This presentation premiered at WaterSmart Innovations

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SNWA's Cooling Tower Conservation Efforts

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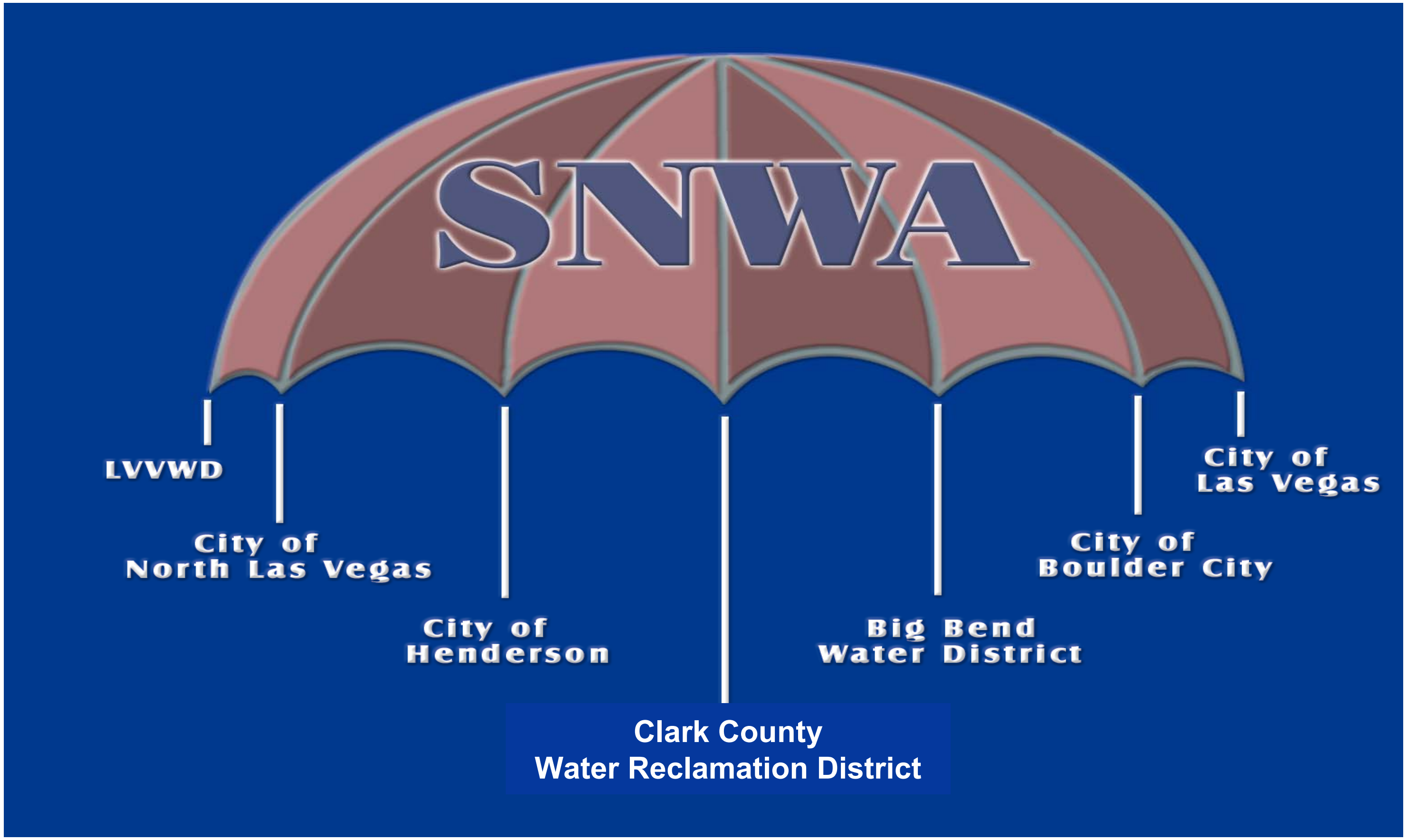
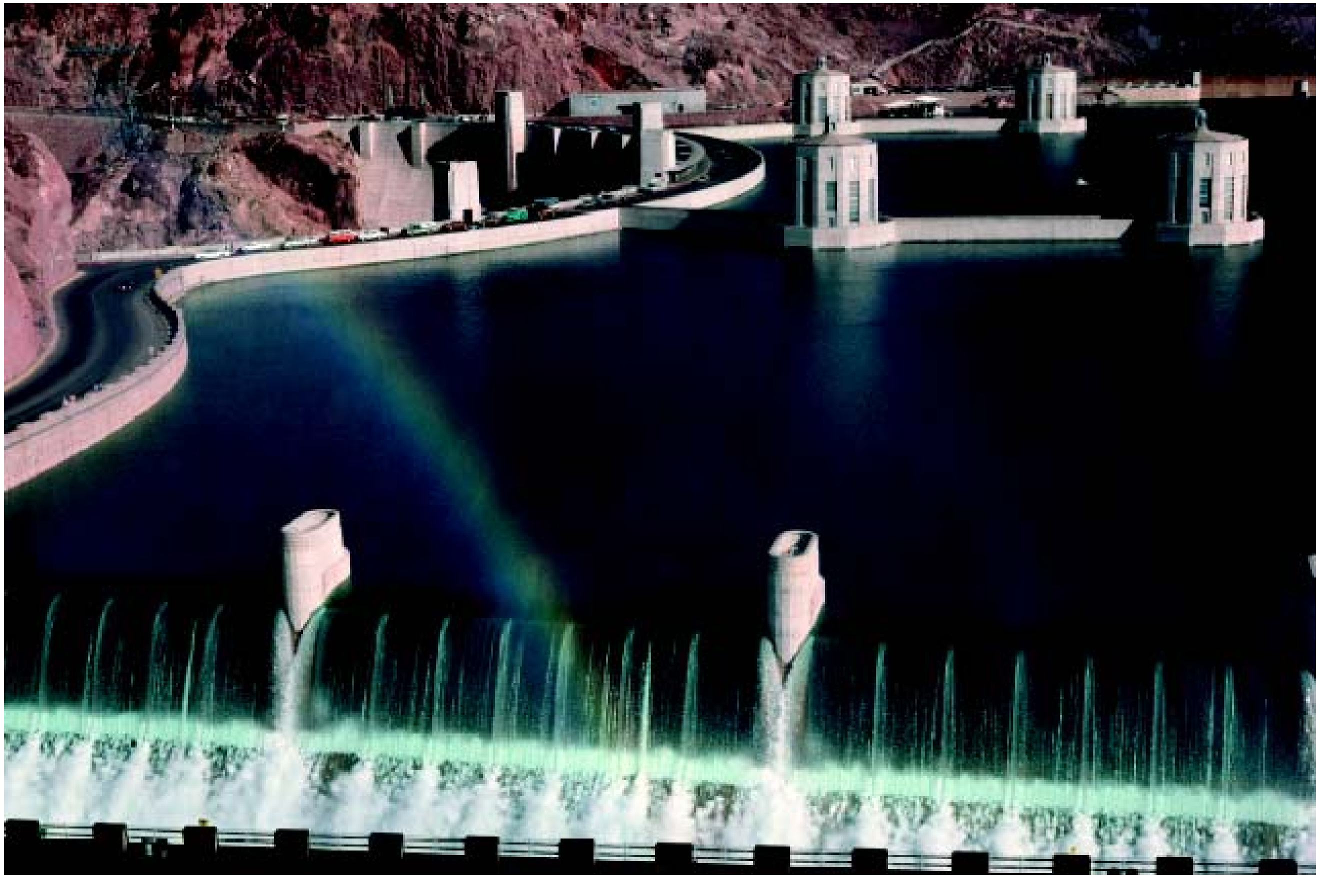
Who are we?



