Nitrate Removal from Potable Water

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ResinTech Inc.
INNOVATIONS IN ION EXCHANGE

How do nitrates get into our water?

Outline

- History of Regulations
- Nitrate Chemistry
- Methods of Nitrate Removal
- Ion Exchange Theory
- Focus on Ion Exchange
- Closure
- Q & A

How Nitrates Get into Water

- Surface runoff from agricultural areas
- Livestock
- Non-agricultural sources of nitrate
  - Lawn fertilizers
  - Septic systems
  - Domestic animals in residential areas

Health Effects

Nitrate and Nitrite

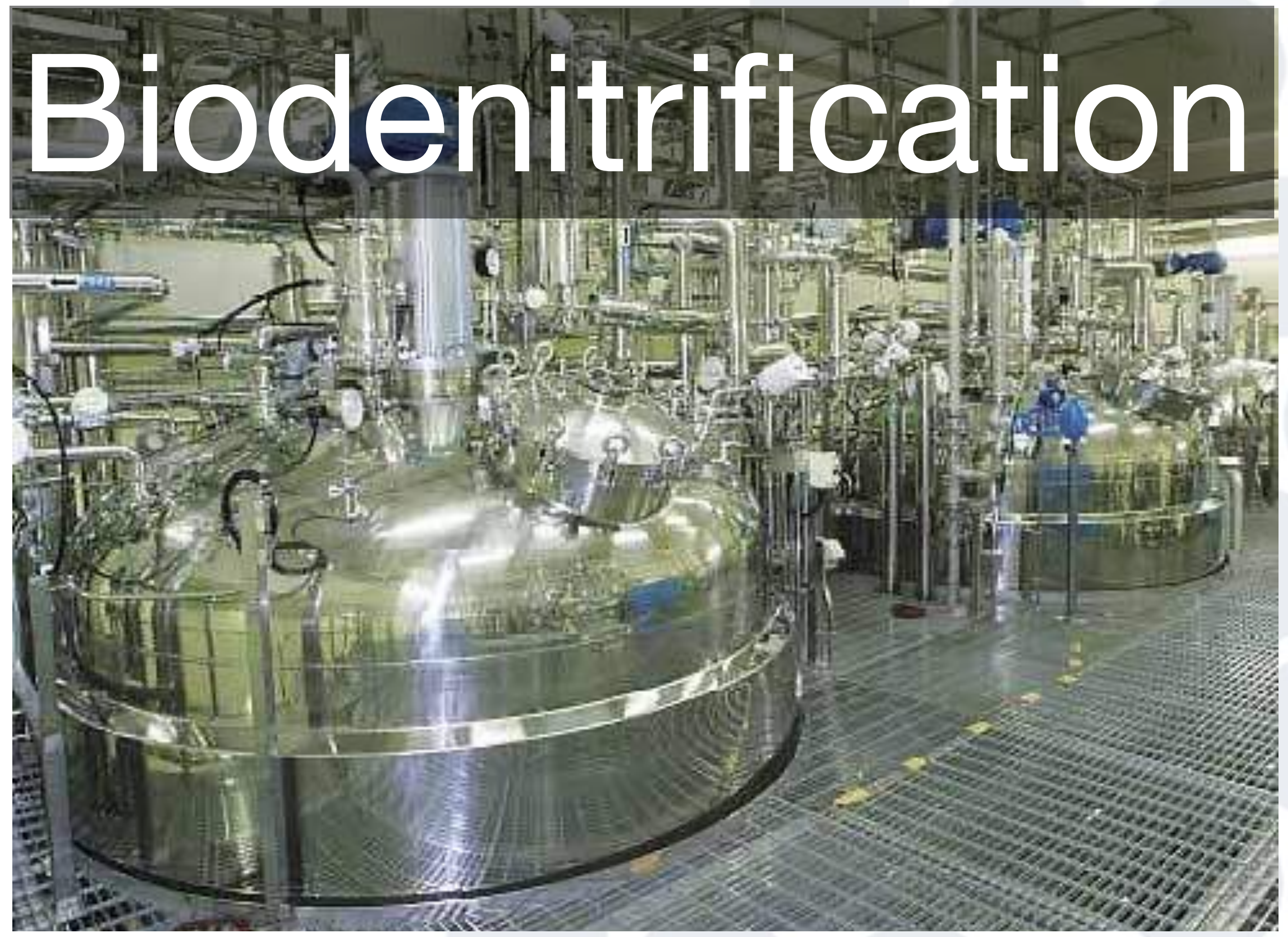
- **Primarily**
  - Methemoglobinemia
    (Fetuses and infants <6 months old are most at risk)

- **Secondarily**
  - Nutrient Source for Harmful Algae Blooms (HAB)

Nitrate Facts

- Nitrate salts are freely soluble
- Symmetrical ion is difficult to break apart
- Nitrate and uranium are sometimes co-contaminants
- IX resins that remove nitrate also remove uranium
- MCL is 10 mg/L as N (35.7 as $CaCO_3$ and 44.7 as NO_3)

Methods of Nitrate Removal



Focus on Ion Exchange

- Simplified IX Theory
- Choosing the right resin
- Basic sizing
- Resin life
- Regeneration strategies
- Unexpected consequences

Simplified Ion Exchange Theory

Ion exchange resins are **plastic beads** that **take salt out of water** and **put other salts back in.**

ResinTech SIR-100-HP
Nitrate Selective Anion Exchange Resin

Nitrate Reduction by Anion Exchange

$R\text{-}Cl^- + NO_3^- \rightarrow R\text{-}NO_3^- + Cl^-$

What else do we need to know?

