

Cost of Removing PFAS from WRRF Effluent and Biosolids



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2024 Battelle Chlorinated Conference

June 6, 2024



Project partners



LCCMR Project ID#:
2020-013



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Agenda



1. Project background
2. Technology screening and PFAS management alternatives evaluation
3. Preliminary design of alternatives
4. Estimated costs for implementation



Project Background



Project objectives



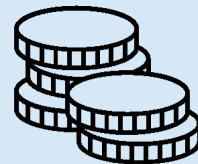
1

Identify currently available and effective technologies for PFAS separation and destruction



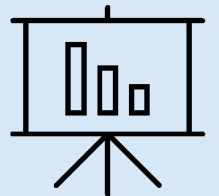
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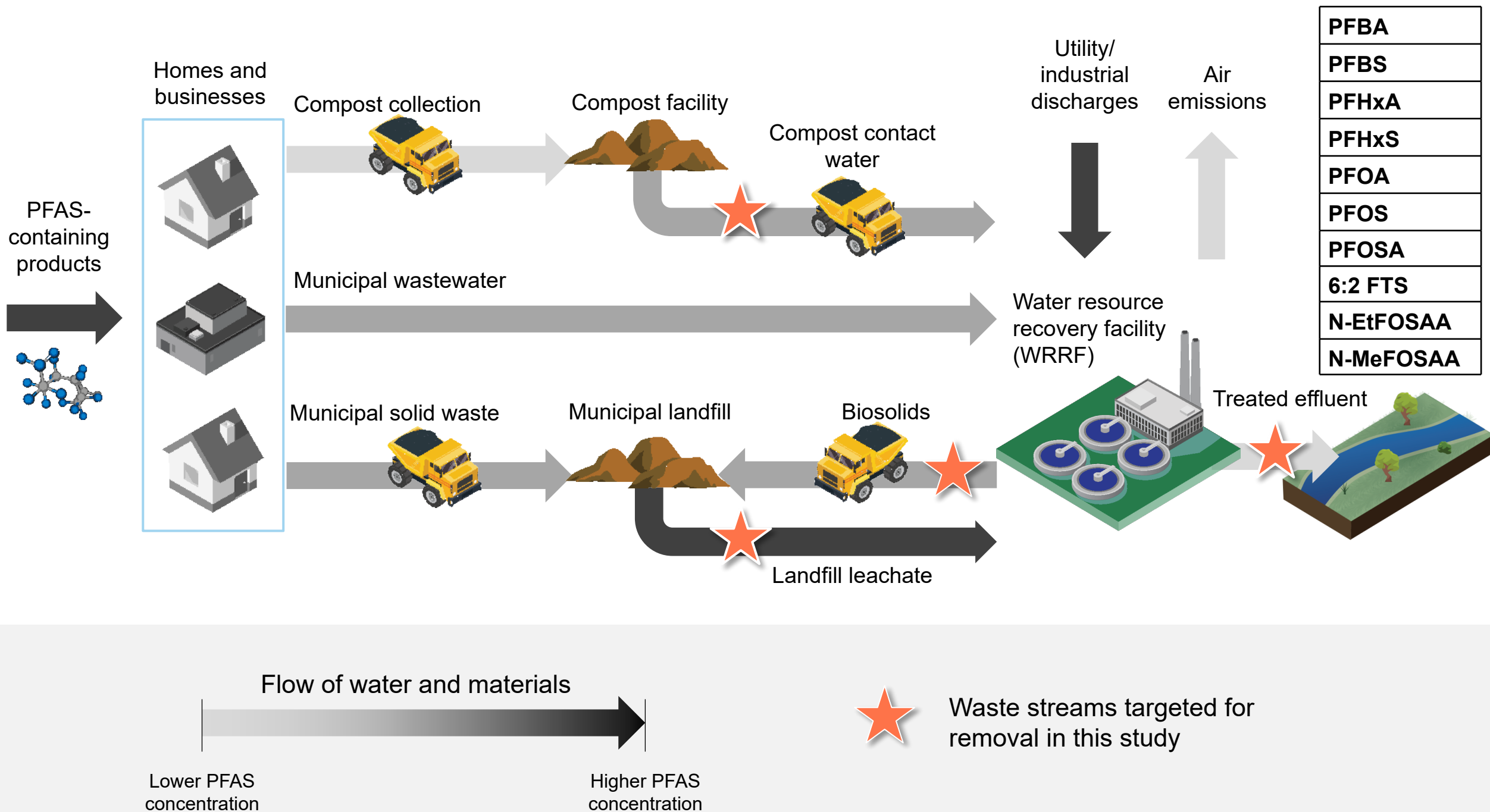
Develop representative costs for PFAS separation/destruction, including potential implementation at a regional scale

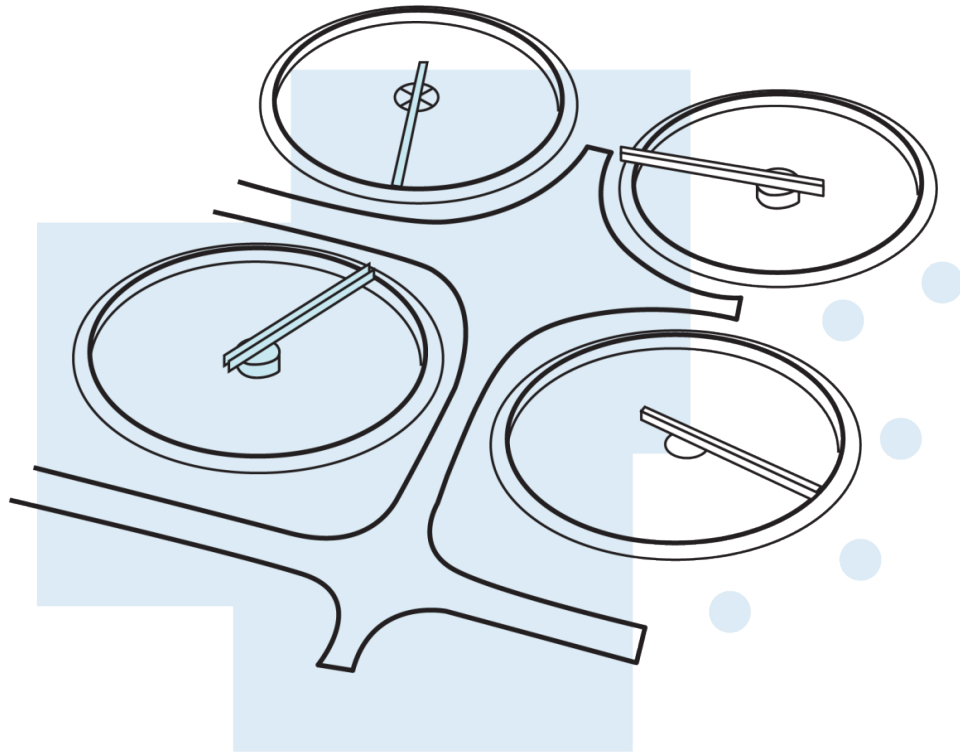


3

Share results in a MPCA-published report, peer-reviewed journal article, and at conferences







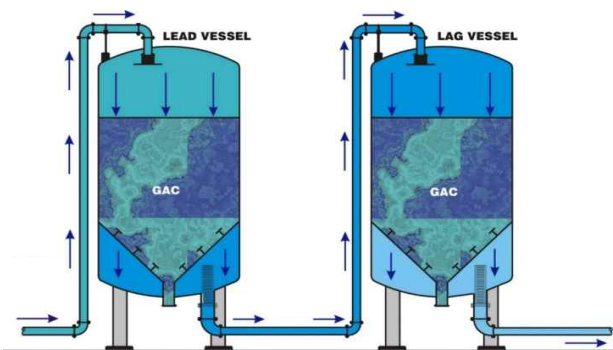
Technology Screening and Alternatives Evaluation



PFAS separation technologies passing screening



Liquid to solid separation (media)



**Granular
activated carbon
(GAC) media**



**Anion exchange
(AIX) resin**

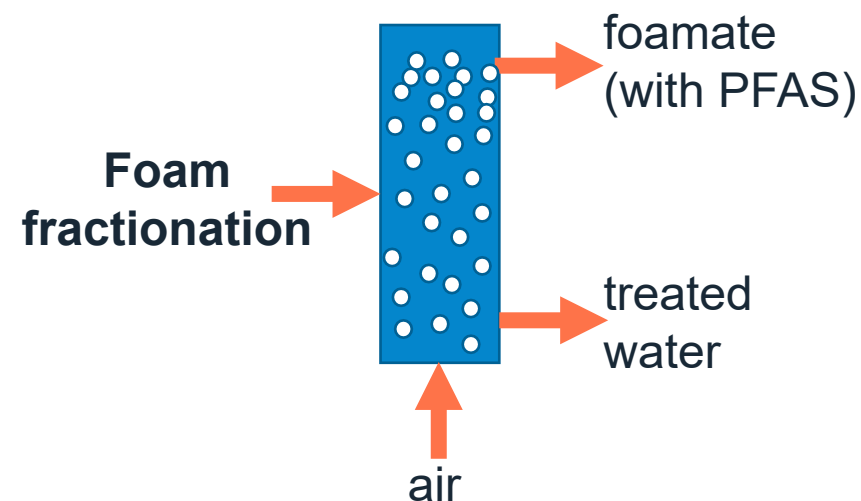
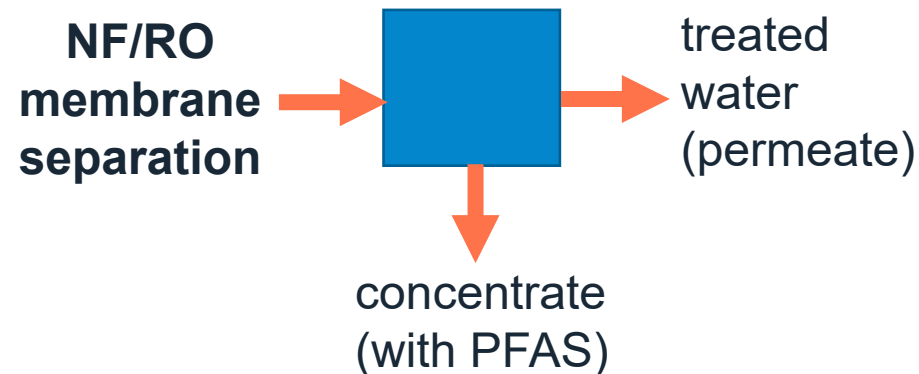


