Metal Finishing Workshop for Captive and Job Shop Metal Finishers

Session 3: Water Use and Recovery

10:45am – 11:15am

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NYSP2I

Overview

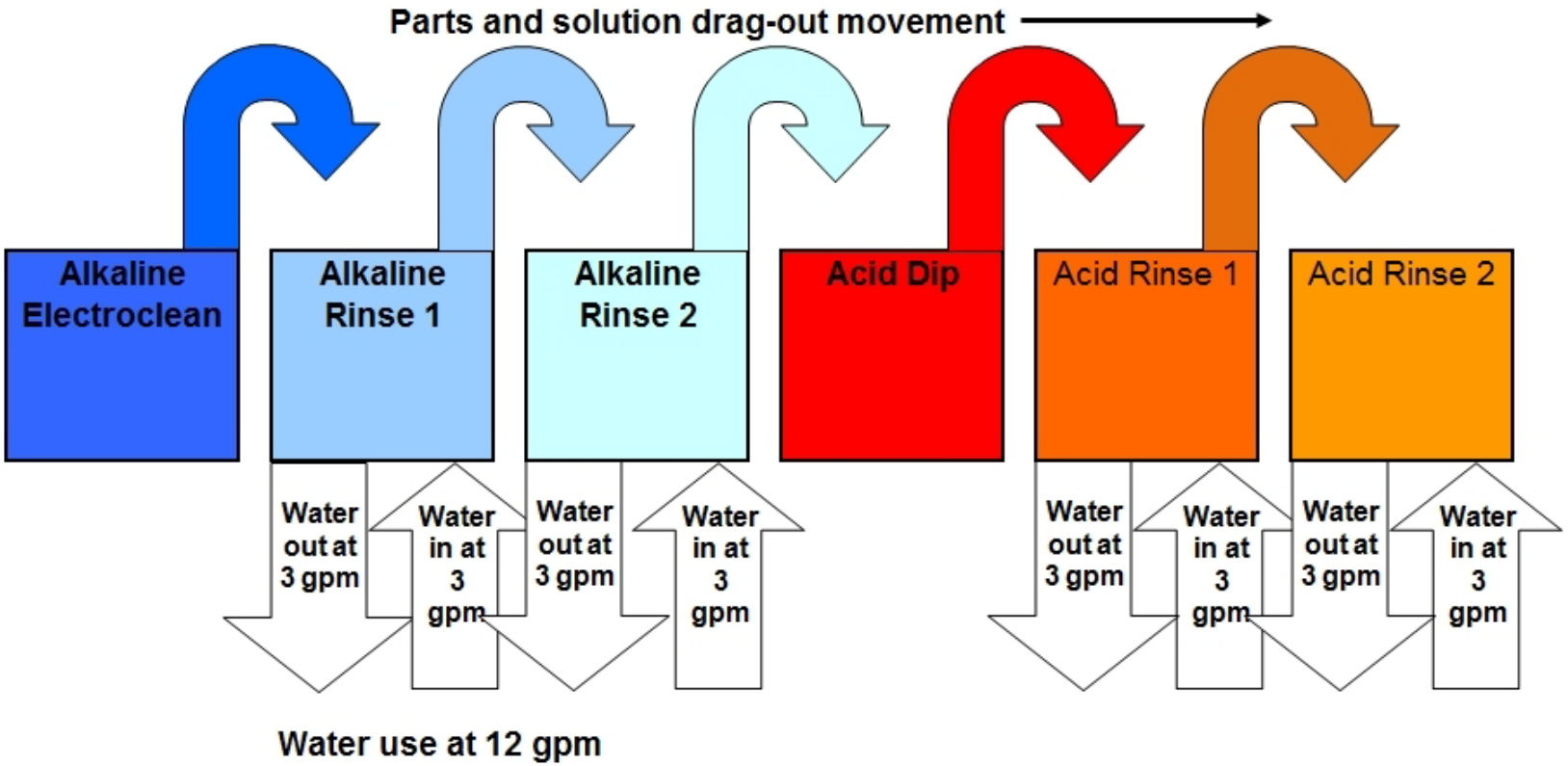
- Optimizing Rinse Water Use

- Water Recovery
  - Technologies
  - Rinse Water Requirements
  - Which Technologies make sense
  - Cost and Payback considerations