- TDS or conductivity
- pH
- Hardness
- Sulfate
- Nitrate
- Chloride
- Alkalinity

ResinTech Water Testing Kit

Nitrate Removal Resins

Category Type	DMEA *Type II*	TEA *Nitrate Selective*	TBA *Super Selective*
ResinTech product	SBG2-HP	SIR-100-HP	SIR-110-HP
“K” (NO_3/Cl)	3	5	23
“K” (SO_4/Cl)	0.15	0.02	0.003
Capacity (meq/mL)	1.45+	0.95	0.75

DMEA - DIMETHYLETHANOLAMINE TEA - TRIETHYLAMINE TBA - TRIBUTYL AMINE

Nitrate Removal Versus Softening

Nitrate Removal	Hardness Removal
K(NO_3/Cl) remains constant	K(hardness/Na) is high at low TDS and low at high TDS
Needs high salt dose	Needs low salt dose
High nitrate leakage in service cycle	Low hardness leakage in service cycle

Choosing a Nitrate Removal Resin

Type	DMEA	TEA	TBA
ResinTech Equivalent	SBG2-HP	SIR-100-HP	SIR-110-HP
Cost	Low	Higher	Highest
Nitrate Dumping	Possible	Rare	None
Capacity - Low SO_4	Highest	Lower	Lowest
Capacity - High SO_4	Low	Higher	Highest

Basic Sizing Guidelines

Flow Rate is Key (based on average flow)

	Municipal	Residential / POE
Linear Flow Rate (gpm / ft^{2})	10	10
Service Flow Rate (gpm / ft^{3})	2 - 4	2 - 4
Min. Bed Depth (Inches)	60”	24”

Residential

Point of Entry System (POE)

Point of Use System (POU)

Municipal

Municipal

Design Guidelines
Resin Requirements

Parameter	Value	Reason
Min. Run Time	4 hours	Shorter Cycle = Shorter Lifetime
Min. Service Flow Rate	0.5 gpm/cu.ft	Too Slow = Risk of Channeling
Max. Service Flow Rate	5 gpm/cu.ft	Too Fast= Inadequate Contact Time for Exchange
Min. Linear Flow Rate	2 gpm/sq.ft	Too Slow = Risk of Channeling
Max. Linear Flow Rate	20 gpm/sq.ft	Too Fast= Excessive Pressure Drop

Resin Cycle Time and Lifetime Cycles

Average resin life is ~3,000 cycles

1 cycle / day

8 years

4 cycles / day

2 years

Loss of Capacity over Time

- All anion resins lose capacity over time
- Physical losses ~1% per year
- Chemical losses - 2 to 5% / yr. for chloride form anion resins
- Fouling (increases apparent capacity loss)
  - Organics
  - Iron, manganese

Factors affecting Resin life

- Chlorine in feedwater
- Frequency of regeneration
- Feedwater has foulants
- Feedwater is biologically active

ResinTech Lab Services

Examples of Nitrate Removal Projections

In all cases we fixed the following:

Chloride = 100 mg/L as Cl

Alkalinity = 50 mg/L as HCO_3

Nitrate = 20 mg/L as N

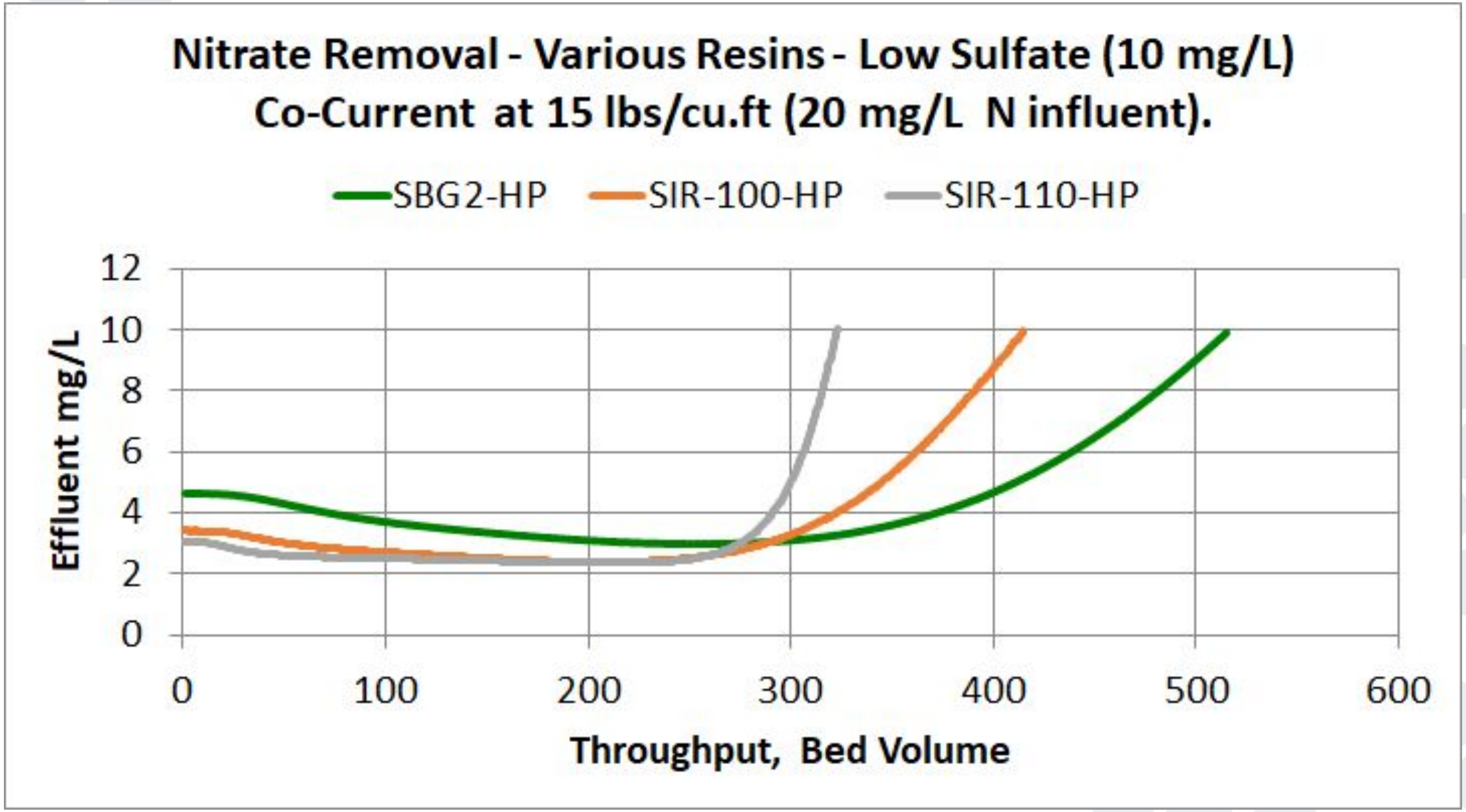
Sulfate was varied to illustrate differences in resin performance

