GANNETT FLEMING

PFAS PROJECT CONSIDERATIONS & LESSONS LEARNED

October 2023

Pennsylvania PFAS MCL Rule

The PFAS MCL Rule was published in the *Pennsylvania Bulletin* on January 14, 2023. This rule establishes maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) for 2 PFAS –: perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) –, which are two of the more common and persistent PFAS chemicals detected in the human body in published toxicological studies as of 2022. The MCLs and MCLGs set by this rule, in nanograms per liter (ng/L) or parts per trillion (ppt), are:

	MCLG (ng/L or ppt)	MCL (ng/L or ppt)
PFOA	8	14
PFOS	14	18

Source: PADEP Bureau of Safe Drinking Water PFAS MCL Rule Website

EPA Proposed PFAS National Primary Drinking Water Regulation

EPA's Proposed Action for the PFAS NPDWR

Compound	Proposed MCLG	Proposed MCL (enforceable levels)
PFOA	0 ppt*	4.0 ppt*
PFOS	0 ppt*	4.0 ppt*
PFNA	1.0 (unitless) Hazard Index	1.0 (unitless) Hazard Index
PFHxS		
PFBS		
HFPO-DA (commonly referred to as GenX Chemicals)		

The Hazard Index is a tool used to evaluate potential health risks from exposure to chemical mixtures.

*ppt = parts per trillion (also expressed as ng/L)

EPA United States Environmental Protection Agency — Office of Water

EPA anticipates finalizing the regulation by the end of 2023

Source: EPA PFAS Substances Website

Horsham Air National Guard Base, PA

- 200 GPM
- Groundwater Well
- ~13,000 ppt PFOS, PFOA
- Granular Activated Carbon

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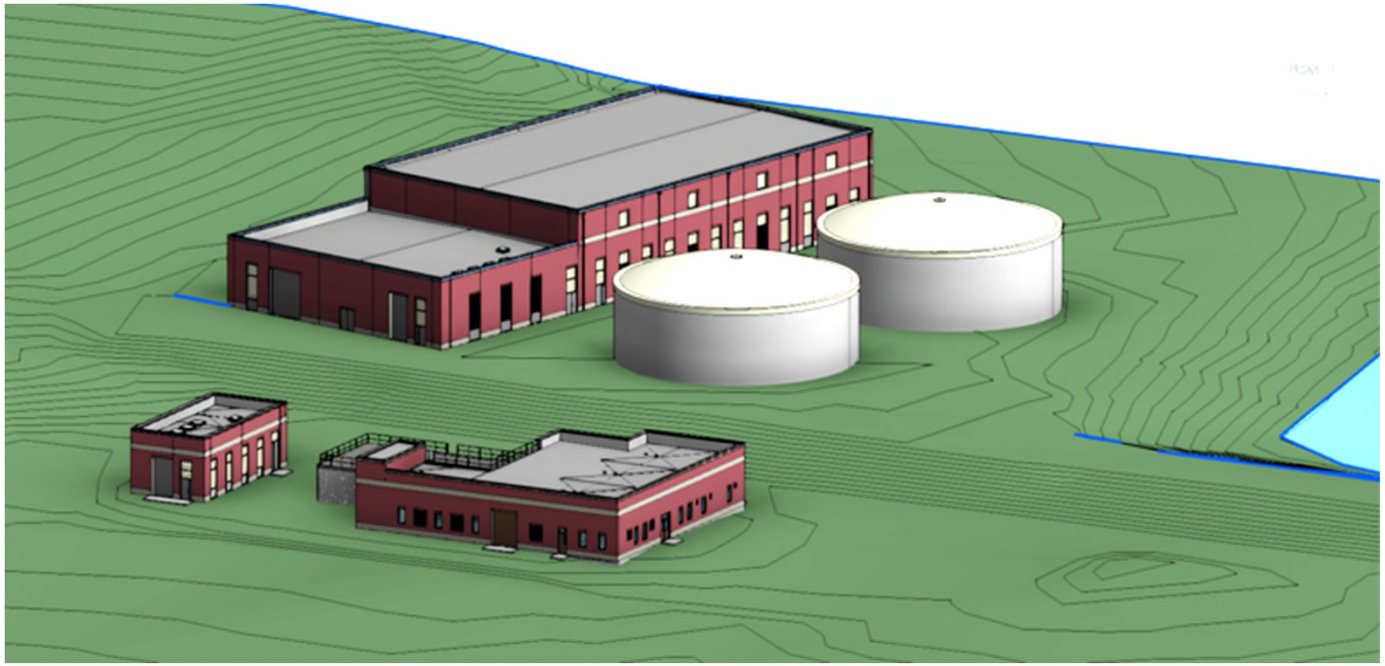
Northeast NY

- 20 MGD
- Surface Water Treatment Plant
- ~15 ppt PFOS, PFOA
- Granular Activated Carbon Contactors



Central PA

- 2 Well Sites @150 GPM
- Groundwater Wells
- ~10 ppt PFOS, PFOA
- Granular Activated Carbon

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North NJ

- 4 MGD
- 12 Groundwater Wells
- ~20 ppt PFOS, PFOA
- Ion Exchange

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Central NY

- 3 MGD
- 9 Groundwater Wells
- ~10 ppt PFOS, PFOA
- GAC Contactors

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PFAS Project Components & Considerations to be Discussed Today

- Pilot Testing
- Hydraulic Analysis
- Pre-Filtration
- Chemical Feed Placement
- Start Up Backwash
- ‘Normal Operations’ Backwash
- Flow Control & Monitoring
- Media Exchange
- Structural/ Architectural
- Site Development
- Permitting

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What's Best for My Project - GAC or Resin ??

- **GAC**
  - Shorter Bed Life may result in Shorter Pilot Test Period
  - Long History of Performance Data
  - PADEP usually doesn't require Pilot Testing
  - CAN be Backwashed after placed in operation to resolve HL

- **Resin**
  - Longer Bed Life may result in Longer Pilot Test Period
  - Shorter History of Performance Data
  - PADEP usually requires Pilot Testing
  - CAN NOT be Backwashed after placed in operation

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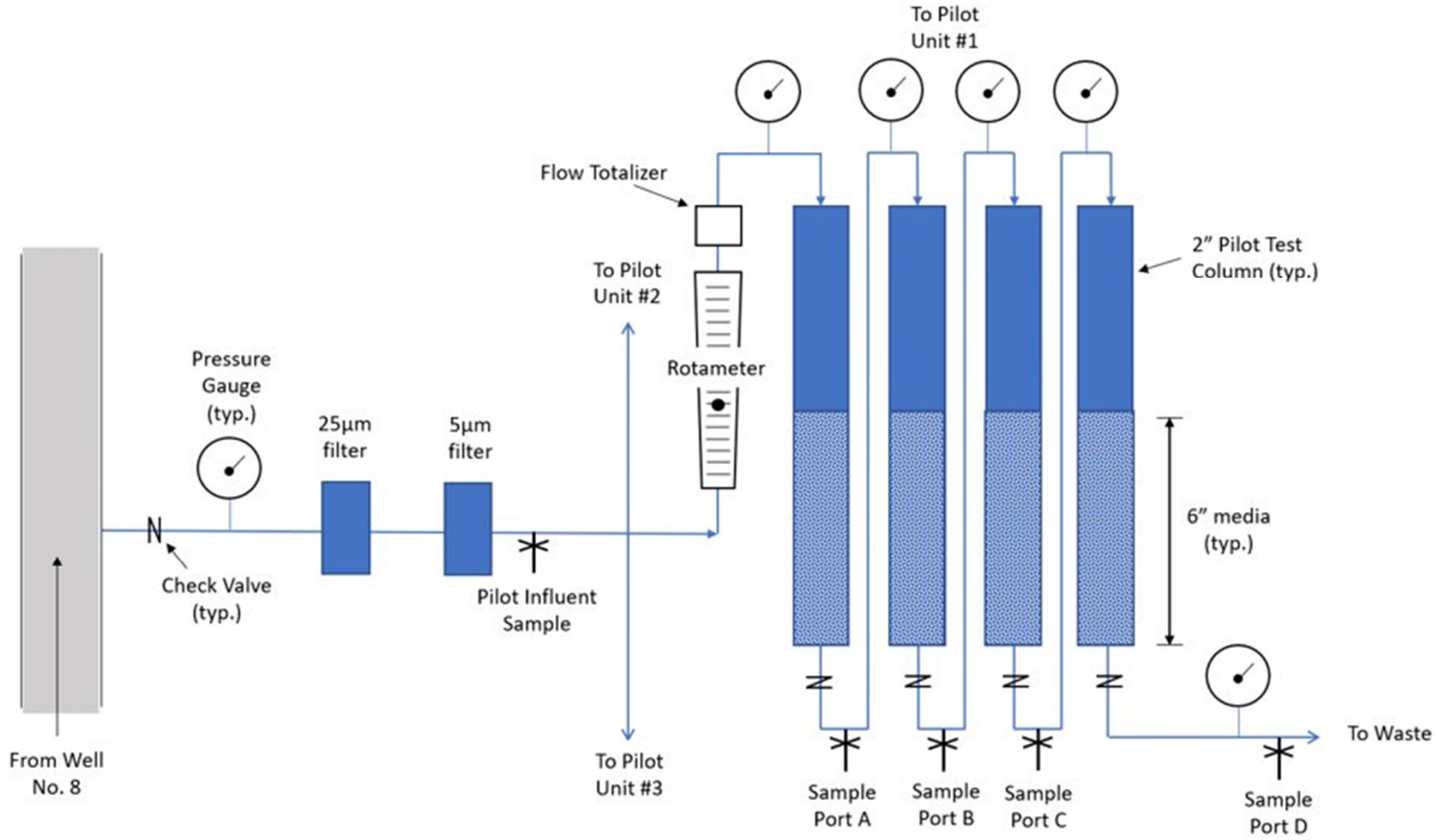
Small Scale Pilot Test Arrangement



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Small Scale Pilot Test Arrangement

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Pilot Test Monitoring Schedule

Table 4-1: Pilot Test Monitoring

Parameter	Location	Frequency of Analysis
Flow Rate	Pilot Influent	Daily[1] for Week 1, then 2x/Week
Treated Volume	Pilot Influent	Daily[1] for Week 1, then 2x/Week
Pressure	Raw Water	Daily[1] for Week 1, then 2x/Week
	Pilot Influent	Daily[1] for Week 1, then 2x/Week
	Sample Port D	Daily[1] for Week 1, then 2x/Week
PFOA, PFOS, PFBS PFHpA, PFHxS, and PFNA	Raw Water	Every 2 Weeks
	Sample Port A	Every 2 Weeks until equal to influent, then Monthly
	Sample Port B	Every 2 Weeks
	Sample Port C	Monthly, then every 2 weeks following PFOA/PFOS detection in Port A
	Sample Port D	Monthly, then every 2 weeks following PFOA/PFOS detection in Port B
pH	Raw Water	Daily[1] for Week 1, then Weekly
	Sample Port D	Daily[1] for Week 1, then Weekly[2]
Temp	Raw Water	Weekly
Alkalinity	Raw Water	Daily[1] for Week 1, then Weekly
	Sample Port D	Daily[1] for Week 1, then Weekly[2]
Nitrate	Raw Water	Weekly
	Sample Port D	Weekly
Chloride	Raw Water	Weekly
	Sample Port D	Weekly
Sulfate	Raw Water	Weekly
	Sample Port D	Weekly

[1]Daily samples will be collected each day during the work week, but not on weekends or holidays.

