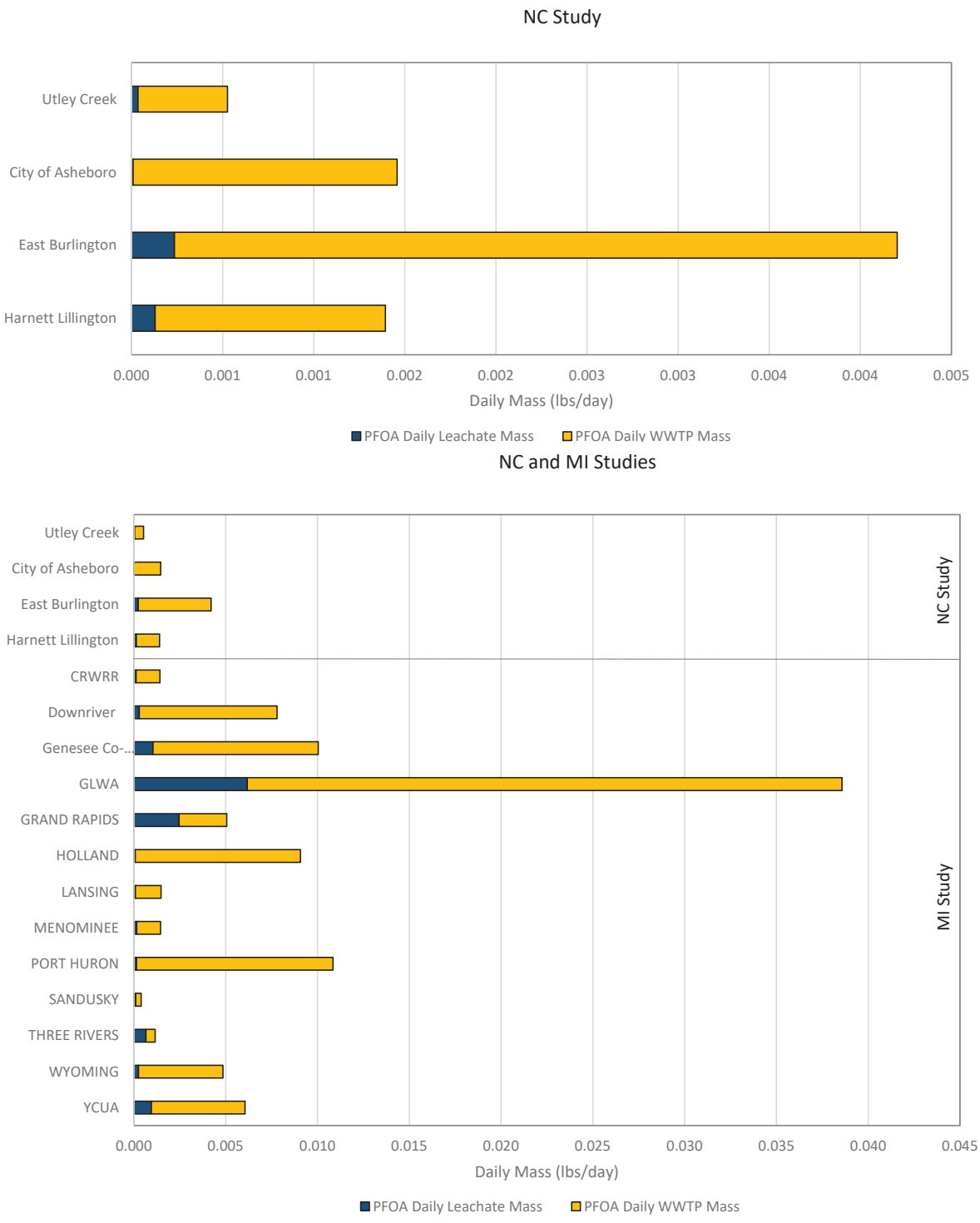
Figure 5 - PFOS Landfill Leachate Contribution to WWTP Daily Mass