Low sulfate = 10 mg/L as SO_4

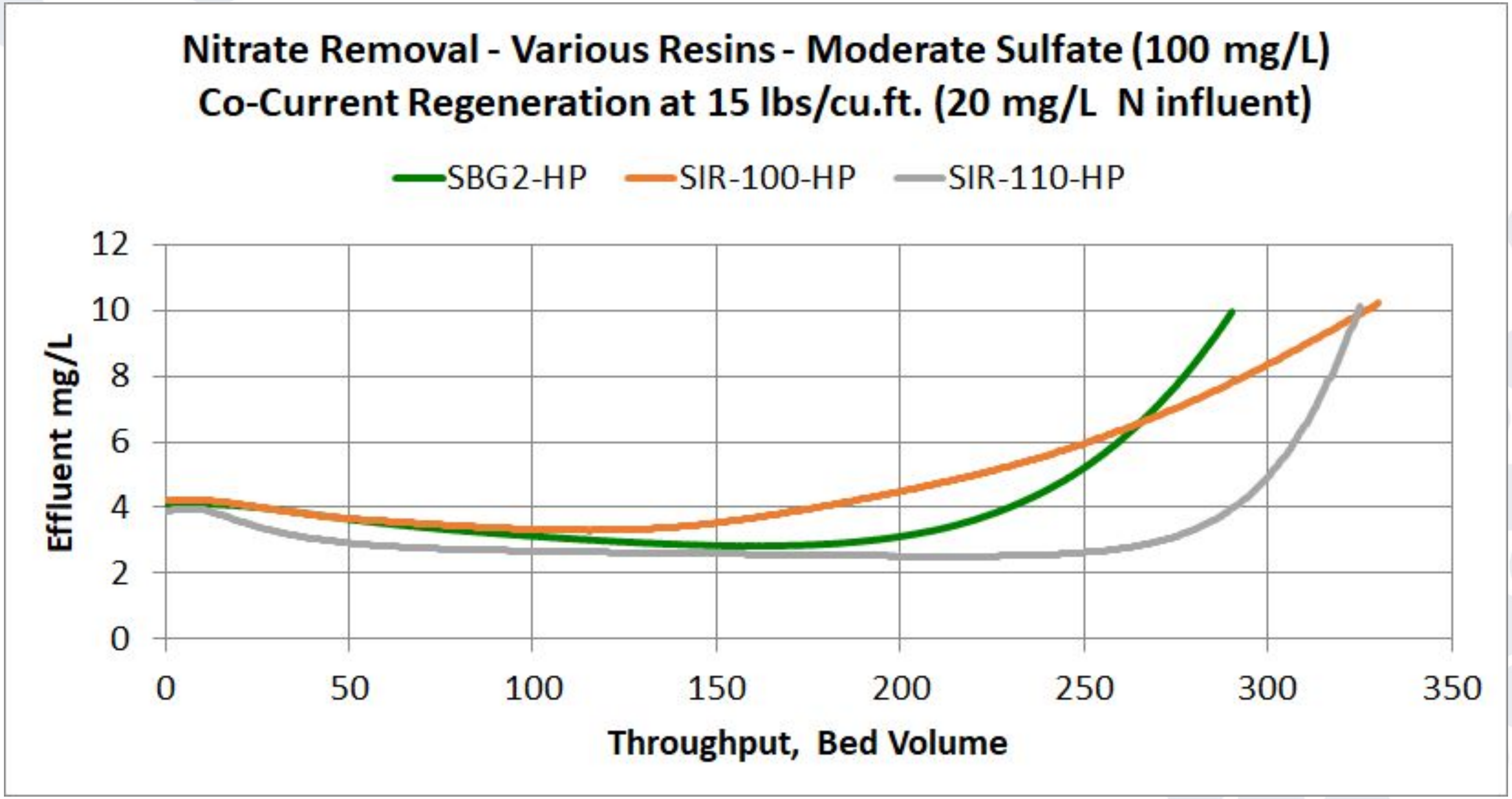
Medium sulfate = 100 mg/L as SO_4

High sulfate = 500 mg/L as SO_4