**Modified
clay media**

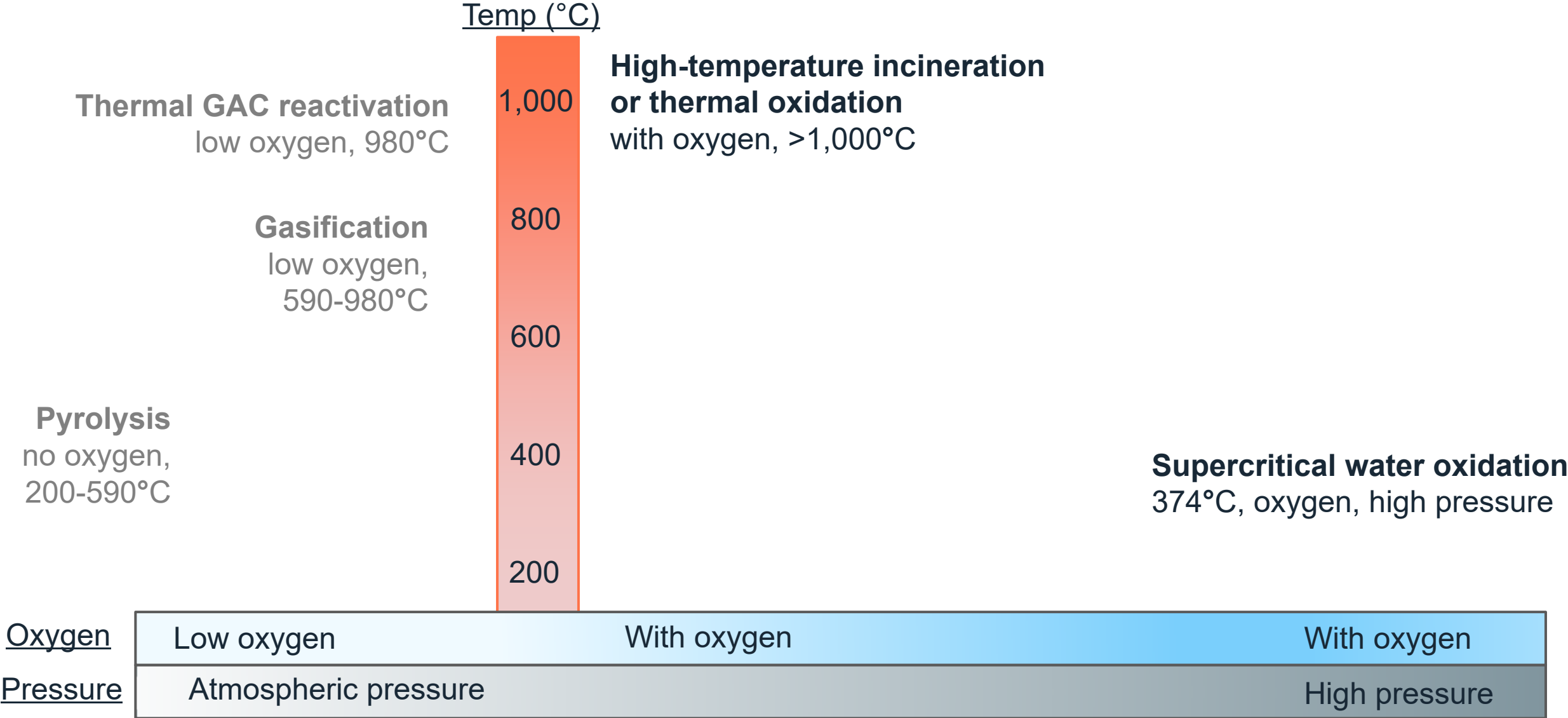


- Single-use ► disposal
- Reactivated ► reactivation, reuse (PFAS to thermal oxidation)
- Single-use ► disposal
- Regenerable ► regeneration, reuse (PFAS to brine and destruction option)
- Single-use ► disposal

Liquid to liquid separation



PFAS destruction technologies passing screening



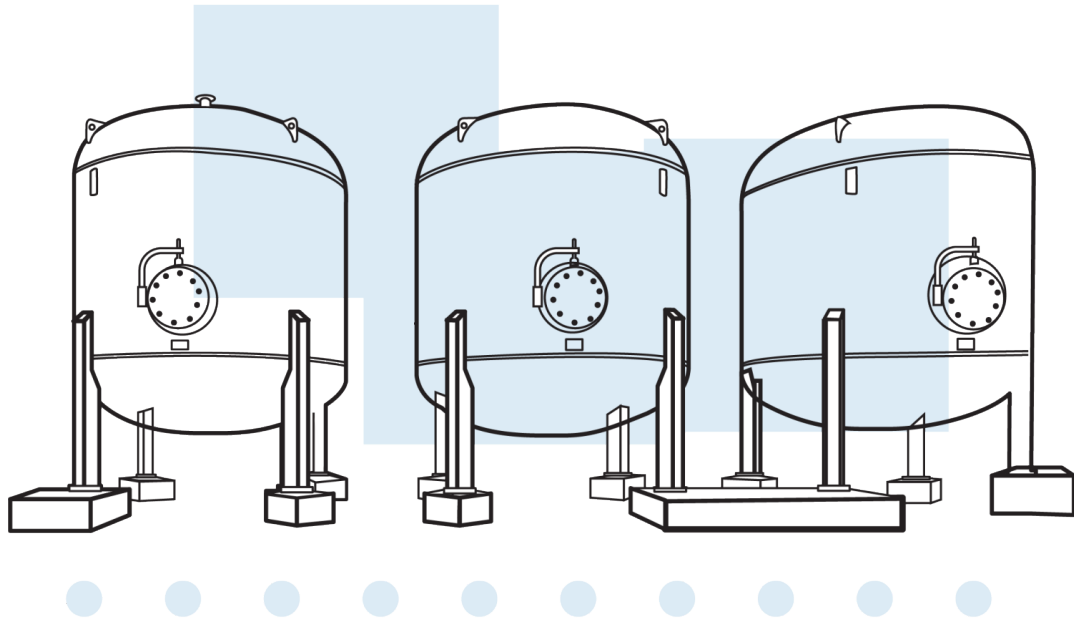
Assembled alternatives passing to preliminary design

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	Liquid Separation Process	Sorption Separation Process 1	Sorption Separation Process 2	Destruction Process
Municipal Wastewater		GAC		HTI/reactivation
		AIX		HTI
		GAC	AIX	HTI/reactivation
	RO	GAC	AIX	HTI/reactivation
Biosolids				SCWO
				Pyrolysis/gasification

None of these technologies currently in use in Minnesota for the targeted waste streams.

RO = RO membrane separation, GAC = granular activated carbon, AIX = single-use anion exchange, HTI = high-temperature incineration, SCWO = supercritical water oxidation, TO = thermal oxidation



Preliminary Design



Preliminary design process



Establish design basis for each waste stream

Range of flows or mass input
Pretreated water quality (before PFAS removal)
Initial PFAS concentrations
Pretreatment needed



Prepare conceptual design for each alternative for each waste stream



Use vendor budgetary estimates and previous project experience to estimate costs

Assumed influent concentrations and treatment goals for target PFAS

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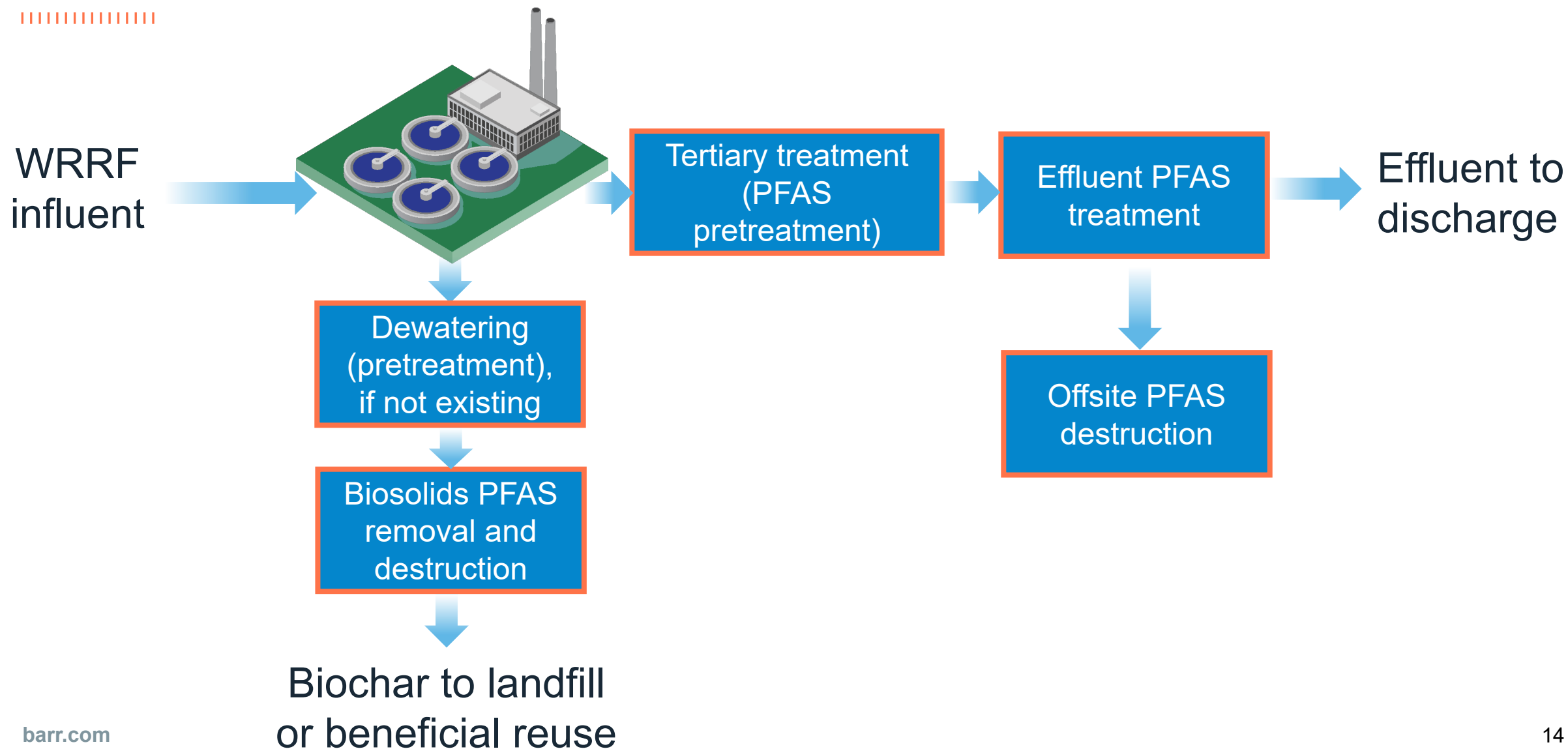
WRRF Effluent (ng/L)

