Assessment of PFAS Levels in Washington State Biosolids

By

Mounia Sassi, Emily Kijowski, Amber Corfman

For the

Solids Waste Management Program

Washington State Department of Ecology
Olympia, Washington

September 2025, Publication 25-07-057

Publication Information

This document is available on the Department of Ecology's website at:
https://apps.ecology.wa.gov/publications/summarypages/2507057.html[1]

Related Information

- Quality Assurance Project Plan (QAPP)[2] for this project.
- Quality Assurance Project Plan Addendum[3] for this project.
- Focus on PFAS in Biosolids[4]
- PFAS 1633 Report Data, PFAS EOF Report Data, PFAS TOP Report Data

Contact Information

Solid Waste Management Program

P.O. Box 47600
Olympia, WA 98504-7600
Phone: 360-407-6000
Website[5]: Washington State Department of Ecology

ADA Accessibility

The Department of Ecology is committed to providing people with disabilities access to information and services by meeting or exceeding the requirements of the Americans with Disabilities Act (ADA), Section 504 and 508 of the Rehabilitation Act, and Washington State Policy #188.

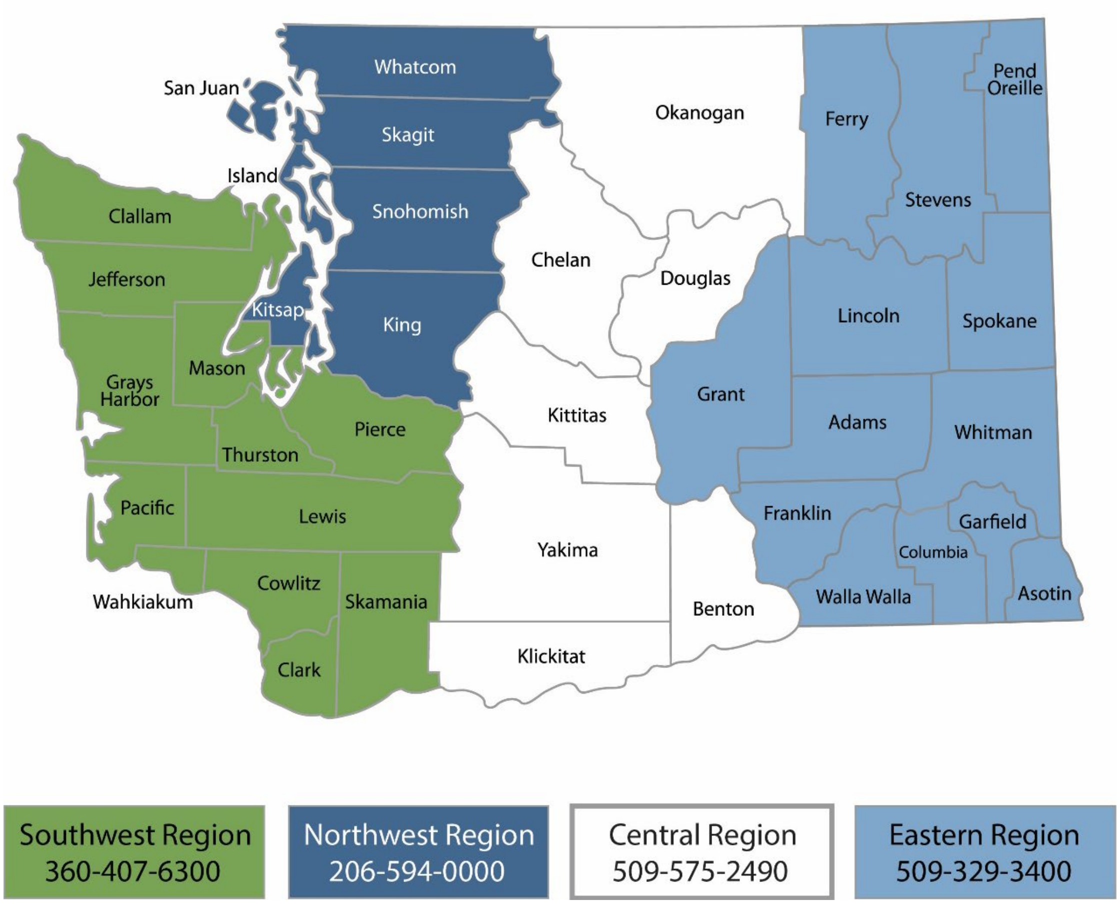
To request an ADA accommodation, contact Ecology by phone at 360-407-6831or email at ecyadacoordinator@@ecy.wa.gov, or visit https://ecology.wa.gov/accessibility. For Washington Relay Service or TTY call 711 or 877-833-6341. Visit Ecology's website for more information.

---

[1] https://apps.ecology.wa.gov/publications/summarypages/2507045.html[1]
[2] https://apps.ecology.wa.gov/publications/SummaryPages/2407040.html
[3] https://apps.ecology.wa.gov/publications/SummaryPages/2507048.html
[4] https://apps.ecology.wa.gov/publications/SummaryPages/2507020.html
[5] www.ecology.wa.gov/contact

Department of Ecology's Regional Offices

Map of Counties Served



Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	P.O. Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	P.O. Box 330316 Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 West Alder Street Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 North Monroe Spokane, WA 99205	509-329-3400
Headquarters	Statewide	P.O. Box 46700 Olympia, WA 98504	360-407-6000

Assessment of PFAS Levels in Washington State Biosolids

Solid Waste Management Program
Washington State Department of Ecology
Olympia, WA

September 2025| Publication 25-07-057

Table of Contents

List of Figures and Tables

Charts

Tables

Acknowledgements

The authors of this report thank the following people for their contribution to this study:

- Biosolids Advisory committee
- Washington State of Ecology staff:
    - Terri Costello
    - Shawnte Greenway
    - Ruby Irving-Hewey
    - Eddie Simons
    - Nancy Rosenbower
    - Christina Frans
    - John Weakland
    - Marni Solheim
- SGS AXYS Analytical Services Staff:
    - Georgina Brooks
    - Richard Grace

Special thanks to all participating facilities for allowing Ecology to collect samples at their sites.

Abstract

Per- and polyfluoroalkyl substances (PFAS) are a group of manmade chemicals that are resistant to natural decomposition. Because of their mass production and use since the 1940s, they are widespread in our environment today. While not sources themselves, Wastewater Treatment Plants (WWTPs) receive PFAS in wastewater from upstream sources, both residential and industrial. PFAS have been identified in influent, effluent, sewage sludge, and biosolids across the United States.

In 2024, the Washington Department of Ecology (Ecology) carried out a study to assess PFAS concentrations in biosolids generated at 44 WWTPs across Washington state. There are approximately 375 WWTPs across the state. Participating facilities varied in size, location, and types of residential and industrial inputs they receive.

The goals of the study were to (1) begin collecting data on the levels of PFAS concentrations in Washington biosolids, and (2) gain a better understanding of the sampling process for U.S. Environmental Protection Agency (EPA) Method 1633. This study will strengthen the technical assistance Ecology staff provides to WWTPs in the future.

During this study Ecology discovered a limitation with using EPA Method 1633 for liquid biosolids that were less than 5% solids. This limitation affected seven of the participating WWTPs' results. We discuss further details of this limitation and potential solutions in the Results and Discussion section of this report. The results from the remaining 37 WWTPs show PFOS and PFOA concentrations in the biosolids were relatively low; samples from these facilities all contained less than 60 ppb (parts per billion) PFOS, and less than 20 ppb PFOA. Most states with established PFAS regulations would allow land application of the majority (70%) of these biosolids without any restrictions.

While this study allowed us to gather initial data on PFAS levels in Washington biosolids, it was limited in scope. Additional data is needed both in frequency and location to inform future policy decisions. The passing of Senate Bill 5033 "Concerning sampling or testing of biosolids for PFAS chemicals"[6] (SB 5033), during the 2025 legislative session will help Ecology gather additional data.

[6] https://lawfilesext.leg.wa.gov/biennium/2025-26/Pdf/Bills/Session Laws/Senate/5033-S.SL.pdf

Introduction

Ecology collected a wide variety of data during this study using the analysis methods listed below:

- EPA Method 1633
- Total Oxidizable Precursor (TOP) Assay
- Extractable Organic Fluorine (EOF)

Although EPA Method 1633 measures 40 different PFAS chemicals, Ecology's focus in this report is on PFOS and PFOA as these are the PFAS chemicals that EPA and other state agencies are currently focusing on in biosolids.

The additional analysis types were included for a few reasons. First, they were included for comparison to EPA Method 1633, as well as to determine if there was an appropriate screening method for PFAS in biosolids that could address concerns about cost and lack of laboratory capacity, limitations causing long delays in receiving results for EPA Method 1633. This additional data can be found in Appendix C.

In planning this study, Ecology established and consulted with an advisory committee to gather input. This committee included people from a wide variety of backgrounds whose interactions with biosolids and PFAS varied, including researchers, universities, members from the regulated community, tribes, environmental interest groups, and Washington Department of Health.

Biosolids Background

Biosolids are a byproduct of the wastewater treatment process that preserves nutrients and organic matter. Beneficial microorganisms in the wastewater treatment system are able to break down the solids and destroy pathogens. After this treatment, the residual solids and microorganisms are separated from the liquid portion. Those solids are collected, treated, and tested. When they meet state and federal regulatory standards, they are considered biosolids. Biosolids can replace commercial fertilizers as a soil amendment -- adding organic matter, nitrogen, and other nutrients back to the soil.

Anything that flows into a WWTP has the potential to end up in biosolids. Federal and state regulations work together to protect humans and the environment from known pollutants and pathogens. Ongoing research and studies like this one work to identify if additional regulations are necessary to ensure safe management of biosolids.

Approximately 85 percent of biosolids generated in Washington are beneficially used as a soil amendment. In 2020 biosolids were applied to 28,000[7] acres of land in Washington state.

[7] Acreage does not include exceptional quality biosolids due to regulatory differences in the way these biosolids are tracked (WAC 173-308-200). Exceptional quality biosolids accounted for approximately 16% of biosolids generated in 2020.

According to the American Farmland Trust[8] there are 15,398,200 acres of agricultural land in Washington state. Data from the U.S. census[9] puts Washington's agricultural land at 14,679,857 acres (per the USDA Natural Agricultural Statistics Service[10]).

Using the lower figure of available agricultural land of 14,679,857 acres, and the conservative (high-end) value of 30,000 acres receiving biosolids annually, we find that just about 0.2% of farmland in Washington state receives biosolids each year. Not all biosolids are applied to farmlands, and not all land characterized as agricultural is used to grow food chain crops. This means that less than 0.2% of food chain crops receive biosolids annually.

Per- and polyfluoroalkyl substances (PFAS)

PFAS are a group of several thousand manmade chemicals used in a variety of consumer products and industrial applications since the 1940s. Their ability to repel oil, water, and grease make them useful additions to a wide variety of consumer products and industrial processes. Many household products contain PFAS like personal care products, makeup, cooking pans, carpets and textiles, and food packaging. Common industries that use PFAS in their process include chrome plating, microchip production, aerospace, medical device manufacturing, and paper and packaging manufacturing. While PFAS based aqueous film-forming foams (AFFF)[11] used to fight flammable liquid fires are being phased out in many areas, it is still required for use in certain industries like airports and military non-training events.

PFAS have been coined “forever chemicals” due to their persistence in the environment. Some PFAS bioaccumulate in people, animals and persist in the environment over time, and are not easily removed or broken down. Due to this persistence and their widespread use, most people in the United States may have been exposed to PFAS. Continued exposure to some PFAS may lead to adverse health effects (Ecology 2022).

PFAS and biosolids

PFAS make their way into biosolids from residences and industries that discharge wastewater to WWTPs. In this way WWTPs are not producers of PFAS, instead they receive these chemicals from upstream sources. Currently there are no proven treatment technologies that can remove PFAS from biosolids. Reducing the amount of PFAS in consumer products and manufacturing remains the best method for reducing PFAS levels in biosolids.

Many studies looking at PFAS and biosolids have been conducted by researchers well versed in PFAS and biosolids land application practices. An outline of some of these efforts is compiled in the State Environmental Policy Act Checklist for the General Permit for Biosolids

---

[8] https://farmlandinfo.org/statistics/washington-statistics/
[9] https://www.census.gov/quickfacts/WA
[10] https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/Washington/st53_1_0007_0008.pdf
[11] https://ecykenpub/waste-toxics/reducing-toxic-chemicals/washingtons-toxics-in-products-laws/toxics-in-firefighting

Management[12], pages 20-23. Although our understanding of PFAS in biosolids has grown in recent years, data gaps persist.

EPA is working to assess PFAS in biosolids and the potential impact to human health and the environment. On January 14, 2025, EPA published a Draft Sewage Sludge Risk Assessment for PFOA and PFOS[13] (Draft Risk Assessment). This Draft Risk Assessment is preliminary and was available for public comment through August 14, 2025. Although it is not a regulation or EPA guidance, and does not compel action, this risk assessment will likely inform EPA's future regulatory actions.

Ecology appreciates EPA's ongoing and needed efforts to assess potential risks of exposure to PFOA and PFOS from contaminated biosolids. We also have concerns about the Draft Risk Assessment that are shared by many other organizations and agencies as indicated by comments that were submitted. Michigan's EGLE program submitted a detailed and well thought out response to the EPA's Draft Risk Assessment, posted to the federal register[14].

Below are a couple of the high-level concerns Ecology and others identified with the Draft Risk Assessment.

