Treating PFAS to Near-Zero Concentrations: Life Cycle Assessment Considerations

B3. PFAS Program Management in a Rapidly Changing Regulatory Environment

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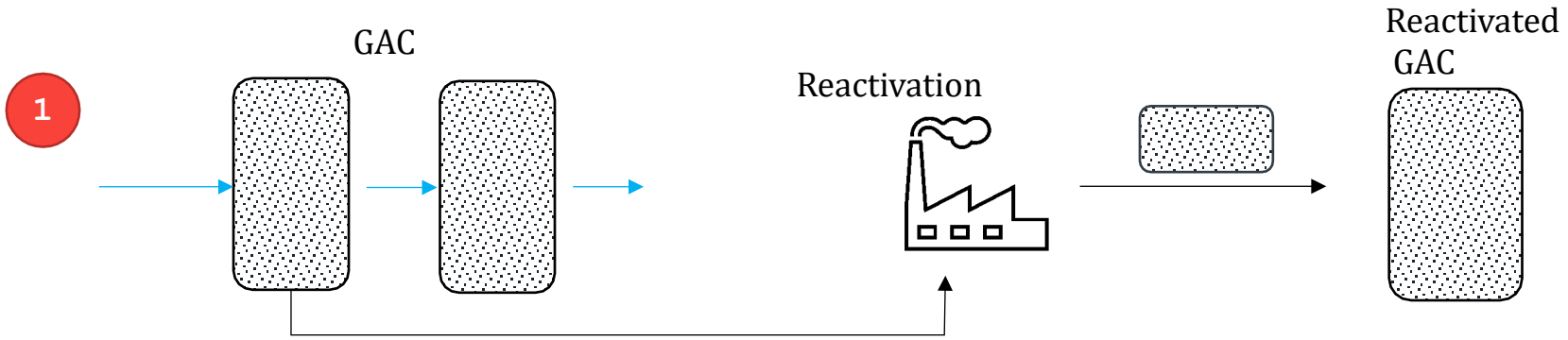
Six Ex-Situ Full-Scale Groundwater Treatment Scenarios

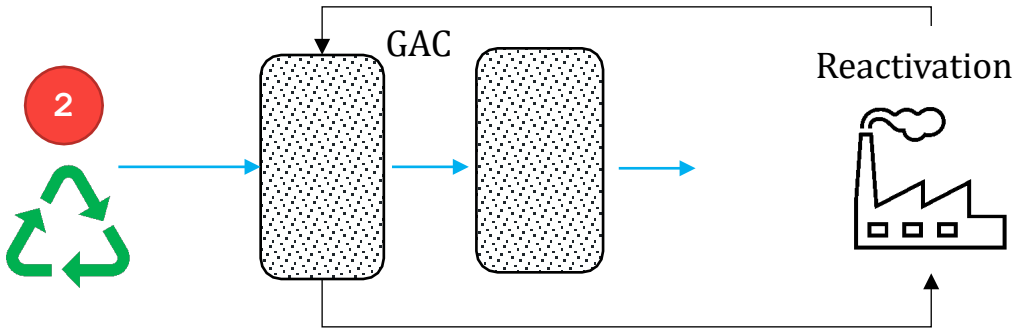
13 PFAS Treatment Systems

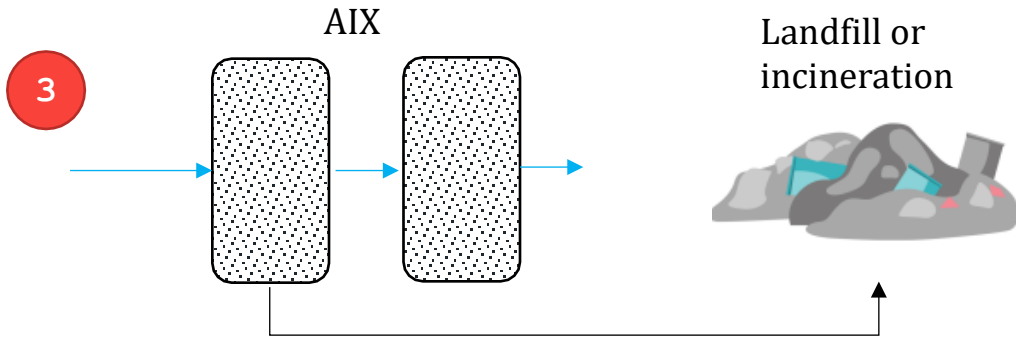
- All treatment systems were built and operated in compliance with local, state and federal treatment criteria
- Treatment criteria do vary from non-detect for all target PFAS to PFOS+PFOA< 70 ppt
- Lead GAC or IX vessel changeout strategy vary for meeting treatment goals of final effluent
- Pretreatment requirements vary between systems and the costs are included into CAPEX and OPEX
- PFAS monitoring mostly based on USEPA Method 537 mod

