ROCS-Net
Regional-ORD Community of Science Networking Program

ADDRESSING DATA GAPS AND RISK COMMUNICATION ISSUES RELATED TO PFAS IN DRINKING WATER

Overview of the Science Issue:

The greatest science issue in Region 1 currently is the presence of PFASs at many NPL sites and a lack of toxicity data for developing applicable risk numbers. Of additional concern is the presence of PFAS at a variety of facilities, some ubiquitous and not currently regulated by EPA such as fire stations, and the resulting contamination of public and private drinking water wells.

In May 2016, EPA issued drinking water lifetime health advisories for PFOA and PFOS at 70 ppt individually or combined. The HA identified chronic oral RfDs values of 2E-05 mg/kg-day for PFOA and PFOS. PFBS has a chronic oral RfD of 2E-02 based on a PPRTV.

In the absence of a federal drinking water MCL, each state in Region 1 (and neighboring states) has a different approach to PFAS in drinking water, which makes risk communication a challenge. For example, Vermont adopted a lower health advisory for PFOA of 20 ppt, Connecticut has an action level of 70 ppt for 5 PFAS, and Rhode Island is enforcing EPA's health advisory.

PFOA, PFOS, and PFBS are the only PFAS compounds that have available toxicity information, however sampling often includes results for many other PFAS compounds which do not currently have toxicity data. This makes it very difficult to determine the potential human health risks posed by these contaminants.

With limited resources, investigative well sampling may only occur once despite evidence of PFAS results variability over time. This may provide false confidence in low or absent results. There is limited guidance available on this variability and how to address it in combination with resource limitations.

Ongoing Activities:

Sampling efforts to determine presence of PFASs are underway at many NPL sites in R1. All PFAS actions, including plans to sample, must be approved by HQ. Screening levels for PFOA, PFOS, and PFBS are calculated using the EPA Regional Screening Level Calculator.

Most states in the region are not waiting for a federal regulation; they have conducted, or are in the process of conducting, sampling of susceptible public and private drinking water wells, as well as environmental site investigations, despite limited resources and federal funding. States are using their individual enforcement authority to require corrective action. Rhode Island Department of Health recently conducted a statewide sampling study of priority public wells within 1 mile of potential PFAS facilities. RI Department of Environmental Management developed a Groundwater Quality Standard for PFOA and PFOS to match the health advisory.

Science Needs:

More toxicity data is needed on PFAS compounds. Currently, there is only data available for PFOA, PFOS and PFBS, however sampling efforts often obtain results for a list of PFAS compounds including many that do not have any toxicity information. In the absence of additional toxicity information, perhaps information on how/whether to account for other PFAS compounds in a qualitative manner would be useful.

EPA does not have any data on inhalation toxicity or dermal toxicity for any PFAS compounds.

A review of the EPA PFOA and PFOS health advisory in comparison with the lower standards being set by states

Courtney Carroll | Region 1 | Office of Site Remediation and Restoration
Amy Parmenter | Rhode Island Department of Health

such as Vermont, New Jersey, and New York. Risk communication guidance on these discrepancies.

Potential Impacts:

If R1 had more toxicity information about PFAS compounds, the region would be much better equipped to understand the risks to human health and the environment, and would be in a much better position to determine the proper cleanup measures.

Guidance on the occurrence and effects of PFAS at small, common facilities such as fire stations and landfills will assist states with focusing limited resources on the most vulnerable drinking water wells, in addition to outreach to facilities on best management practices.

Suggested human health risk communication regarding conflicting state drinking water standards and action levels throughout the region will better inform decisions made by the state and affected public.

OVERCOMING OBSTACLES IN TENTATIVELY IDENTIFIED COMPOUND (TIC) EVALUATION

Overview of the Science Issue:

There are several high-profile Superfund sites in Region 2 where measurements for specific target compounds have detected potentially significant levels of site-related, unknown chemicals. With additional analytical testing, these tentatively identified compounds (TICs) are reported with estimated concentrations and can be identified as a specific chemical or as a member of a chemical family (e.g., volatile and semi-volatile organic compounds).

Currently, there is no clear guidance available to evaluate the human health risks associated with TICs. This lack of guidance can pose significant challenges in characterizing site-specific risk as little toxicity information is generally known regarding a given TIC. As a result, the human health risks associated with exposures to TICs—not only in Region 2, but across all EPA Regions—can be considerably underestimated. Consequently, while TICs may not be selected as the driver for remediation at a given site, failing to account for TICs may ignore additional site-specific pathways of concern (e.g., due to the ability of some TICs to migrate offsite). These issues often create difficulties in establishing TIC cleanup goals and communicating risk to the public.

Ongoing Activities:

Specific TICs can be nominated to the Integrated Risk Information System (IRIS) or Provisional Peer-Reviewed Toxicity Value (PPRTV) programs for the derivation of a toxicity value (*i.e.*, Tier I and II values, respectively). However, TICs do not usually meet national needs, as any one TIC may be unique or infrequently detected across all EPA Regions. As a result, Tier III values (*i.e.*, toxicity values not derived by IRIS or PPRTV) can be used, when available, to evaluate TICs.

