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# PFAS Treatment: Large and Small

Presentation to: New Jersey Water Association
Date: October 19th, 2021

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## PFAS FACTS

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## PFAS Briefing

- PFAS = Per- and Polyfluoralkyl substances
- Developed by DuPont in a NJ lab on April 6th, 1938, as a refrigerant
- Synthetically manufactured since the 1940s
- Because of their persistence are known as “forever chemicals”
- Found in/on Teflon, Scotchgard, Gore-Tex, stain resistant and waterproof clothing, carpeting, shampoo, chapstick, dental floss, electrical wiring, cookware, everywhere
- Present in tri-state area surface and groundwaters
- Most likely in your bloodstream at this moment

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## PFAS Removal Methodologies

- Powder Activated Carbon (PAC)
- Granular Activated Carbon (GAC)
- Anion or Ion Exchange (IX)
- High Pressure Membrane Technologies
  - Nanofiltration
  - Reverse Osmosis (RO)

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## Members of the PFAS family of chemicals

- PFOS (perfluorooctane sulfonic acid): phased out
- PFOA (perfluorooctanoic acid): phased out
- PFNA (perfluorononanoic acid)
- PFBS (perfluorobutane sulfonic acid)
- PFDA (perfluorodecanoic acid)
- PFOSA (perfluorooctane sulfonaminde)
- PFHxS (perfluorohexane sulfonic acid)
- GenX (HFPO-DA or hexafluoropropylene oxide dimer acid): replaces PFOA

= regulated by NJDEP

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## Regulated PFAS chemicals

- PFOS MCL = 13 ng/L
- PFOA MCL = 14 ng/L
- PFNA MCL = 13 ng/L

MCL = maximum contaminant level
ng/L = nanograms per liter

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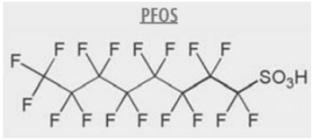
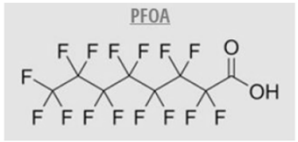
## PFOS and PFOA

- Both PFOS and PFOA are known as long chain PFAS
- PFOS is a sulfonate, which is easily removed from drinking water by IX resin or GAC with longer run/life times
  - Sulfonates contain carbon chain lengths ≥6 carbons




- PFOA is a carboxylate, which is difficult to remove from drinking water by IX resin or GAC with shorter run/life times
  - Carboxylates contain carbon chain lengths ≥8 carbons

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## IX

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## IX Explained

- IX can either be a cation or an anion based process
- PFAS removal process consists of anion exchange, where a positively charged ion exchange resin with an affinity for molecules having net negative surface charges attracts a negatively charged ion
- Anion exchange resins typically exchange chloride for anionic contaminants, such as PFOA
- Media is typically a commercial resin, which is a petrochemical compound shaped into beads

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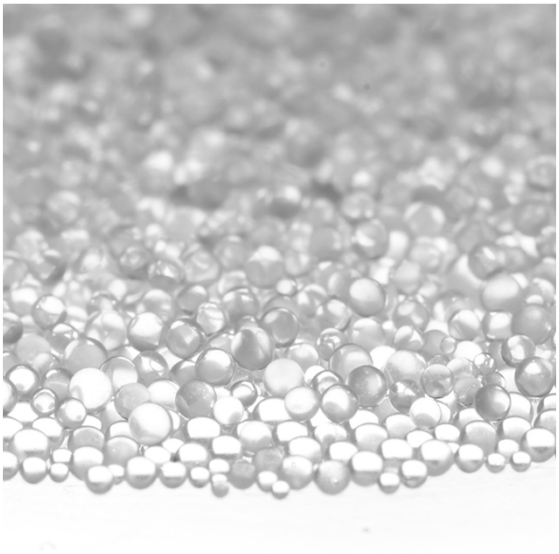
## IX Explained (cont'd)

Purolite PFA694E resin media



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## IX Treatment Process Logistics

- IX reactors/filter vessels are typically set up in series
- Because IX media is sensitive to raw water turbidity levels, bag filters must precede treatment
- IX resin can handle high exchange rates
- IX resin typically requires an empty bed contact time (EBCT) of 2 to 5 minutes
- After breakthrough, expended resin is evacuated and replaced with regenerated resin