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

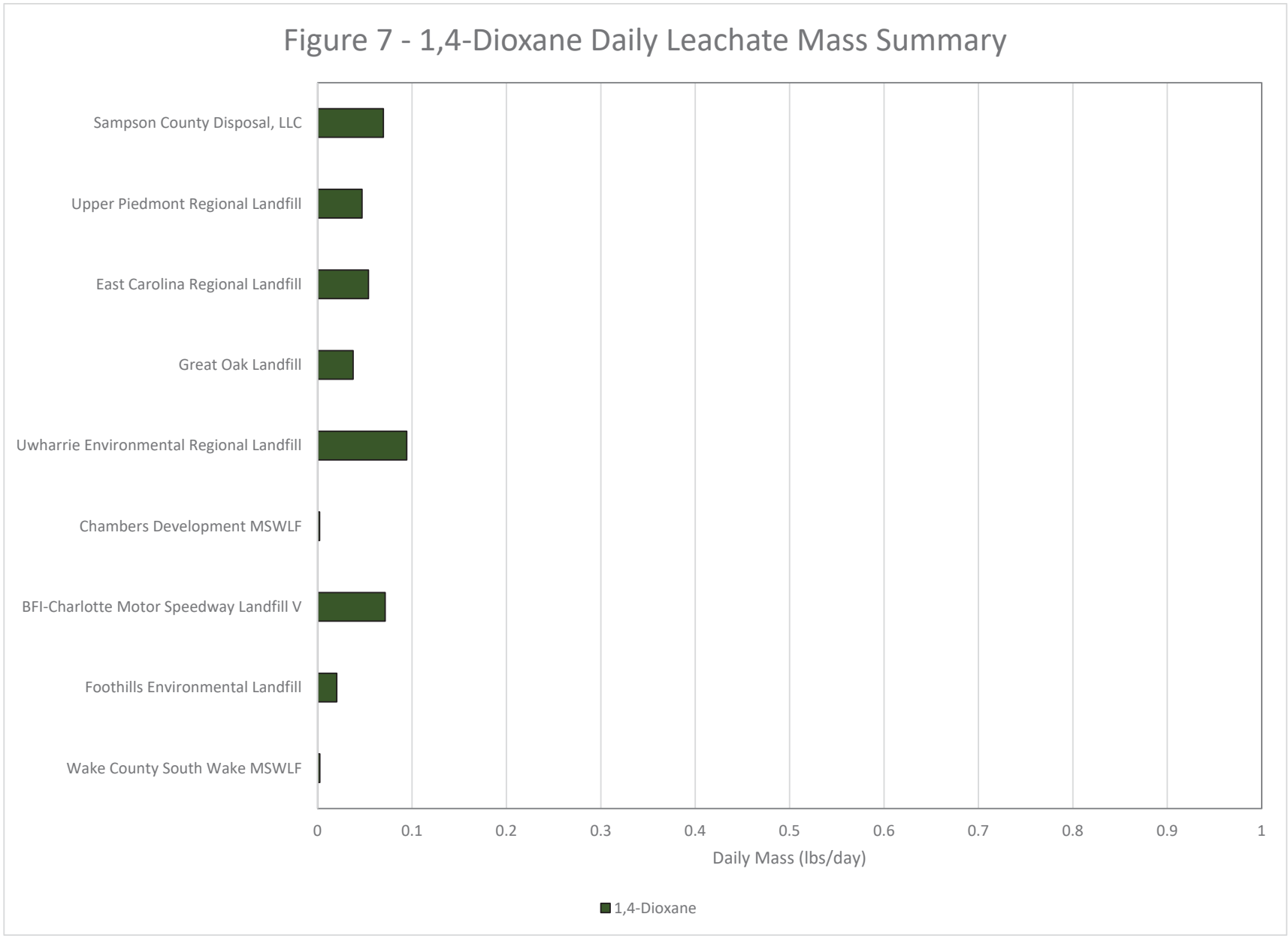
ATTACHMENT D

Figure 6 - PFOA Landfill Leachate Contribution to WWTP Daily Mass



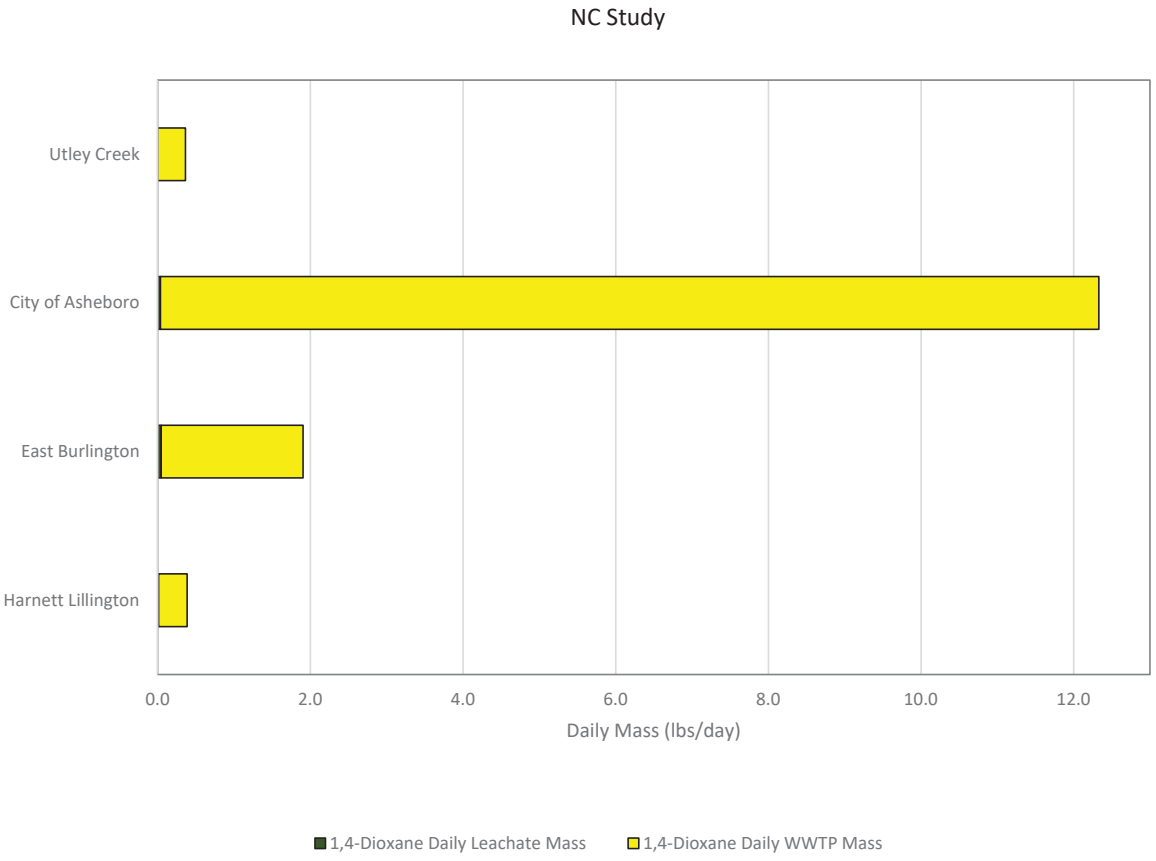
Notes:
1. MI Study = Michigan Waste & Recycling Association Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent (March 2019)
2. lbs/day = pounds per day

ATTACHMENT D



Note:
1. lbs/day = pounds per day

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.

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

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

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 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												

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 forSouth Wake MSWLF

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

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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%)		

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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%)		

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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%)		

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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					

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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

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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

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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.

ATTACHMENT D

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

490673
490885 mg 9/19/19

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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: 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)

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	<-- Preservative Type (6)	Comments
9222-1	09-18-19	1000	N	N	ML			4	X	X		Note: extra sample is required for sample specific QC

Chain of Custody Signatures

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

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

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA

SDG/AR/COC/Work Order: 490673

Received By: AJK

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
A)Shipped as a DOT Hazardous?		✓
B) Did the client designate the samples are to be received as radioactive?		✓
C) Did the RSO classify the samples as radioactive?		✓
D) Did the client designate samples are hazardous?		✓
E) Did the RSO identify possible hazards?		✓

*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.