[2] If the parameter isn't stable by the end of the first week, daily sampling will be extended until the effluent quality is stable.

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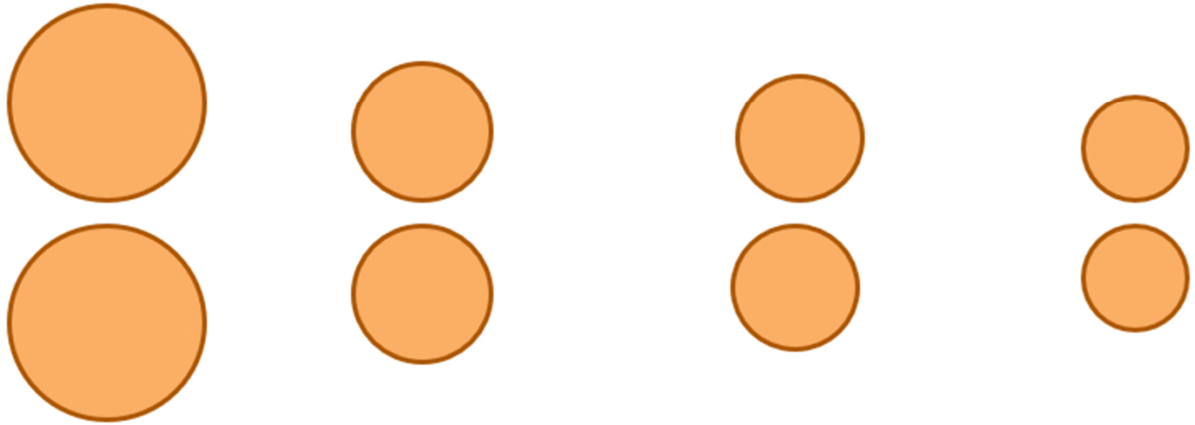
Relative Reactor Size

	GAC	Anion Exchange Resin
Loading Rates	4 gpm/sf to 8 gpm/sf	10 gpm/sf to 14 gpm/sf



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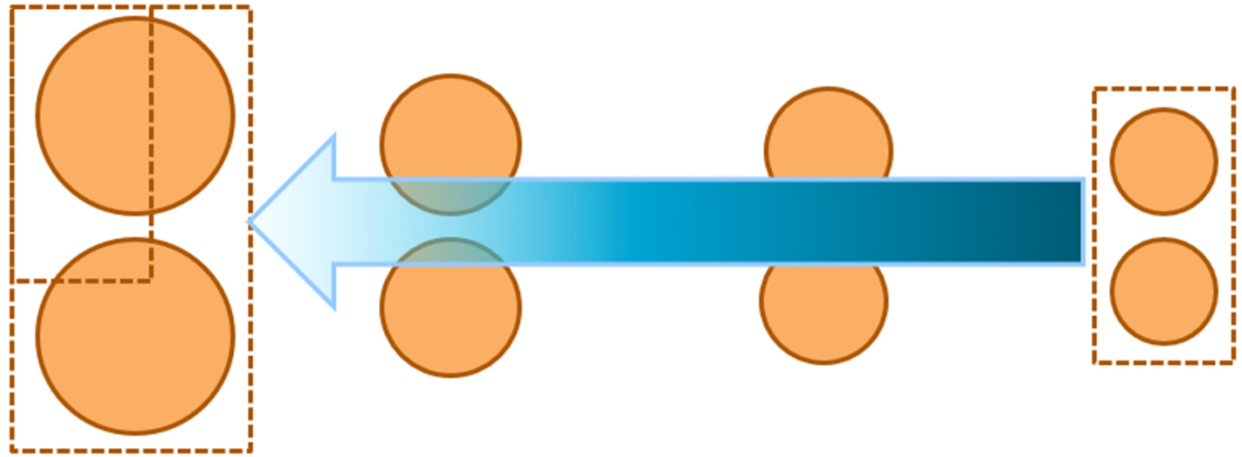
Footprint Comparison

	GAC	Resin
Loading Rates	4 gpm/sf to 8 gpm/sf	10 gpm/sf to 14 gpm/sf



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Reactor Height Comparison

	GAC	Resin
Effective Bed Contact Time	10 Minutes EBCT	3 Minutes EBCT

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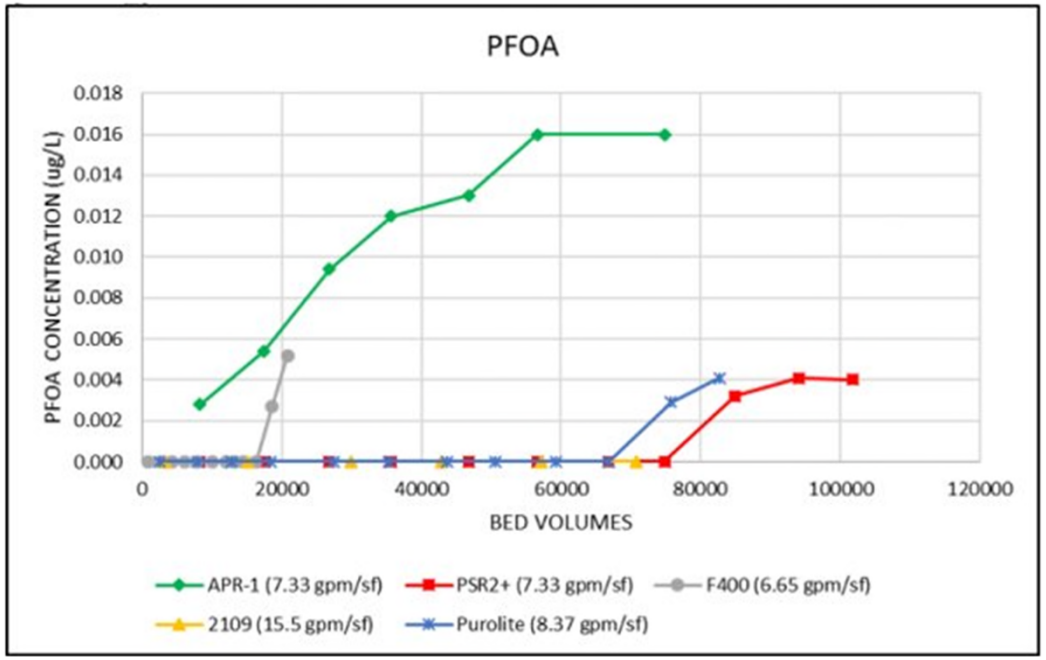
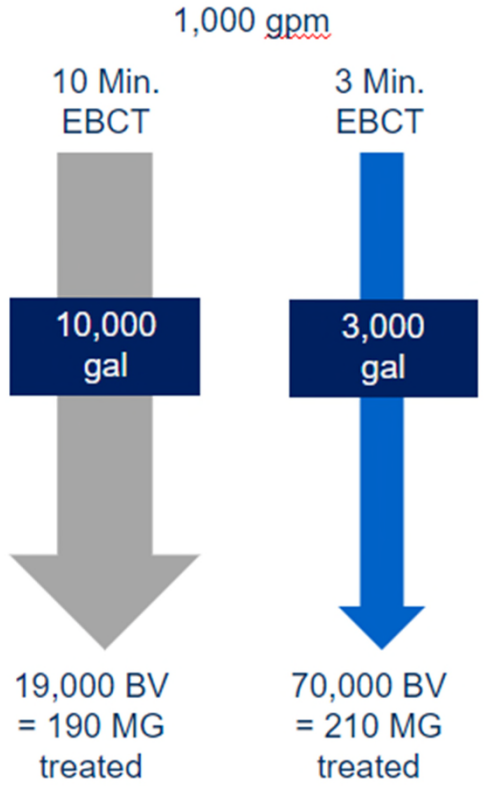
How Long will the Media Last ???



Bed Volumes vs Bed Life



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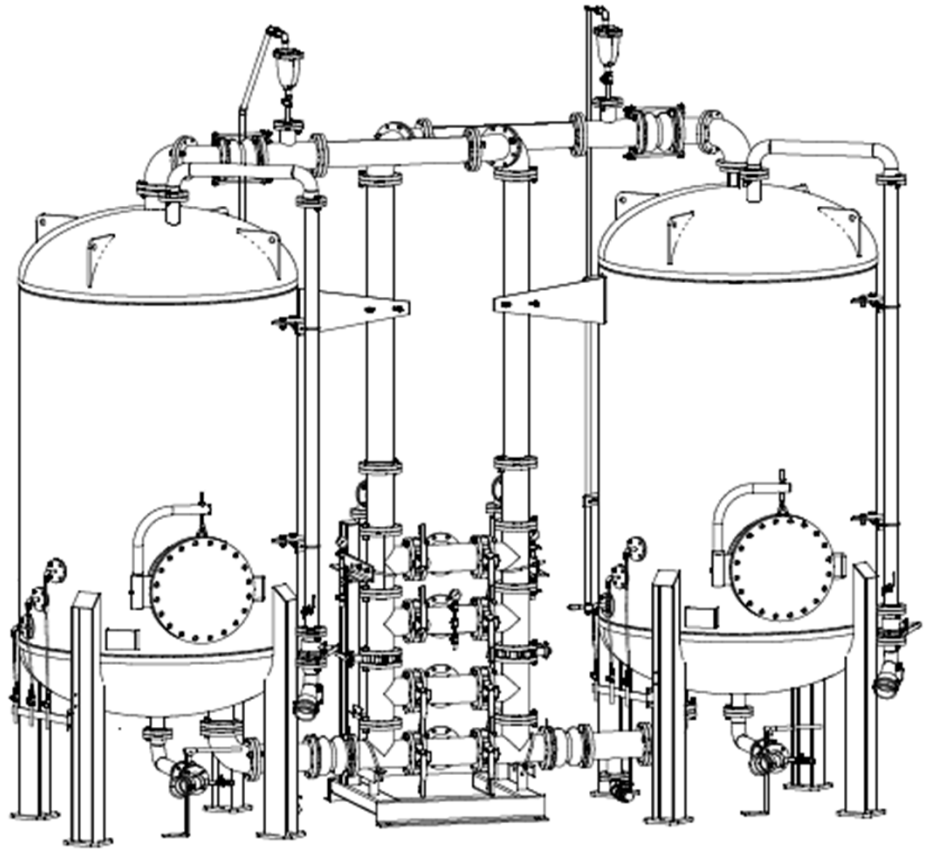
Filtration Package Components

