**Electronic Supplementary Information**

# Removal of Per and Polyfluoroalkyl Substances by Granular Activated Carbon and Anion Exchange Resins from Contaminated Groundwater: A Pilot-Scale Comparative Assessment

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## 1.0 Column Operating Conditions

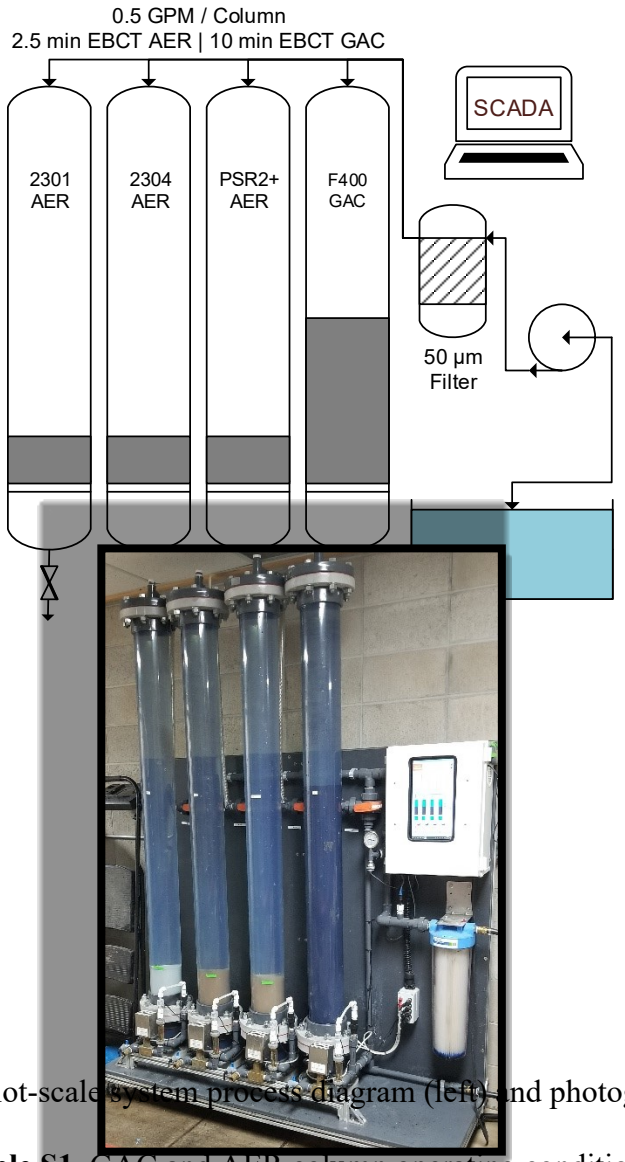



**Figure S1.** Pilot-scale system process diagram (left) and photograph (right).

**Table S1.** GAC and AER column operating conditions

| Condition | GAC | AER |
|---|---|---|
| Media Height (in) | 45.0 (114.3 cm) | 11.3 (28.7 cm) |
| Column Diameter (in) | 5.7 (14.5 cm) | 5.7 (14.5 cm) |
| Flowrate/Column (gpm) | 0.5 (1.9 Lpm) | 0.5 (1.9 Lpm) |
| Total Bed Volume (gal) | 5 (18.9 L) | 1.3 (4.7 L) |
| Total Run Time (day) | 343 | 343 |
| Hydraulic Loading Rate (gpm/ft$^2$) | 2.8 (114.6 Lpm/m$^2$) | 2.8 (114.6 Lpm/m$^2$) |
| Empty Bed Contact Time (min) | 10 | 2.5 |

**2.0 PFAS Sample Analysis**

All samples were collected in 50 mL polypropylene centrifuge tubes (Falcon; Corning, NY) tubes. The following reagents were added to each aliquot: 63.8% water sample, 3.3% Fisher Scientific Optima™ LCMS grade water (Hampton, NH) mixed with 0.1% of Optima™ LCMS grade ammonium hydroxide, 13.6% Optima™ LCMS grade methanol, 9.6% of Optima™ LCMS grade isopropanol surrogate mixture, and 9.6% of Optima™ LCMS grade methanol surrogate mixture. Labeled PFAS (in methanol and isopropanol) internal standards were spiked at 74 pg/mL. Samples were vortexed at 4000 rpm for 10 min and a 1.35 mL aliquot of sample was transferred into a 2 mL autosampler vial.

One mL of sample was injected onto a SCIEX X500R QTOF System (Framingham, MA). The analytical column used was Phenomenex Gemini C18, 3 mm × 100 mm × 5 µm (Torrance, CA) paired with a Phenomenex C18 SecurityGuard™ 4 mm × 2 mm (Torrance, CA) and two Agilent Zorbax 4.6 mm × 12.5 mm × 6 µm DIOL guard columns (Santa Clara, CA). A Phenomenex Luna 5 um C18(2) 100 Å LC column 30 × 3 mm (Torrance, CA) was used as a delay column to aid in chromatographic separation. The column oven temperature was set to 40 °C. The eluent mobile phases used were (A) Optima™ LCMS grade water with 20 mM Fisher Scientific HPLC grade ammonium acetate (Hampton, NH) and (B) 100% Optima™ LCMS grade methanol. The autosampler rinse solution was 100% Optima™ LCMS grade isopropanol. Eluent flow rate was held at 0.60 mL/min, and composition was ramped from 90% A to 50% A over the first 0.5 min, then to 1.0% A at 8 min and held until 13 min, then ramped to 90% A at 13.5 min and held constant until 20 min.

