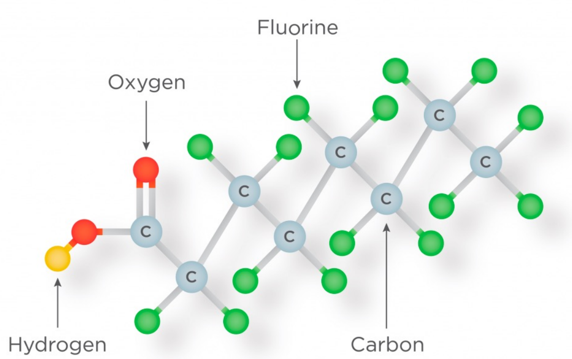
PFAS Environmental and Health Information and Recommended Actions for Water Reclamation Facilities in Utah



Joint Preliminary Recommendation from:

WASATCH FRONT WATER QUALITY COUNCIL

PROTECTING WASATCH FRONT WATERS THROUGH COLLABORATIVE, APPLIED RESEARCH

UTAH DEPARTMENT *of* ENVIRONMENTAL QUALITY

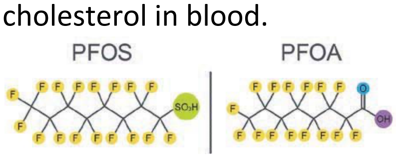
WATER QUALITY

PFAS and Wastewater

Executive Summary

Per and polyfluoroalkyl substances (PFAS) are a group of manmade fluorinated compounds which are used for a variety of applications by both industry and residential households. PFAS have been designed by scientists not to break down in the environment, which is why they are often called “forever chemicals.” PFAS are in countless commercial, consumer, and industrial products and are acknowledged by the EPA to be widely present in the environment. PFAS enter public wastewater treatment systems through industrial, commercial, and domestic sources. Activities ranging from washing PFAS-treated pots and pans to putting out fires with certain foams can all introduce PFAS into the sewers. As receivers of PFAS, wastewater facilities can leave PFAS in the water or sequester it in the biosolids. Treatment does not change PFAS.

Health impacts from high doses of PFAS have been found to have a probable links between exposure and six diseases: testicular cancer, kidney cancer, ulcerative colitis, thyroid disease, pregnancy-induced high blood pressure, and an excess of cholesterol in blood.



In 2022 EPA took the following action relative to PFAS.

Drinking Water Health Advisories:

PFAS Type	Concentration
PFOA	0.004 PPT
PFOS	0.02 PPT
GenX	10 PPT
PFBS	2,000 PPT

PPT – Parts per trillion

Draft Fresh Water Aquatic Life Criteria (Chronic):

PFAS Type	Concentration
PFOA	94 PPB
PFOS	8.4 PPB

PPB – Parts per Billion

Conclusions:

1. Exposure to PFAS is virtually universal and safe levels are not well defined.
2. Drinking water and reclaimed water will need high level filtration to remove PFAS, but residuals still remain in the solids/biosolids.
3. The Pretreatment Program will probably be used to reduce PFAS to treatment facilities.
4. The is significant potential for cost increases in rates to pay for PFAS in wastewater or biosolids.

PFOA or PTFE in Non-Stick Frying Pans

Recommended Actions:

1. WRF (Water Reclamation Facilities) should test influent, effluent, and biosolids for PFAS frequently.
2. In the effluent concentrations of PFOA and PFOS are below the draft EPA Freshwater Aquatic Life WQ Criteria for chronic water column, then continue to test. If the concentration exceeds the chronic water column concentration, develop a source tracking program to investigate for sources.
3. For biosolids, if the concentration is below 20 µg/kg PFOS, continue testing. If it is over 20 µg/kg concentration of PFOS in the biosolids, develop a source tracking program to investigate sources. If the biosolids concentration exceeds 50 µg/kg, inform the owner of the land where biosolids are being applied.
4. Inform the Division of Water Quality of test results at least annually.

PFAS Environmental and Health Information and Recommended Actions for Water Reclamation Facilities

The following information is provided for water reclamation facilities concerning per- and polyfluoroalkyl substances (PFAS). The guidance is broken down into the following sections:

- General Information on PFAS
- Concerns Surrounding PFAS
- Regulatory Actions on PFAS
    - Drinking Water
    - Wastewater
    - Biosolids
    - Treatability in Water
- Conclusions
- Recommendations

General Information on PFAS

Per- and Polyfluoroalkyl Substances (PFAS) are a family of chemicals used in many industrial and commercial applications that have been around since the 1940's because of their useful properties. There are several thousand different PFAS compounds, some of which have been more widely used and studied than others. One major characteristic of concern with PFAS is that many break down very slowly or not at all, and can build up in people, animals, and the environment over time. In the past couple of decades there has been increasing concerns about possible harmful effects of these chemicals. PFAS are often called forever chemicals because of the difficulty of degrading/destroying the molecules and their persistence in the environment. They have been detected virtually everywhere, even in the blood of polar bears living in the Artic. In an Interstate Technology Regulatory Council fact sheet on the history of PFAS it states:

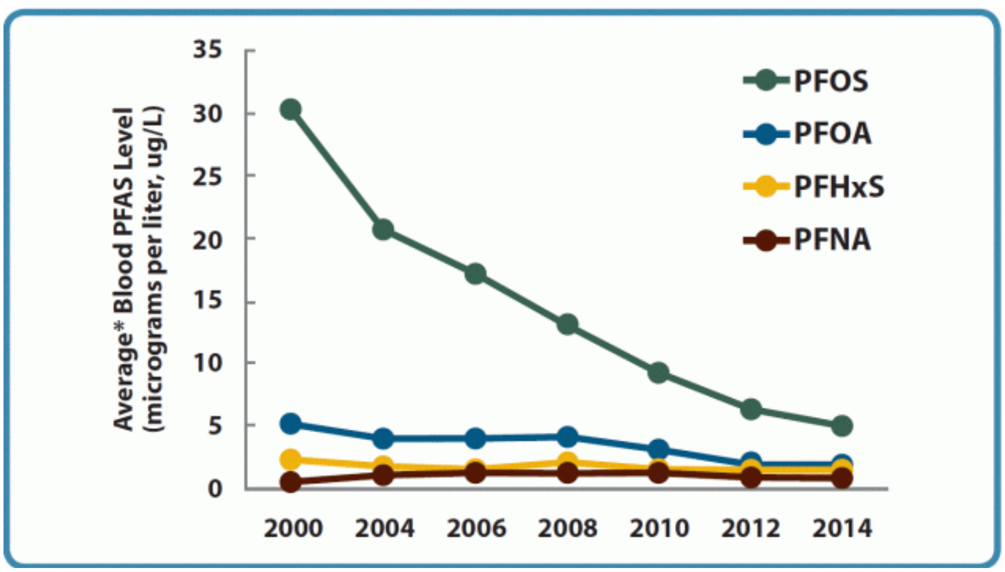
> “PFAS are a family of thousands of chemicals that vary widely in their chemical and physical properties, as well as their potential risks to human health and the environment. The unique physical and chemical properties of PFAS impart oil, water, stain, and soil repellency, chemical and thermal stability, and friction reduction to a range of products. These products have application in many industries, including the aerospace, semiconductor, medical, automotive, construction, electronics, and aviation industries, as well as in consumer products (such as carpets, clothing, furniture, outdoor equipment, food packaging), and firefighting applications.“

The US Centers for Disease Control website states PFAS is an area of significant concern and further stated (https://www.atsdr.cdc.gov/pfas/health-effects/us-population.html):

> “International concern regarding potential health effects associated with PFAS exposure began in the early 2000s when perfluorooctanesulfonate (PFOS) was detected in the blood of polar bears in the Arctic and wildlife in other remote regions. Early data on PFOS bioaccumulation in aquatic food webs indicated the propensity for human exposure to these compounds through seafood. The U.S. Centers for Disease Control and Prevention (CDC) later reported these compounds are detectable in the blood of virtually all Americans (98%). Between 2000–2002, the main global manufacturer of PFASs (3M) voluntarily discontinued manufacturing of the parent chemical used to produce PFOS and its precursors. The United States (U.S.) introduced a variety of programs to curb use of the most abundant environmental PFASs, including the PFOA [Perfluorooctanoic acid] Stewardship Program enacted in 2006 to end production of the longest chained compounds by 2015. PFOS was added to the Stockholm Convention’s list of globally restricted Persistent Organic Pollutants (POPs) in 2009.
>
> Human exposures to PFOS and PFOA have been declining in western countries and Japan over the last decade due to these regulatory interventions while understanding of their adverse effects on human health has been rapidly advancing. At the same time, a

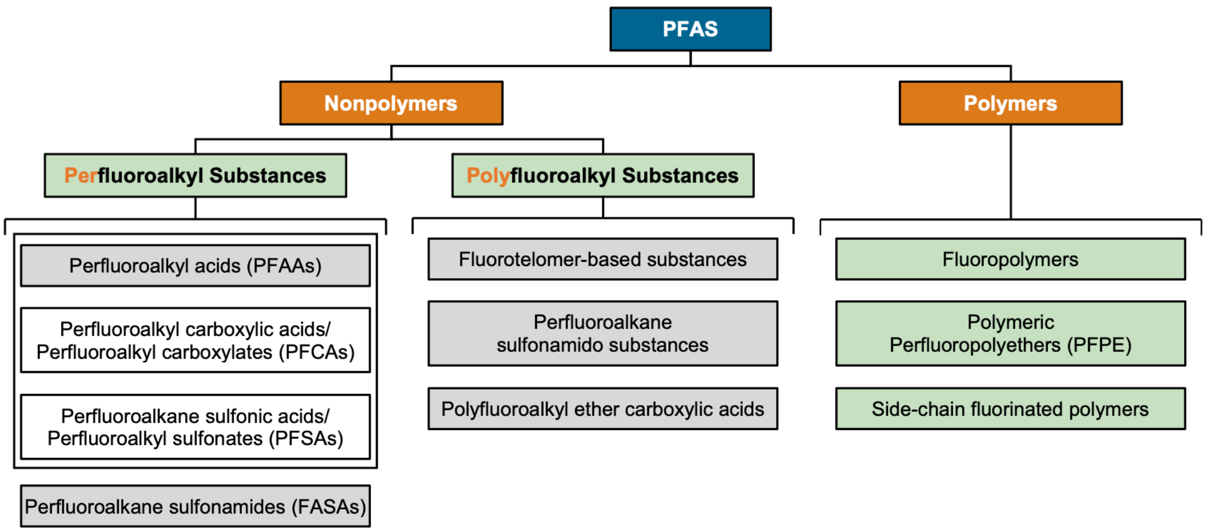
proliferation of new PFASs have been reported in the environmental literature as industry has rapidly replaced PFOS and PFOA with shorter chain length PFASs and new chemicals that are difficult to detect using standard methods."