- GAC or Ion Exchange Resin Filtration Media
- Vessels
- Valve Tree
- Sample Ports
- Air Relief Valves
- Differential Pressure Switch & Transmitter
- Rupture Disk
- Expansion Joints



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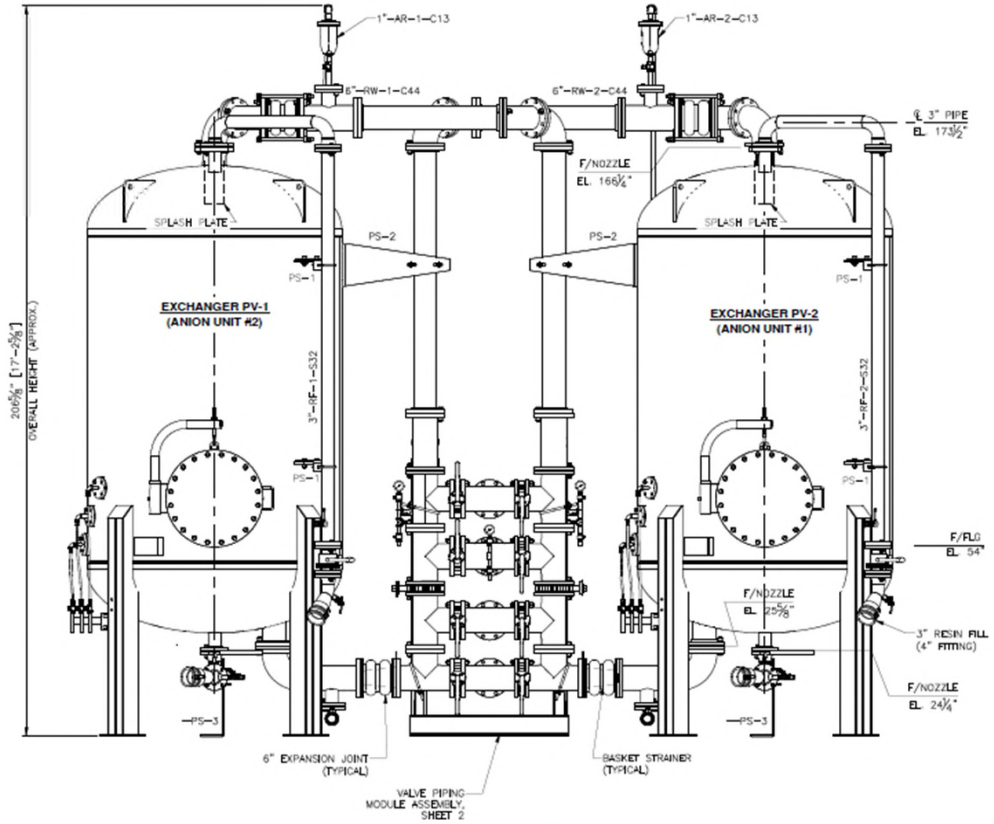
Resin Units
400 GPM

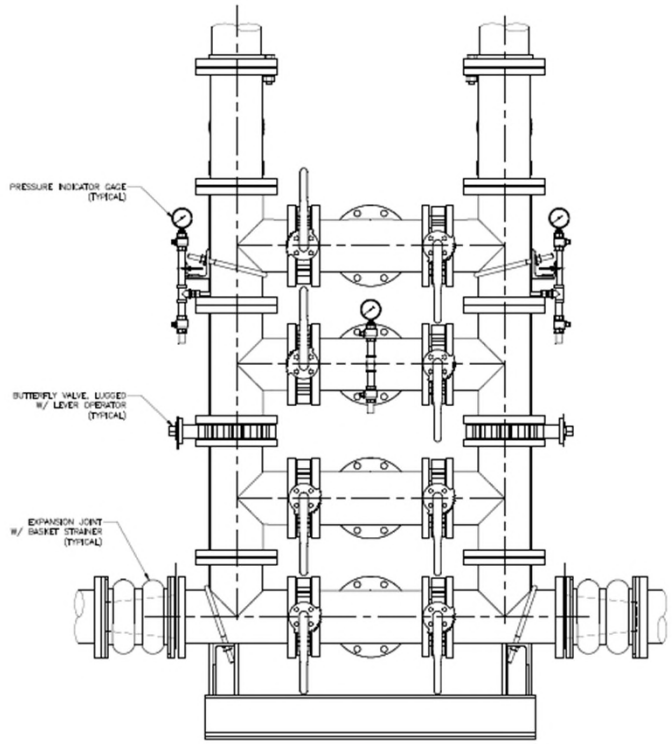
Overall Height = 18 feet
Overall Length = 20 feet
Overall Width = 8 feet
Diameter = 6 feet

Add Working Clearance

Footprint = ~ 300 SF



ELEVATION



VALVE PIPING MODULE ASSEMBLY

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Hydraulic Analysis

Existing Well Pump upsizing may be required to accommodate additional Head Loss / added TDH

B70 - 3. Head Loss Calculations

Description	PSI	TDH (ft)	Notes
Prefilter[1]	16	37	Per Fil-Trek Model S4LP18-312-4F-B-150
GAC Contactor[2]	14.6	34	Per Calgon Model
Miscellaneous Head Loss	3.46	8	Piping and other equipment (see Appendix D for Hydraulic Calculation)
Total Additional **Head Loss**		79	

[1] 1 psi clean bag head loss and 15 psi maximum allowable differential pressure head loss.

[2] 10 psi dirty bed head loss and 4.6 psi of clean bed head loss.

B70 - 4. Well Pump Replacement

Description	Pump Replacement
Type of Pump	Submersible
Number of Pumps	1
Capacity of Pump (gpm)	200
Total Dynamic Head (feet)	525
Motor (hp)	30
Motor Voltage/Phases	480/3
Motor Starting	VFD with Bypass
System Pressure (psi)	100
Number of Stages	9

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How Does WQ Affect Media Life???

Water Quality	*Recommendation*
Total Suspended Solids (TSS)	Pre-Filtration with Bag or Cartridge Filter
Dissolved Iron & Manganese	Greensand or Resin Filtration to remove Fe & Mn BEFORE PFAS Filters
Oxidants - Chlorine, Chloramine, Hypochlorite, Permanganate	Remove with Sodium Biulfate, Sodium Thisulfate, GAC,... BEFORE PFAS Filters
Calcium Carbonate Scaling	Slightly Positive Langlier Saturation Index (LSI) = 0.20 to 0.50 is considered OK Higher Positive LSI = 1.0 to 2.0 can cause Excessive Scale Precipitation on Media Consider Acid Feed
Total Organic Compounds (TOC)	TOC > 2 ppm, GAC or Resin Filtration BEFORE PFAS Filters
Volatile Organic Compounds (VOC)	GAC Pre-Filtration BEFORE PFAS Filters

Note: Consult Media Vendor for recommendations pertaining to their particular product