In 2013, the OSWER Human Health Risk Assessors Forum (OHHRRAF) assembled a white paper to streamline the process that can be used to identify and select Tier III values[1]. However, publicly available, peer reviewed toxicity values that meet the criteria for being a Tier III toxicity value are often lacking for TICs. The absence of readily available and credible toxicity values represents an obstacle regarding the evaluation of TICs.

In response, members of OHHRRAF have begun compiling a list of TICs nationally detected at Superfund sites along with their concentrations and detection frequencies over a 10-year period. In doing so, this OHHRRAF effort aims to prioritize certain TICs for which additional toxicological evaluation may be warranted. Although this compilation effort is ongoing, resources for site-specific and literature-based research are scarce. Ultimately, the lack of a prioritization scheme represents another obstacle regarding the evaluation of TICs.

Science Needs:

To overcome the above obstacles, the following resources and approaches are envisioned:

<u>Obstacle #1: Prioritization of TICs</u>

In coordination with OHHRRAF members and ORD staff from across the Agency, as well as technical staff within Region 2, additional resources allocated to the collection and analyses of TIC data from various sites could be used

[1] US EPA. 2013. *Tier 3 Toxicity Value White Paper*. Regional Tier 3 Toxicity Value Workgroup. OSWER 9285.7-86. May.

Nick Mazziotta | EPA Region 2 | Emergency Remedial Response Division
Brian Pachkowski | New Jersey Department of Environmental Protection

to prioritize specific, frequently detected TICs at elevated concentrations for further toxicological evaluation. Such a collaboration may identify quantitative benchmarks for frequency of detection and concentration levels that may trigger further Agency action for specific TICs.

Obstacle #2: Identifying Tier III values for TICs

Using the 2013 OHHRRAF white paper as a starting point along with appropriate technical expertise from ORD scientists would help determine a path forward in selecting Tier III values defensible for risk characterization, communication and subsequent decision making for priority TICs. In situations where a Tier III value cannot be identified for a TIC, a focus on the identification and review of the literature for an appropriate surrogate chemical for which a toxicity value has been derived could be used to overcome this obstacle for a priority TIC.

Potential Impacts:

There are numerous Superfund sites across the nation contaminated with high concentrations of TICs having little or no toxicity information. Although media containing site-related TICs are often associated with completed exposure pathways, the corresponding risk estimates are underestimated and highly uncertain due to limited or inadequate toxicity information for TICs.

The ability to streamline TIC toxicological evaluation through prioritization and using the existing OHHRRAF Tier III toxicity value framework coupled with additional toxicological research would allow the Agency to more accurately define risk at both the Regional and National scale. Agency approved toxicity values, or the streamlined approach to obtain them, would be further beneficial to the Agency's State partners.

In addition, although the issue presented here is within the context of TICs and Superfund sites, it is envisioned that the prioritization and toxicity value evaluation approaches identified from this work may be applied to additional contexts. For example, the approaches could be used to prioritize which contaminants of emerging concern found within drinking water supplies are prioritized for evaluation and what approaches are used to identify appropriate toxicity values.

A GROWING NEED FOR PFAS ECOLOGICAL SCREENING LEVELS

Overview of the Science Issue:

Per- and polyfluoroalkyl substances (PFAS) are a large group of manmade, generally persistent, bioaccumulative, and toxic contaminants that cause wide-ranging ecological and environmental effects. PFAS have been used in a diversity of common commercially available household and industrial products, though the most well-known source of PFAS releases to the environment is aqueous film forming foams (AFFF) (Schultz et al. 2003; UNEP 2005; ATSDR 2009; EPA 2009; OECD 2002). AFFF, patented in 1966 for use extinguishing flammable-liquid hydrocarbon fires, releases PFAS to the environment during firefighting, training exercises, and inadvertently when supply lines and tanks leak (DoD SERDP 2012). These foams are frequently used at airports and petroleum refineries including DoD locations such as Air Force bases and naval stations.

Two of the most widely studied PFAS, PFOA and PFOS, can remain in organisms as they undergo limited metabolism due to strong carbon-fluorine bonds. Similarly, due to the strength of these bonds, PFOA and PFOS persist in the environment and are biologically, chemically, and thermally stable. These chemicals pose remediation challenges because of resistance to breakdown via biodegradation, hydrolysis, photolysis, and photooxidation (OECD 2002, Schultz et al. 2003).

The environmental fate and transport of PFAS is not limited to a localized or even regional problem. Some PFAS can migrate through atmospheric, aquatic, and terrestrial pathways and are unlikely to be removed from the environment by natural means. Some PFAS in soil leach into groundwater where they are water-soluble in anionic forms, and migrate long distances threatening surface water (Davis et al. 2007; Post et al. 2012). PFAS are readily bioavailable (Higgins et al. 2007). Atmospheric PFOA and PFOS adsorb to soil and sediment particles, settling onto the ground through wet or dry deposition (Barton et al. 2007; Hurley et al. 2004) and can be transported atmospherically, directly by ocean currents, or as marine aerosols (Armitage et al. 2006, Post et al. 2012). Long-range transport of PFOA and PFOS has been demonstrated by the presence of compounds in the environment in remote areas of the Arctic (Lau et al. 2007; Martin et al. 2004; Young et al. 2007). PFAS are found globally in everything from air, landfill leachate, organisms, sediment, surface water, sewage sludge, to wastewater treatment plant effluent (EPA 2002, OECD 2002). Nationwide, blood samples have shown the presence of PFAS in both humans and wildlife, “indicating that exposure to the chemicals is widespread” (ATSDR 2009, EPA 2006).

