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U.S. DEPARTMENT OF ENERGY

PFAS Contamination at BNL

DOE PFAS R&D Workshop
Brookhaven Site Office
July 9, 2024

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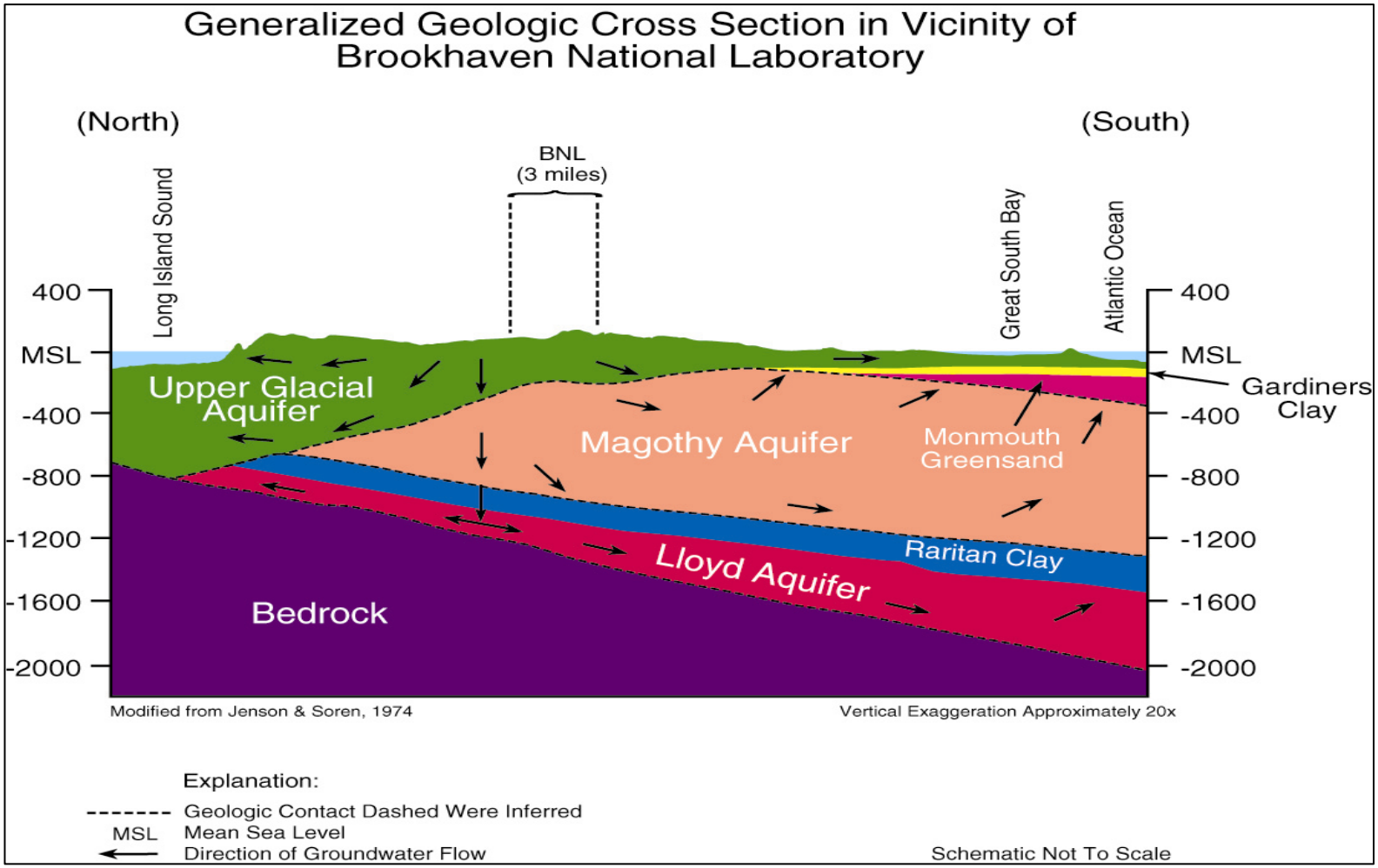
@BrookhavenLab



- **Aquifers are composed of highly permeable sand and gravel**
- **Shallow depth to groundwater (5 – 50 feet)**
- **EPA designated Sole Source Aquifer System**

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PFAS Detected in Groundwater at BNL

2017: PFAS were detected in samples from four BNL potable water supply wells

- Combined PFOS and PFOA concentrations were below the former 70 ng/L (parts per trillion) Health Advisory Level that EPA established in 2016
  - The big question: Where was the PFAS coming from?
  - Initially there was some confusion about BNL's past use of aqueous film forming foam (AFFF)
  - BNL's groundwater monitoring and restoration program was not testing for PFAS

2017-2021: Identified 12 PFAS release areas

- BNL fire protection engineers found records (including several photos) that AFFF had been used during the 1970s and 1980s for fire suppression systems at several research facilities
- Search of BNL's photo archive and discussions with long-term firefighters helped to identify several other AFFF release areas
- Four release areas are located within source water contributing areas of BNL's water supply wells

Summary of PFAS Releases

Foam Releases (AFFF)

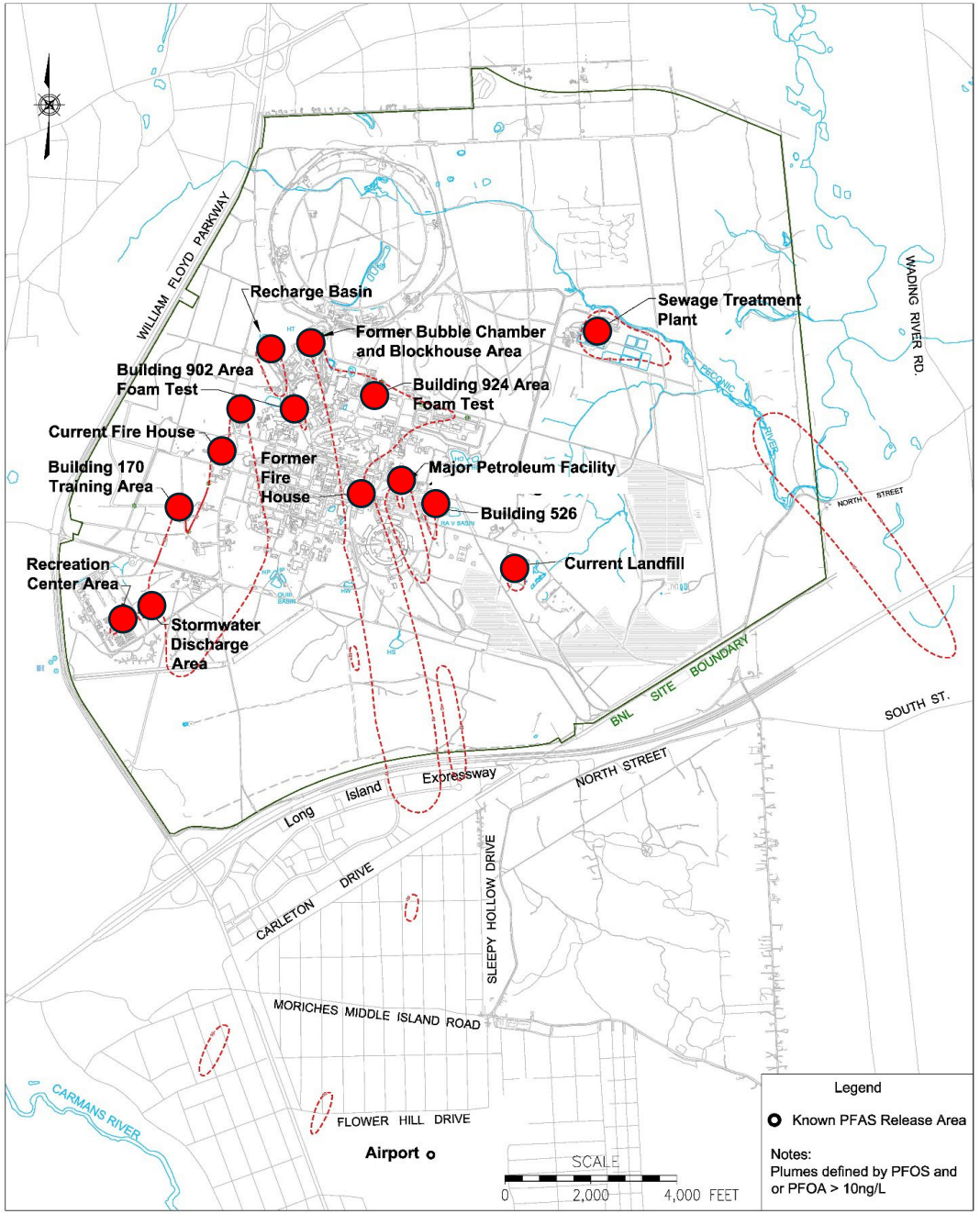
- **Firefighters**
  - Firefighters released foam in five areas (that are known)
    - Highest PFAS concentrations in groundwater are associated with three primary firefighter training areas
    - Training with foam was conducted from 1966 - 2008
    - PFAS-free foam was purchased in 2019
- **Fire Suppression Systems**
  - Four suppression systems were located at research facilities
    - Foam was released to adjacent outdoor areas during periodic system testing
    - The suppression systems were decommissioned in the 1980s

Other PFAS Releases

- **Landfill Disposal**
  - Low levels of PFAS detected in groundwater at a closed on-site landfill
- **Discharges to Sanitary System**
  - PFAS impacted potable water used for sanitary system operations
    - PFAS detected in groundwater at the sanitary treatment plant
    - Possible AFFF releases to firehouse floor drain that is connected to sanitary
    - Possible sanitary line leakage may have spread PFAS
- **Potable Water**
  - Uncertainties about when PFAS started to impact wells and concentrations
    - PFAS detected at water treatment facility which removes high levels of natural iron in water from several of the PFAS impacted supply wells
    - Routine flushing of water lines/fire hydrants may have spread PFAS
    - Potable water is used for cooling systems – which is discharged to recharge basins

