

Memorandum

June 5, 2026

To: Kevin Kalefern, Pete Adolphson, Chance Asher, Rachel McDermott, Corey King, and Chase Williams, Washington State Department of Ecology-Toxics Cleanup Program

From: Jennifer Benaman, PhD, Sarah LaRoe, PhD, Mark Larsen, Clay Patmont, Erik Naylor, Evan Thomas, Tasha Sorensen, and Nathan Soccorsy, Anchor QEA

Re: Comments on PFAS Guidance for Sediment Cleanup Sites

Anchor QEA appreciates the opportunity to provide feedback to the Washington State Department of Ecology (Ecology) regarding the development of policy for addressing per- and polyfluoroalkyl substances (PFAS) at sediment sites, including potential updates to the Sediment Cleanup User's Manual (SCUM). We commend Ecology for proactively engaging stakeholders on this important and rapidly evolving issue. The development of clear, scientifically sound PFAS sediment policy is both important and necessary, particularly as PFAS considerations increasingly affect sediment investigations, cleanup decisions, dredged material management, disposal planning, and long-term remedy evaluations. At the same time, PFAS science and regulation continue to advance quickly, including with respect to analytical methods, precursor compounds, sediment-to-biota exposure pathways, bioaccumulation, background conditions, source attribution, and risk-based decision-making. For that reason, we believe Ecology should develop any PFAS sediment policy through a transparent and deliberate rule-making or formal guidance-development process that allows for technical review, stakeholder input, and careful consideration of the evolving scientific record. Anchor QEA recommends that Ecology defer statewide numeric PFAS sediment screening levels; convene a technical advisory process including Tribal, port, municipal, academic, consultant, and federal participants; make supporting data and reports publicly available; and develop interim site-specific evaluation guidance while regional data and peer-reviewed studies continue to mature.

The comments below identify several key scientific and policy issues that Anchor QEA believes should be addressed before PFAS sediment guidance is finalized or applied broadly to sediment cleanup.

Global Comments

As set forth in the Washington State Model Toxics Control Act (MTCA) cleanup regulation, it is vitally important that any guidance developed by Ecology for PFAS at sediment cleanup sites be grounded in technically sound science. While Ecology is taking an initial step by reviewing some of the available technical studies, given the rapidly evolving science regarding PFAS and their widespread environmental occurrence, Ecology would benefit from drawing on a broader technical record and engaging recognized national experts to develop appropriate guidance for PFAS at sediment cleanup

sites. Additional investments will also need to be made in technical studies to better understand the source, distribution and fate of PFAS in Washington's waterways and associated aquatic life.

The challenge with PFAS is, in short, that they are complicated. They are relatively new, there are many of them, and they behave differently in the environment and the food web than other compounds for which Ecology has established guidance. Some of the tools developed for other compounds like dioxin/furans or mercury simply don't work when applied to PFAS.

The MTCA rule anticipated the need for technical input at times like this by including provisions for a Science Advisory Board to deal with new scientific information (WAC 173-340-702(15)) and the evolution of toxicology and risk-assessment methods (including WAC 173-340-708(7)(g) and WAC 173-340-708(9)(b)). We recommend that Ecology reconvene a Science Advisory Board or suitable equivalent to ensure that the citizens of Washington and the Tribes within our boundaries have the benefit of technically sound science pertaining to PFAS at sediment cleanup sites.

There is a large and growing technical community to draw from for this purpose. For example, experts from the U.S. Army Corps of Engineers Research and Development Center (ERDC), universities, and other states facing similar challenges are available and interested in assisting Ecology in this endeavor. For example, ERDC has been compiling and summarizing the rapidly expanding scientific data pertaining to PFAS in the aquatic environment to support appropriate risk management decisions nationwide. They have been open to collaboration with others. Consequently, we would encourage Ecology to consider reaching out to David Moore, PhD, ERDC's Senior Environmental Science Research Scientist (David.W.Moore@usace.army.mil, 601-634-4199). Experts with the Interstate Technology & Regulatory Council are also available (<https://pfas-1.itrcweb.org/>).

In their March 2026 paper on PFAS in aquatic environments, ERDC provided the following summary comments and recommendations, which are all relevant to the questions Ecology is considering:

PFAS are numerous, diverse and unfortunately ubiquitous in the environment [...] significant steps have been taken to restrict or eliminate industrial production, phase out commercial applications, and intensely regulate the presence of PFAS in the environment. Indeed, the regulatory landscape is rapidly evolving in the US, at both the federal and state level, with the imposition of increasingly stringent regulatory criteria [...] there are some positive indications of a general downward trend in environmental concentrations, especially of some longer-chain legacy PFAS (e.g., PFOS and PFOA) [...] While significant resources have been expended over the past two decades to improve our understanding of the fate and effects of PFAS, critical data gaps remain and must be addressed to provide the necessary technical basis for effective, risk-based management of PFAS [...] Understanding where

PFAS reside in the environment (i.e., sediment, soil, water or atmosphere) and the factors controlling the availability for biological uptake is critical to our understanding and to managing risk [...] Unlike most other organic compounds that concentrate in the lipid-rich tissues of organisms, PFAS concentrate in protein-rich tissues (e.g., liver, gills, serum albumin and eggs). Improvements in analytical capabilities will undoubtedly lead to additional questions but will also help further our understanding of the environmental cycling of PFAS, including transformation, partitioning and movement of PFAS through environmental media. While some transformation processes have been identified, the environmental factors controlling those processes and the rates of transformation are poorly understood. (ERDC 2026)

While the Science Advisory Board was eliminated during 2009 as part of recession-driven budget cuts, Ecology has demonstrated its continued capacity to solicit meaningful engagement on complex topics. The MTCA Stakeholder and Tribal Advisory Group that was convened as part of the recent MTCA rule revision process in 2023 provides a good example of what can be accomplished, even over the course of a global pandemic.