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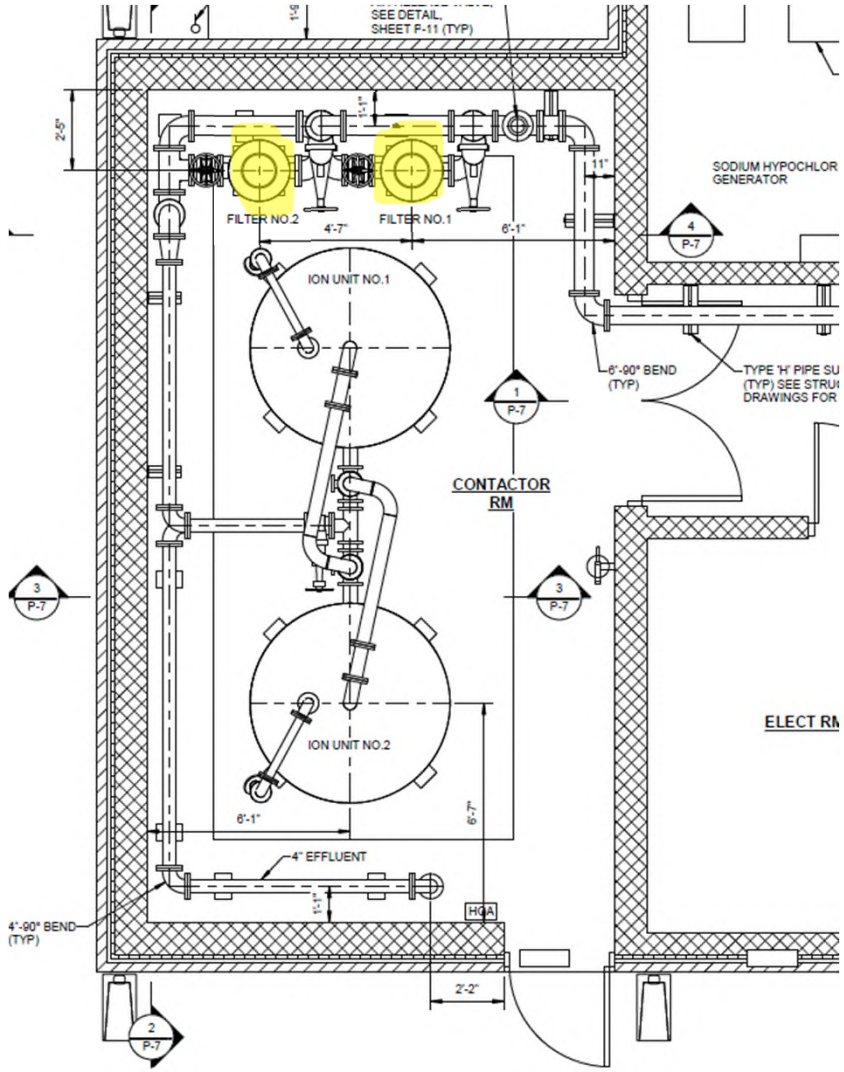
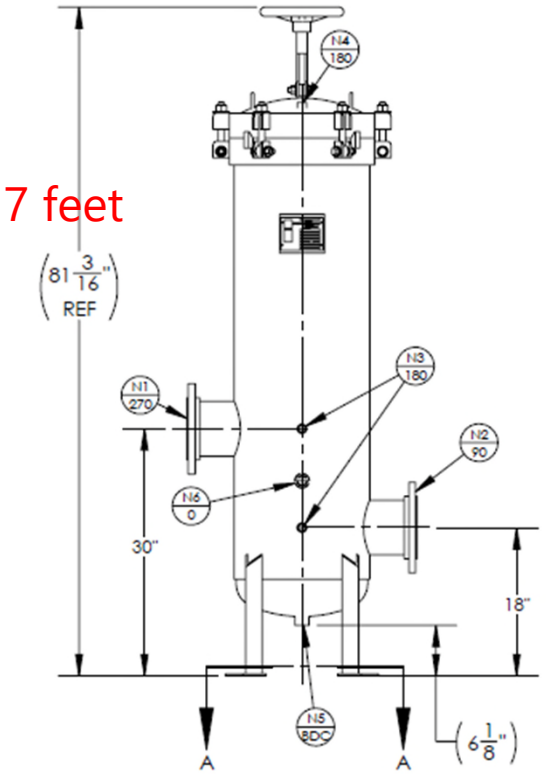
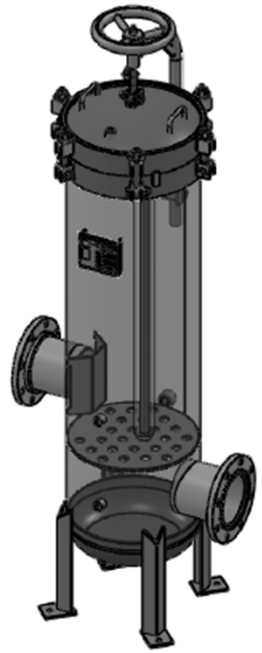
Example of Pre-Filtration for TSS



Cartridge Filter Vessel

~ 7 feet





~ 2 feet diameter

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Chemical System Considerations

- **Evaluate Chemical Feed Impacts on PFAS Filtration Media**
- Some Treatment Chemicals may Harm Media and Shorten Life
- Locate Feed Pump Injection Points Accordingly !!
- Floor Plan Layout & Space Allowance for –
  - Bulk Storage Tanks
  - Day Tanks
  - Chemical Containment Areas
- Emergency Eyewash Stations
- Sampling Points / Sample Sink
- Chemical Residual Analyzers
- Chemical Delivery Access / Fill Panels / Overfill Alarms

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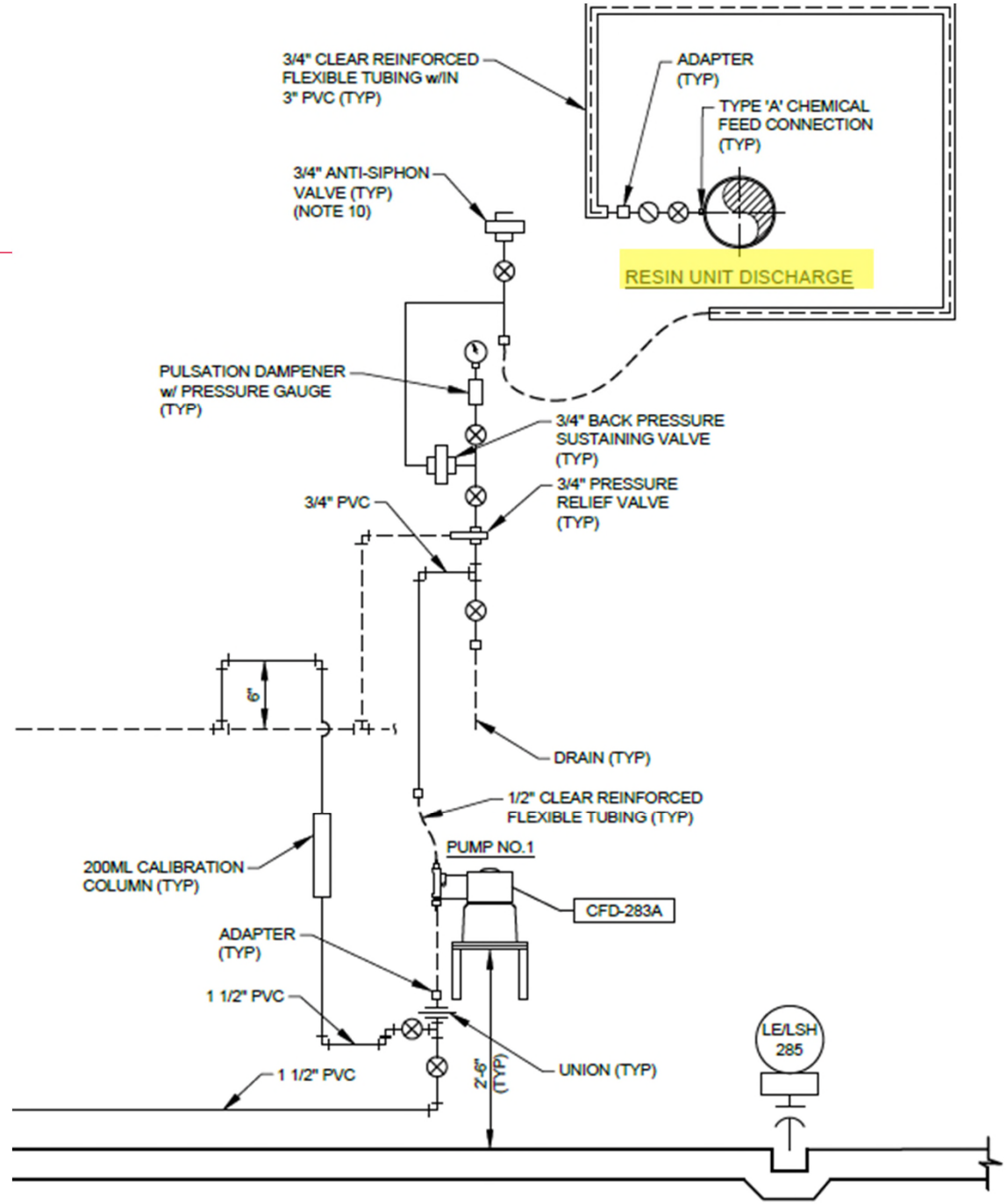
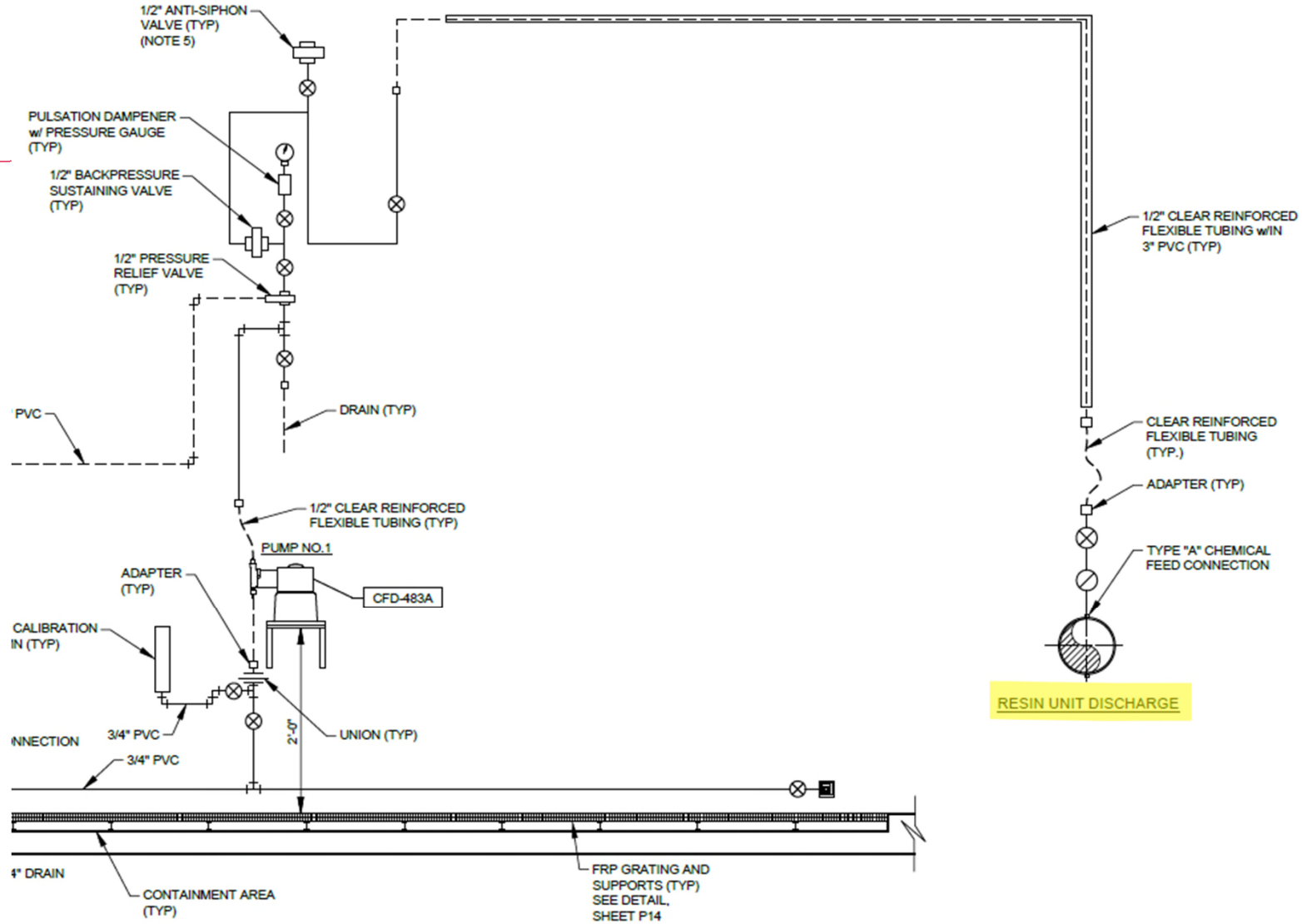
Chlorine Feed