Identified PFAS Release Areas

Groundwater quality has been impacted in each release area



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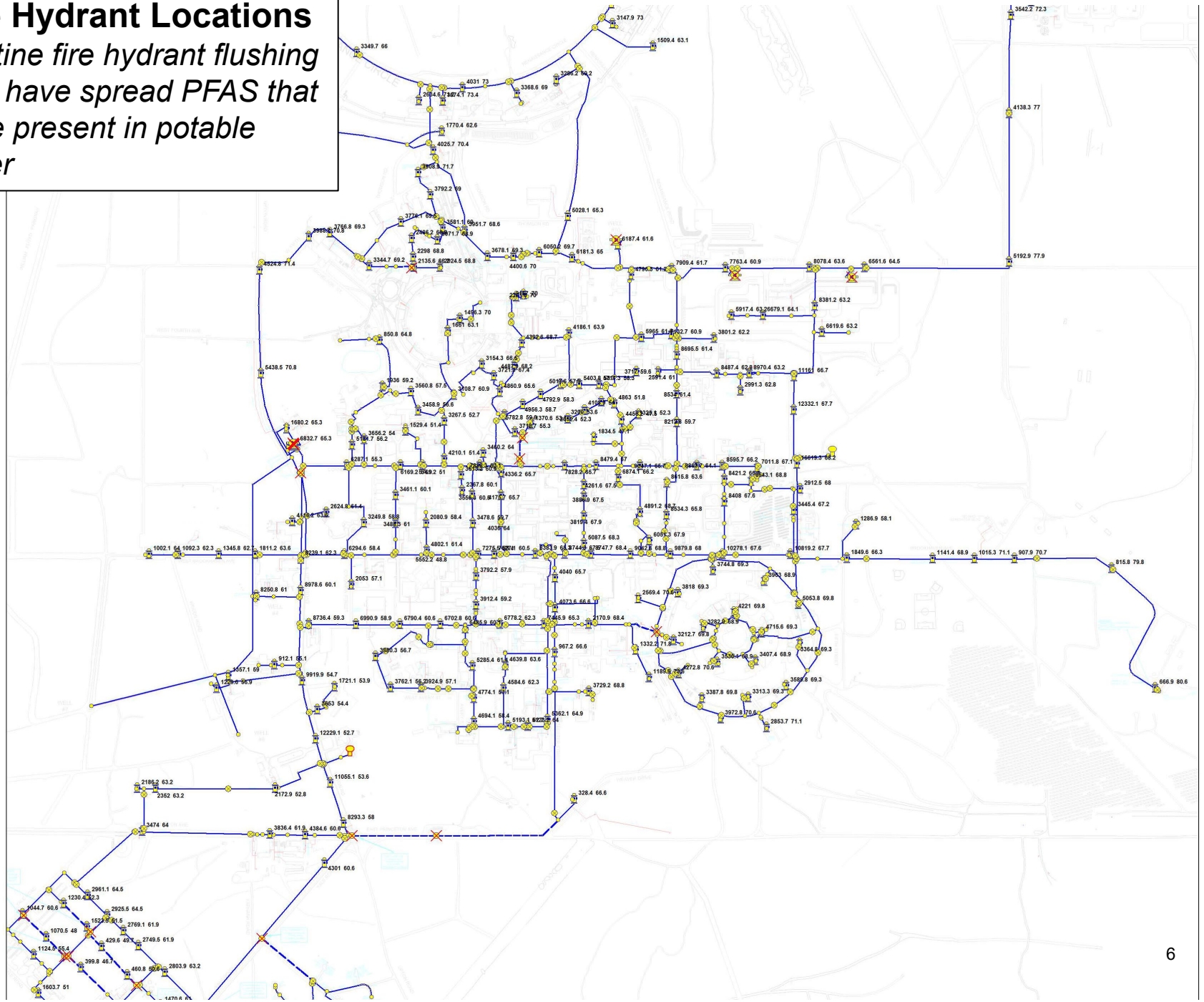
Fire Hydrant Locations

Routine fire hydrant flushing may have spread PFAS that were present in potable water



PFAS in Rainwater (May 2020)

- Samples collected from two BNL rain collection stations
  - PFAS not detected in the rain sampler equipment blank or field blank
  - Analyzed by Method 537.1

	Station P4 (ng/L)	Station S5 (ng/L)
PFOS	ND	ND
PFOA	**2.79**	**2.2**
PFNA	**1.99**	**2.01**
PFBA	ND	**2.8**
6:2 FTS	ND	**5.01**
PFHpA	**1.63 J**	**1.38 J**
PFHxA	**1.36 J**	**1.14 J**
PFPeA	**0.59 J**	ND
PFUnDA	**0.64 J**	ND
PFOSAm	**1.02 J**	ND

J: Estimated concentration
ND: Not detected

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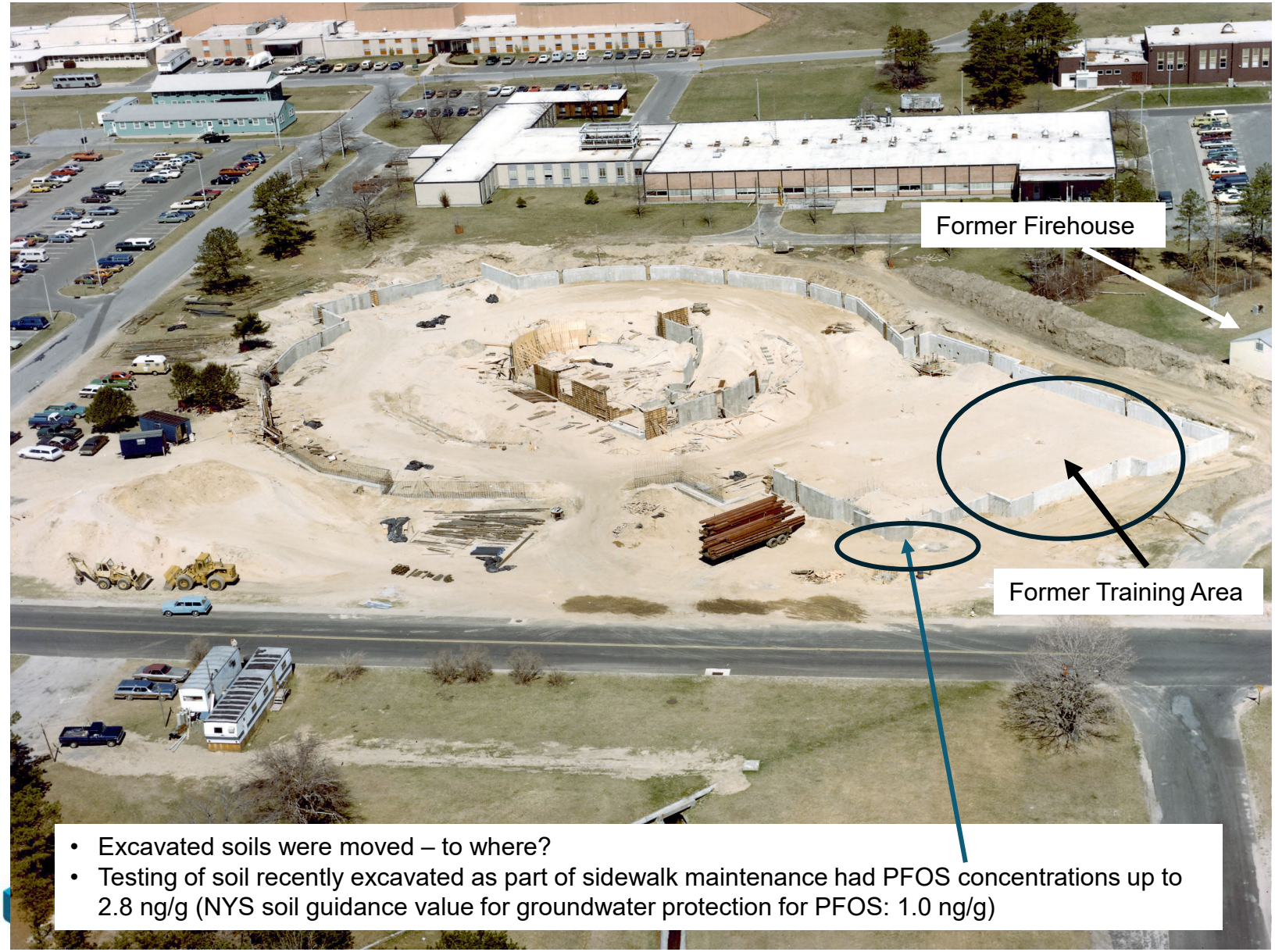
Former Firehouse (1947-1985)
Training Area

Former Firehouse Training Area

Construction of Building 725 - Former NSLS Facility (1979)



- Excavated soils were moved – to where?
- Testing of soil recently excavated as part of sidewalk maintenance had PFOS concentrations up to 2.8 ng/g (NYS soil guidance value for groundwater protection for PFOS: 1.0 ng/g)

Current Firehouse (1986-Present)

Primary Foam Training Area (1986-2008)

Building 170 Foam Training Area (1986-1990s?)

Training area "rediscovered" during PFAS plume characterization

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Fire Suppression System Test - Building 902 Area

Former Bubble Chamber Experiment Area #1

Foam release area now covered by ~10 feet of soil

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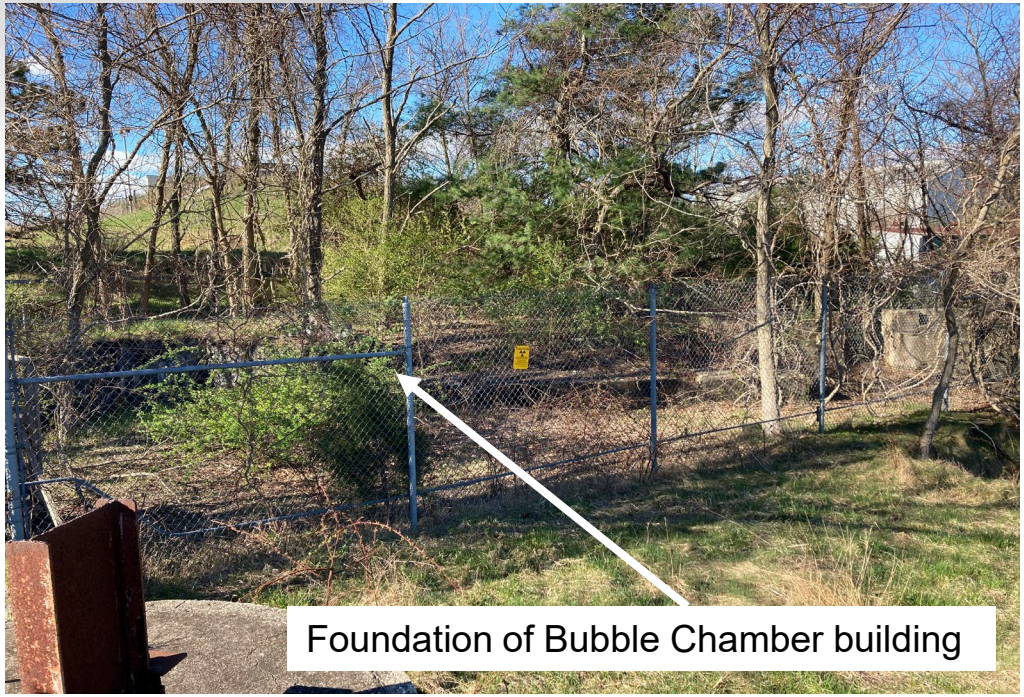
Building Fire Suppression System Test
Former Bubble Chamber Experiment Area #2