Electrospray ionization in negative mode (ESI-) with SWATH® Data-Independent Acquisition for both TOFMS and MS/MS mode were used. Precursor ion data was collected for m/z 100-1200 for 1283 cycles with a total scan time of 842 ms and accumulation time of 20 ms, with ion spray voltage set at - 4500 V and temperature set to 550 ºC. The ion source, curtain, and collision (CAD) gas were set to 60 psi, 35 psi, and 10 psi, respectively. For QTOF scanning, the collision energy was set to -5 V and the declustering potential to -20 V, both with no spread. Product ion (MS/MS) scanning was conducted for m/z 50-1200 Da. The accumulation time for each SWATH window is 50 ms and collision energy was -35 V with 30 V spread. The instrument was mass calibrated every 5 injections using SCIEX ESI Negative Calibration Solution.

For quantitative analysis, data processing was done using SCIEX OS (Versions 1.30-1.6.0) to quantify targeted analytes. Retrospective analysis of the QTOF data allows unknown PFASs identification using the MS/MS library and an extracted ion chromatogram (XIC) list; however, these data and the qualitative analysis procedures are not included in this manuscript. Targeted analyte confirmation is based on accurate mass (XIC window 0.01 Da) and retention time compared to analytical standards with signal to noise ratio >10:1. A middle calibration point ran at the beginning of each run was used to determine the expected retention time for each compound. Integration parameters included a 2 min baseline-subtract window, 90% lowest-intensity peak defined as noise, minimum peak intensity of 100, and a peak width of 10 points. Manual integration of selected peaks not meeting the minimum peak intensity occurred if retention time, accurate mass, and isotope confidence were determined as satisfactory. Calibration, quantification, and upper and lower limits of quantitation for each compound are based on a 15-point calibration curve

determined in SCIEX OS Analyst software. Limit of quantification values generally ranged from 0.7 ng/L to 370 ng/L.

## 3.0 Results

### 3.1 Measured PFAS Feed Concentrations

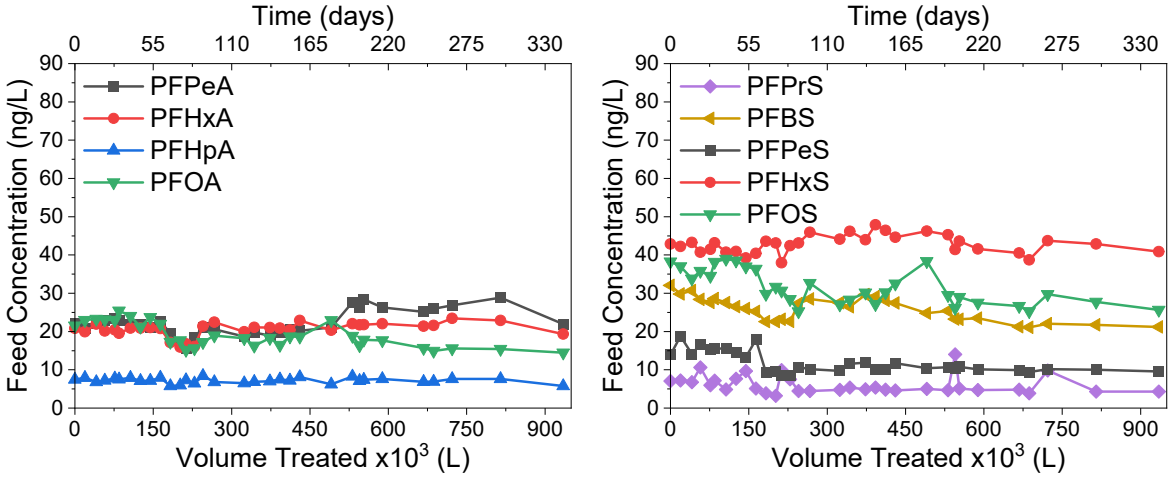



**Figure S2.** Measured PFAS feed concentration (ng/L) overtime

### 3.2 Media Usage Rate Calculations

Media usage rate (g of media / L of water treated) is calculated as follows in **Equation 1** where specific throughput (L of water treated / g of media) is defined in **Equation 2**, where $t_{bk}$ is the time to breakthrough (days), EBCT is the empty bed contact time (days), and ρ is the bulk density of the media (g/L).

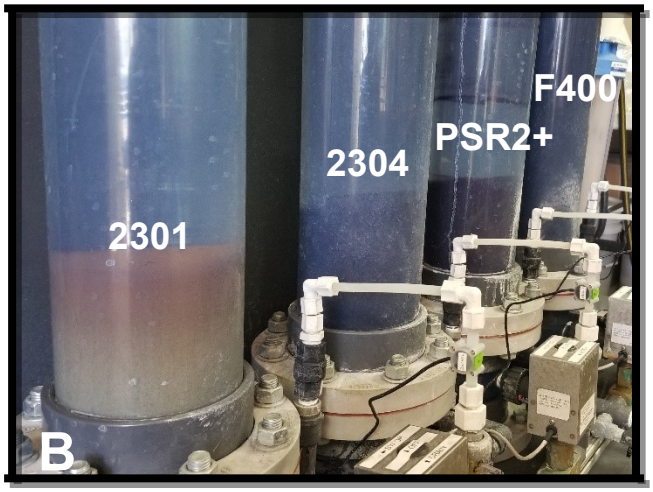
$$media\ usage\ rate = \frac{1}{specific\ throughput}$$