PFAS	Typical	High	Treatment Target
PFBA	15	200	5
PFBS	15	50	5
PFHxA	30	60	5
PFHxS	5	15	5
PFOA	40	80	5
PFOS	5	30	5
6:2 FTS	5	150	5

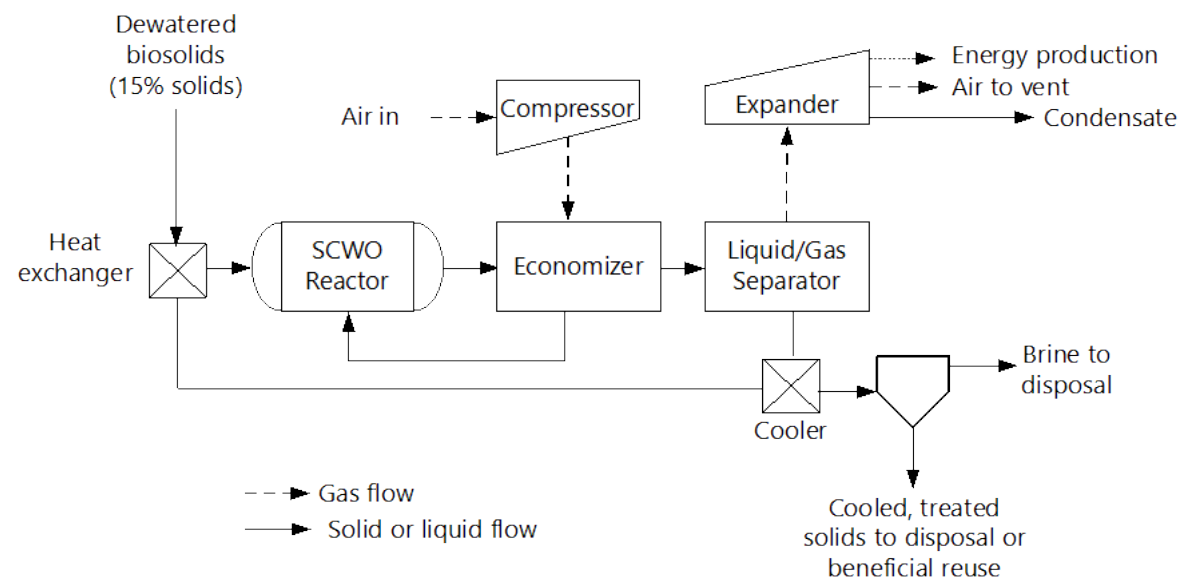
WRRF Biosolids (ng/g)

	Typical	High	Treatment Target
PFBA	2	5	5
PFBS	20	40	5
PFHxA	5	15	5
PFHxS	15	30	5
PFOA	60	200	5
PFOS	400	600	5
PFOSA	20	70	5
N-EtFOSAA	30	60	5
N-MeFOSAA	100	200	5

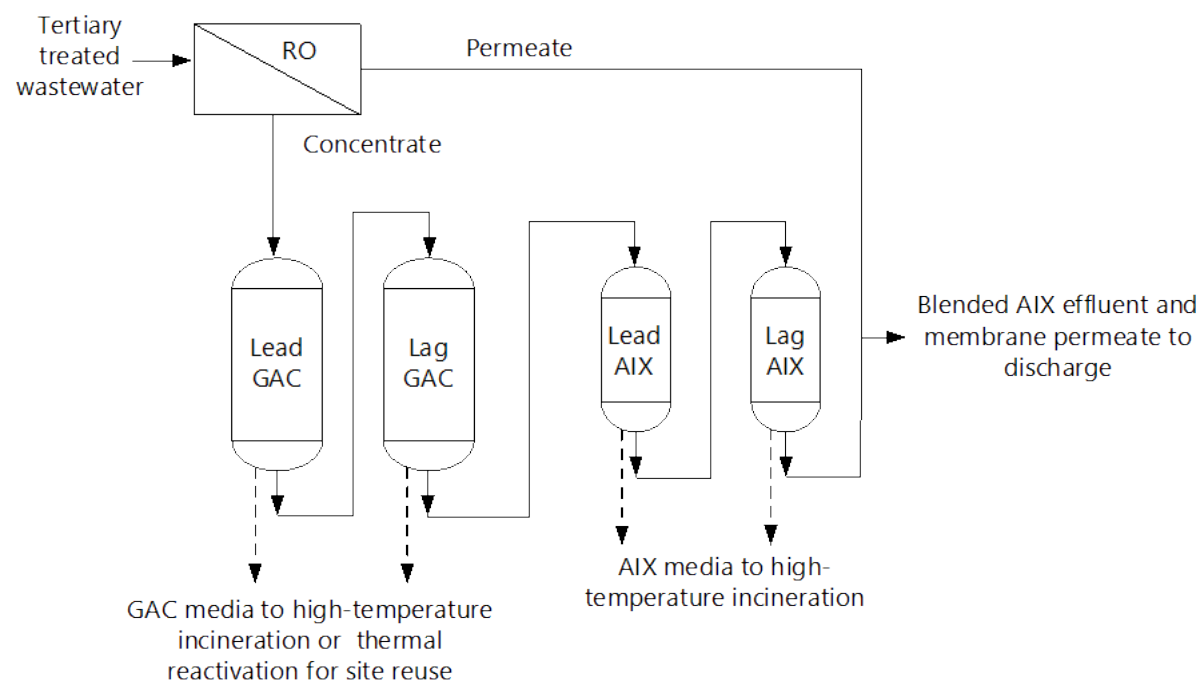
High-level treatment location at WRRFs



Conceptual process flow diagrams for WRRF biosolids and effluent



SCWO



RO + GAC + IX

Minnesota puts a cost estimate on getting toxic PFAS out of wastewater: At least \$14 billion

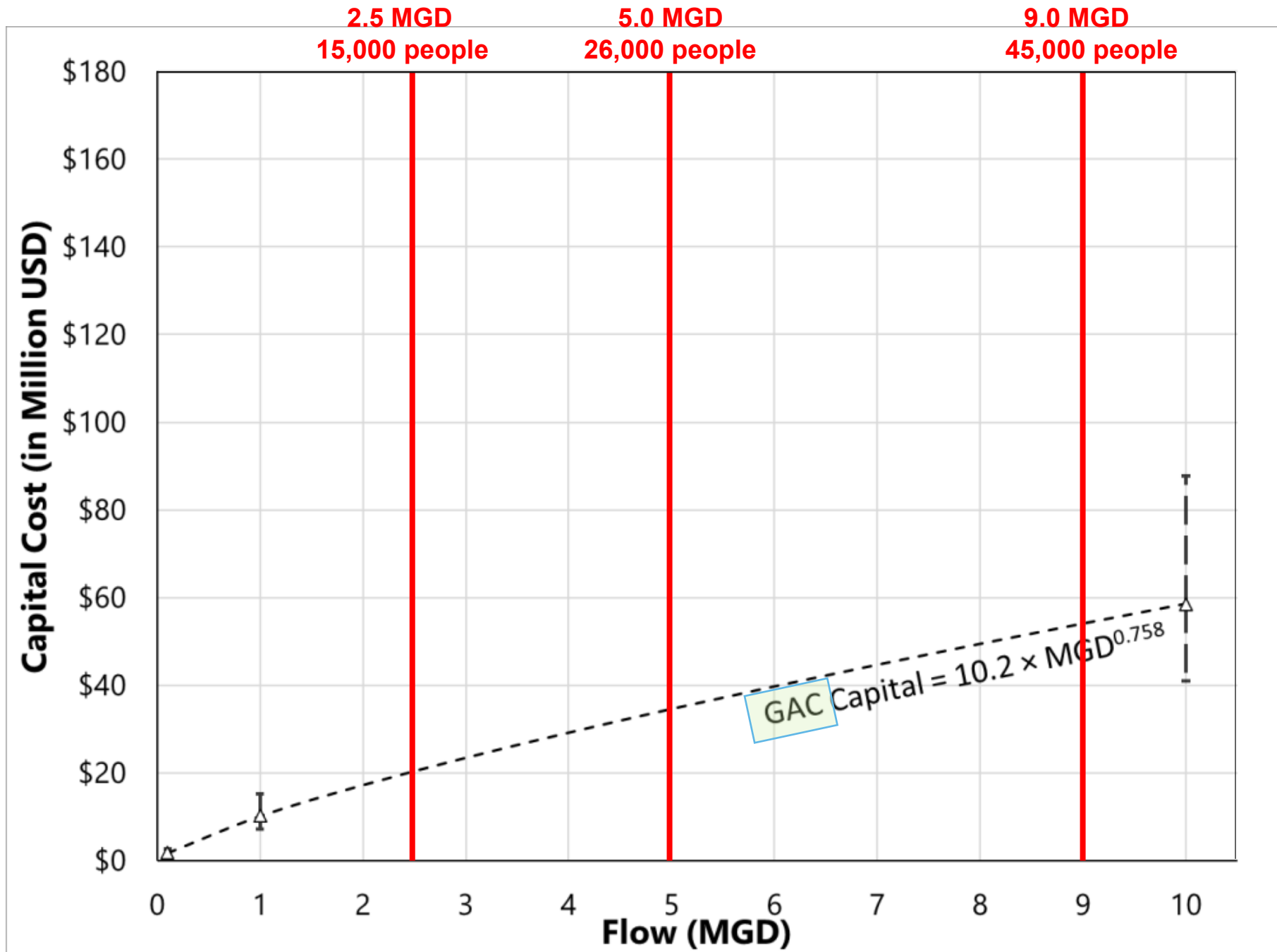
The study offered a wide range of costs — up to \$28 billion — to implement still-new technologies that would remove and destroy "forever chemicals" from wastewater.