* EBCT = Volume of vessel (empty), gallons / flow in gpm

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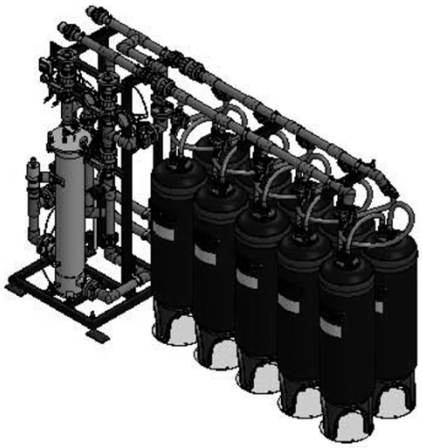
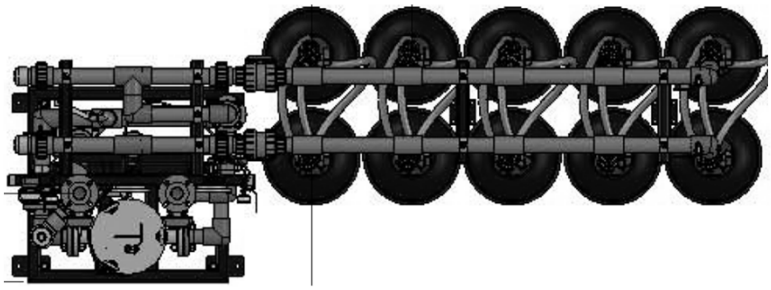
## Small IX Systems – Cartridges

Down Flow Treatment System
5 Train, 2 Vessel arrangement
10 gpm cartridges x 5 = **50 gpm**





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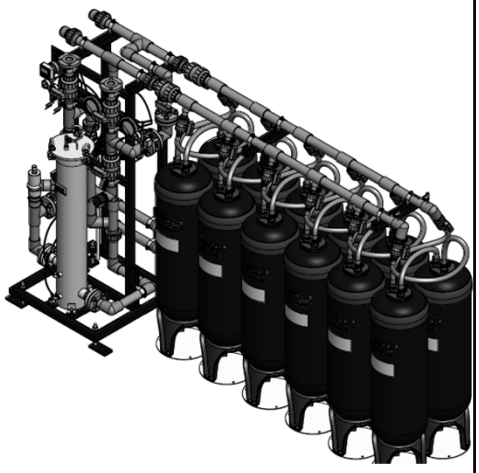
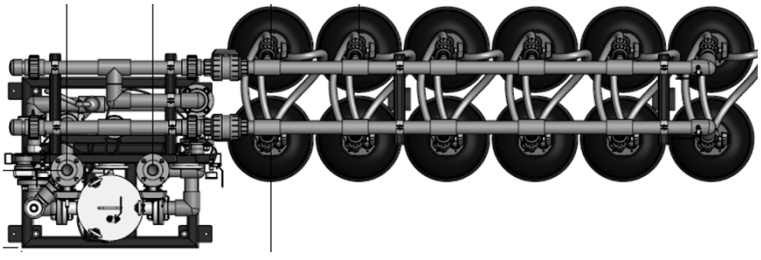
## Small IX Systems – Cartridges

Down Flow Treatment System
6 Train, 2 Vessel arrangement
10 gpm cartridges x 6 = **60 gpm**





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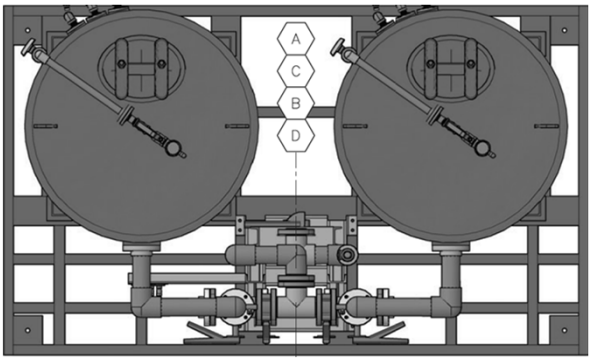
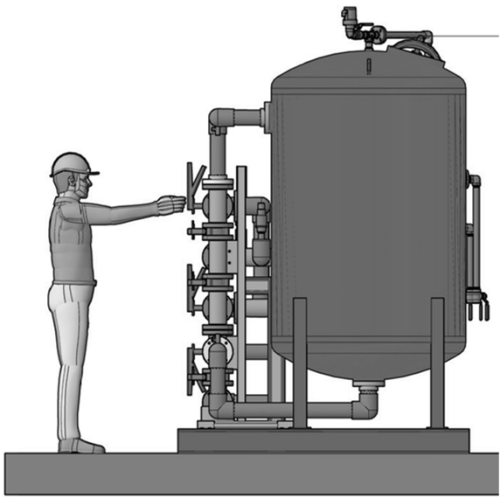
## Small IX Systems – Skid Mounted Tanks

Down Flow Treatment System
1 Train, 2 Vessels in Series Arrangement
85 gpm System Example



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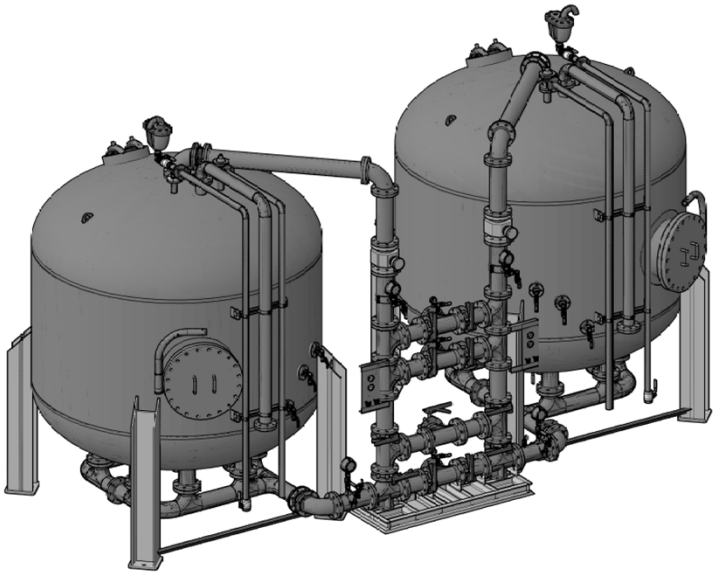
## Large IX Systems – Stand Alone Tanks