- Inject POST PFAS Filters
- Resin Unit Discharge Piping



Corrosion Inhibitor Feed

- Inject POST PFAS Filters
- Resin Unit Discharge Piping



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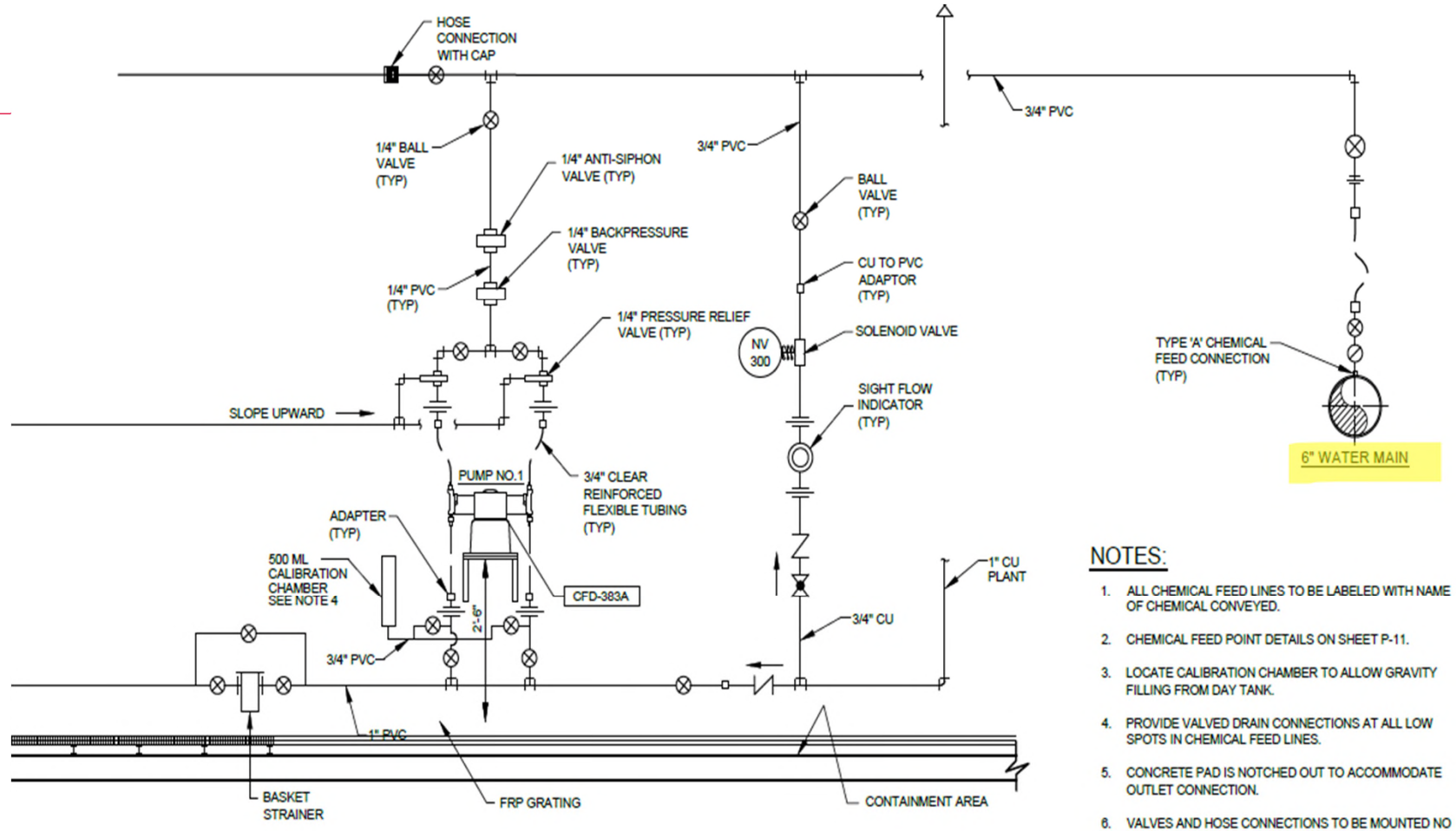
Ammonia Feed

- Inject POST PFAS Filters
- System Sendout Yard Piping



NOTES:

1. ALL CHEMICAL FEED LINES TO BE LABELED WITH NAME OF CHEMICAL CONVEYED.
2. CHEMICAL FEED POINT DETAILS ON SHEET P-11.
3. LOCATE CALIBRATION CHAMBER TO ALLOW GRAVITY FILLING FROM DAY TANK.
4. PROVIDE VALVED DRAIN CONNECTIONS AT ALL LOW SPOTS IN CHEMICAL FEED LINES.
5. CONCRETE PAD IS NOTCHED OUT TO ACCOMMODATE OUTLET CONNECTION.
6. VALVES AND HOSE CONNECTIONS TO BE MOUNTED NO HIGHER THAN 6' ABOVE FINISHED FLOOR.

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Backwash Considerations – Start Up & Operations

- Is My Site Backwash Supply & Pressure Adequate?
- Site Supply Options – Hydrant, Yard Piping, Tanker Truck & Pump Skid
- GAC requires initial BW to remove fines and Arsenic
  - Normal Ops BW may be required
- Ion Exchange Resins require initial BW to remove fines
  - Volume Required is significantly less that GAC
  - Resin SHOULD NOT be Backwashed after placed in service
- Backwash Disposal - Storage Tank, Frac Tank, Sanitary Sewer

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GAC Installation, Backwashing, & Conditioning

2.6.2 GAC Installation and Wetting

Bulk trailers loaded with dry GAC will arrive at the site and will be filled with clean water to generate slurry. The water should be supplied at a minimum of 100 gpm and 30 psi. The carbon slurry is transferred into the vessels through disinfected hoses.

2.6.3 Backwash

Backwashing and conditioning fresh GAC before placing into operation is critical to GAC performance. The reasons for backwashing before placing fresh media online are to: (1) size segregate the media so subsequent backwashing will return the media to the same relative position in the bed, (2) remove any remaining air from the bed, and (3) remove media fines which can lead to excessive pressure drop and flow restriction. Backwash water used will be from the distribution system. A frac tank will be used to hold backwash waste.

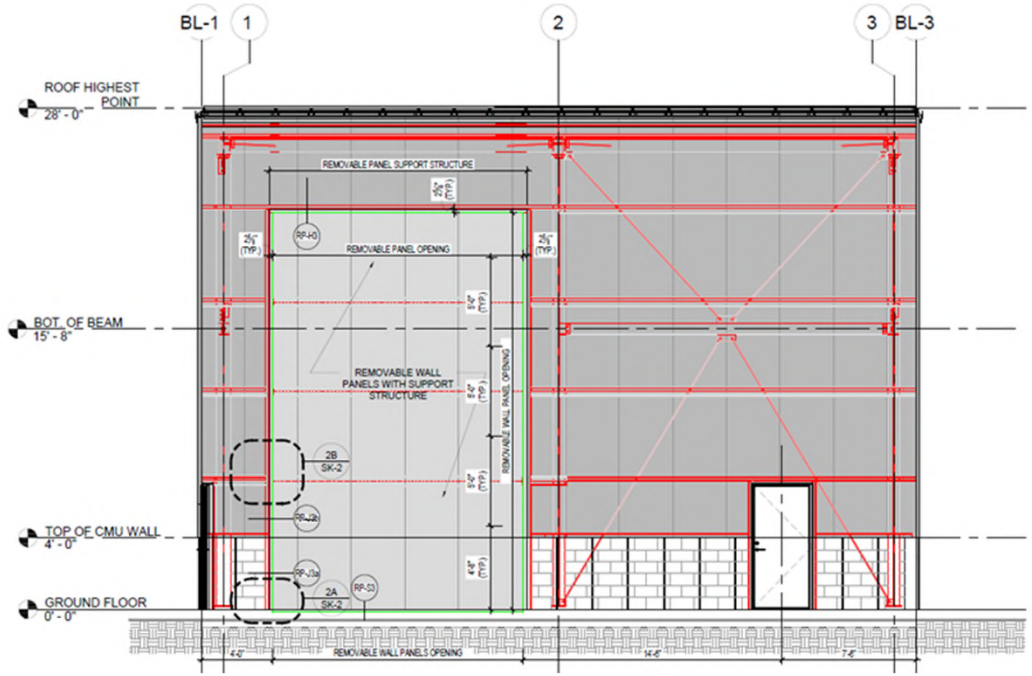
Below are the recommended steps for proper conditioning and backwashing of GAC based on Filtrasorb 400 GAC being backwashed at 55°F:

1. Fully submerge GAC bed in clean, contaminant free water for at least 16 hours (overnight)
2. Open backwash inlet and begin up-flow at 3 gpm/ft^2 for 2 minutes
3. Increase flow to 5 gpm/ft^2 and maintain for 2 minutes
4. Increase flow to 7 gpm/ft^2 and maintain for 2 minutes
5. Increase flow to 8.5 gpm/ft^2 and maintain for 30 minutes*
6. Decrease flow to 7 gpm/ft^2 and maintain for 2 minutes
7. Decrease flow to 5 gpm/ft^2 and maintain for 2 minutes
8. Decrease flow to 3 gpm/ft^2 and maintain for 2 minutes
9. Close backwash inlet and stop flow

*Duration representative of initial backwash conditions. Required duration during operational backwashes can be shorter but will vary by utility, solids load, and GAC throughput. Contact Calgon Carbon for more information"

Structural/ Architectural Considerations

- Masonry vs Pre-Engineered Building
- Hybrid Masonry & Pre-Engineered
- Interior Room Layout (Chem, Elec, Mech)
- Provide 3’ min clearance around vessels
- Rollup Door vs ‘Knock Out’ Panels
- Windows & Louvers
- HVAC