PFOS and PFOA are members of the PFAS family and have been primary concerns for health impacts. The term C8 is often used to reference PFOA and is used generically to include all PFAS compounds containing eight carbon atoms. The producers of PFOS/PFOA have voluntarily stopped production in the US but these chemicals are still being manufactured elsewhere and replacement chemicals have now been produced. Since the reduction of PFOS/PFOA in the US has taken place, the concentrations of these in US blood samples have been steadily going down as shown in the following graph following (**Data Source:** Centers for Disease Control and Prevention. Fourth Report on Human Exposure to Environmental Chemicals, Updated Tables, (January 2017). Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention).



Even with the reduction of PFOS/PFOA use and the concentration of them in human blood samples, there is still significant concerns because the family of PFAS chemicals has over 4,000 different varieties. There are both short carbon chain molecules and long carbon chain molecules as well as polymer and nonpolymer variants. The Interstate Technology Regulatory

Council fact sheet on PFAS naming conventions shows the following graph demonstrating the major family of PFAS chemicals:



As can be seen, the variations of compounds in the PFAS family are significant.

In general, research on the hazards of each chemical in the PFAS family does not keep up with the introduction of new PFAS chemicals. As such, many research articles and agencies advise caution on the use of the entire family of chemicals until specific research on the safety of that individual chemical is well understood.

Concerns Surrounding PFAS

Since shortly after their introduction, there have been concerns about the PFAS family of chemicals. These concerns were initially centered around locations where significant sources, either industrial or firefighting had spread PFAS in their local environment. One sentinel occurrence of health impacts was in West Virginia and involved DuPont chemical. The health impacts are described in the following quote (https://pfasproject.com/parkersburg-west-virginia/):

> DuPont began using PFOA to manufacture Teflon at its Washington Works plant in 1951. The company knew that PFOA is toxic in 1961.
>
> In 1981, DuPont found evidence of birth defects in babies born to female employees who worked in its West Virginia plant, and decides to pull female employees from Teflon work. Drinking water monitoring conducted by DuPont in 1984 confirmed elevated PFOA levels around the Washington Works plant . . .
>
> DuPont employees found an elevated number of leukemia deaths at the West Virginia plant in 1989. Several months later, they measured an unexpectedly high number of kidney cancers among male workers. Both elevations were plant-wide and not specific to workers who handled PFOA.

After finding dead cattle below a non-hazardous landfill constructed by DuPont, lawsuits were filed on behalf of the farmer, employees and others who had negative health outcomes. The result of one such lawsuit was the establishment of a science panel to investigate the pollution (C8 Science Panel). A large-scale investigation of the health impacts took place and significant findings were published. In the Social Studies Science Journal in 2018 (Vol. 48(5) 691-714) an article reported:

> With over 69,000 participants, this was an exceptionally large study and hence able to identify exposure-disease relationships that are difficult to observe through smaller sample sizes. By 2012, the C8 Science Panel had released a series of results from their epidemiological study, finding probable links between exposure and six diseases: testicular cancer, kidney cancer, ulcerative colitis, thyroid disease, pregnancy-induced hypertension, and hypercholesterolemia.

The CDC has classified the relationship between health impacts and exposure to PFAS for some health outcomes as “Strong/Near Certain” while other health impacts are “More Likely Than

Not" the result of PFAS exposure. Given the strong scientific correlation between PFAS and negative health outcomes, EPA and some states have taken preliminary actions. In addition, there are several environmental or consumer groups which advise on how to avoid exposure to PFAS. Since PFAS is often found in drinking water, soils, food, and even the air and can build up over time, concerns are increasing. According to EPA (https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas),

Current research has shown that people can be exposed to PFAS by:

- Working in occupations such as firefighting or chemicals manufacturing and processing.
- Drinking water contaminated with PFAS.
- Eating certain foods that may contain PFAS, including fish.
- Swallowing contaminated soil or dust.
- Breathing air containing PFAS.
- Using products made with PFAS or that are packaged in materials containing PFAS.

Given the health consequences surrounding PFAS exposure at high levels and the pervasive exposure everyone has to low levels of PFAS, the concern is defining in regulations a safe level of exposure either to specific PFAS chemicals or the family of PFAS compounds in total.