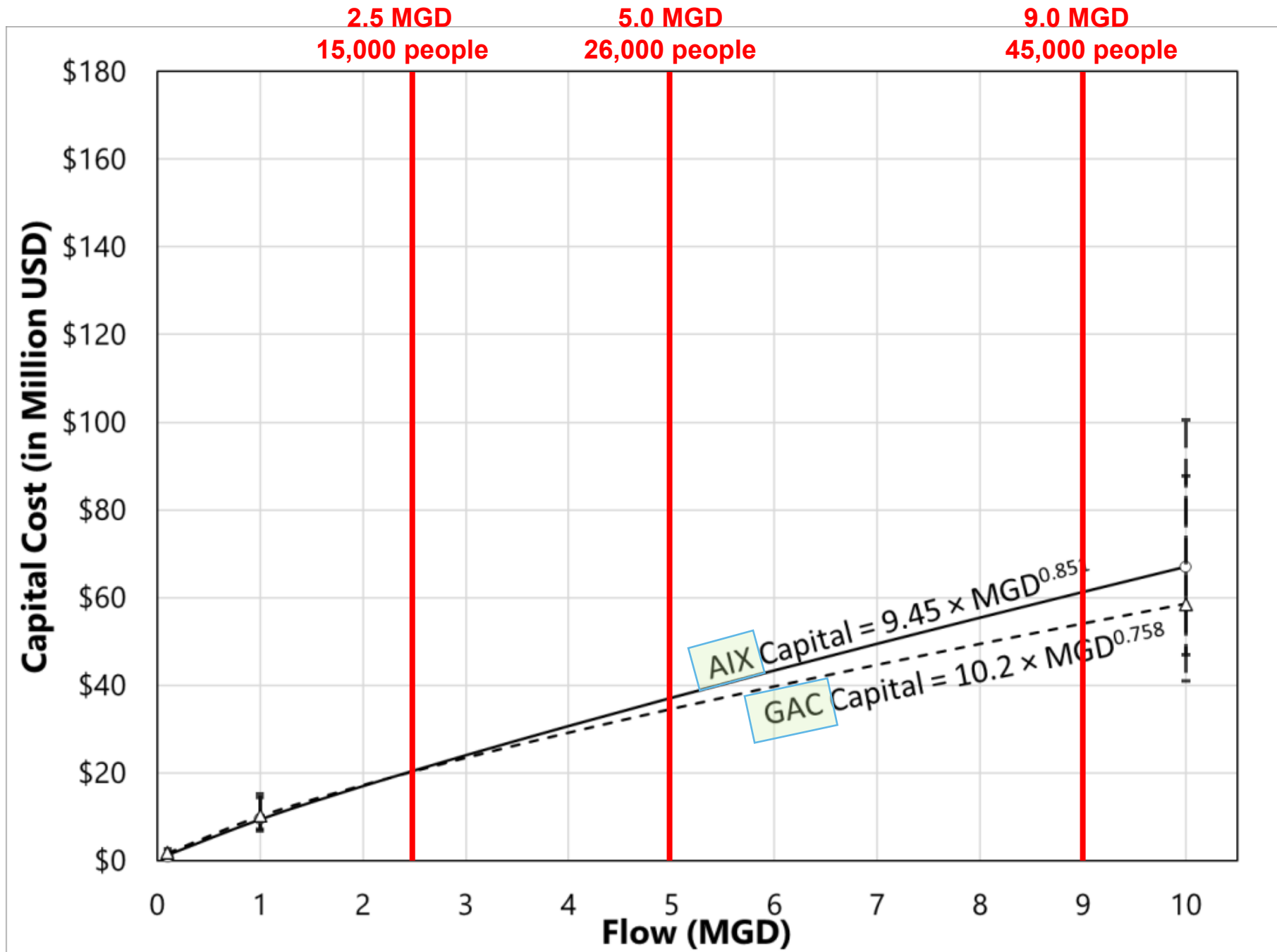
By **Chloe Johnson** Star Tribune | JUNE 6, 2023 — 5:10PM