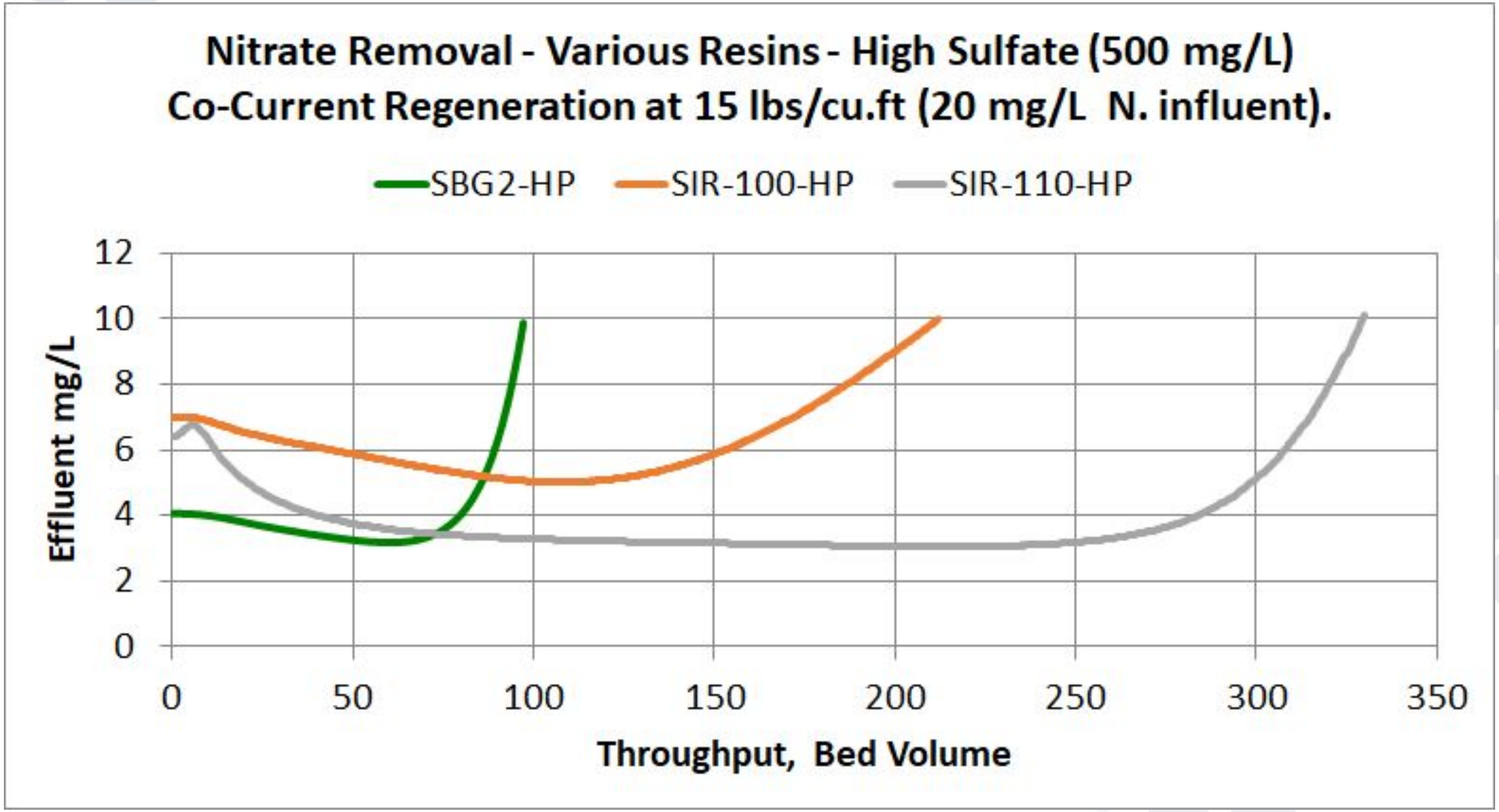
Low Sulfate (10 mg/L as SO_4)



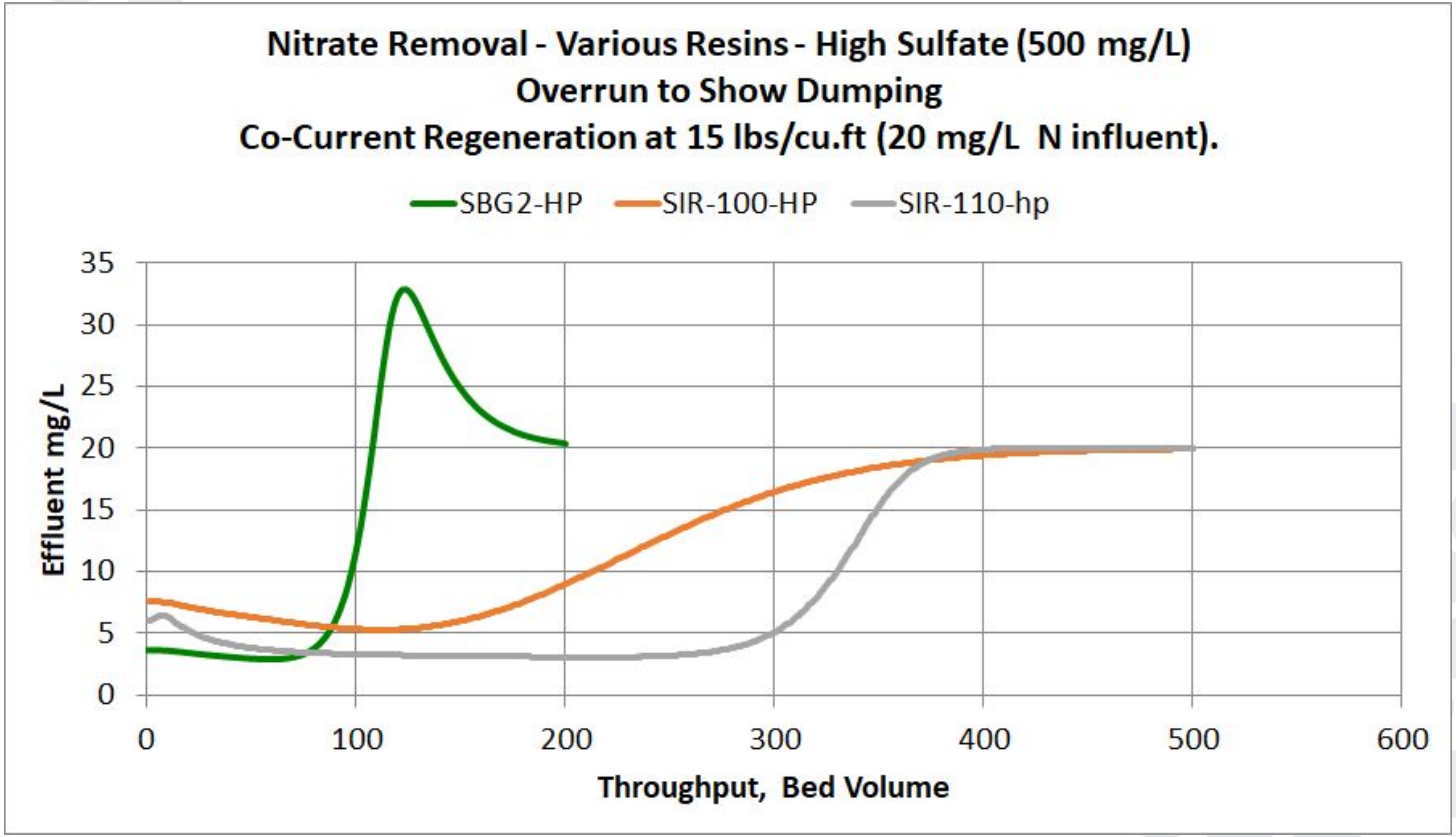
Moderate Sulfate (100 mg/L SO_4)