Ecology is concerned with the number of uncertainties identified in the data used. Literature included to inform the modeling was not comprehensive and relied on studies that are not representative of current biosolids land application practices. For example, the fate and transport considerations included reference to sites with well-known highly industrially impacted biosolids and industrial sludges in Maine, Michigan, and Alabama. Another study referenced included only three sites for which the PFAS source was solely municipal biosolids, and one of those was known to be industrially impacted. The main source for the remaining 1000+ sites included in the study was known to be industrially impacted with PFAS coming from AFFF from non-biosolids sources (Brusseau et al., 2020).

The Draft Risk Assessment does not incorporate a risk management assessment that would evaluate things like environmental justice matters, costs, benefits, technological feasibility, and ecological impacts of current and alternative management options. This process is separate from but often done in tandem with risk assessment work. Both assessments are used to make decisions when implementing risk reduction activities. Risk management is also used to communicate risks to impacted parties and the general public. EPA previously stated this piece will come in the future. Until the risk management piece is complete, the Draft Risk Assessment on its own does not provide actionable guidance for the general public or regulatory agencies like Ecology.

---

12 https://apps.ecology.wa.gov/separ/Main/SEPA/Document/DocumentOpenHandler.ashx?DocumentId=185805
13 https://www.epa.gov/system/files/documents/2025-01/draft-sewage-sludge-risk-assessment-pfoa-pfos.pdf
14 https://www.regulations.gov/document/EPA-HQ-OW-2024-0504-0001/comment?filter=michigan

Relying on incomplete data to guide future regulatory guidance could present an inaccurate assessment of true risks posed and result in policy ineffective at mitigating potential harm.

For these reasons, it is not appropriate to compare the results of our sampling study to the Draft Risk Assessment. Ecology is monitoring EPA efforts and other states' initiatives on PFAS in biosolids as we work to develop our own strategy.

Goals of this study

In 2022, Ecology developed a PFAS Chemical Action Plan (CAP) that identified, characterized, and assessed uses and releases of PFAS in Washington State. CAPs incorporate feedback from interested community members and guide actions to address priority toxic chemicals[15]. Biosolids were considered in writing the PFAS CAP. Appendix 8 of the CAP recommended assessing PFAS concentrations in biosolids. This study works towards a recommendation established by the CAP to gather more data on the levels of PFAS in Washington biosolids.

In planning this study, Ecology's goals were to:

1. Begin collecting data on the levels of PFAS concentrations present in biosolids generated in Washington State, and
2. Gain a better understanding of the sampling process required for EPA Method 1633 to better support permittees with this sampling if needed.

[15] https://ecology.wa.gov/waste-toxics/reducing-toxic-chemicals/addressing-priority-toxic-chemicals

Regulations

Biosolids are regulated federally under the EPA's Clean Water Act under 40 CFR Part 503 Standards for the Use or Disposal of Sewage Sludge[16]. Ecology also regulates biosolids generated, managed, and land applied in Washington. The Washington State legislature passed a bill on PFAS in biosolids during the 2025 legislative session that will temporarily increase sampling requirements for facilities subject to these regulations.

State and federal biosolids regulations

The Department of Ecology was charged by the legislature in 1992 to establish a biosolids management program. Ecology established the Biosolids Management Rule (Chapter 173-308 WAC[17]) that is in keeping with -- or more stringent -- than federal regulations. Ecology has been implementing this rule via a Statewide General Permit for Biosolids Management since 1998. The general permit contains minimum requirements that all biosolids facilities must meet and allows Ecology to increase environmental protections or establish more stringent biosolids management requirements for facilities on a case-by-case basis, as necessary.

Solids generated from the wastewater treatment process that meet the standards in Chapter 173-308 WAC are considered "biosolids" and may be land applied to farmland as a fertilizer or soil amendment. The legislature requires Ecology to maximize beneficial use of biosolids in a manner protective of public health and the environment.

PFAS and biosolids legislation

The signing of Washington SB 5033[6] into law on May 17, 2025 adds PFAS sampling requirements for biosolids generated and land applied in Washington. The bill requires facilities to sample and analyze biosolids for PFAS between January 1, 2027 and July 1, 2028. Facilities must supply results to Ecology to analyze and draft a report to the legislature, including recommendations on any next steps. The bill will help generate more data on the levels of PFAS concentrations in Washington biosolids. For facilities that generate liquid biosolids, Ecology will identify appropriate solutions to address the limitations identified with EPA Method 1633 prior to implementation of SB 5033. We discuss potential solutions in the Recommendations section below.

Many other states have acted to mitigate PFAS impacts from contaminated biosolids in the form of land application bans, restrictions, or interim plans. Michigan and Colorado are two states that implemented PFAS regulations requiring WWTPs to sample prior to land application. They have both set regulatory PFAS concentration limits that biosolids must meet to be eligible for land application. Please see Appendix B for an outline of Michigan, Colorado, and other states' biosolids PFAS regulations.

---

[16] https://www.govinfo.gov/content/pkg/CFR-2018-title40-vol32/xml/CFR-2018-title40-vol32-part503.xml
[17] https://app.leg.wa.gov/wac/default.aspx?cite=173-308

Sampling and Methodology

Sample collection

Ecology collected biosolids and Quality Control (QC) samples from 44 WWTPs located across Washington state of differing sizes and treatment processes. All samples were collected between April 15 and June 7 of 2024. A detailed list of facility characteristics that participated in this study is included in Appendix A.

Ecology staff collected dewatered biosolids samples following the protocol established in the Quality Assurance Project Plan[18] (QAPP) Appendix B.

Liquid biosolids samples were collected by Ecology staff in collaboration with WWTP facilities staff. For these samples, Ecology followed the protocol established in QAPP Appendix B, in addition to the QAPP Addendum[19].

Blanks were collected following the protocol established for field and equipment blanks in QAPP Appendix A.

A second round of sampling was done at 15 of the participating WWTPs in this study in Spring of 2025. This additional sampling was completed in an effort to explore the limitations of EPA Method 1633 when analyzing liquid biosolids. These results will be released when complete as an addendum to this report.

Laboratory analysis

A total of 219 samples were collected; this total includes replicate biosolids samples and blanks.

Table 1. Samples Analysis

# of Facilities	# of Samples	Methodology Used
44	219	EPA Method 1633
26	26	total oxidizable precursor (TOP) Assay
10	10	extractable organic fluorine (EOF).
44	Approx. 200	EPA Office of Research and Development (ORD) analyzing for a wide range of PFAS analytes using a non-targeted analysis. *Ecology is awaiting results.*

EPA method 1633

This method analyzes 40 PFAS compounds in aqueous, solid, biosolids, and tissue samples by liquid chromatography with tandem mass spectrometry (LC-MS/MS). This method is recommended by EPA for the analysis of PFAS chemicals in wastewater, surface water,

[18] https://apps.ecology.wa.gov/publications/documents/2407040.pdf
[19] https://apps.ecology.wa.gov/publications/documents/2507048.pdf

groundwater, soil, biosolids, sediment, landfill leachate, and fish tissue. All the collected samples including QC samples were analyzed using this method.

Total oxidizable precursor (TOP) assay

This method identifies the presence of chemicals that can transform into PFOA or other Perfluoroalkyl Acids (PFAAs) under specific environmental circumstances. This method is able to measure 32 PFAS chemicals.

This analysis is typically used in tandem with EPA Method 1633. TOP does not have an established analysis methodology, so results from different labs cannot necessarily be used to make direct comparisons. For this reason, Ecology ruled out TOP as a regulatory tool, and we will not be focusing on results from this method in this report. However, this method may be useful for WWTPs working to implement source control strategies.

Please see Appendix C for TOP Assay results.

Extractable organic fluorine (EOF)

This method quantifies the total extractable organic fluorine selectively using combustion ion chromatography. This method reports fluoride concentration in a sample, which means it identifies fluorine associated with PFAS and non-PFAS chemicals as well. This method helps estimate levels of total PFAS and determine the potential presence or absence of PFAS in the sample.

A similar method, total organic fluorine (TOF), was recommended for inclusion by the advisory committee (mentioned above) for use in comparing PFAS contamination between different consumer products. Ecology was unable to identify a lab that could conduct both EPA Method 1633 and TOF. Instead, Ecology identified EOF as an alternative. EOF may be a useful initial screening tool for WWTPs trying to identify whether they may be receiving PFAS from upstream sources.

After reviewing results, Ecology determined EOF is not a useful regulatory tool for biosolids at this time because it is considerably less precise than EPA Method 1633, and it quantifies both PFAS and non-PFAS fluorine-containing chemicals. Therefore, we will not be focusing on results from this method in this report.

Please see Appendix C for EOF results.

Quality Control

Sampling quality control

Ecology collected the following QC samples in keeping with the QAPP and QAPP Addendum. These terms are described in more detail in the QAPP.

- Field blanks
- Equipment blanks
- Replicate samples
- Matrix Spikes and Matrix Spike Duplicates

Results showed all the equipment blanks were non-detect for PFAS. This confirms Ecology staff decontaminated sampling equipment appropriately between sampling events. Proper cleaning prevents PFAS from one sampling location from contaminating following locations' samples.

All but one of the field blanks' results were non-detect, with one having a very low concentration of PFAS. The highest concentration was negligible at around 7 parts per trillion (ppt). In comparison to measured results for biosolids in parts per billion (ppb), this is three orders of magnitude smaller; 7 ppt in the field blank equals 0.007 ppb.

Laboratory quality control

For every batch of up to 20 biosolids samples, SGS AXYS Analytical Services Ltd (SGS AXYS Lab) ran one set of QC samples including a method blank, a sample duplicate, and a matrix spike, and matrix spike duplicate. One sample from 7 different WWTPs was used as a lab duplicate. These samples were split at the lab and run as two separate samples, so these facilities have four sets of results instead of three.

Data validation

Ecology's Manchester Environmental Lab (MEL) completed Stage 4 validation for EPA Method 1633 and Stage 2B data validation for TOP Assay and EOF analysis as per the QAPP, section 13.0 Data Verification. See the QAPP for more information on data validation.

Result qualifiers

MEL QC coordinator followed the QAPP and Ecology Environmental Information Management Data Qualifiers Guidance[20] to verify the quality of the data for this project. Here are the qualifiers used in this report:

- U (*): non-detect, a non-detect result in environmental testing or laboratory analysis indicates that a specific substance (analyte) was not found at a concentration that could be reliably detected by the analytical method used. It essentially means the substance's concentration is below the detection limit of the method.
- J: Analyte was positively identified. The reported result is an estimate.
- B: Analyte detected in sample and lab method blank. Reported result is sample concentration without blank correction or associated quantitation limit.

[20] https://apps.ecology.wa.gov/eim/help/ValidValues/DataQualifiers

Results and Discussion

Dewatered biosolids results

Ecology collected dewatered biosolids from 37 WWTPs and SGS AXYS Lab analyzed them using the top three methods listed in Table 1 above. We are focusing on the results from EPA Method 1633 in this report. The levels of PFAS found in dewatered biosolids were in a range Ecology expected.

- PFOA levels were below 20 ppb in all dewatered biosolids in this study. Most states with established PFAS regulations would allow land application of these biosolids without any restrictions.
- PFOS levels were below 60 ppb in all dewatered biosolids in this study, with 70% of results below 20 ppb.
- PFAS levels found in dewatered biosolids in this study are comparable to results from other states where no known PFAS manufacturing exists. This indicates concentrations consistent with use of PFAS-containing products, such as stain and water-resistant coatings.
- Dewatered biosolids analyzed using EPA Method 1633 produced consistent results across triplicate samples for each WWTP.

Tables 2 and 3 show the PFAS interim strategies for biosolids for Colorado and Michigan, respectively. Ecology used these established programs to compare our study results too. Other states have established similar thresholds for PFOA and PFOS, we included them in Appendix B.

Table 2. Colorado PFAS Interim Strategy for Biosolids[21]

Chemical	Threshold	Grouping	Requirements
PFOS	<50 ppb	Individual	No additional requirements.
PFOS	>50 ppb	Individual	Source control identification and reduction plan.