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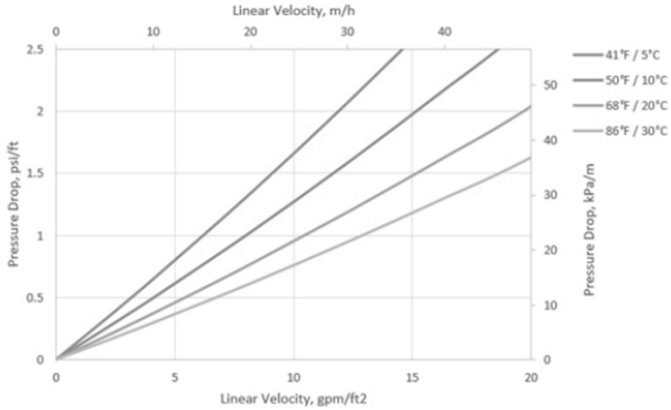
## IX Filter – Pressure Drop Considerations

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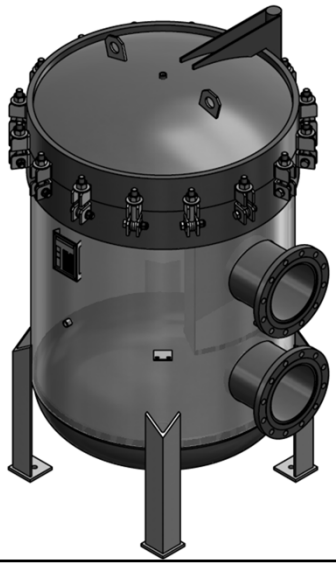
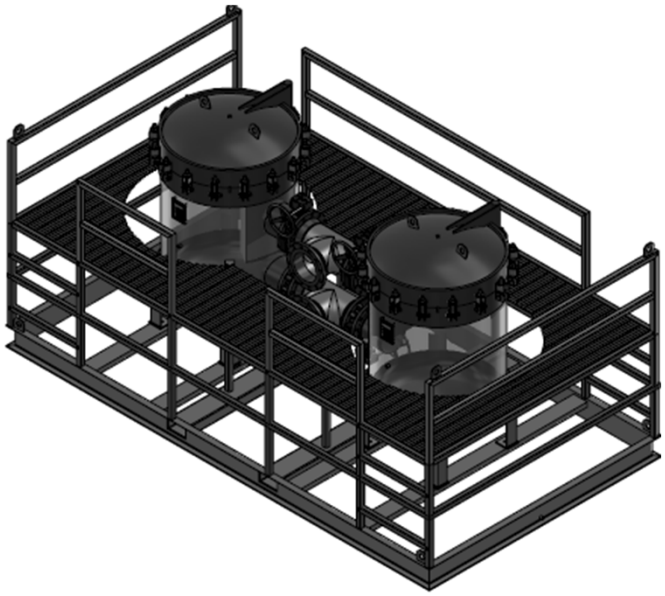
## Bag Filter





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## Bag Filter


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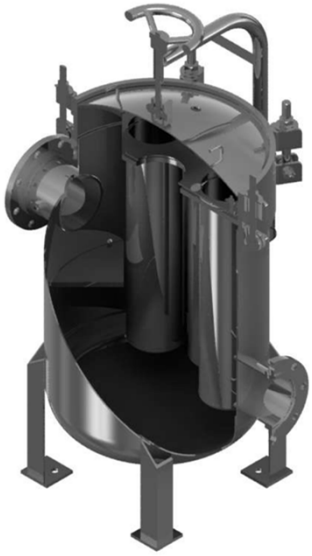
## Bag Filter Element



For a flow of 2,400 gpm, a 42” diameter bag filter is required.
With a 42” diameter bag filter, 19 elements are provided.