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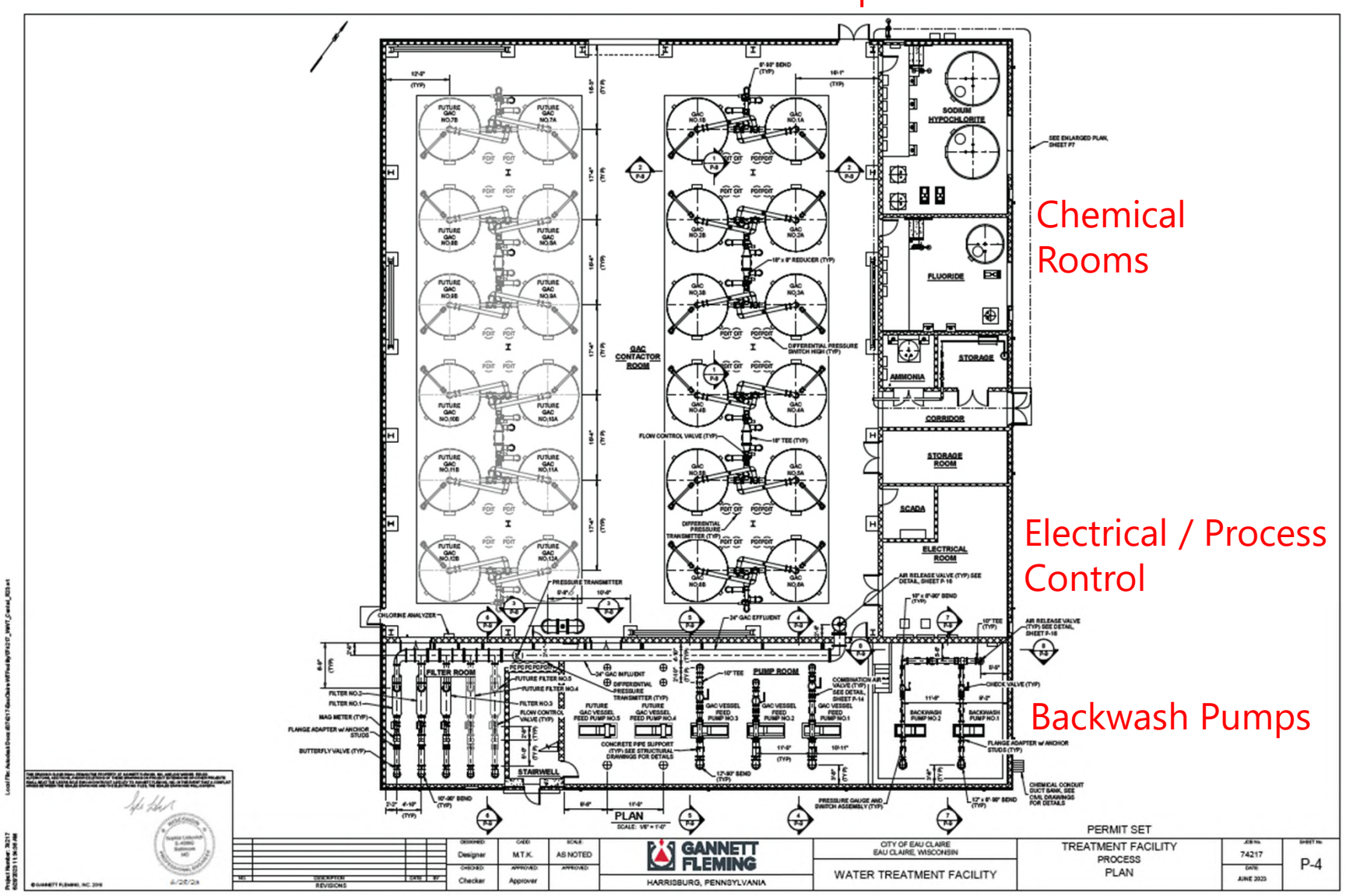
Future Vessel Line Up



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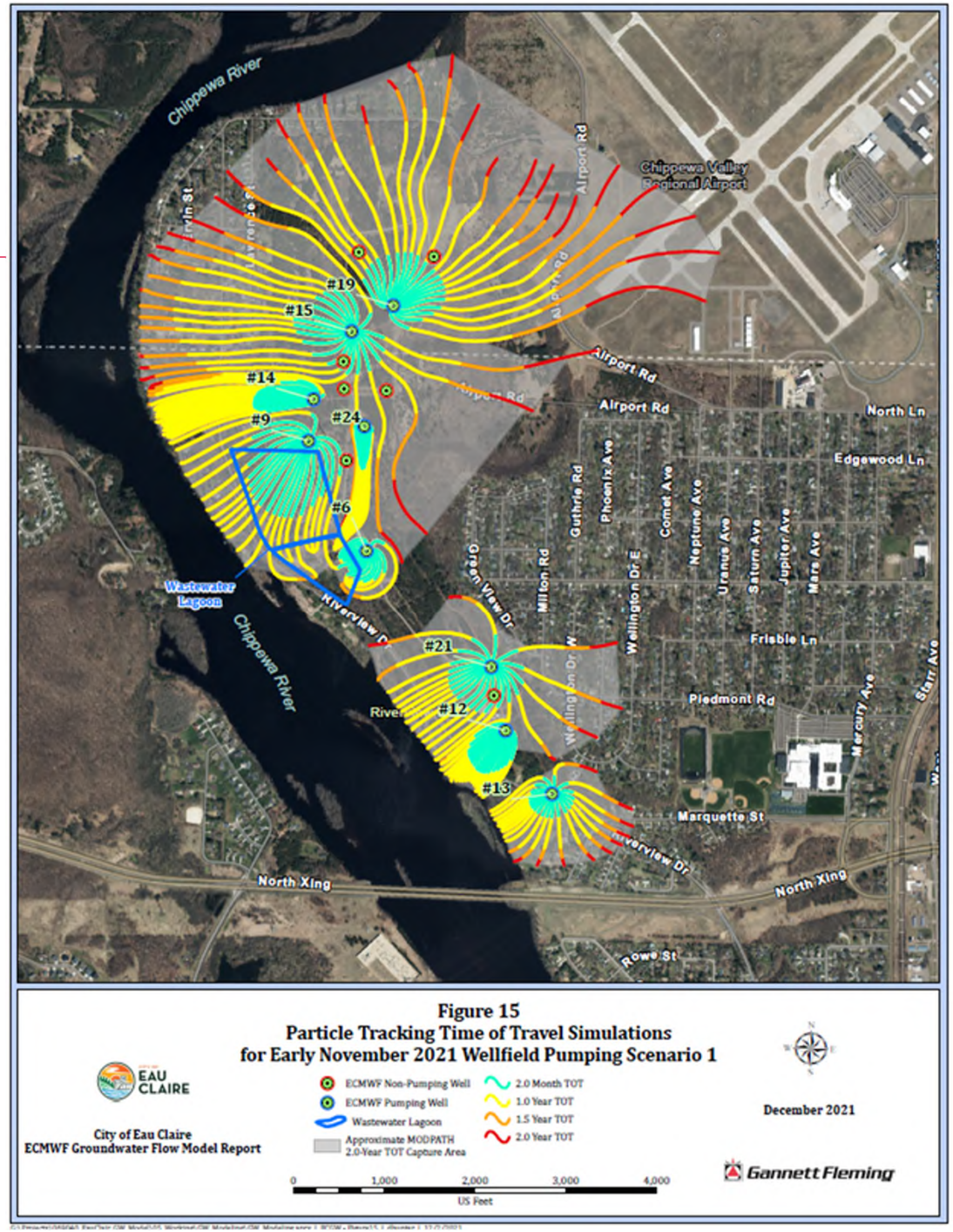
PFAS Model Simulation - MODPATH

- Develop Particle Tracking & Time of Travel Simulations for different system pumping scenarios
- Estimate drawdown capture areas around actively pumping wells
- Simulate contamination plume flow paths
- Develop PFAS isolation strategies



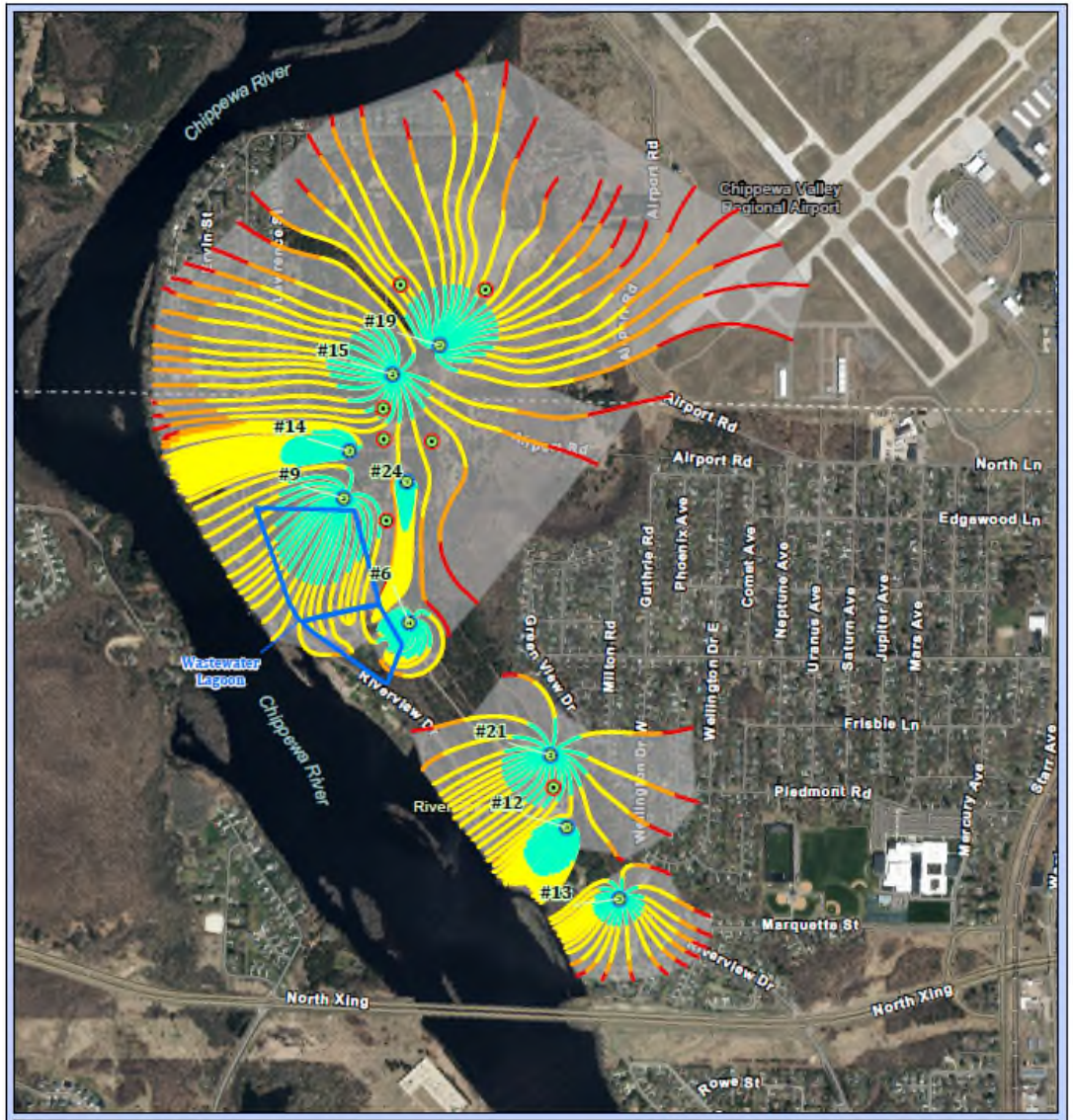


Figure 15
Particle Tracking Time of Travel Simulations for Early November 2021 Wellfield Pumping Scenario 1