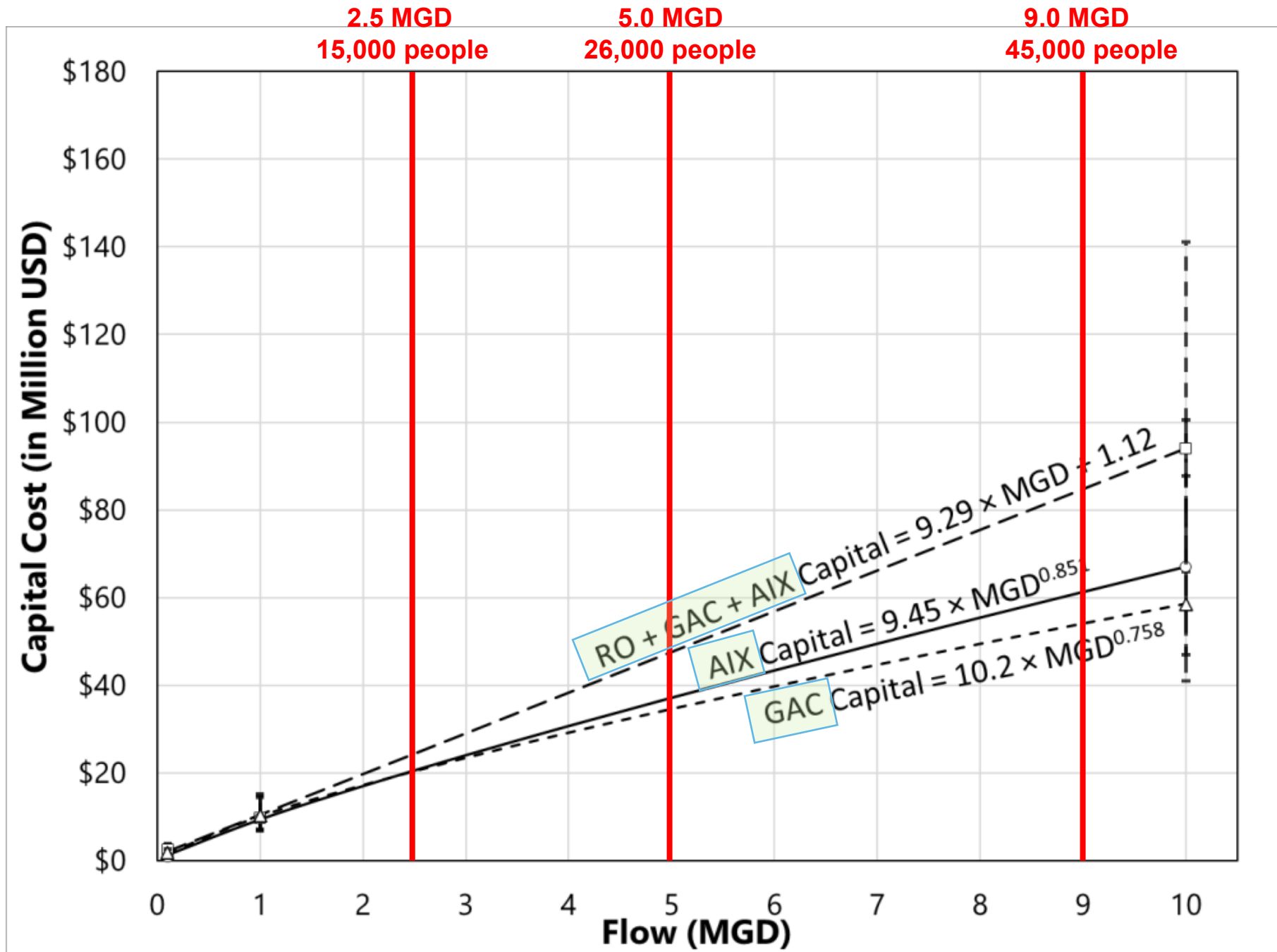


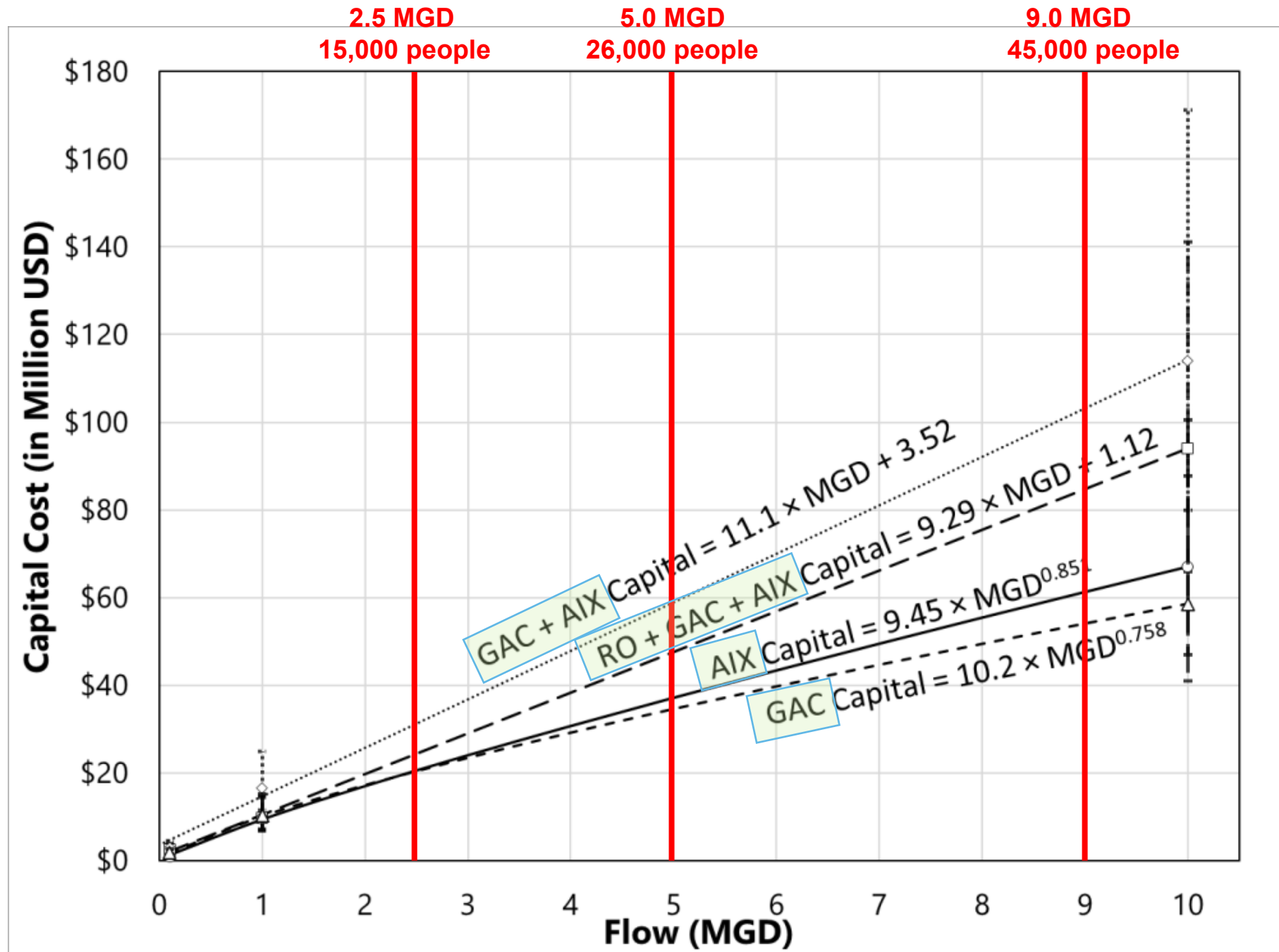
Estimated Costs

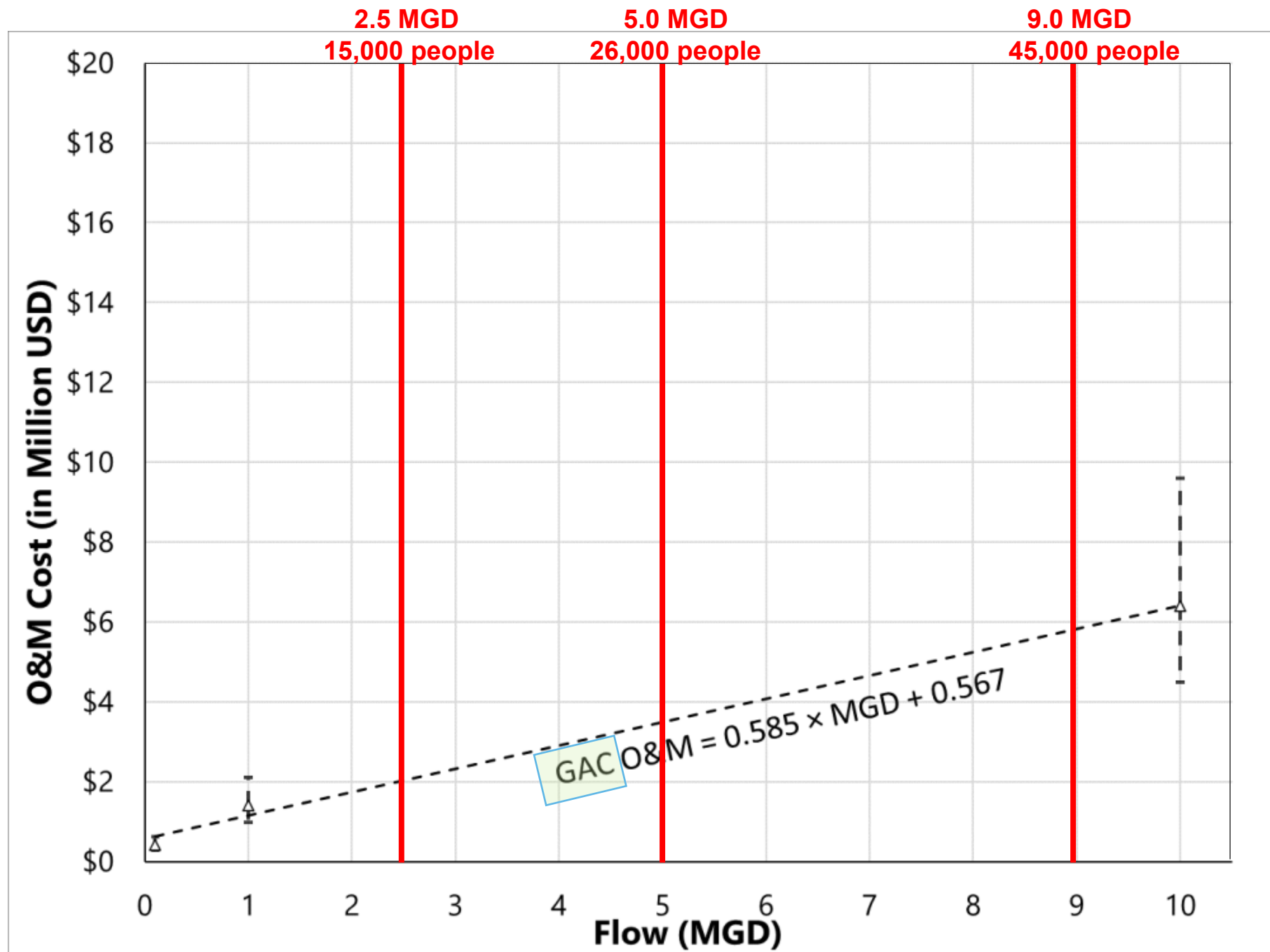


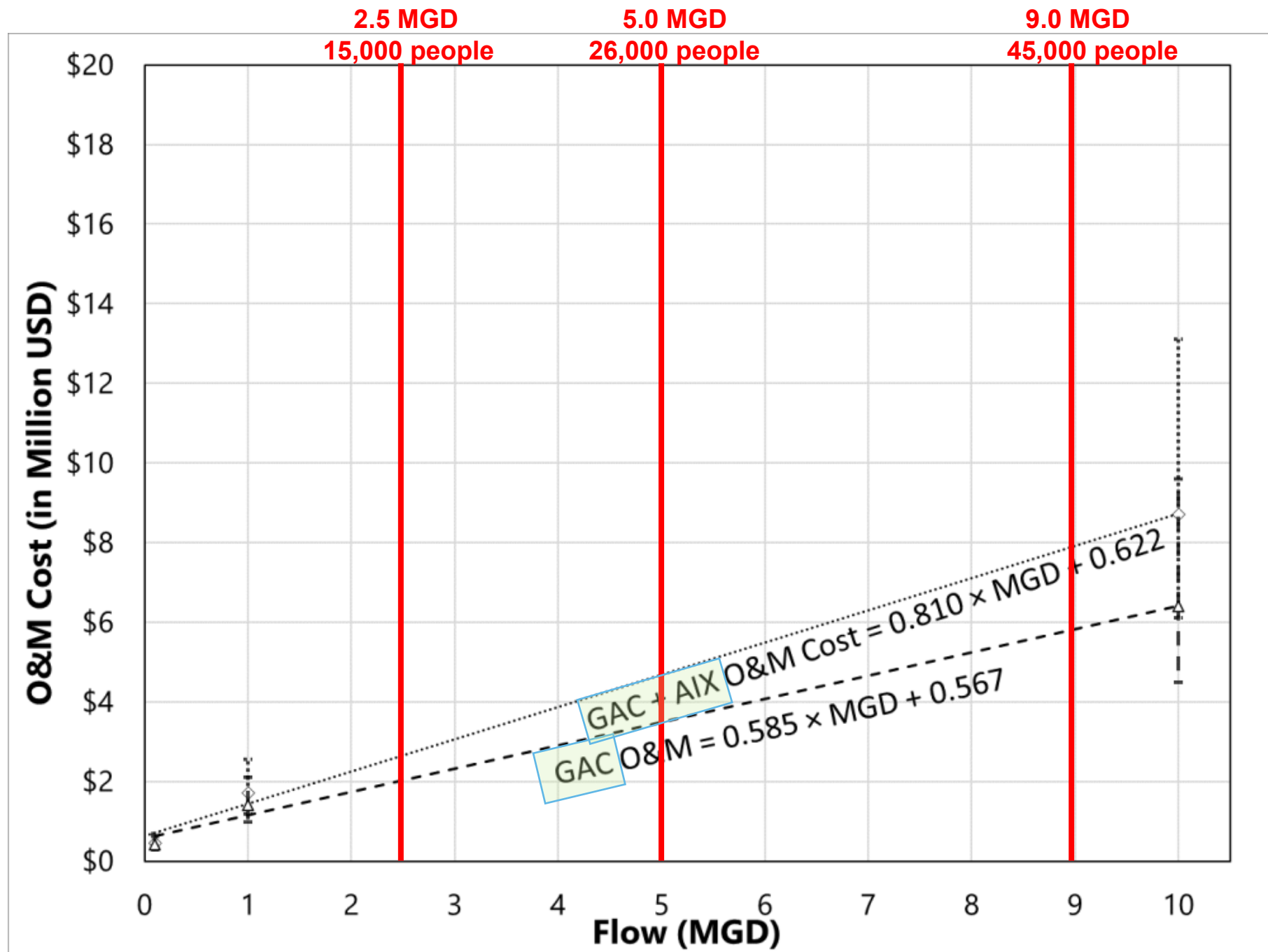


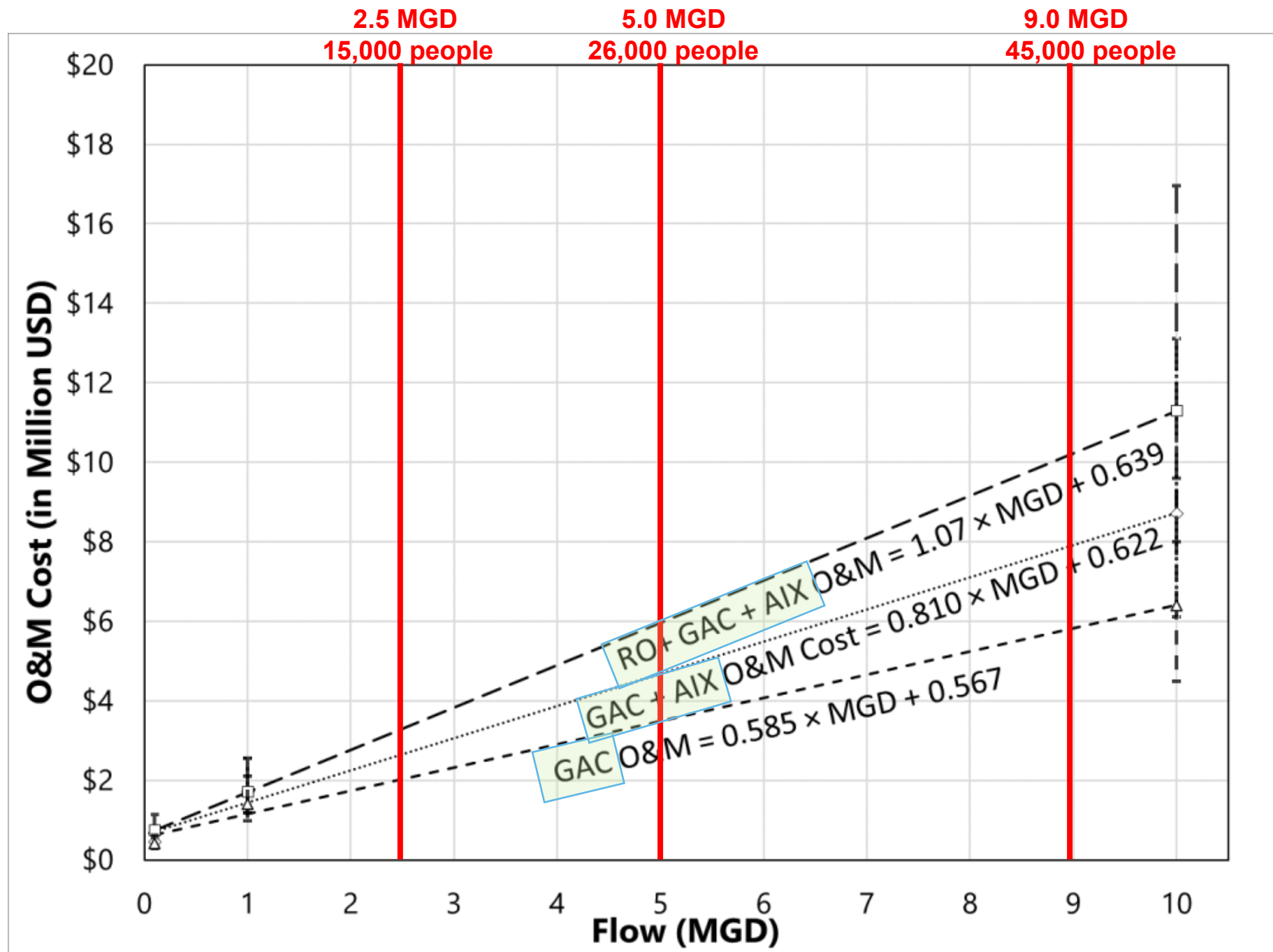


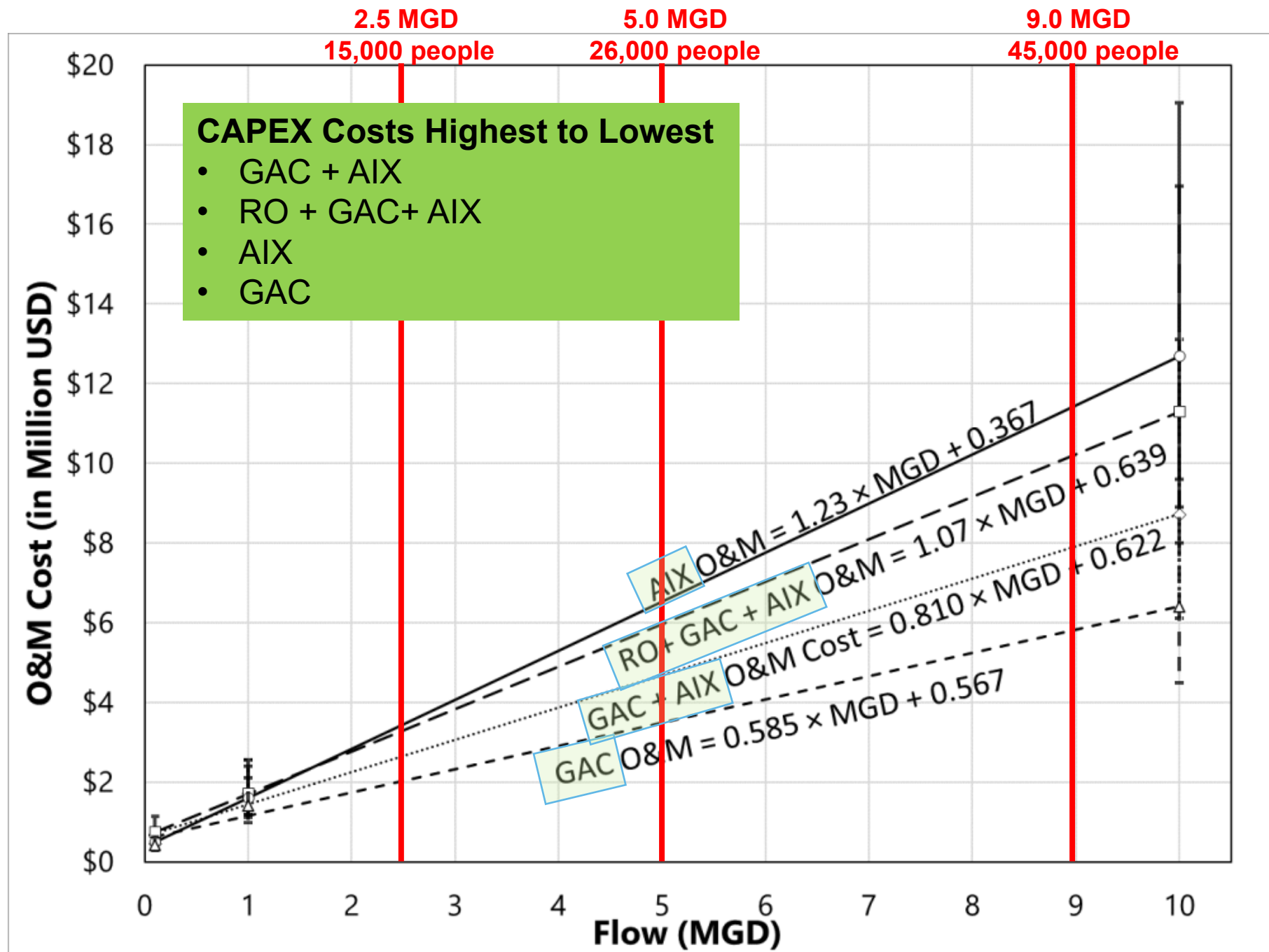