High Sulfate (500 mg/L as SO_4)



Overrun High Sulfate (500 mg/L as SO4)



Co-flow vs Countercurrent Regeneration

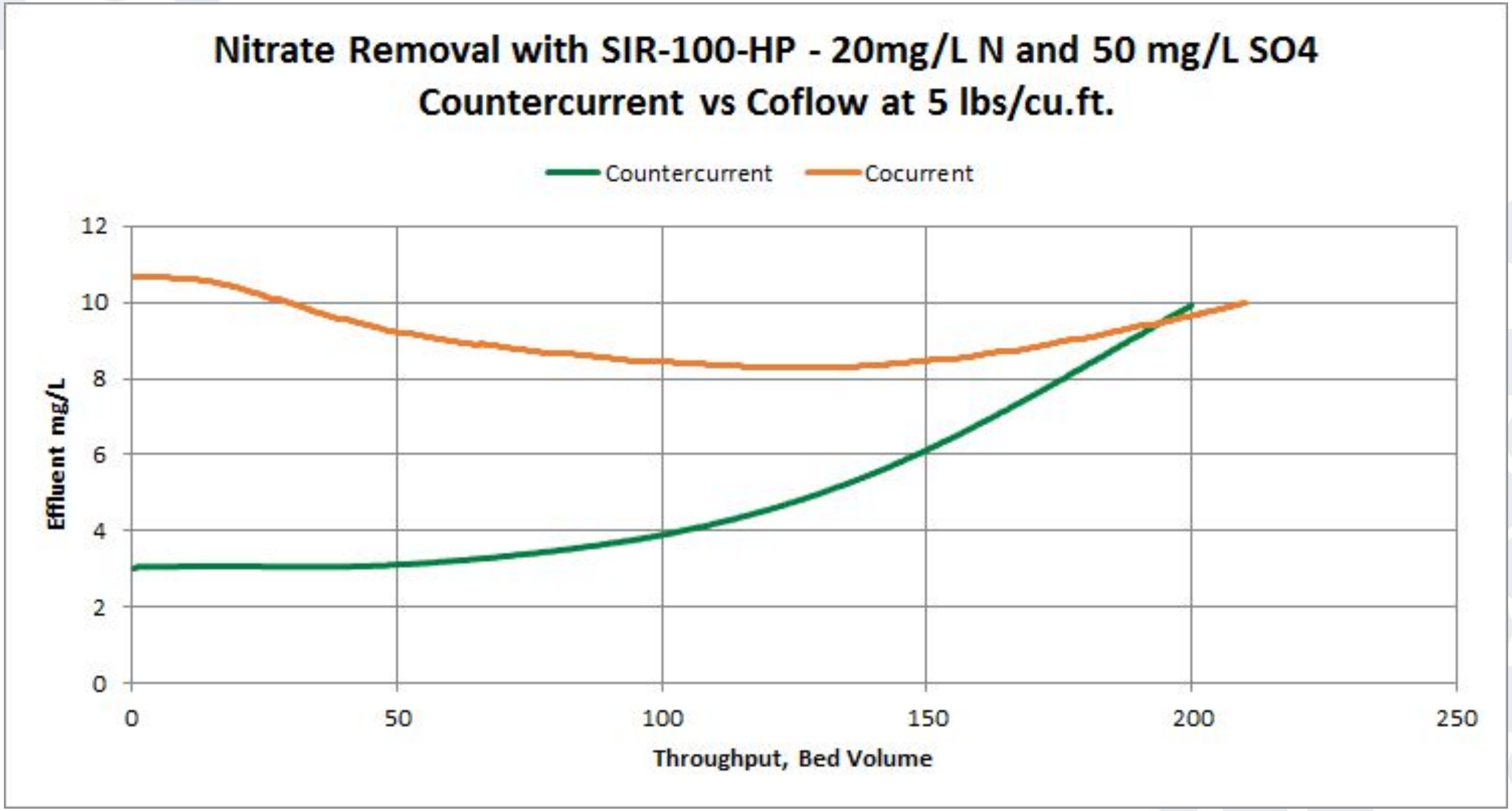
Co-flow

- Best known
- Most forgiving