Regulatory Actions on PFAS

Drinking Water:

Although industry determined that there was some level of toxicity from PFAS as early as the 1960's, it wasn't until occupational studies performed in the 1970s found detections of some PFAS in the blood of exposed workers at PFAS manufacturing facilities, and further studies in the 1990's reported detections in the blood of the general human population. By the early 2000's the occurrence of PFAS became a very active area for research for surface and groundwater, sediments, and wildlife. The West Virginia lawsuit and subsequent C8 Panel report published by 2009 confirmed significant health effects from high levels of environmental PFAS. EPA has taken the following numeric consent order actions or health advisories for PFAS in drinking water:

EPA Health Actions

Year	EPA Action Source	Regulatory Limit	Other Actions	Source of Information
2006	Order of Consent	500 PPT of C-8 (PFOA)	Required to provide drinking water treatment	EPA Order of Consent Docket # SDWA-03-2007-039-DS
2009	Order of Consent	400 PPT of C-8 (PFOA)	Temporary Alternate Drinking Water Provision	EPA Order of Consent Docket # SDWA-03-2009-0127-DS
2016	Lifetime Health Advisories	70 PPT PFOA and PFOS	Lifetime Health Advisories	EPA Fact Sheet 2016 PFOA & PFOS Drinking Water Adv.
2022	Lifetime Health Advisories	PFOA - 0.004 PPT PFOS - 0.02 PPT Gen X - 10 PPT PFBS - 2,000 PPT	PFOS/PFOA Interim Health Advisory GenX/PFBS Final Health Advisory	EPA Fact Sheet 2022 Drinking Water Advisories

PPT – Parts Per Trillion

Appendix 1 contains fact sheets or settlement orders documenting the values shown in the table above.

As can be seen from the table the advisory levels continue to decline as more information is gained about the impacts to health from long term exposure to PFAS compounds. In general, the health risk levels are being driven by a common theme that no significant exposure to at least C8 elements has been proven to be safe. In a 2019 commentary in Public Health Reports the authors of an article titled “Per- and Polyfluoroalkyl Substances: A National Priority for Safe Drinking Water” (Public Health Reports 2019, Vol 134(2) 112-117) stated a common theme about health protection:

> Protecting public health means preventing exposure to all PFASs that are present in water supplies and other environmental media above risk thresholds. Because the risk thresholds continue to decrease, prevention may be accomplished only by controlling

> and decreasing exposures to PFASs already in the environment. Measures also need to be taken to restrict or ban the manufacture of these toxic chemicals.

The 2022 exposure to C8, PFOA and PFOS, are so low that they are orders of magnitude lower than the analytical ability to detect them. For perspective, one part per trillion is the equivalent of four grains of sugar in an Olympic sized swimming pool, or the equivalent of one second in 32,000 years, or $1.50 out of all the US currency in the world. The new health limit for PFOA is 1/250 of a part per trillion. For the 2022 lifetime health exposure limits, the most sensitive non-cancer exposure effect, forms the basis for the interim updated health advisories for PFOA and PFOS, and is based on the suppression of vaccine response (decreased serum antibody concentrations) in children.

Should a State implement the 2022 health advisory concentration into their drinking water standards it means that if a drinking water supply who sees any detection of PFOS/PFOA would have to add treatment like micro or carbon filtration on their water systems as a barrier to PFAS contamination. Preemptively filtering the drinking water would be the only way to, hopefully, ensure the low health advisory standards are met. Even if a water supplier never saw a PFOS/PFOA detection in water testing it does not guarantee the thresholds are being met because the analytical detection limits are higher than the health limits. EPA's recommendation is that if people are concerned then they may consider in-home water treatment filters that are certified to lower the levels of PFAS in water (https://www.epa.gov/sciencematters/epa-researchers-investigate-effectiveness-point-usepoint-entry-systems-remove-and).

This does not mean that all waters are contaminated with PFAS of some sort. It means at ultra-low levels that are not detectable the possibility exists. It may be comforting to know the following:

> A close examination of 23 studies on the environmental occurrence of PFASs in the US along with similar studies in the other countries in this review has revealed a few trends.

> PFAS concentrations in surface water and groundwater are highly influenced by upstream sources with PFAS-related industries and landfill leachates being the major contributors. Hydrophilic short-chain PFASs tend to have a greater presence in natural water bodies, while hydrophobic long-chain PFASs are more likely to accumulate in sediments. PFASs cannot be effectively removed in conventional WWTPs [wastewater treatment plants], while DWTPs [drinking water treatment plants] are somewhat more effective, likely due to less PFAS-impacted influents, and the advanced filtration processes.
> Further research is needed to analyze a wider array of PFASs, particularly to cover those playing roles in PFAS degradation pathways. (Occurrence of per- and polyfluoroalkyl substances in water: a review. Environ. Sci.: Water Res. Technol. , 2022, 8, 1136-1151).