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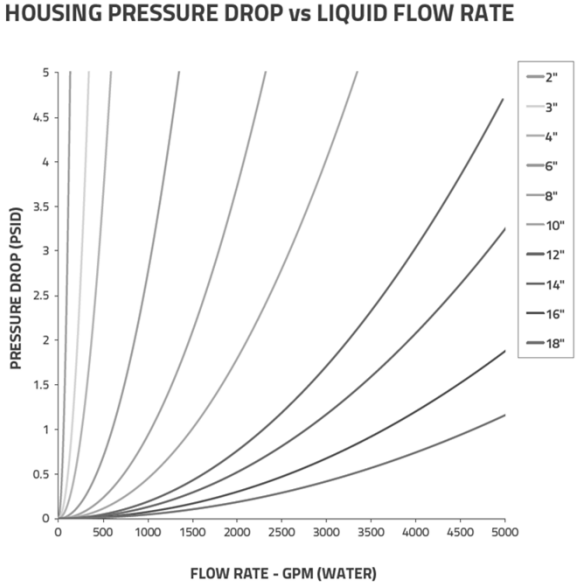
## Bag Filter – Pressure Drop Considerations

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## GAC

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## GAC Explained

- GAC utilizes an adsorption based process
- Adsorption concept: think of painting a grain of sand vs. absorption which would be a sponge-like action
- PFAS removal process consists of contaminants being adsorbed into the pores and onto the surface of the media
- Media is activated carbon, which is charcoal that has been granulated and exposed to high temperatures, having a specific mean diameter and angularity

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## GAC Explained (cont'd)

GAC media

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## GAC Treatment Process Logistics

- GAC reactors/filter vessels typically operate in series
- GAC media is robust and not affected as much by turbidity, therefore bag filters are not needed in advance of treatment
- GAC can handle moderate exchange rates
- GAC typically requires an EBCT of 10 to 20 minutes
- After breakthrough, expended GAC is evacuated and replaced with virgin GAC (**not** reactivated GAC)

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## Small GAC Systems – Stand Alone FRP Tanks

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## Large GAC Systems – Stand Alone Steel Tanks


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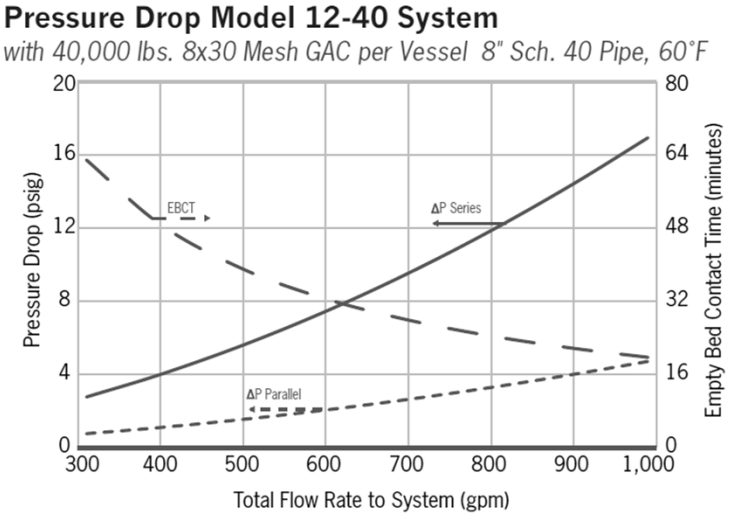
## Large GAC Systems – 12’ Diameter Tank TDH Considerations

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## IX vs. GAC

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## IX Talking Points vs. GAC

**PROS**

- Smaller footprint
- Higher feed rates
- PFAS-selective resin removes 5 to 10 times more PFOA
- Higher mass loading capacity
- More effective at removing short chain PFAS

**CONS**

- Media capital costs are higher
- Requires pretreatment i.e.: bag filters > higher TDH
- With higher TDHs, larger HP pumps required

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## GAC Talking Points vs. IX

**PROS**

- Does not require pretreatment
- Media capital costs are lower
- Media is more robust and therefore able to withstand water chemistry changes
- Bonus: tastes, odors, and color are removed

**CONS**

- Larger footprint is required, which increases initial capital investment costs for vessels
- Because of larger footprint, more building and land space is required
- GAC media requires backwashing and rinsing before use

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## Vessel Sizes and Collateral Effects

- EBCT is up to 5 times larger for GAC than for IX
- GAC filter vessels need to be 3 to 5 times larger in empty bed volume than IX filter vessels
- With larger volume vessels comes higher building ceilings, larger concrete pads/floors, additional piping, and additional conduit/wiring run lengths

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## General Comparison Observations

- Surface water treatment schemes favor GAC
- Groundwater treatment schemes favor IX
- If real estate is available and space restrictions are not an obstacle, GAC use becomes more competitive
- IX, as a synthetically produced product, is engineered to remove specific, targeted contaminants
- GAC, as a natural media, removes a wide range of contaminants

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## PROJECT EXAMPLES

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## Eagleswood Village (Small) – Background

- 80 person population with 53 service connections
- Maximum 65 gpm groundwater system
- PFOA at 43 ppt and PFOS at 47 ppt
- Two 36” diameter pressure vessel operating in series
- Other collateral issues: hydropneumatic tank failure, need to replace building and building systems