Exposure to PFAS varies by species and trophic level. PFOA and PFOS pose a risk to upper trophic levels due to bioaccumulation, the net accumulation in an organism or tissue from environmental media exposures (air, soil, sediment, water) and diet (Sinclair et al. 2006; Kowaleczyk et al. 2012; Vestegren et al. 2013; Quinete et al. 2009), biomagnification, the increase in concentration through multiple levels of the food web (Houde et al. 2006; Müller et al. 2011), and bioconcentration, the net accumulation in an organism resulting from direct uptake (Kannan et al. 2005). Accordingly, PFAS mixtures as well as other chemicals are an important consideration in ecological risk assessments.

Ongoing Activities:

Research is ongoing and PFAS have been increasingly studied with a focus on human health effects; a great need for ecological understanding remains. Many PFAS compounds have not been tested for toxicity and long-term effects are largely unknown. ORD research includes investigating PFAS in water and the impacts to fish population health, which will be used to protect human

Kimberly Plank | Region 3 | Hazardous Sites Cleanup Division
Brie Sterling | Pennsylvania Department of Environmental Protection

health related to fish consumption. An EPA HQ working group regularly discusses regional issues. An Adverse Outcome Pathway is under development. The Ecological Risk Assessment Forum (ERAF) PFAS work group and has reviewed over 380 documents and are in the beginning stages of development of Toxicity Reference Values (TRVs).

Challenges Associated with PFAS

- Inherent chemical properties and carbon-fluorine bond strength make these extremely stable compounds recalcitrant/resistant to degradation by conventional/traditional treatment strategies
- Toxicokinetic complexity
- Variability in half-lives between and within species
- Spatial variation, temporal variation, and comparatively low octanol-water partition coefficients (Ela et al. 2009)
- Robust but diverse animal studies
- Animal studies lack NOAELs

Science Needs:

There are currently no ecological screening values for PFAS adopted by the EPA. Nationally, DoD has identified more than 600 sites with PFAS contamination. Region III has the highest number of federal facilities where PFAS compounds have been identified. Airfields, firefighting training areas, chrome-plating facilities, waste water treatment plants, and landfills are all sites with very high probability of impacting adjacent ecological habitats. Contaminated sites are often immediately adjacent to undeveloped terrestrial habitats and are drained by creeks that can host aquatic wildlife. Due to their moderate solubility in water, offsite transport of PFAS to aquatic habitats is likely due to the expansive radius of impact.

There is a national and regional need for a consistent set of screening levels by ecological risk assessors for aquatic and terrestrial organisms exposed to PFAS- contaminated groundwater, surface water, sediment, and soil. Region III would benefit from additional technical expertise and research to address ongoing and widespread PFAS problems and would like to be involved in the efforts to develop ecological screening levels and other efforts underway to develop knowledge about these compounds. Specific needs include concentrations that are protective of eco receptors exposed to PFAS contamination, ability to identify further evaluation (higher tier risk assessment), and formulation of cleanup levels.

Potential Impacts:

An ecological risk assessment should characterize the exposure and effects of PFAS on ecologically relevant assessment endpoints that are sensitive from both direct exposure and through bioaccumulation. Consideration for ecological risk assessments should include the susceptibility of organisms and the toxicological significance of PFAS. Organisms with the greatest risk are those with both high exposure and high bioaccumulation, as organisms have little or no ability to metabolize PFAS.

The creation of consistent ecological screening levels would aid Risk Assessors, Site Assessment Managers, Remedial Project Managers, and all levels of management in making informed decisions during the hazardous sites cleanup process.

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ACIDOPHILIC MICRORGANISMS FOR USE IN NUTRIENT REDUCTION IN WASTEWATER

Overview of the Science Issue:

EPA Region 4 Superfund Division and the Mississippi Department of Environmental Quality (MDEQ) are seeking solutions for passive pretreatment of acidic wastewater with high nutrient loads. Acidic wastewaters from mining and other industries are present at superfund sites across the country where long-term treatment has become unavoidable. Passive treatment technologies such as biochemical reactors (BCR) provide a low-cost solution and have been exercised successfully for metals removal in acidic mine waters. However, while beneficial for removal of metal ions, BCRs do not directly translate to removal of all contaminants of concern. Likewise, low-intensity treatment technologies such as migroalgae culture ponds are specifically designed for nutrient removal but are not optimized for an acidic environment.

Diammonium phosphate (DAP) fertilizer plants generate acidic wastewater (pH 2.4) with high nutrient loads (phosphorus and nitrogen as ammonia) from rainfall that comes in contact with large phosphogypsum stacks. EPA Region 4 ERRPB has been managing wastewater at the closed Mississippi Phosphates Site under a removal action since 2017 using traditional chemical precipitation treatment methods requiring large volumes of lime. Planned closure of the stack will reduce the rate of impact water generated, but long-term treatment of leachate will still be necessary. A conceptual pretreatment process would be seeding and/or promoting the growth of an acidophilic algae or other acidophilic microorganism in the source water, with the objective of uptake and reduction of nutrient loads. This would increase efficiencies in downstream treatment systems. The technology would be transferable to similar Sites within the EPA Region 4 state of Florida.