Various States in the United States have approached regulations of PFAS in water differently. Many have adopted health advisories like the 2016 EPA lifetime health advisory concentrations. Others have adopted different values based on their own assessments. The Interstate Technology Regulatory Council prepared an April 2022 spreadsheet outlining the actions by different States. An extract from the spreadsheet can be found in Appendix 2. The first two sheets are PFOA and PFOS values adopted by states. The third sheet is a list of abbreviations. The final three sheets are the full spreadsheet tab for water, but these sheets are difficult to read due to print size. The action spreadsheet can be found at the following web location https://pfas-1.itrcweb.org/fact-sheets/. Values for PFOS and PFOA are given in parts per billion. As can be seen, none are as low as the June 2022 lifetime health advisories from EPA. In addition, Utah has so far not taken any regulatory action on PFAS.

Wastewater:

PFAS in wastewater is a complex issue. This is because it is not readily destroyed. As such PFAS which arrives at a wastewater reclamation facility (WRF) will end up either in the water in the WRF discharge or in the biosolids. In addition, PFAS has multiple sources of addition to wastewater including industrial discharges and consumer goods. A recent study in the Yale

School of Public Health report found PFAS was in measurable amounts in household dust (https://ysph.yale.edu/news-article/study-identifies-potentially-harmful-substances-in-household-dust/). If you dust the house and simply wash the dust cloth the PFAS ends in wastewater. Hence WRF are not generators of PFAS but are aptly classified as PFAS receivers. A group of organizations representing receivers (including NACWA and WEF) recently prepared a fact sheet on the challenges faced by receivers (included in Appendix 3). This group stated, "none of these essential public service providers utilize or profit from PFAS chemicals. Rather, they are "receivers" of these chemicals used by manufacturers and everyday consumers, and merely convey and/or manage the traces of PFAS coming into our systems daily." The group also distinguishes between highly contaminated sites and background levels. For background levels the group recommends a cautious regulatory approach when stating "In fact, stringent state requirements could have significant unintended impacts on public municipalities and individuals, if public systems are deemed unusable and/or need to install prohibitively expensive supplemental treatment systems. Similarly, policies that limit the landfill disposal of PFAS containing wastes could force alternative means of disposal that are less protective of public health and the environment." The goal would be to manage PFAS holistically including limits on usage as a form of source reduction and other forms of pollution prevention.

That said, in April 2022 EPA proposed "Draft 2022 Aquatic Life Ambient Water Quality Criteria for Perfluorooctanoic acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS)" (Fact Sheet in Appendix 3, also). This report contained the following table titled "Draft Recommended Freshwater Aquatic Life Water Quality Criteria for PFOA and PFOS:

Criteria Component	Acute Water Column (CMC)[1]	Chronic Water Column (CCC)[2]	Invertebrate Whole-Body	Fish Whole-Body	Fish Muscle
PFOA Magnitude	49 mg/L	0.094 mg/L	1.11 mg/kg ww	6.10 mg/kg ww	0.125 mg/kg ww
PFOS Magnitude	3.0 mg/L	0.0084 mg/L	0.937 mg/kg ww	6.75 mg/kg ww	2.91 mg/kg ww
Duration	1-hour average	4-day average	Instantaneous[3]		
Frequency	Not to be exceeded more than once in three years, on average	Not to be exceeded more than once in three years, on average	Not to be exceeded more than once in ten years, on average		

[1] Criterion Maximum Concentration.
[2] Criterion Continuous Concentration.
[3] Tissue data provide instantaneous point measurements that reflect integrative accumulation of PFOA or PFOS over time and space in aquatic life population(s) at a given site.

These values are substantially higher than the ones for lifetime health exposure in drinking water. For example, the lifetime drinking water health exposure level For PFOA is 0.004 ppt compared to the water quality standard above of 94,000 ppt. Likewise, for PFOS the drinking water lifetime health exposure level is 0.02 ppt against the water quality value above of 8,400 ppt. Given the significant difference, if a water source is used for drinking water, the question would be if a lower standard to protect drinking water would be implemented? If so, how low?

Finally, on April 28, 2022, EPA issued a memo “Addressing PFAS Discharges in EPA-Issued NPDES Permits and Expectations Where EPA is the Pretreatment Control Authority.” (Included in Appendix 3). This memo states that EPA will require “Monitoring [that] should include each of the 40 PFAS parameters detectable by draft method 1633 and the monitoring frequency should be at least quarterly to ensure that there are adequate data to assess the presence and concentration of PFAS in discharges.” It will also require “Best Management Practices (BMPs) for PFAS, including product substitution, reduction, or elimination for discharges with PFAS as detected by method 1633.” Finally, it will also address issues relating to PFAS-containing firefighting foams in stormwater. While the memo is specific to EPA issued permits and EPA pretreatment where EPA is the control authority the memo also states:

> The Office of Water will re-engage with the national PFAS workgroup to identify needs for training and technical assistance to implement the Administrator's PFAS priorities in NPDES permits and coordinate permit efforts. EPA plans to issue additional guidance to state permit writers and local pretreatment authorities to address PFAS.