**Equation S1**. Media usage rate

$$specific\ throughput = \frac{t_{bk}}{EBCT * \rho}$$

**Equation S2**. Specific throughput

### 3.3 Resin Color Change During Pilot Operation

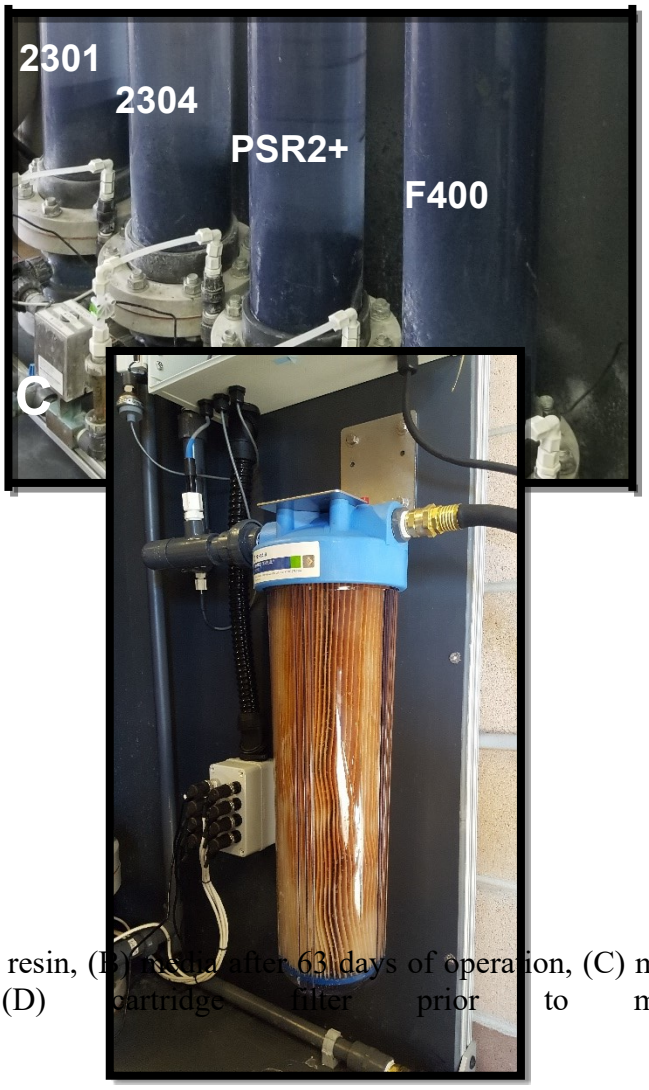



**Exhibit S1**. (A) Virgin resin, (B) media after 63 days of operation, (C) media after 180 days of operation, and (D) cartridge filter prior to monthly changeout.