Hazard Class Shipped: UN#:
If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___

COC notation or radioactive stickers on containers equal client designation.

Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM / mR/Hr
Classified as: Rad 1 Rad 2 Rad 3

COC notation or hazard labels on containers equal client designation.

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°
5	Sample containers intact and sealed?			✓	Secondary Temperature Device Serial # (If Applicable): 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 VK 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

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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 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

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

GEL LABORATORIES LLC
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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	Project:	NWRA00119
Sample ID:	490860001	Client ID:	NWRA001
Matrix:	Misc Liquid		
Collect Date:	16-SEP-19 09:20		
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	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												

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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	Project:	NWRA00119
Sample ID:	490860001	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	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

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QC Summary

Report Date: November 8, 2019

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%)		

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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										
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%)		

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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										
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					

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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										
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

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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

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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.

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

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)

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	<-- Preservative Type (6)	Comments
1403-1	09-16-19	0920	N	N	ML			4	X	X		Note: extra sample is required for sample specific QC

Chain of Custody Signatures

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

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

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	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
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

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 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

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

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 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:

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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%)		

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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%)		

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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%)		

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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					

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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

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

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.

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

490866

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: 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)

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: (T) Known or possible hazards	Total number of containers	PFAS 21 cmpd list by EPA 537 mod	1,4-Dioxane by EPA 8270SIM	<-- Preservative Type (6)
1304-1	09-16-19	1255	N	N	ML			4	X	X	

Comments
Note: extra sample is required for sample specific QC

Chain of Custody Signatures

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

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

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: 490866
Received By: AyA	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
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 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

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

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 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												

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 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%)		

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

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%)		

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

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%)		

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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					

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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

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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

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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

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.

ATTACHMENT D

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

490872

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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: 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)

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	<-- Preservative Type (6)	Comments
0403-1	09-16-19	1530	N	N	ML			4	X	X		Note: extra sample is required for sample specific QC

Chain of Custody Signatures

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

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

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

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: 490672
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 Secondary Temperature Device Serial # (If Applicable): TEMP: 1°
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 VK 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
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

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

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
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												

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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

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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%)		

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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										
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: **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%)		

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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					

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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										
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

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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

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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

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.

ATTACHMENT D

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)

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	<-- Preservative Type (6)
6204-1	09-17-19	0855	N	N	ML			4	X	X	

Comments
Note: extra sample is required for sample specific QC

Chain of Custody Signatures

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

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

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

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: 490875
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
a member of The GEL Group INC

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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

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

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
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	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

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:

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-EB	Project:	NWRA00119
Sample ID:	490876002	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	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: **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%)		

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										
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%)		

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										
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: **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

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

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.

ATTACHMENT D

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

490876
GEL Work Order Number:

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

Chain of Custody and Analytical Request

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.)	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	<-- Preservative Type (6)	Comments
7607-1	09-17-19	1310	N	N	ML			4	X	X		Note: extra sample is required for sample specific QC
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	[illegible]	9/19/19	0850
2						
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
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.)*

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

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

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

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
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 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

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

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 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												

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 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	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: **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%)		

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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										
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: **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%)		

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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										
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					

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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										
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

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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

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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 NWRA 0019
GEL Quote #: NWRA Quote
COC Number (1): N/A
PO Number: Bill to NWRA

490877

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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: Gena Olson JOlson@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 8270 SIM	Comments
<-- Preservative Type (6)									N	Note: extra sample is required for sample specific QC
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	[signature]	9-19-19	1700	1	Fedex	9-19-19	1700
2				2	A. Olmer [signature]	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.)

Page 4 of 15 SDG 490877 Rev1

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 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: Jenna Olsen jolsen@horthickman.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)	Should this sample be considered: (7) Known or possible hazards	Total number of containers	Sample Analysis Requested (5) (Fill in the number of containers for each test): VOCs (21-compound list modified per BAS37)	N	-- 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	[signature]	9-19-19	1700	1 Fedex	9-19-19	1700
2				2 A. Almon	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: ___ °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.)*

Page 1 of 1 SDG 498877 Rev1

ATTACHMENT 2

GEL Laboratories LLC

JR

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: 490877
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	✗		✓	Circle Applicable: (Not relinquished) Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials AG 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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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 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

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

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 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:

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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

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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%)		

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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%)		

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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%)		

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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					

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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

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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

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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.

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.

ATTACHMENT D

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

490879

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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: 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)

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	<-- Preservative Type (6)
7304-1	09-17-19	1525	N	N	ML			2	X	

Comments
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. Stevens	09-18-19	1630	1 [signature]	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
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.)*

Page: 1 of 1
Project #: 190772 NWRA 00119
GEL Quote #: NWRA Quote
COC Number (1): N/A
PO Number: Bill to NWRA

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: 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: Gonna 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	1,4-Dioxane by EPA 8270 SIM									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 [signature]	9-19-19	1700	1 Fedex	9-19-19	1700
2			2 [signature]	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: ____ °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

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

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 (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

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? AA 9/20	X		✓	Circle Applicable: (Not relinquished) Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials AG 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 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

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

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 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

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 forSampson County Disposal, LLC

Client Sample ID: 8202-1 Project: NWRA00119
Sample ID: 490881001 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

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 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	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: **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%)		

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

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%)		

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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										
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					

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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										
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					

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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.

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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.

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.