Engagement alone will only take Ecology so far in this process. More scientific data specific to the Pacific Northwest will also be required. To date, significant gains have been made through the work of the Puget Sound Ecosystem Monitoring Program (PSEMP) and related studies. Ecology's recent PFAS investigation of the Lake Washington watershed (Ecology 2025) is an example of the type of studies that will be needed to support guidance grounded in technically sound science. That work highlighted the importance of diffuse, ongoing sources of PFAS to water, sediments and tissue within the lake, and the importance of source control to reduce PFAS concentrations in all environmental media. More work of that caliber will be required. Similar studies are taking place in the Great Lakes, in the San Francisco Bay area and around the U.S. and Canada. But our region will need site-specific data to support informed decisions.

With respect to Ecology's proposed timeline to establish PFAS guidance, a 2027 SCUM revision may not provide sufficient time to develop durable statewide PFAS sediment guidance, given the current state of the science. Before appropriate numeric screening levels and risk-based guidance can be established, more data are needed to characterize current PFAS concentration distributions, ongoing sources, projected (likely downward) temporal trends over the next decade or more, and the fate of PFAS in sediments, including bioaccumulation and the influence of precursors. Many such studies are underway in other regions. For example, ERDC is currently conducting a comprehensive sediment PFAS study in the Great Lakes, with results anticipated later in 2026.

With respect to the technical evaluations presented at the May 7 Sediment Management Annual Review Meeting (SMARM), and as these efforts move forward, stakeholders and Tribes need to have

full, transparent access to the supporting reports and technical papers as they become available. Publication and peer review of key studies will be important to provide additional confidence in the study assumptions and conclusions that may ultimately inform consequential policy decisions.

In the meantime, and where there is appropriate need, MTCA and the Washington State Sediment Management Standards (SMS) both allow investigation and risk management decisions to continue on a site-specific basis. The SMS regulations address this through criteria for “Other Deleterious Substances.” But the establishment of broad PFAS guidance and criteria for application throughout the state will require a longer, more deliberate process.

The remaining sections of this memorandum address the nine questions posed by Ecology during their May 7 SMARM and highlight our thoughts around each. In particular, we provide examples of ongoing research as well as significant technical aspects around PFAS in Washington’s waters that we believe are critical to understand before numeric levels for sediment are considered.

Question 1: Should Ecology develop screening levels? For which receptors (benthic community, higher trophic levels, human health)?

Premature screening levels could have limited practical value and may create uncertainty or unintended delays at existing sediment cleanup sites. Importantly, there appears to be limited precedent for broadly applicable PFAS sediment screening levels in North America. While Ecology’s leadership on this issue is important to protect ecological and human health, the lack of precedence highlights the challenges in establishing these levels when much of the needed scientific data are still being obtained.

With respect to benthic screening levels, the PFAS concentrations detected to date in Washington sediments appear unlikely to result in measurable sediment toxicity. This is consistent with information presented during the May 7 SMARM and findings from the broader scientific literature. For example, Simpson et al. (2021) did not observe adverse effects on survival or reproduction in two estuarine species during acute and chronic sediment exposure tests at perfluorooctane sulfonic acid (PFOS) concentrations up to 180 micrograms per kilogram ($\mu\text{g}/\text{kg}$). Similarly, Krupa et al. (2025) evaluated elutriates generated from both field-collected and highly spiked PFAS-contaminated sediments and found no effects on survival in multiple freshwater and estuarine test species, despite PFAS concentrations in the water phase that exceeded levels known to cause effects in sensitive aquatic organisms. Together, these studies suggest that PFAS in sediment and PFAS released to the water column during sediment resuspension may have relatively low potential to cause acute toxicity under environmentally relevant conditions.

Given the currently available information, development of PFAS-specific benthic bioassays may not be an immediate priority relative to other research needs, such as understanding bioaccumulation pathways, food-web transfer, and risks to human and higher trophic level receptors. Where

site-specific confirmation of sediment toxicity is warranted, existing sediment bioassay protocols contained in the SCUM and SMS provide a well-established framework for evaluating potential biological effects.

For screening level development, more robust studies similar to the Lake Washington study are critical (Ecology 2025). These studies need to be mindful of temporal and spatial variability of PFAS when assessing the effect between receptors and potential exposure. The need for adequately paired data can be seen in Geosyntec's recently presented results, where 23% of PFOS were desorbed from sediment after 28 days. In addition, it has been shown that fish have the potential for relatively quick depuration of PFOS. For example, Falk (2015) demonstrated a half-life of 8.4 days for PFOS in rainbow trout muscle tissue. Additionally, research conducted by Dr. Gobas and his students at Simon Fraser University also shows rapid depuration for fish once water concentrations are reduced (Maika et al. 2026). These relatively quick changes in both sediment and fish concentrations highlight the importance of strict temporal and spatial pairing of sediment (i.e., potential exposure) and receptor concentrations, especially within aquatic organisms. These types of studies will inform a better understanding of pathways, potential receptor exposure/uptake, and receptor response—all of which are critical to assessing risk and potential system response to cleanup.