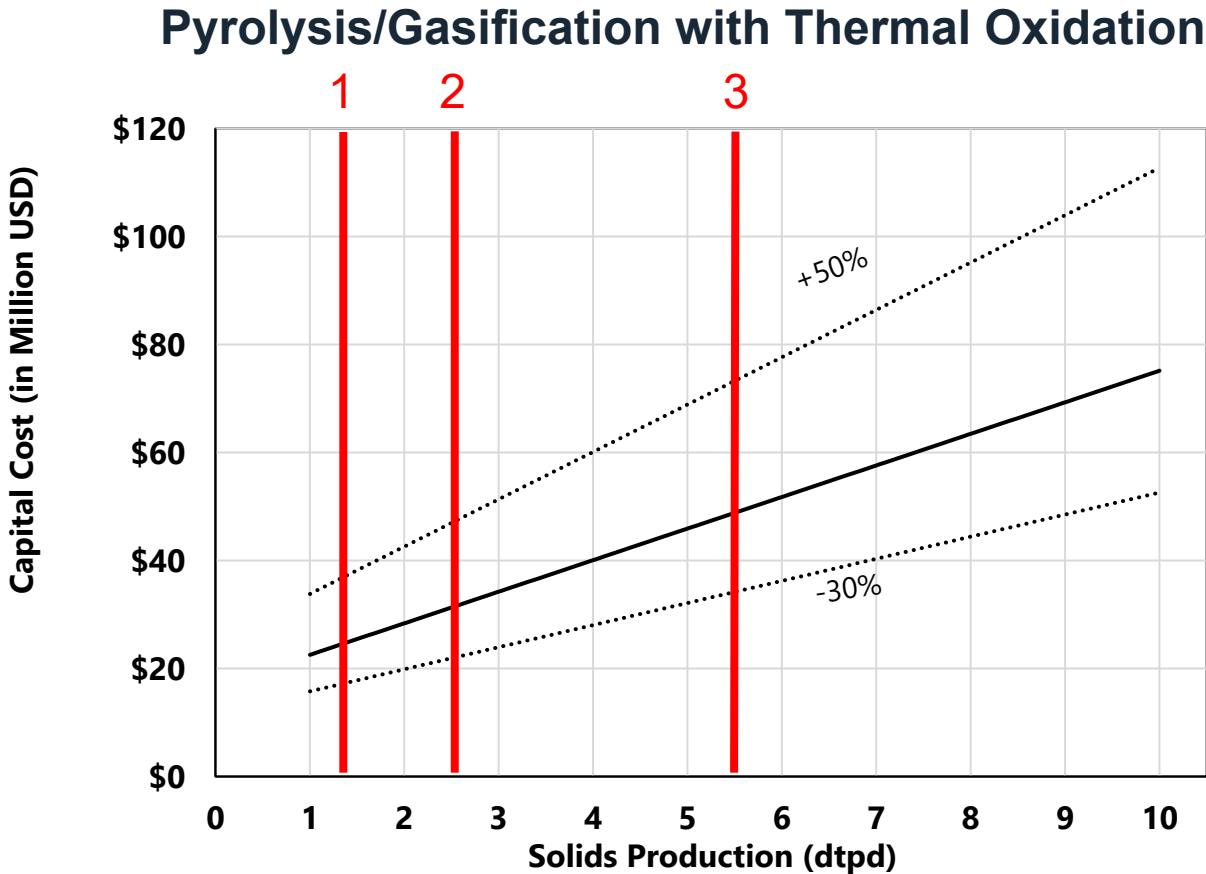




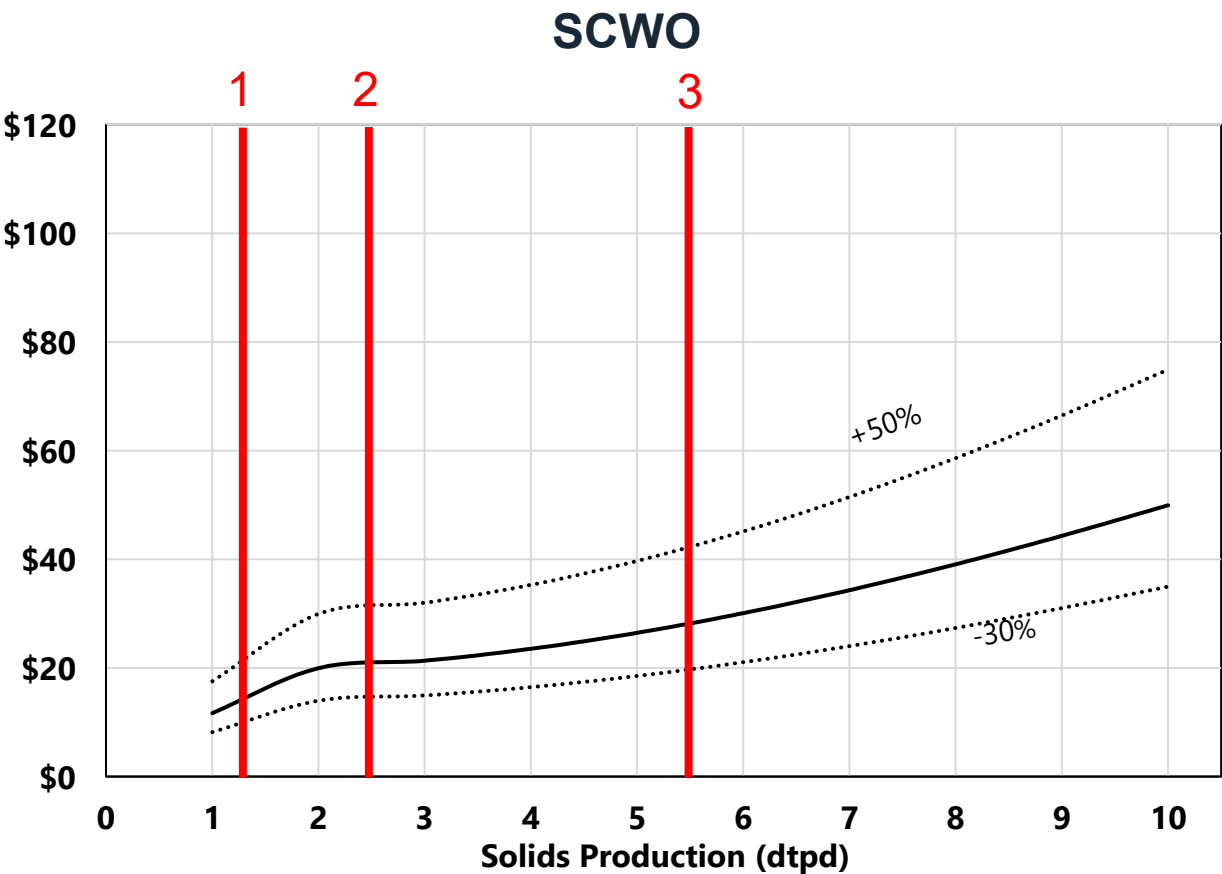
Biosolids capital cost curves



WRRF #1 – 1.3 dtpd (26,000 people)
WRRF #2 – 2.5 dtpd (45,000 people)
WRRF #3 – 5.5 dtpd (69,000 people)
dtpd = dry tons per day



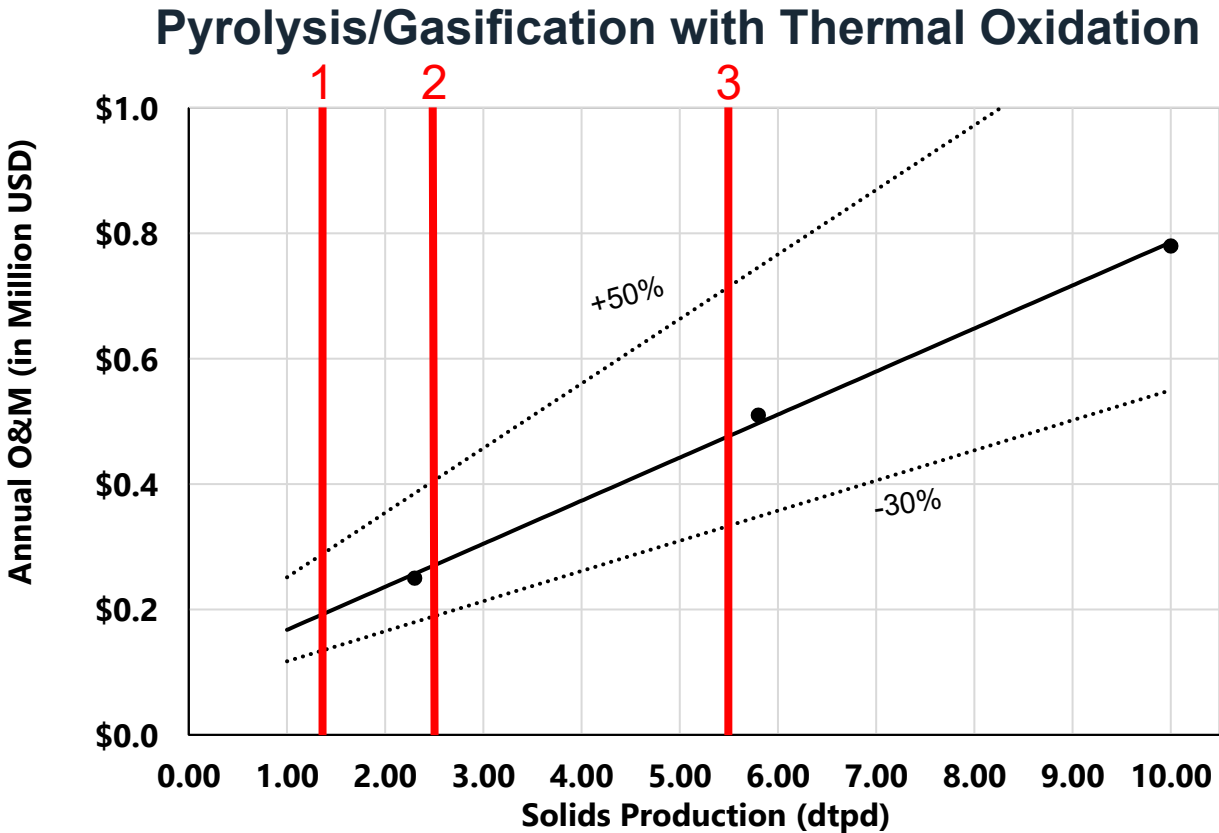