Ongoing Activities:

The Mississippi Phosphates Site has been proposed for listing to the National Priorities List, and a Non-Time-Critical Removal Action is planned in the near-term which will begin closure of the uncovered phosphogypsum stack and its ponds. Treatment technologies are being investigated to manage the perpetual leachate that will be generated at the Site. The treatment system will eventually be transferred to the State of Mississippi.

Technical literature has been examined to locate case-studies but: (1) bioremediation case studies for treatment of acidic wastewater are not clear on efficacy of nutrient removal as a contaminant of concern; and (2) bioremediation systems for treatment of phosphorus (such as the A/O Process) are not evaluated against acidic source waters. ERRPB has not been able to measure microorganism species currently within the wastewater at the example site. There is a limited technical capability to conduct these research activities within the branch.

Science Needs:

Assistance is needed in identifying established treatment technologies evaluated in case studies or laboratory studies using source water comparable to water at the Mississippi Phosphates Site. In addition, Identification of microorganisms growing in source water and evaluating their nutrient uptake potential is necessary to determine which known microorganism/s may be suitable. Nutrient removal by microbial treatment could have the additive effect of their assimilation by algae, biological processes (nitrification/denitrification), and stripping phenomena such as ammonia volatilization and phosphorus precipitation. However, bench-scale laboratory testing would be needed to identify growing condition ranges

Matthew Huyser | Region 4 | Superfund Division
Thomas Wallace | Mississippi Department of Environmental Quality

using source water from relevant sites and measuring the nutrient removal rates under those conditions. If artificial measures are necessary to maintain functional growing conditions, then a pilot scale test would be conducted to evaluate the effectiveness of the system.

Potential Impacts:

Several sites that produce acidic wastewater will continue to do so, at least to some degree, in perpetuity. Implementing lower-cost treatment and pretreatment methods will assist EPA and the States in managing these Sites. If the technology is successful and transferable, both government and privately managed facilities may benefit while reducing impacts to the environment.

SUBSURFACE HEATING EVENTS AT SOLID WASTE LANDFILLS

Overview of the Science Issue:

A subsurface heating event is typically characterized by a subsurface landfill fire, slow pyrolysis, or subsurface oxidation (Ohio EPA, 2011). Elevated landfill gas temperature, or higher operating value (HOV), collected at gas extraction wellheads is an indicator of a subsurface heating event (Ohio EPA, 2011). Under the Federal New Source Performance Standards (40 CFR Part 60), landfill gas temperatures at the wellhead must be maintained below 55 °C or 131 °F for non-hazardous or municipal solid waste landfills.

Subsurface heating events are a risk to human health and the environment due to numerous factors that impact human health, safety and the environment. These factors include odors, smoke, toxic emissions, ground and surface water contamination, failure of engineering controls (damage to liner or cap systems), compromised gas control structures, and leachate management (poor quality and increased quantity). Local communities surrounding these landfills are especially at risk because of their potential for increased exposure to these impacts. Elevated temperatures can also kill the microorganisms responsible for the crucial anaerobic degradation within the landfill. The balance between these microorganisms and their ability to keep the various chemical reactions in check can be compromised. As with any biological balance, reduction or death of these necessary microbes can cause a buildup and release of noxious gases or volatile compounds, resulting in a high number of citizen complaints due to the overwhelming odor.

This issue emerged in Region 5 through concerns raised by Ohio EPA resulting from their investigation of reported elevated landfill gas well temperatures and subsequent review of the gas data. A landfill may establish an HOV if supporting documentation of their gas quality and quantity does not indicate a subsurface heating event or inhibition anaerobic decomposition. Ohio EPA considers these HOV requests on a case-by-case basis by evaluating the landfill's supplied supporting data. The state currently has approximately 100 gas extraction wells at seven operating landfills that are reporting landfill gas temperatures above the New Source Performance Standards (NSPS).

What makes this issue more concerning is the potential for these reactions to impact individuals and environments far outside of the immediate scope of the local landfill. Leachate generated during these subsurface heating events increases substantial in volume and as well as decrease in quality (increased ammonia, pH extremes, and increased biological oxygen demand). Thus, potentially resulting in a complete failure of the waste water treatment system to process this liquid and discharge non-contaminated water to streams and rivers. Ultimately, communities and individuals depending on safe water for potable use downstream may be compromised.

Ohio is not an outlier in this situation as this issue is occurring at various municipal solid waste landfills around the nation. But, not all states are conducting a comprehensive, multi-program review of gas wellhead temperature data, thus creating uncertainty about the frequency of subsurface heating events in other parts of the country. Case on point, Illinois' HOV requests are reviewed by U.S. EPA Region 5 Air and Radiation Division (ARD) to review. In light of the situation in Ohio, the RCRA Subtitle D landfill contacts recently met with the ARD staff responsible for these HOV requests to discuss this issue of subsurface heating events. ARD staff stated they have seen an increased frequency of requests from Illinois. One issue of notable concern, is the ongoing collapse of gas extraction wells due to the gas well piping becoming

Camille Lukey | Region 5 | Land and Chemicals Division
Holly Hillyer | Ohio Environmental Protection Agency

unable to withstand the increasingly high gas temperatures within the well.