This gives the indication that such actions could be required of all NPDES permits administered by State authorities such as those in Utah.

Biosolids:

Because the fate of PFAS at WRF does not currently include destruction, this means that it either stays in the effluent water or partitions to the biosolids. The presence of PFAS in biosolids and the application on land for beneficial use is becoming a major concern. On April 20, 2022, the Governor of Maine signed LD1911 which banned the spreading of sludge and sludge-derived compost as fertilizer. This ban immediately caused widespread cost increases for disposal of biosolids in that state. In an article in a Maine paper, Spectrum News, it stated "In the short term, stakeholders said they expect the new ban to have big cost ramifications for waste handlers and potentially the public, especially in combination with another new law barring disposal of out-of-state waste at public landfills in Maine (PUBLISHED 7:00 AM ET MAY. 02, 2022)." The article further stated that it is likely Maine will have issues finding disposal locations for biosolids at local landfills or incinerators anywhere.

Currently this ban has only happened in Maine, but it could occur in other locations in the future. In a cost analysis published by the North East Biosolids and Residuals Association (NEBRA) the impacts of PFAS on biosolids management was explored (included in Appendix 4). In the summary of the report, it states the following conclusions:

- Average biosolids management cost increased by approximately 37% in response to PFAS concerns.
- Facilities which show minimal to no impacts to their management costs generally

    - Manage their biosolids utilizing methods other than beneficial reuse
    - Operate in states that do not yet have quantifiable PFAS regulations.
- Beneficial reuse programs appear to experience the most significant cost impacts due to PFAS.
- Facilities which reverted to landfill disposal after abatement of beneficial reuse programs have been burdened with biosolids management costs at least double their previous cost levels
- Some of the most common concerns regarding the impacts of PFAS regulations expressed by participants were:
    - lack of land fill capacity for biosolids disposal,
    - public perception,
    - political vs. science-based decisions, and
    - liability and cost burden.

Perhaps of greatest concern with the loss of biosolids beneficial reuse through land application is the possibility that there will not be enough landfills to accept the current biosolids waste load. Some landfills in Utah have already expressed concerns over too much biosolids. Since landfills are also a possible "hotspot" for PFAS, the recycling of landfill leachate to wastewater treatment plants has shown to increase the concentration of PFAS in wastewater. A recent study in the Journal of the Royal Society of Chemistry in 2020 (Environ. Sci.: Water Res. Technol., 2020, 6, 1300) concluded that:

> PFAS were detected more frequently in leachate (92%) than in influent (55%). Total PFAS concentrations in leachate (93 100 ng L−1) were more than 10 times higher than in influent (6950 ng L−1) and effluent samples (3730 ng L−1) [from WRF].

Thus, PFAS will likely cycle between consumer goods/industrial discharges to wastewater, to biosolids, back to landfills, and then returning to wastewater. Unless changes are made to destruct or remove PFAS in the first place, the cycle will continue.

Michigan is one of the few states that has developed a strategy for managing biosolids containing PFAS when land application occurs. Their July 2021 Interim Strategy stated:

> Of the 162 WWTPs that analyzed biosolids for PFAS in 2021, 155 WWTPs, or 96 percent, had PFOS concentrations at or below 50 µg/kg, with 136 WWTPs, or 84 percent, reporting PFOS under 20 µg/kg. Only seven WWTPs had a PFOS concentration above 50 µg/kg, four of which were below 100 µg/kg. The average concentration of all samples submitted under the 2021 Interim Strategy was 14 µg/kg and the median concentration was 8 µg/kg.

Based on their assessment, Michigan's Strategy (Full document in Appendix 4) developed the following trigger points for actions relative to biosolids:

- PFOS at or above 125 µg/kg.
    - Biosolids exceeding 125 µg/kg PFOS are deemed to be industrially impacted and cannot be land applied.
    - Immediately notify EGLE, WRD staff.
    - Sample effluent and investigate potential sources to develop a source reduction program, if they have not already done so under the IPP PFAS Initiative.
    - Arrange alternative treatment or disposal of solids.
- PFOS at or above 50 µg/kg but below 125 µg/kg.
    - Immediately notify EGLE, WRD staff.
    - Sample effluent and investigate potential sources to develop a source reduction program, if they have not already done so under the IPP PFAS Initiative.
    - To reduce overall loading to the site, reduce land application rates to no more than 1.5 dry tons per acre (or submit an Alternative Risk Mitigation Strategy).
- PFOS above 20 µg/kg, but below 50 µg/kg.

- EGLE recommends investigating sources and sampling the WWTP effluent for PFAS. Guidance can be obtained from the WRD IPP PFAS staff.
- If a WWTP on the Permit Cycle (five year) sampling frequency has a PFOS result above 20 µg/kg, the WWTP will be required to sample each year the WWTP intends to land apply, prior to land application.

- PFOS at or below 20 µg/kg.
  - This number is based on the averages derived from the Summary Report: Statewide Biosolids and WWTP Study and other available data. No additional requirements to comply with the Interim Strategy.