EAU CLAIRE

City of Eau Claire
ECMWF Groundwater Flow Model Report

ECMWF Non-Pumping Well
ECMWF Pumping Well
Wastewater Lagoon
Approximate MODPATH 2.0-Year TOT Capture Area
2.0 Month TOT
1.0 Year TOT
1.5 Year TOT
2.0 Year TOT

0 1,000 2,000 3,000 4,000
US Feet

December 2021

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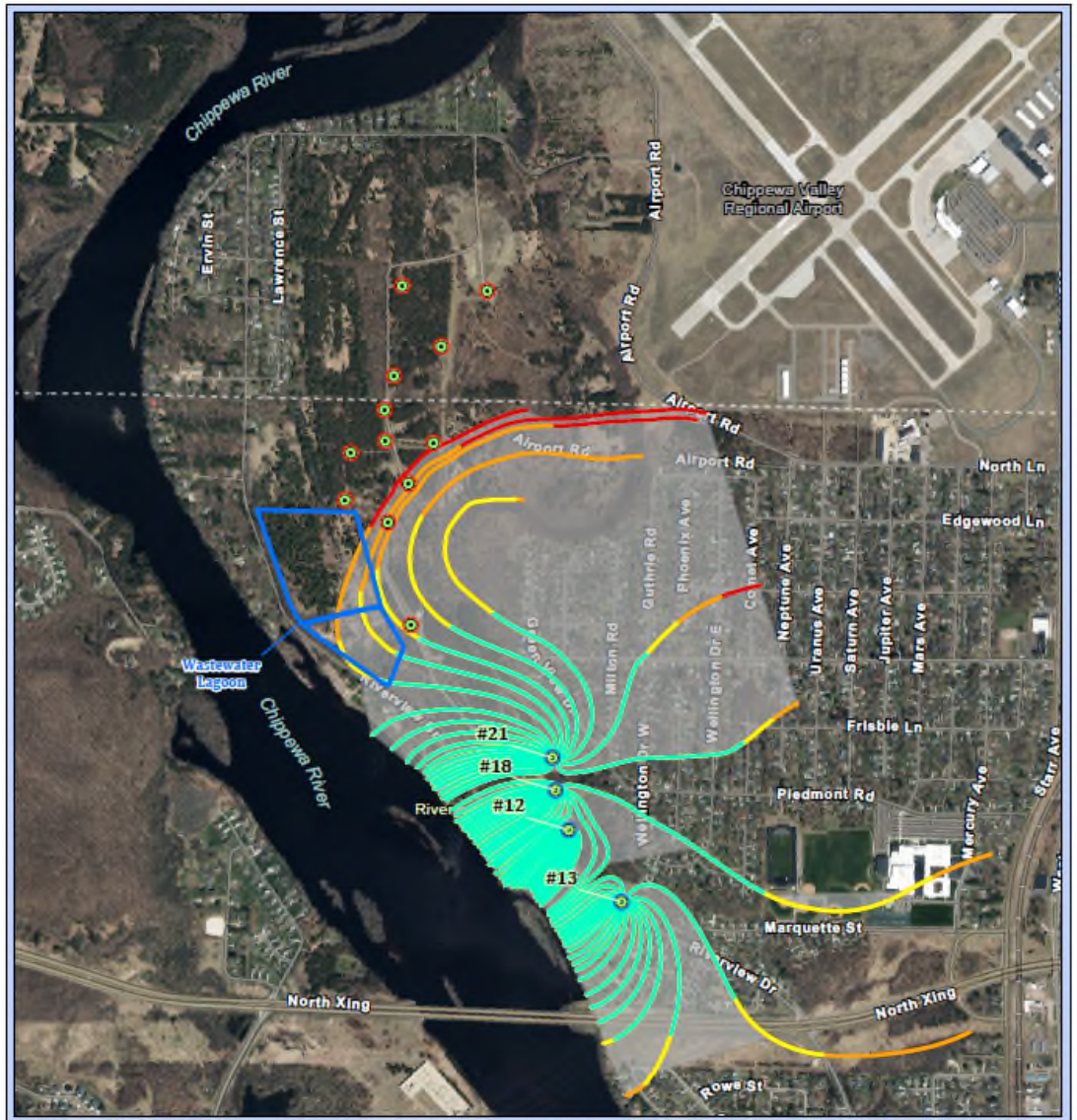


Figure 17
Particle Tracking Time of Travel Simulations for Proposed South Wellfield Pumping Scenario 2

EAU CLAIRE

City of Eau Claire
ECMWF Groundwater Flow Model Report

ECMWF Non-Pumping Well
ECMWF Pumping Well
Wastewater Lagoon
Approximate MODPATH 15.0-Year TOT Capture Area
2.0 Year TOT
5.0 Year TOT
10.0 Year TOT
15.0 Year TOT

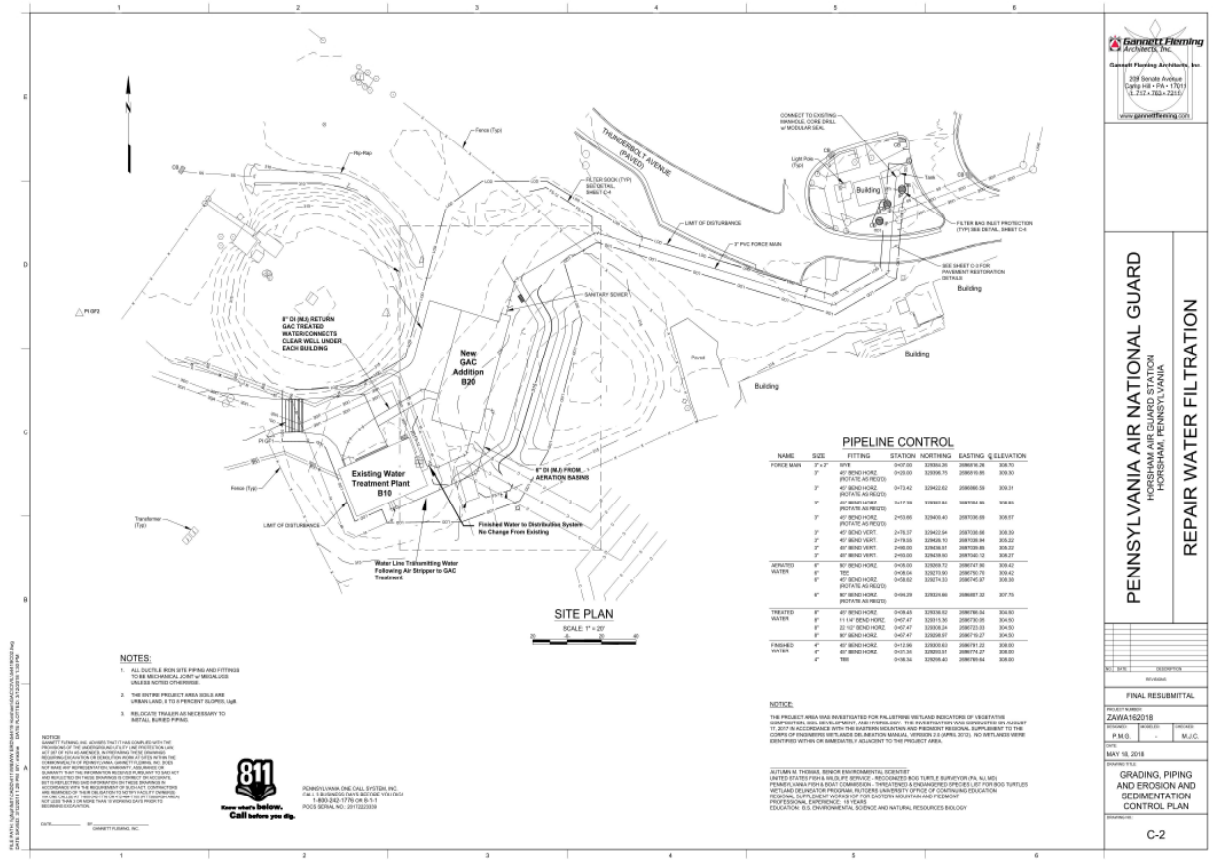
0 1,000 2,000 3,000 4,000
US Feet

December 2021

Gannett Fleming

Site Considerations

- **Initial Backwash**
  - Frac Tank Staging Area if applicable
- **Backwash Discharge/Disposal - Storage Tank, Frac Tank, Sanitary Sewer**
- **Media & Chemical Deliveries**
  - Access
  - ~50’ truck turning radius allowance
- **Stormwater Management**
- **Landscaping Screening for Residential Areas**



