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Emerging Contaminants in Groundwater at BNL

Introduction

This Operating Experience Summary provides information about per-and polyfluoroalkyl substances (PFAS) that have been identified in drinking water and groundwater at the U.S. Department of Energy's (DOE's) Brookhaven National Laboratory (BNL) on Long Island, New York (NY). Due to soil and groundwater contamination from legacy chemical and radionuclide releases, in 1989 the BNL site was included on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The DOE, U.S. Environmental Protection Agency (EPA) and NY State Department of Environmental Conservation (NYSDEC) entered into a Federal Facilities Agreement to coordinate environmental remediation activities at the site.

PFAS are a family of more than 4,500 man-made fluorinated organic chemicals that have been produced since the mid-20th century. They have been used for various purposes such as Teflon®-coated cookware, stain-resistant carpets, water-resistant textiles, food wrappers, and firefighting foam. PFAS has also been used in operational processes such as metal plating, uranium processing, and highly corrosive applications.

Long Island's drinking water is obtained from groundwater withdrawn from an EPA designated sole source aquifer system. Long Island's groundwater is highly vulnerable to contamination as the aquifers are composed of highly permeable sand and gravel. At BNL, because groundwater is encountered very close to the land surface (10 to 50 feet), chemical releases can have almost immediate impacts to groundwater quality.

The source of PFAS contamination at BNL is linked to the historical use of aqueous film forming foam (AFFF) which is used to fight Class B (or fuel) fires.

Background

From 2013 to 2015, water systems serving more than 10,000 customers began testing for PFAS under the Safe Drinking Water Act (SDWA). The SDWA's Third Unregulated Contaminant Monitoring Rule (UCMR-3) program included six PFAS compounds as emerging contaminants of concern.

Currently, there are no specific Federal or NY State drinking water standards for PFAS. In 2016, EPA established a Lifetime Health Advisory Level (HAL) of 70 ng/L (or 70 *parts per trillion*) for the individual or combined concentrations of two PFAS compounds; Perfluorooctane sulfonate (PFOS) and Perfluorooctanoic acid (PFOA). In December 2018, the NY State Drinking Water Quality Council recommended individual drinking water standards of 10 ng/L each for both PFOS and PFOA.

These proposed standards received 2,700 comments when published in the NY State Register in July 2019. They are expected to be finalized and published in 2020.

In March 2017, Suffolk County Department of Health tested water samples from BNL's potable water supply wells for the same six PFAS compounds monitored under UCMR-3. PFAS were identified in three out of five active water supply wells. The presence of PFAS was confirmed by analyzing multiple samples between 2017 and 2019. Although the combined PFOS and PFOA concentrations in the supply wells are typically less than the 70 ng/L HAL, individual PFOS concentrations in three of the wells routinely exceed the proposed 10 ng/L drinking water standard.

In 2018, routine PFAS testing was added to BNL's potable water monitoring program and samples are now tested for PFAS on a quarterly basis.

Groundwater Characterization

In 2018 and 2019, approximately 600 groundwater water samples were tested for 21 PFAS compounds. Most of the samples were collected from temporary monitoring wells installed to characterize PFAS concentrations in supply well source water contributing areas and at known AFFF release areas. Additional samples were collected from existing groundwater treatment systems and extraction wells, and from permanent monitoring wells located in landfill areas, at BNL's wastewater treatment plant and along the BNL site boundary. Samples of the wastewater treatment plant's effluent were also tested for PFAS.

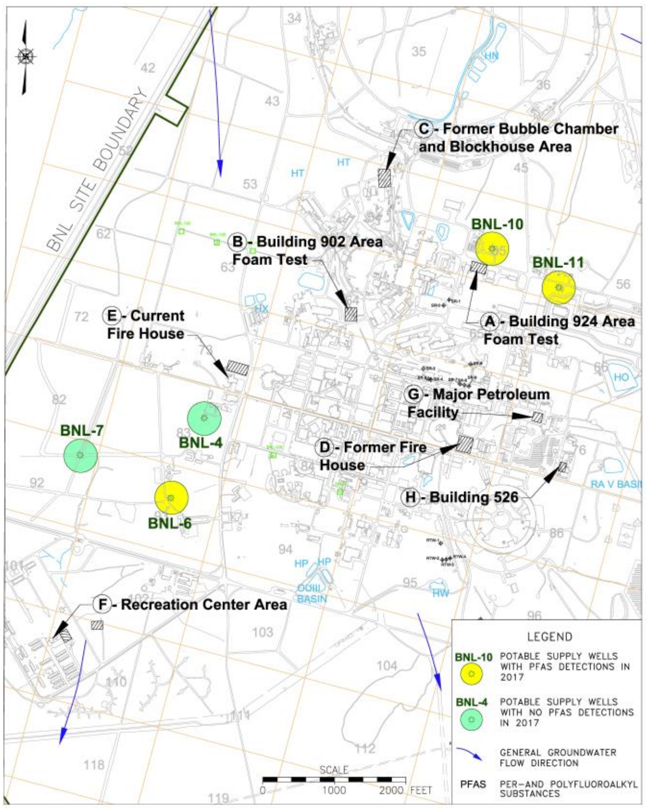

Figure 1. BNL Foam Use Areas and Potable Water Supply Wells

Foam Use Areas

Based upon review of available records and interviews with current long-term firefighters and retirees, eight AFFF release locations were identified and investigated (Figure 1). Most of the AFFF releases were the result of firefighter training (from 1966-2008) and fire suppression system testing and maintenance (from 1970-1980s). PFAS were detected in the groundwater at all eight foam use areas. PFAS were also detected in the groundwater at BNL's wastewater treatment plant, which indicates that AFFF had been released to the sanitary system. The highest PFOS/PFOA concentrations were found in groundwater at the former and current firehouse facilities where routine training with AFFF had taken place. At the former and current firehouse facilities, the maximum combined concentrations of PFOS/PFOA in groundwater were 5,371 ng/L and 12,440 ng/L, respectively. High levels (>1,000 ng/L) of several other PFAS compounds were also detected.