SNWA addresses all aspects of Water Resources on a Regional Basis in S. NV

The Past



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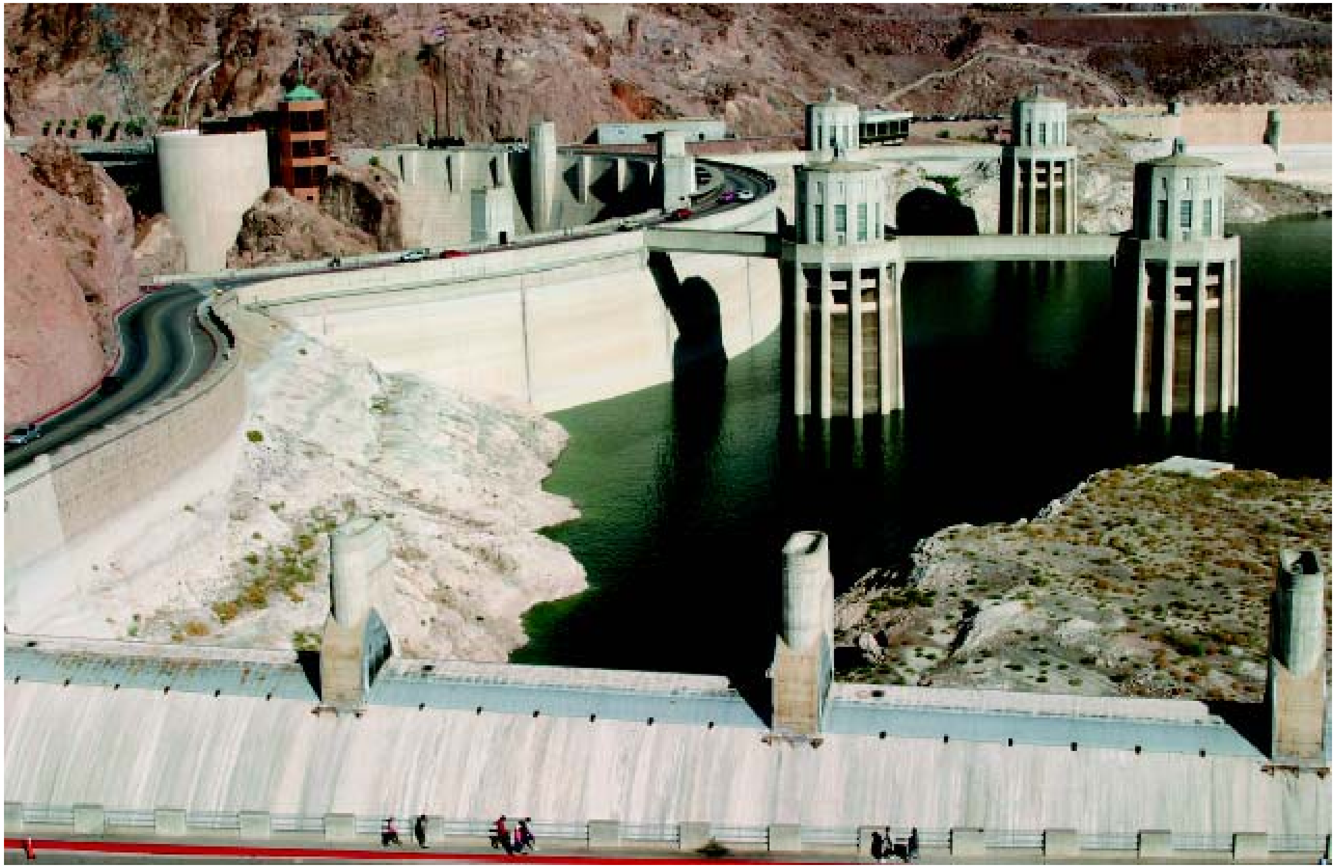
The Present



it's even lower now!

And remember this is our primary supply!

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Water Efficient Technologies Program -- W.E.T.

The SNWA provides
incentives for customers
to find their *own* creative solutions
to conserve water.