Full-Scale PFAS Treatment Scenarios



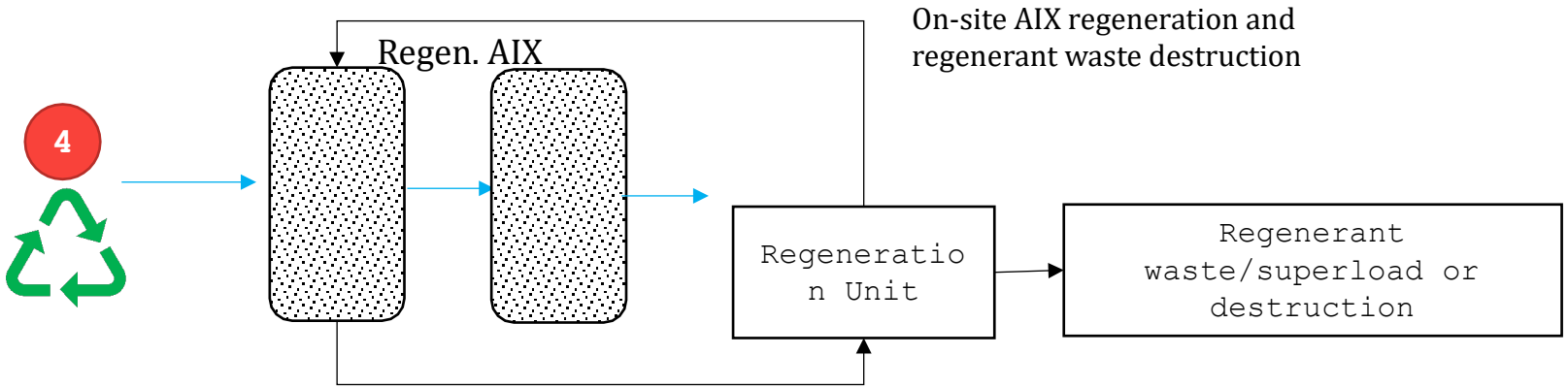
Custom Municipal Reactivated Carbon (CMRC)



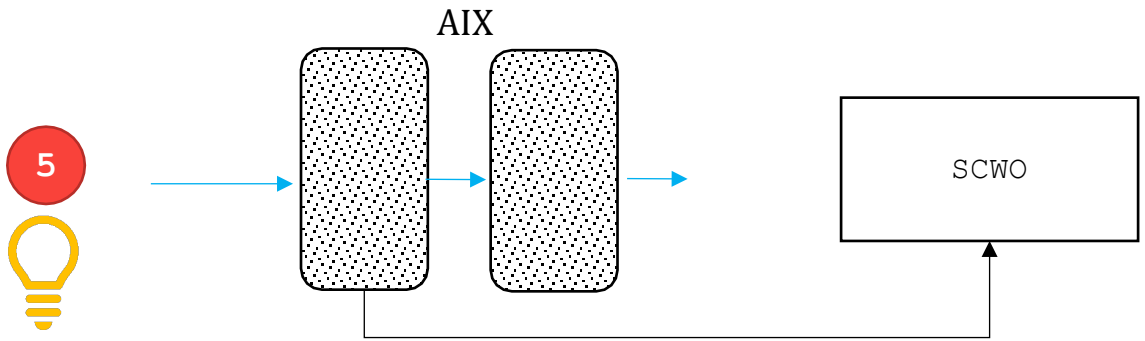


GAC: Granular Activated Carbon
AIX : Single-Use Anion Exchange Resins
: Spent media is regenerated and reused

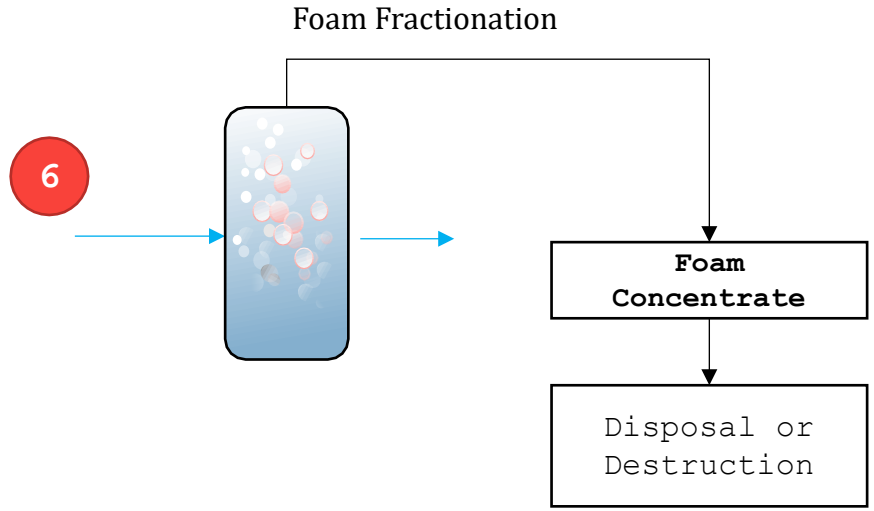
Full-Scale PFAS Treatment Scenarios



On-site AIX regeneration and regenerant waste destruction



AIX with supercritical water oxidation (SCWO) to mineralize spent media and destroy PFAS