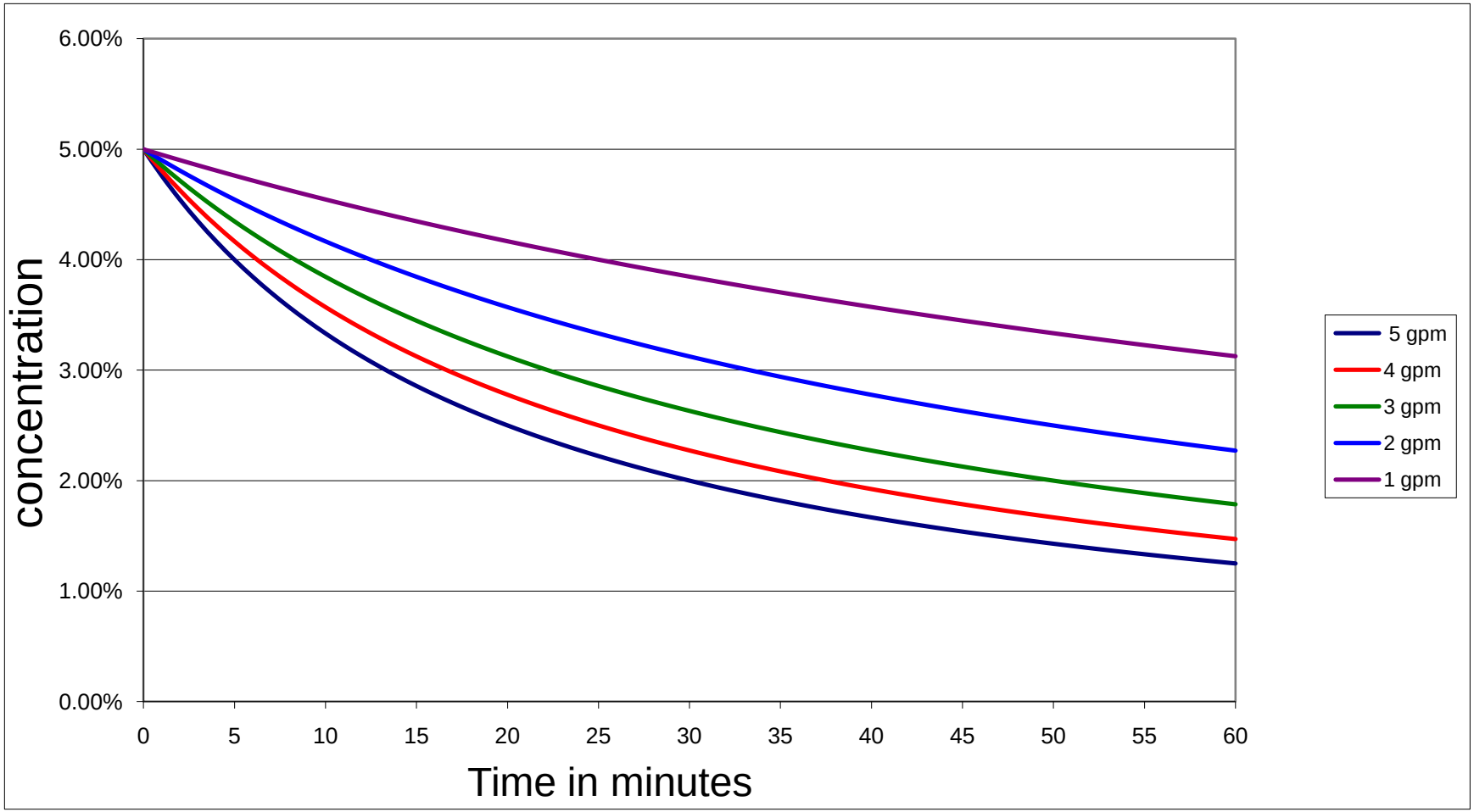
Typical Cleaning Steps

1. Alkaline cleaner, could include ultrasonics, agitation, or electrocleaning to assist the cleaning chemistry in contaminant removal. Contaminants are typically oil, dirt, buffing compound, fingerprints, etc.
2. Rinses (parts drag alkali into rinse water)
3. Acid etch, to remove light rust or oxides
4. Rinses (parts drag acid into rinse water)
5. Sometimes a repeat of the alkaline and acid steps including rinses