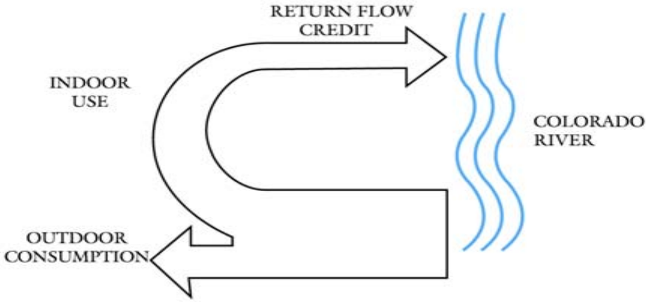
New & Improved W.E.T. Program

- Program is designed to encourage capital improvements that can result in saving **at least 250,000 gallons per year**
- Maximum 50% of product cost. No maximum per property!
- Two Program Tracks:
  - Menu Item – Select from a list of pre-approved technologies with assigned incentive values
  - Performance-based – For custom conservation solutions (rebate contingent on performance)

The New and *Shocking* incentive levels . . .

W.E.T. incentive levels

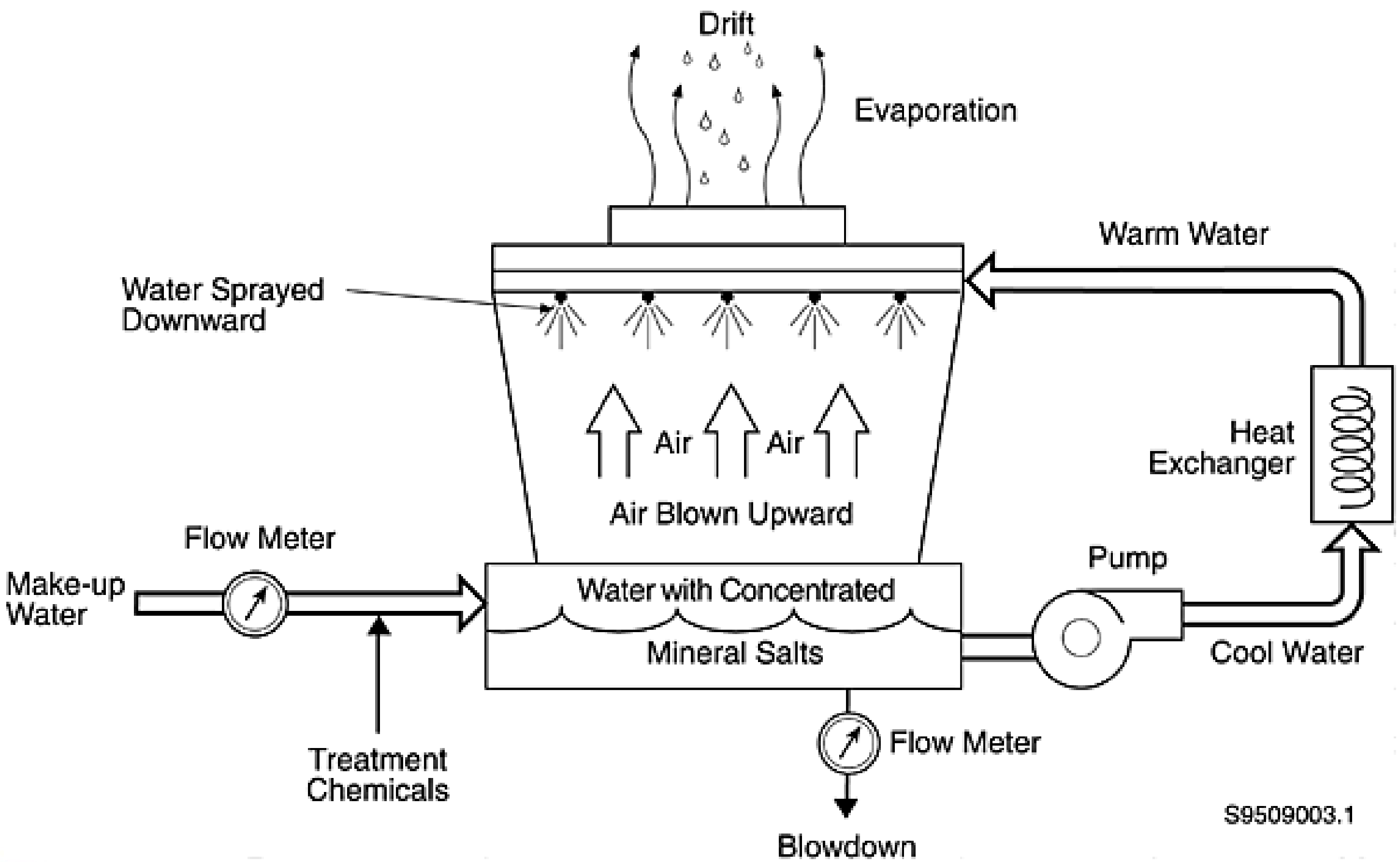
- Up to $8.00 per 1,000 gallons conserved annually for non-consumptive water saving technologies (most *indoor*) i.e. Concentration Ratio improvements
- Up to $25 per 1,000 gallons conserved annually for consumptive water saving technologies (most *outdoor*) i.e. Drift Reduction and Fill Changes