ATTACHMENT D

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

490881

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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)

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	GenX by EPA 537 mod
8202-1	09-18-19	1220	N	N	ML			2	X	X

<-- Preservative Type (6)

Comments
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. Stevens	09-18-19	1630	[illegible]	9/19/19	0850
2						
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
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.)*

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

Project # 190772-NWRA0019
GEL Quote #: NWRA Quote
COC Number (1): N14
PO Number: Bill to NWRA

490881

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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 # 919-862-2784
Project/Site Name: Sampson County Disposal, LLC Fax #
Address: 7434 Roseboro Hwy, Roseboro, NC 28382
Collected By: P. Stevens Send Results To: Gena Olson jolson@hearthickman.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 isotope info.)	Should this sample be considered: (7) Known or possible hazards	Total number of containers	Sample Analysis Requested (5) (Fill in the number of containers for each test): 1,4-Dioxane by 8270 SIM	<-- Preservative Type (6)	Comments Note: extra sample is required for sample specific QC
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	[signature]	9-19-19	1700	Fedex	9-19-19	1700
2				[signature]	9/20/19	8:55
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.)*

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

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 (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

GEL Laboratories LLC

JR

SAMPLE RECEIPT & REVIEW FORM

Client: MWRA	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	✗		✓	Circle Applicable: (Not relinquished) Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials AG 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

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

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

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

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
Sample ID: 491597001
Matrix: Misc Liquid
Collect Date: 30-SEP-19 09:55
Receive Date: 01-OCT-19
Collector: Client

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	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
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

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	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: 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

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

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.

Project # NWA-001
GEL Quote #: NWRA Quote
COC Number (1): N/A
PO 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 Roopsen

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 Land Fill Fax #
Address: 3597 Old Cedar Falls Rd, Randleman NC 27317
Collected By: P. Stevens Send Results To: gaken@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										Preservative Type (6)	Comments Note: extra sample is required for sample specific QC
									Metals by 6020A											
7607-EB	09-30-19	955	EB	N	ML			2	X											
7607-2	↓	1035	EQ	N	ML			2	X											

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
Patricia Hart	9/30/19	1600	1 Dyrosa Datan	10/01/19	850
			2		
			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: [ ] 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 LLC

491 597

SAMPLE RECEIPT & REVIEW FORM

Client: NWRA	SDG/AR/COC/Work Order: J.R.
Received By: TYE	Date Received: 10-1-19
Carrier and Tracking Number	Circle Applicable: FedEx Express FedEx Ground UPS Field Services Courier Other 7763 8929 7206

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 #: IR-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

GL-CHL-SR-001 Rev 6

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

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

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

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	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: 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

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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.

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** gel.com Laboratories LLC Chemistry I Radiochemistry I Radiobioassay I Specialty Analytics **Chain of Custody and Analytical Request** *GEL Work Order Number:* *GEL Project Manager:* 498420	GEL Laboratories, LLC 2040 Savage Road Charleston, SC 29407 Phone: (843) 556-8171 Fax: (843) 766-1178

Client Name: Phone #

Project/Site Name: Fax #

Address:

Collected By: Send Results To:

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 (8270)										<-- Preservative Type (6) Comments Note: extra sample is required for sample specific QC
1	12-04-19	13:30						1											
1A	⎮	⎮						1											
2	⎮	⎮						1											
2A	⎮	⎮						1											

Chain of Custody Signatures						TAT Requested: Normal: ____ Rush: ____ Specify: ____ (Subject to Surcharge)
Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time	Fax Results: [ ] Yes [ ] No
1			1 A. Alm	12/5/19	8:50	Select Deliverable: [ ] C of A [ ] QC Summary [ ] level 1 [ ] Level 2 [ ] Level 3 [ ] Level 4
2			2			*Additional Remarks:*
3			3			*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
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

GEL Laboratories LLC

JH

SAMPLE RECEIPT & REVIEW FORM 494420

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 1023 6338 6000

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

GL-CHL-SR-001 Rev 6

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

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

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.