Today



Most of the foam release area is now covered by the AGS to RHIC beam line (soil berm)

Efforts to Understand Extent of PFAS
(2017-2024)

Tested for PFAS at ~800 on-site and off-site locations

- ~465 on-site and off-site monitoring wells
  - Routine sampling of 100+ wells for the new PFAS treatment systems
- ~210 temporary (one-time use) groundwater monitoring wells
  - Collected ~10 samples at each well to determine the vertical distribution of PFAS
- On-site and off-site groundwater treatment systems
  - Individual extraction wells
  - Treatment system influent and effluent
- BNL's sewage treatment facility influent and effluent (2019-2020, 2024)*
- Rainwater (2020)
- Routine testing of BNL's water supply wells (quarterly since 2018)
- Cooperative testing with county health department of 82 private wells (2019-2020)
  - Four private wells that are part of a long-term monitoring program are tested annually for PFAS (2018-present)
- To date, only limited testing of soils for PFAS

*NYS is requiring BNL to conduct three months of testing of SPDES discharges for PFAS and 1,4-dioxane – to be completed by October 31, 2024

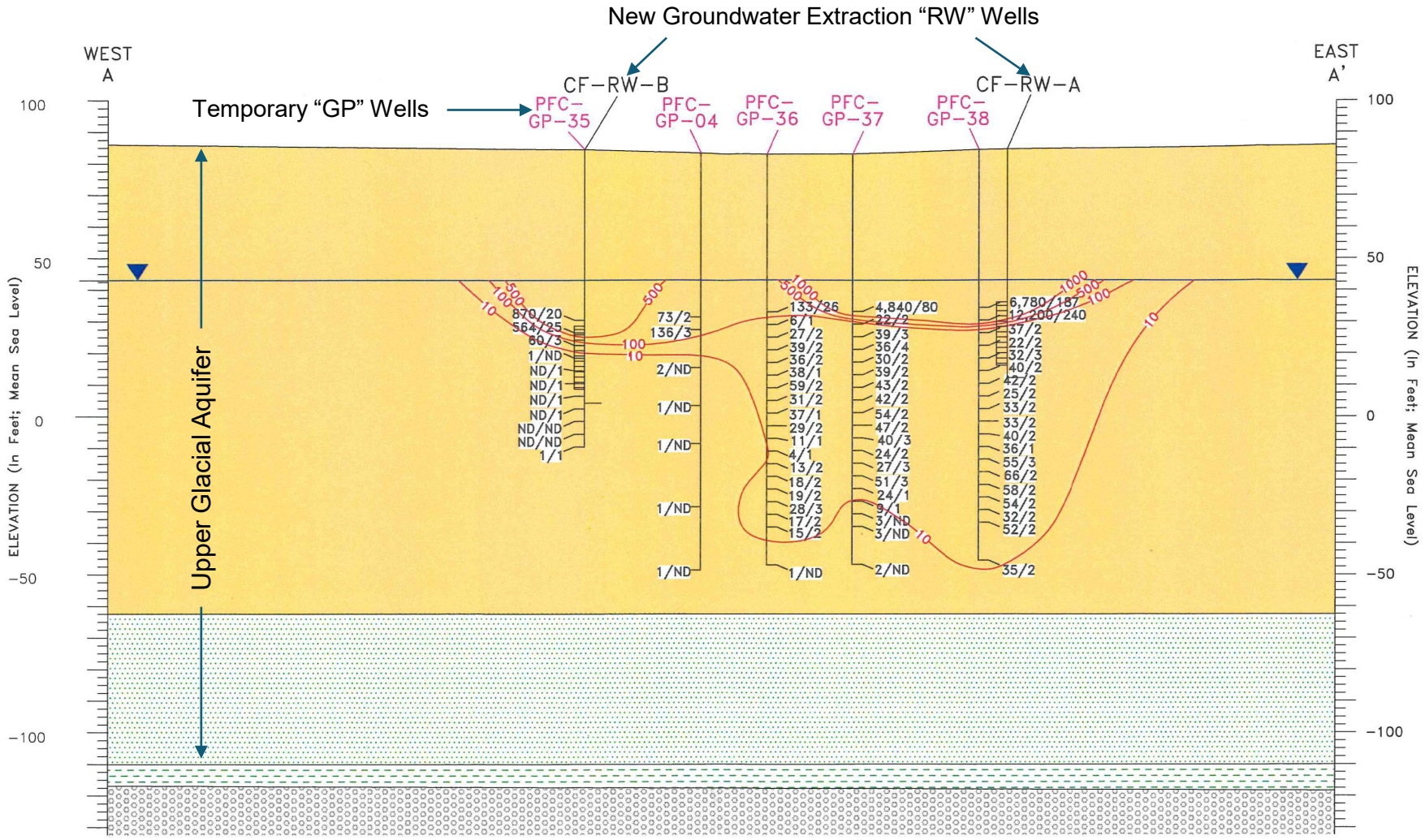
Testing for PFAS in Groundwater


Sampling a permanent monitoring well


Sampling a temporary “GP” well

- BNL has an extensive network of on-site and off-site groundwater monitoring wells
- BNL installs temporary groundwater monitoring wells to fill in data gaps in monitoring network and to conduct initial characterization of contaminant plumes
- Precautions are taken to prevent/limit cross contamination during sampling (e.g., PTFE)

Temporary wells used to profile vertical distribution of PFAS in groundwater



Current Firehouse Source Area

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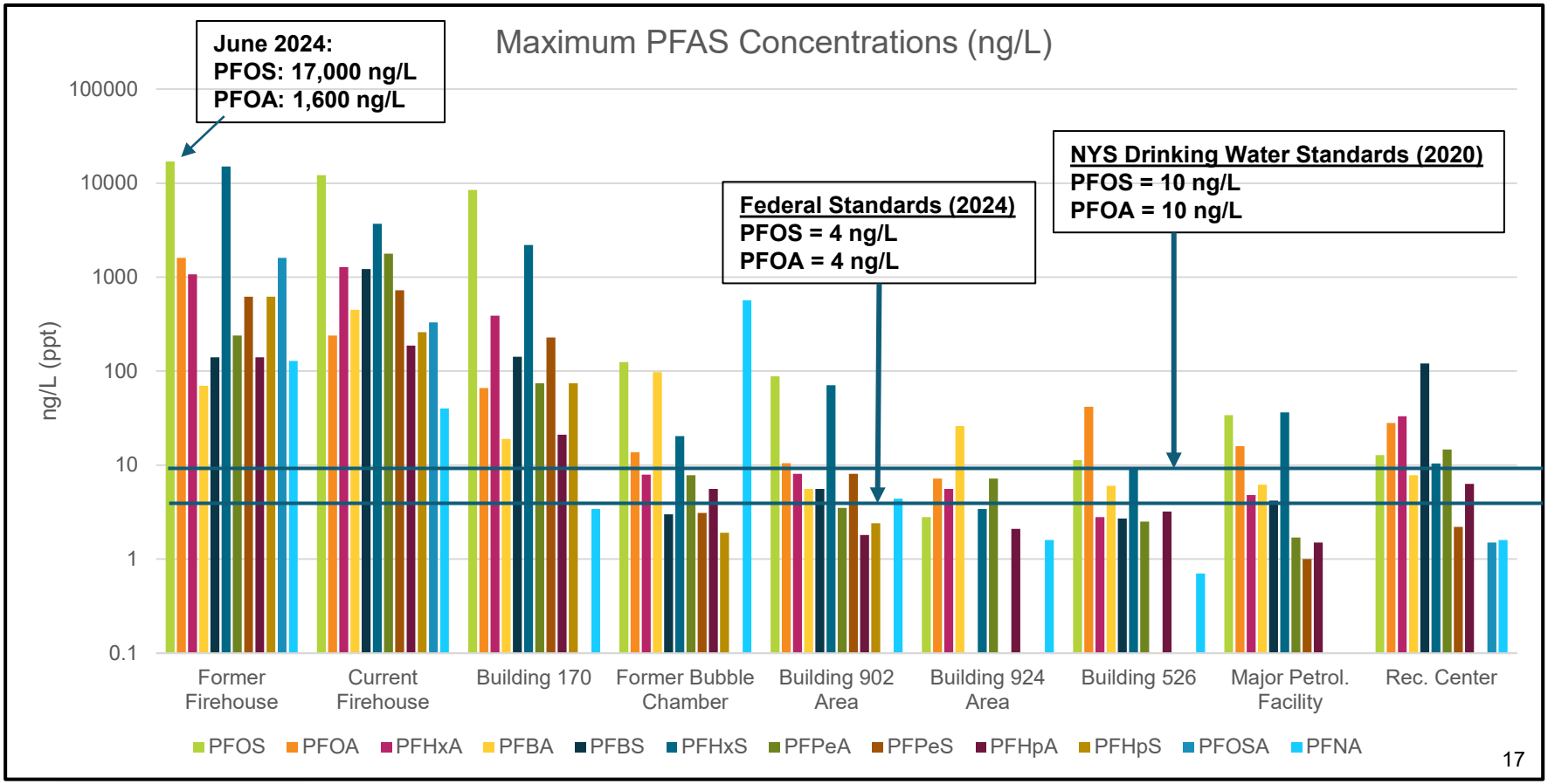
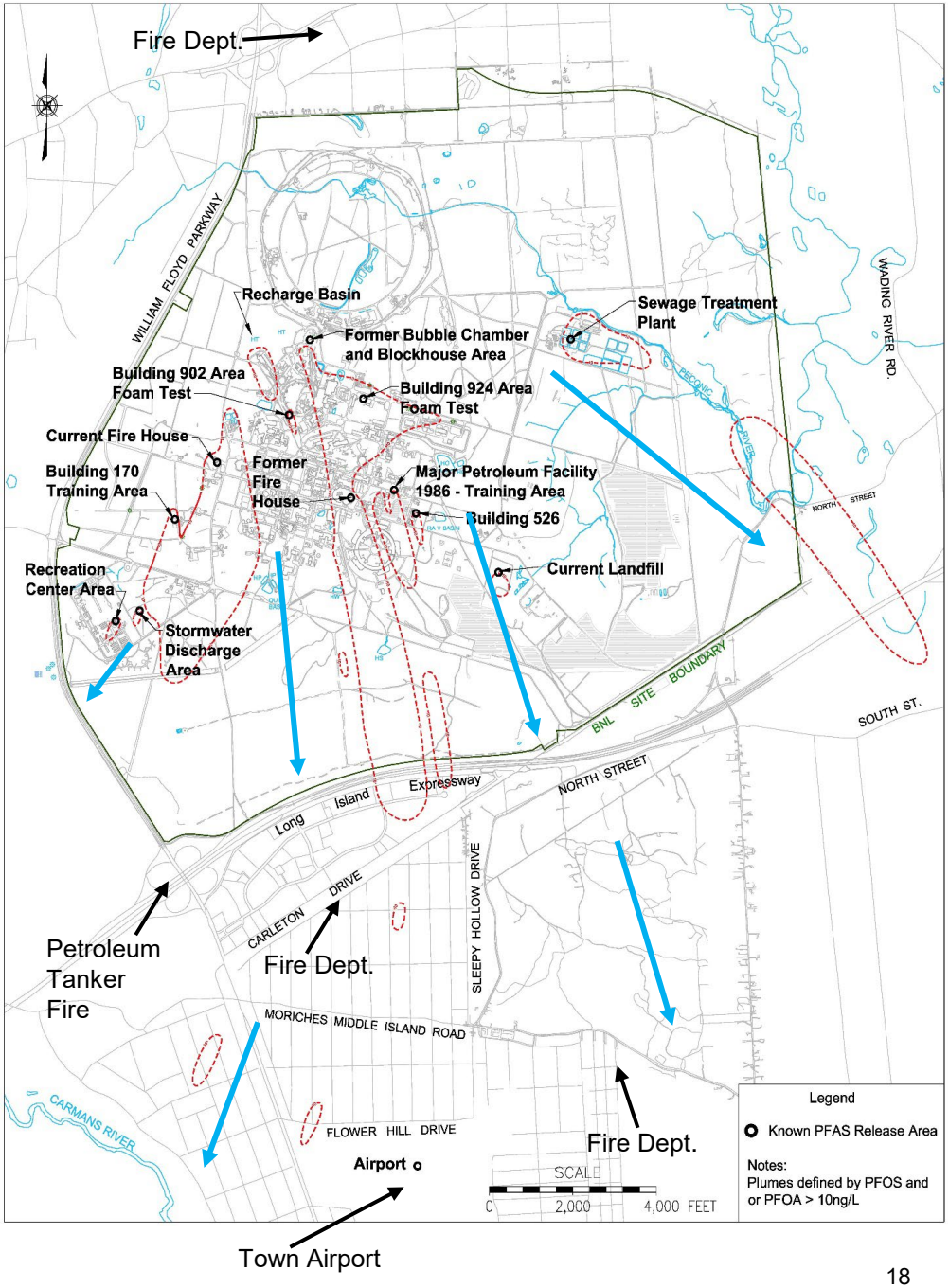
PFAS in Groundwater at Foam Release Areas