The Michigan approach is preferrable to the Maine approach in that it addresses immediate action when concentrations are high but allows for continued beneficial reuse when the concentrations are low. This allows for continued WRF operations while source reduction is implemented, allowing more time for research to determine safe levels, and allows for the phase out of PFAS or at least those specific PFAS compounds that are considered harmful.

One final biosolids concern has to do with a January 14, 2021, advance notice of proposed rulemaking relative to PFAS issued by EPA. The proposed rule would list PFOS and PFOA, including their salts and structural isomers, under CERCLA as hazardous substances. Relative to the proposed rule the National Association of Clean Water Agencies has stated (https://www.nacwa.org/docs/default-source/resources---public/2022-nacwa-wef-pfas-multi-page-advocacy-asks_final.pdf?sfvrsn=e2d8c461_2):

> The clean water community and other passive receivers are not responsible for creating PFAS concerns, yet they could face severe unintended consequences of potential liability and clean-up costs if federal or state legislation or regulators move forward without recognizing the key dichotomy between PFAS receivers and PFAS producers. A broad Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substance designation without protective guardrails will have far

reaching implications and severe consequences for public water and wastewater utilities that have played no role in placing PFAS into commerce or the environment in the first place. With a proposed U.S. Environmental Protection Act (EPA) rulemaking pending review with the Office of Management and Budget to list two of the more prominently found PFAS constituents—polyfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS)—as hazardous substances under CERCLA, Congress must exclude public utilities to ensure CERCLA's core strength, a "polluter pays" model is adhered to for PFAS producers and not place the financial clean-up and liability burdens on communities.

As stated above, the risk to WRF's could include significant liability for clean-up if biosolids were land applied and then the site was deemed polluted, hence the request for the exclusion of public utilities from CERCLA liability for these chemicals.

Treatability in Water

EPA has discussed removal of PFAS from water systems in several reports and on its website. On its website for "Reducing PFAS in Drinking Water with Treatment Technologies" it states the following about technologies available (https://www.epa.gov/sciencematters/reducing-pfas-drinking-water-treatment-technologies):

Activated Carbon:

Activated carbon treatment is the most studied treatment for PFAS removal. Activated carbon is commonly used to adsorb natural organic compounds, taste and odor compounds, and synthetic organic chemicals in drinking water treatment systems. Adsorption is both the physical and chemical process of accumulating a substance, such as PFAS, at the interface between liquid and solids phases. Activated carbon is an effective adsorbent because it is a highly porous material and provides a large surface area to which contaminants may adsorb. Activated carbon (GAC) is made from organic materials with high carbon contents such as wood, lignite, and coal; and is often used in granular form called granular activated carbon (GAC).

GAC has been shown to effectively remove PFAS from drinking water when it is used in a flow through filter mode after particulates have already been removed. EPA researcher Thomas Speth says, “GAC can be 100 percent effective for a period of time, depending on the type of carbon used, the depth of the bed of carbon, flow rate of the water, the specific PFAS you need to remove, temperature, and the degree and type of organic matter as well as other contaminants, or constituents, in the water.”

For example, GAC works well on longer-chain PFAS like PFOA and PFOS, but shorter chain PFAS like Perfluorobutanesulfonic acid (PFBS) and Perfluorobutyrate (PFBA) do not adsorb as well.

Another type of activated carbon treatment is powdered activated carbon (PAC) which is the same material as GAC, but it is smaller in size, powder like. Because of the small particle size, PAC cannot be used in a flow through bed, but can be added directly to the water and then removed with the other natural particulates in the clarification stage (conventional water treatment or low-pressure membranes - microfiltration or ultrafiltration). Used in this way, PAC is not as efficient or economical as GAC at removing PFAS. Speth says, “Even at very high PAC doses with the very best carbon, it is unlikely to remove a high percentage PFAS; however, it can be used for modest percent removals. If used, however, there is an additional problem with what to do with the sludge that contains adsorbed PFAS.”

Ion Exchange Treatment:

Another treatment option is anion exchange treatment, or resins. Ion exchange resins are made up of highly porous, polymeric material that is acid, base, and water insoluble. The tiny beads that make up the resin are made from hydrocarbons. There are two broad categories of ion exchange resins: cationic and anionic. The negatively charged cationic exchange resins (CER) are effective for removing positively-charged contaminants and positively charged anion exchange resins (AER) are effective for removing negatively charged contaminants, like PFAS. Ion exchange resins are like tiny powerful magnets that attract and hold the contaminated materials from passing through the water system. Negatively charged ions of PFAS are attracted to the positively charged anion resins. AER has shown to have a high capacity for many PFAS; however, it is typically more expensive than GAC. Of the different types of AER resins, perhaps the most promising is an AER in a single use mode followed by incineration of the resin. One benefit of this treatment technology is that there is no need for resin regeneration so there is no contaminant waste stream to handle, treat, or dispose.

Like GAC, AER removes 100 percent of the PFAS for a time that is dictated by the choice of resin, bed depth, flow rate, which PFAS need to be removed, and the degree and type of background organic matter and other contaminants of constituents.