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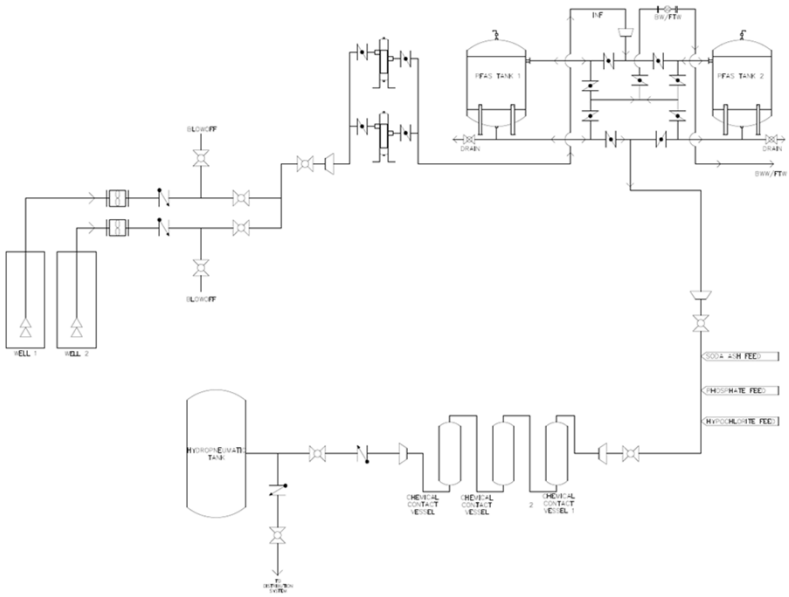
## Eagleswood (Small) – Process Schematic

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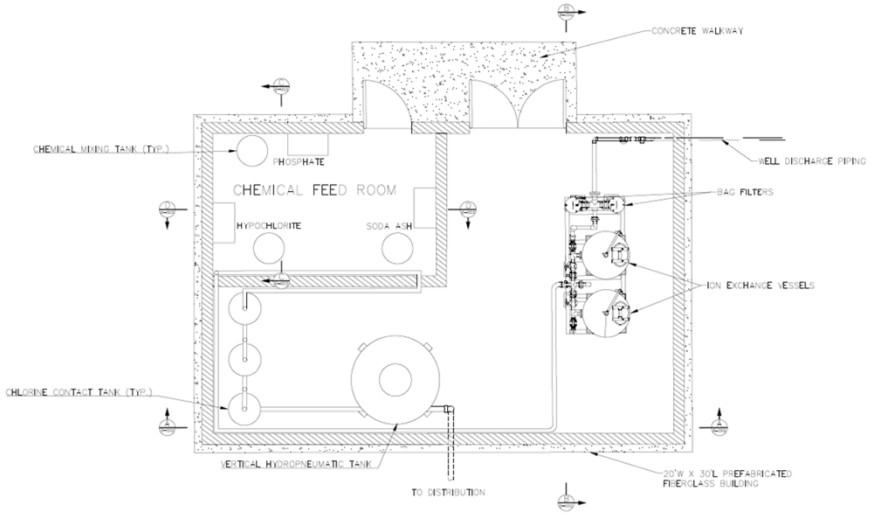
## Eagleswood (Small) – Design Features

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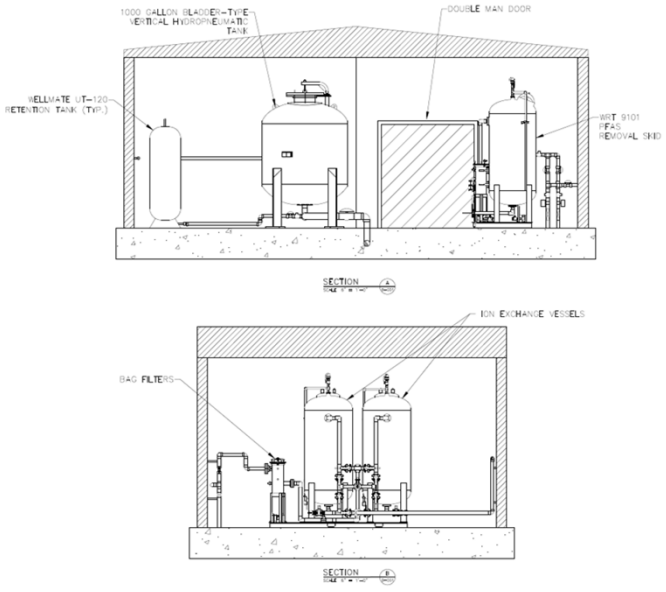
## Eagleswood (Small) – Design Features

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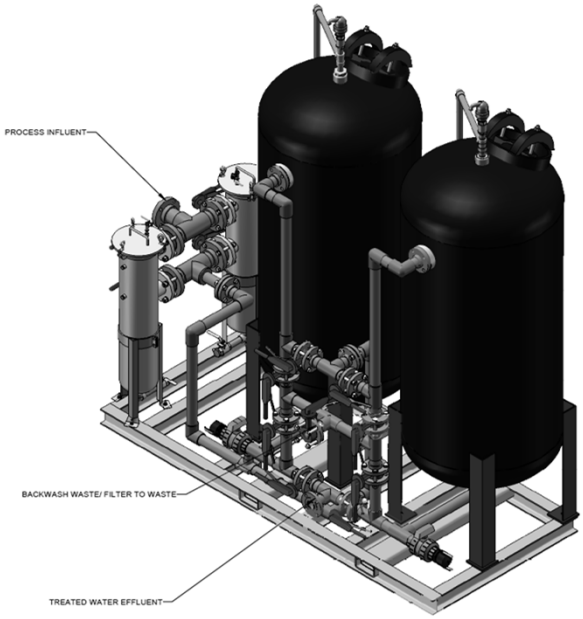
## Eagleswood (Small) – Design Features