Ongoing Activities:

Ohio EPA waste and air programs hold monthly meetings with several of the landfills mentioned above, in conjunction with the Regional Air Pollution Control Agency, and the local Public Health Department to discuss the landfill's status for addressing issues arising from their subsurface heating event. The landfill provides monthly reports outlining their progress including gas collection system monitoring, surface emission monitoring, ambient air monitoring, settlement survey, and odor control.

Ohio EPA recently requested the assistance of ORD Researcher, Dr. Thabet Tolaymat, to help investigate the cause and potential remedies for correcting these subsurface heating events at municipal solid waste landfills. The Director of Ohio EPA, Craig Butler, also presented the issue to neighboring states during a meeting earlier this year at the Cincinnati Laboratory. As part of his presentation, Director Butler suggested investigation of elevated landfill gas temperatures as a potential research item of interest.

In Region 5, we are encouraging our state Solid Waste Program counterparts to begin reaching out to their air landfill counterparts to discuss landfill gas temperature data.

Science Needs:

In order to address this issue, additional research efforts involving the cause of these elevated landfill gas temperatures is essential. To initiate this understanding of the root cause of these situations, there appears to be a few main areas: 1) Identify the source of the heat accumulation and the mechanism by which the reactions begin (Ohio EPA, 2011), 2) Develop a thorough understanding of the science behind the breakdown process of municipal solid waste, 3) Recognize the possible interactions and reactions of various waste streams within the landfill's waste mass, 4) Understand how these factors may contribute, exacerbate, or change the heating event, and 5) Develop remediation options. The more we learn, the better equipped we will be to provide critical information to regional states regarding the prevention of subsurface heating events.

Potential Impacts:

If this issue is resolved, the health risk placed on communities surrounding these landfills, and the environmental threats to ground water and air emissions will reduce. Odors will also decrease, which would likely lead to fewer complaints from residents. Lastly, landfills will progress to an operational management position where the landfill is cooler and the gas recovery provides an additional revenue source.

The impact would extend beyond the state of Ohio and Region 5. Landfills around the country that are experiencing HOVs will benefit from this research.

Based on this research, Ohio may develop Best Management Practices (BMP) to help minimize these events. If successful, those BMP will be codified into rule.

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THE CHALLENGES OF PROVIDING SAFE DRINKING WATER

Overview of the Science Issue:

Providing safe drinking water is becoming more challenging in Region 6 due to emerging waterborne pathogens, limited safeguards to prevent contaminants from entering drinking water systems, natural disasters that wreak havoc on drinking water infrastructure, and the lack of supply. These concerns are prevalent in Region 6 due to the population changes in the South, balancing the needs of industry's and society's thirst for water, along with changes in the normal weather patterns.

After the impact from Hurricane Katrina, the State of Louisiana suffered a population change where residents from impacted areas migrated elsewhere. As a result of this, there was less demand for drinking water as the existing distribution system was delivering water to less people creating water stagnation and water quality issues.

Recently Region 6 water systems encountered issues such as contaminants entering the distribution system due to the lack of safeguards in the water system. Increased research into advanced sensing or real-time water quality monitoring efforts would greatly assist the Region in safeguarding the water system and quality. These technologies can assist with accidental releases or determine when compounds such as perfluoroalkyl substances enter the water system.

With the impact from Hurricane Harvey in Texas this past summer dropping over 50 inches of rain to the drought years of 2010 to 2014, availability of water varies from year to year. Additional research is needed on long term water storage and drought resiliency such as direct reuse, rainwater harvesting and long-term water storage are needed for this Region.

Ongoing Activities:

To address these concerns in Region 6, outreach activities focused on water systems such as distribution system optimization, data collection practices and targeted Regional Applied Research Effort (RARE) projects have been utilized to address these issues. Optimization activities such as performing calculated flush times, determining disinfection residuals, monitoring and trending data, along with analyzing water quality parameters have been implemented to assist water systems. In addition, RARE projects related to water quality from direct potable reuse and rainwater harvesting have provided valuable input to water systems and individuals considering these technologies. A recent RARE project related to distribution system water quality focused on disinfection byproducts, nitrification and emerging waterborne pathogens was implemented in the State of Louisiana that will benefit the state along with the partner water systems with tools to assist in the maintenance of water quality.

Science Needs:

The Region would benefit the most by having projects related to drinking water quality that focuses on water treatment and maintaining of water quality throughout the distribution system. Technical expertise related to naturally occurring ammonia in groundwater, and if not properly treated, the potential for AOB biofilms and other associated biological communities to occur in the distribution system, along with controlling lead and copper exceedances would ultimately benefit the Region by empowering Regional staff to have a better understanding of the issue and to think of innovative ways to address these concerns.

The use of additional hands-on and one-on-one training are highly encouraged to build working partnerships with

Andrea Abshire | Region 6 | Water Division
John Williams | Louisiana Department of Health

water systems and States to address these drinking water concerns. Through this approach, ORD can have a field perspective on the actual research that is needed along with how applicable these technologies are to individual water systems, both large and small.

Potential Impacts:

Sharing knowledge and experience to bring awareness of emerging waterborne pathogens and potential drinking water risk factors will benefit everyone involved in maintaining and protecting the public health of community water systems in the Region.