Table 3. Michigan PFAS Interim Strategy for Biosolids[22]

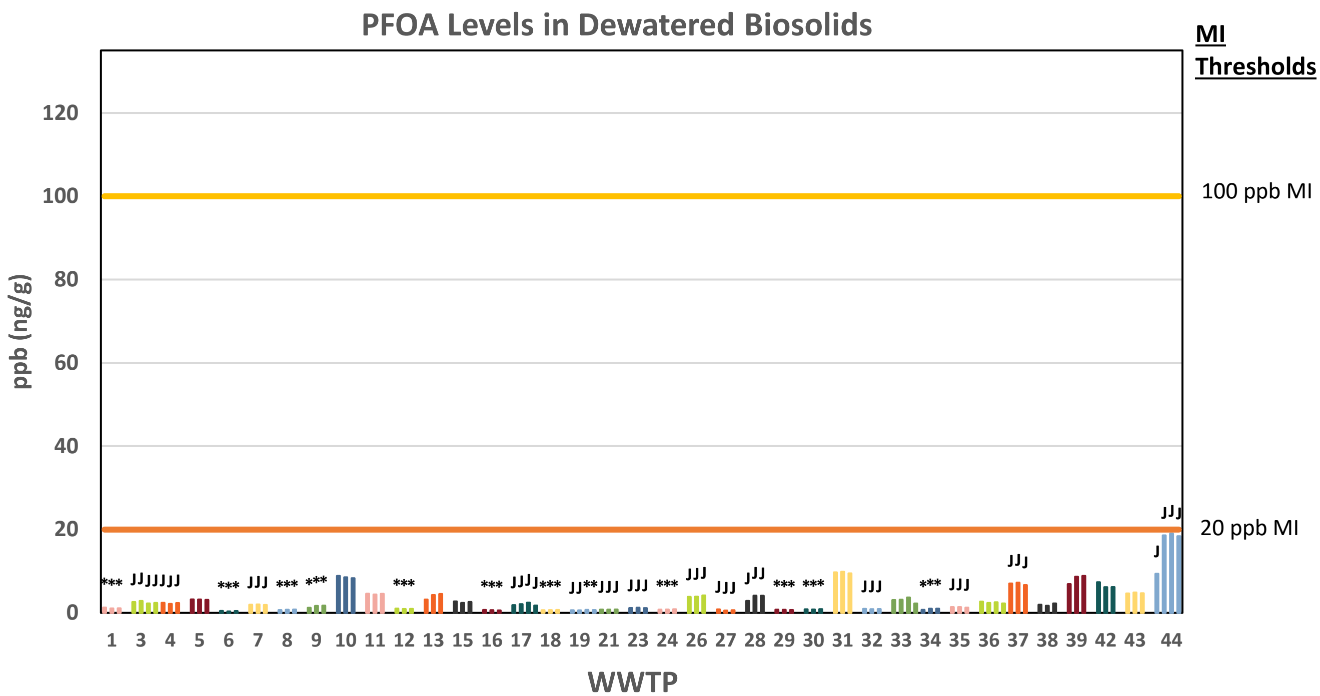
Chemical	Threshold	Grouping	Requirements
PFOA, PFOS	<20 ppb	Individual	No additional requirements.
PFOA, PFOS	20-100 ppb	Individual	Source reduction implementation & Land application rate reduction to 1.5 dry tons per acre.
PFOA, PFOS	>100 ppb	Individual	No land application allowed & source reduction plan.

[21] https://drive.google.com/file/d/1bZk4wBZ8AK3nDTSQFVi4R1R7KO4L2Fk6/view
[22] https://www.michigan.gov/egle/about/organization/water-resources/biosolids/pfas-related/interim-strategy

PFOA

Chart 1 shows PFOA results for all dewatered biosolids in this study as well as Michigan's PFOA land application thresholds depicted as horizontal lines. Based on the PFOA results in Chart 1, these biosolids would be eligible for land application under Michigan's PFAS Interim Strategies for biosolids.

Chart 1. PFOA levels in dewatered biosolids from 37 WWTPs using EPA Method 1633



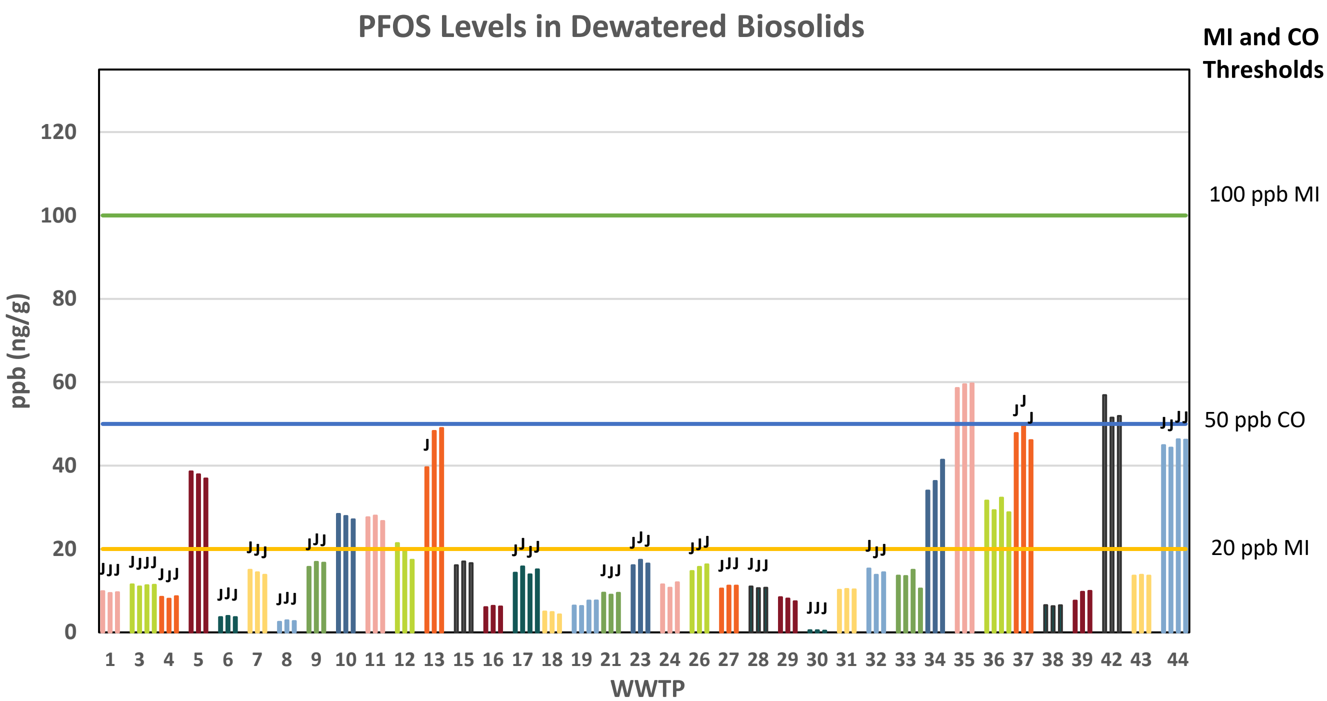
* – Indicates a Non-Detect
J – Indicates an estimated value
Numerical data for Chart 1 can be found in Appendix C, Table C-1

PFOS

Chart 2 shows PFOS results for all dewatered biosolids in this study as well as Michigan and Colorado's PFOS land application thresholds depicted as horizontal lines.

All results from dewatered biosolids in this study were below 60 ppb PFOS. Based on the PFOS results in Chart 2, these biosolids would be eligible for land application under both Michigan and Colorado's PFAS interim strategies for biosolids. The majority (70%) could be land applied without additional requirements.

Chart 2. PFOS levels in dewatered biosolids from 37 WWTPs using EPA Method 1633



J – Indicates an estimated value
Numerical data for Chart 2 can be found in Appendix C, Table C-1

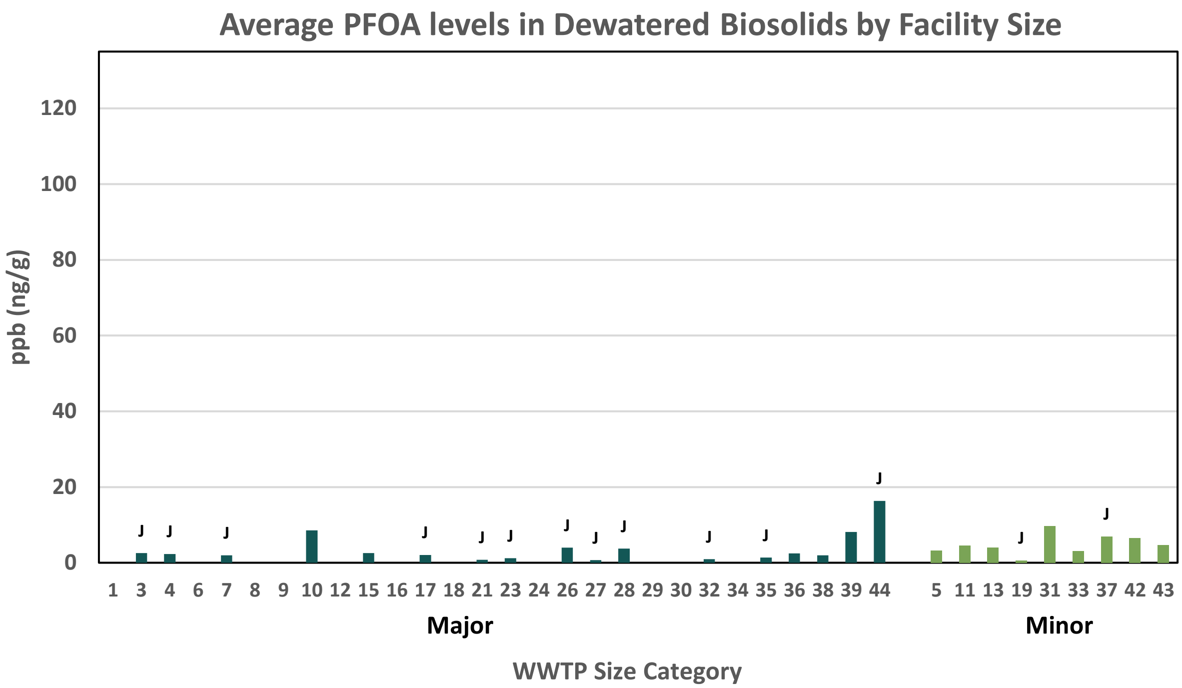
PFOA and PFOS concentrations based on facility size

Ecology expected to see larger WWTPs have higher amounts of PFOA and PFOS present in their biosolids due to the higher probability of receiving industrial inputs. However, when comparing results between Major and Minor WWTPs, that was not supported by the study results.

A Major WWTP is defined by the EPA as a facility that receives a flow of over 1,000,000 gallons per day of wastewater and has a population over 10,000 people. Minor WWTPs are facilities receiving less wastewater with smaller populations. Charts 3 and 4 show the average amounts of PFOA and PFOS present in biosolids sampled at Major versus Minor WWTPs.

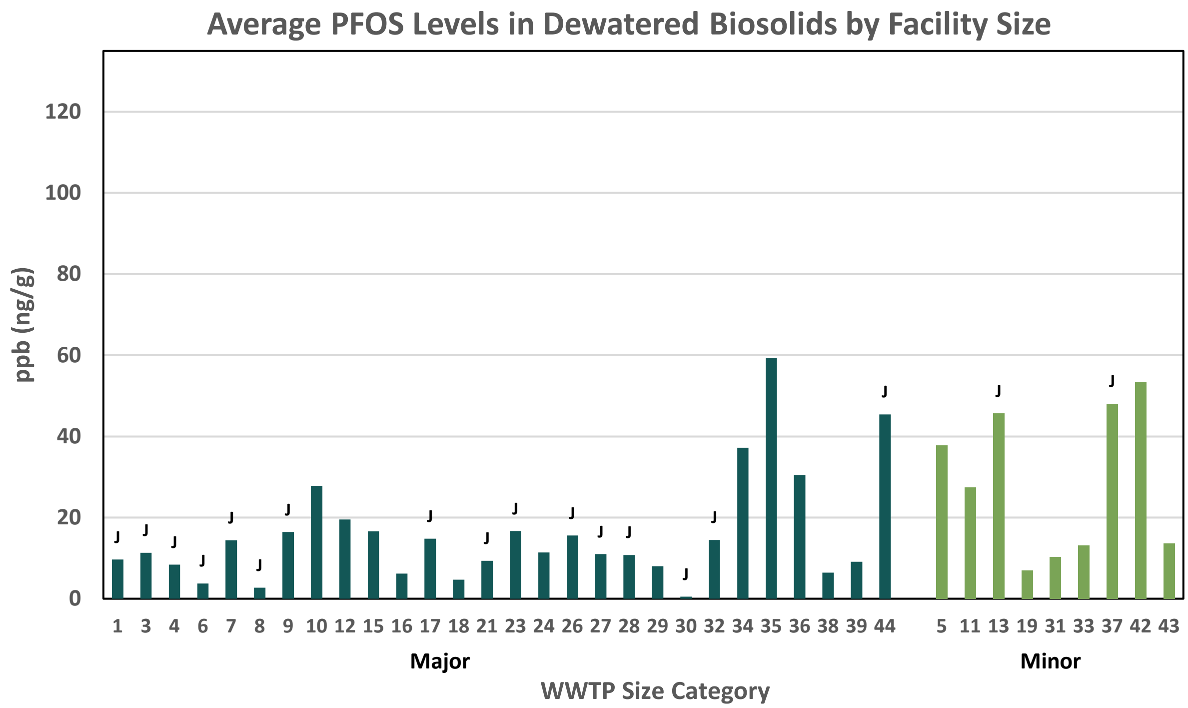
The widespread presence of these chemicals indicates that wastewater coming from our homes may have just as much impact on biosolids as discharges coming from business and industry. This observation should be confirmed through further investigation to see if this correlation is accurate. Future sampling should not be limited to major urban centers or to locations where industrial uses of PFAS have been identified.

