CLAIMS

1. A system for removing and concentrating per- and polyfluoroalkyl substances (PFAS) from water, the system comprising:

anion exchange vessel, including an anion exchange resin therein configured to remove PFAS from the water;

a line coupled to the anion exchange vessel, configured to introduce a flow of water contaminated with PFAS such that the PFAS bind to the selected anion exchange resin in the anion exchange vessel and are thereby removed from the water;

a regenerant solution line coupled to the anion exchange vessel configured to introduce regenerant solution comprising a solvent, water and a salt and/or a base to the anion exchange vessel to remove the PFAS from the anion exchange resin in the anion exchange vessel, thereby regenerating the anion exchange resin and generating a spent regenerant solution comprising the removed PFAS and an optimized regenerant solution;

a separation and recovery subsystem configured to receive a spent optimized regenerant solution and separate and concentrate the removed PFAS to produce;

a reclaimed solvent solvent having a concentration of the solvent that is greater than a concentration of the solvent in the spent regenerant solution, and

a solution comprising removed PFAS, salt and/or base, and water, the solution having a concentration of removed PFAS in the spent regenerant solution and the solution having a concentration of salt and/or base that is greater than a concentration of the salt and/or base in the spent regenerant solution; and

a super-loading recovery subsystem configured to receive the solution comprising removed PFAS, salt and/or a base, and water and to separate removed PFAS from the

solution by adsorbing removed PFAS onto additional anion exchange resin to create a concentrated PFAS waste product.

2. The system of claim 1 in which the PFAS is removed from the anion exchange resin in the anion exchange vessel by a dual mechanism including desorption and anion exchange.

3. The system of claim 2 in which the desorption includes providing the regenerant solution having a concentration of a solvent configured to displace the adsorbed hydrophobic tails of PFAS from the backbone of the anion exchange resin jn the anion exchange vessel with the solvent, and providing a concentration of salt and/or base configured to displace hydrophilic heads of PFAS with inorganic anions.

4. The system of claim 1 in which the solvent includes an alcohol.

5. The system of claim 4 in which the regenerant solution includes about 50% to about 90% methanol by volume, about 10% to about 50% water by volume, and about 1 % to about 5% salt or base by weight.

6. The system of claim 5 in which the regenerant solution includes about 70% methanol by volume, about 28% water by volume, and about 2% salt or base by weight.

7. The system of claim 1 in which the anion exchange resin in the anion exchange vessel includes a macroporous, strong base, anion exchange resin.

8. The system of claim 1 in which the separation and recovery subsystem includes one or more of: an evaporation subsystem, a distillation subsystem, and/or a membrane separation subsystem.

9. The system of claim 8 in which the evaporation subsystem and/or the distillation subsystem further includes a condenser coupled to the evaporation or distillation unit configured to condense the reclaimed regenerant solution.

10. The system of claim 1 further including a solvent purification subsystem coupled to the separation and recovery subsystems by a line, the solvent purification subsystem configured to remove carryover PFAS from the separation and recovery subsystem and to provide a purified, reclaimed solvent.

11. The system of claim 10 in which the solvent purification subsystem includes anionic exchange resin housed in a vessel.

12. The system of claim 1 in which the super-loading recovery subsystem is configured to create a solution of concentrated salt and/or base and water, wherein a concentration of the salt and/or base in the solution created by the super-loading recovery subsystem is greater than a concentration of the salt and/or base in the solution comprising removed PFAS, salt and/or base, and water received by the super-loading recovery subsystem.

13. The system of claim 1 in which the super-loading recovery subsystem includes the additional anionic exchange resin housed in a vessel.

14. The system of claim 12 further comprising a line connecting the super-loading recovery subsystem to the anion exchange vessel and configured such that the solution of salt and/or base and water produced by the super-loading recovery subsystem can be transported from the super-loading recovery subsystem to the anion exchange vessel.

15. A method for removing and concentrating per- and polyfluoroalkyl substances (PFAS) from water, the method comprising:

introducing water contaminated with PFAS to an anion exchange vessel including an anion exchange resin therein such that the PFAS bind to the selected anion exchange resin and are thereby removed from the water;

introducing a regenerant solution comprising a solvent, water, and a salt and/or base to the anion exchange vessel to remove the PFAS from the anion exchange resin thereby regenerating the anion exchange resin and generating a spent regenerant solution comprising removed PFAS and an optimized regenerant solution; and

subjecting the spent regenerant solution to a separation and recovery process in which removed PFAS is separated and concentrated to produce:

reclaimed solvent having a concentration of the solvent that is greater than a concentration of the solvent in the spent regenerant solution, and

a solution comprising removed PFAS. Salt and/or base, and water, the solution having a concentration of removed PFAS that is greater than a concentration of removed PFAS in a spent regenerant solution and the solution

having a concentration of the salt and/or base that is greater than a concentration of the salt and/or base in the spent regenerant solution: and

subjecting the solution comprising removed PF AS. salt and/or base. and water to a super-loading recovery process in which removed PF AS is adsorbed onto

additional anion exchange resin in an anion exchange vessel to create a concentrated PF AS waste product..

16. The method of claim 15 in which the PFAS is removed from the anion exchange resin in the anion exchange vessel by a dual mechanism including desorption and anion exchange.

17. The method of claim 16 in which the desorption includes providing a concentration of a solvent configured to displace hydrophobic tails of the PFAS on the backbone of the anion exchange resin in the anion exchange vessel with the solvent and providing a concentration of anions configured to displace hydrophilic heads of the PFAS with the anions.

18. The method of claim 15 in which the solvent includes an alcohol.

19. The method of claim 18 in which the regenerant solution includes about 50% to about 70% methanol by volume, about 2% to about 28%) water by volume, and about 1% to about 5% salt or base by weight.

20. The method of claim 15 in which the regenerant solution includes about 70% methanol by volume, about 28% water by volume and about 2% salt or base by weight.

21. The method of claim 15 in which the selected anion exchange resin includes a macro-porous, strong base, anion exchange resin.

22. The method of claim 15 in which the separation and recovery process is configured to maximize recovery of regenerant solution and minimize volume of concentrated desorbed PFAS.

23. The method of claim 15 in which the separation and recovery process includes one or more of evaporation, distillation and membrane separation.

24. The method of claim 23 in which the separation and recovery process includes one or more of evaporation and/or distillation, and in which the evaporation and/or distillation includes condensing the spent regenerant solution.

25. The method of claim 24 in which the separation and recovery process includes removing carryover PFAS to provide a purified reclaimed solvent.

26. The method of claim 15 in which subjecting the solution comprising removed PFAS, salt and/or base, and water to the super-loading recovery process further creates solution of the salt and/or base and water having a concentration of the salt and/or base that is greater than a concentration of the salt and/or base in the solution comprising removed PFAS, salt and/or base, and water.

27. The method of claim 15, wherein the PFAS comprises at least one perfluoroalkyl substance.

28. The method of claim 15, wherein the PFAS comprises at least one polyfluoroalkyl substance.

29. The method of claim 15, wherein the PFAS comprises at least one perfluoroalkyl substance and at least one polyfluoroalkyl substance.

30. The method of claim 15, wherein the PFAS is perfluorooctanoic acid (PFOA).