Cooling Towers Program - Status

- To date we have developed relationships with more than 40 facilities.
- Average facility has 2630 tons of cooling capacity (range is 125 up to over 10,000 tons).
- Have collected data for over 100,000 tons total.

Cooling Tower Operation



Make-up Water Required Ŧ

Make-up = Evaporation+(Bleed-off+Drift)

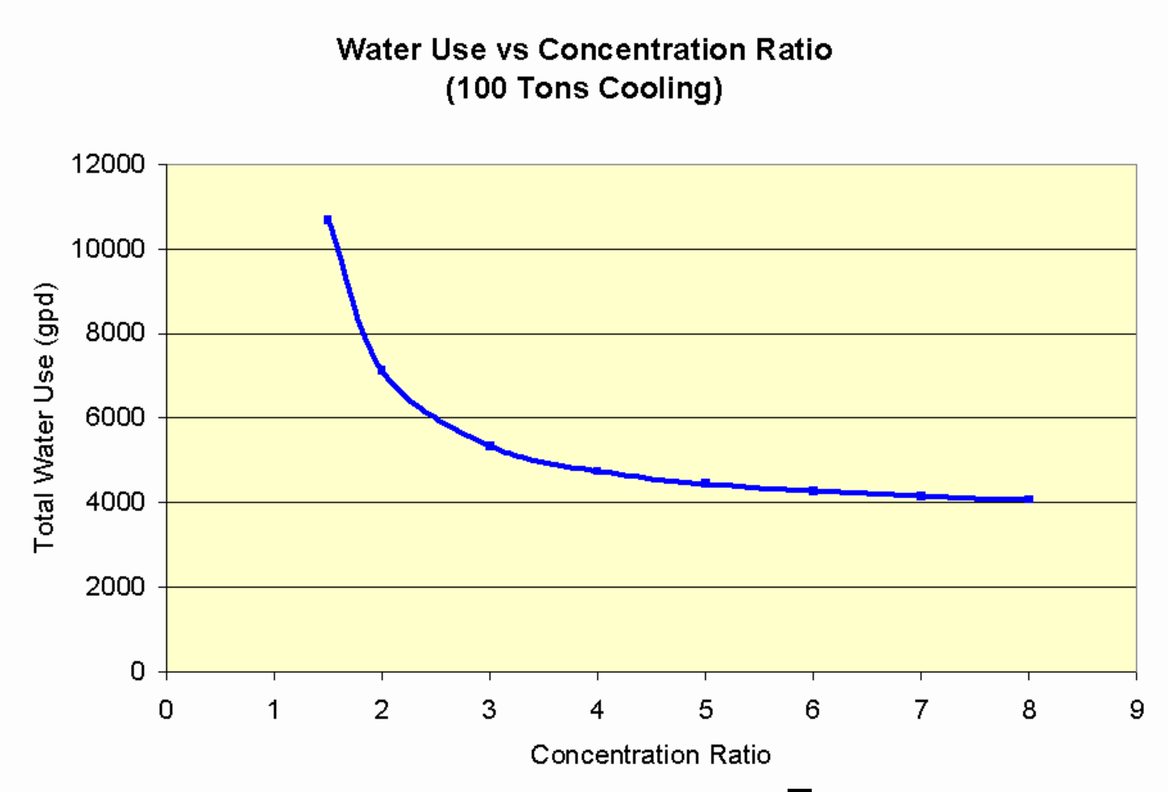
Concentration Ratio {CR} = Make-up/(Bleed + Drift)