Chart 3. Average PFOA levels in dewatered biosolids using EPA Method 1633 identified by facility size



J – Indicates an estimated value

Chart 4. Average PFOS levels in dewatered biosolids using EPA Method 1633 identified by facility size

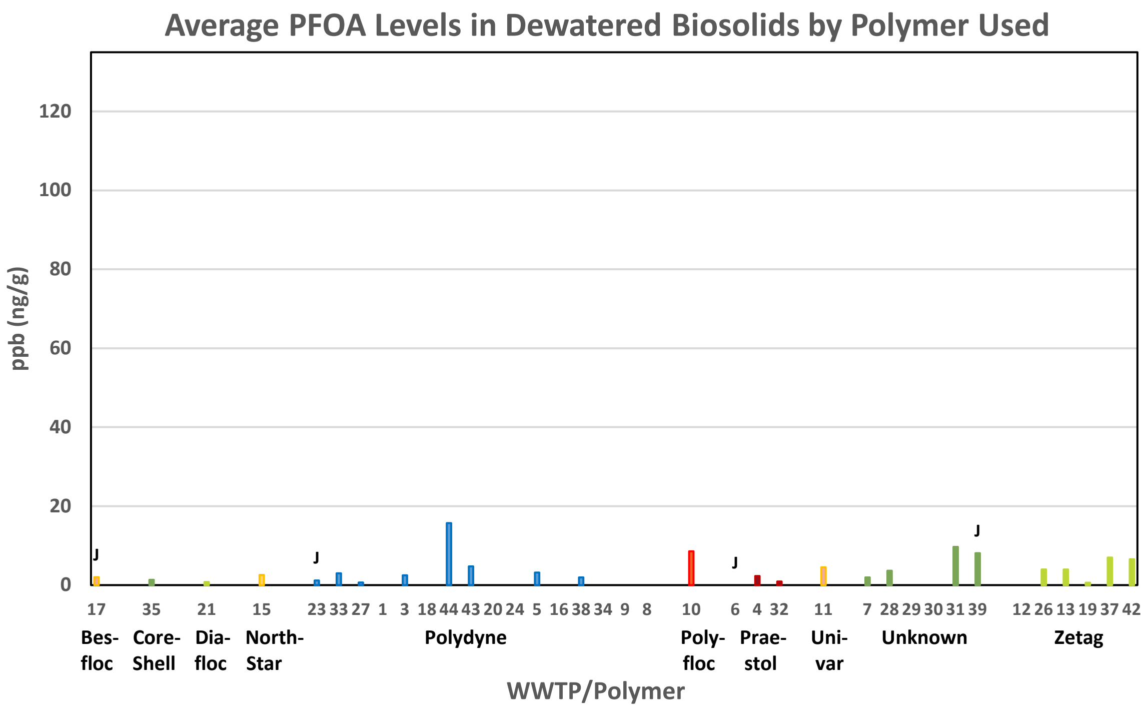


J – Indicates an estimated value

Potential for PFAS contribution from polymer

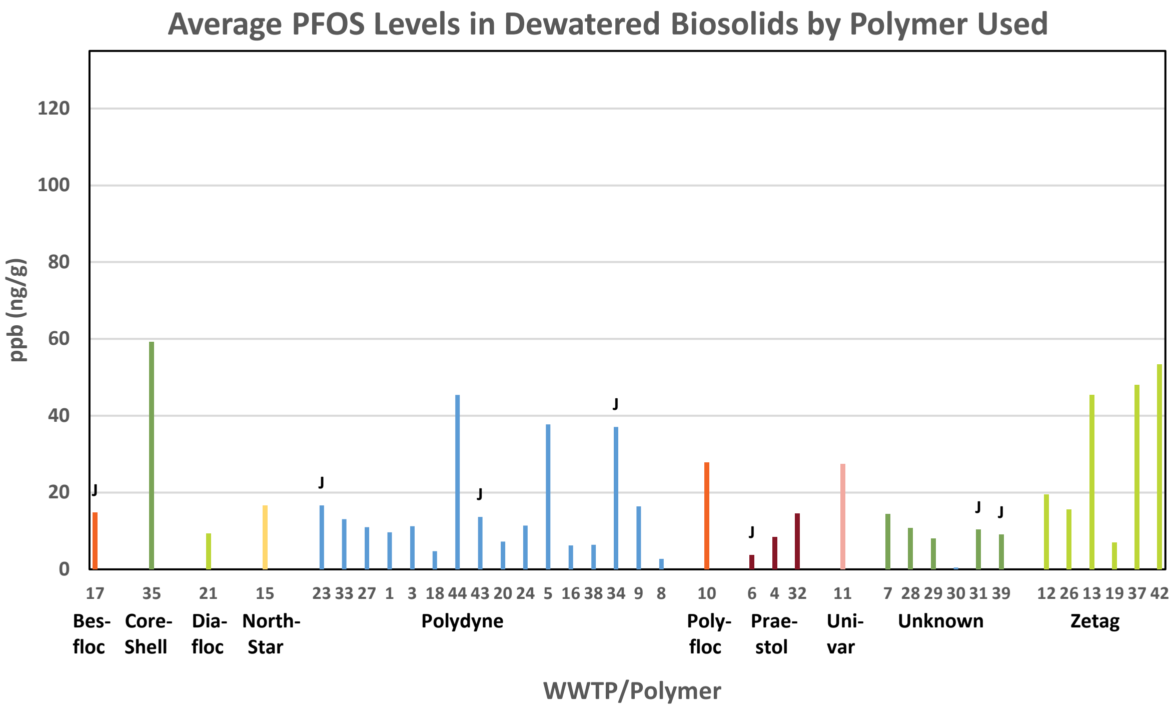
One of the most common questions Ecology staff received from participating facilities was whether the polymer they used to dewater their biosolids could be contributing PFAS chemicals to the biosolids. Due to funding limitations, Ecology did not sample polymers for PFAS at this time. Instead, Ecology documented the brand of polymer each facility used and compared facility results in Chart 5 below. We were not able to identify any relationship between the brand of polymer used and PFOA or PFOS levels.

Chart 5. Average PFOA levels in dewatered biosolids using EPA Method 1633 compared to polymer used



J – Indicates an estimated value

Chart 6. Average PFOS levels in dewatered biosolids using method 1633 compared to polymer used



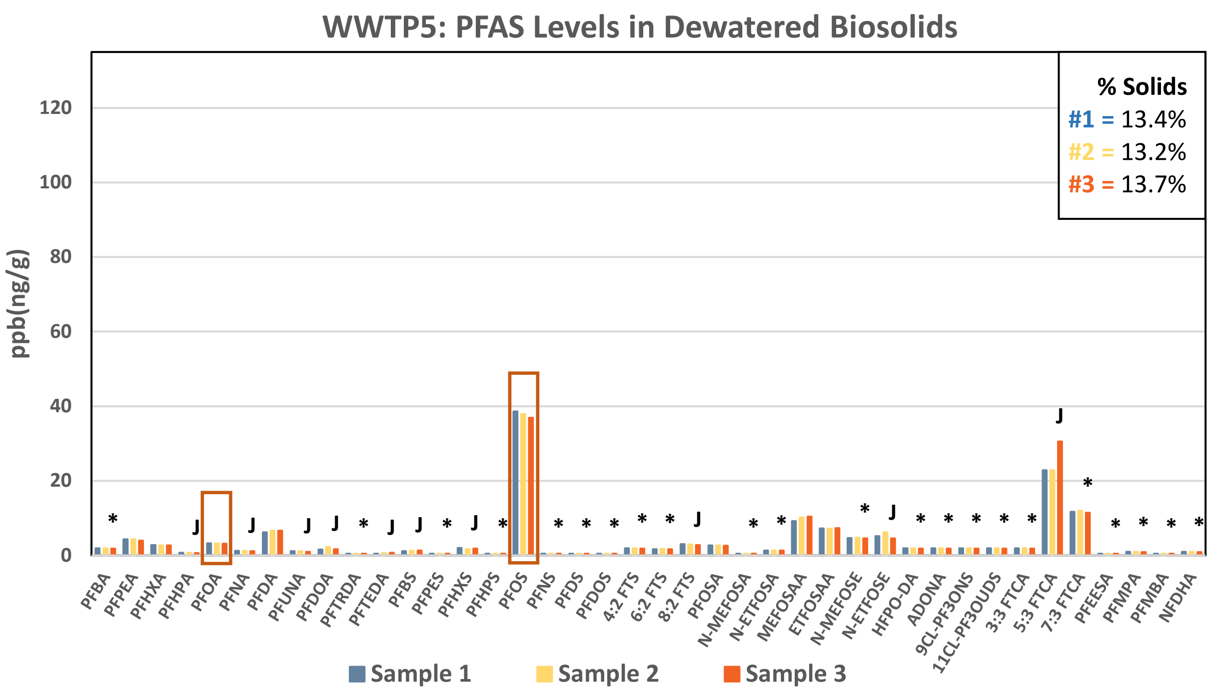
J – Indicates an estimated value

Consistency of results for dewatered biosolids

Ecology collected three samples at each WWTP from the same biosolids materials. The results of these triplicate samples were similar as evidenced by Charts 1 and 2, and the low variability across replicate samples as measured by the coefficient of variation (CV; Zar 1994 , pg. 32). Coefficient of Variance (CV) is one way of measuring consistency. It measures how much a set of samples differ from each other.

Chart 7 below depicts all PFAS results using EPA Method 1633 from WWTP5 that generates dewatered biosolids. The CV for PFOA and PFOS for WWTP 5 are both 2%. This low variability indicates consistent and reproducible results, meaning we have high certainty that the results are precise. Higher variability indicates greater uncertainty in the results. At each WWTP all triplicate samples were taken on the same day, typically within an hour of each other, so the low variation among replicates gives high confidence in these results. In the section below on liquid biosolids, Chart 9 below shows the percent variance for both liquid and dewatered biosolids.

Chart 7. PFAS levels in dewatered biosolids from WWTP 5 using EPA Method 1633



* – Indicates a Non-Detect

J – Indicates an estimated value

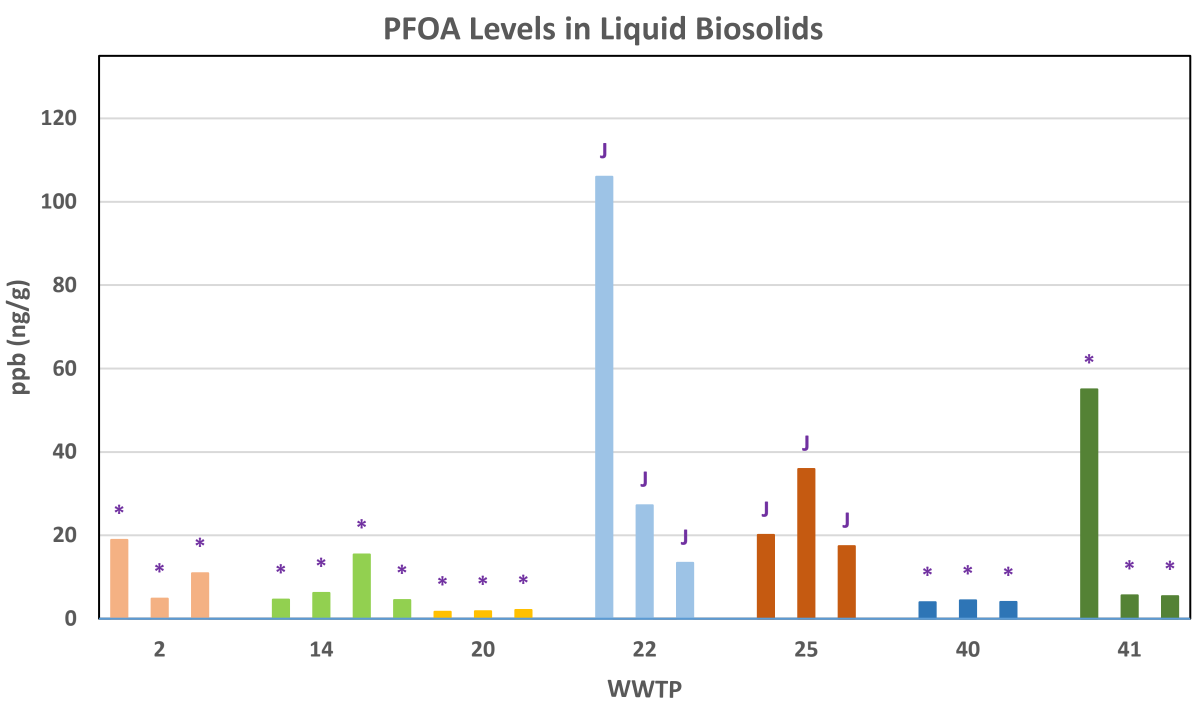
Liquid biosolids samples

Variability of results in liquid biosolids

As with the dewatered biosolids, three samples were taken at each WWTP. Ecology staff, in collaboration with WWTP staff, collected 12 grab samples from the WWTP's digester or lagoon and combined them in a clean 5-gallon bucket and stirred the materials to ensure it was a well-mixed sample. Each set of triplicate samples was collected from the bucket over the course of less than 10 minutes, stirring between samples to prevent settling, per the QAPP Addendum.