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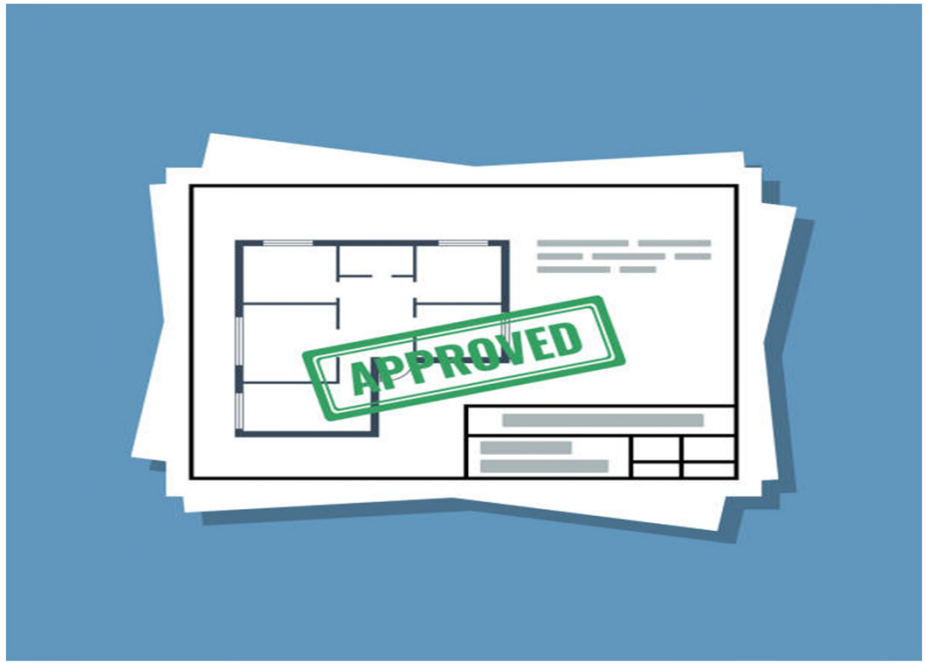
PFAS Permit Requirements and Other Approvals

- **Permitting as Part of Design**
  - Local Planning Commission/Zoning
  - Land Development/Stormwater Management
  - State DEP/Public Water Supply
    - Simultaneous Compliance
  - NPDES Construction/Conservation District
  - Municipal-specific Ordinances (e.g. sprinklers)

  Backwash
    - Act 537 Sewage Planning/Exemption
    - NPDES Permit
    - Flow rate discharge limits or sampling requirements



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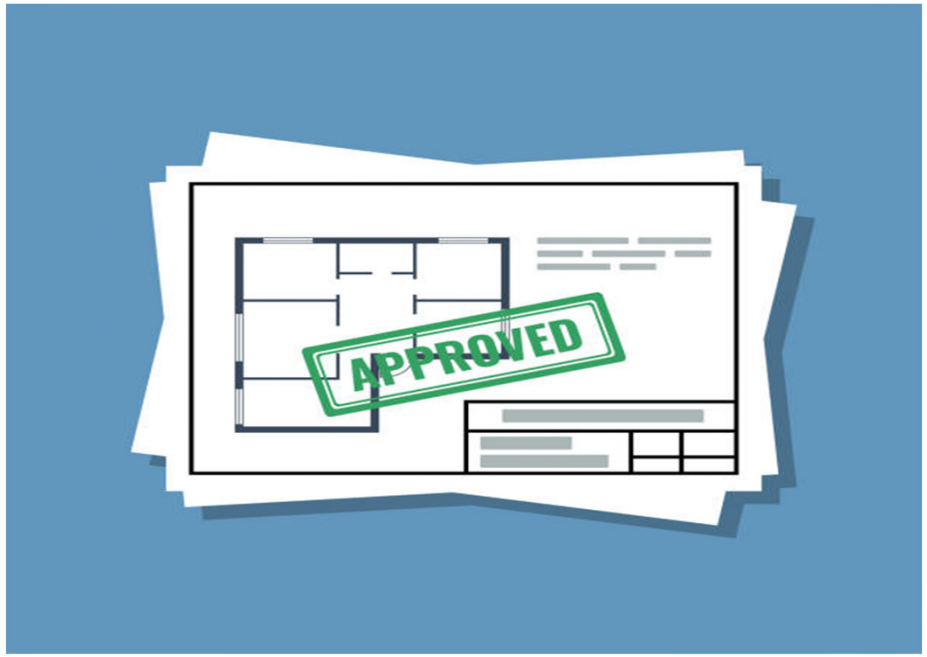
PFAS Permit Requirements and Other Approvals

- **Public Meeting**
  - Landscaping/Rendering
  - Architectural Considerations
- **Construction**
  - Building Permit/Code Inspections
- **Operations**
  - DEP Operations Permit/Special Conditions
  - Sampling



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Operations - What Have We Learned?

- **Site Access**
  - Potential residential impacts
- **Startup Sampling/Secondary Contaminants**
  - Sampling not typically required as part of Compliance Monitoring Schedule (TDS, chloride, etc.)
  - Changes from Historic Source Water Quality
    - Expand background sampling during design
- **Simultaneous Compliance**
  - Return to Initial Lead/Copper Monitoring

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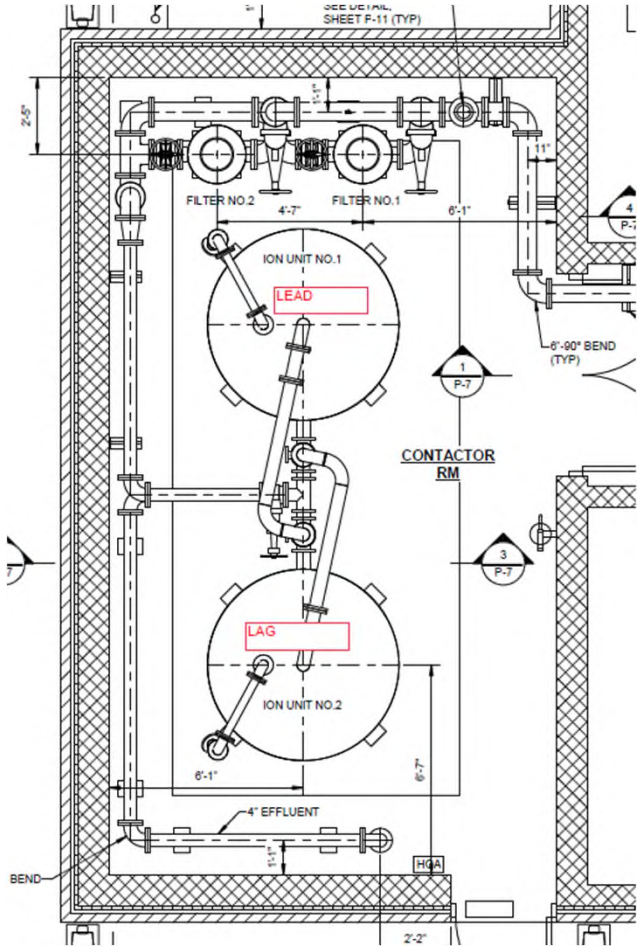
Operations - What Have We Learned?

- **Media Change Out**
  - Single Treatment Train – Unit 1 Lead, Unit 2 Lag (Series operation)
  - Monitor mid-treatment concentrations
  - When media in Unit 1 (Lead) is spent, replace with new or reactivated media.
  - Unit 2 moved to the Lead position.
  - Unit 1, with fresh media, placed in the Lag position.
  - The effluent of Unit 2 (now Lead) is monitored to trigger changeout.
  - **Each Site Unique - Break Through Time Varies Widely based on Water Quality Parameters and Plant Sendout (Higher Influent PFAS ≠ Shorter Run Time and vice-versa)**
    - Pilot Test results may be the best predictor
  - **Sampling requirements with new media/rinsing**
    - Arsenic
    - Chloride/sulfate ratio
    - Can impact time system is out-of-service for changeout



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Operations - What Have We Learned?

- **Adding GAC where Aeration is existing**
  - GAC may remove contaminants targeted by aeration (VOCs)
    - Competing contaminants
    - Pilot testing/Permit modifications
  - Precipitation of calcium can affect carbon
- **Low levels of Iron/Manganese**
  - GAC may eliminate need for sequestering
    - Permit modification
- **Nitrates**
  - IX resin may favor nitrate removal over PFAS
- **TOC**
  - IX and GAC can reduce DBP formation
  - Higher TOC negatively impacts effective PFAS removal with GAC

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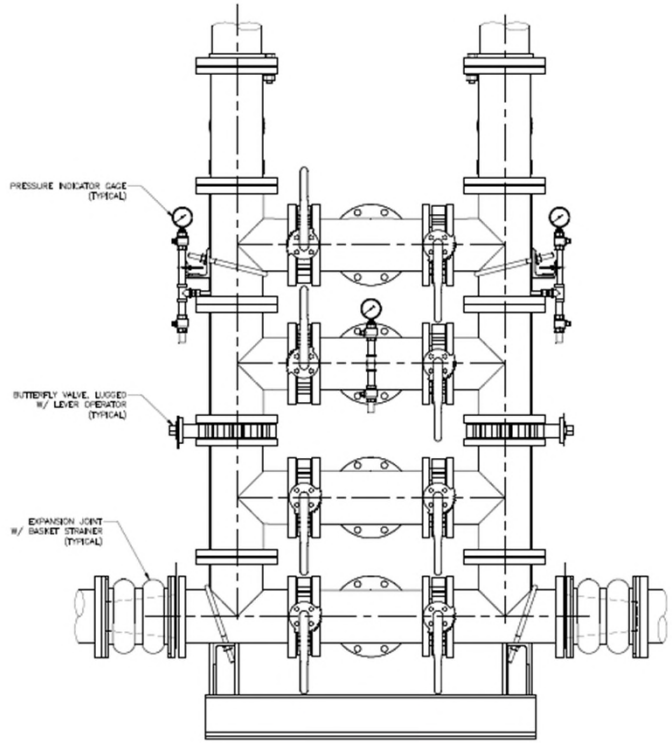
Operations - What Have We Learned?

- **Piping and Valves**
  - Maintain wet carbon bed
    - Add check valve/pipe loop
  - Permit requirements
    - Eliminate potential bypass of system
      - Block and bleed valves
      - Spool pieces and blind flanges
      - Real world operation
- **Operational Costs are Real**
  - Compliance and Operational Sampling (cost and TAT)
    - How frequent if proposed MCLs are 4 ppt?
  - Media Changeout Cost
  - Media Disposal – cost and responsibility
  - Rate impacts



VALVE PIPING MODULE ASSEMBLY

GANNETT FLEMING

Beyond Drinking Water

- **Wastewater**
  - NPDES Permit limits
    - Monitor and Report
  - PFAS impaired waters
- **Sludge**
  - Disposal/Land Application
- **Soil/Groundwater**
  - Hazardous substance designation – CERCLA/Superfund
- **Air**
  - Carbon incineration
- **PFAS Destruction**
  - Hydrothermal Processes
  - UV

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Open Discussions/ Q&A

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THANK YOU!

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