High-pressure Membranes:

High-pressure membranes, such as nanofiltration or reverse osmosis, have been extremely effective at removing PFAS. Reverse osmosis membranes are tighter than nanofiltration membranes. This technology depends on membrane permeability. A standard difference between the two is that a nanofiltration membrane will reject hardness to a high degree, but pass sodium chloride; whereas reverse osmosis membrane will reject all salts to a high degree. This also allows nanofiltration to remove particles while retaining minerals that reverse osmosis would likely remove.

Research shows that these types of membranes are typically more than 90 percent effective at removing a wide range of PFAS, including shorter chain PFAS. With both high pressure membrane types, approximately 80 Percent of the feed water, the water coming into the membrane, passes through the membrane to the effluent (treated water). Approximately 20 percent of the feedwater is retained as a high-strength concentrated waste. A high-strength waste stream at 20 percent of the feed flow can be difficult to treat or dispose, especially for a contaminant such as PFAS, according to [EPA researcher Thomas] Speth. Perhaps this technology is best suited as a point of use technology for a homeowner, since the volume of water being treated is much smaller and the waste stream could be disposed of more easily with less cause for concern.

For a more detailed discussion of mature and emerging technologies, refer to Table 12-1 Liquid Technologies – Remediation Technologies and Methods Comparison prepared by the Interstate Technology Regulatory Council and found at the following link:

https://pfas-1.itrcweb.org/wp-content/uploads/2022/02/ITRC_PFASTable12-1LiquidsUpdateOct2021.pdf

Of note, methods to destroy PFAS are somewhat limited at the present time. Most current methods include some form of high temperature chemical breakdown, or incineration. Specific methods will not be discussed in the document.

Conclusions

The following conclusions can be drawn about PFAS.

1. The PFAS family of chemicals has many beneficial uses and has over 4,000 different products in the chemical family. Some compounds of the PFAS family, such as PFOA and PFOS, have been found to be toxic and cause major health impacts. While PFOA and PFOS use has been drastically reduced due to toxicity, many others in the family are still being used while research to determine health impacts and what, if any, constitutes safe levels is being conducted.
2. Exposure to PFAS is almost virtually universal. Safe levels are not well defined. For PFOA and PFOS, EPA has set lifetime health concentrations substantially below

analytical detection levels. As such, if they are ever detected they are perceived to be a problem. EPA has also established health advisories for PFBS and GenX which are replacement compounds for PFOA and PFOS, but these levels are within the detection range.

3. It is possible that to be protective all water treatment plants may have to provide micro filtration such as reverse osmosis to ensure PFAS is no longer in drinking water. WRF discharging to water bodies that are drinking water supplies, could also have to treat to low levels to protect drinking water.
4. EPA has issued draft water quality criteria for PFOA/PFOS that appear to be achievable if the WRF has no significant industrial sources of these compounds. In addition, there are fish concentration advisory levels to protect public health.
5. Regulating PFAS through the Industrial Pretreatment Program could be required to ensure industry is minimizing or treating waste streams. This would possibly require significant testing to identify possible dischargers needing regulation.
6. WRF are not generators of PFAS but are receivers of the compounds from industrial, commercial, and residential users either as a discharge from an industrial process, as a biproduct from firefighting, or as waste when products containing PFAS are cleaned, and the cleaning water is discharged to the sewer.
7. Biosolids are a significant area of concern for WRF especially relating to liability for land application for beneficial reuse. WRF that have industrial dischargers using PFAS or receive wastewater from airports using firefighting foam ladened with PFAS may be significantly impacted. Land application or distribution of biosolids or biosolids products such as compost, could be severely restricted as has been done in Maine. In addition, should EPA include the PFAS family of compounds or ones known to be toxic such as PFOA/PFOS under CERCLA as hazardous substances, WRF may incur significant potential biosolids liability, if land applied, unless public utilities are excluded.

Recommendations

Based on current levels of information, it is recommended that WRF take the following actions relating to PFAS:

1. WRF should test influent, effluent and biosolids at least quarterly to determine the concentrations of PFAS compounds (at least those that are currently able to be detected using recommended analytical methods.) in their discharge and biosolids.
2. In the effluent, if the concentrations of PFOA and PFOS are below the draft EPA Freshwater Aquatic Life WQ Criteria for chronic water column, then continue to test. If the concentration exceeds the chronic water column concentration recommended by EPA, develop a source tracking program to investigate within the collection system to see if a source can be identified. Then implement the source tracking program.
3. For biosolids, compare the WRF biosolids PFOS concentration with Michigan's PFOS range of values and recommended actions. If the concentration is below 20 µg/kg, continue testing. If it exceeds the 20 µg/kg concentration of PFOS in the biosolids then develop a source tracking program to investigate within the collection system to see if a source can be identified. Then implement the source tracking program. If the biosolids concentration exceeds 50 µg/kg, the owner of the application site should be informed of the concentration and discuss implications. It may be necessary to test the field to see if application should continue.
4. Inform the Utah State Division of Water Quality annually of test results for the prior year.