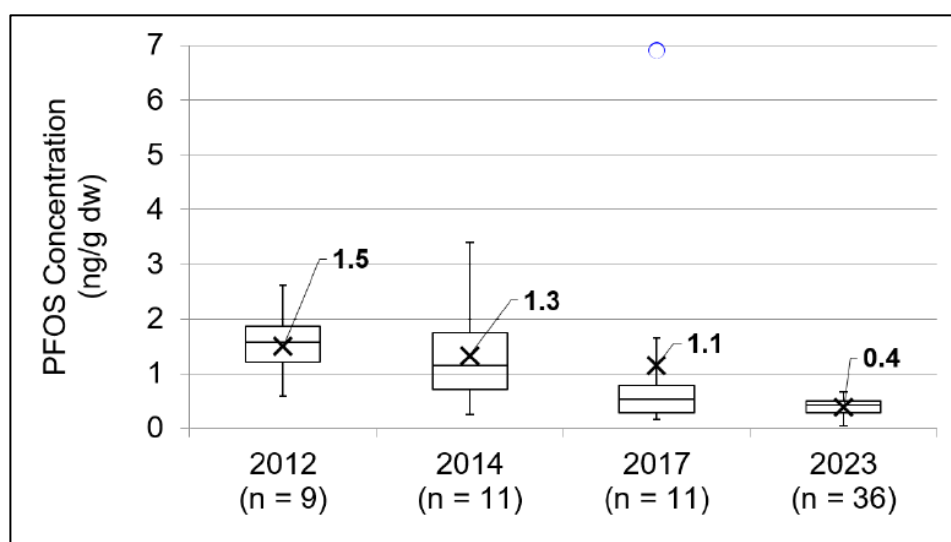
Questions 2 and 3: Should Ecology establish sediment natural background? For which media (marine sediment, freshwater sediment, or both)? If both, which is the highest priority?

Ecology should take steps to understand regional reference conditions as part of any future sediment evaluation framework. A clearer understanding of reference PFAS concentrations would help distinguish widespread environmental occurrence from localized source areas and improve interpretation of future sediment investigation results. This distinction is particularly important for PFAS given their broad use, persistence, and potential for regional transport across multiple media. Because of the greater number of ongoing sediment cleanup projects in Puget Sound, establishing regional PFAS reference concentrations for Puget Sound is the highest priority.

Documenting natural and/or regional background conditions is only one part of the puzzle for PFAS. The existing water and tissue data Ecology and PSEMP have started to collect, alongside with sediment data will be essential to benchmark the status of source control and/or recontamination over time and to identify where PFAS-related risks need to be controlled. We recommend that Ecology consider opportunities for ongoing collaboration and data sharing with existing monitoring and research programs, including the National Oceanic and Atmospheric Administration's (NOAA's) Mussel Watch Program, marine mammal monitoring efforts, Tribal fisheries departments, the Urban Waters Institute, and local universities. Leveraging these existing efforts could help expand the available PFAS dataset, improve understanding of regional trends, and maximize the value of ongoing monitoring investments.

Importantly, temporal trends in PFAS concentrations need to be considered when evaluating previously collected sediment data for reference evaluations. We'd ask that Ecology clarify whether and how temporal recovery trends, product phase-outs, and source control history were considered in the May 7 SMARM analysis using Ecology's Environmental Information Management (EIM) database¹. Studies, including work by San Francisco Estuary Institute (Mendez et al. 2025; see Figure 1) have documented declining concentrations of PFAS compounds in environmental media following manufacturing changes and product phase-outs (EPA 2000, 2021). In fact, data from the EIM show similar trends to the San Francisco Bay study (Figure 2).

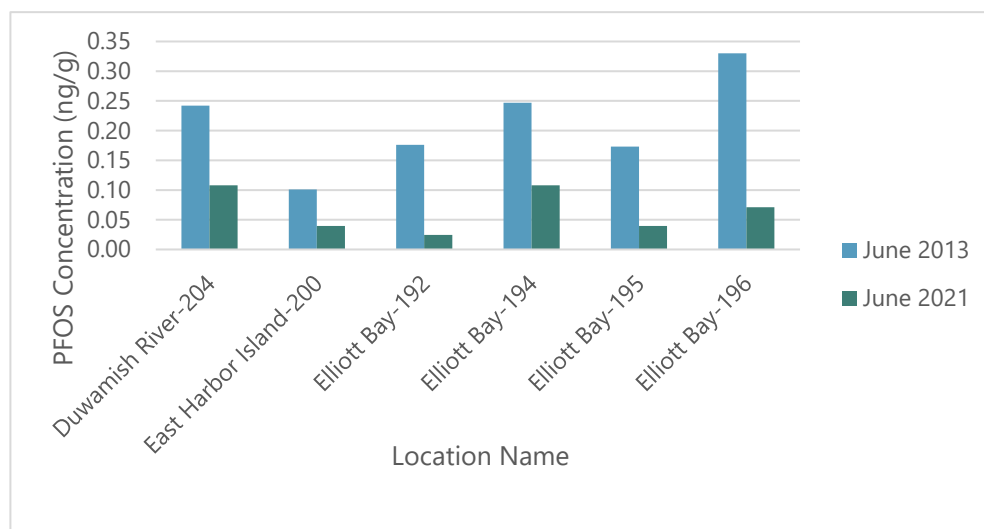
Figure 1
PFOS in San Francisco Bay Sediment



Note: Figure taken from Figure 5 of Mendez et al. (2025). The box represents the interquartile range (IQR), with the median line inside and X representing the average. Whiskers extend to the most extreme data points within 1.5*IQR; outliers are plotted individually.