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4 Regenerable AIX for PFAS Treatment - Separate, Concentrate, Destroy

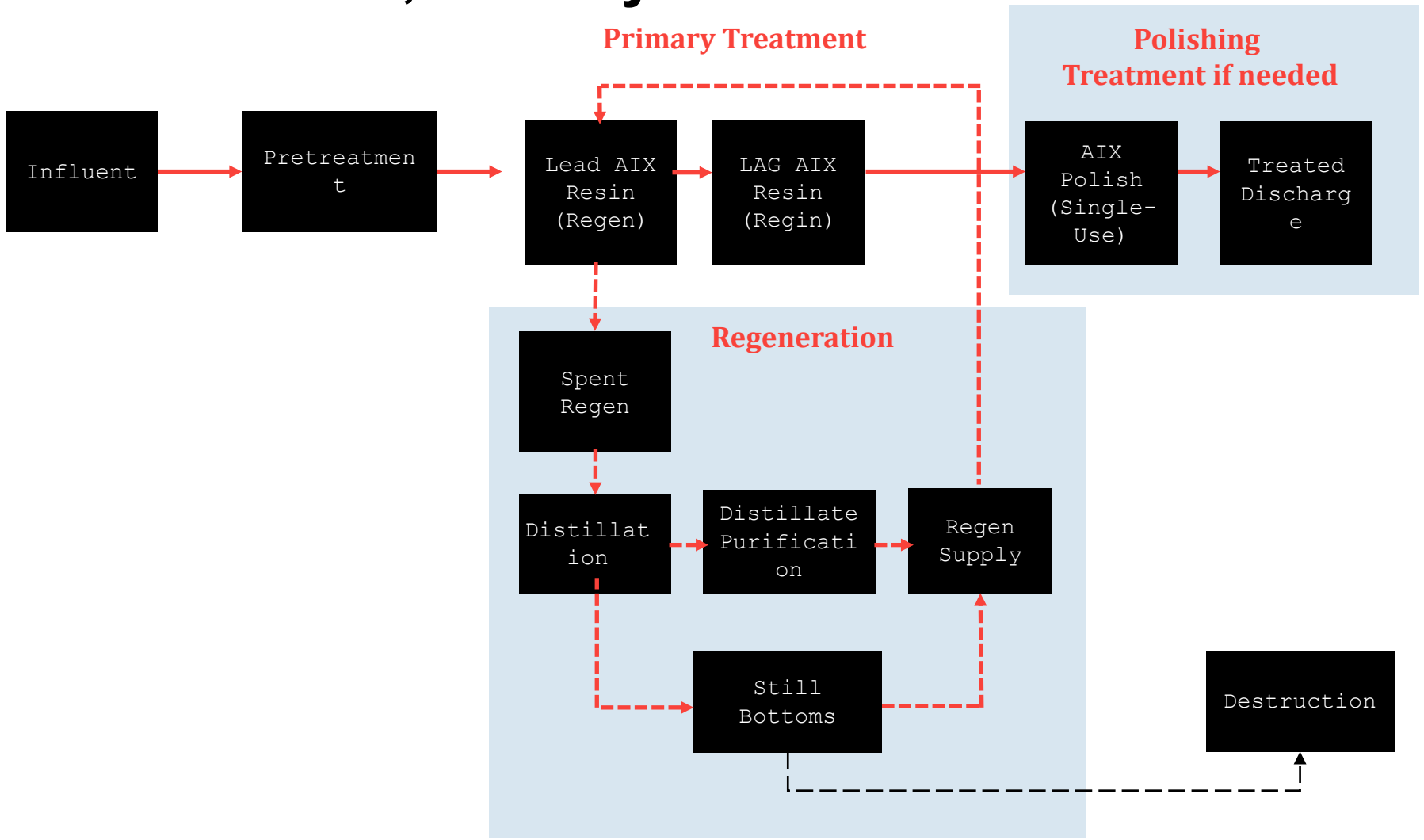

Image provided courtesy of ECT2 and WSP

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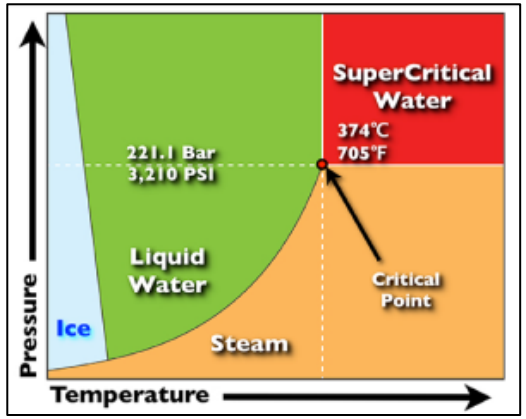
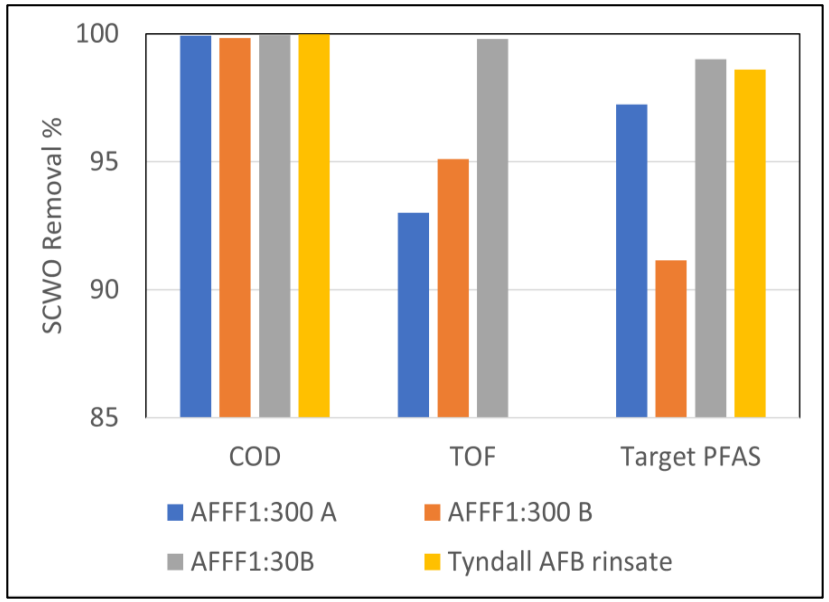