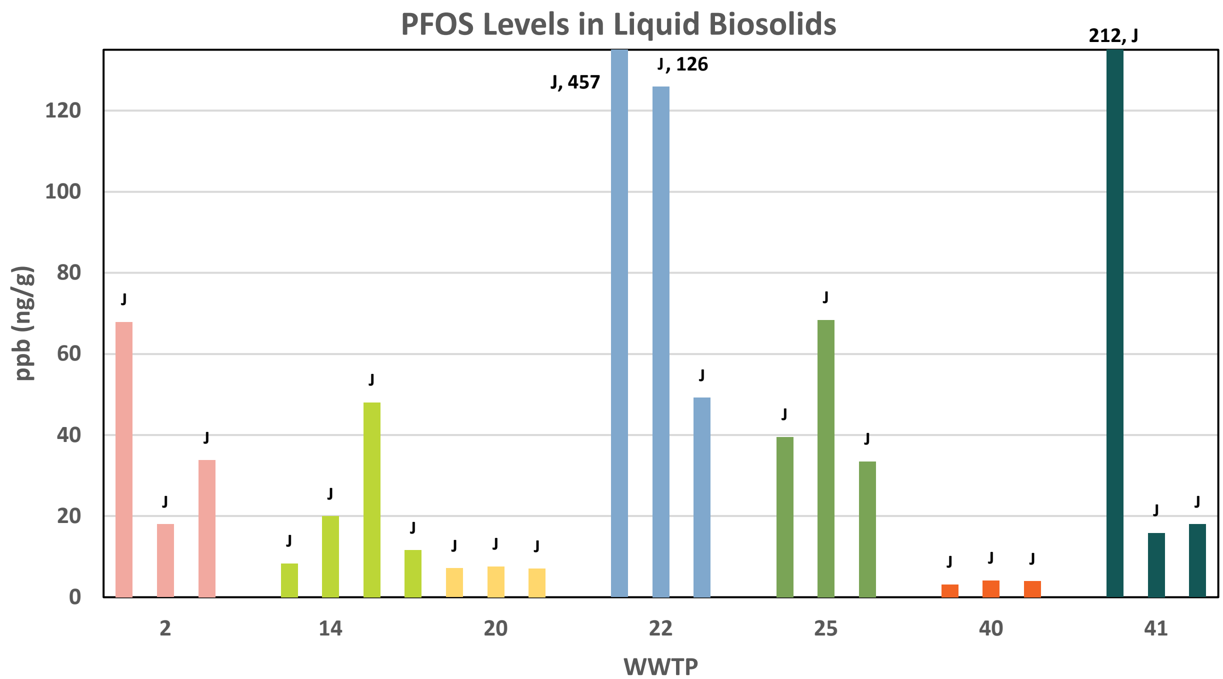
Despite how well mixed these triplicate samples were, the results at each of the 7 WWTPs with liquid biosolids were highly variable compared to the dewatered results. The average CV in liquid biosolids for PFOA was 49%, and 52% for PFOS. By comparison, the average CV for dewatered biosolids for PFOA was 8%, and 4% for PFOS. Charts 8 and 9 depict the variability of the liquid biosolids results included in this study.

Chart 8. PFOA levels in liquid biosolids from 7 WWTPs using EPA Method 1633



* – Indicates a Non-Detect
J – Indicates an estimated value
Numerical data for Chart 8 can be found in Appendix C, Table C-2

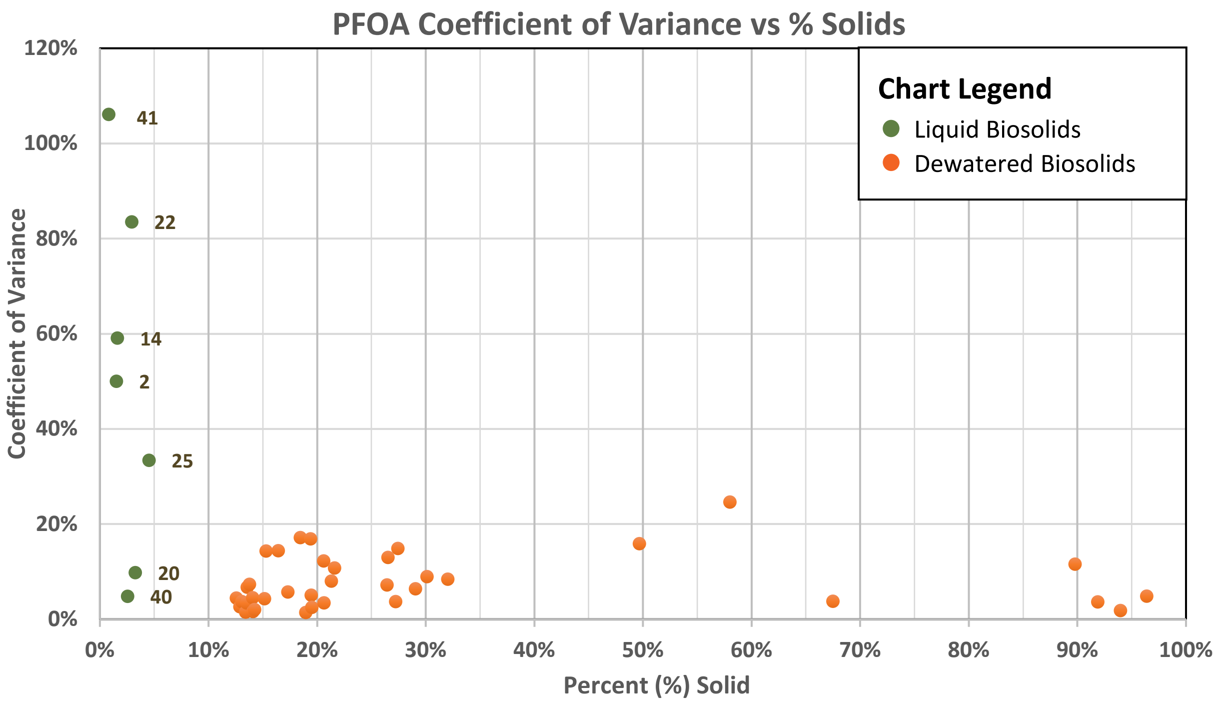
Chart 9. PFOS levels in liquid biosolids from 7 WWTPs using EPA Method 1633



J – Indicates an estimated value
Numerical data for Chart 9 can be found in Appendix C, Table C-2

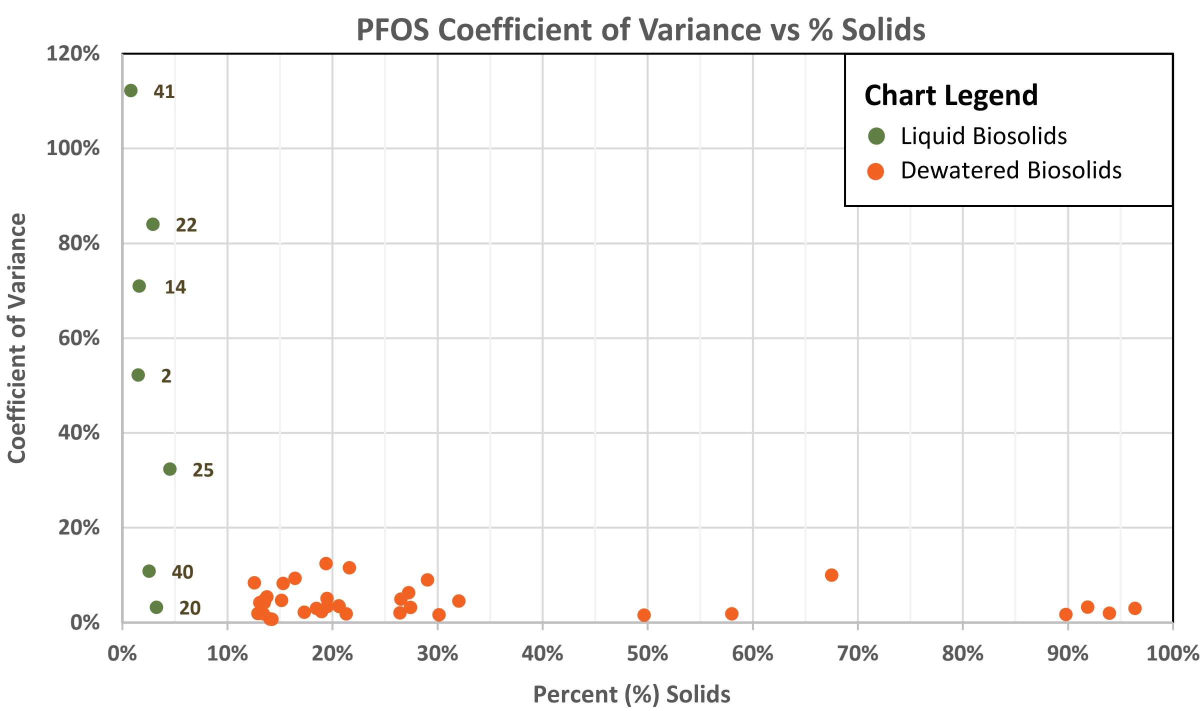
The CV for the liquid biosolids in this study ranges from 11-112%. The higher variance in these results, given that samples were taken from a representative sample, indicates that they are less precise and show greater uncertainty. Charts 10 and 11 below show the percent variance for both liquid and dewatered biosolids in comparison to the average percent solids for each WWTP.

Chart 10. PFOA coefficient of variance vs % solids in liquid and dewatered biosolids



WWTP IDs were included for the Liquid Biosolids WWTPs only.

Chart 11. PFOS coefficient of variance vs % solids in liquid and dewatered biosolids



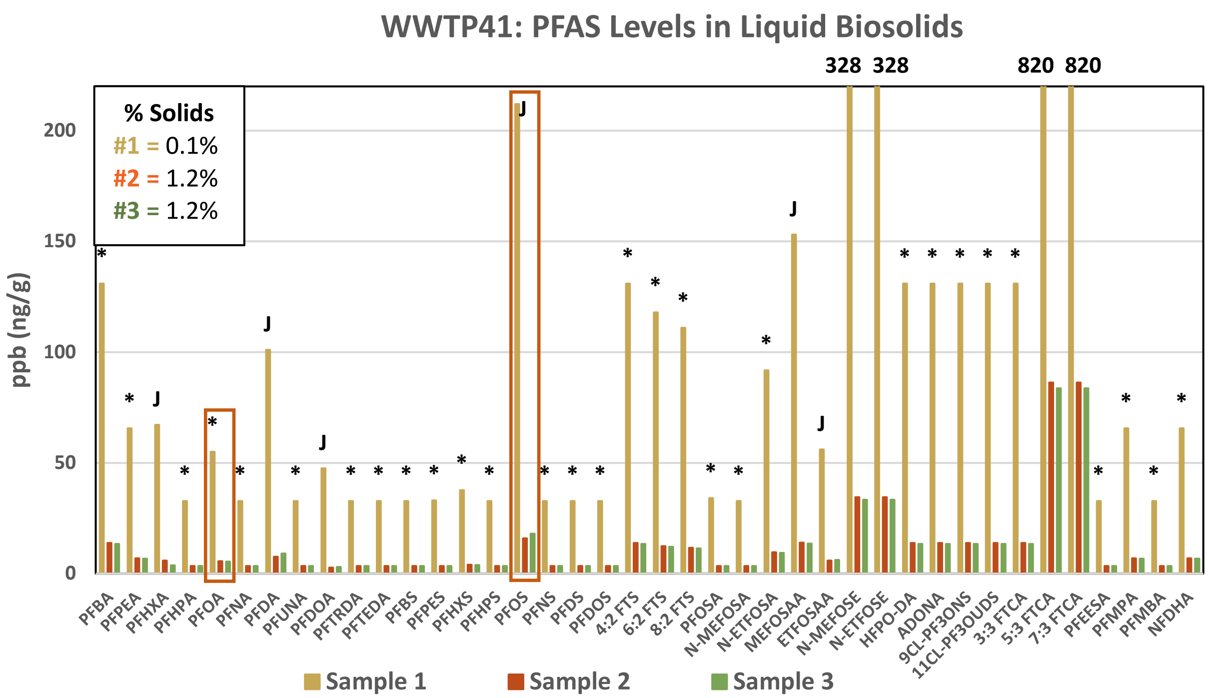
WWTP IDs were included for Liquid Biosolids WWTPs only.

Chart 12 shows the variability is proportional across every PFAS chemical, with sample one being much higher than samples two and three. This indicates the limitation is with EPA Method 1633, not a difference in the PFAS concentrations. For example, if sample one was high in PFAS, you would expect to see a few PFAS chemicals with higher results. You would not see sample one consistently 10 times higher than samples two and three across all types of PFAS as is depicted in Chart 12.

It's possible that sample collection may have been a contributing factor in these inconsistent results. The additional sampling conducted in Spring 2025 was designed to rule out possible issues with sample collection. Since conducting the second round of sampling, Ecology has learned other states have identified the same issues with variable results when sampling liquid biosolids with EPA Method 1633 and have attributed that to the analysis method. The results from this additional sampling will be released when complete as an addendum to this report.

Because of the inconsistency of these results paired with the higher coefficient of variance (CV), Ecology can't rely on these results to inform policy.

Chart 12. PFAS levels in liquid biosolids from WWTP 41 using EPA Method 1633



* Indicates non-detect
J Indicates an estimated
Please note the vertical axis of Chart 12 uses a different scale than most of the other Charts in this report for readability.

EPA Method 1633 is designed for either aqueous or solid matrices. An aqueous matrix has less than 50 mg of solids per liter of water (0.005% solids). An example of an aqueous matrix is WWTP influent or stormwater. A good example of a solid matrix is soil, something with a high solids content. The liquid biosolids we sampled in this study have a consistency like thick, soft, wet mud (<5.5% solids), which does not fit well into either of the categories. The way the analysis method is currently written does not address the difficulty in processing these liquid biosolids samples.

After discussing the results with SGS AXYS Lab and reviewing their QC protocols and Standard Operating Procedures (SOP), Ecology is confident the analysis was conducted in accordance with EPA Method 1633. Based on this, conversations with researchers, US EPA, and other state agencies, that encountered the same issue Ecology believes additional sample preparation is needed for liquid biosolids. Additional preparation would make the material more appropriate to run as either the aqueous or solid matrix using EPA Method 1633. We will discuss this further in the recommendations that follow.

Recommendations

Ecology accomplished its goals of collecting data on the levels of PFAS present in Washington biosolids and becoming more familiar with the sampling process and analysis using EPA Method 1633. We also learned about the limitation of the analysis method and gained a better understanding of potential inputs from residential and industrial dischargers of PFAS to WWTPs.