- Groundwater samples during 2018-2022 were tested for 23 PFAS (537.1)
- Current analytical methods test for up to 40 PFAS (1633)
  - ~15 different PFAS are routinely detected in groundwater samples
  - Highest concentrations are usually PFOS, PFOA, PFHxS, PFHxA, PFHpA, PFHpS



Known Extent of PFAS in Groundwater

- BNL PFAS plumes extend off-site in several areas
  - Additional characterization is required
- Known/potential off-site sources:
  - Town Airport
    - Now a NYS Superfund site due to PFAS contamination
  - Local fire departments
    - FD substation adjacent to the airport is now a NYS Superfund site due to PFAS contamination
  - Response to vehicle fires along local roadways?



CERCLA Response: PFAS and 1,4-Dioxane*

- Investigations and remedial responses are conducted under the Interagency Agreement (IAG) between DOE, EPA and New York State
- Operable Unit (OU) 10 was established in 2021
  - Current scope is to address PFOS, PFOA and 1,4-Dioxane
    - Likely to cover additional PFAS as they become regulated
  - Remediation of three high concentration PFAS plumes is being conducted as a Time Critical Removal Action (TCRA)
  - Remedial Investigation/Feasibility Study (RI/FS) will be required to fully characterize the plumes and develop additional remedial responses

*BNL is also investigating the extent of 1,4-dioxane, which was used as a chemical stabilizer for the solvent 1,1,1-Trichloroethane (TCA). TCA has impacted groundwater quality in several on-site and off-site areas. The treatment systems used for VOCs such as TCA are not effective for 1,4-dioxane.

Time Critical Removal Action

- BNL constructed two treatment systems to remediate groundwater with highest PFAS concentrations
  - Current Firehouse/Building 170 treatment system operations started in October 2022
  - Former Firehouse treatment system operations started in January 2023
- Combined, the two systems can treat ~750 gpm of PFAS contaminated groundwater
  - Water is treated using Granular Activated Carbon (GAC) filters
  - Treated water is returned to the aquifer using recharge basins
  - The systems are meeting NYS Effluent Limits* for PFOS and PFOA that are lower than the 10 ng/L NYS drinking water standards, and the new 4 ng/L federal standard for PFOS
    - PFOS: 2.7 ng/L
    - PFOA: 6.7 ng/L

Note: Two other on-site treatment systems do not currently meet the effluent limit for PFOS

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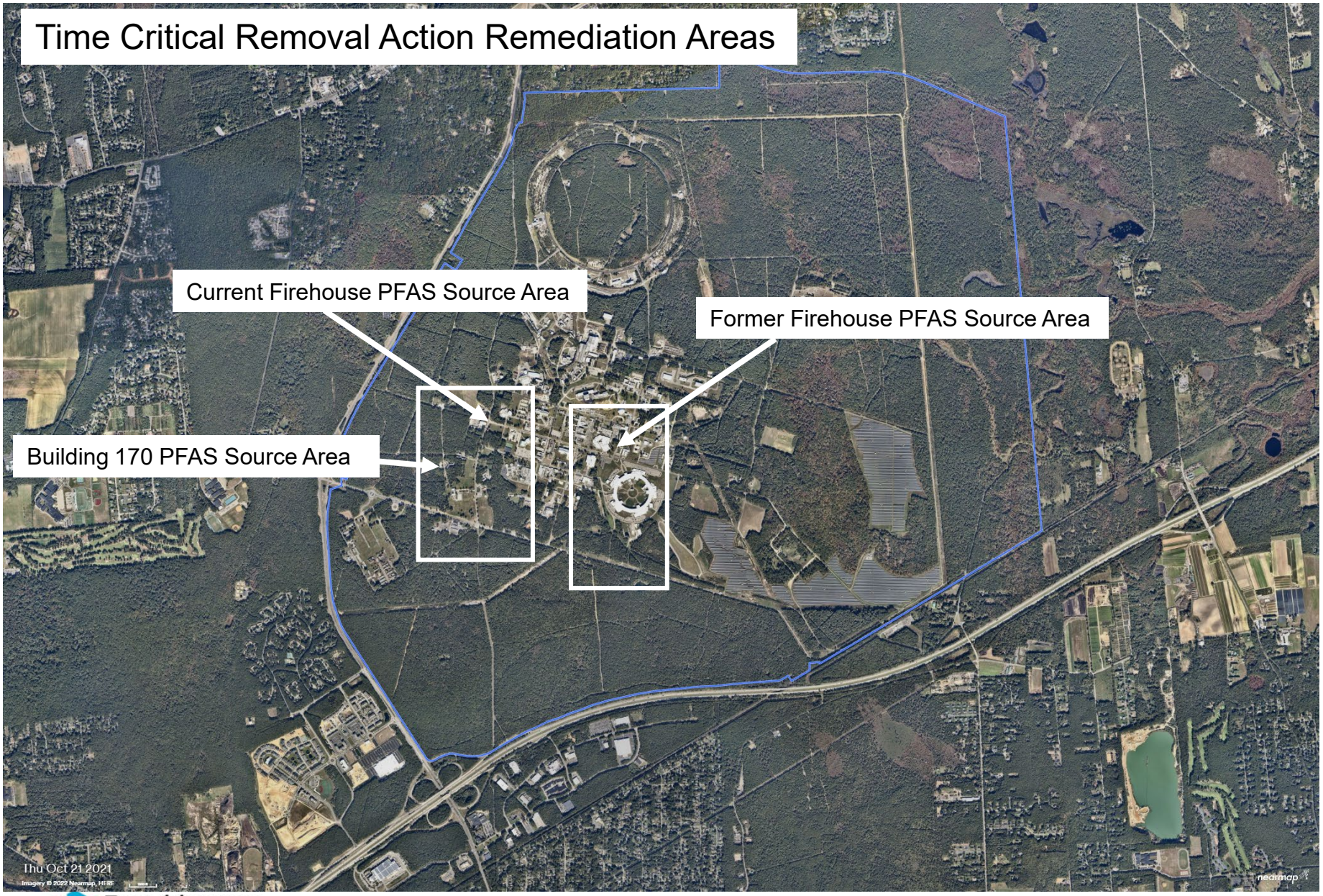
* NY State Ambient Water Quality Guidance Values Published March 15, 2023