PFAS Destruction Using Supercritical Water Oxidation





Source: 374water

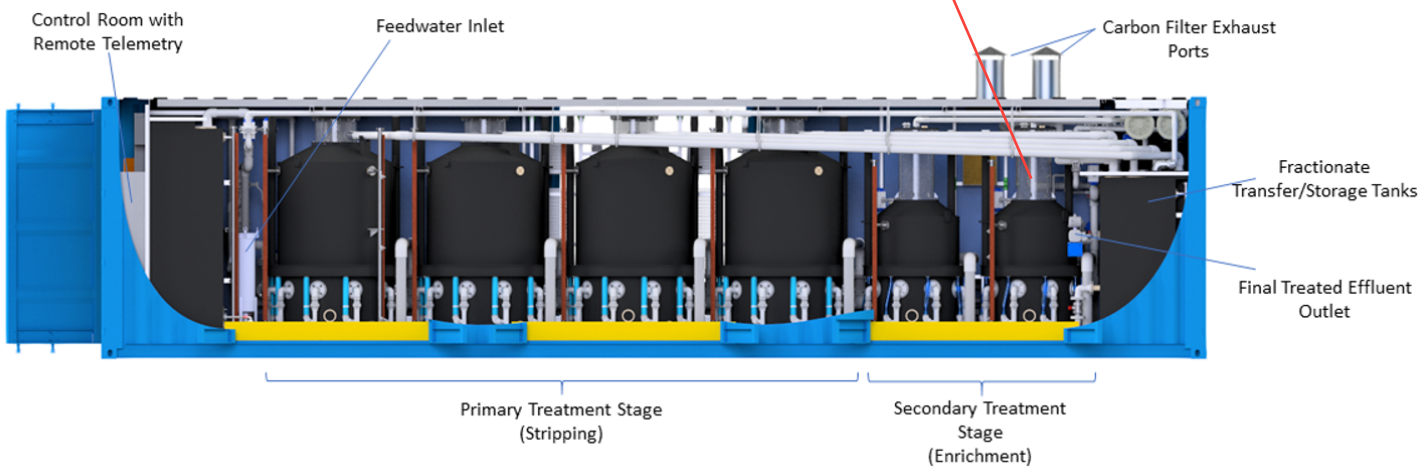
USEPA Draft Method 1633	Calculated mass on spent AIX, **mg/kg**	SCWO EFF **ng/L**, ppt
PFBA	25.8	ND
PFOA	**1,659**	**ND**
PFBS	934.2	0.47J
PFHXS	**19,064**	**6.45**
PFOS	**13,863**	**62.70**
6:2 FTS	384.6	ND