Based on the limited data collected during this study, Ecology has developed recommendations to better understand concentrations of PFAS in Washington biosolids. The efforts listed below may help inform future policy decisions. These recommendations are listed in no particular order.

- Identify a solution to ensure consistent reproducible results when analyzing liquid biosolids using EPA Method 1633
- Increase biosolids permit fees to support a growing need for research into priority toxic chemicals in biosolids
- Compile a focus sheet that provides information on levels of PFAS in consumer goods and contaminated biosolids
- Collect more data on the levels of PFAS in biosolids in Washington State

Liquid biosolids analysis

In this study, Ecology identified a limitation when analyzing liquid biosolids with less than 5% solids using EPA Method 1633. In Washington many WWTPs generate liquid biosolids. This limitation would make it difficult for them to accurately identify levels of PFAS in the biosolids they produce. SB 5033 will require WWTPs to sample their biosolids using EPA Method 1633 by 2027 and provide the results to Ecology. Because of the inconsistency of these study results paired with the higher coefficient of variance (CV), Ecology can't rely on these results to inform policy. To collect meaningful data that can inform future decisions, we need to identify a solution to the limitation of using EPA Method 1633 for liquid biosolids for PFAS.

In trying to find a solution, Ecology consulted with other states, researchers, and the EPA. During these conversations several possible solutions surfaced, all of which were additional sample preparation processes. See Table 4 below for details.

While EPA is aware of this limitation, Ecology is unsure whether they will make amendments to the analysis method prior to the sampling required by SB 5033. In lieu of an updated method from the EPA, Ecology needs to identify appropriate sampling preparation for liquid biosolids. The preparation options below are being considered for inclusion in the sampling guidance SB 5033 has directed Ecology to develop.

Table 4. Liquid biosolids sample preparation options prior to running EPA Method 1633

Preparation Process	Pros	Cons	Location
Additional replicates	Will provide additional data	Very expensive. Number of replicates needed is unknown.	WWTP
Centrifugation	Most labs have this capability	Requires paying for two analyses for each sample, the liquid portion and the dewatered solids.	Lab
Bucket scale dewatering	Does not require lab to do additional processes	Requires paying for two analyses for each sample, the liquid portion and the dewatered solids. Unknown if this will dry solids portion effectively.	WWTP
Freeze drying	Produces a completely dry sample appropriate for analysis	Very expensive. Most labs don't have this capability	Lab or third party

Additional replicates

This process is conducted at the WWTP. Collecting additional replicates for analysis would generate more data to draw conclusions from. It is unknown how many replicates are needed to produce an accurate representation of the levels of PFAS in the biosolids.

Centrifugation

This process is conducted in a laboratory. Centrifugation uses centripetal force generated by spinning to separate liquids from solids in a sample. Once the sample is separated into liquid and solid portions, analysis is conducted on each using EPA Method 1633 for aqueous and solid matrices respectively. The results are combined to produce totals for each PFAS chemical in the sample.

Bucket scale dewatering

This process is conducted at the WWTP. Bucket scale dewatering uses a polymer to separate liquids from solids on a small scale, typically done in a clean bucket. Once the sample is separated into liquid and solid portions, analysis is conducted on each using EPA Method 1633 for aqueous and solid matrices respectively. The results are combined to produce totals for each PFAS chemical present in the sample.

Freeze drying

This process is conducted in a laboratory or third party. Freeze drying removes all the liquid from a sample. Depending on the sample size and percent solids content, it may take several hours to several days to completely dry a sample. Once the sample is dry analysis is conducted using EPA Method 1633 for solids matrices.

Increase program fees

Ecology’s biosolids program is supported by permit fees established under the Biosolids Management rule (WAC 173-308-320) for facilities subject to the Biosolids General Permit. These permit revenues fund the implementation of the biosolids program including staff that provide permit oversight, technical assistance, and enforcement of the rule.

Permit fees also funded this sampling study. This sampling study was the first of its kind for Ecology’s biosolids program. The program would like to conduct similar projects like this one in the future.

The rule dictates that permit fees will be adjusted by the annual fiscal growth factor. Ecology has exercised a biosolids permit fee increase only 5 times since establishing the permit fee structure in 1997. Due to an increased need for research into priority toxic chemicals like PFAS, biosolids staff responsibilities have grown and the biosolids program budget has not increased adequately over the last 10 years to meet today’s needs. Ecology recommends increasing the biosolids permit fees as dictated by the rule annually to support these necessary efforts.

PFAS in consumer goods and biosolids focus sheet

The general public is potentially exposed to PFAS from a number of sources. This may include primary exposure from consumer products like textiles treated with stain-resistant compounds and personal care products, and potential secondary exposure from contaminated biosolids. Ecology will work to compile a focus sheet describing relative levels of PFAS in consumer goods and biosolids that would help to communicate potential for exposure to the public.

Collect additional data

Even though the sample size of this study was small (44 out of a total 375 WWTPs in Washington), and it was only a one-time sampling event, it provided Ecology with some insights into PFAS levels in Washington biosolids. In an effort to collect data that is representative of biosolids being generated in the state, a variety of WWTP sizes, types, and locations were included in this study. The participating WWTPs included larger facilities with more industrial inputs as well as very small facilities without any known industrial inputs. The results support Ecology’s hypothesis that the levels of PFAS in Washington biosolids would be lower than in states with industries manufacturing PFAS.

Additional data is needed both in frequency and location to inform future policy decisions. Ecology recommends collecting more data on the levels of PFAS in biosolids generated in Washington State. The 2025 passage of SB 5033 will help generate more data by requiring WWTPs to sample for PFAS.

Source reduction and control remain the most effective approach to reduce human and environmental exposure to PFAS from biosolids. Additional data generated by SB 5033 will inform WWTPs and Ecology when there is a need to look at upstream dischargers and work to decrease the amount of PFAS chemicals making their way to WWTPs and biosolids.

Additional Study Data

Ecology collected a wide variety of data during this sampling study using multiple analysis methods. This report is primarily focused on concentrations of PFOS and PFOA using EPA Method 1633. Additional data can be found online: PFAS 1633 Report Data, PFAS EOF Report Data, PFAS TOP Report Data.

References

Brusseau, Anderson, Guo, 2020. PFAS concentrations in soils: Background levels versus contaminated sites. https://guolab.arizona.edu/pdfs/publications/2020_Brusseau_et_al_PFAS_in_Soil_STE.pdf

Colorado CDPHE, 2025. Colorado Biosolids-Interim Strategy, Colorado Department of Public Health and Environment. Revised 2025. https://drive.google.com/file/d/1bZk4wBZ8AK3nDTSQFVi4R1R7KO4L2Fk6/view

Ecology, 2007. Chapter 173-308 WAC Biosolids Management. https://apps.leg.wa.gov/WAC/default.aspx?cite=173-308&full=true

Ecology, 2018. PFAS in Washington State Products, 2018. https://apps.ecology.wa.gov/publications/documents/2303007.pdf

Ecology, 2022. Per- and Polyfluoroalkyl Substances Chemical Action Plan. https://apps.ecology.wa.gov/publications/documents/2104048.pdf

Ecology, 2024. Quality Assurance Program Plan- Assessment of PFAS in Biosolids in Washington, https://apps.ecology.wa.gov/publications/SummaryPages/2407040.html

Ecology, 2024. State Environmental Policy Act Checklist for the General Permit for Biosolids Management, https://apps.ecology.wa.gov/separ/Main/SEPA/Record.aspx?SEPANumber=202404276

Ecology, 2025. QAPP Addendum – PFAS in Biosolids, https://apps.ecology.wa.gov/publications/SummaryPages/2507048.html

Ecology, 2025. Statewide general Permit for Biosolids management. https://apps.ecology.wa.gov/publications/SummaryPages/2507001.html

Ecology. Environmental Information Management-Data Qualifier Code. https://apps.ecology.wa.gov/eim/help/ValidValues/DataQualifiers

Ecology. Toxics in firefighting law. https://ecykenpub/waste-toxics/reducing-toxic-chemicals/washingtons-toxics-in-products-laws/toxics-in-firefighting

EPA, 2025. Draft Sewage Sludge Risk Assessment for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS). https://www.epa.gov/system/files/documents/2025-01/draft-sewage-sludge-risk-assessment-pfoa-pfos.pdf

EPA, 2025. Comments on the Draft Sewage Sludge Risk Assessment: Perfluorooctanoic Acid and Perfluorooctane Sulfonic Acid. https://www.regulations.gov/document/EPA-HQ-OW-2024-0504-0001/comment

EPA, 1994. Part 503-Standard for the Use or Disposal of Sewage Sludge. https://www.govinfo.gov/content/pkg/CFR-2018-title40-vol32/xml/CFR-2018-title40-vol32-part503.xml

EPA, 2024. Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Soil, Biosolids, and Tissue Samples by LC-MS/MS. https://www.epa.gov/system/files/documents/2024-12/method-1633a-december-5-2024-508-compliant.pdf

MEL, 2008. Manchester Environmental Laboratory Lab User's Manual, Ninth Edition. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

MEL, 2016. Manchester Environmental Laboratory Quality Assurance Manual. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

Michigan EGLE, 2018. MDEQ PFAS Sampling Quick Reference Field Guide. https://www.michigan.gov/pfasresponse/-/media/Project/Websites/PFAS-Response/Sampling-Guidance/Quick-Reference-Field-Guide.pdf

Michigan EGLE, 2022. Biosolids and Sludge PFAS Sampling Guidance. Revised April 2022. https://www.michigan.gov/pfasresponse/-/media/Project/Websites/PFAS-Response/Sampling-Guidance/Biosolids.pdf

Michigan EGLE, 2024. Interim strategy requirements: land application of biosolids containing PFAS. Revised January 2024. https://www.michigan.gov/egle/about/organization/water-resources/biosolids/pfas-related/interim-strategy

Michigan EGLE, 2024. Michigan Biosolids PFAS related information and links. Revised April 2024. https://www.michigan.gov/egle/about/organization/water-resources/biosolids/pfas-related

Appendix A. Facility Characteristics

Table A-1. Sample Collection Schedule and Location Description

Facility	Collection Date	Treatment Details	Dewatering Process	Sample Type	Polymer Used	Sample Type	Solid (%)
WWTP 1	5/20/2024	WAS, Anaerobic Digestion	Centrifuge	Biosolids	Polydyne	Dewatered	21.3
WWTP 2	4/30/2024	Lagoon, Evaporation	Lagoon	Biosolids	NA	Liquid	1.5
WWTP 3	5/24/2024	WAS, Anaerobic Digestion	Centrifuge	Biosolids	Polydyne	Dewatered	26.3
WWTP 4	5/21/2024	WAS, Heat Drying	NA	Biosolids	Praestol	Dewatered	96.4
WWTP 5	5/3/2024	WAS, Aerobic Digestion	Rotary Fan Press	Biosolids	Polydyne	Dewatered	13.4
WWTP 6	5/23/2024	Trickling Filter, Anaerobic Digestion	Rotary Fan Press	Biosolids	Praestol	Dewatered	20.6
WWTP 7	5/21/2024	MBBR	Centrifuge	Biosolids	Unknown	Dewatered	19.5
WWTP 8	5/23/2024	WAS, Anaerobic Digestion	Screw Press	Biosolids	Polydyne	Dewatered	13.8
WWTP 9	5/20/2024	WAS, Anaerobic Digestion	Centrifuge	Biosolids	Polydyne	Dewatered	27.4
WWTP 10	5/3/2024	Composting	Belt Press	Biosolids	Polyfloc	Dewatered	12.9
WWTP 11	4/30/2024	WAS, Heat Drying	Centrifuge	Biosolids	Univar	Dewatered	94
WWTP 12	4/29/2024	WAS, Heat Drying	Belt Press	Biosolids	Zetag	Dewatered	12.6
WWTP 13	5/1/2024	WAS	Screw Press	Biosolids	Zetag	Dewatered	16.4
WWTP 14	4/29/2024	Lagoon	Lagoon	Biosolids	NA	Liquid	1.6
WWTP 15	5/2/2024	Anaerobic Digestion	Centrifuge	Biosolids	Northstar	Dewatered	17.3
WWTP 16	5/2/2024	WAS, Incineration	Belt Press	Sludge	Polydyne	Dewatered	26.4
WWTP 17	7/4/2024	WAS, Aerobic Digestion	Screw Press	Biosolids	Besfloc	Dewatered	26.5
WWTP 18	7/6/2024	Primary treatment, Incineration	Gravity Belt/ Centrifuge	Sludge	Polydyne	Dewatered	27.2