## 4.0 Water Quality Results

### 4.1 Cationic Species Analysis

**Table S2.** Column influent and effluent metals concentrations

| Influent (mg/L) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Liters Treated | Days | As | B | Ba | Ca | Fe | K | Li | Mg | Mn | Mo | Na | S | Si |
| 0 | 0 | 0.02 | 0.19 | 0.05 | 91.73 | 0.04 | 5.57 | 0.04 | 27.30 | 0.09 | 0.01 | 121.06 | 81.17 | 7.89 |
| 40878 | 15 | 0.01 | 0.16 | 0.04 | 76.38 | 0.00 | 5.28 | 0.04 | 25.37 | 0.08 | 0.01 | 88.53 | 74.37 | 7.46 |
| 76306 | 28 | 0.02 | 0.21 | 0.05 | 85.88 | BDL | 5.49 | 0.04 | 25.86 | 0.09 | 0.01 | 94.30 | 74.03 | 7.69 |
| 106283 | 39 | BDL | 0.16 | 0.05 | 82.55 | BDL | 5.24 | 0.04 | 24.09 | 0.10 | 0.01 | 83.24 | 73.16 | 7.66 |
| 144436 | 53 | 0.01 | 0.20 | 0.04 | 81.39 | BDL | 5.15 | 0.04 | 24.33 | 0.09 | 0.01 | 88.52 | 70.63 | 7.49 |
| 182588 | 67 | 0.02 | 0.15 | 0.04 | 78.05 | BDL | 4.74 | 0.04 | 23.47 | 0.09 | 0.01 | 82.00 | 69.61 | 7.62 |
| 212566 | 78 | 0.02 | 0.18 | 0.04 | 79.79 | BDL | 4.99 | 0.04 | 25.06 | 0.10 | 0.01 | 89.04 | 69.36 | 6.81 |
| 245268 | 90 | 0.01 | 0.15 | 0.04 | 77.25 | 0.01 | 4.57 | 0.03 | 23.05 | 0.10 | 0.01 | 72.92 | 65.18 | 7.20 |
| 324299 | 119 | 0.02 | 0.15 | 0.04 | 77.65 | BDL | 4.80 | 0.03 | 23.53 | 0.11 | 0.01 | 72.44 | 66.24 | 7.41 |
| 373352 | 137 | 0.01 | 0.15 | 0.04 | 80.06 | BDL | 4.92 | 0.03 | 23.98 | 0.13 | 0.01 | 64.45 | 66.31 | 7.14 |
| 411505 | 151 | 0.01 | 0.15 | 0.04 | 79.33 | BDL | 4.98 | 0.03 | 24.30 | 0.14 | 0.01 | 69.25 | 70.34 | 7.47 |
| 490536 | 180 | 0.02 | 0.15 | 0.04 | 78.62 | 0.01 | 4.81 | 0.03 | 24.10 | 0.13 | 0.01 | 76.35 | 86.85 | 7.54 |
| 545040 | 200 | 0.02 | 0.14 | 0.04 | 77.49 | 0.00 | 4.79 | 0.04 | 22.66 | 0.15 | 0.01 | 74.04 | 82.14 | 6.73 |
| 667674 | 245 | 0.02 | 0.14 | 0.04 | 74.93 | 0.01 | 4.75 | 0.03 | 22.57 | 0.16 | 0.01 | 73.15 | 80.20 | 6.69 |
| 722178 | 265 | 0.02 | 0.09 | 0.04 | 77.97 | 0.00 | 4.95 | 0.04 | 22.51 | 0.15 | 0.01 | 74.52 | 74.03 | 5.67 |
| 814835 | 299 | 0.02 | 0.16 | 0.04 | 77.84 | 0.00 | 5.05 | 0.04 | 22.67 | 0.15 | 0.01 | 73.43 | 82.24 | 7.43 |
| 934744 | 343 | 0.02 | 0.15 | 0.04 | 75.50 | 0.00 | 4.73 | 0.04 | 22.86 | 0.17 | 0.01 | 73.60 | 79.72 | 7.37 |
| Average | | 0.02 | 0.16 | 0.04 | 79.55 | - | 4.99 | 0.04 | 23.98 | 0.12 | 0.01 | 80.64 | 74.45 | 7.25 |
| F400 Effluent (mg/L) | | | | | | | | | | | | | | |
| Liters Treated | Days | As | B | Ba | Ca | Fe | K | Li | Mg | Mn | Mo | Na | S | Si |
| 0 | 0 | 0.01 | 0.17 | 0.05 | 65.96 | 0.05 | 5.51 | 0.04 | 26.19 | 0.00 | 0.01 | 96.08 | 76.59 | 7.62 |
| 40878 | 15 | 0.01 | 0.14 | 0.03 | 69.65 | BDL | 5.41 | 0.04 | 25.54 | 0.05 | 0.01 | 95.17 | 74.39 | 7.26 |
| 76306 | 28 | 0.01 | 0.17 | 0.03 | 54.34 | BDL | 5.36 | 0.04 | 24.90 | BDL | 0.01 | 89.80 | 73.15 | 7.57 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106283 | 39 | 0.01 | 0.16 | 0.05 | 81.97 | BDL | 5.25 | 0.04 | 24.80 | BDL | 0.01 | 88.50 | 72.73 | 7.62 |
| 144436 | 53 | 0.02 | 0.20 | 0.04 | 80.04 | BDL | 5.09 | 0.04 | 23.31 | BDL | 0.01 | 70.09 | 69.60 | 7.65 |
| 182588 | 67 | 0.02 | 0.17 | 0.04 | 79.50 | BDL | 4.86 | 0.04 | 24.10 | BDL | 0.01 | 77.72 | 68.66 | 7.48 |
| 212566 | 78 | 0.01 | 0.15 | 0.04 | 80.66 | BDL | 4.97 | 0.04 | 24.08 | BDL | 0.01 | 75.69 | 68.72 | 7.53 |
| 245268 | 90 | 0.02 | 0.16 | 0.04 | 80.60 | BDL | 5.07 | 0.04 | 23.21 | BDL | 0.01 | 69.30 | 67.97 | 7.15 |
| 324299 | 119 | 0.01 | 0.18 | 0.04 | 77.44 | BDL | 4.76 | 0.03 | 23.40 | BDL | 0.01 | 67.67 | 68.53 | 7.70 |
| 373352 | 137 | BDL | 0.17 | 0.04 | 78.76 | BDL | 4.78 | 0.03 | 23.62 | BDL | 0.01 | 71.82 | 69.65 | 7.64 |
| 411505 | 151 | 0.02 | 0.16 | 0.04 | 81.63 | BDL | 4.94 | 0.03 | 24.52 | BDL | 0.01 | 70.17 | 68.77 | 7.41 |
| 490536 | 180 | 0.02 | 0.14 | 0.04 | 79.47 | 0.00 | 4.87 | 0.03 | 23.92 | 0.00 | 0.01 | 75.05 | 83.25 | 7.29 |
| 545040 | 200 | 0.01 | 0.14 | 0.04 | 77.76 | 0.00 | 4.85 | 0.03 | 23.48 | BDL | 0.01 | 74.22 | 82.72 | 7.34 |
| 667674 | 245 | 0.01 | 0.14 | 0.04 | 75.38 | 0.00 | 4.45 | 0.04 | 22.80 | BDL | 0.01 | 71.59 | 79.70 | 7.16 |
| 722178 | 265 | BDL | 0.08 | 0.04 | 74.61 | 0.01 | 5.23 | 0.04 | 22.24 | 0.00 | 0.01 | 74.54 | 74.67 | 9.33 |
| 814835 | 299 | 0.02 | 0.16 | 0.04 | 77.41 | 0.00 | 4.79 | 0.03 | 23.68 | BDL | 0.01 | 73.24 | 83.34 | 7.44 |
| 934744 | 343 | 0.02 | 0.14 | 0.04 | 74.42 | 0.02 | 5.02 | 0.03 | 22.31 | 0.00 | 0.01 | 71.42 | 79.14 | 7.18 |
| Average | | 0.02 | 0.16 | 0.04 | 75.86 | - | 5.01 | 0.04 | 23.89 | - | 0.01 | 77.18 | 74.21 | 7.55 |