B61 PFAS-laden spent media destruction using SCWO, May 10 at 1:50PM

6 Surface Active Foam Fractionation (SAFF™)

- Separates + Concentrates PFAS
- ‘AIR IN – PFAS OUT’
- No solid sorbent, applicable for leachate, GW and surface water treatment
- Process generates small volume of foam concentrate

OPEC SYSTEMS



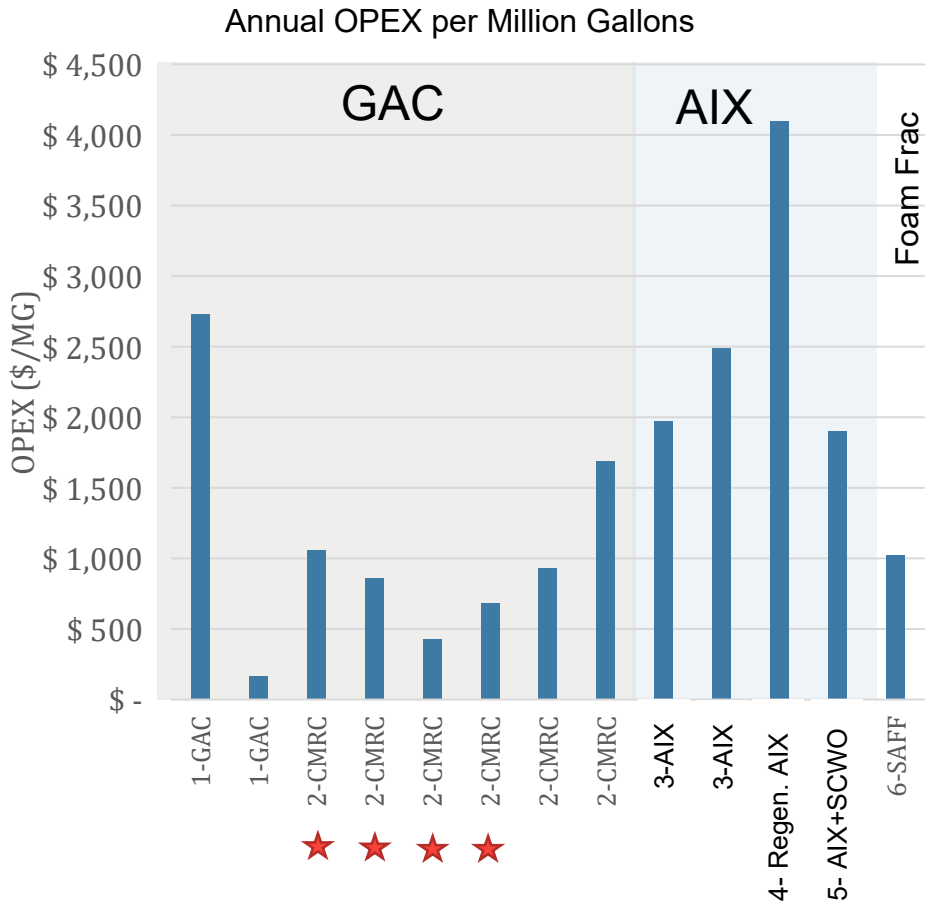
Full-Scale Water Treatment System Data

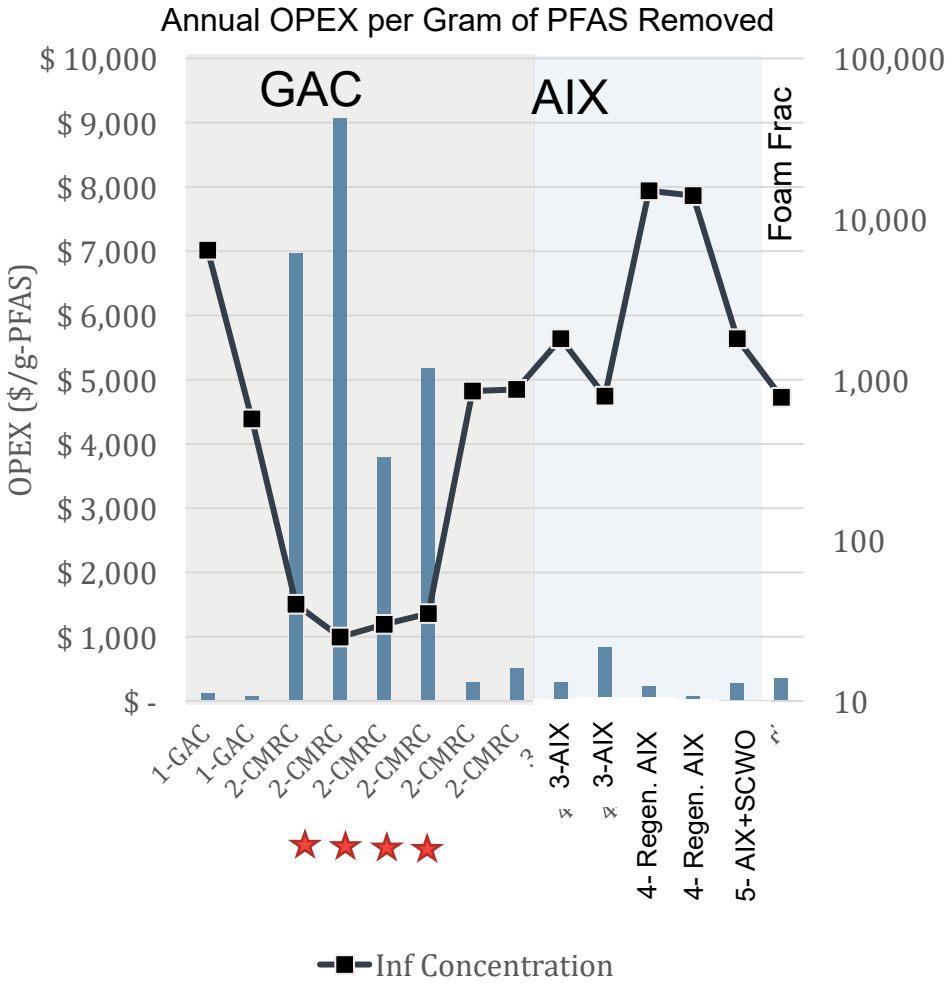
	Facility	Inf PFOS+PFOA (ppt)	Scenario-Processes	Age Yr	Flow rate, gpm	# of changeout	CAPEX ~$M	OPEX[4] /MG[5] $
<100 ★	PA	25-40 (below 70)	2- 4 wells, CMRC[1]	3	166-365	3	1 each	430-1,056
	MI	570	1- GAC	5	320	7	3.65	165
100+	AU	777	6- Foam fractionation	2	75-220	0	1.8	1,022
	MI	790	3- Single use AIX	3	184	4	1	2,492
	PA	850/870	2- 2 wells, CMRC[1]	5	93/215	5/8	1 each	929/1,689
1,000+	NH	1,800	3- Single use AIX	3	700	3	12	1,974
	NH	1,800	5- Single use AIX+SCWO[2]	3	700	3	13.2	1,903
	MI	6,400	1- GAC	7	238	27	2.4	2,733
10,000+	AU	14,000	4- Regenerable AIX[3]	4.5	175	22	2.3	4,102
	NH	15,000	4- Regenerable AIX[3]	4	150	2	8	12,797

1: GAC changeout based on any detected PFAS, CMRC: Custom Municipal Reactivated Carbon
2: Hypothetical scenario of using single-use AIX as primary treatment and spent media destruction using SCWO
3: Destruction cost not included
4: Operation, maintenance, monitoring, media, waste management
5: MG: million gallons
CAPEX: capital expenditure
OPEX: operation expense

OPEX Comparison of 6 Scenarios

- Volume based OPEX : Regen AIX>AIX>GAC=FF
- Mass based OPEX sensitive to influent concentrations