- Least efficient

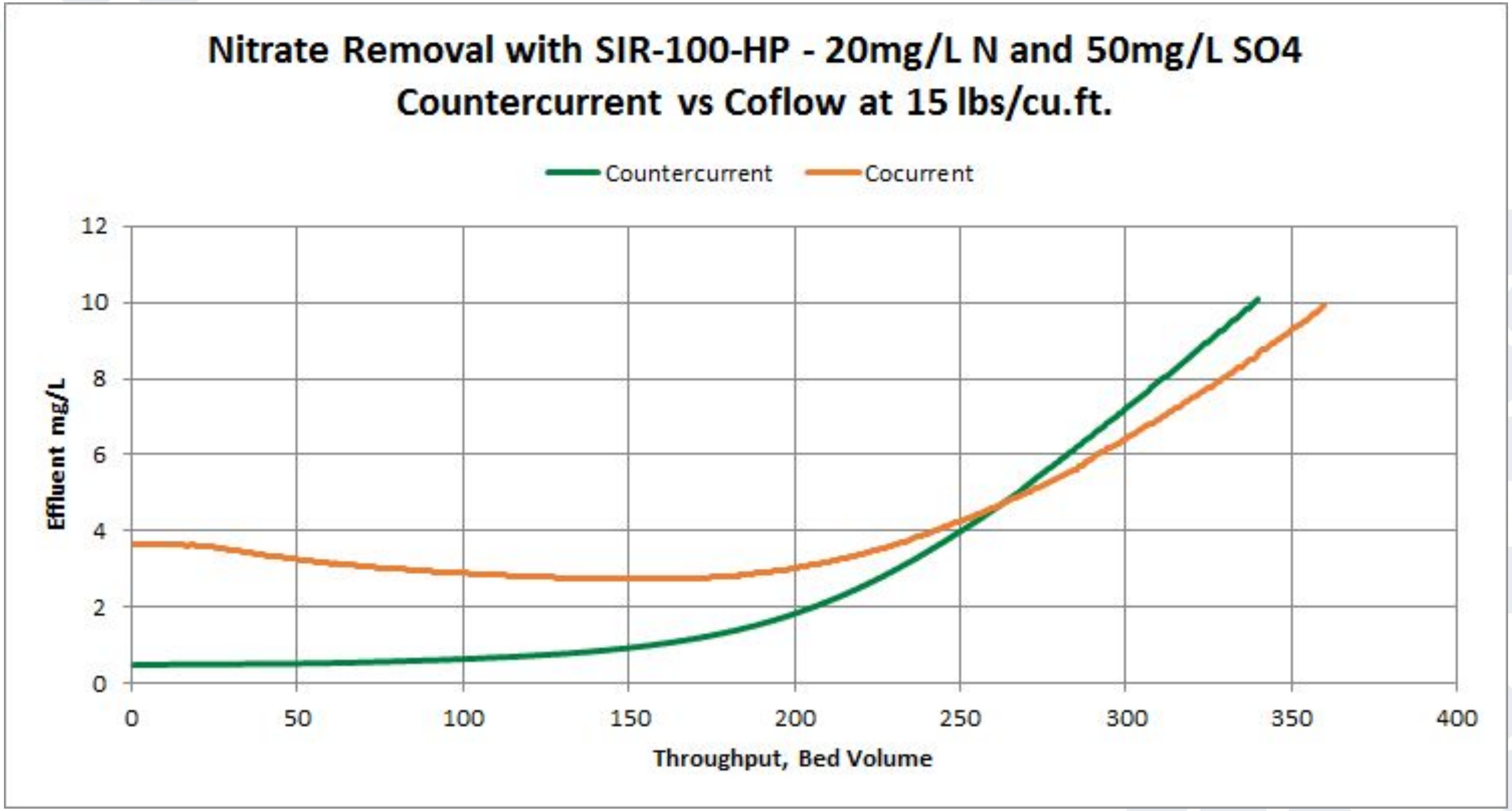
Countercurrent

- More complicated (except packed beds)
- Higher salt efficiency (at low salt doses)
- Lower nitrate leakage