Capital Cost (million USD) = 5.85 x DTPD + 16.7



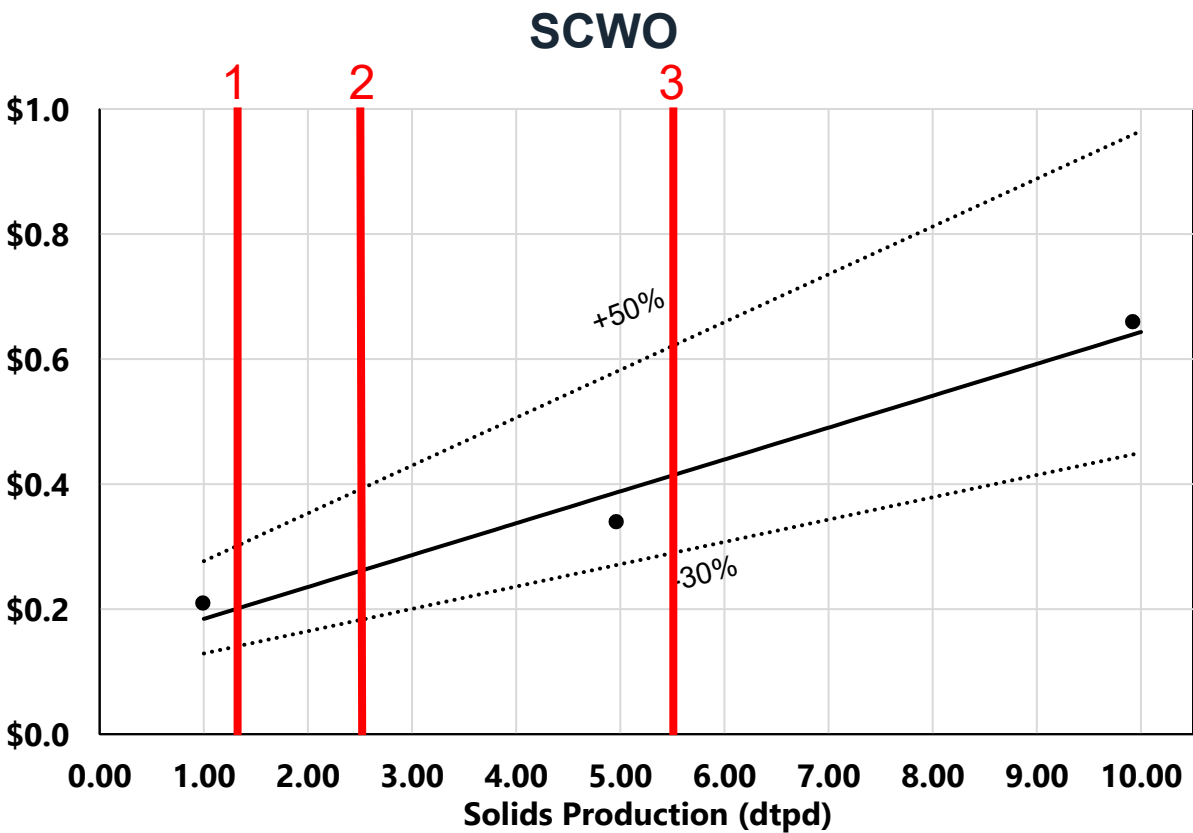
Capital Cost (million USD) = -0.01 x DTPD³ + 0.52 x DTPD² – DTPD + 20

Biosolids annual operation & maintenance costs

WRRF #1 – 1.3 dtpd (26,000 people)
WRRF #2 – 2.5 dtpd (45,000 people)
WRRF #3 – 5.5 dtpd (69,000 people)



