WUE Optimization

Summary:

Recently two data centers saw opportunity to cut cost by using Your Water Dr.:

Data Center 1

a. The cycles limiting factor was not clearly identified – It was magnesium silicate and pH
b. Resulting in less than optimal operation
    i. Site was running 2 cycles of concentration
        1. The stated target was 2.5 cycles
            a. 35 million gallons of water and sewer wasted
            b. $683,000 per year wasted
        2. The technical limit without pH control was 3 cycles
            a. 52 million gallons of water and sewer wasted
            b. $1,020,000 per year wasted
        3. The technical limit with pH control was 7 cycles
            a. 86 million gallons of water and sewer wasted
            b. $1,700,000 per year wasted

	Concentrations or Cycles - Data Center 1					
	1 or Make Up Water	1.5	2	2.5	3	7
Conductivity	500	750	1000	1250	1500	3500
Ca	4	6	8	10	12	28
Si	20	30	40	50	60	140
Fe	0.1	0.15	0.2	0.25	0.3	0.7
As a % of Make Up	Bleed Rate	67%	50%	40%	33%	14%
	GPY Bleed	207,436,800	103,718,400	69,145,600	51,859,200	17,286,400
	Bleed Cost	$ 1,627,880	$ 813,940	$ 542,627	$ 406,970	$ 135,657
	GPY Make Up	311,155,200	207,436,800	172,864,000	155,577,600	121,004,800
	Make Up Cost	$ 3,702,248	$ 2,468,165	$ 2,056,804	$ 1,851,124	$ 1,439,763
	Total Water Cost	$ 5,330,127	$ 3,282,105	$ 2,599,431	$ 2,258,094	$ 1,575,420
	Tns Cooling	8000	Savings	$ 682,674	$ 1,024,011	$ 1,706,685

2. Annual changes in make-up water were not considered
    a. Resulting in less than optimal operation
        i. Excess cost

Your Water Dr. is in the process of correcting the inefficiencies

Data Center 2

a. The cycles limiting factor was not clearly identified – It was bicarbonate

b. Resulting in less than optimal operation

   i. Site was running 4 cycles of concentration

      1. The stated target was 6 cycles of concentration

         a. 8.6 million gallons of water and sewer wasted

         b. $66,000 per year wasted

      2. The technical limit with out pH control was 7 cycles

         a. 11 million gallons of water and sewer wasted

         b. $83,000 per year wasted

      3. The technical limit with pH control was 9 cycles

         a. The site had pH control

         b. 14 million gallons of water and sewer wasted

         c. $104,000 per year wasted

	Concentrations or Cycles - Data Center 2						
	1 or Make Up Water	1.5	2	4	6	7	9
Conductivity	500	750	1000	2000	3000	3500	4500
Ca	4	6	8	16	24	28	36
Si	20	30	40	80	120	140	180
Fe	0.1	0.15	0.2	0.4	0.6	0.7	0.9
As a % of Make Up	Bleed Rate	67%	50%	25%	17%	14%	11%
	GPY Bleed	129,648,000	64,824,000	21,608,000	12,964,800	10,804,000	8,103,000
	Bleed Cost	$ 746,772	$ 373,386	$ 124,462	$ 74,677	$ 62,231	$ 46,673
	GPY Make Up	194,472,000	129,648,000	86,432,000	77,788,800	75,628,000	72,927,000
	Make Up Cost	$ 374,553	$ 249,702	$ 166,468	$ 149,821	$ 145,660	$ 140,457
	Total Water Cost	$ 1,121,326	$ 623,088	$ 290,930	$ 224,498	$ 207,891	$ 187,131
	Tns Cooling	5000		Savings	$ 66,432	$ 83,040	$ 103,799

2. Annual changes in make-up water were not considered

   a. Resulting in less than optimal operation

      i. Excess cost

Your Water Dr. identified and eliminated these inefficiencies

Background:

<u>The primary function of a cooling tower</u> is to reject heat through:

1. Evaporative Heat Transfer (Latent Heat) – Highest in Summer
    a. 12,000 BTU / ton of cooling
    b. 970 BTU / lb water evaporated
    c. 1.48 gallons of water evaporated per hour per ton
        i. This is the primary mechanism in most cooling towers.
        ii. Warm water from the system is sprayed or distributed over the cooling tower fill material, increasing its surface area.
        iii. Air flows over the water, and a portion of the water evaporates, absorbing latent heat from the remaining water, cooling it in the process.
        iv. The heat from the system is carried away with the water vapor into the atmosphere.