¹ The age of PFAS data is important to consider with respect to the analytical method used and any associated issues related to quality assurance/quality control, interferences, lack of suitable standards, comparability, and sensitivity. U.S. Environmental Protection Agency (EPA) Method 1633: Analysis of Per- and Polyfluoroalkyl Substances in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS was finalized in January 2024. Prior to the finalization of EPA Method 1633, an assortment of non-standardized and user defined methods, modified drinking water methods, and low-resolution methods were used to measure PFAS in tissue and sediment samples. Data generated from modified non-standard methods may not be comparable to one another and have reliability concerns.

Figure 2
Examples of PFOS Recovery in Washington Sediment



Note: Sediment data are single samples selected from Ecology's EIM database, downloaded on 6/1/2026. Data were selected where there were paired concentrations from different dates at a common location name. Data should be considered illustrative only and not necessarily representative of a comprehensive, statewide trend.

These trends suggest that concentrations of some PFAS have dramatically declined in recent years in response to shifts in product use, regulatory actions, and source controls, especially long-chain PFAS that are typically the most regulated compounds.

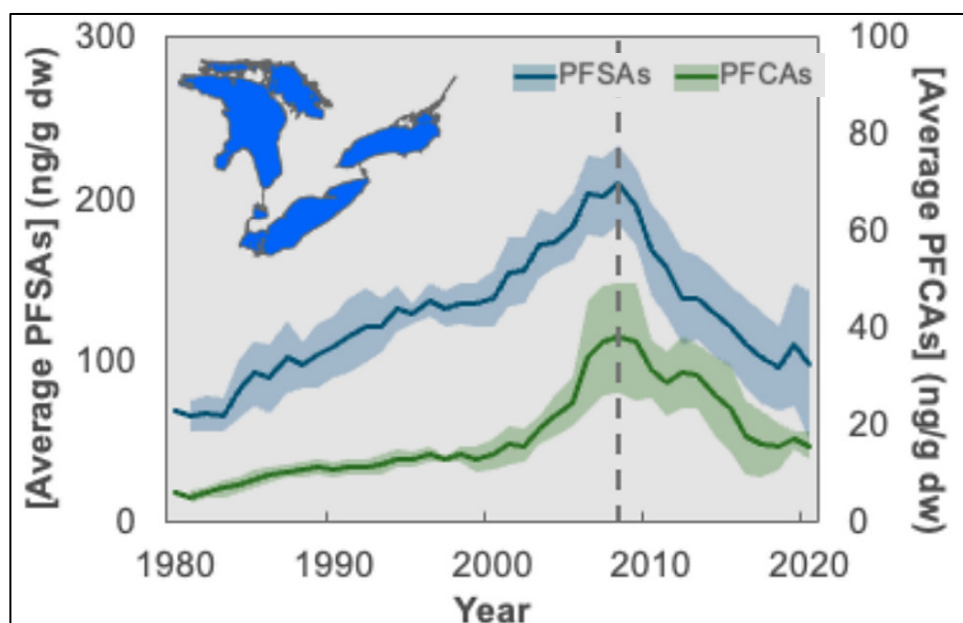
Understanding whether PFAS concentrations are increasing, stable, or decreasing may provide important context for future management decisions. Accounting for temporal trends would help Ecology distinguish between ongoing source contributions, legacy impacts, and broader regional background conditions, including how systems may have recovered compared to data that may have been sampled a few years ago. It may also help inform decisions about monitoring frequency, the need for additional source control, and how sediment data should be interpreted over time.

Additionally, the data analysis presented at the May 7 SMARM appears to aggregate data across diverse site types and time periods and lacks important site-specific nuances such as locations that have undergone remediation and/or source control, proximity to ongoing sources, and separation between urban and remote waterways.

Understanding trends in sediment, water, and tissue will be critical to assessing the impacts of source control and the potential need for remedial actions. We are starting to see some of these efforts reach maturity in the Great Lakes, where much has been done to track trends in fish tissue. Balgooyen et al. (2026) have reported substantial decreases in Great Lakes fish tissue concentrations, especially in the Eastern Lakes (see Figure 3), which they attribute to the reduction of long-chain

PFAS production. This kind of large-scale temporal analysis suggests that PFAS-impacted aquatic ecosystems may recover following source reductions. Ideally, such data should be available when making decisions about any screening level, because the object of setting such guidelines is to control concentrations in media that represent ongoing sources to the surrounding environment. The available data do not yet support a generalized assumption that sediment functions as a persistent dominant source of PFAS.