2301 Effluent (mg/L)

| Liters Treated | Days | As | B | Ba | Ca | Fe | K | Li | Mg | Mn | Mo | Na | S | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0.02 | 0.18 | 0.05 | 81.06 | 0.11 | 5.56 | 0.04 | 27.37 | 0.00 | 0.01 | 100.44 | 79.75 | 7.63 |
| 40878 | 15 | 0.02 | 0.17 | 0.05 | 81.90 | 0.01 | 5.42 | 0.04 | 25.98 | 0.05 | 0.01 | 94.34 | 75.80 | 7.63 |
| 76306 | 28 | 0.02 | 0.17 | 0.05 | 84.53 | BDL | 5.29 | 0.04 | 25.16 | 0.09 | 0.01 | 93.17 | 75.29 | 7.74 |
| 106283 | 39 | 0.01 | 0.16 | 0.04 | 83.47 | BDL | 5.17 | 0.04 | 25.00 | 0.08 | 0.01 | 86.62 | 71.90 | 7.64 |
| 144436 | 53 | 0.02 | 0.17 | 0.04 | 80.14 | BDL | 4.95 | 0.04 | 23.83 | BDL | 0.01 | 77.80 | 68.68 | 7.48 |
| 182588 | 67 | 0.01 | 0.16 | 0.04 | 77.31 | BDL | 5.08 | 0.04 | 23.14 | BDL | 0.01 | 72.89 | 67.67 | 7.36 |
| 212566 | 78 | 0.02 | 0.16 | 0.04 | 79.76 | BDL | 4.84 | 0.03 | 23.30 | BDL | 0.01 | 73.87 | 69.66 | 7.60 |
| 245268 | 90 | 0.02 | 0.16 | 0.04 | 80.11 | BDL | 4.88 | 0.03 | 23.28 | BDL | 0.01 | 60.56 | 68.83 | 7.61 |
| 324299 | 119 | 0.01 | 0.16 | 0.04 | 78.24 | 0.02 | 4.73 | 0.03 | 24.18 | BDL | 0.01 | 72.71 | 66.43 | 7.35 |
| 373352 | 137 | 0.01 | 0.15 | 0.04 | 77.17 | BDL | 4.62 | 0.03 | 23.78 | BDL | 0.01 | 68.07 | 67.74 | 7.38 |
| 411505 | 151 | 0.01 | 0.15 | 0.04 | 78.77 | BDL | 4.88 | 0.03 | 24.10 | BDL | 0.01 | 64.87 | 69.97 | 7.49 |
| 490536 | 180 | 0.02 | 0.15 | 0.04 | 79.29 | 0.01 | 4.69 | 0.03 | 24.20 | 0.00 | 0.01 | 75.55 | 84.12 | 7.36 |
| 545040 | 200 | 0.01 | 0.14 | 0.04 | 76.28 | 0.00 | 4.79 | 0.02 | 23.15 | BDL | 0.01 | 73.40 | 83.62 | 7.26 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 667674 | 245 | 0.02 | 0.14 | 0.04 | 77.72 | 0.00 | 4.95 | 0.03 | 23.30 | 0.01 | 0.01 | 73.66 | 84.57 | 7.54 |
| 722178 | 265 | BDL | 0.08 | 0.04 | 76.25 | BDL | 4.74 | 0.03 | 22.86 | 0.01 | 0.01 | 77.91 | 77.29 | 7.00 |
| 814835 | 299 | 0.02 | 0.16 | 0.04 | 77.57 | 0.00 | 4.85 | 0.03 | 23.12 | 0.23 | 0.01 | 73.26 | 80.57 | 7.21 |
| 934744 | 343 | 0.02 | 0.14 | 0.05 | 74.51 | 0.01 | 5.14 | 0.03 | 22.73 | 0.45 | 0.01 | 71.80 | 80.26 | 7.33 |
| Average | | 0.02 | 0.15 | 0.04 | 79.06 | - | 4.98 | 0.04 | 24.03 | - | 0.01 | 77.11 | 74.83 | 7.45 |

2304 Effluent (mg/L)

| Liters Treated | Days | As | B | Ba | Ca | Fe | K | Li | Mg | Mn | Mo | Na | S | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0.01 | 0.18 | 0.05 | 77.16 | 0.10 | 5.59 | 0.04 | 27.39 | 0.01 | 0.01 | 98.60 | 80.53 | 7.48 |
| 40878 | 15 | 0.01 | 0.16 | 0.04 | 76.83 | 0.12 | 5.32 | 0.04 | 26.23 | 0.07 | 0.01 | 97.28 | 75.31 | 7.63 |
| 76306 | 28 | BDL | 0.17 | 0.03 | 56.15 | BDL | 5.28 | 0.04 | 24.70 | 0.04 | 0.01 | 80.39 | 73.74 | 7.76 |
| 106283 | 39 | 0.02 | 0.15 | 0.04 | 74.32 | BDL | 4.95 | 0.04 | 24.62 | 0.03 | 0.01 | 72.47 | 71.35 | 7.35 |
| 144436 | 53 | 0.01 | 0.16 | 0.04 | 78.50 | BDL | 4.86 | 0.04 | 24.17 | 0.00 | 0.01 | 83.40 | 71.26 | 7.75 |
| 182588 | 67 | 0.01 | 0.15 | 0.04 | 78.37 | BDL | 4.85 | 0.03 | 22.99 | BDL | 0.01 | 72.06 | 67.91 | 7.51 |
| 212566 | 78 | 0.01 | 0.15 | 0.04 | 78.29 | BDL | 4.72 | 0.03 | 23.92 | 0.02 | 0.01 | 71.83 | 68.97 | 7.62 |
| 245268 | 90 | 0.01 | 0.16 | 0.04 | 80.32 | BDL | 4.94 | 0.03 | 23.77 | BDL | 0.01 | 65.40 | 68.72 | 7.60 |
| 324299 | 119 | 0.01 | 0.15 | 0.04 | 77.49 | BDL | 4.63 | 0.03 | 22.56 | BDL | 0.01 | 61.48 | 65.88 | 7.36 |
| 373352 | 137 | 0.01 | 0.14 | 0.04 | 78.08 | BDL | 4.60 | 0.03 | 23.80 | BDL | 0.01 | 72.24 | 68.52 | 7.37 |
| 411505 | 151 | 0.02 | 0.18 | 0.04 | 80.36 | BDL | 4.71 | 0.03 | 23.99 | BDL | 0.01 | 68.04 | 69.39 | 7.53 |
| 490536 | 180 | 0.02 | 0.14 | 0.04 | 77.92 | 0.01 | 4.88 | 0.03 | 23.67 | 0.00 | 0.01 | 74.62 | 82.87 | 7.31 |
| 545040 | 200 | 0.02 | 0.14 | 0.04 | 76.63 | 0.00 | 4.99 | 0.04 | 22.91 | 0.00 | 0.01 | 73.19 | 83.08 | 7.45 |
| 667674 | 245 | 0.01 | 0.13 | 0.04 | 75.46 | 0.00 | 4.59 | 0.04 | 22.20 | 0.01 | 0.01 | 72.27 | 79.07 | 7.21 |
| 722178 | 265 | BDL | 0.08 | 0.04 | 75.62 | 0.00 | 5.06 | 0.03 | 23.11 | 0.05 | 0.01 | 80.62 | 78.36 | 6.84 |
| 814835 | 299 | 0.02 | 0.16 | 0.04 | 77.33 | 0.00 | 5.01 | 0.03 | 23.73 | 0.24 | 0.01 | 76.95 | 83.55 | 7.20 |
| 934744 | 343 | 0.03 | 0.15 | 0.04 | 78.95 | 0.00 | 5.37 | 0.05 | 24.33 | 0.25 | 0.01 | 79.55 | 85.41 | 7.32 |
| Average | | 0.02 | 0.15 | 0.04 | 76.34 | - | 4.96 | 0.04 | 24.01 | - | 0.01 | 76.49 | 74.94 | 7.43 |