Typical Cleaning and Rinsing Layout

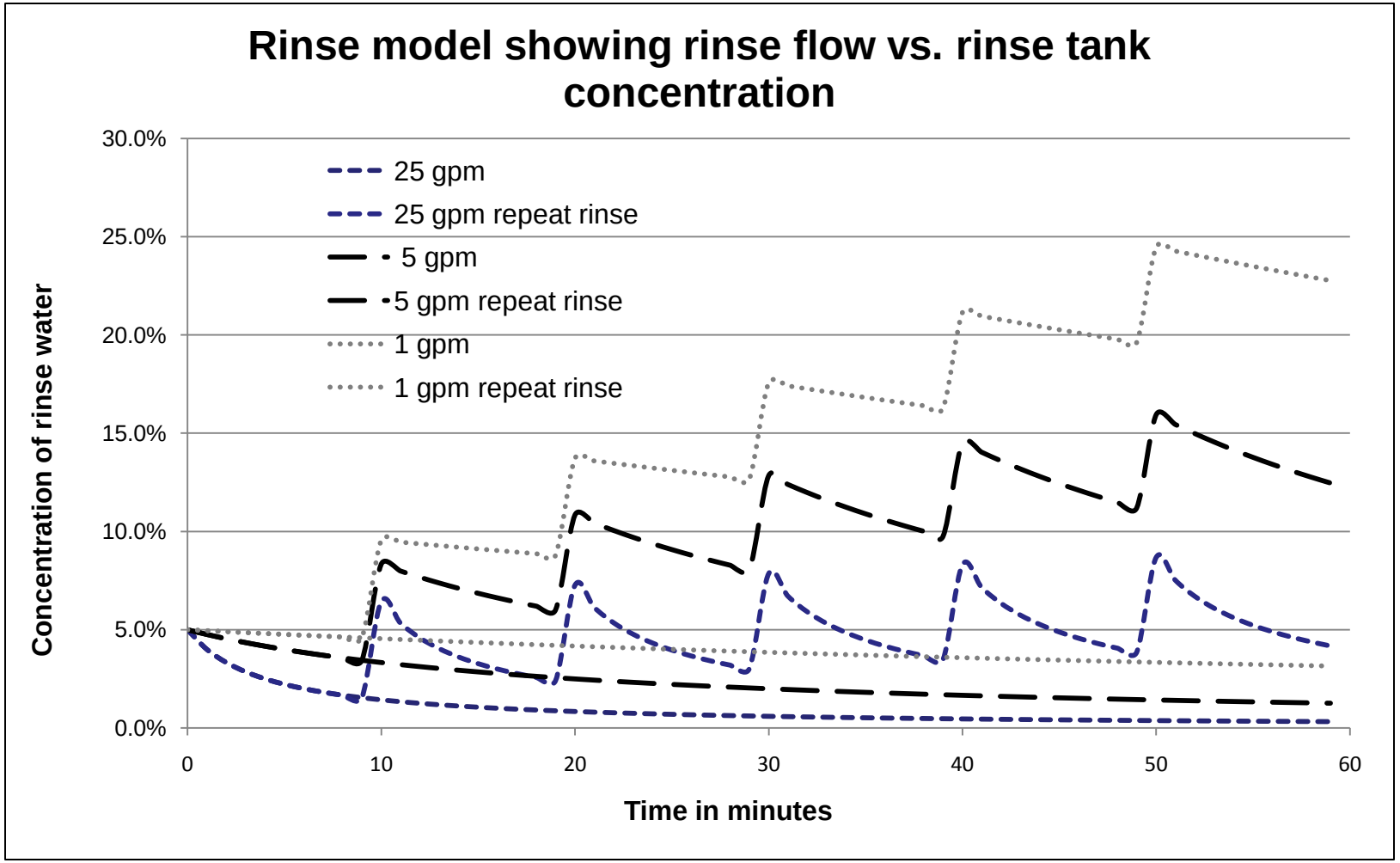


Single Rinse Dilution Model



100 gallon tank, .05 gal. dragout, 100 gm/gallon in dragout

Single Rinse Dilution Model



Single Rinse

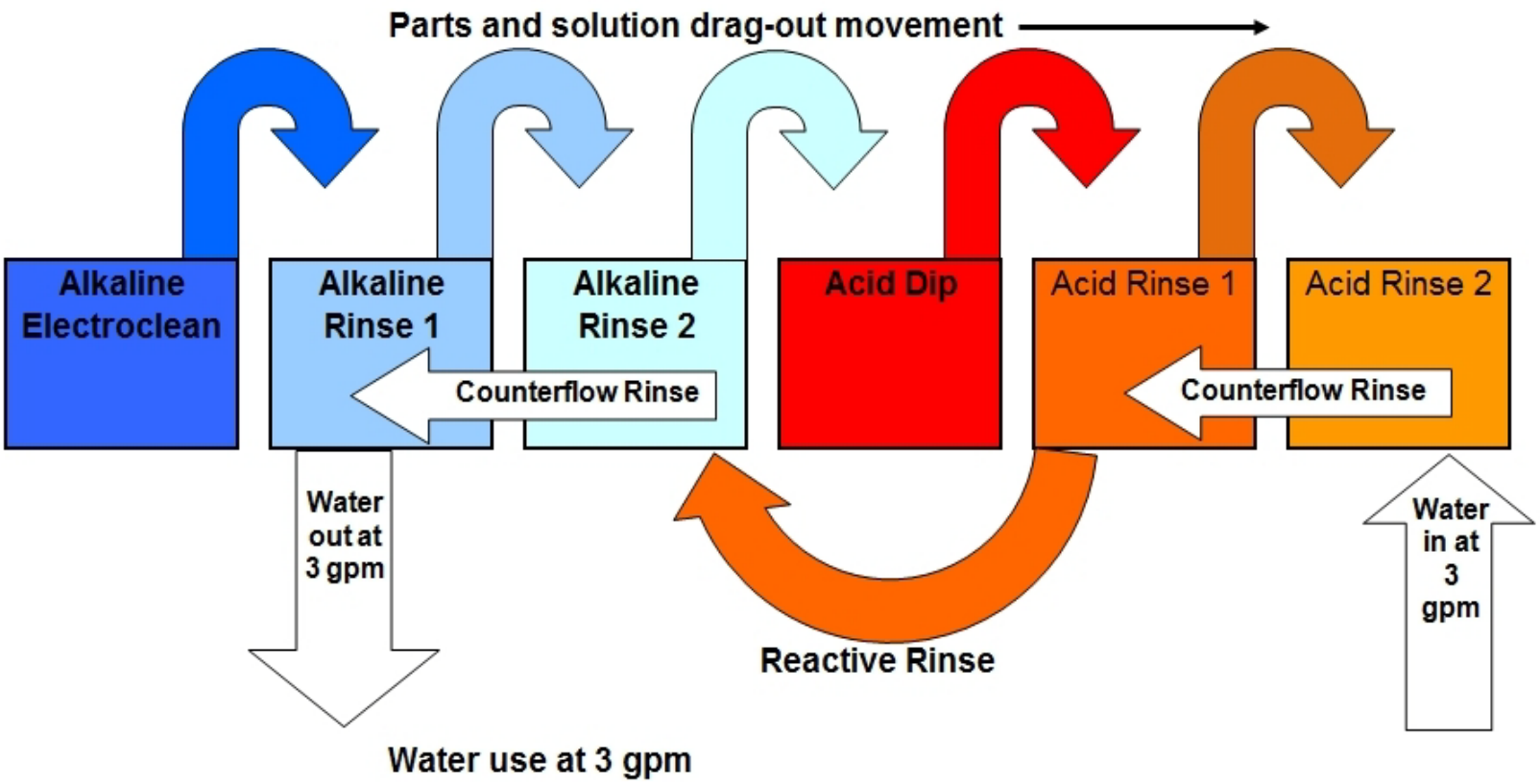
- Conclusion: Based on the rate of dilution in even a small tank (100 gallons), it is very difficult to obtain good rinsing with a single rinse tank. Even relatively high flow rates of 5 gpm cannot keep up with the contamination loading from parts dragout.
- Therefore, there really needs to be a second rinse tank for critical rinsing.
- And……it becomes very important to determine your real rinse tank dynamics by measuring flow and conductivity/TDS

Purpose of Rinsing

- First rinse tank
  - remove most of the previous tank's chemicals from the part
  - Stop the chemical reaction from the previous tank
- Second rinse tank
  - Final rinse to remove additional chemicals and maximize part cleanliness
  - Minimize contamination of next chemical tank

If there was zero dragout of chemicals then there would be no need to rinse!!!

Optimized Cleaning and Rinsing Layout



Water Use in Finishing: Rinse Water

- Measure the flow rate on each rinse tank to determine the rinse water use
  - Needed: ruler, tape measure, stop watch, small pump and hose
  - Pump the tank down 1-2” inches
  - Measure the time it takes for the water level to move some convenient amount (1/2”, 1”, etc.)
  - Measure the surface area of the tank (length, width)
  - Length x width x change in water level = volume in cubic inches (231 cubic inches =1 gallon)
  - Gallons/measured time gives the flow rate

Monitoring the Rinse

- Rinse water contaminants (chemical solution dragout) are typically electrically conductive in solutions.
- As more solution gets dragged into a rinse tank the rinse conductivity goes up.
- As the rinse flow is increased the contamination level drops more rapidly due to dilution (and vice versa)

Note: Conductivity is directly related to total dissolved solids or TDS

Flow vs. Concentration

- Measuring contamination in rinse water
  - Chemical analysis (slow and expensive)
  - Solution conductivity: start with a beaker (create a curve), end with on-line rinse tank measurements