Time Critical Removal Action Remediation Areas



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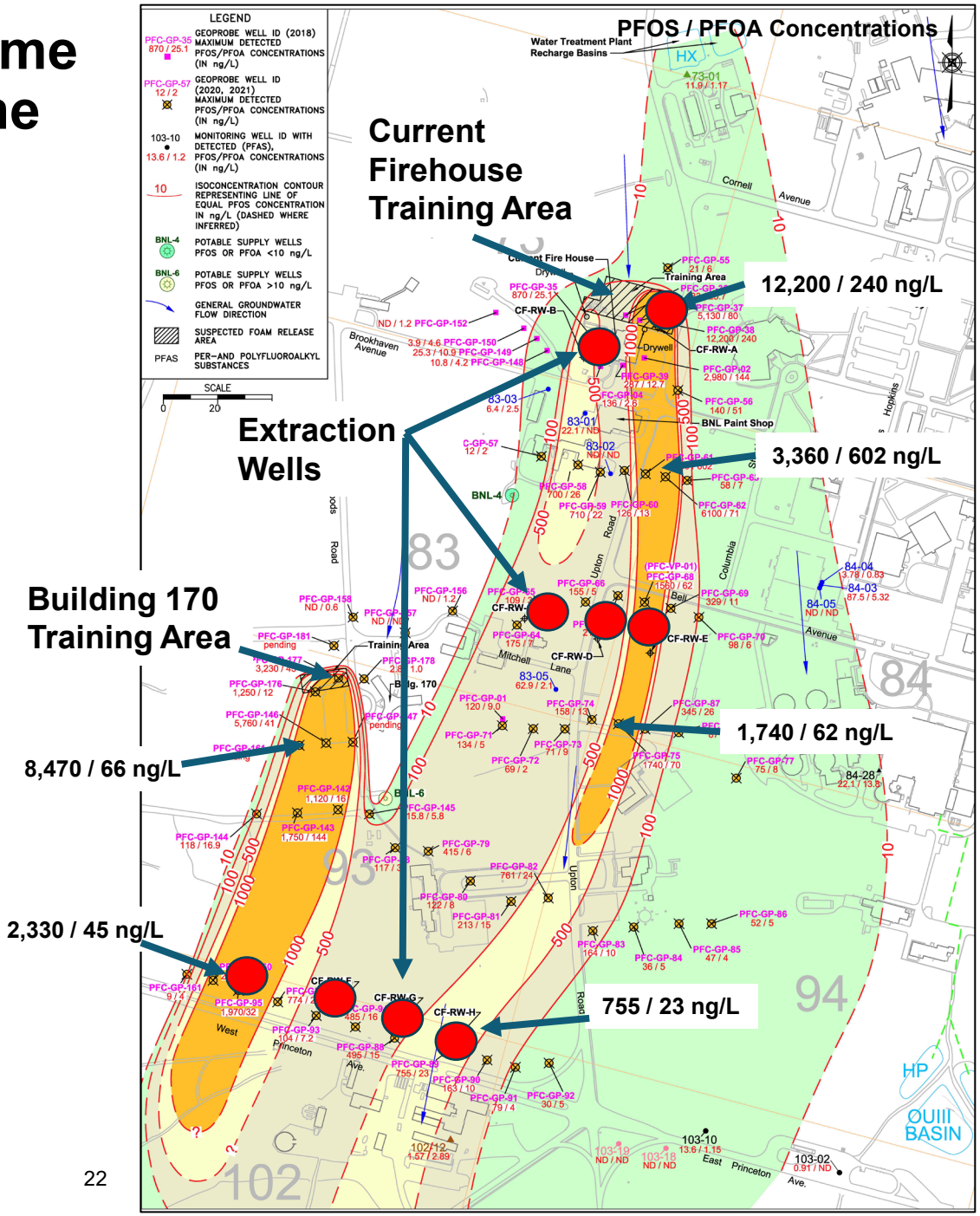
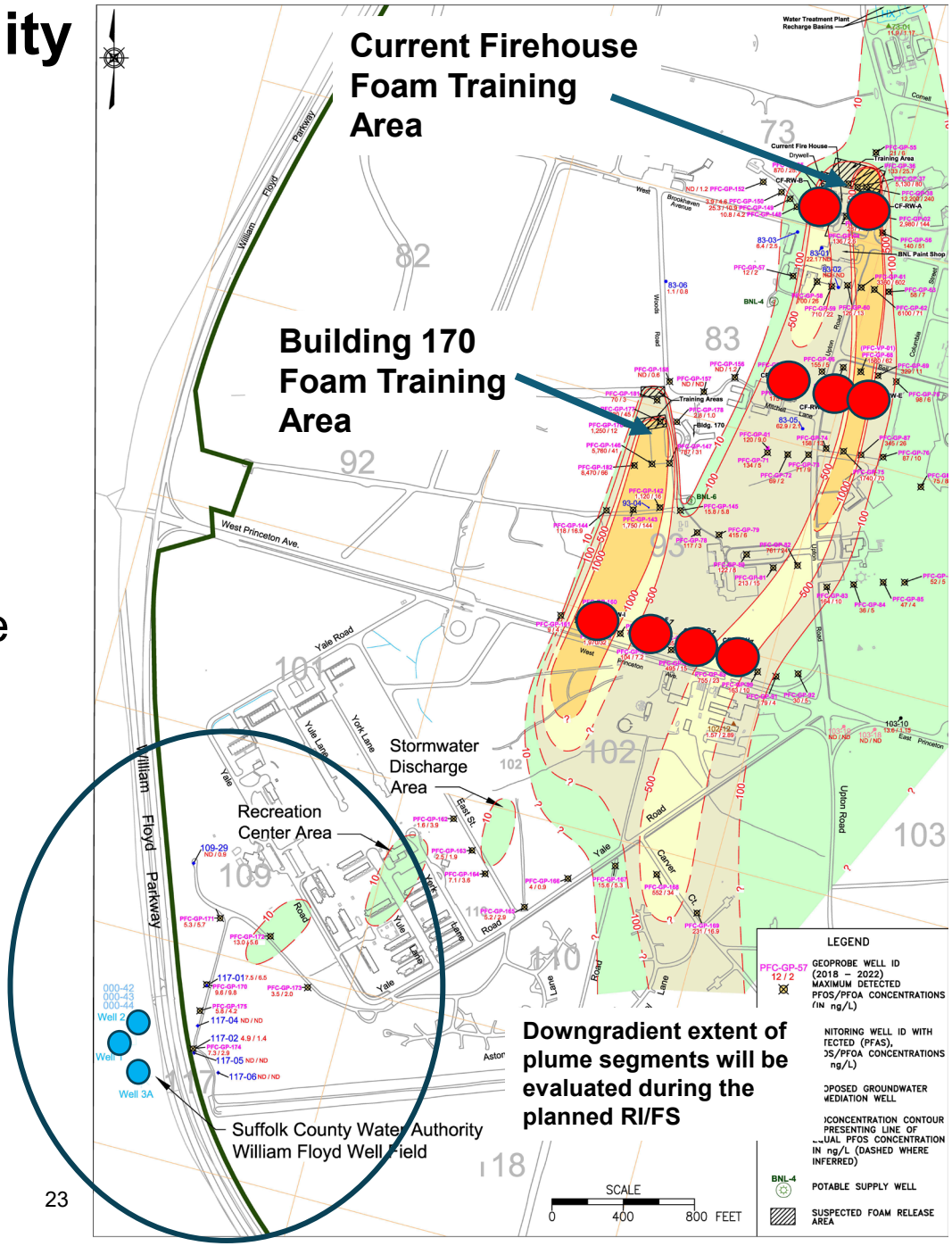
Current Firehouse Plume and Building 170 Plume Remediation

- Installed 87 temporary vertical profile wells to characterize plumes
  - Each well had ~10 sample intervals
- Treatment System
  - Nine extraction wells
    - Pump ~500 gpm
  - Goal is to remediate groundwater with PFOS or PFOA concentrations >100 ng/L



PFAS Plumes in Proximity to Off-Site Municipal Water Supply Wells

- PFOS (<5 ng/L) and PFOA (<2.5 ng/L) detected in several off-site municipal supply wells
- Low-level BNL PFAS source area is present within the well field's source water contributing area
- The off-site supply wells do not have GAC filters
- BNL shares monitoring results with the county health department and water authority



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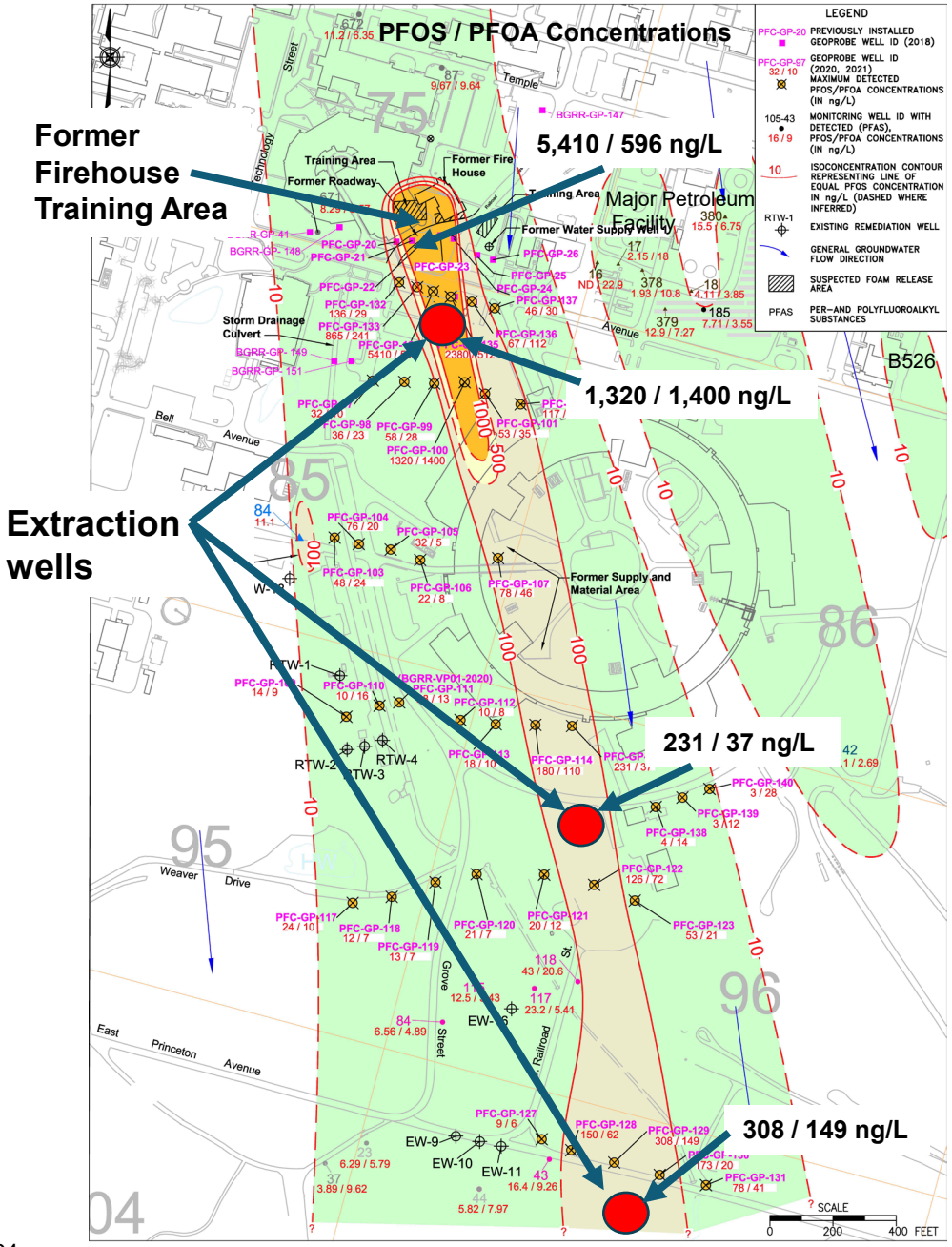
Former Firehouse Plume Remediation