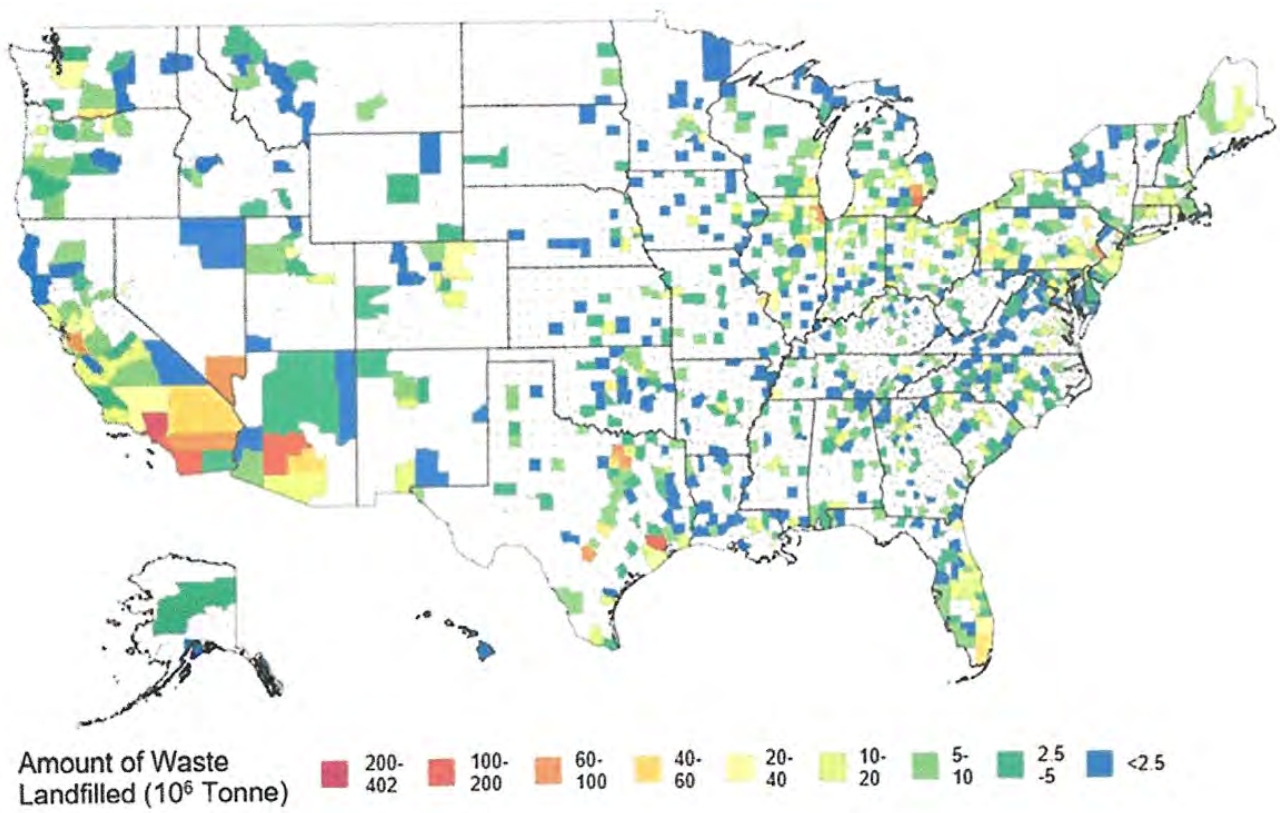

Figure 1
Map of landfilled waste by counties in the U.S. Credit: Waste Informatics: Establishing Characteristics of Contemporary U.S. Landfill Quantities and Practices, September 2016, Environmental Science & Technology, by Jon Powell, José Carlos Pons, and Marian Ruth Chertow, Yale

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:

$$M0 + (min - mout + Rnet)\Delta t = M0+\Delta t,$$

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.

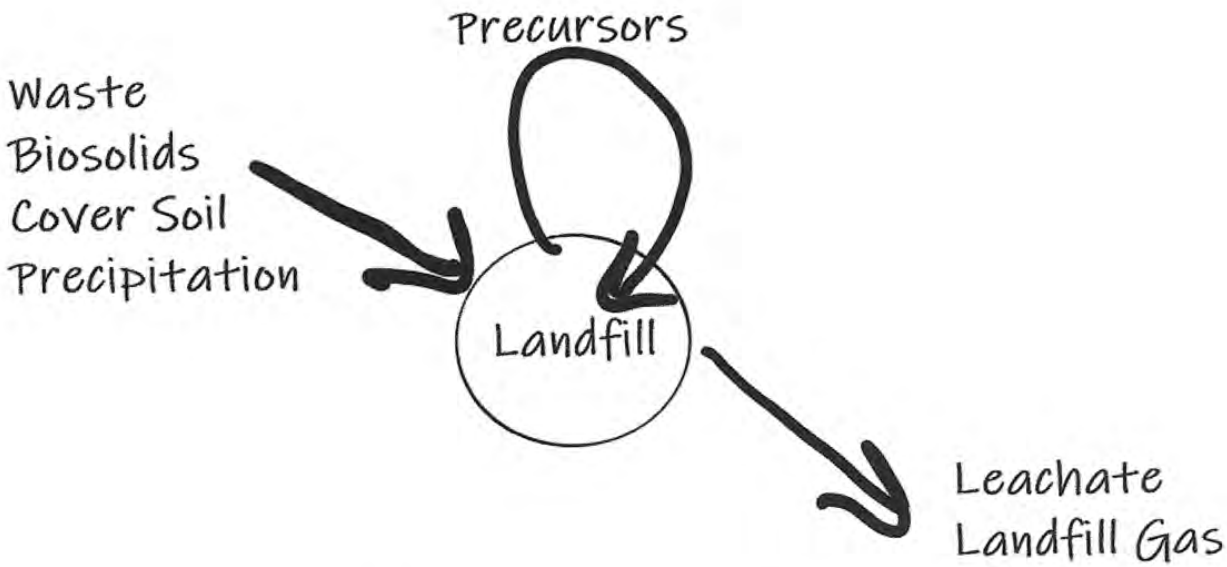

Figure 2: Schematic of mass balance approach.
Image courtesy of Tetra Tech, Inc.

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).

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.

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

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

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- Lang JR, Allrad BM, Field JA, Levis JW, and Barlaz MA, 2017, National Estimate of Per- and Polyfluoroalkyl Substances (PFAS) Release to US Municipal Landfill Leachate, Environmental Science & Technology, January 20, 2019, Volume 51(4), pp 2197.
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Note

1. Estimated as 50 percent of the leachate PFAS mass loading.

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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.

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.

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.

Preparing Samples

LABORATORY MATERIALS

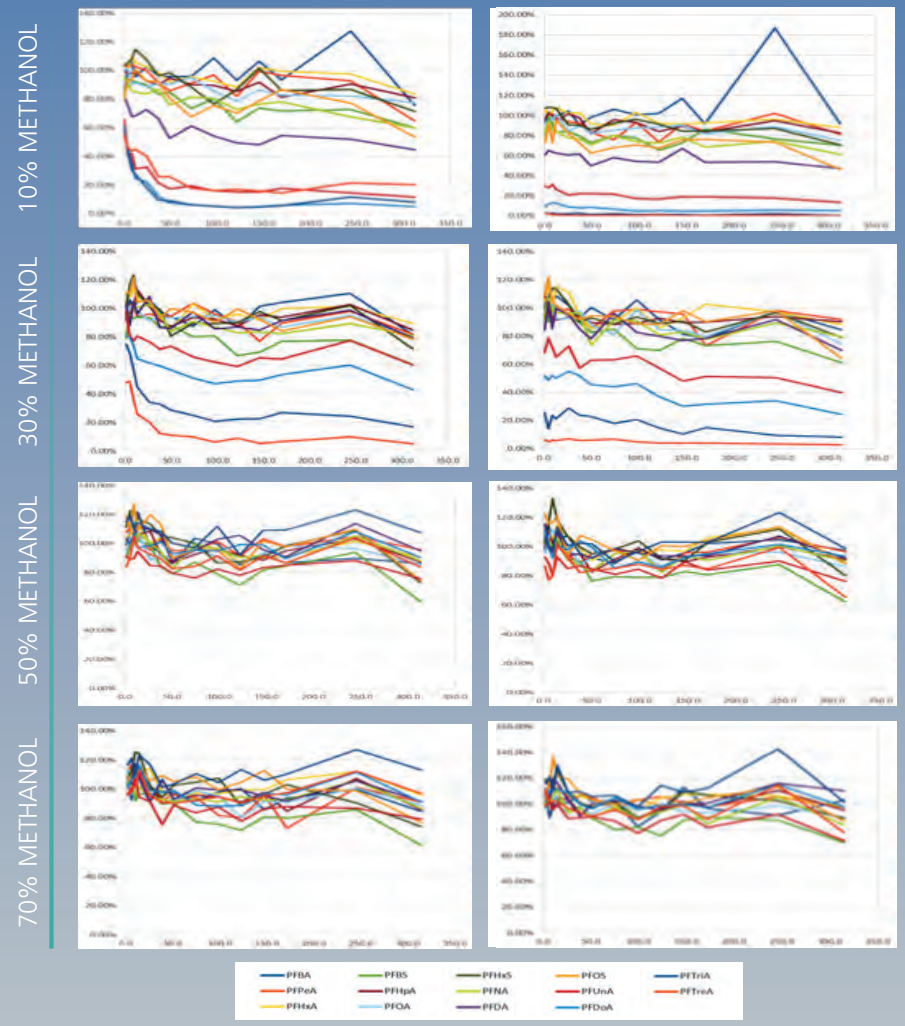
Preparation and Storage of Stock Solutions and Standards