PSR2+ Effluent (mg/L)

| Liters Treated | Days | As | B | Ba | Ca | Fe | K | Li | Mg | Mn | Mo | Na | S | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0.02 | 0.18 | 0.05 | 75.12 | 0.04 | 5.68 | 0.04 | 26.84 | 0.01 | 0.01 | 91.13 | 80.48 | 7.79 |
| 40878 | 15 | BDL | 0.16 | 0.04 | 68.58 | 0.02 | 5.25 | 0.04 | 25.15 | 0.05 | 0.01 | 89.69 | 75.80 | 7.82 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 76306 | 28 | BDL | 0.07 | 0.03 | 42.32 | BDL | 1.93 | 0.02 | 10.03 | 0.04 | 0.00 | 32.30 | 35.47 | 5.28 |
| 106283 | 39 | 0.02 | 0.17 | 0.04 | 83.57 | BDL | 5.30 | 0.04 | 24.41 | 0.09 | 0.01 | 79.07 | 70.51 | 7.41 |
| 144436 | 53 | BDL | 0.16 | 0.04 | 81.29 | BDL | 4.85 | 0.04 | 23.89 | BDL | 0.01 | 75.69 | 70.20 | 7.59 |
| 182588 | 67 | 0.02 | 0.16 | 0.04 | 76.76 | BDL | 4.92 | 0.04 | 24.52 | BDL | 0.01 | 82.37 | 67.08 | 7.32 |
| 212566 | 78 | 0.02 | 0.15 | 0.04 | 79.35 | BDL | 4.84 | 0.04 | 23.77 | 0.03 | 0.01 | 73.82 | 68.18 | 7.47 |
| 245268 | 90 | 0.02 | 0.17 | 0.04 | 79.98 | BDL | 4.75 | 0.03 | 24.02 | BDL | 0.01 | 68.94 | 68.52 | 7.56 |
| 324299 | 119 | 0.02 | 0.17 | 0.04 | 78.09 | BDL | 5.00 | 0.04 | 23.83 | BDL | 0.01 | 69.68 | 68.25 | 7.63 |
| 373352 | 137 | 0.02 | 0.15 | 0.04 | 80.95 | BDL | 4.69 | 0.03 | 24.18 | BDL | 0.01 | 65.07 | 68.06 | 7.42 |
| 411505 | 151 | 0.02 | 0.15 | 0.04 | 79.42 | BDL | 4.87 | 0.03 | 24.60 | BDL | 0.01 | 71.88 | 67.97 | 7.34 |
| 490536 | 180 | 0.02 | 0.15 | 0.04 | 70.34 | 0.01 | 5.33 | 0.03 | 24.83 | 0.00 | 0.01 | 79.46 | 84.83 | 7.38 |
| 545040 | 200 | 0.02 | 0.14 | 0.04 | 76.50 | 0.00 | 4.73 | 0.03 | 23.07 | 0.01 | 0.01 | 73.67 | 80.02 | 7.25 |
| 667674 | 245 | 0.02 | 0.14 | 0.04 | 76.50 | 0.00 | 4.87 | 0.04 | 22.63 | 0.01 | 0.01 | 71.99 | 78.83 | 7.21 |
| 722178 | 265 | BDL | 0.11 | 0.04 | 74.80 | 0.00 | 4.88 | 0.05 | 22.44 | 0.03 | 0.01 | 75.36 | 75.36 | 6.99 |
| 814835 | 299 | 0.02 | 0.15 | 0.04 | 75.57 | 0.01 | 4.74 | 0.03 | 22.36 | 0.00 | 0.01 | 72.56 | 78.12 | 7.15 |
| 934744 | 343 | 0.02 | 0.15 | 0.04 | 76.57 | 0.01 | 4.71 | 0.04 | 23.15 | 0.00 | 0.01 | 74.12 | 81.87 | 7.43 |
| Average | | 0.02 | 0.15 | 0.04 | 75.04 | - | 4.78 | 0.03 | 23.16 | - | 0.01 | 73.34 | 71.74 | 7.30 |

Detection Limit (mg/L)

| As | B | Ba | Ca | Fe | K | Li | Mg | Mn | Mo | Na | S | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0080 | 0.0161 | 0.0003 | 0.0254 | 0.0016 | 0.1081 | 0.0049 | 0.0203 | 0.0002 | 0.0012 | 0.0193 | 0.0148 | 0.1031 |