- Installed 51 temporary vertical profile wells to characterize plumes
  - Each well had ~10 sample intervals
- Treatment System
  - Three extraction wells
    - Pump ~250 gpm
  - Goal is to remediate groundwater with PFOS or PFOA concentrations >100 ng/L



PFAS plume extends south beyond site boundary

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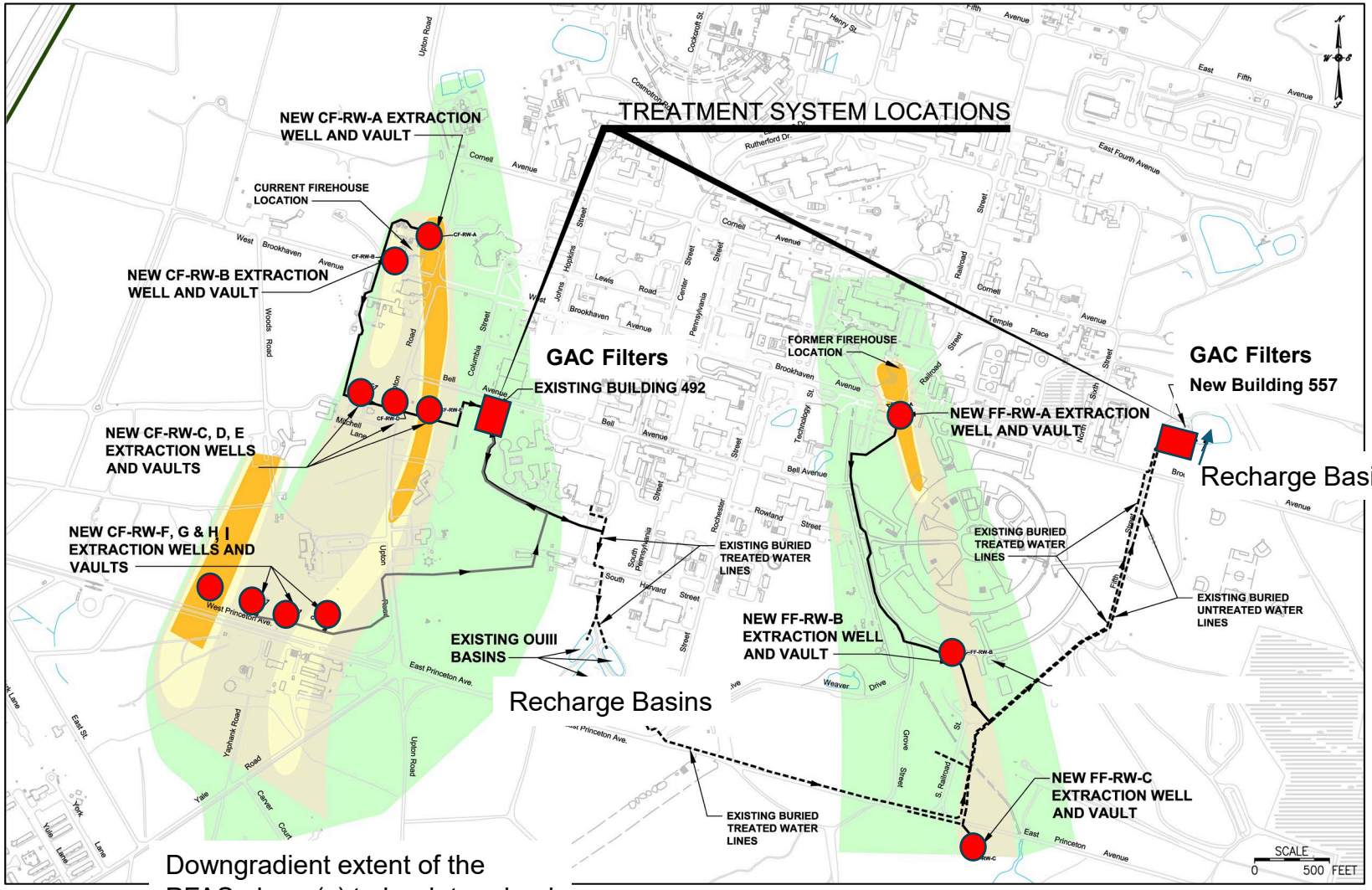
PFAS Treatment Systems



Downgradient extent of the PFAS plume(s) to be determined during planned RI/FS

PFAS plume (>10 ng/L) extends south beyond site boundary

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Treatment System for Former Firehouse PFAS Plume

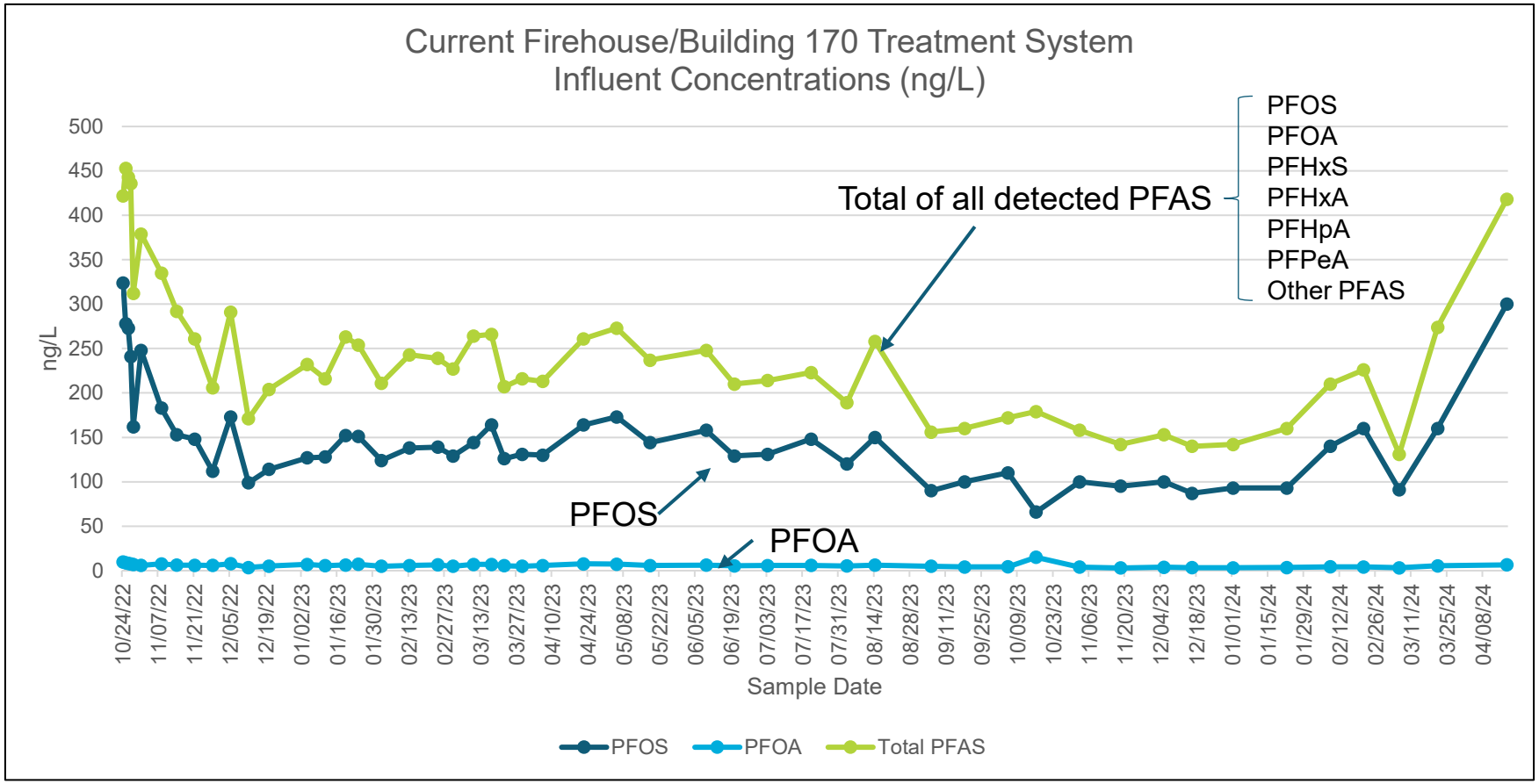
Granular Activated Carbon Filters

Photo Credit: DHGCarbon

Current Monitoring Program

- Treatment system influent, midpoint and effluent are sampled 2 times/month
- Individual extraction wells are sampled 1 time/month
- 118 monitoring wells
  - 23 source area monitoring wells are sampled 4 times/year
  - Remaining plume monitoring wells are sampled 2 times/year

Current Firehouse/Building 170 Treatment System
Influent Concentrations



- **Most PFAS are not detected in the treatment system effluent**
- **PFBA is periodically detected in effluent (<2.5 ng/L)**