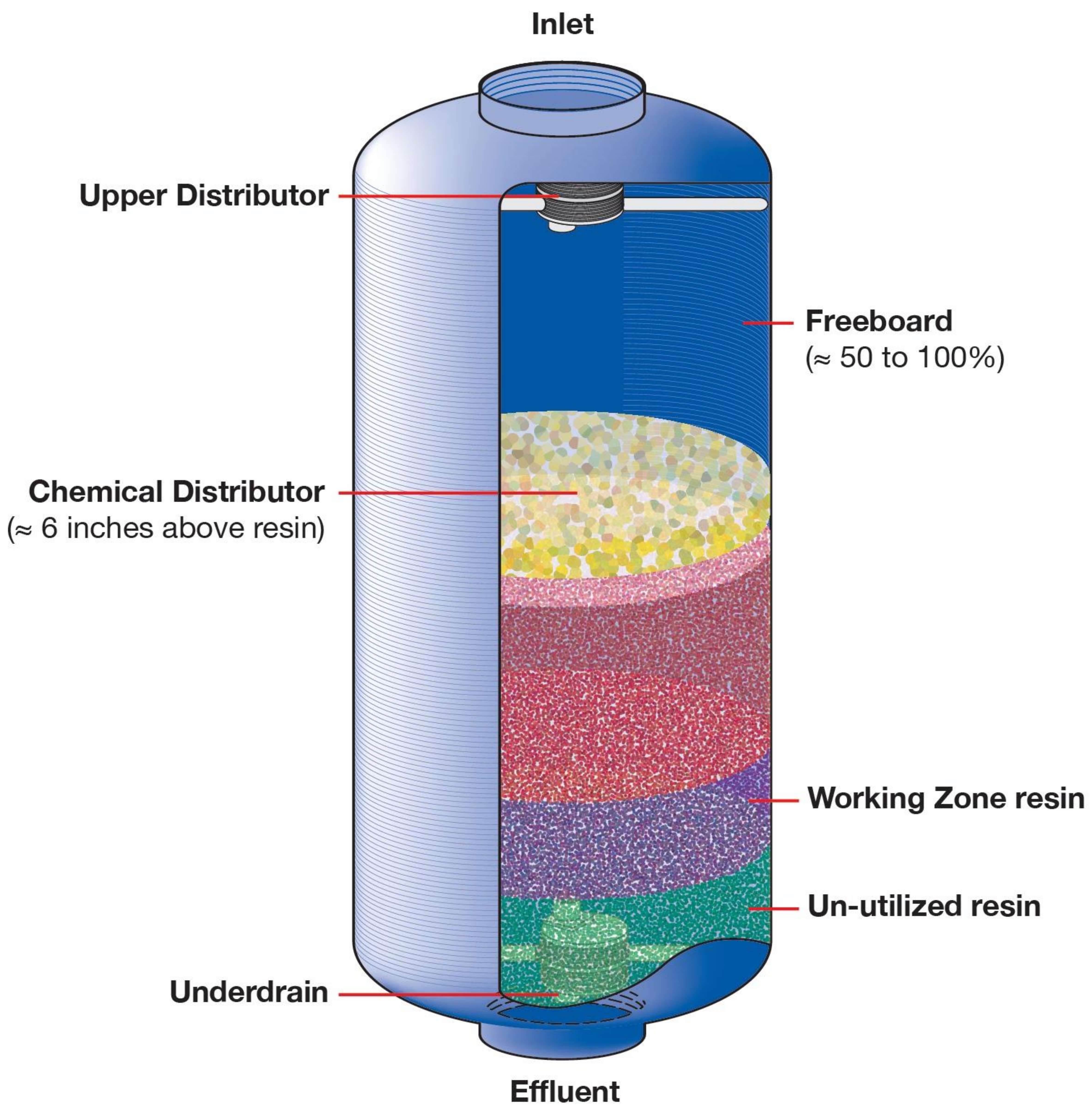
CCR vs Coflow @ 5 lbs/cu.ft. Regeneration Dose



CCR vs Coflow @ 15 lbs/cu.ft. Regeneration Dose



Co-Flow Ion Exchanger

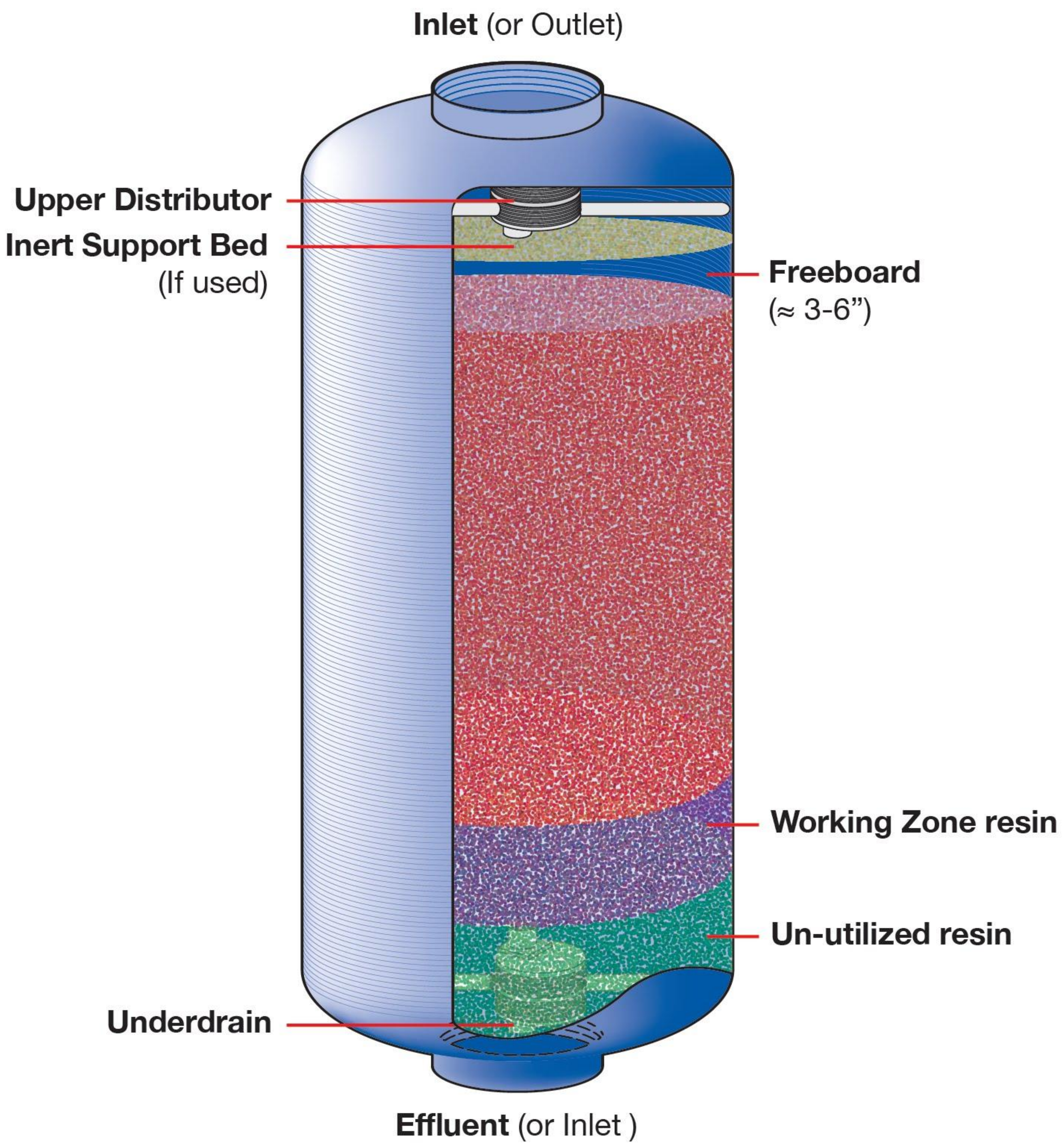


Co-Flow Design

Countercurrent Regeneration

Pros	Cons
Simplest	relatively inefficient
Least expensive	higher leakage in high TDS water