Figure 3
Moving Averages of PFCA and PFSA Fish Concentrations in the Eastern Great Lakes

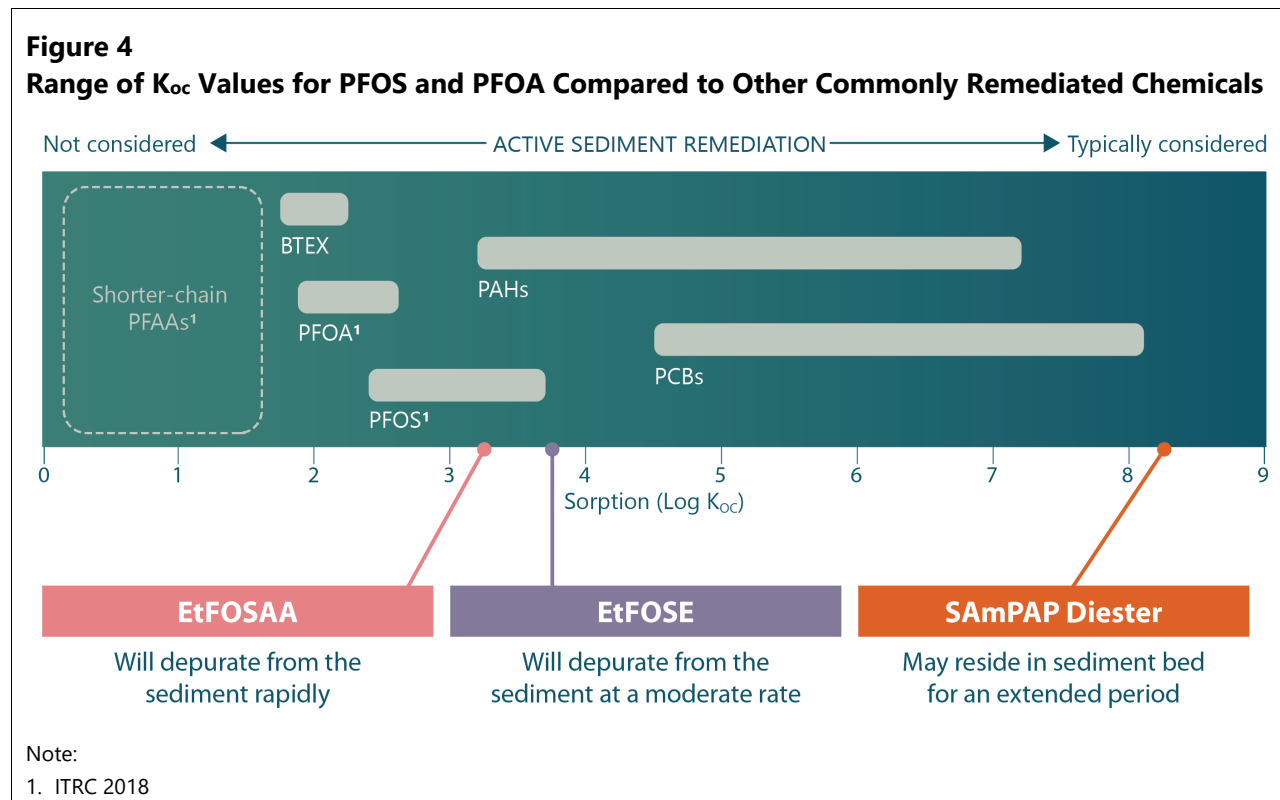


Note: Figure taken from Figure 3b of Balgooyen et al. (2026). The shaded area around each trendline represents the standard error of the moving average. Dashed lines indicate when perfluorinated carboxylate (PFCA) concentrations begin to decrease. Values below the detection limit are not included.

Question 4: Should Ecology identify processes to assess risks from PFAS?

Ecology should identify processes for assessing potential risks from PFAS at sediment sites, but those processes should recognize that the science regarding PFAS fate and transport, sediment bioavailability, and aquatic food-web bioaccumulation remains in an early and developing stage. For example, if source control results in rapid recovery of the sediments, focusing remedial efforts on sediment may not necessarily have an impact on risk reductions. Unlike many legacy hydrophobic organic contaminants, PFAS are ionizable and surface-active compounds that can partition between sediment, porewater, surface water, and biological tissue in ways that are not well described by conventional sediment cleanup models.

Information provided by Geosyntec in their May 7 SMARM presentation highlighted the importance of chain length on uptake. However, our current understanding of other factors that may be important (e.g., feeding behavior, organic carbon content, salinity) were not discussed and would need to be well-understood before any process to identify risks is established. Additionally, while it is true that longer-chain PFAS adsorb more readily to sediments than shorter chain PFAS, overall, alkyl acids have low K_{oc} values relative to more traditional hydrophobic chemicals that are remediated at cleanup sites. In fact, the most commonly investigated PFAS in sediments, PFOS, has a K_{oc} ² similar to a low molecular weight polycyclic aromatic hydrocarbon (PAH; see Figure 4; Higgins and Luthy 2006; ITRC 2018), indicating that if sources are controlled, the chemical may decline over shorter timeframes than more strongly sorbed legacy contaminants, particularly where external sources are controlled, allowing for natural recovery to occur. This is reflected in the materials that Geosyntec presented on Ecology's behalf during the May 7 SMARM where sediments saw a 23% reduction in PFOS concentration over just 28 days once sources were controlled.