### 4.2 Anionic Species Analysis

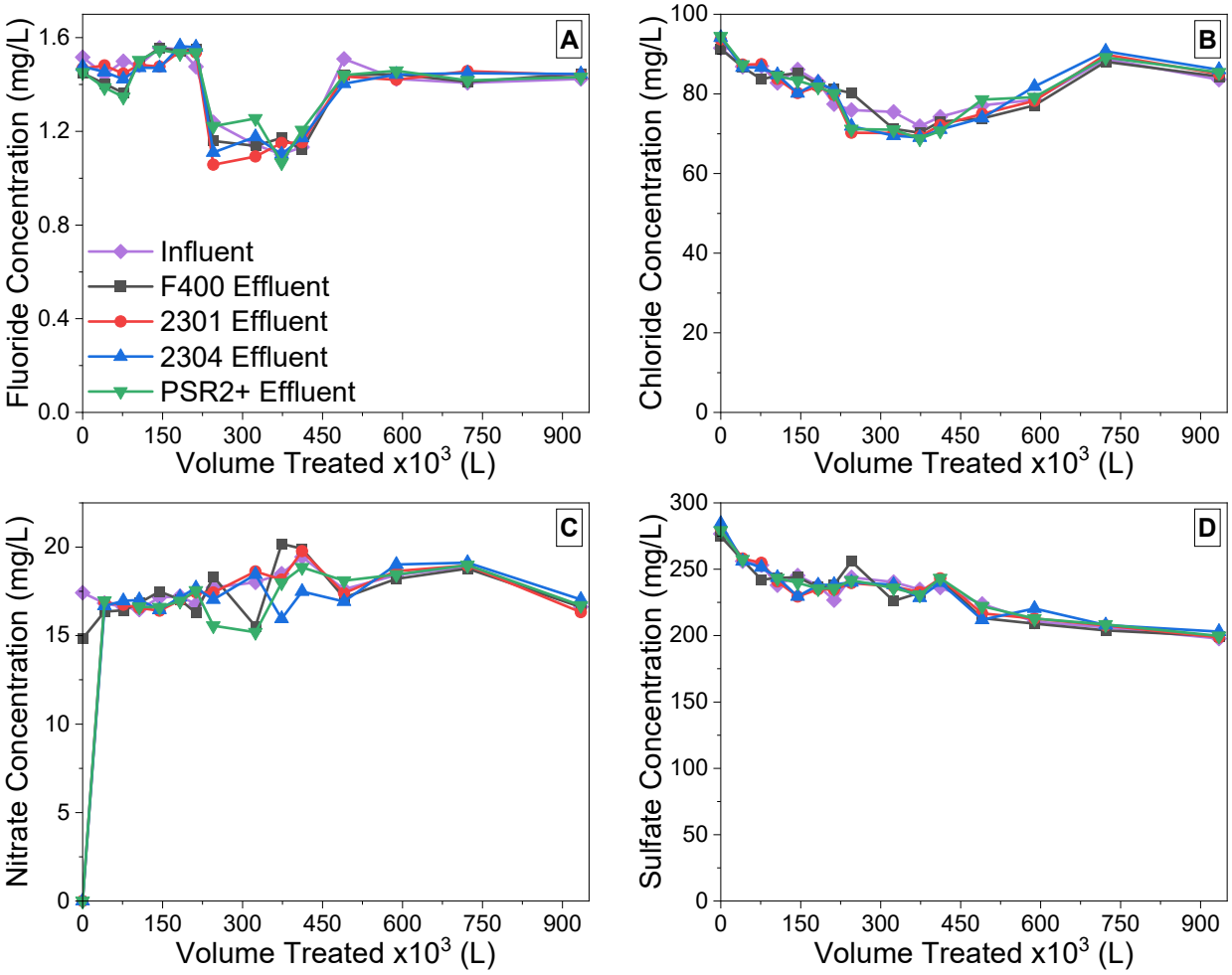



**Figure S3.** Prominent anionic species influent and effluent concentrations (A) fluoride, (B) chloride, (C) nitrate, and (D) sulfate.

**Table S3.** Summarized water quality

| Analyte | Average Concentration in Feed Groundwater (mg/L) |
|---|---|
| TOC | 1.92 ± 0.42 |
| TN | 0.34 ± 0.34 |
| pH | 7.33 ± 0.15 |
| Alkalinity (as $CaCO_3$) | 180 ± 7.0 |
| F | 1.39 ± 0.16 |
| Cl | 81.35 ± 5.96 |
| $NO_3$ | 17.58 ± 0.91 |
| $SO_4$ | 235.12 ± 20.26 |
| As | 0.02 ± 0 |

| | |
|---|---|
| B | 0.16 ± 0.03 |
| Ba | 0.04 ± 0 |
| Ca | 79.55 ± 4.11 |
| Fe | - |
| K | 4.99 ± 0.28 |
| Li | 0.04 ± 0 |
| Mg | 23.98 ± 1.32 |
| Mn | 0.12 ± 0.03 |
| Mo | 0.01 ± 0 |
| Na | 80.64 ± 13.23 |
| S | 74.45 ± 6.53 |
| Si | 7.25 ± 0.53 |

Error represents standard deviation of n=3 samples for pH and alkalinity, n=15 samples for TOC, TN, and anionic species, and n=17 samples for cationic species.

## 5.0 Cost Estimate Modeling

The basis for the unit costs presented in this assessment were estimates obtained by a research team of academics, consultants, and vendors. These values are explained in more detail elsewhere [1]. Briefly, ~1.1 media changeouts were estimated to occur per year for GAC and ~0.3 media changeouts were estimated to occur per year for AER. Mobilization costs were calculated based on an estimated time of 20 hours for two consulting engineers and equipment providers ($155/person/hour) and travel costs of $1,500 to coordinate and supervise each media change-out. As the model does not discount expenditures over time and normalizes costs per year, the mobilization costs are less for AER than for GAC per year. Disposal costs were higher for GAC then AER due to the greater GAC volume used in treatment. The disposal costs presented were for a hypothetical large facility using incineration as the method of PFAS waste disposal. Per research presented by others, the estimates were for $2,200 per tanker to transport the waste to an incineration facility and $0.20 per gallon of waste (up to 4,500 gallons per tanker). At the time of the model's development, PFAS waste disposal via hazardous waste incineration was determined to be the cost-effective disposal method. However, certain jurisdictions have now banned incinerating PFAS wastes as there is much uncertainty on the viability of this disposal method due to proposed legislation and litigation surrounding the practice. Analytical costs were the same for GAC and AER assuming 5 samples per month.

Note that capital costs of the infrastructure and the operational costs included in this assessment are not all inclusive. Smaller and specific disbursements that water treatment providers would encounter such as electrical costs from additional power consumption to pump influent water through the treatment pods are not included in this assessment. Similarly, the comparison conducted assumes retrofitting an existing treatment system, therefore labor (technical and administrative), building costs, heating, cooling, and ventilation are already accounted for in the water provider's annual operating expenses and are not considered additional expenditures.