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.

Sample Preparation and Injection

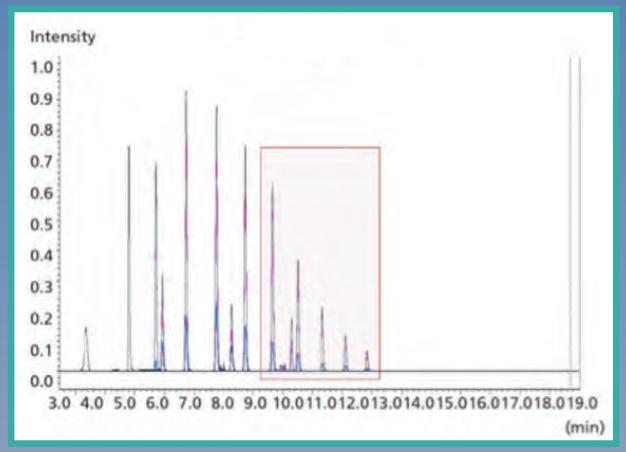
Some currently published methods (EPA 537, EPA 537.1) require a step of sample pre-concentration by solid phase extraction (SPE). Materials used in the manufacturing of supplies for preparing the samples by SPE may also contain PFAS. To avoid pre-concentrating the background PFAS during this step of 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.

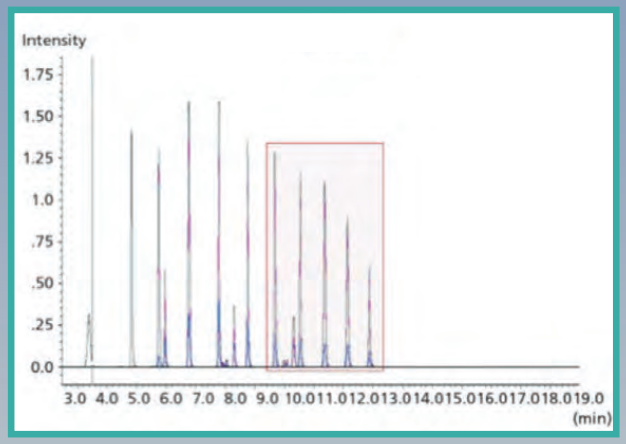
Once samples are pre-concentrated and ready for injection in the LC-MS/MS or samples are prepared accordingly to methods that allow for large volume injection (ASTM D7979), they may sit in the autosampler tray for extended periods of time. In these situations, some PFAS compounds may settle, precipitate 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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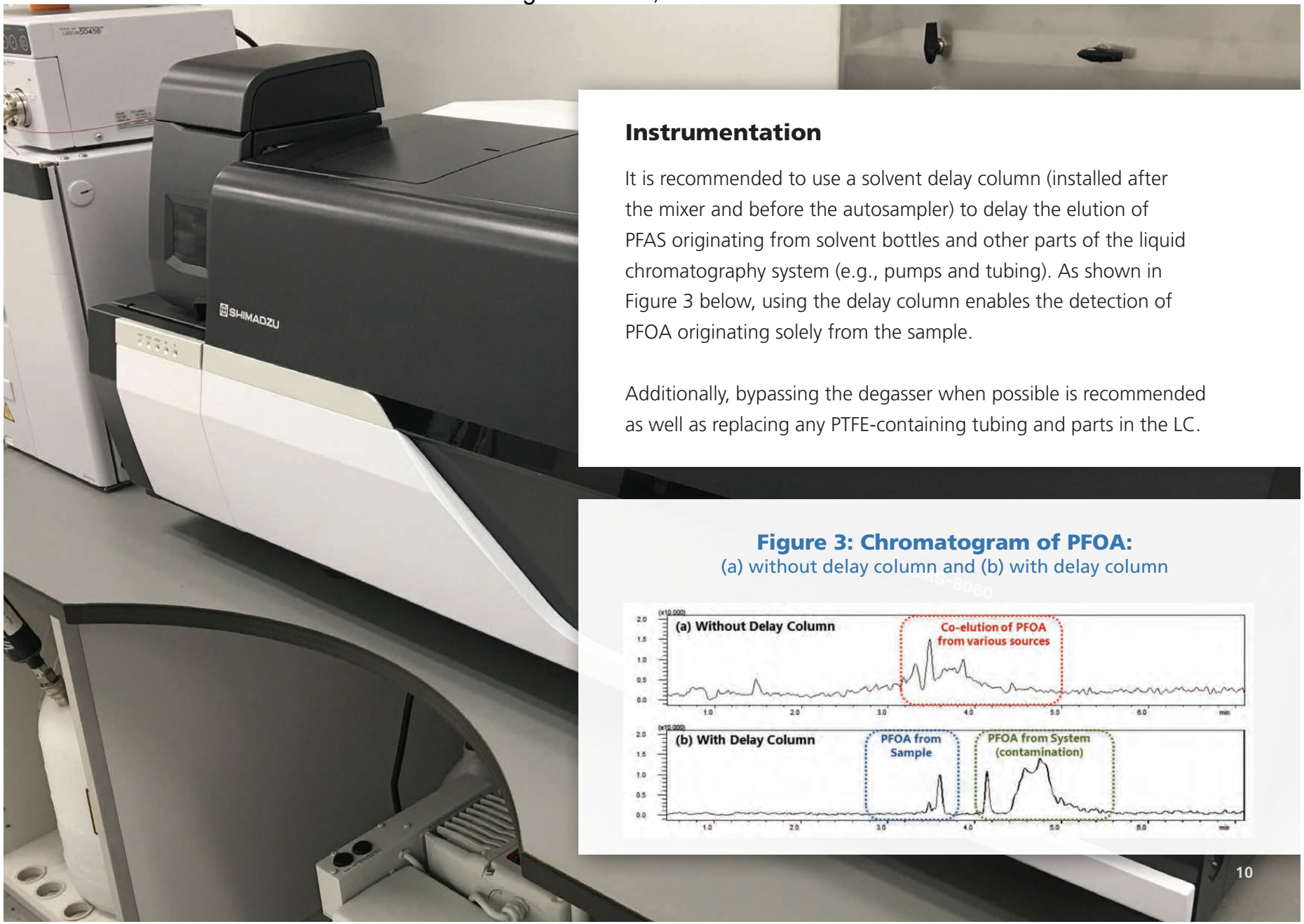