In addition, more recent bioaccumulation work suggests that water-column exposure may be more important than bulk sediment concentrations for some receptors and site settings, and that

² There has been much research on the partitioning behavior of PFAS in sediment and soils. While Higgins and Luthy (2006) is an older publication, subsequent research has generally confirmed their findings and support that, for long-chain PFAS, hydrophobic properties are a good approximation of partitioning behavior over electrostatic conditions for moderate to high organic carbon containing solids (Brusseau 2024; Hu et al. 2025).

bioaccumulation factors derived for one organism, site, or PFAS mixture may not be transferable to another without careful technical review. As an example, the paper cited in Geosyntec's May 7 SMARM presentation to support sediment potentially being an important source of PFAS to fish, Larson et al. (2018) modeled avian exposures at aqueous film-forming foam (AFFF)-impacted aquatic habitats and found that sediment-associated PFAS, rather than water-associated PFAS, produced the highest predicted avian exposures, with PFOS and other perfluoroalkyl sulfonic acids (PFASs) dominating modeled exposure. However, Larson et al. was a screening level modeling effort that relied on available bioaccumulation assumptions and expressly identified the need for additional empirical biota-sediment accumulation factors (BSAFs), bioaccumulation factors (BAFs), bioconcentration factors (BCFs), biomagnification factors (BMFs), and information on polyfluoroalkyl precursors that may transform to stable PFASs and perfluorinated carboxylates (PFCAs). Importantly, more recent studies have shown that the BSAF Larson et al. chose for their model (1.22 kilogram [kg]-Organic Carbon (OC)/kg-wet weight [ww]) is on the high end when considering a more robust assessment of possible values. Burkhard and Votava (2023) show that PFOS BSAF values for fish above 1 kg-OC/kg-ww are unusual, with a median value for a PFOS BSAF of 0.0387 kg-OC/kg-ww and an average of 0.274 kg-OC/kg-ww using whole body fish and field measurements. In the same way, more recent studies for BAFs indicate the impact of water exposure may be higher than what was assumed by Larson et al. A compilation study performed by Burkhard (2021) reviewed 52 freshwater studies and 28 marine studies and found that the log BAF for fish had a median value of 3.35 liters per kilogram (L/kg)-ww, when the assumed value for Larson was Log BAF of 2.25 L/kg-ww. This highlights the importance of site-specific information when assessing the relative impacts of sediments on potential PFAS concentration in fish. If the Larson et al. model was rerun using the median values from these more recent studies, different conclusions would likely have been drawn for the relative impact of sediment versus water concentrations on resulting fish concentrations.

Similarly, Divine et al. (2020) developed ecological risk-based screening levels for PFAS in soil, sediment, surface water, and prey using standard U.S. Environmental Protection Agency (EPA) ecological risk-assessment approaches but also noted that sediment screening levels for benthic invertebrates and sediment risk-based screening levels for fish could not be developed because relevant toxicity data were unavailable or insufficient. Burkhard and Votava's more recent PFAS BSAF compilation (2023) further reinforces this uncertainty: while BSAF data are increasingly available for carbonyl and sulfonyl PFAS classes, data remain sparse for phosphate, ether, and fluorotelomer PFAS, and BSAFs vary across taxa, study quality, site conditions, and PFAS chemistry. Recent work by Gobas and coauthors further highlights the need to refine PFAS bioaccumulation in fish (Maika et al. 2026) before using models for regulatory decision-making. Together, these studies support evaluating sediment as part of PFAS risk assessment, but they do not support applying generic sediment-to-biota assumptions as fixed cleanup triggers without careful site-specific review.

For these reasons, we strongly recommend that Ecology avoid adopting a framework that presumes sediment is the dominant exposure pathway whenever PFAS are detected in sediment. High PFAS concentrations in sediment may indicate that an active or continuing source remains present in the watershed, such as stormwater, wastewater, groundwater discharge, landfill leachate, AFFF-impacted runoff, industrial discharges, or atmospheric deposition. Where ongoing sources are present, sediment-focused remedial actions may not meaningfully reduce risk unless source control is first implemented and shown to be effective. Conversely, where source control results in declining water, porewater, and tissue concentrations, natural recovery or monitored natural recovery may be more appropriate than active sediment remediation. We therefore recommend that Ecology's process requires evaluation of whether sediment remediation would actually reduce fish, shellfish, wildlife, or human-health exposure, or whether risk reduction would be more effectively achieved through source control, exposure controls, monitoring, and adaptive management.

It is also important to distinguish between direct ecological toxicity and human-health or wildlife exposure through fish and shellfish consumption. Available sediment and aquatic risk-assessment literature suggests that direct benthic toxicity thresholds for PFOS may occur at concentrations substantially higher than those typically measured in many field sediments, whereas fish and shellfish tissue concentrations may exceed risk-based consumption thresholds at much lower environmental concentrations. This distinction is important because PFAS sediment policy should not be framed solely as a benthic toxicity issue. Instead, the more likely risk driver at many sites may be bioaccumulation into aquatic organisms and subsequent consumption by humans, wildlife, or Tribal and subsistence fishers. Accordingly, risk-assessment processes should include decision points for determining when tissue data, food-web modeling, porewater data, or site-specific bioaccumulation evaluations are needed, rather than relying exclusively on bulk sediment chemistry.

In short, we recommend that Ecology identify a process for assessing PFAS risks at sediment sites, but that process needs to remain flexible and science-based. It should prioritize source control, evaluate sediment within the broader PFAS cycle, distinguish direct toxicity from consumption-based exposure, and allow for site-specific lines of evidence before requiring sediment remediation. We recommend Ecology continue to track emerging literature, including studies of sediment-water partitioning, porewater exposure, precursor transformation, BSAFs, fish and shellfish bioaccumulation, and marine/estuarine toxicity. Until the science matures, PFAS sediment guidance should be implemented as a structured weight-of-evidence framework rather than as a rigid sediment-concentration trigger for cleanup.