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## City of Orange Township (Large) – Background

- Mid-size city population (approximately 31,000 residents) served by a multiple deep well groundwater system
- Targeted 2,400 gpm treatment capacity
- PFOA at 23 ppt and PFOS at 5.8 ppt
- Two 12 foot diameter pressure vessels operating in parallel
- Temporary system, tight operating space
- Design-Build contractual arrangement

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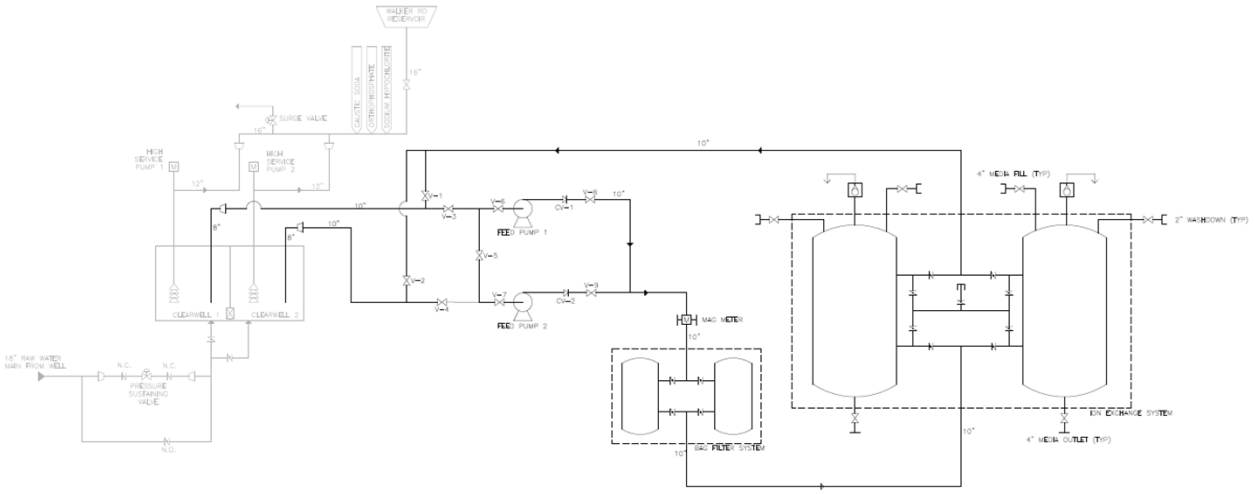
## City of Orange Township (Large) – Process Schematic

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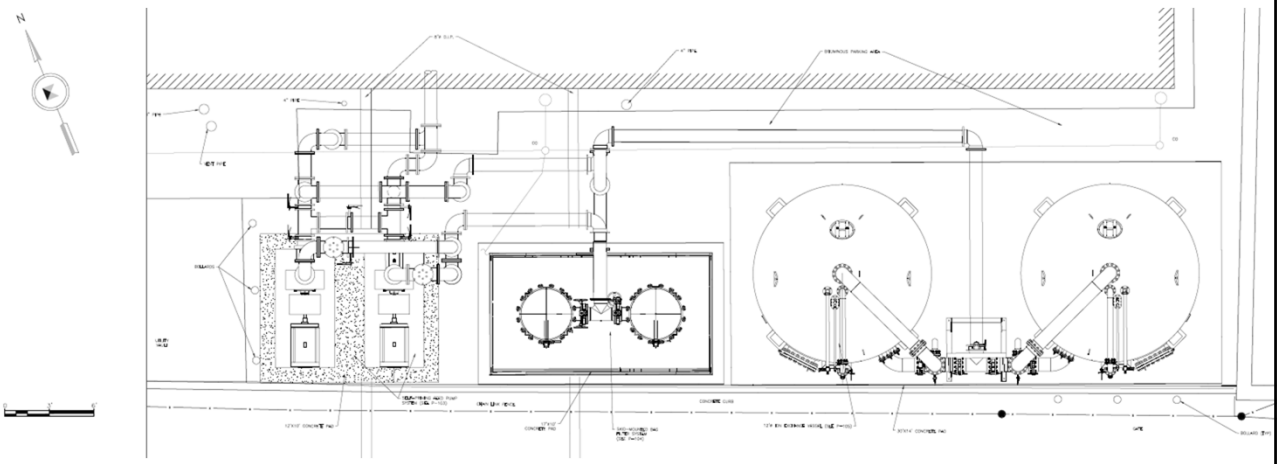
## City of Orange Township (Large) – Overall Treatment Plan