Conductivity/TDS meters cost from $140-$900

Flow Controls in Immersion Rinsing

- In-line flow restrictors: the hand operated valve has an aperture to restrict the flow to some maximum value at maximum valve opening.
- Conductivity controls: rinse valve opens and closes based on TDS value of rinse tank

From: www.freshwatersystems.com

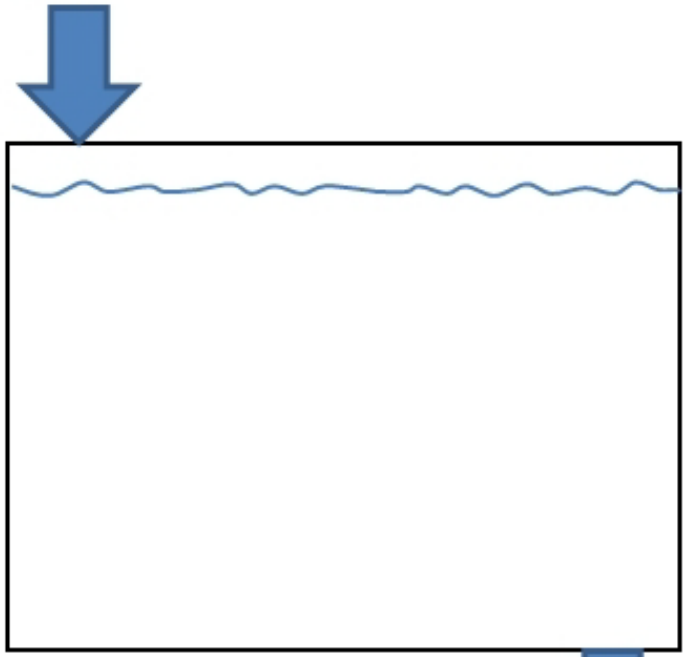
From: Myron L Company, Controlstik Systems

Conductivity/TDS Controls

- Finding the best TDS set points (valve opens when water reaches maximum TDS set point, valve closes when water reaches minimum TDS set point)
- Measure the TDS with a meter in the critical rinse tanks. Knowing the existing flow rate also helps.

Immersion vs. Spray Rinsing

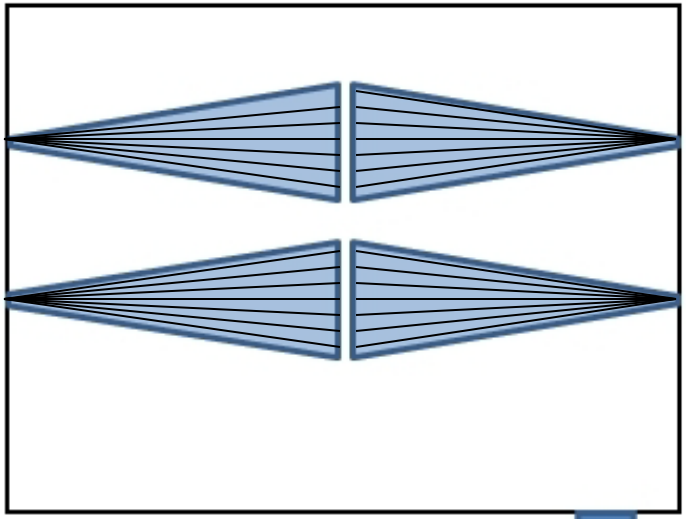
3 gpm continuous



100 gallon tank
turnover rate is 33 minutes

3 gpm continuous

8 spray nozzles, each running 0.75 gpm
total water use per minute is 6 gpm
rinse for 2 minutes every 10 minutes