As water system operators in the Region become aware of the issues that directly impact drinking water through education or outreach efforts, public health protection will be greatly improved. Efforts undertaken now before issues arise are easier to manage and building trust among water operators and state partners can go a long way to build relationships.

Overall, the ability to produce safe drinking water is a task that is becoming more and more challenging each day. With the right resources, tools and skill sets the Region along with water systems and state partners can be prepared to address the next water crisis with confidence.

ADDRESSING PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) CONTAMINATION IN REGION 7

Overview of the Science Issue:

Longer chain PFAS, including PFOA and PFOS, are persistent, toxic, mobile, bioaccumulative and can have a deleterious impact on human health and the environment (EPA, 2009d). PFAS compounds are bio-accumulative in humans, animals and plants and evidence exists of bio-magnification between trophic levels. PFOA and PFOS were detected in blood serum in 99% of the US general population between 1999-2012. The half-life in humans for occupationally exposed workers for PFOA is 3.8 years and for PFOS is 5.4 years (EPA 2016).

PFAS compounds' water-resistant and lipid-resistant chemical properties led to their use in a wide variety of industrial and household products in order to enhance stain, grease and water resistance. The use of PFAS compounds in clothing and flooring treatments can be a particularly important exposure route for infants and children because of their hand-to-mouth behaviors (ATSDR 2009).

Adverse health effects from exposure to high concentrations of PFAS compounds include potential links to Parkinson's disease, thyroid disease, kidney cancer, hypertension/heart disease, ulcerative colitis, osteoarthritis, and developmental effects of decreased body weight and neurotoxicity. The U.S. Environmental Protection Agency (EPA) in 2016, issued a Lifetime Drinking Water Health Advisory for PFOA and PFOS each individually and combined at 70 parts per trillion (EPA 2016).

Ongoing Activities:

One of the aquifers in Kansas, with the potential for use as a drinking water source, has detected 950 ppt PFOA and PFOS. The aquifer is not currently a drinking water source. Any future use of the aquifer as a drinking water source will require a remedy that removes the contamination to be protective of public health.

Below I have listed just a few of the documented contaminations in the US in recent years.

- 3M Company in Cottage Grove, MN disposed of PFAS in landfills in Washington County, Minnesota from the 1940s-2002. Leachate from the landfills was identified in 2007 as contaminating groundwater. In 2017 Minnesota Department of Health identified contamination in 120 private drinking water wells and in the municipal drinking water systems of Cottage Grove, Oakdale, Woodbury, St Paul Park and Bemidiji, MN.
- 3M Company and a subsidiary in Decatur, Alabama self-identified in 2007, that they had discharged high concentrations of industrial waste containing PFAS compounds to the Decatur, AL municipal wastewater treatment plant during decades of production, ending in 2002. The Decatur WWTP had land applied biosolids on to 5000 acres in Lawrence, Morgan, and Limestone Counties. PFOA and PFOS were detected at 110ppt in West Morgan-East Lawrence Water and Sewer Authority, nearly 100,000 people in north Alabama were advised not drink water from their taps due to elevated levels of PFOA and PFOS. Affected areas include Morgan County, Lawrence County, Etowah County, Fort Payne, Centre, and West Point.
- Barnstable County Fire Training Academy in Massachusetts used PFAS-containing firefighting foams at its training facility until 2009. The PFAS compounds contaminated two of 11 public water systems wells serving Hyannis, Hyannisport, and West Hyannisport,

Kimberly Burr | Region 7 | Superfund Division
Scott Nightingale | Kansas Department of Health and Environment

Massachusetts. In 2017, the Barnstable County settled a $3 million lawsuit to provide the PWS with the funds to treat the finished drinking water for the removal of PFASS compounds.

Science Needs:

The EPA PFAS Coordinating Committee has identified near term actions that will help support states and local communities address PFAS. R7 is interested in the following work ORD is doing on PFAS:

1. How is ORD providing technical support to EPA Regions, States, Tribes, and local governments?
2. Is ORD addressing critical data gaps in the evaluation of environmental contamination and human exposure to PFAS compounds?
3. How is ORD assisting states with site characterizations at military installations where aqueous, film-forming foams had impacted groundwater, because of the number of potentially-impacted military installations in the Region.

Potential Impacts:

During a detail in Superfund, I produced a Region 7 Superfund Roadmap for Addressing Per- and Polyfluoroalkyl Substances (PFAS) and developed a Tier system of criteria to rank CERCLA sites for the potential for PFAS compound contamination. The State of Nebraska has identified 900 potential sites for PFAS compound contamination in the State. The DoD is planning to sample at Offutt Air Force Base and McConnell Air Force Base in early 2018. All of these potentials for PFAS compound sampling could drive Region 7 to adopt a PFAS action plan and the ROCS-Net could provide an avenue to interact closely with scientists already working on the issue.