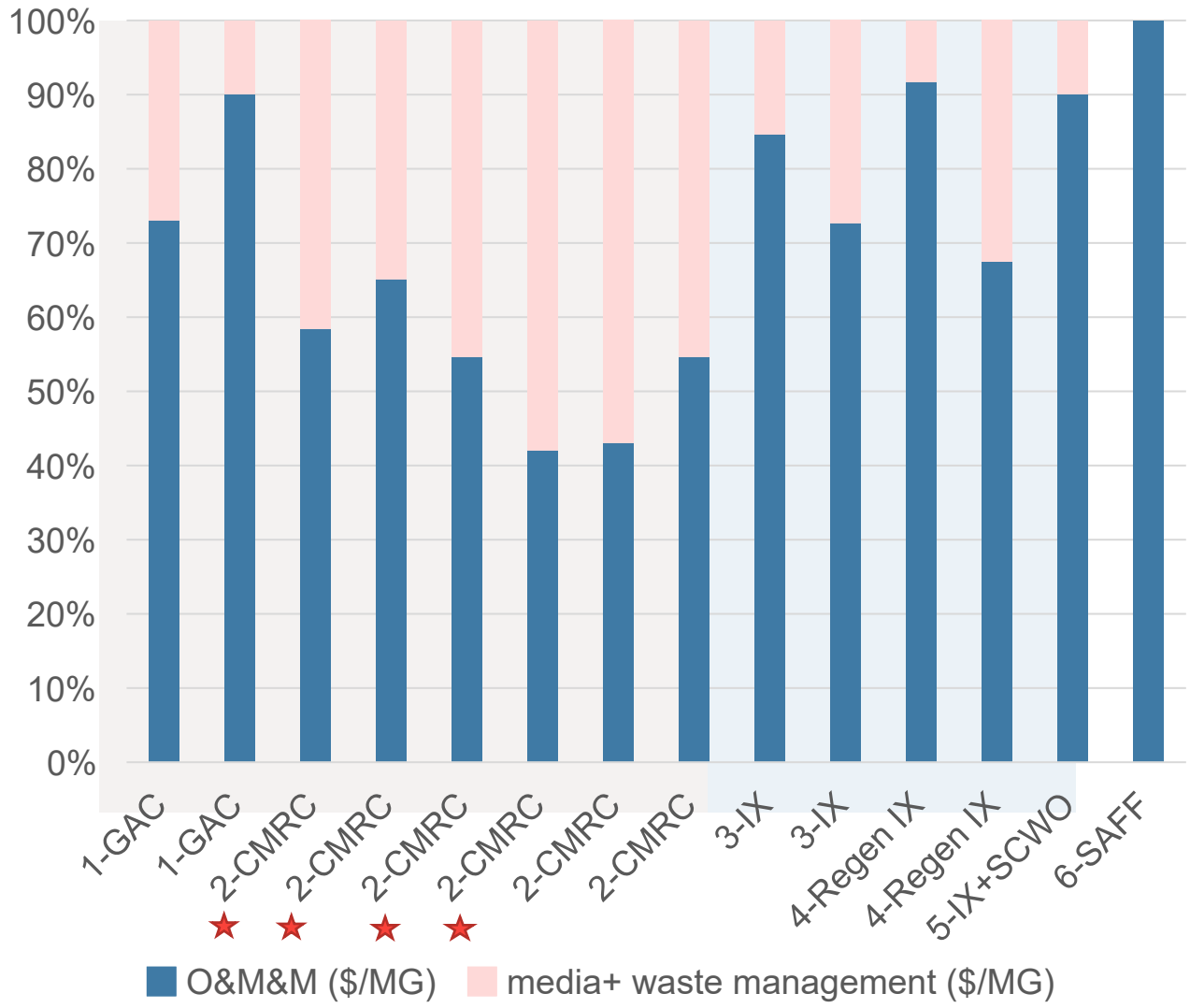


Annual OPEX ($12,797/MG) for regenerable IX is not included
MG: million gallons

PFAS mass is based on PFOS and PFOA only

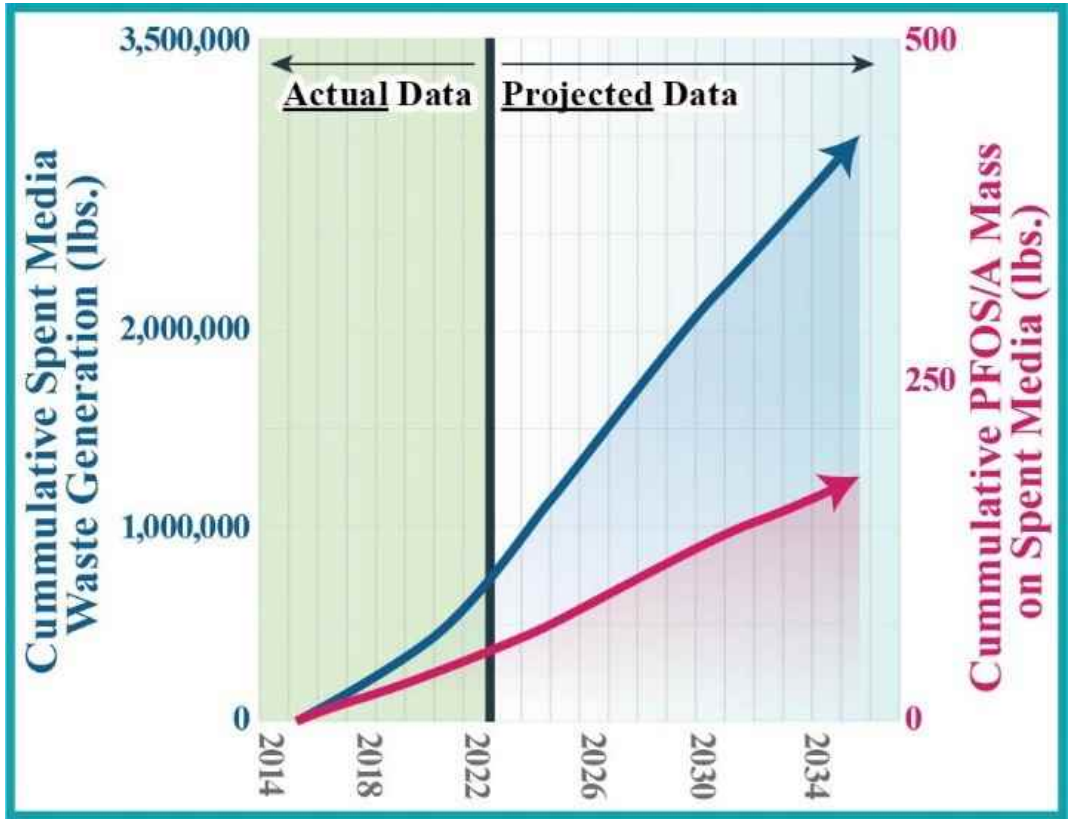
% OPEX Distribution

- Media + waste management cost vs total OPEX cost
  - GAC: 10-58%
  - Single use AIX: 10-27%
  - Regen. AIX: 8% vs 33%
- Factors driven the media+waste management cost
  - Treatment technologies
    - % OPEX: GAC>AIX, Regen. AIX > FF
  - Media changeout frequency



Potential Impact of Lowered Treatment Standards

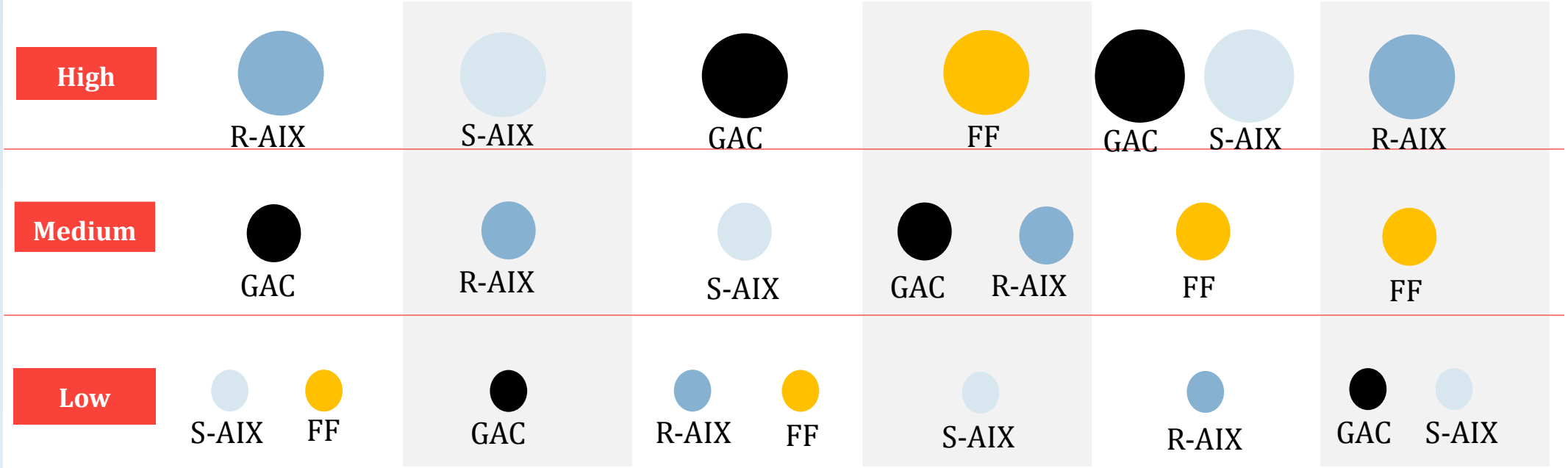
- More PFAS treatment facilities
- Larger vessels and more sorbents
  - Sorbent supply shortage
- More changeouts
  - More waste generation
  - Reduced waste acceptance and capacity
- More tracking, reporting and permitting requirements
- Long wait on analytical results
- Increased need for destruction technologies
- Estimated 30% increase to OMM cost



Other Critical Considerations

Universally important to all technologies:

- Influent concentrations
- Co-contaminants
- Regulatory acceptance



Takeaways– Life Cycle Assessment Considerations

- Critical life cycle assessment considerations
  - *Treatment technology selection*
  - *PFAS influent concentrations*
  - *Cleanup standards*
  - *Pretreatment requirements*
  - *Waste management options*
- Capital and operation costs may increase >30% in the future
- Emerging technologies (e.g., foam fractionation) offer sustainable opportunities to reduce/eliminate remediation waste
- The costs for emerging technologies can be comparable with traditional linear treatment processes
- Bottleneck exists for near-zero PFAS future
  - Supply chain, analysis, waste management

Thank You

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