averaged flow, 1.2 gpm

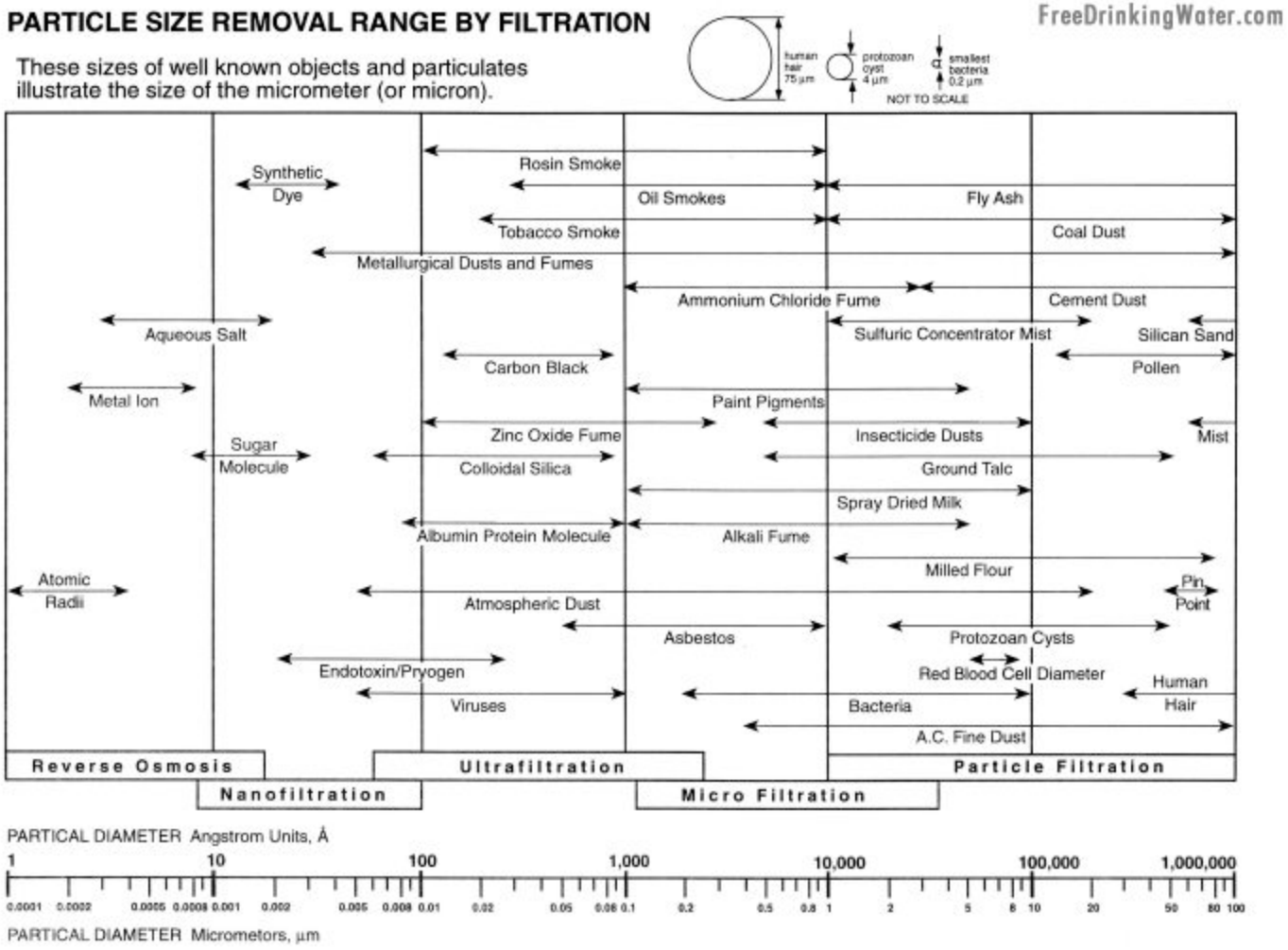
Other options for spray rinsing

- If part geometry is difficult to rinse with fixed spray, if the line is a manual line then the operator can use a manual spray rinse to reach the hard-to-rinse areas of the parts
- If the chemistry is difficult to rinse with cold water, set up an in-line heater for the spray water supply or have a pre-heated supply tank

Available Water for Reuse

- Rinse water
  - Primary rinse water (high in TDS, variable pH)
  - Secondary rinse water (low in TDS, variable pH)
- Treated waste water
  - Very low in dissolved metals
  - Very high in TDS from neutralization and treatment
  - Consistent pH, typically slightly alkaline from metal precipitation process
  - Typically room temperature
  - May have some other residuals such as oils, soaps, or emulsifiers

Water Recovery Technologies



Source: http://www.freedrinkingwater.com/water-education/quality-water-filtration-method.htm

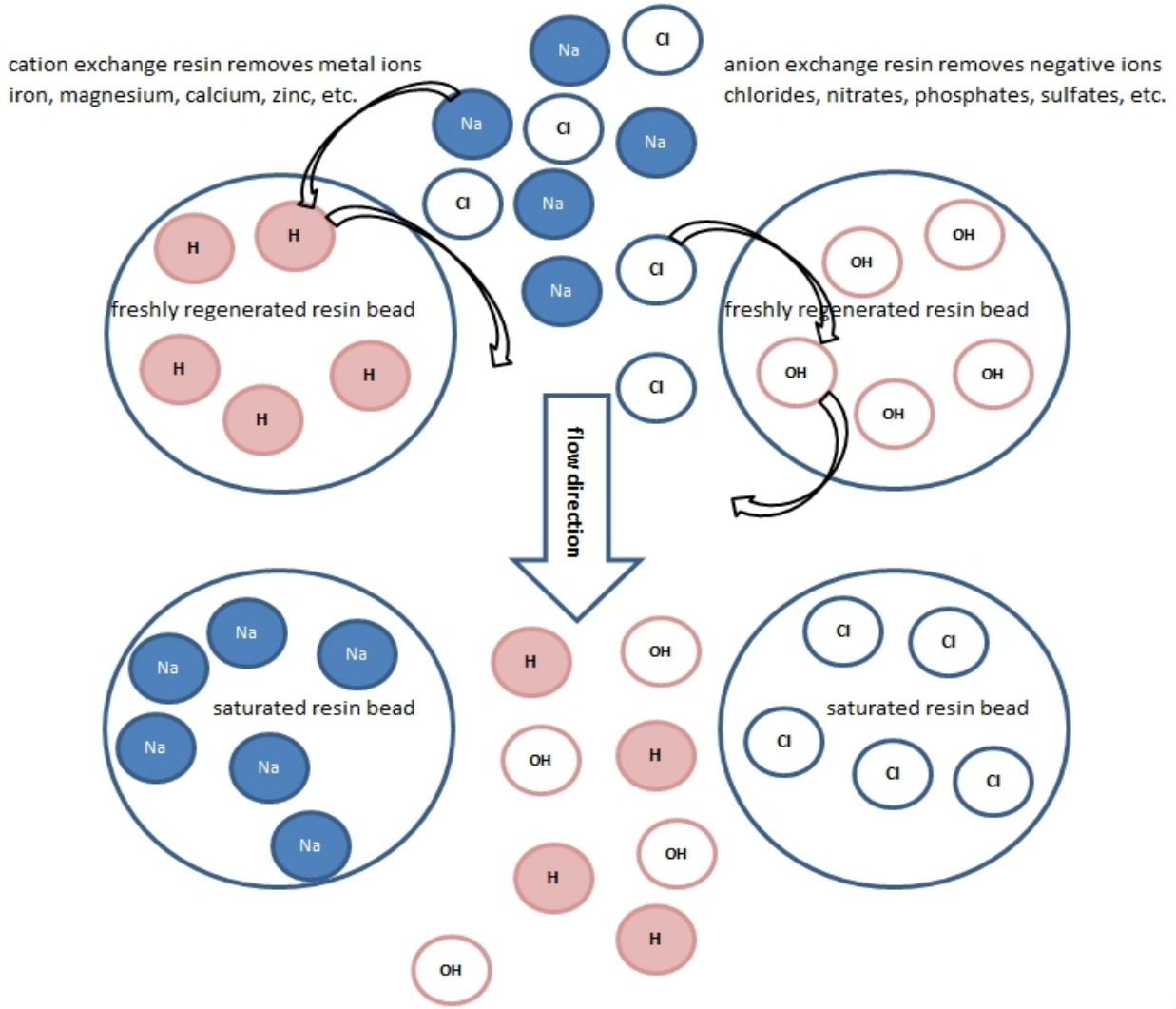
Rinse Water Requirements

- For reuse as rinse water, water needs to be:
  - low in TDS
  - near neutral in pH to avoid possible contamination of the chemical tanks by rinse dragout
  - Free of oils, soaps, etc.
  - RO/DI, if necessary