Ŧ (Kobrick & Wilson: Conserve 1993)
& Sandia Labs 2002

Cycles and Relationship to Water Usage Ŧ

CR=dissolved solids in bleed-off water / dis. solids in makeup water

% Conservation = [(CR2-CR1)/(CR1 X CR2-1)] X 100



Initial Balanced State CR = 1.82 @ Previous EquationsŦ by: Aquacraft 2003 for CalFed § based upon Manufacturers (EVAPCO) Recommended Bleed of 3 GpM / 100 Tons

Ŧ (Kobrick & Wilson: Conserve 1993) & Sandia Labs 2002

Cooling Tower Calculations Θ

Cooling Tower Basics - per: Sandia Labs, June 2002					
Per 1000 tons of Capacity @ 2.5 Cycles					
Hot H2O In:			3000	gpm	
Evaporation:		1.00%	30	gpm	
Drift:		0.05%	1.5	gpm	
Blow Down:		0.80%	24	gpm	
Make-Up:		1.85%	55.5	gpm	
Cooled H2O Out:			3000	gpm	
MakeUp=	Evaporation +	Drift +	Blowdown	=	1.85%
	1.00%	0.05%	0.80%		

Concentration Ratio (CR) or Cycles of Concentration
CR = Make-Up/Blow Down

Blow Down = (Evap. + Drift) / (CR-1)

% Blow Down or Chemicals CONSERVED = (CR2 - CR1)/(CR2 - 1)

Make-Up = (lbs. Chemical used X 10to6th)CR/
(ppm dose rate X chemical density{in lbs. Per gallon})

300 gpm of tower water circulating **per 100 tons** of cooling

2.5 to 3.0 gpm of **Evaporation per 100 tons** cooling
{use **3.0 gpm** / **100 tons for Southern Nevada** area}