References:

EPA 2009. "Provisional Health Advisories for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS)" https://www.epa.gov/sites/production/files/2015-09/documents/pfoa-pfos-provisional.pdf

EPA. 2016. "Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)" https://www.epa.gov/sites/production/files/2016-05/documents/pfos_health_advisory_final_508.pdf

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ATSDR. 2009. "Draft Toxicological Profile for Perfluoroalkyls." http://www.atsdr.cdc.gov/toxprofiles/tp200.pdf

ROCS-Net
Regional-ORD Community of Science Networking Program

PROTECTING DRINKING WATER SUPPLIES: NITROSAMINES AND CHLORAMINES FOR AQUIFER STORAGE AND RECOVERY PROJECTS

Overview of the Science Issue:

In our region, nitrosamines have recently become an issue for our Underground Injection Control (UIC) permits for Aquifer Storage and Recovery (ASR). In these permits, water quality parameters must not exceed background concentration levels or exceed Safe Drinking Water Act concentrations. Public water systems in Colorado desire to inject drinking water into the aquifer for future water demands.

On type of nitrosamines is N-Nitrosodimethylamine (NDMA), which has a 10-6 cancer risk of 0.6 ng/L. NDMA has been detected above 2 ng/L in the ASR applicant's public water system. Thus, NDMA is a concern to prevent contamination of the aquifer, which leads to the question, "Why can I drink it, if it will contaminate the aquifer for future uses?"

Chloramines have been introduced into our public water systems to control regulated Disinfection Byproducts (DBPs); however, the use of this disinfectant contributes to higher levels of nitrosamines, which have a higher cancer risk than currently regulated DBPs.

As noted in EPA's six-year review 3 Technical Support Document for Nitrosamines dated December 2016[1], the Agency is not making a regulatory determination for nitrosamines at this time due to the complexity of maintaining simultaneous compliance for nitrosamines and existing regulations. Thus, the DBP Rule may need to be evaluated to reconcile challenges of protecting our drinking water supplies from byproducts like NDMA in excess of 10-6 cancer risk.

Ongoing Activities:

Ongoing activities regarding the health impacts and tools available to meet nitrosamines concerns have been limited; however, we are considering additional monitoring requirements for ASR permits. Region 8 has been networking with states and regional staff interested in nitrosamine concerns in Aquifer and Storage Recovery projects, and is gathering literature available on this topic.

Science Needs:

A more robust understanding of the laboratory analytical methods needs to be developed. Based on the 10-6 cancer risk, the recommended toxicity level of NDMA is 0.6 ng/L; however, we can only quantitatively measure this contaminant down to 2 ng/L. Thus, more precise analytical methods need to be developed. There doesn't appear to be a clear understanding of the Nitrosamine precursors and treatment techniques to mitigate nitrosamine development. Chloramines appear to have increased levels of NDMA; however, there doesn't appear to be a clear alternative, which will remain in compliance with existing regulations.

Potential Impacts:

If this issue is resolved, we may immediately see more ASR projects proposed in our region which would counter the issue of water mining regional aquifers with limited recharge ability.

In the long term, we may be able to achieve simultaneous compliance between reducing all DBPs of concern while alleviating microbial and corrosion concerns for public drinking water systems.

[1] https://www.epa.gov/sites/production/files/2016-12/documents/810r16009.pdf

Seth Tourney | Region 8 | Office of Partnerships and Regulatory Assistance
Kristy Richardson | Colorado Department of Public Health and Environment

HYDROGEN GAS PERMEABLE MEMBRANE TECHNOLOGY AS A BENEFICIAL ALTERNATIVE TO ETHANOL-BASED FLUIDIZED BED REACTORS FOR EX-SITU TREATMENT OF PERCHLORATE-CONTAMINATED GROUNDWATER

Overview of the Science Issue:

The Nevada Environmental Response Trust (NERT), a RCRA Corrective Action facility located in Nevada (USEPA Region 9), has one of the largest perchlorate groundwater plumes in the nation. Perchlorate, an oxidizer used for munitions and explosives, is highly soluble in water, relatively stable, and mobile in surface water and groundwater systems. As a result, perchlorate groundwater plumes can migrate great distances. In Region 9 (CA, NV, AZ, HI, and Guam), perchlorate-impacted surface water flows across state borders, involving multiple stakeholders concerned about potential impacts to drinking water. The NERT currently operates ethanol-based fluidized bed reactors for the extraction and biological treatment of perchlorate-impacted groundwater. The NERT intends to conduct a treatability study to evaluate Hydrogen Gas Permeable Membrane technology as a potential alternative to the current ethanol-based FBR system.

Ongoing Activities:

The alternative Hydrogen Gas Permeable Membrane technology is like an FBR, in that the treatment is biological. However, the electron donor is hydrogen gas instead of carbon in ethanol, and the bacteria needed for biological reduction of perchlorate are grown on gas-permeable membrane sheets woven of hollow fibers instead of sand or activated carbon. During the hydrogen gas permeable membrane treatment process, the hollow membrane fibers are filled with pressurized hydrogen gas which diffuses through the membrane into the biofilm growing on the outside of the membrane. Perchlorate from the contaminated groundwater in contact with the outside of the membrane also diffuses into the biofilm, and the perchlorate and hydrogen are consumed by the bacteria.

Science Needs:

Hydrogen Gas Permeable Membrane technology is said to yield the following benefits compared with ethanol-based FBRs: (1) reduced operating costs, (2) lower donor cost related to direct addition of hydrogen versus a carbon donor which needs to be converted to hydrogen by the FBR, and (3) waste reduction from a decrease in biomass generation. Although the technology appears promising and is approved in the State of California for drinking water treatment to low ppb levels, there is still limited data supporting that the technology would be a beneficial alternative to FBRs with high influent perchlorate concentrations. The treatability study being considered by NERT in Region 9 may provide evidence that the Hydrogen Gas Permeable Membrane technology is a beneficial alternative to ethanol based FBRs. Region 9 would benefit by having involved the ORD with this issue through the ROCS-Net program, as there may be broader national implications for the ex-situ treatment of perchlorate.