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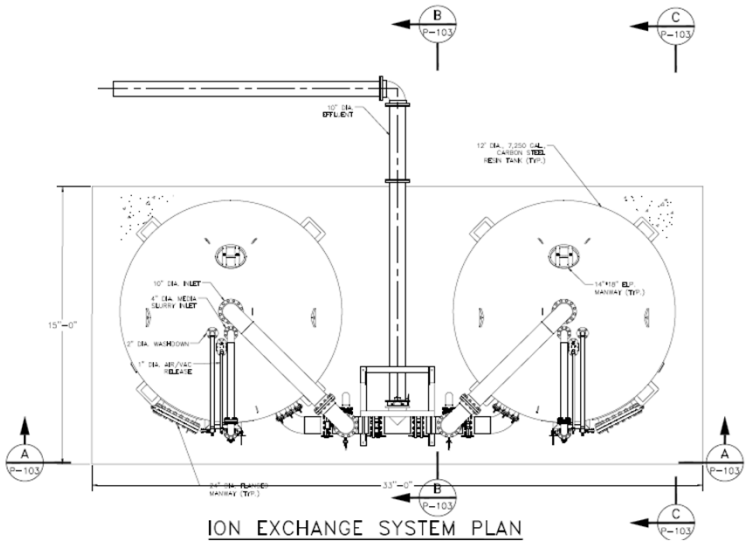
## City of Orange Township – Design Features – IX System




ION EXCHANGE SYSTEM PLAN

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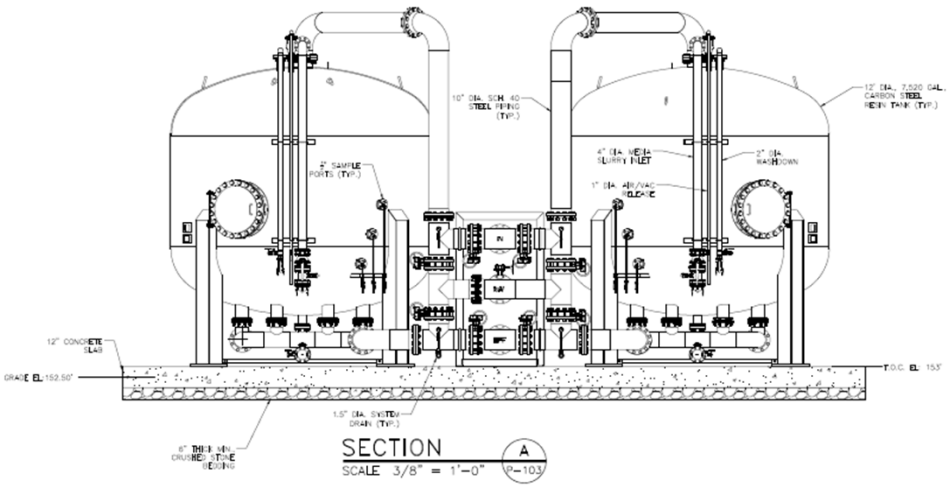
## City of Orange Township – Design Features – IX System




SECTION A
SCALE 3/8" = 1'-0"
P-103

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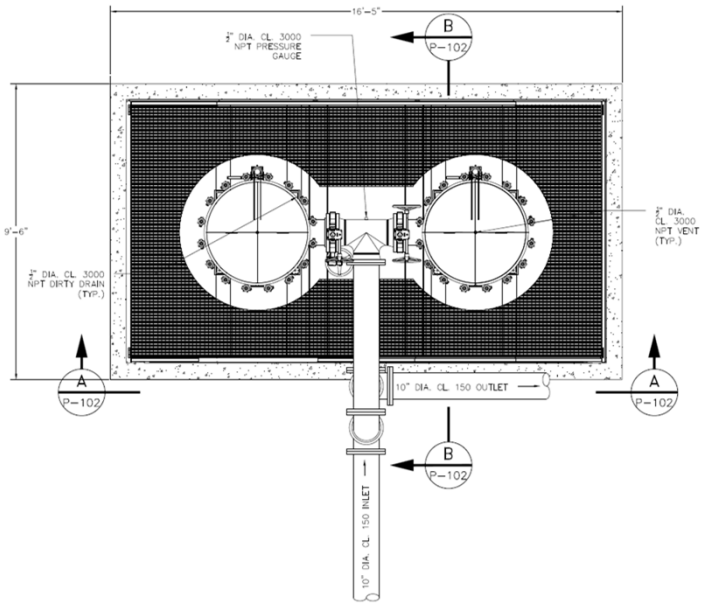
## City of Orange Township – Design Features – Bag Filtration