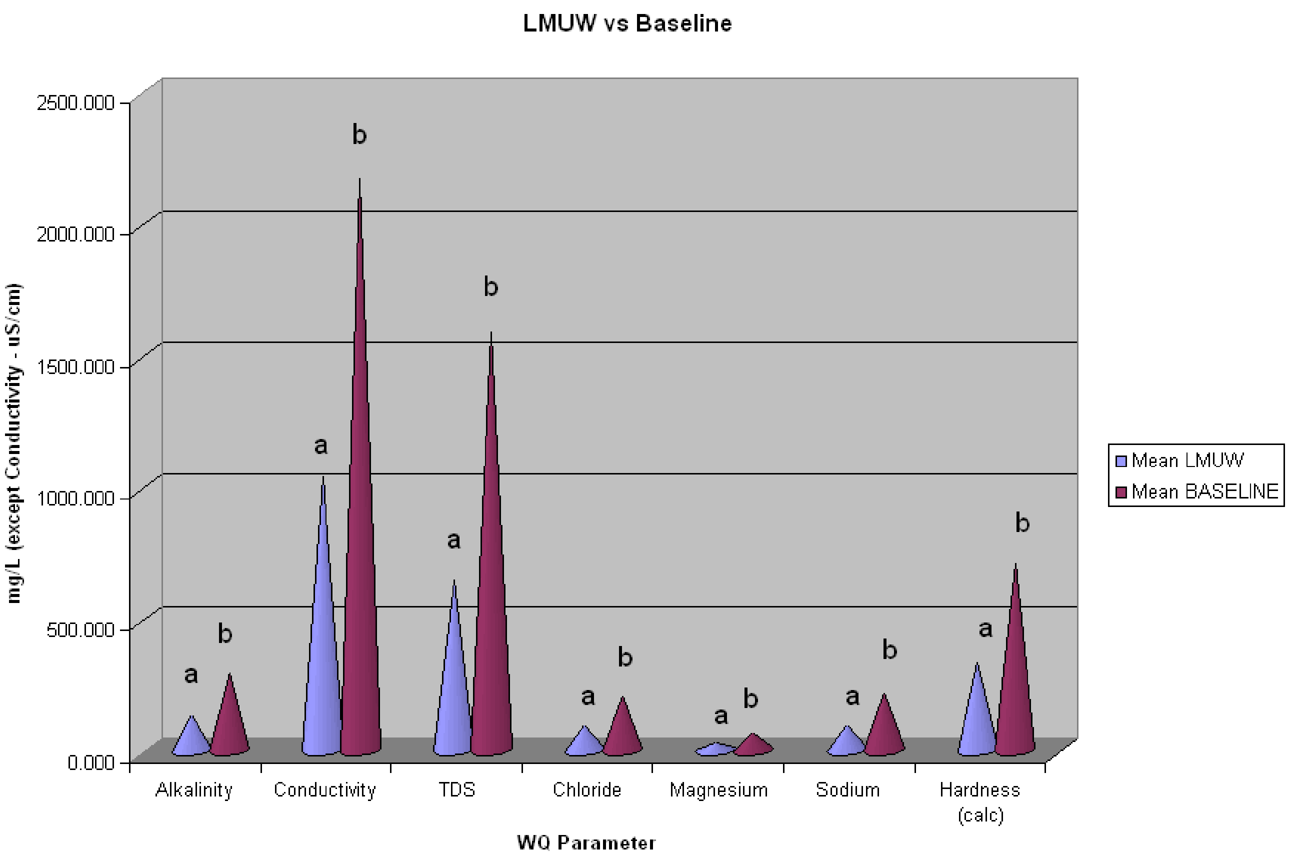
Blow Down WATER CONSERVATION for CR Changes:				
Tons of Capacity		1000		
	/	1000		
			1.00	
		(Evaporation + Drift = 31.5 gpm) / 1000 Tons of Capacity		
1	X	31.5		
		(Evap. + Drift)	31.5	gpm
31.5	/			
CR1 (Original)		2.00	-1	
	=		31.50	gpm
			(Evap. + Drift) / (CR1-1) = BD #1	
31.5	/			
CR2 (Proposed)		3.25	-1	
	=		14.00	gpm
			(Evap. + Drift) / (CR2-1) = BD #2	
Water Savings:	{BD #1 - BD #2}		**17.50**	**gpm**
			1,050.00	gph
			25,200.00	gpd
			176,400.00	gpw
	IF: 24 X 365		**9,198,000.00**	**gpy**
SAVINGS factored by Operation:			(66% Duty Cycle)	
gph X	hr/day X	days/yr		
1,050.00	24	240	6,048,000.00	gpy
1,050.00	*24*	*49*	*1,234,800.00*	
1,050.00	*22*	*86*	*1,986,600.00*	
1,050.00	*18*	*98*	*1,852,200.00*	
1,050.00	*12*	*83*	*1,045,800.00*	
1,050.00	*6*	*49*	*308,700.00*	
WEATHER Temp Curve CYCLE (72%			***6,428,100.00***	***gpy***

Θ As adapted from Sandia 2002;
See also NM State Engineers Water Conservation Guide for CII Users 1999

Avg. Makeup (SNWA) Water

WQ Parameter	Valid N	**Mean**	**Unit**	Minimum	Maximum	Std.Dev.	Standard Error
Alkalinity	38	**137.6**	**mg/L**	127.0	165.0	9.3	1.5
Conductivity	38	**1042.0**	**µS/cm**	734.0	1340.0	101.4	16.5
pH	38	**8.0**		7.7	8.1	0.1	0.0
Silica	36	**8.2**	**mg/L**	7.3	12.0	1.0	0.2
TDS	38	**648.5**	**mg/L**	434.0	858.0	69.2	11.2
Temperature Deg. C	38	**21.1**	°C	11.9	23.9	2.5	0.4
Chloride	37	**94.1**	**mg/L**	44.0	130.0	14.4	2.4
Sulfate	36	**254.5**	**mg/L**	101.0	350.0	42.4	7.1
Magnesium	38	**30.4**	**mg/L**	25.0	98.0	11.5	1.9
Potassium	38	**8.4**	**mg/L**	4.0	101.0	15.7	2.5
Sodium	38	**99.6**	**mg/L**	43.0	320.0	40.6	6.6
Hardness (calc)	38	**336.6**	**mg/L as $CaCO_3$**	260.0	1100.0	130.3	21.1