Facility	Collection Date	Treatment Details	Dewatering Process	Sample Type	Polymer Used	Sample Type	Solid (%)
WWTP 19	7/5/2024	WAS, Lime	Belt Press	Biosolids	Zetag	Dewatered	29.1
WWTP 20	5/22/2024	WAS	Gravity Belt	Biosolids	Polydyne	Liquid	3.3
WWTP 21	5/22/2024	WAS, Anaerobic Digestion	Centrifuge	Biosolids	Diafloc	Dewatered	19
WWTP 22	7/5/2024	WAS, Aerobic Digestion	Membrane Thickener	Biosolids	NA	Liquid	2.9
WWTP 23	7/4/2024	WAS, Anaerobic Digestion	Heat Dryer	Biosolids	Polydyne	Dewatered	91.9
WWTP 24	6/7/2024	WAS, Anaerobic Digestion	Belt Press	Biosolids	Polydyne	Dewatered	15.2
WWTP 25	5/24/2024	WAS, Aerobic Digestion	NA	Biosolids	NA	Liquid	4.5
WWTP 26	7/3/2024	Oxidation Ditch, Aerobic Digestion	Belt Press	Biosolids	Zetag	Dewatered	13.1
WWTP 27	7/3/2024	WAS, Anaerobic Digestion	Screw Press	Biosolids	Polydyne	Dewatered	18.5
WWTP 28	4/16/2024	WAS, Drying Beds	Gravity Belt	Biosolids	Unknown	Dewatered	49.7
WWTP 29	4/17/2024	WAS, Anaerobic Digestion	Centrifuge	Biosolids	Unknown	Dewatered	19.5
WWTP 30	4/17/2024	Drying Beds	Belt Press	Biosolids	Unknown	Dewatered	67.5
WWTP 31	4/15/2024	WAS, Aerobic Digestion	Belt press	Biosolids	Unknown	Dewatered	14.1
WWTP 32	5/29/2024	WAS, Anaerobic Digestion	Belt press	Biosolids	Praestol	Dewatered	13.5
WWTP 33	4/18/2024	WAS, Aerobic Digestion, Drying Beds	Centrifuge	Biosolids	Polydyne	Dewatered	19.4
WWTP 34	5/6/2024	WAS, Anaerobic Digestion	Belt Press	Biosolids	Polydyne	Dewatered	15.3
WWTP 35	5/14/2024	WAS, Sludge Storage Tank	Belt press	Sludge	Coreshell	Dewatered	14.1
WWTP 36	5/6/2024	WAS, Composting	Belt Press	Biosolids	Zetag	Dewatered	13.6

Facility	Collection Date	Treatment Details	Dewatering Process	Sample Type	Polymer Used	Sample Type	Solid (%)
WWTP 37	5/28/2024	WAS, Aerobic Digestion	Belt Press	Biosolids	Zetag	Dewatered	20.6
WWTP 38	5/15/2024	WAS, Anaerobic Digestion	Rotary Drum Thickener	Biosolids	Polydyne	Dewatered	89.8
WWTP 39	4/15/2024	WAS, Thermophilic Aerobic Digestion	Centrifuge	Biosolids	Unknown	Dewatered	21.6
WWTP 40	7/5/2024	WAS, Aerobic Digestion	Dissolved Air Rotation	Sludge	Zetag	Liquid	2.6
WWTP 41	4/16/2024	Lagoon, Evaporation	NA	Biosolids	NA	Liquid	0.8
WWTP 42	5/15/2024	WAS, Old Pump	Bag	Sludge	Zetag	Dewatered	32
WWTP 43	5/14/2024	WAS, Decant	Belt press	Sludge	Polydyne	Dewatered	14.2
WWTP 44	5/28/2024	WAS, Drying Beds	Belt press	Biosolids	Polydyne	Dewatered	58

Appendix B. Other States' Interim Plans

Table B-1. Minnesota PFAS Interim Strategy for Biosolids

Chemical	Threshold	Grouping	Requirements
PFOA, PFOS	<19 ppb	Individual	No additional requirements.
PFOA, PFOS	20 – 49 ppb	Individual	Track cumulative land application & notify MCPA and farmer.
PFOA, PFOS	50 - 124 ppb	Individual	Source reduction implementation & land application rate reduction to 1.5 dry tons per acre.
PFOA, PFOS	>125 ppb	Individual	No land application allowed & source reduction plan.

Table B-2. Wisconsin PFAS Interim Strategy for Biosolids

Chemical	Threshold	Grouping	Requirements
PFOA + PFOS	<20 ppb	Sum	No additional requirements.
PFOA + PFOS	20 – 50 ppb	Sum	Source investigation and reduction plan & Track application rate & notify farmer and DNR.
PFOA + PFOS	50 - 150 ppb	Sum	Notify DNR & farmer. Source reduction plan & Land application rate reduction to 1.5 dry tons per acre. Track cumulative application rate & report to DNR.
PFOA + PFOS	>150 ppb	Sum	No land application allowed & source reduction plan.

Table B-3. New York PFAS Interim Strategy for Biosolids

Chemical	Threshold	Grouping	Requirements
PFOA, PFOS	<20 ppb	Individual	No additional requirements.
PFOA, PFOS	20 – 50 ppb	Individual	Additional sampling required & recycling restriction steps if it does not lower to below 20 ppb within one year.
PFOA, PFOS	>50 ppb	Individual	Recycling prohibition taken.

Table B-4. Maryland PFAS Interim Strategy for Biosolids

Chemical	Threshold	Grouping	Requirements
PFOA, PFOS	<20 ppb	Individual	No additional requirements.
PFOA, PFOS	20 – 50 ppb	Individual	Source reduction implementation & land application rate reduction to 3 dry tons per acre.
PFOA, PFOS	50 - 100 ppb	Individual	Source reduction implementation & land application rate reduction to 1.5 dry tons per acre.
PFOA, PFOS	>100 ppb	Individual	No land application allowed & source reduction plan.

Appendix C. Additional Sampling Results

Ecology collected a wide variety of data during this sampling study using multiple analysis methods. This report is primarily focused on concentrations of PFOS and PFOA using EPA Method 1633. Below is the data used in producing this paper. Additional data from EPA Method 1633 and other analysis methods can be found at PFAS 1633 Report Data, PFAS EOF Report Data, PFAS TOP Report Data

EPA Method 1633

Table C-1. PFOA and PFOS data using EPA Method 1633 for dewatered biosolids

†Indicates results above 20 ppb PFOA or PFOS.

Facility ID	Sample ID	PFOA (ppb)	PFOS (ppb)	%Solid
WWTP 1	2405046-01	1.3*	9.9	21.0
WWTP 1	2405046-02	1.1*	9.4	21.2
WWTP 1	2405046-03	1.1*	9.6	21.7
WWTP 3	2405046-41	2.6	11.5	25.9
WWTP 3	2405046-41 (Dup)	2.9	11.0	26.3
WWTP 3	2405046-42	2.3	11.3	26.4
WWTP 3	2405046-43	2.4	11.4	26.4
WWTP 4	2405046-16	2.4	8.5	96.0
WWTP 4	2405046-17	2.2	8.1	96.3
WWTP 4	2405046-18	2.4	8.7	96.9
WWTP 5	2405043-41	3.2	38.6†	13.4
WWTP 5	2405043-42	3.2	37.9†	13.2
WWTP 5	2405043-43	3.1	36.9†	13.7
WWTP 6	2405046-31	0.5*	3.7	19.3
WWTP 6	2405046-32	0.3*	3.9	20.2
WWTP 6	2405046-33	0.4*	3.7	22.3
WWTP 7	2405046-11	2.0	15.0	19.9
WWTP 7	2405046-12	2.0	14.4	19.1
WWTP 7	2405046-13	1.9	13.8	19.5
WWTP 8	2405046-36	0.7*	2.5	13.9
WWTP 8	2405046-37	0.7*	2.9	14.4
WWTP 8	2405046-38	0.8*	2.7	13.0
WWTP 9	2405046-06	1.2*	15.7	27.8
WWTP 9	2405046-07	1.7*	16.9	27.2
WWTP 9	2405046-08	1.7*	16.7	27.3
WWTP 10	2405043-36	8.9	28.4†	12.8
WWTP 10	2405043-37	8.5	27.9†	12.7
WWTP 10	2405043-38	8.3	27.1†	13.2
WWTP 11	2405043-11	4.6	27.6†	92.5

Facility ID	Sample ID	PFOA (ppb)	PFOS (ppb)	%Solid
WWTP 11	2405043-12	4.4	28.0†	93.9
WWTP 11	2405043-13	4.6	26.7†	95.4
WWTP 12	2405043-01	1.0*	21.4†	11.7
WWTP 12	2405043-02	0.9*	19.7	12.5
WWTP 12	2405043-03	0.9*	17.4	13.5
WWTP 13	2405043-21	3.2	39.6†	18.7
WWTP 13	2405043-22	4.3	48.3†	15.0
WWTP 13	2405043-23	4.5	49.0†	15.6
WWTP 15	2405043-26	2.8	16.1	17.7
WWTP 15	2405043-27	2.4	17.0	17.6
WWTP 15	2405043-28	2.6	16.6	16.6
WWTP 16	2405043-31	0.7*	6.0	26.7
WWTP 16	2405043-32	0.6*	6.4	26.8
WWTP 16	2405043-33	0.6*	6.2	25.8
WWTP 17	2406043-11	1.9	14.3	26.6
WWTP 17	2406043-11 (Dup)	2.1	15.8	26.5
WWTP 17	2406043-12	2.5	13.9	26.4
WWTP 17	2406043-13	1.8	15.1	26.6
WWTP 18	2406043-36	0.6*	5.0	26.6
WWTP 18	2406043-37	0.7*	4.9	26.6
WWTP 18	2406043-38	0.7*	4.3	28.5
WWTP 19	2406043-21	0.6	6.4	30.2
WWTP 19	2406043-22	0.6	6.3	30.1
WWTP 19	2406043-23	0.7*	7.6	27.8
WWTP 19	2406043-23 (Dup)	0.7*	7.6	28.1
WWTP 21	2405046-21	0.8	9.5	18.9
WWTP 21	2405046-22	0.8	9.0	19.1
WWTP 21	2405046-23	0.8	9.5	18.9
WWTP 23	2406043-16	1.2	16.1	92.2
WWTP 23	2406043-17	1.2	17.4	92.3
WWTP 23	2406043-18	1.1	16.5	91.2
WWTP 24	2406043-41	0.8*	11.5	14.4
WWTP 24	2406043-42	0.8*	10.7	16.0
WWTP 24	2406043-43	0.9*	12.0	15.1
WWTP 26	2406043-01	3.8	14.7	13.4
WWTP 26	2406043-02	3.9	15.7	13.2
WWTP 26	2406043-03	4.2	16.3	12.6
WWTP 27	2406043-06	0.8	10.5	17.1
WWTP 27	2406043-07	0.6	11.2	18.9
WWTP 27	2406043-08	0.6	11.2	19.4
WWTP 28	2404052-11	2.9	11.0	79.4

Facility ID	Sample ID	PFOA (ppb)	PFOS (ppb)	%Solid
WWTP 28	2404052-12	4.1	10.6	31.8
WWTP 28	2404052-13	4.1	10.7	37.8
WWTP 29	2404052-26	0.8*	8.4	18.7
WWTP 29	2404052-27	0.7*	8.1	19.3
WWTP 29	2404052-28	0.7*	7.5	20.4
WWTP 30	2404052-21	0.9*	0.5	63.2
WWTP 30	2404052-22	0.8*	0.5	69.8
WWTP 30	2404052-23	0.9*	0.4	69.5
WWTP 31	2404052-01	9.7	10.2	13.9
WWTP 31	2404052-02	9.9	10.4	13.9
WWTP 31	2404052-03	9.5	10.3	14.5
WWTP 32	2405059-11	1.0	15.3	13.0
WWTP 32	2405059-12	0.9	13.8	13.2
WWTP 32	2405059-13	0.9	14.4	14.3
WWTP 33	2404052-31	3.1	13.6	19.1
WWTP 33	2404052-31 (Dup)	3.2	13.5	18.0
WWTP 33	2404052-32	3.7	15.0	20.8
WWTP 33	2404052-33	2.3	10.5	19.7
WWTP 34	2405044-01	0.7*	34.0†	16.1
WWTP 34	2405044-02	1.0*	36.3†	15.8
WWTP 34	2405044-03	1.0*	41.4†	14.0
WWTP 35	2405045-01	1.4	58.6†	13.9
WWTP 35	2405045-02	1.4	59.5†	14.0
WWTP 35	2405045-03	1.3	59.7†	14.3
WWTP 36	2405044-06	2.7	31.6†	13.1
WWTP 36	2405044-07	2.4	29.3†	13.6
WWTP 36	2405044-07 (Dup)	2.6	32.3†	13.2
WWTP 36	2405044-08	2.3	28.8†	14.3
WWTP 37	2405059-01	7.1	47.8†	20.3
WWTP 37	2405059-02	7.3	50.1†	19.5
WWTP 37	2405059-03	6.7	46.1†	22.1
WWTP 38	2405045-16	2.0	6.5	89.2
WWTP 38	2405045-17	1.7	6.3	89.9
WWTP 38	2405045-18	2.3	6.5	90.3
WWTP 39	2404052-06	6.9	7.6	19.2
WWTP 39	2404052-07	8.7	9.7	23.0
WWTP 39	2404052-08	8.9	9.9	22.6
WWTP 42	2405045-11	7.4	56.9†	26.4
WWTP 42	2405045-12	6.2	51.5†	32.3
WWTP 42	2405045-13	6.2	51.9†	37.4
WWTP 43	2405045-06	4.7	13.6	14.5

Facility ID	Sample ID	PFOA (ppb)	PFOS (ppb)	%Solid
WWTP 43	2405045-07	4.9	13.8	14.3
WWTP 43	2405045-08	4.7	13.6	13.9
WWTP 44	2405059-06	9.4	44.9†	53.7
WWTP 44	2405059-07	18.6	44.3†	70.0
WWTP 44	2405059-08	19.0	46.3†	53.8
WWTP 44	2405059-08 (Dup)	18.4	46.2†	54.5

†Indicates results above 20 ppb PFOA or PFOS.