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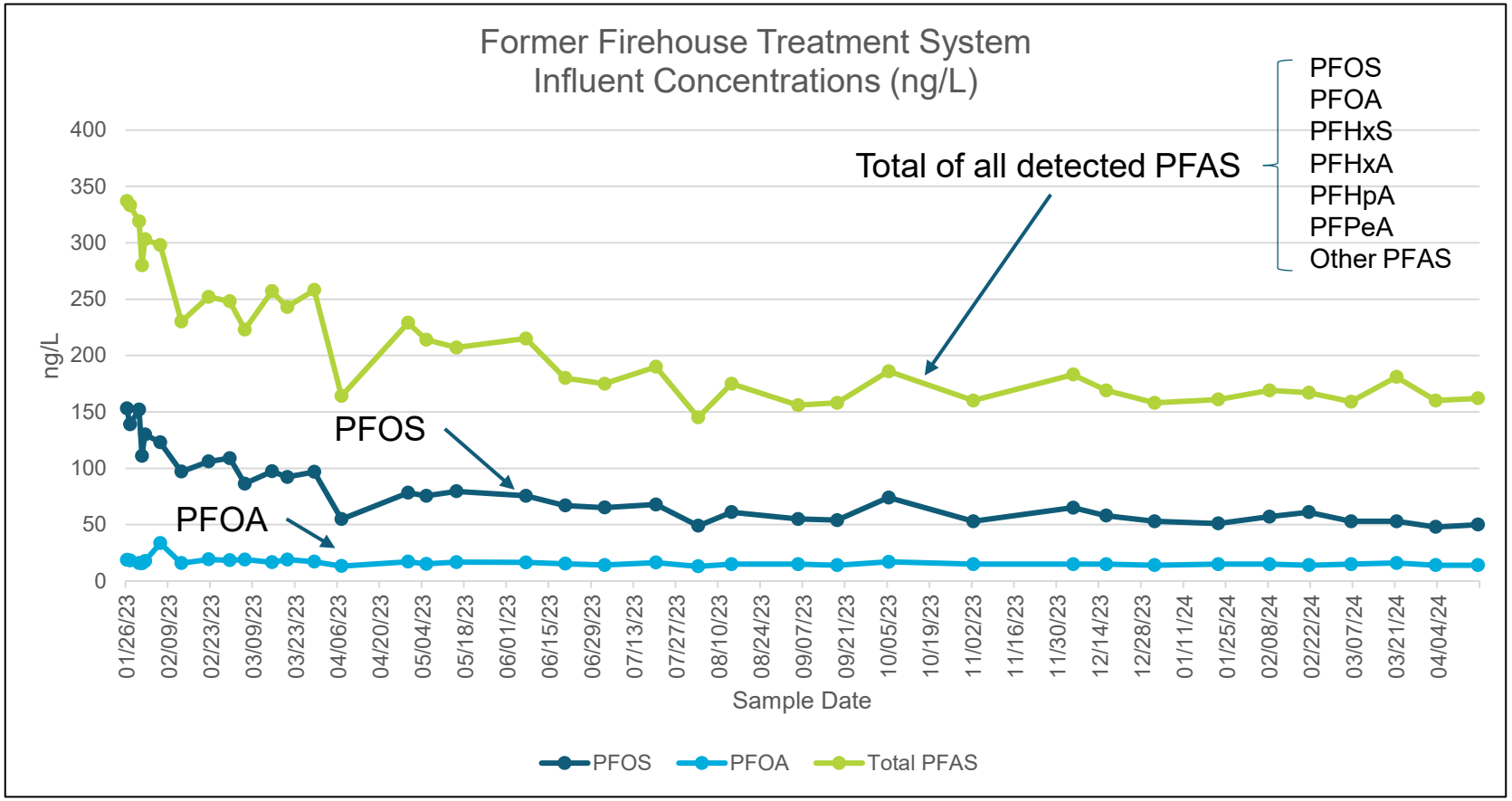
Former Firehouse Treatment System
Influent Concentrations



- **Most PFAS not detected in the treatment system effluent**
- **PFBA is routinely detected in effluent (up to 12 ng/L)**

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Treatment Totals

To date, the two treatment systems have:

- Treated ~300 million gallons of groundwater
- Removed ~0.6 lbs. of total PFAS

GAC Filter Maintenance

In November 2022, BNL received DOE approval to have spent GAC thermally treated (reactivated) at the GAC supplier's facility in Pennsylvania

Current Firehouse/Building 170 System

- After eight months of operation PFOS was consistently detected in mid-point samples (up to 11 ng/L), but not in the effluent
  - November 2023 and June 2024: GAC in the lead vessel was changed

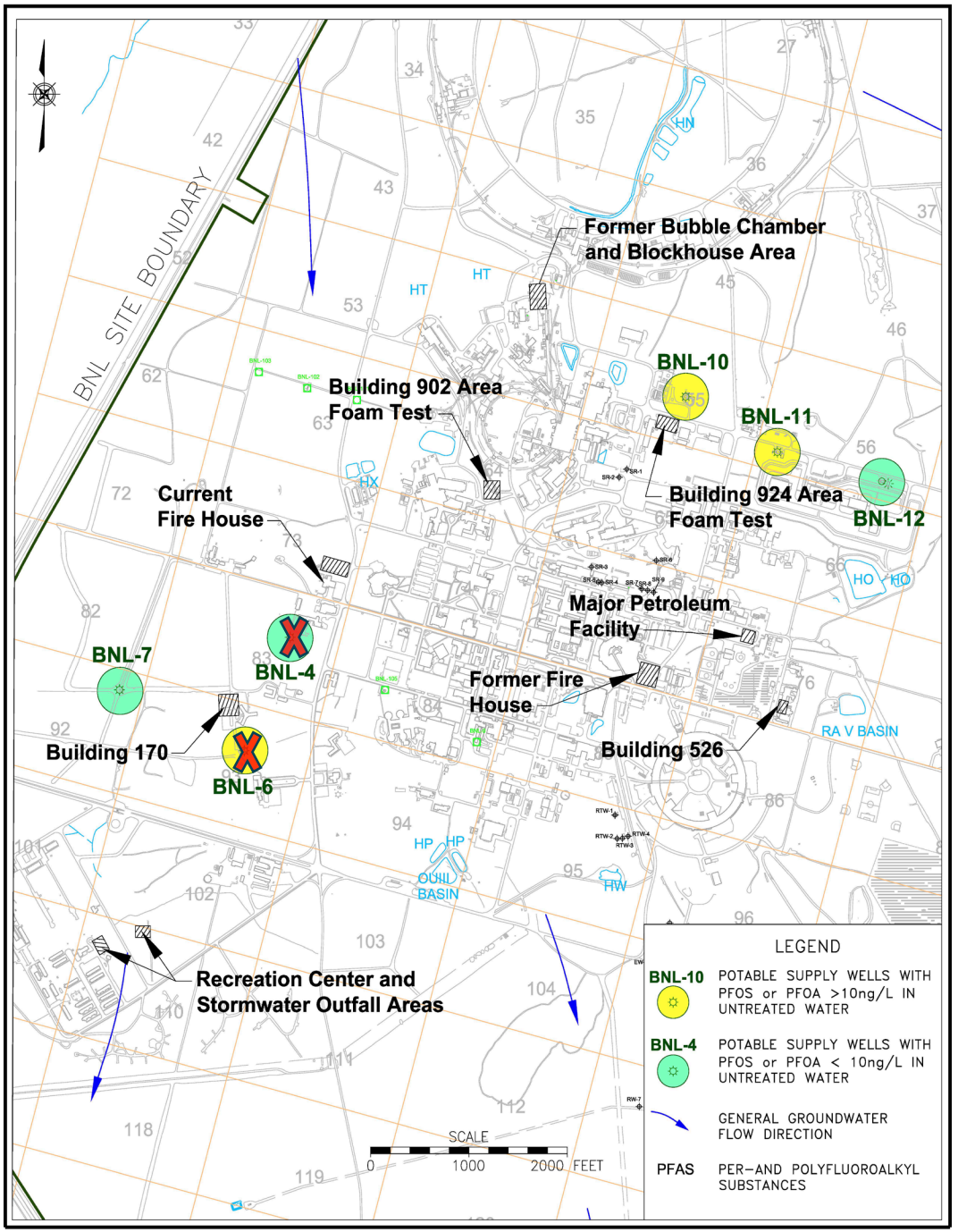
Former Firehouse System

- After six months of operation PFBA (currently unregulated) was consistently detected in mid-point and effluent samples (up to 12 ng/L)
  - May 2024: GAC in the lead vessel was changed

Reactivated GAC is being stored at the supplier's facility for reuse at BNL

BNL Water Supply Wells Impacted by PFAS

- In August 2020, New York established drinking water standards of 10 ng/L for PFOS and PFOA
  - PFOS concentrations in water from three supply wells were >10 ng/L
- BNL returned to service GAC filters at BNL-10, BNL-11 and BNL-12
  - Filters were installed in the 1990s to address VOC contamination
    - Filters were taken out of service by ~2010
  - Filters are effectively removing PFOS and PFOA to non-detectable levels
    - However, there is breakthrough of PFBA
  - BNL-4 and BNL-6 have been taken out of service permanently
    - They are not equipped with GAC filters



New National Drinking Water Standards

Maximum Contaminant Levels Goals (MCLGs) and Maximum Contaminant Levels (MCLs)

Contaminants	MCLG (ng/L)	MCL (ng/L)
PFOS	ND	4
PFOA	ND	4
PFNA	10	10
PFHxS	10	10
HFPO-DA (GenX)	10	10
HFPO-DA (GenX), PFBS, PFNA and PFHxS	Hazard Index of 1.0*	Hazard Index of 1.0*

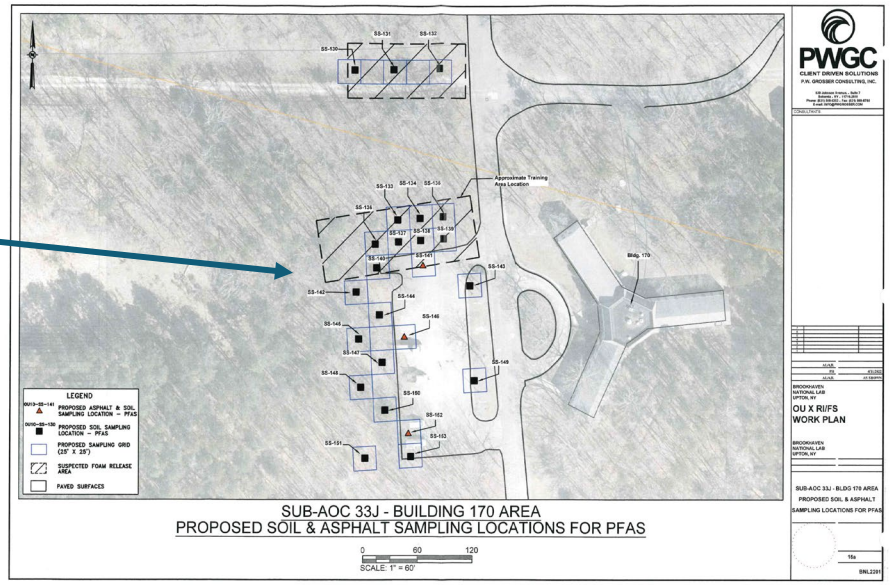
***Hazard Index Calculation: (GenX / 10 ng/L) + (PFBS / 2,000 ng/L) + (PFNA / 10 ng/L) + (PFHxS / 10 ng/L)**

Divide Measured Concentrations by the EPA Health Based Water Concentrations (HBWCs)