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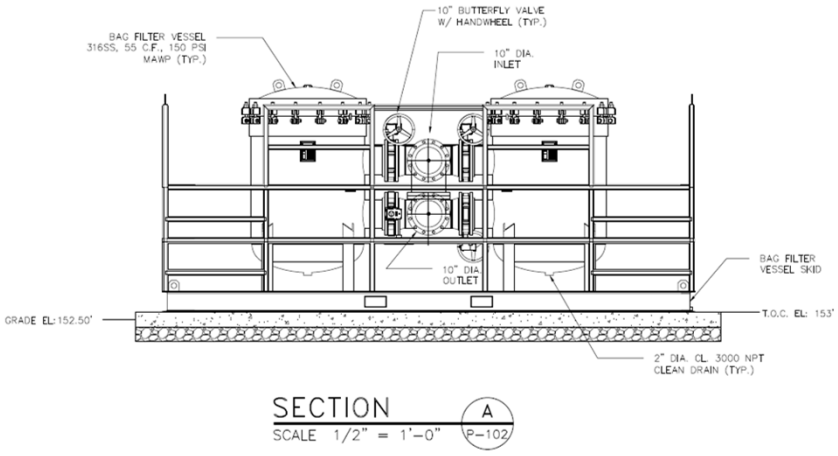
## City of Orange Township – Design Features – Bag Filtration

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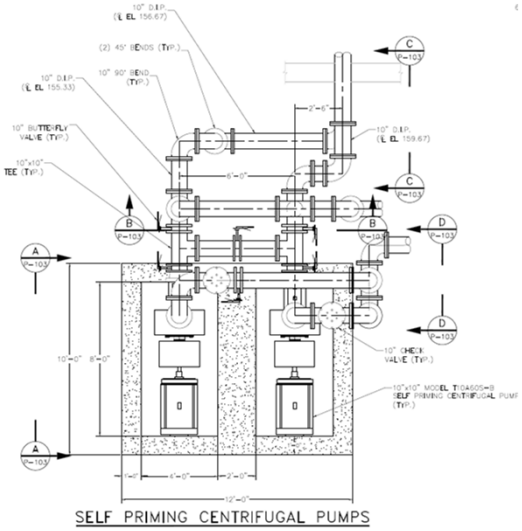
## City of Orange Township – Design Features – Feed Pumps

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## City of Orange Township (Large)

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## City of Orange Township (Large)

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## City of Orange Township (Large)


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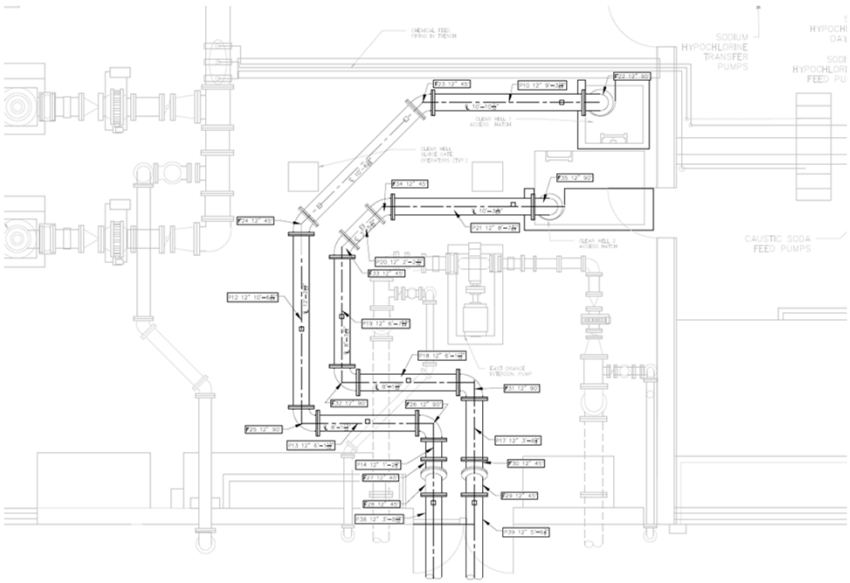
## City of Orange Township – Design-Build Features

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## City of Orange Township (Large)


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## CHALLENGES AND SUCCESSES

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## City of Orange Township -- Challenges

- Early July, 2020 D-B authorization, September 15th, 2022 functional deadline
- COVID supply chain issues
  - Small inventory of immediately available feed pumps
  - Pressure vessel steel availability and tank welding shortages
  - Bag filters: 6 month lead time
- Interruption of operations with pipe gallery and door/wall penetrations

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## City of Orange Township – Challenges (cont'd)

- Complicated raw water supply delivery flow rates and logistics
- Clearwell water suction and discharge points
  - 2 clearwells – one serving as suction point, the other serving as discharge point
  - Need to alternate suction and discharge operations
  - Very narrow high and low water operating band
- Needed to start system up without bag filters in place, causing:
  - Particulate settlement on top of and throughout IX media
  - Superficially low feed pump TDHs which created cavitation

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## City of Orange Township – Successes

- System was operational by September 15th, 2020 deadline
- Delivered water was devoid of PFOA (100% removal)
- Minimal operations interruptions during construction

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## SUMMARY

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## Take Aways

- IX and GAC are both effective at removing PFAS
- GAC removes a range of contaminants
- IX selectively removes contaminants
- Best media type is partially dependent on water source quality
- Best media type is specific to contaminant(s) targeted for removal
- Available real estate and project site elbow room will help to drive media selection

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## THANK YOU

**David Applegate, P.E.**
**dapplegate@kielybuilds.com**
**908-745-8871**

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