Methods of Removing TDS

- Mixed bed resin columns (ion exchange) to remove both cations and anions (will not remove dissolved organics such as sacharin)
- Reverse Osmosis to remove all solids and solubles except for small amounts of NaCl (0.5 to 3% of the initial concentration)

Resin Columns (ion exchange)



Advantages/disadvantages of Ion Exchange

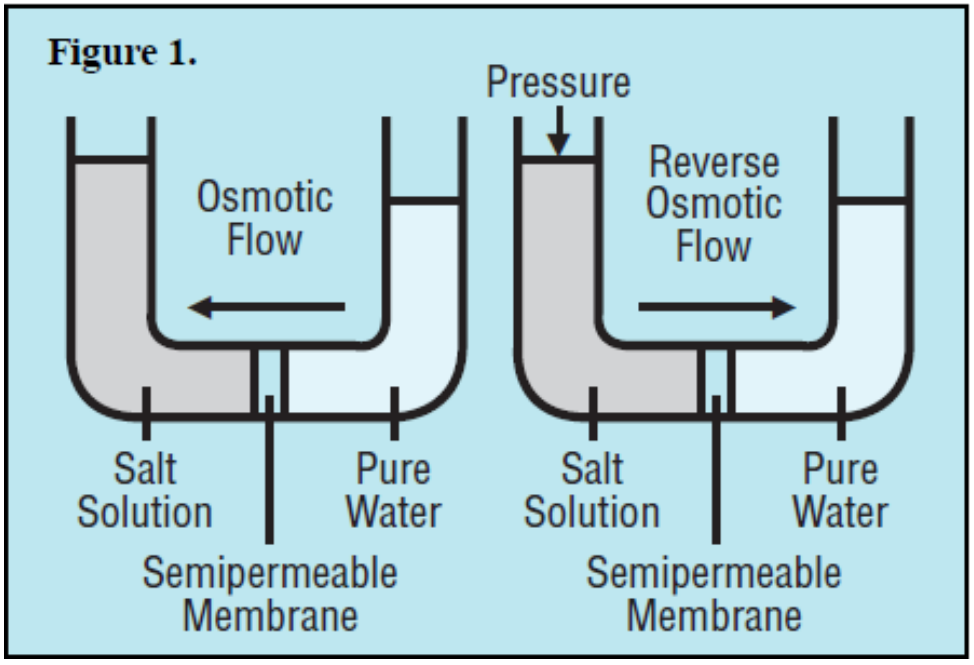
Advantages

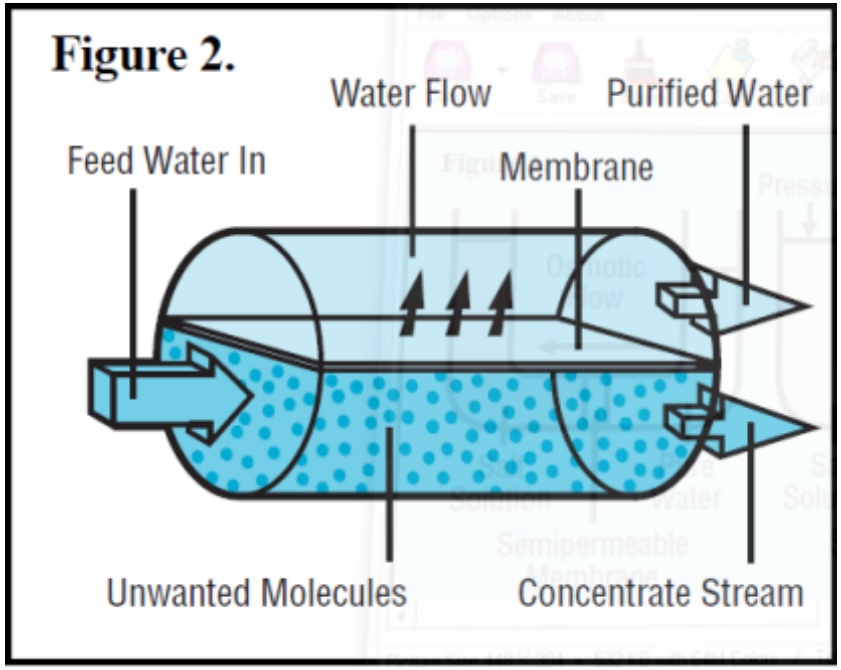
- Excellent ion removal
- Flow rate can be increased with a larger diameter column

Disadvantages

- Requires a carbon filter to remove organics
- Requires additional filtration to remove particulate and any resin bead particles
- Requires regular cylinder exchange or regular regeneration to maintain ion removal rate

Reverse Osmosis





Advantages/disadvantages of RO

Advantages:

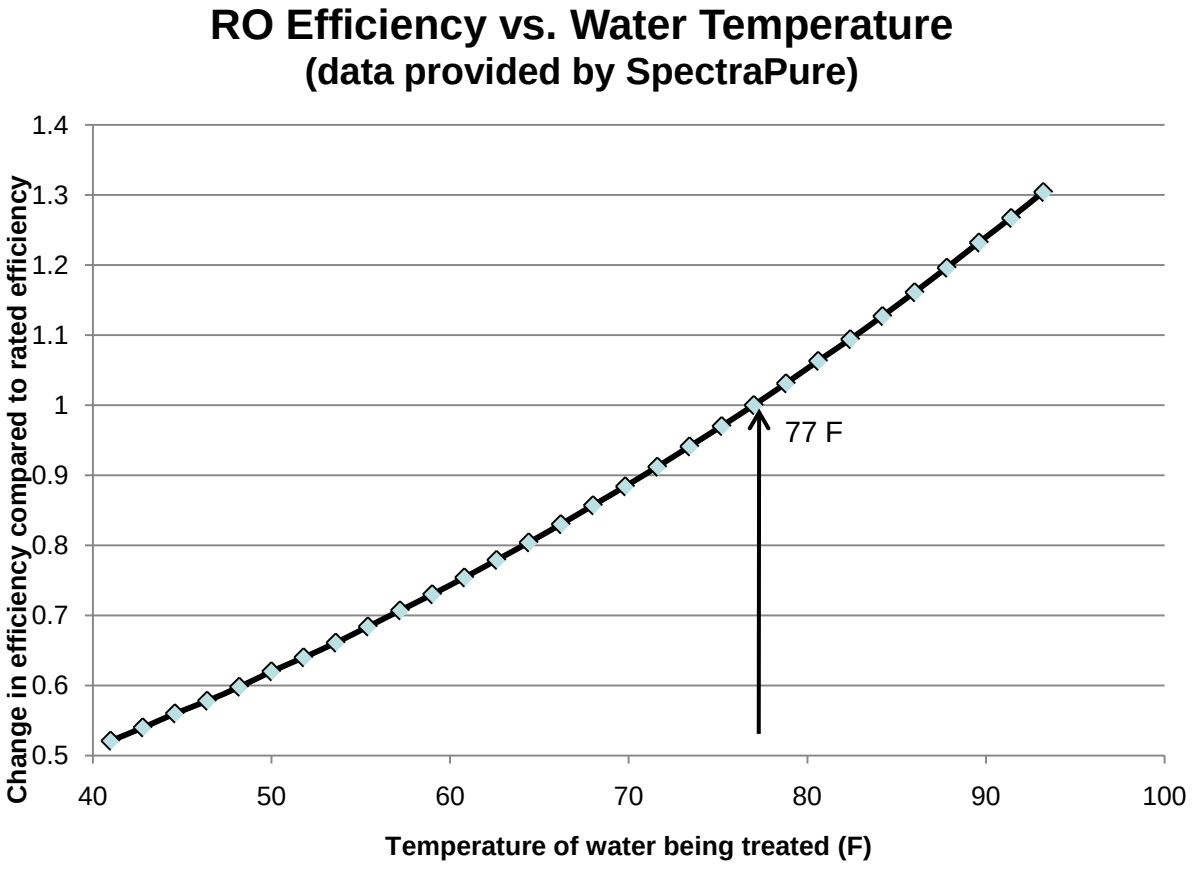
- Removes everything: ions*, bacteria, viruses, solids
- Relatively simple, low maintenance system

Disadvantages:

- Low temperature water produces lower pure water yields
- Higher TDS water produces lower pure water yields
- *Tend to leak small amounts of single charge ions (Na^+, K^+)
- Membrane can foul rapidly if suspended solids are high (may require pre-filtration with ultrafilter)
- Current technologies allow up to about 75% fresh water yields (typical yields ~50%)

RO-Temperature Relationship

- Higher water temperatures, over 77º F but no higher than 100F, will have water recovery yields greater than the rated yields.



Different RO Membrane Types

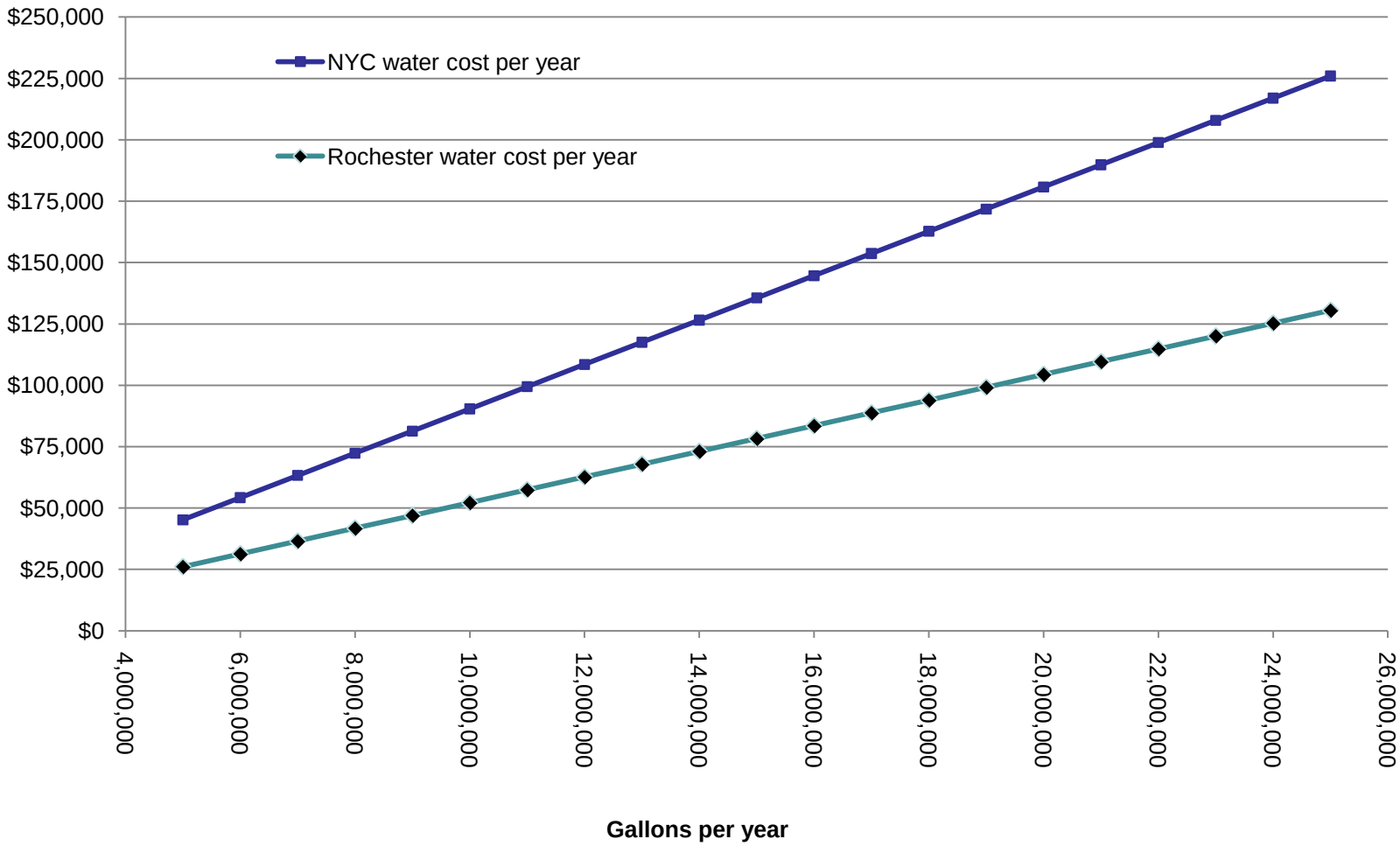
Cellulose Acetate	Low cost	Medium water flow	pH range 4-8	Max. temp. 95 F	Oxidation resistant
Composite (thin film composite, TFC)	High cost	High water flow	pH range 2-11,	Max. temp. 113 F	Vulnerable to oxidizers (chlorine)
Aromatic Polyamide	Medium cost	Low water flow	pH range 4-11	Max. temp, 95 F	Oxidation resistant