All other method 1633 data can be viewed at PFAS 1633 Report Data, PFAS EOF Report Data, and PFAS TOP Report Data

Table C-2. PFOA and PFOS data using EPA Method 1633 for liquid biosolids

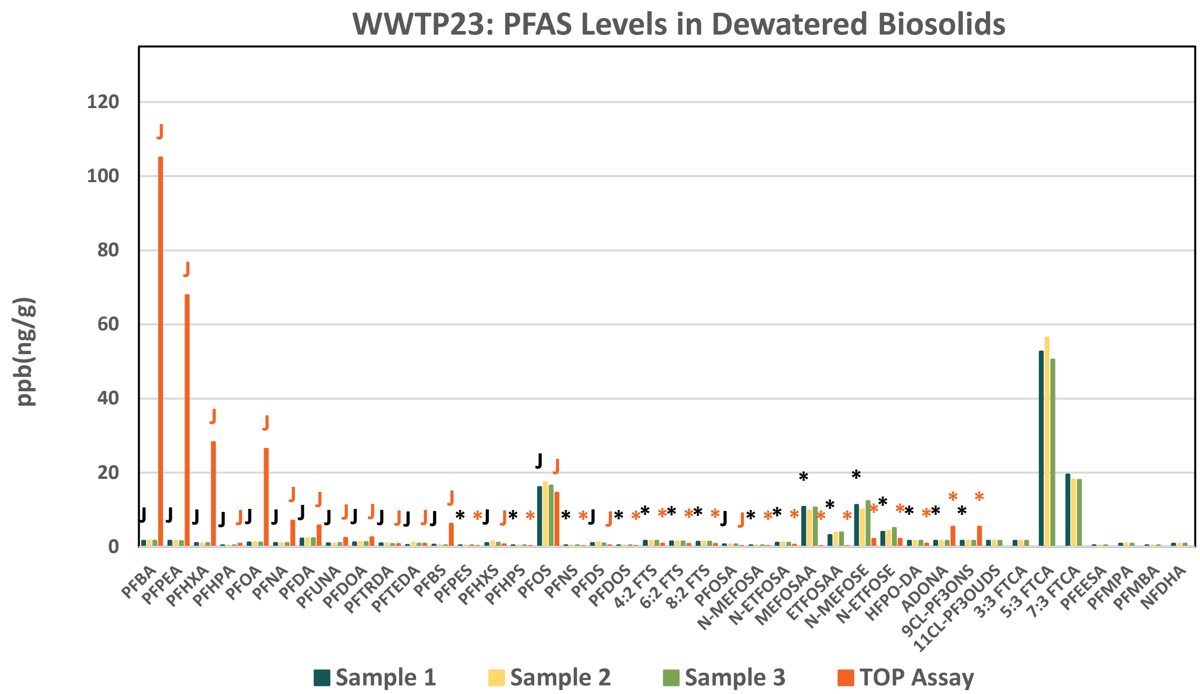
See Results and Discussion section for liquid biosolids data quality issues.

† Indicates results above 20 ppb PFOA or PFOS.

Facility ID	Sample ID	PFOA	PFOS	%Solid
WWTP2	2405043-16	18.9*	67.9†	0.7
WWTP2	2405043-17	4.8*	18.0	2.7
WWTP2	2405043-18	10.9*	33.8†	1.2
WWTP14	2405043-06	4.6*	8.4	1.8
WWTP14	2405043-06 (Dup)	6.2*	20.0	1.8
WWTP14	2405043-07	15.4*	48.0†	0.6
WWTP14	2405043-08	4.5*	11.6	2.3
WWTP20	2405046-26	1.7*	7.2	3.3
WWTP20	2405046-27	1.8*	7.6	3.4
WWTP20	2405046-28	2.1*	7.0	3.1
WWTP22	2406043-26	106.0†	457.0†	1.4
WWTP22	2406043-27	27.2†	126.0†	5.5
WWTP22	2406043-28	13.4	49.2†	1.9
WWTP25	2405046-46	20.1†	39.5†	5.1
WWTP25	2405046-47	35.9†	68.4†	3.0
WWTP25	2405046-48	17.4	33.5†	5.5
WWTP40	2406043-31	3.9*	3.2	3.0
WWTP40	2406043-32	4.4*	4.1	2.3
WWTP40	2406043-33	4.0*	4.0	2.4
WWTP41	2404052-16	55.0*	212.0†	0.1
WWTP41	2404052-17	5.6*	15.9	1.2
WWTP41	2404052-18	5.4*	18.0	1.2

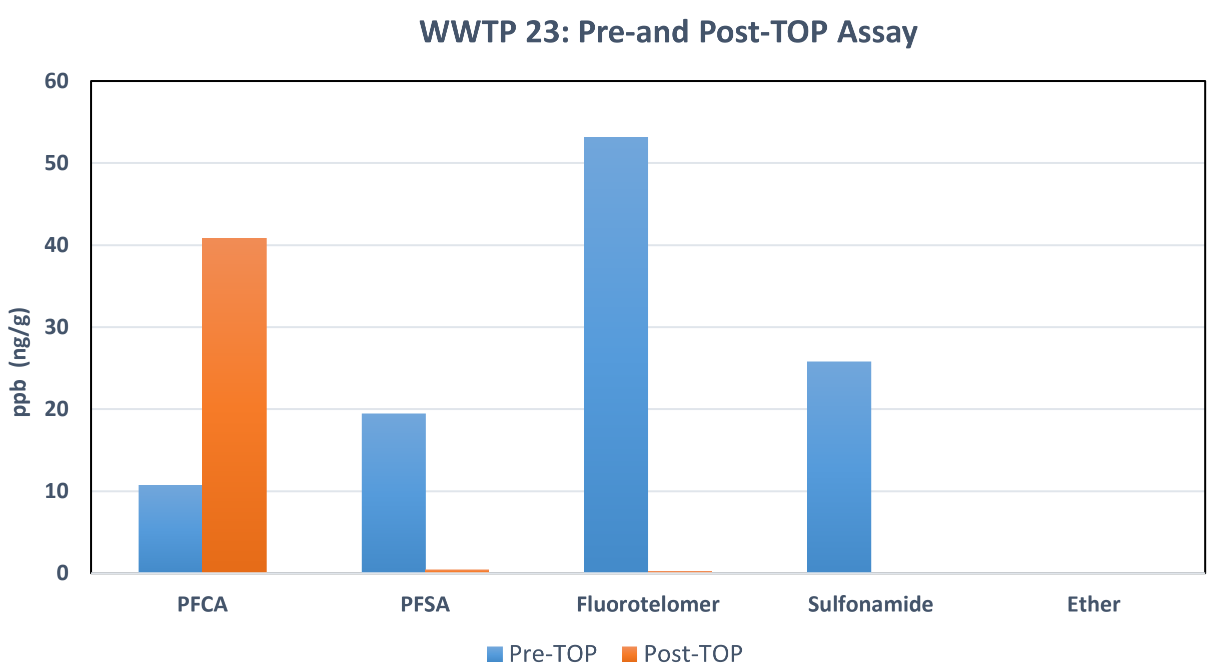
Total Oxidazible Precursor (TOP) Assay

Chart C-1. Comparing dewatered biosolids results for WWTP 23 using EPA method 1633 vs TOP Assay



* – Indicates a Non-Detect
J – Indicates an estimated value

Chart C-2. Pre-TOP and Post-TOP data results for WWTP 23



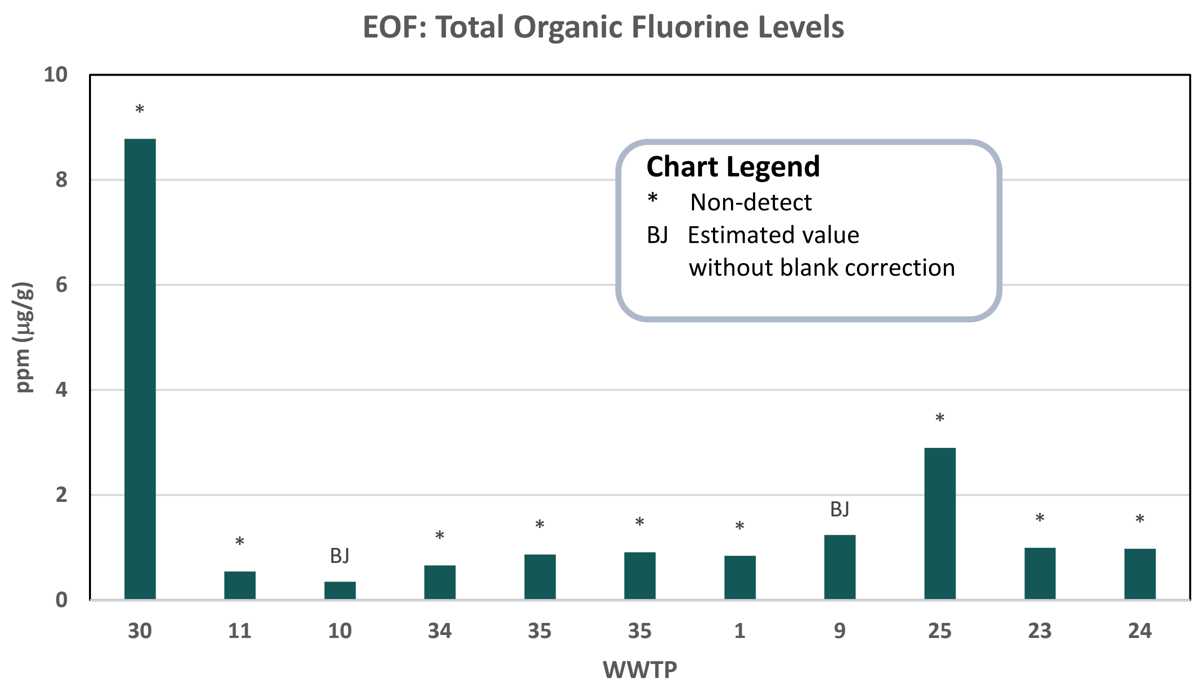
Extractable Organic Fluorine (EOF)

Table C-3. EOF sample Results

Facility ID	Sample ID	EOF (µg/g)
WWTP01	2405046-01	0.842*
WWTP09	2405046-06	1.24
WWTP10	2405043-36	0.352
WWTP11	2405043-11	0.544*
WWTP23	2406043-16	0.997*
WWTP24	2406043-41	0.975*
WWTP25	2405046-46	2.9*
WWTP30	2404052-21	8.78*
WWTP34	2405044-01	0.663*
WWTP35	2405045-01	0.87*
WWTP35	2405045-01	0.912*

** – Indicates a Non-Detect*

Chart C-3. EOF sample results



* – Indicates a Non-Detect
BJ – Indicates an estimated value without blank correction

Appendix D. Acronyms, Abbreviations, and Glossary

Acronyms and Abbreviations

ECY	WA State Department of Ecology
EPA	United States Environmental Protection Agency
Facility	Wastewater Treatment Plant
MBBR	Moving Bed Biofilm Reactor
ORD	Office of Research and Development
PFAAs	Perfluoroalkyl Acids
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
QAPP	Quality Assurance Project Plan
QC	Quality Control
SOP	Standard Operating procedures
WAS	Waste activated sludge
WWTP	Wastewater Treatment Plant

Unit of Measurement

g	gram, a unit of mass
MGD	million gallons per day, Flow.
mg	milligram, a unit of mass equal to 1/1,000 gram
ng/g	nanograms per gram (parts per billion, ppb)
ng/L	nanograms per liter (parts per trillion, ppt)
µg/g	micrograms per gram (parts per million, ppm)
ppb	part per billion (1/1.000.000.000)
ppm	part per million (1/1.000.000)
ppt	part per trillion (1/1.000.000.000.000)

Glossary

Biosolids: Means municipal sewage sludge that is a primarily organic, semisolid product resulting from the wastewater treatment process, that can be beneficially recycled and meets all applicable requirements under this chapter (chapter 173-308 WAC, Biosolids Management). Biosolids includes a material derived from biosolids, and septic tank sludge, also known as septage, that can be beneficially recycled and meets all applicable requirements under this chapter. For the purposes of this rule, semisolid products include biosolids or products derived from biosolids ranging in character from mostly liquid to fully dried solids.

Dewatered Biosolids: Biosolids goes through a process of removing enough water from the biosolids but may still contain significant amount of water often as much as 90%.

Exceptional Quality Biosolids: means biosolids that meet the pollutant concentration limits in Table 3 of WAC **173-308-160**, and at least one of the Class A pathogen reduction requirements in WAC **173-308-170**, and at least one of the vector attraction reduction requirements in WAC **173-308-180**.

Minor Facility: Facility serving communities of 10,000 or fewer inhabitants and an average wastewater flow of less than one MGD.

Major Facility: Facility serving communities of more than 10,000 inhabitants with an average wastewater flow greater than 1 million gallons per day.

Liquid Biosolids: Are essentially 94 to 97 percent water with relatively low amounts of solids (3 to 6 percent). It is usually derived from lagoons and digesters but can sometimes be found in system with incomplete dewatering process.

Sewage Sludge: Is solid, semisolid, or liquid residue generated during the treatment of domestic sewage in a treatment works. Sewage sludge includes, but is not limited to, domestic septage; scum or solids removed in primary, secondary, or advanced wastewater treatment processes; and a material derived from sewage sludge. Sewage sludge does not include ash generated during the firing of sewage sludge in a sewage sludge incinerator or grit and screenings generated during preliminary treatment of domestic sewage in a treatment works.