Question 5: Should Ecology further clarify when and how to analyze for PFAS?

Ecology's preliminary source/pathway-based sampling triggers are generally understandable; however, one criterion would benefit from additional explanation: one should sample a sediment site

that is located near another sediment site with PFAS contamination. We'd recommend clarification on defining a "sediment site with PFAS contamination" for this purpose.

For example, it would be helpful to understand whether this criterion is intended to apply only to sites where PFAS concentrations exceed a specific level, or whether any detection of PFAS in sediment would be sufficient. We'd ask that Ecology also clarify how proximity would be evaluated, including whether the determination would be based on distance, shared depositional areas, hydrologic or sediment transport pathways, common source areas, or other lines of evidence. Providing this clarification would improve consistency in applying the criterion and help stakeholders better understand when PFAS sampling is expected.

Questions 6 and 7: Should Ecology revise the Sediment Management Standards or the Model Toxics Control Act? If so, what key provisions should be revised?

As discussed in the sections above, given the significant uncertainty that currently exists due to lack of sufficient science and data, revising MTCA and/or SMS to specifically address PFAS would be premature at this stage without additional technical development and stakeholder review. Both regulations can handle emerging compounds such as PFAS as-is on a case-by-case basis. Under SMS, PFAS can be addressed as "other deleterious substances" (WAC 173-204-200(17)). The MTCA risk-assessment procedures (WAC 173-340-708) provide the necessary framework for evaluation of risk, including how to address new scientific information.

In the near term, Ecology can rely on existing MTCA and SMS authorities while focusing on scientific record needed to support future statewide policy.

Question 8: Are there other questions Ecology should be asking?

As discussed at the May 7 SMARM, surface sediment contaminant concentrations in Puget Sound rapidly (i.e., within several years) equilibrate with ongoing source inputs, even at sites with relatively low net sedimentation rates. These observations have important ramifications for sediment management throughout Washington State, confirming that PFAS source reduction is likely to be a more effective first-line risk-reduction strategy in many PFAS-affected systems.

Given that regional and national studies have all highlighted the importance of diffuse, ongoing sources of PFAS to water, sediments, and tissue, we believe Ecology should prioritize its PFAS efforts on identifying and implementing effective source control strategies, including further shifts away from PFAS product use. As discussed in our response to Questions 2 and 3, fish concentrations of PFAS in the Great Lakes have been reduced substantially over the past 20 years through source control efforts, demonstrating the rapid and widespread progress that can be achieved through source control actions.

Additionally, PFAS precursors are polyfluorinated compounds that may not themselves be terminal perfluoroalkyl acids but can transform through biotic or abiotic processes into persistent perfluoroalkyl carboxylic acids and sulfonic acids, including perfluorooctanoic acid (PFOA), PFOS, perfluorohexanoic acid (PFHxA), perfluorohexanesulfonic acid (PFHxS), perfluorononanoic acid (PFNA), and related PFAAs. This distinction is important for sediment sites because conventional targeted liquid chromatography-tandem mass spectrometry (LC-MS/MS) methods generally quantify only a defined list of known analytes for which analytical standards are available, and therefore may miss unknown, proprietary, or non-target precursor compounds. EPA Method 1633A, for example, is a major advance for PFAS analysis in sediment, soil, biosolids, tissue, and water, but it remains a targeted method rather than a comprehensive measure of all PFAS mass. Broader tools such as the total oxidizable precursor assay, extractable organic fluorine, adsorbable organic fluorine, and non-target high-resolution mass spectrometry can help identify otherwise unmeasured precursor burdens, although these methods are still developing and results can be matrix-dependent and difficult to translate into regulatory screening values.

Ecology should consider PFAS precursors as a line of evidence when evaluating whether terminal-PFAS screening levels may underestimate long-term risk, recontamination potential, or source control needs. Studies of PFAS-impacted aquatic systems have found that targeted analytes may account for only part of the extractable organic fluorine in sediment and that hydrophobic precursor compounds in sediment may transform and contribute to PFAA accumulation in aquatic biota, including fish (Langberg et al. 2020). Accordingly, sediment screening frameworks that consider only terminal PFAAs may understate future exposure potential where AFFF, wastewater, landfill leachate, biosolids, stormwater, treated paper/textile sources, or other precursor-rich inputs are present. Because precursor transformation rates, end products, analytical recoveries, and food-web implications remain areas of active research, precursor results are best treated as a supporting line of evidence in the development and application of sediment PFAS guidance, rather than as independent numeric pass/fail criteria.

Question 9: Do you have more questions or thoughts for Ecology or Geosyntec?

As discussed above, source control is one of the most effective tools to effectively reduce PFAS exposure in aquatic environments. Continued efforts to better understand both point and nonpoint sources—including industrial discharges, stormwater pathways, wastewater systems, atmospheric deposition, and other diffuse inputs—would provide important context for future sediment management decisions.

The source-identification framework used in other Ecology contaminant reduction programs (e.g., <https://apps.ecology.wa.gov/publications/summarypages/1103024.htm>) should be applied to PFAS to 1) identify the primary sources of PFAS; and 2) estimate annual releases of PFAS to

Washington State aquatic environments. The source-identification framework studies have revealed that most contaminants are released from a diverse array of sources; this situation is likely to be particularly true for PFAS. The source-identification framework would provide important information for understanding PFAS loading pathways and prioritizing actions that achieve the greatest environmental benefit.