In short, no perfect membrane material

Water Cost vs. RO Equipment Cost

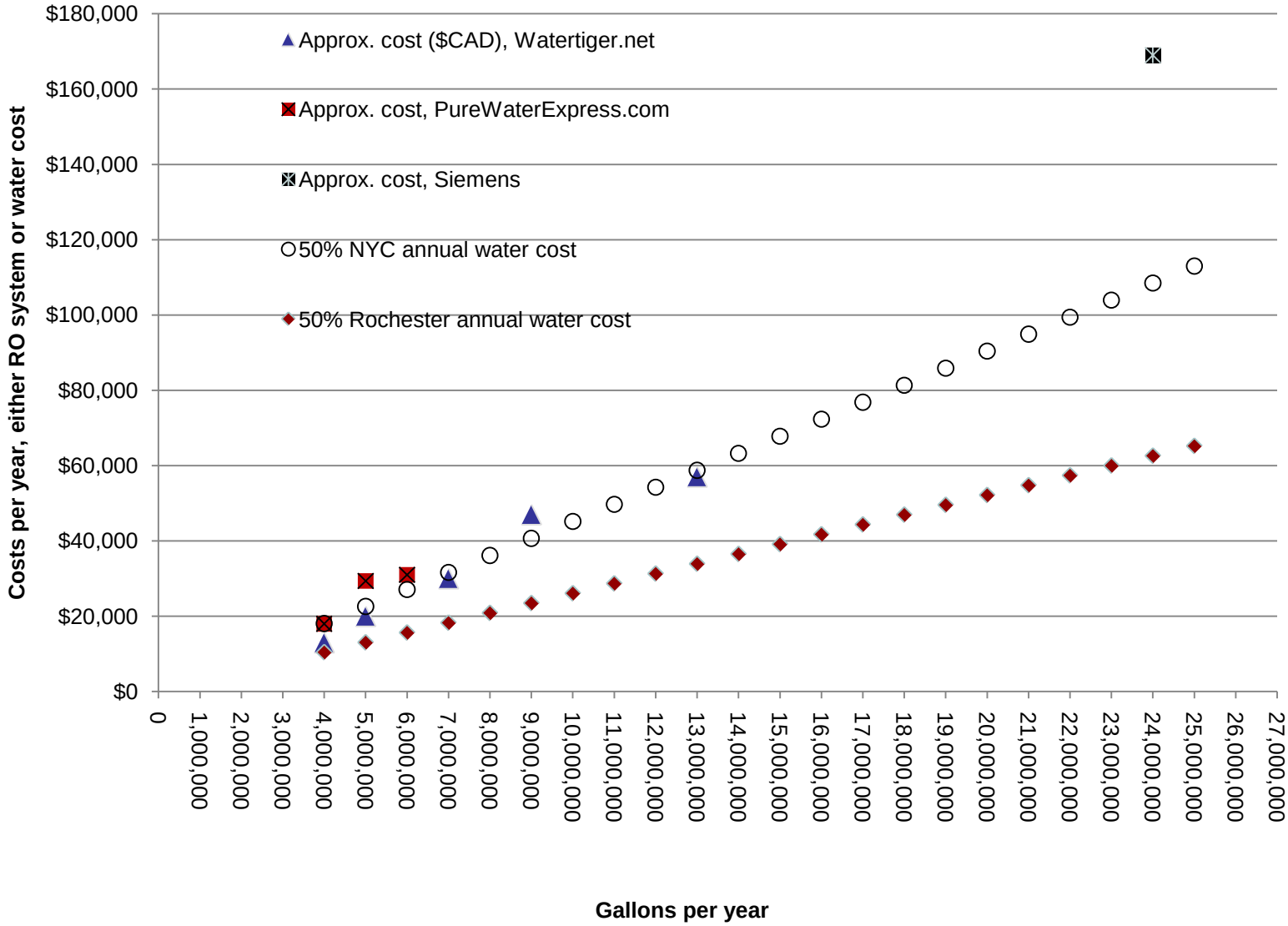
- Some cost comparisons from on-line prices (Watertiger, PureWaterExpress, Siemens)
- Rochester city water charges $5.22/1000 gallons ($2.67 water bill, $2.55 water treatment tax)
- New York City, $9.04/1000 gallons with sewer charges included

Water Cost Curves



Water Recovery Cost

- For an 8 hour operation, pure water storage and waste water storage is needed to obtain the best use of RO equipment (16 hours of off-shift filtration available).
- An RO system should be sized for less than the lows of daily water use.
- Be sure that the concentrate from the RO is still below the metals concentration limit for disposal.


$180,000
$160,000
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
Costs per year, either RO system or water cost
Approx. cost ($CAD), Watertiger.net
Approx. cost, PureWaterExpress.com
Approx. cost, Siemens
50% NYC annual water cost
50% Rochester annual water cost
0
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26,000,000
27,000,000
Gallons per year

Payback Considerations

- At the right place, both DI and RO systems can help recover water for either rinsing or makeup water.
- As water prices continue to rise, the payback for these systems gets better.
- In the previous RO example, NYC costs make an RO system pay for itself in approximately one year.

Questions/Discussion