O&M Cost (million USD) = 0.07 x DTPD + 0.10



O&M Cost (million USD) = 0.05 x DTPD + 0.13

Costs per mass PFAS removed



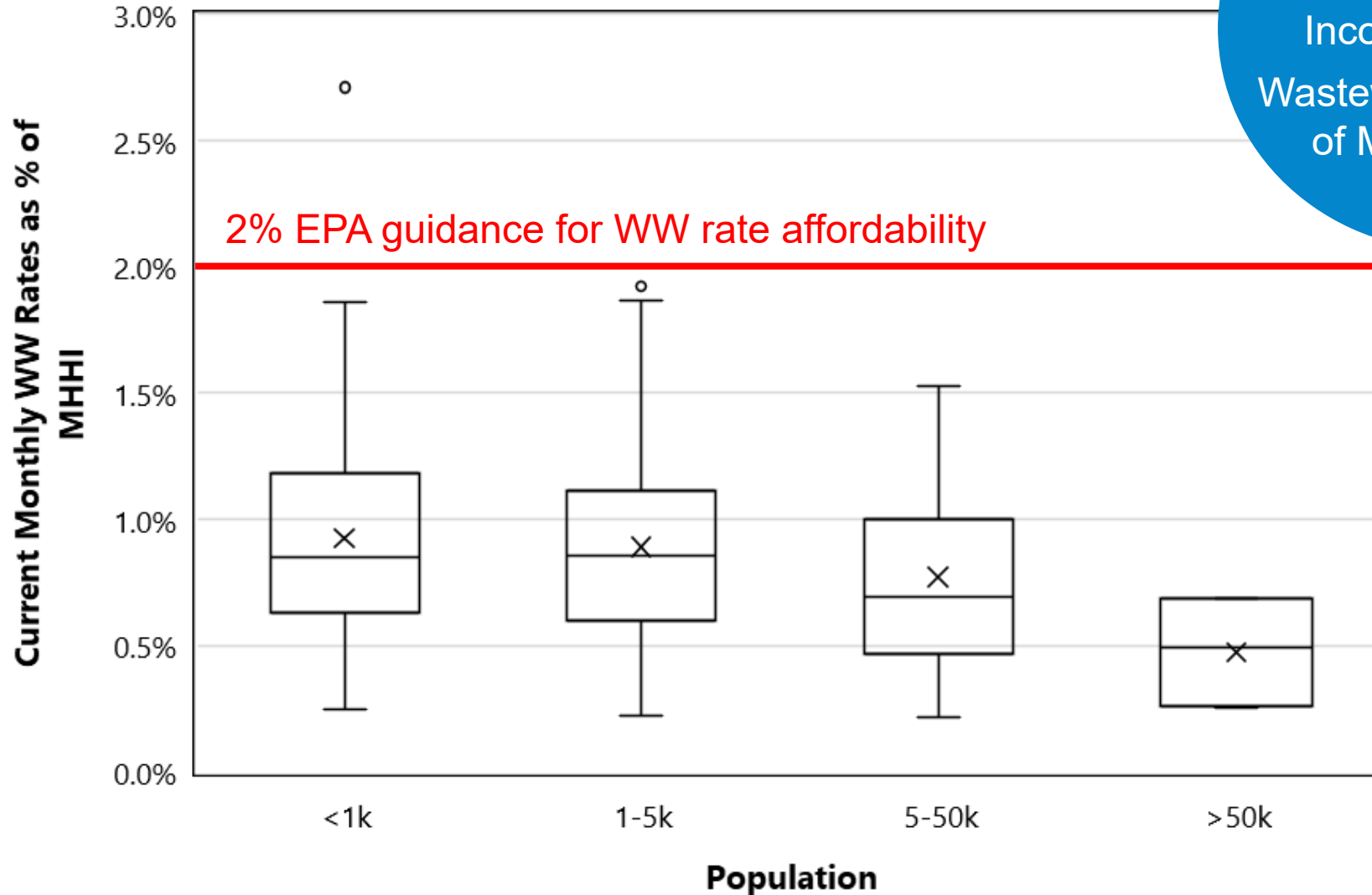
\$14 - \$28 billion
Estimated 20-year costs for target PFAS removal
(WRRF effluent and biosolids across Minnesota)

Cost per pound of PFAS removed over 20-year life cycle, in million USD

Municipal WRRF facility (GAC + HTI/reactivation)	0.1 MGD	1 MGD	10 MGD
	\$18.1M	\$6.8M	\$2.7M
Municipal WRRF biosolids (Pyrolysis/gasification)		1 DPTD	10 DPTD
		\$2.7M	\$1.0M
Municipal landfill facility (GAC + HTI)	1 GPM	10 GPM	100 GPM
	\$12M	\$1.4M	\$0.40M
Composting facility (GAC + HTI)	1 GPM	10 GPM	100 GPM
	\$39.3M	\$4.5M	\$1.3M

Wastewater rates affordability analysis

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Minnesota median household

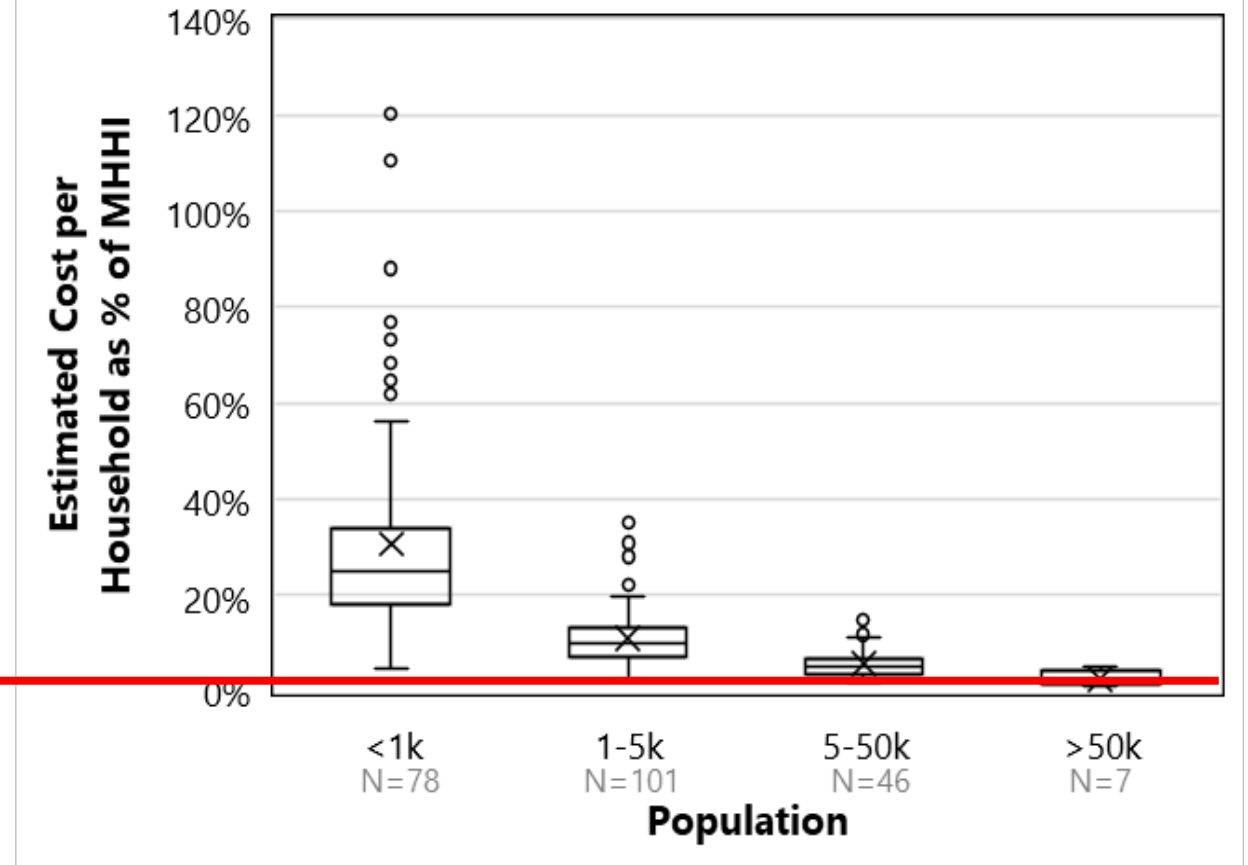
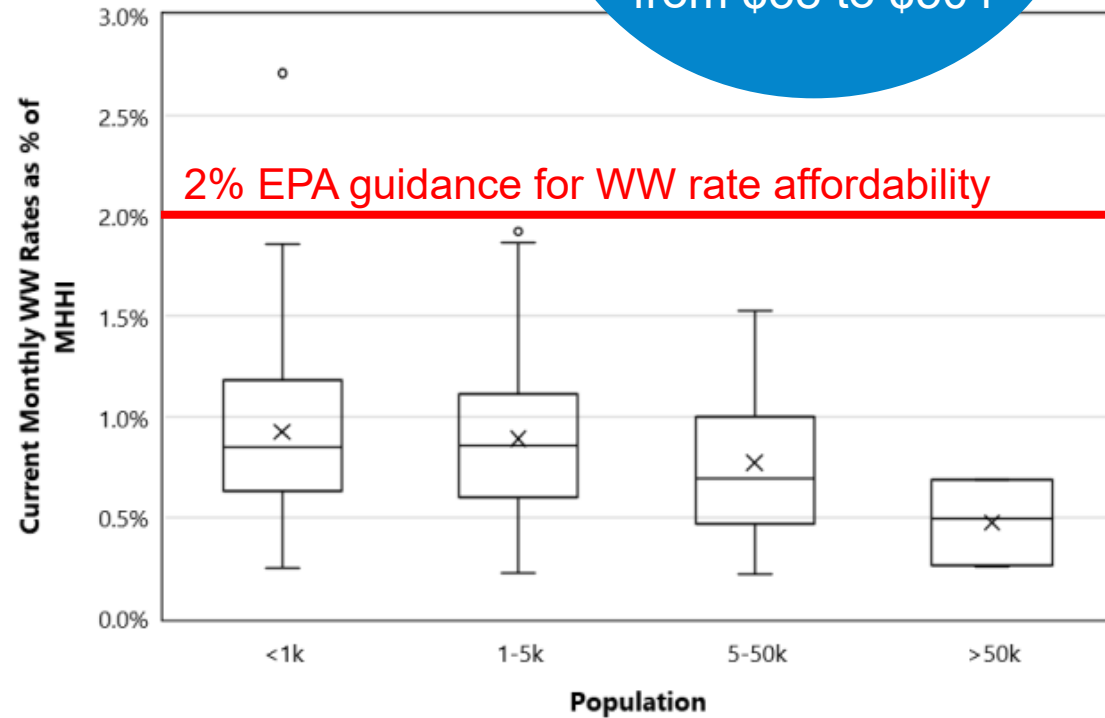
Income: \$55,000

Wastewater rate as % of MHHI: 0.82%

Wastewater rates affordability analysis

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Minnesota median household
Wastewater rate as % of MHHI: 11%
Monthly rate increase from \$38 to \$504





Thank You



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