Instrumentation

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

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.

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An Equipment Manufacturer's Perspective on Regulatory Guidance and Ambiguity on PFAS in Groundwater Sampling

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QED Environmental Systems Inc.
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Why do we use Teflon®?

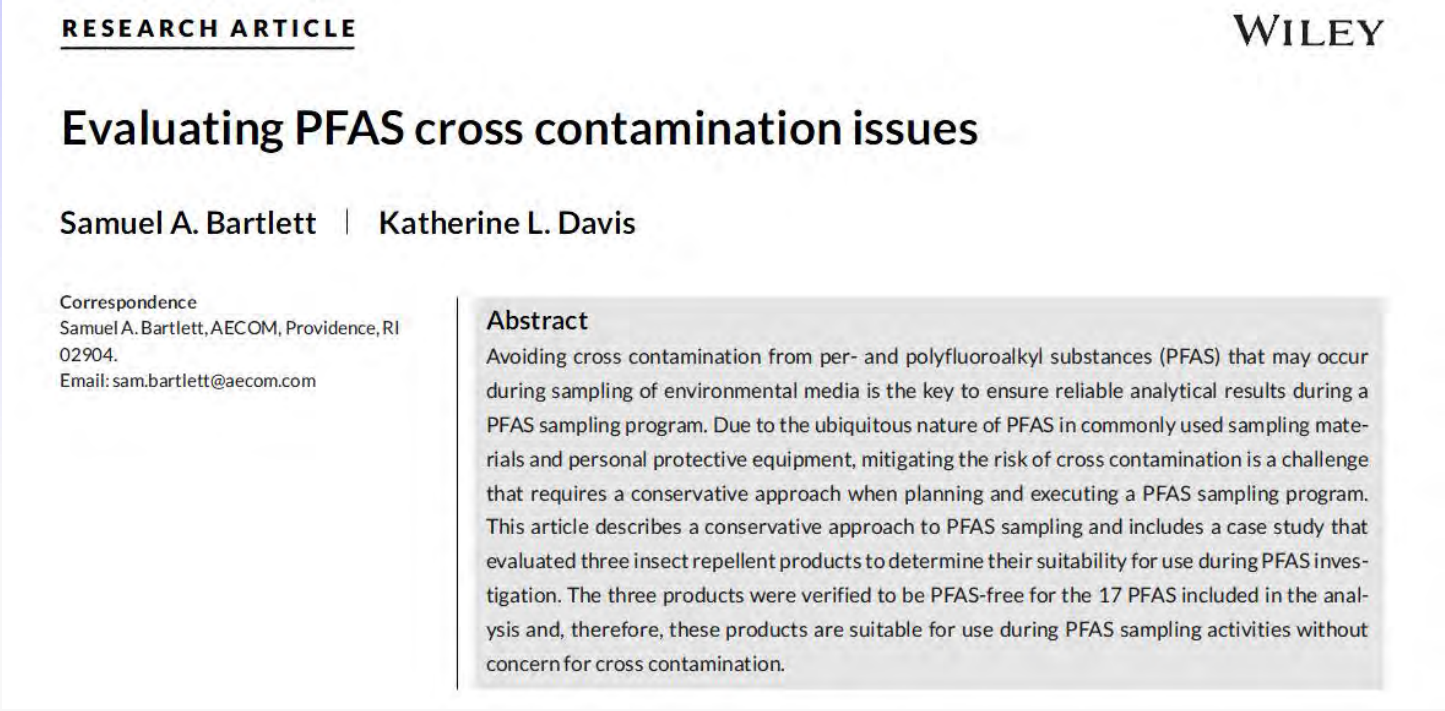
- Groundwater sampling equipment, including pumps, bailers, tubing and other components, have historically been manufactured using Teflon* and other fluoropolymers due to its many advantageous properties:
  - Chemically inert
  - Non-reactive
  - Highly resistant to sorption and leaching of common groundwater 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)