- The standards were published in the Federal Register on April 26, 2024
  - Standards became effective June 25, 2024
  - 3 years to conduct initial monitoring of water systems (by April 26, 2027)
    - Provide public notice of monitoring results
  - 2 additional years to come into compliance (by April 26, 2029)
- **BNL water supply is already tested quarterly for PFAS (537.1 and 533)**
- **By using GAC filters at three of four active water supply wells, BNL's drinking water already complies with the new standards**

Next Phase: Conduct RI/FS

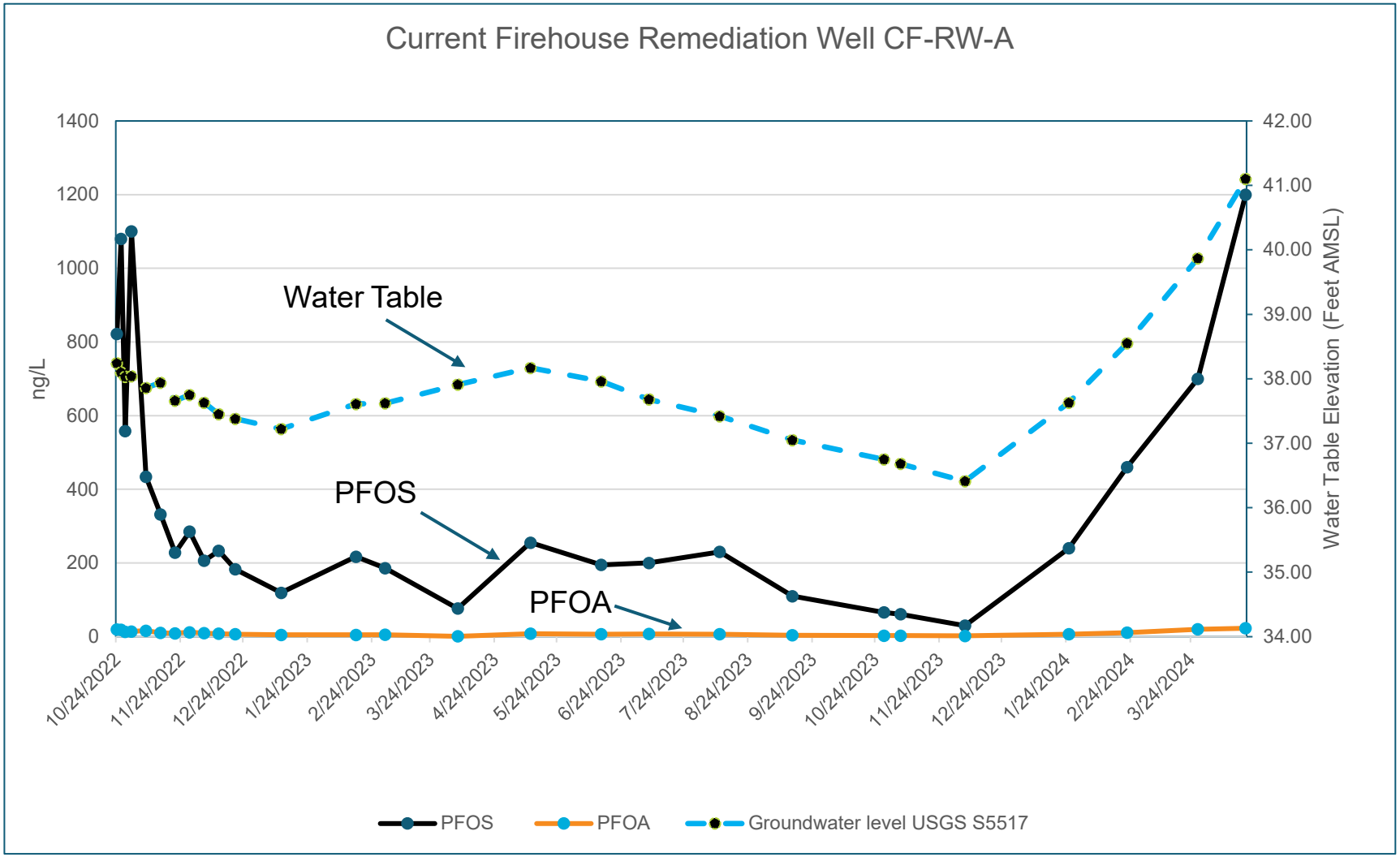
- Draft RI/FS Work Plan has been prepared
- The Work Plan builds upon the extensive groundwater characterization work conducted to date
  - Groundwater
    - Better define extent of previously identified PFAS and 1,4-Dioxane plumes, sampling will be performed at:
      - 498 existing on-site and off-site wells
      - 92 temporary (one-time use) vertical profile wells
      - 91 new wells for long-term monitoring (screened based on temp. well data)
      - 17 on-site and off-site groundwater
        - Influent and effluent
        - 81 extraction wells
  - Soil and sediments
    - Collect ~680 soil samples in AFFF release areas



Ongoing Characterization Efforts

- Completed one year of quarterly sampling of active groundwater treatment systems to evaluate compliance with NYS discharge standards. Results suggest:
  - One on-site system requires modification to treat PFAS and 1,4-dioxane
  - One off-site system requires modification to treat 1,4-dioxane
- Install 14 temporary wells (June-August)
  - To evaluate a possible easterly shift in the Current Firehouse and Building 170 plume segments
  - Further characterize the downgradient extent of the Current Firehouse and Building 170 plume segments
- Collect soil samples (July-August)
  - Collect continuous samples from land surface to the water table (to depth of ~45 feet) at the Current Firehouse source area
    - To understand the vertical distribution of PFAS in the vadose zone

Changes in PFOS and PFOA Concentrations In Current Firehouse Source Area Extraction Well Relative to Changes in Water Table Elevations



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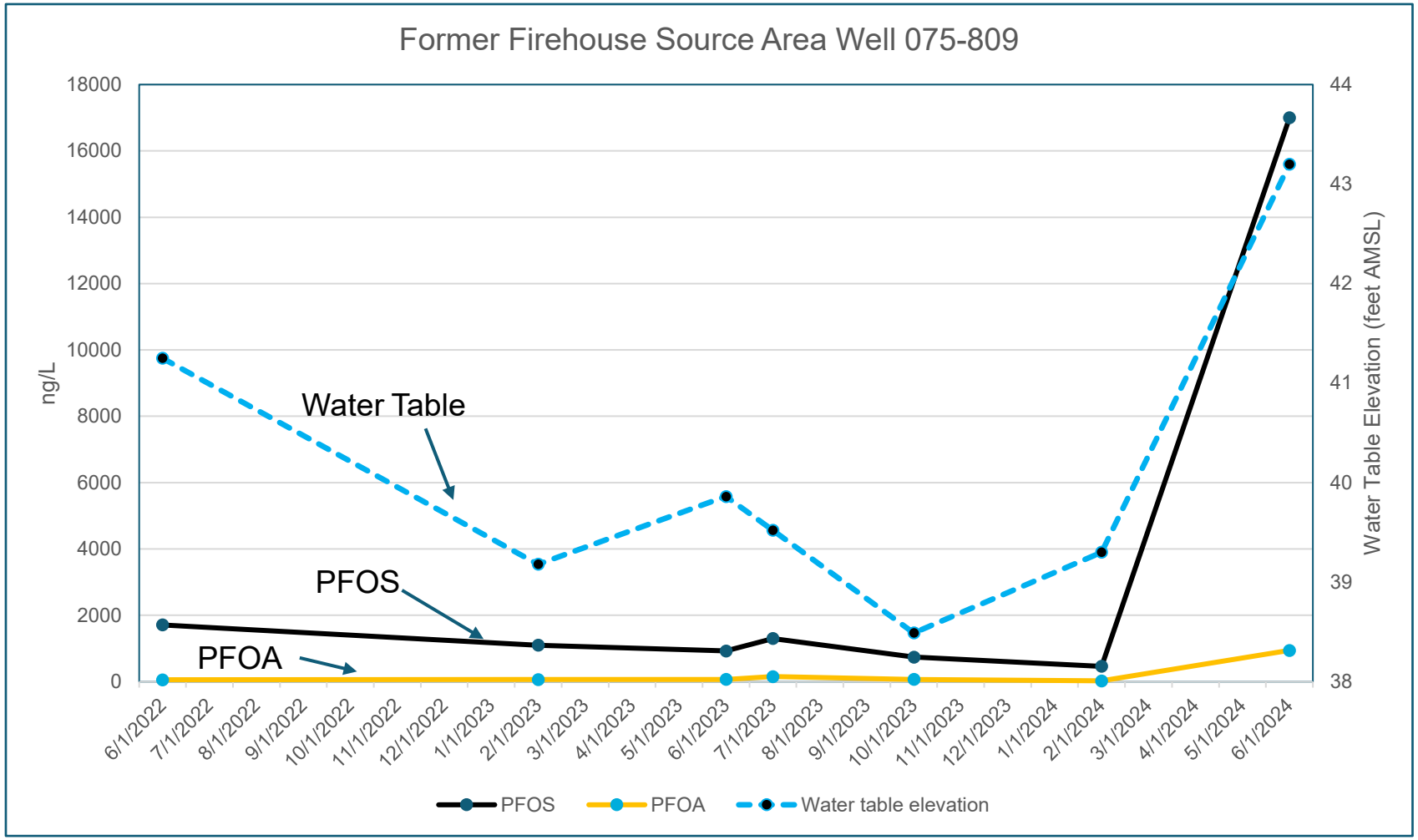
Changes in PFOS and PFOA Concentrations In Former Firehouse Source Area Monitoring Well Relative to Changes in Water Table Elevations



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Issues Going Forward

- **Forever -** After 50+ years, even one-time releases of AFFF are still impacting groundwater quality
- Extent of PFAS
  - Groundwater – we've learned a lot, but there are still many data gaps
    - **Where is non-detect?**
  - Source area soil – needs extensive characterization
    - Percent of PFAS in near surface vs. close to the water table?
- Without adequate source controls, groundwater treatment systems alone cannot meet expected/reasonable remediation timeframes
  - Soil removal vs. in-place treatment?
    - Treat impacted soil to depths of ~50 feet
  - Short- and long-term effectiveness of currently available sequestration methods (e.g., liquid carbon injections)?
- While use of GAC for groundwater remediation is effective, it requires frequent changeouts and off-site thermal treatment or disposal
  - Breakthrough of short-chained PFAS
  - Alternative methods would need to treat large volumes of groundwater (individual systems up to ~1,000 gpm)
- Expect more PFAS to be regulated & changes to standards