Potential Impacts:

If Hydrogen Gas Permeable Membrane technology is shown to be a beneficial alternative to ethanol based FBRs, a reduction in cost and waste generation at ex-situ perchlorate treatment systems currently using FBR technology could be realized on a larger scale.

Mark Duffy | Region 9 | Land Division
Alan Pineda | Nevada Division of Environmental Protection

GROUNDWATER/SURFACE WATER INTERACTION

Overview of the Science Issue:

Characterizing groundwater/surface water interaction within the hyporheic zone has remained a significant issue at a number of Superfund sites in the Pacific NW. These sites, located where industry was built up alongside rivers or lakes may have contaminated groundwater that subsequently discharges to the surface water body. As an example, monitoring wells located between a decommissioned aluminum smelter and two major rivers have not shown significant reductions in fluoride concentrations after years of monitoring and remediation. This was noted in trend plots of fluoride contamination in the Groundwater Monitoring Reports[1], and the recent Optimization Report[2]. This represents a lack of effective remedial technology/design and is a potential data gap that has not been thoroughly defined. Regarding the characterization of conditions near the GW/SW interface, we note that there are only two permanent wells along approximately 8000 ft. of shoreline. Furthermore, data from these wells do not characterize the temporal and spatial variability in GW/SW interactions caused by tidal changes, seasonal changes in river stage, and other factors.

The river reaches where groundwater may be discharging are rearing areas and migration routes for several economic and culturally important species of fish including runs of endangered salmon and steelhead. Under even low levels in typically soft-water environments, fluoride has been shown to interfere with the migration of species back to their spawning grounds [3]. The fluoride concentrations found in the groundwater at this site exceed these values.

An improved characterization of GW/SW interactions will help identify optimal locations and timing for collecting surface water and pore-water samples. This data will improve our understanding of fluoride impacts to surface water and whether the existing remedy adequately protects the beneficial uses of the Sandy and Columbia Rivers.

Ongoing Activities:

In the past, temporary direct-push wells were spaced approximately 475 ft. apart along the Sandy and Columbia Rivers to get a snap-shot indication of fluoride concentration in the groundwater. These wells were not only temporary in nature, but they were also placed too deep to give a good indication of surface/groundwater interaction. In addition, it is unknown if their locations were representative of potential groundwater discharge locations. Additional monitoring wells are proposed by the PRP to be put in this year along the Columbia and Sandy Rivers, yet samples would again be only a point in time and it is unknown if the locations are representative of primary groundwater discharge areas.

EPA Region 10 is proposing to put in mini-piezometers to measure the water quality in the hyporheic zone including, pH, temperature, dissolved oxygen, conductivity, oxidation-reduction potential, and turbidity. In addition, we will measure the difference in water pressure height between the groundwater and surface water measured with a manometer, and take a water sample to measure

[1] 2017 Groundwater Monitoring and FE/PWO System Operation Report Reynolds Metals Troutdale Superfund Site Troutdale, Oregon, February 2018.

[2] Optimization Review Report Operation and Maintenance Optimization Study Reynolds Metals Company Superfund Site Multnomah County, Oregon EPA Region 10, March 2018.

[3] Camargo, J.A. (2003) Fluoride toxicity to aquatic organisms: a review Chemosphere 50: 251–264

Ted Repasky | Region 10 | Office of Environmental Review and Assessment
Henning Larsen| Oregon Department of Environmental Quality

the ionic fluoride concentration. Again, these measurements represent a single point in time and it is unknown if these values may change with water level changes.

Current monitoring wells at the site are sampled annually or bi-annually to monitor fluoride concentration. The majority of the shallow fluoride plume is assumed to be controlled from migrating off-site through the use of deep high-volume extraction wells (former facility production wells pumping approximately 1,800 gpm). A consequence of operating these deep production wells is that some of the fluoride is being pulled down to a deeper aquifer that is considered a drinking water source.

Science Needs:

An inexpensive method to define the GW/ SW interactions is needed to identify potential groundwater discharge locations to the river so that we can understand a key part of the contaminated groundwater pathway. It would be especially beneficial if the system can be left in place to monitor conditions to evaluate temporal changes due to tidal effects, river stage, and seasonal influences.

An additional science need would be to quantify an aquatic species toxicity and avoidance values for fluoride that can be used throughout EPA. Currently drinking water standards are being used for the discharge of water contaminated with fluoride. However, some studies have shown these to be higher than what fish and other species may tolerate.

Potential Impacts:

If a simple and inexpensive method can be deployed to show where and when groundwater is discharging to the surface water, it would have the potential to better characterize a site and further define the environmental impact. Additional contaminated sites located next to surface water bodies could use the same methodology to quantify the water flux flowing through the hyporheic zone.

An aquatic species toxicity value for fluoride would also help define cleanup levels for contaminated sites next to surface water bodies. This would be encompassing to include not only direct discharge values, but what may also be upwelling through the groundwater flux into the surface water body.