Private Well Testing

The Suffolk County Health Department identified properties hydraulically downgradient of BNL that are not connected to a public water supply. In April 2019, BNL and the Health Department established a cooperative agreement to sample the private wells. To date, approximately 70 private wells have been sampled. Three of the wells were found to have PFOA concentrations slightly above the proposed NY State drinking water standard. Two of the wells are located near a regional airport and one well is near a community firehouse. A recent NYSDEC investigation into potential sources of PFAS contamination downgradient of BNL confirmed the presence of PFAS in shallow groundwater at both facilities. A fourth private well had both PFOS and PFOA at concentrations slightly above the proposed drinking water standards. A possible source for this contamination has not been identified.

PFAS Remediation

Treatment Systems for Drinking Water Supply Wells

BNL is working to reactivate an existing carbon filter system at one supply well and is making plans to reactivate a second system. Granular activated carbon systems are a commonly used treatment method that is effective for long-chained PFAS such as PFOS and PFOA. Breakthrough times are faster for shorter-chained PFAS and if required, an ion exchange resin system could be used.

Groundwater Remediation at Source Areas

Additional characterization work is required to determine PFAS distribution in the groundwater downgradient of the source areas. BNL is currently characterizing the extent of the high level PFAS plumes downgradient of the former and current firehouse facilities. These data will be used to design groundwater treatment systems needed to remediate the plumes.

Soil Remediation at Source Areas

PFAS contaminated soils must be controlled or remediated for the planned groundwater remediation systems to be effective. Monitoring results at BNL have demonstrated that even one-time AFFF releases that occurred nearly 50 years ago continue to impact groundwater quality. Because these chemicals do not break down and persist in soil for long periods of time, the distribution of PFAS in soil needs to be characterized from ground surface to the water table. At BNL, the depth to groundwater in the source areas range from about 10 to 50 feet. There are currently no EPA approved analytical methods for PFAS in soil.

Replacement of Firefighting Foam

BNL had approximately 100 gallons of Class B foam concentrate that was manufactured in 2010. This foam was made with the shorter-chained PFAS (e.g., C-6 fluorosurfactants). There have been no emergency responses or training with Class B foam since 2008.

Fluorine-free foam has been proven to be effective and in 2019 as a best management practice, BNL switched to this type of Class B foam. This eliminates the possible impacts to soil and groundwater from the shorter-chained PFAS which require further study to determine their long term environmental and health impacts.

The PFAS-containing foam was properly disposed of at an authorized off-site treatment, storage, and disposal facility.

Challenges

Sampling

Sampling protocols for PFAS are evolving. Current protocols recommend eliminating all sources of PFAS from the sampling location to prevent cross-contamination, which includes eliminating Teflon®, low density polyethylene, waterproof rain gear/boots/jackets, waterproof field books, insecticides, sunscreen, etc. Significant attention should be paid to the sampling equipment/apparatus and personal protective equipment because of the ubiquitous nature of PFAS.

BNL has dedicated bladder sampling pumps in all routinely monitored wells. The pumps and discharge tubing contain Teflon®. While Teflon®-free pumps and tubing are available, replacing the existing equipment would result in a significant cost impact to the monitoring program. Furthermore, because many of BNL's monitoring wells are used to track volatile organic compound (VOC) contamination, care must be taken to ensure that the VOCs would not preferentially adsorb onto the materials in the replacement pumps and discharge lines. Teflon® is also commonly used in groundwater treatment system piping systems, where it is used in sample valves and as sealing tape at piping connections. BNL is currently evaluating whether the existing equipment is suitable for continued use and acceptable to the regulators.

Characterizing Extent of PFAS in Groundwater

Characterizing the extent of PFAS contamination at BNL will be challenging due to on-site water pumpage and recharge operations, which have changed over time, and have impacted contaminant migration pathways and rates.

Soil Remediation

Until the distribution of PFAS in soils has been defined, it is unclear which remediation method(s) (e.g., *in situ* treatment or stabilization, or physical removal) will be most effective. Furthermore, access to some of the PFAS contaminated soils may be limited by buildings and other structures that have been constructed near several of the AFFF release areas.

Regulatory Challenges

The future is unclear as to what PFAS (other than PFOS/PFOA) chemicals may become regulated, or when those changes will take place. BNL is currently testing for six PFAS compounds in drinking water samples and 21 PFAS compounds in samples collected from monitoring wells and treatment systems. The number of PFAS compounds to be routinely tested for are likely to increase over time. Furthermore, cleanup standards and analytical methods for soil are still being developed.

Conclusion

PFAS are emerging as a global environmental problem, with changes occurring in regulations, standards, and technical methods. At Brookhaven, characterizing the extent of PFAS contamination is complicated by on-site groundwater pumping and recharge operations and the presence of many potential off-site sources that need to be investigated. BNL continues to work in close coordination with the regulatory agencies as it takes proactive steps to determine the extent of on-site contamination and identify appropriate remediation activities. PFAS contamination at BNL is a concern because the depth to groundwater is very shallow and the impacted aquifer is a source of drinking water for the lab and the neighboring community. DOE sites with on-site drinking water sources may want to identify whether they have similar characteristics.

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Resources

EPA PFAS Action Plan

EPA Method 537.1: *Determination of Selected Per- and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*

Brookhaven National Laboratory Website