**Table S4.** Detailed GAC costing.

| Unit Media Cost GAC | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Unit Cost ($/lb) | $1.00 | $1.50 | $1.80 | $1.90 | $2.00 | $2.10 | $2.20 | $2.50 | $3.00 |
| Unit Cost ($/kg) | $2.20 | $3.31 | $3.97 | $4.19 | $4.41 | $4.63 | $4.85 | $5.51 | $6.61 |
| Total Media Cost ($) | $51,633.28 | $77,449.93 | $92,939.91 | $98,103.24 | $103,266.57 | $108,429.90 | $113,593.23 | $129,083.21 | $154,899.85 |
| Mobilization ($) | | | | | $7,700.00 | | | | |
| Disposal ($) | | | | | $23,808.15 | | | | |
| Analytical ($) | | | | | $19,470.00 | | | | |
| Total O&M ($) | $102,611.43 | $128,428.08 | $143,918.06 | $149,081.39 | $154,244.72 | $159,408.05 | $164,571.38 | $180,061.36 | $205,878.00 |
| µg PFOA adsorbed / g GAC (assuming GAC media cost of $4.41/kg) | | | | | | | | | |
| µg PFOA adsorbed / g media | 1.05 | 0.875 | 0.77 | 0.735 | 0.7 | 0.665 | 0.63 | 0.525 | 0.35 |
| Total Media Cost ($) | $51,633.28 | $77,449.93 | $92,939.91 | $98,103.24 | $103,266.57 | $108,429.90 | $113,593.23 | $129,083.21 | $154,899.85 |
| Mobilization ($) | $3,850.00 | $5,775.00 | $6,930.00 | $7,315.00 | $7,700.00 | $8,085.00 | $8,470.00 | $9,625.00 | $11,550.00 |
| Disposal ($) | $11,904.08 | $17,856.11 | $21,427.34 | $22,617.74 | $23,808.15 | $24,998.56 | $26,188.97 | $29,760.19 | $35,712.23 |
| Analytical ($) | | | | | $19,470.00 | | | | |
| Total O&M ($) | $86,857.36 | $120,551.04 | $140,767.25 | $147,505.98 | $154,244.72 | $160,983.46 | $167,722.19 | $187,938.40 | $221,632.08 |

**Table S5.** Detailed AER costing.

| Unit Media Cost AER | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Unit Cost ($/lb) | $3.25 | $4.88 | $5.85 | $6.18 | $6.50 | $6.83 | $7.15 | $8.13 | $9.75 |
| Unit Cost ($/kg) | $7.17 | $10.76 | $12.90 | $13.62 | $14.33 | $15.06 | $15.76 | $17.92 | $21.50 |
| Total Media Cost ($) | $58,478.61 | $87,717.91 | $105,261.49 | $111,109.35 | $116,957.21 | $122,805.07 | $128,652.93 | $146,196.52 | $175,435.82 |
| Mobilization ($) | | | | | $2,100.00 | | | | |
| Disposal ($) | | | | | $1,665.94 | | | | |
| Analytical ($) | | | | | $19,470.00 | | | | |
| Total O&M ($) | $81,714.55 | $110,953.85 | $128,497.43 | $134,345.29 | $140,193.15 | $146,041.01 | $151,888.87 | $169,432.46 | $198,671.76 |
| µg PFOA adsorbed / g AER (assuming AER media cost of $14.33/kg) | | | | | | | | | |
| µg PFOA adsorbed / g media | 3.35 | 2.79 | 2.45 | 2.34 | 2.23 | 2.12 | 2.01 | 1.67 | 1.12 |
| Total Media Cost ($) | $58,478.61 | $87,717.91 | $105,261.49 | $111,109.35 | $116,957.21 | $122,805.07 | $128,652.93 | $146,196.52 | $175,435.82 |
| Mobilization ($) | $1,050.00 | $1,575.00 | $1,890.00 | $1,995.00 | $2,100.00 | $2,205.00 | $2,310.00 | $2,625.00 | $3,150.00 |
| Disposal ($) | $832.97 | $1,249.45 | $1,499.35 | $1,582.64 | $1,665.94 | $1,749.24 | $1,832.53 | $2,082.42 | $2,498.91 |
| Analytical ($) | | | | | $19,470.00 | | | | |
| Total O&M ($) | $79,831.58 | $110,012.36 | $128,120.84 | $134,156.99 | $140,193.15 | $146,229.31 | $152,265.47 | $170,373.94 | $200,554.73 |

**Table S6.** Linear regressions for varying O&M costs as a function of changing media performance (µg PFOA / g of media). Adsorption capacity = O&M x [Slope] + [Intercept]

| GAC Media Costs ($/lb) | GAC Media Costs ($/kg) | Slope | Intercept |
|---|---|---|---|
| 2.5 | 5.51 | 4.36E-06 | -0.085 |
| 2 | 4.41 | 5.19E-06 | -0.101 |
| 1.5 | 3.31 | 6.42E-06 | -0.125 |
| 1 | 2.20 | 8.42E-06 | -0.164 |
| AER Media Costs ($/lb) | AER Media Costs ($/kg) | Slope | Intercept |
| 7 | 15.43 | 1.72E-05 | -0.335 |
| 6.5 | 14.33 | 1.85E-05 | -0.360 |
| 6 | 13.23 | 2E-05 | -0.389 |
| 5.5 | 12.13 | 2.17E-05 | -0.423 |

## 6.0 References

[1] R.E. Marshall, PERFORMANCE AND COST-EFFECTIVENESS OF COMMERCIALLY AVAILABLE ADSORPTIVE TECHNOLOGIES FOR TREATMENT OF PER- AND POLY-FLUOROALKYL SUBSTANCES (PFAS) IMPACTED GROUNDWATER, in: Civil and Enviornmental Engineering, Colorado School of Mines, 2019.