2. Sensible Heat Transfer – Can be significant in winter
    a. Heat is transferred directly from the water to the surrounding air through conduction and convection.
    b. The air absorbs heat from the warmer water without a phase change (no evaporation), raising the air temperature.

3. Radiative Heat Transfer (Minor Contribution)
    a. A small amount of heat is radiated from the warm water to the surroundings. This is generally negligible compared to evaporative and sensible heat transfer.

4. Drift Loss (Unintentional)
    a. Small droplets of water are carried away with the airflow, inadvertently removing heat.

5. Blowdown
    a. A small amount of warm water is removed from the system and replaced with cooler makeup water.

<u>In the process of evaporating water</u>, only pure water evaporates. Dissolved and suspended solids remain behind and concentrate up. This concretion effect is known as cycles

Cycles

With no chemical treatment there is a limit as to how much cooling tower water can be concentrated until scale develops. Typically, this is roughly 2 concentrations.

With chemical treatment there is a higher limit as to how much cooling tower water can be concentrated until scale develops. Typically, this is roughly 6 concentrations.

With chemical treatment and pH control the highest limit is possible as to how much cooling tower water can be concentrated until scale develops. Typically, this is roughly 10 concentrations.

One of the following will be the cycle limiting factor, meaning it will generate scale at a given level.

Saturation Ratio	
Calcite	$CaCO_3$
Aragonite	$CaCO_3$
Witherite	$BaCO_3$
Strontianite	$SrCO_3$
Calcium oxalate	CaC_2O_4
Anhydrite	$CaSO_4$
Gypsum	$CaSO_4*2H_2O$
Barite	$BaSO_4$
Celestite	$SrSO_4$
Calcium PO4	$Ca_3(PO_4)_2$
Hydroxyapatite	$Ca_5(PO_4)_3(OH)$
Calcium pyrophosphate	$Ca_2P_2O_7$
Fluorite	CaF_2
Silica	SiO_2
Brucite	$Mg(OH)_2$
Magnesium silicate	$MgSiO_3$
Ferric hydroxide	$Fe(OH)_3$
Siderite	$FeCO_3$
Strengite	$FePO_4$
Zinc hydroxide	$Zn(OH)_2$
Zinc carbonate	$ZnCO_3$
Zinc phosphate	$Zn_3(PO_4)_2$
Zinc pyrophosphate	ZnP_2O_5

Make Up Water

Make up water is provided by

A. City
    i. Potable water - Variable
    ii. Reuse water - Variable
B. Process reclaimed water - Variable
C. On site well water – Consistent

Variable means the constituents of the make up water change over time. Typically, this change forms a predictable pattern of change on an annual basis. For example, winter make-up water can vary significantly from summer make-up water. Or every year there may be a maintenance cycle where water is different for a period of time.

Ions that change can include any of the above

A. Cations - Most importantly Ca, Mg, or Si
B. Anions – Most importantly CO3, SO4, PO4
C. pH

Discussion:

Priorities can be misaligned between the site and the water treatment vendor.
Reducing water helps end users

A. Less water
B. Less sewer
C. Less chemical
D. Lower program costs

Concentrations or Cycles - Data Center 2					
	1 or Make Up Water	3	5	7	9
Conductivity	500	1500	2500	3500	4500
Ca	4	12	20	28	36
Si	20	60	100	140	180
Fe	0.1	0.3	0.5	0.7	0.9
As a % of Make Up	Bleed Rate	33%	20%	14%	11%
	GPY Bleed	32,412,000	16,206,000	10,804,000	8,103,000
	Pounds of Chemical Per Year 100 ppm Chemical Dose	9,011	2,973	1,480	901
	Holding Time (hours)	135	270	405	541
	Tns Cooling	5,000		**System Volume**	500,000

Increasing WUE (reducing water use) may hurt water treatment company's bottom line as

A. Less chemical may be needed
   i. This is especially true if pH control is used.
   ii. Increasing cycles decreases blowdown thus DECREASING the amount of biocide needed as the product stays in the system longer
B. Testing must be more accurate and robust
   i. Detection of changes in make-up water is essential
C. Interpretation of test results must be done regularly - weekly
D. System control must be tighter
   i. Cycles must be based on incoming water not a set conductivity number
   ii. Calibration and replacement of probes becomes far more important
      i. More work for the water treatment vendor
   iii. Chemical dosage must be based on tower water conditions NOT tracing agents

Conclusion:

It is possible to save significant amounts of money and protect the cooling system from scale, corrosion and microbiological attack. Doing so requires more attention and effort on the part of the water treatment company in the face of shrinking revenue which is a contributing factor to why they may be content to operate systems in less than optimized control ranges (from a WUE perspective).