References

- Balگوoyen, S., M. Mahon, A. Krauss, H. Sluka, W. Backe, G. Ankley, and R. Lepak, 2026. "Historical PFAS Trends in the Great Lakes Using Four Decades of Archived Fish." *Journal of Great Lakes Research* 52:102741.
- Brusseau, M.L., 2024. "Field Versus Laboratory Measurements of PFAS Sorption by Soils and Sediments." *Journal of Hazardous Materials Advances* 16:100508.
- Burkhard, L.P., 2021. "Evaluation of Published Bioconcentration Factor (BCF) and Bioaccumulation Factor (BAF) Data for Per- and Polyfluoroalkyl Substances Across Aquatic Species." *Environmental Toxicology and Chemistry* 40(6):1530–1543.
- Burkhard, L.P., and L.K. Votava, 2023. "Biota-Sediment Accumulation Factors for Per- and Polyfluoroalkyl Substances." *Environmental Toxicology and Chemistry* 42(2):277–295.
- Divine, C., J. Zodrow, M. Frenchmeyer, K. Dally, E. Osborn, and P. Anderson, 2020. *Approach for Assessing PFAS Risk to Threatened and Endangered Species*. Final Report. SERDP Project ER18-1653. March 2020.
- Ecology (Washington State Department of Ecology), 2025. *Greater Lake Washington Watershed PFAS Survey, Final Report*. Ecology Publication 25-03-008. July 2025. Accessed June 2026. <https://apps.ecology.wa.gov/publications/SummaryPages/2503008.html>.
- EPA (U.S. Environmental Protection Agency), 2000. "EPA and 3M Announce Phase Out of PFOS." Accessed June 2026. https://www.epa.gov/archive/epapages/newsroom_archive/newsreleases/33aa946e6cb11f35852568e1005246b4.html.
- EPA, 2021. "Fact Sheet: 2010/15 PFOA Stewardship Program. Assessing and Managing Chemicals Under TSCA." Accessed June 4, 2026. <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-20102015-pfoa-stewardship-program>.
- ERDC (U.S. Army Corps of Engineers, Engineer Research and Development Center), 2026. *Overview of PFAS in Aquatic Environments*. Final Technical Report. ERDC/EL TR-26-3. March 2026.

- Falk, S., K. Failing, S. Georgii, H. Brunn, and T. Stahl, 2015. "Tissue Specific Uptake and Elimination of Perfluoroalkyl Acids (PFAAs) in Adult Rainbow Trout (*Oncorhynchus mykiss*) After Dietary Exposure." *Chemosphere* 129:150–156.
- Higgins, C.P., and R.G. Luthy, 2006. "Sorption of Perfluorinated Surfactants on Sediments." *Environmental Science & Technology* 40(23):7251–7256.
- Hu J-J., S-K. Yu, C. Yin, F-J. Peng, S-S. Liu, C-G. Pan, and K. Yu, 2025. "Sorption and Mechanisms of Legacy and Emerging Per- and Polyfluoroalkyl Substances (PFASs) on Different Particle Size Fractions of Marine Sediments." *Environmental Research* 278:121643.
- ITRC (Interstate Technology Regulatory Council), 2018. "Environmental Fate and Transport for Per- and Polyfluoroalkyl Substances." Fact Sheet. March 2018.
- Krupa, P.M., G.R. Lotufo, J. Boyda, N.L. Melby, and A.N. Kimble, 2025. "Toxicity of Per- and Polyfluoroalkyl Substances in Elutriates Prepared with Estuarine and Freshwater Sediments." *Ecotoxicology and Environmental Safety* 290: 117483.
- Langberg, H.A., G.D. Breedveld, G.A. Slinde, H.M. Grønning, A. Høisæter, M. Jartun, T. Rundberget, B.M. Jenssen, and S.E. Hale, 2020. Fluorinated Precursor Compounds in Sediments as a Source of Perfluorinated Alkyl Acids (PFAA) to Biota." *Environmental Science and Technology* 54(20):13077–13089.
- Larson, E.S., J.M. Conder, and J.A. Arblaster, 2018. "Modeling Avian Exposures to Perfluoroalkyl Substances in Aquatic Habitats Impacted by Historical Aqueous Film Forming Foam Releases." *Chemosphere* 201:335–341.
- Maika S., A. McCloy, S. Piña Hodges, B. Kelly, and F. Gobas, 2026. *Modelling the Bioconcentration of Per- and Polyfluoroalkyl Substances (PFAS) in Rainbow Trout (Oncorhynchus mykiss) Using a Chemical Activity-Based Approach*. Pacific Northwest Society of Environmental Toxicology & Chemistry 35th Annual Meeting (Leavenworth, Washington): April 15-17, 2026.
- Mendez, M., E. Miller, D. Lin, and R. Sutton, 2025. *Emerging PFAS Trends in Water and Sediment from San Francisco Bay*. Report from Regional Monitoring Program for Water Quality in San Francisco Bay. Contribution No. 1245. San Francisco Estuary Institute. August 2025.
- Simpson, S.L., Y. Liu, D.A. Spadaro, X. Wang, R.S. Kookana, and G.E. Batley, 2021. "Chronic Effects and Thresholds for Estuarine and Marine Benthic Organism Exposure to Perfluorooctane Sulfonic Acid (PFOS)-Contaminated Sediments: Influence of Organic Carbon and Exposure Routes." *Science of the Total Environment* 776: 146008.