Packed Bed Ion Exchanger



Packed Bed Design

Countercurrent Regeneration

Pros	Cons
high efficiency	more complex
low leakage	more expensive
	needs external backwash

Developing a Regeneration Schedule

All Regeneration Schedules Must Include:

- Backwash (usually ~15 minutes)
- Chemical injection (usually ~30 mins)
- Slow/Displacement Rinse (Target 10-15 gallons/cu.ft)
- Fast Rinse (Target 30-40 gallons/cu.ft)
- Whole Kit and Kaboodle usually takes about 60-90 minutes

Is Softening Necessary?

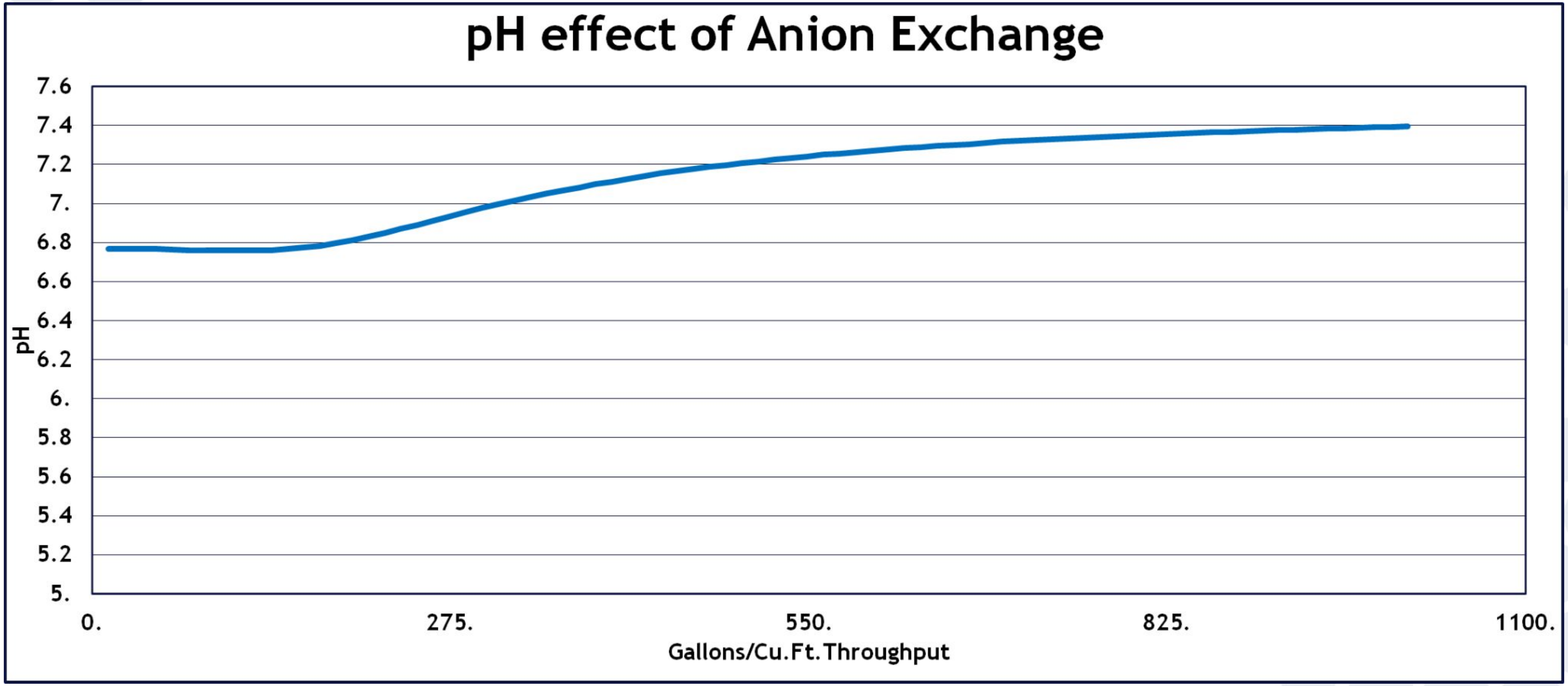
- Exhaustion cycle = sometimes when softening is needed for other reasons
- Regeneration Water = sometimes

Ways to minimize scaling potential in the brine

- Buy soft salt (expensive and sometimes difficult to source)
- Soften dilution water
- Reduce brine concentration (or use two step brine injection)
- Increase brine flow rate
- Nitrate and super nitrate selective resins (ResinTech SIR-100 and SIR-110) are less susceptible to brine scaling than type 1 or type 2 resins

pH Change

from Chloride Form Anion Exchange Resin



Types of Fouling

- **The plastic bag**
  - Anything that coats the beads
  - blocks the ions from getting in or out
- **The sponge**
  - Anything that fills up the spaces among the beads
  - Prevents equal flow
- **Super ions**
  - Any ion with very high selectivity
  - Blocks ion exchange sites

Takeaways

- Water analysis is key
- Sulfate is king
- Regular “wellness checks”

Questions?

THANK YOU

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