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

Some examples…



RESEARCH ARTICLE

WILEY

Evaluating PFAS cross contamination issues

Samuel A. Bartlett | Katherine L. Davis

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Abstract

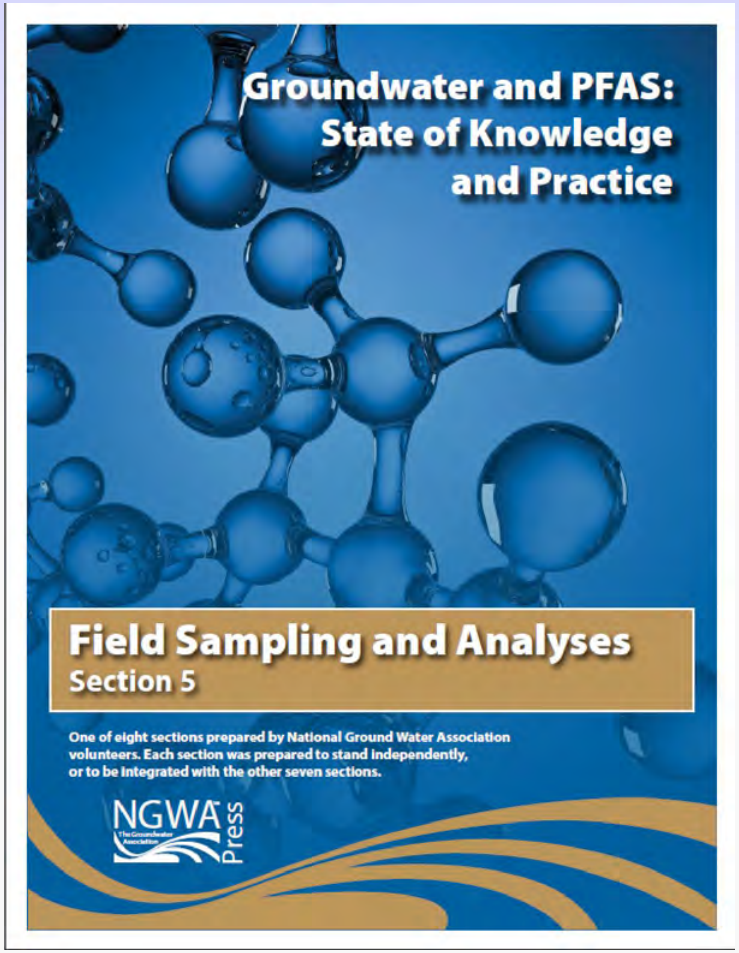
Avoiding cross contamination from per- and polyfluoroalkyl substances (PFAS) that may occur during sampling of environmental media is the key to ensure reliable analytical results during a PFAS sampling program. Due to the ubiquitous nature of PFAS in commonly used sampling materials and personal protective 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…. should be free from polytetrafluorethylene (PTFE) or ethylene tetrafluoroethylene (ETFE) to the maximum extent practicable.



From NGWA, March 2018

Per- and Polyfluoroalkyl Substances (PFAS) Sampling Guidelines

CALIFORNIA STATE WATER QUALITY CONTROL BOARD

DIVISION OF WATER QUALITY

Water Boards

March 20, 2019

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/

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

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

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

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

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

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

Dedicate d Bladder Pumps

Portable Bladder Pumps

QED Sample Pro® PFAS-Free/Teflon-free Portable Bladder Pump Sampling Systems

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

QED

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

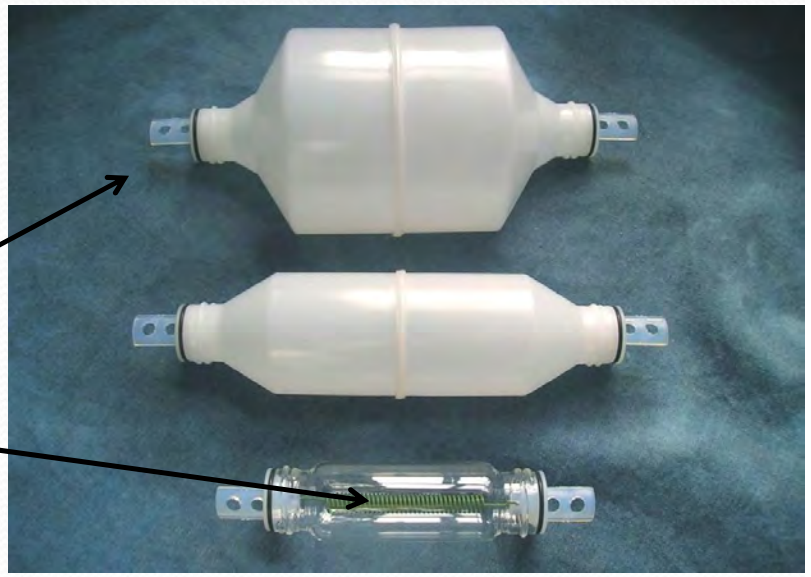
PDB Sampler

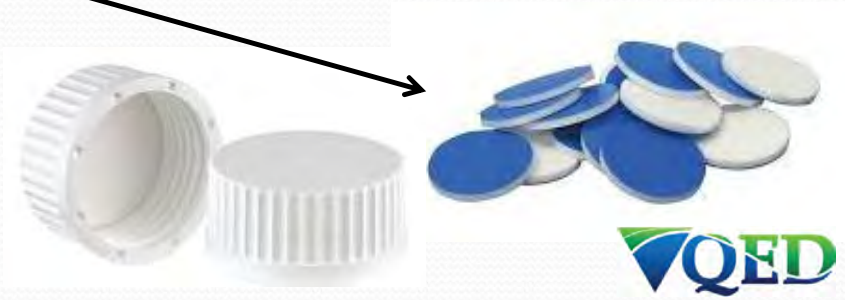
Snap Sampler®

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

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

Question s?

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CERTIFICATE OF SERVICE

I, the undersigned, certify that on this 6th day of December 2022, I electronically served the **NATIONAL WASTE & RECYCLING ASSOCIATION'S INDEX OF EXHIBITS AND THIRD HEARING EXHIBITS** upon the individuals on the attached service list. I further certify that my email address is cmanning@bhslaw.com.

Dated: December 6, 2022

By /s/ Claire A. Manning

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