Avg. Facilities Baseline in LV



Different letters indicate that each series' mean values are statistically different ($p<0.05$) from each other for each WQ parameter

$CR_{avg} = 2.22$

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Typical Treatments for Maintenance Ψ

Table 1. Conditioning Chemicals

Conditioning Chemicals	Use	Application	Recommended Maximum Concentration
Organophosphates (phosphonates)	Control scaling	Continuous	20 mg/L as PO_4
Orthophosphates, polyphosphates	Inhibit corrosion and control scaling	Continuous	20 mg/L as PO_4
Sodium Silicate	Inhibit corrosion	Continuous	150 mg/L as SiO_2
Aromatic azoles	Inhibit corrosion	Continuous	1-4 mg/L
Molybdates[1]	Inhibit corrosion Tracer	Continuous	5-10 mg/L as molybdate
Non-oxidizing biocides such as • Isothiazolin • Dinitriopropionamide • Quaternary amines	Inhibit biological growth	Slug	N/A
Chlorine Bromine	Inhibit biological growth	Continuous or slug	0.5 mg/L 0.2 mg/L

Ψ (…CoolingTowerBMP: JEA 2005)

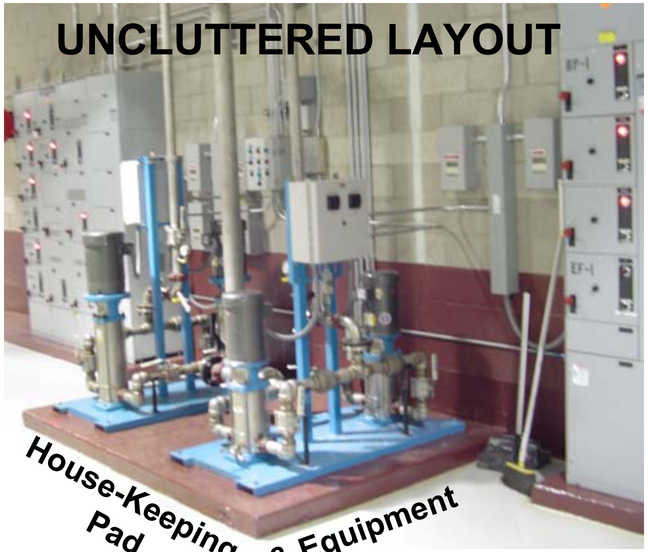
Typical Treatments for Maintenance

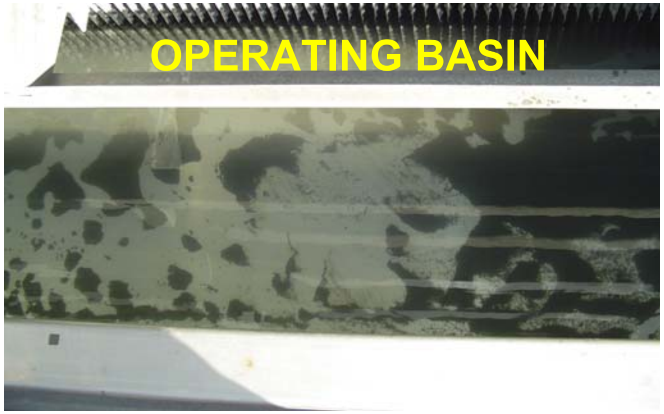
- **Additional MakeUp water treatment(s)**
  - **Chemical Conditioning**
  - **Acidification**
  - **Side Stream Filtration**

SNWA's Experiences

- The "Good"
  - All levels of management Accept Responsibility
- The "Bad"
  - Some levels of management fail…
- The "UGLY"
  - No One seemed to Value the Equipment!
    - » (Historically speaking)

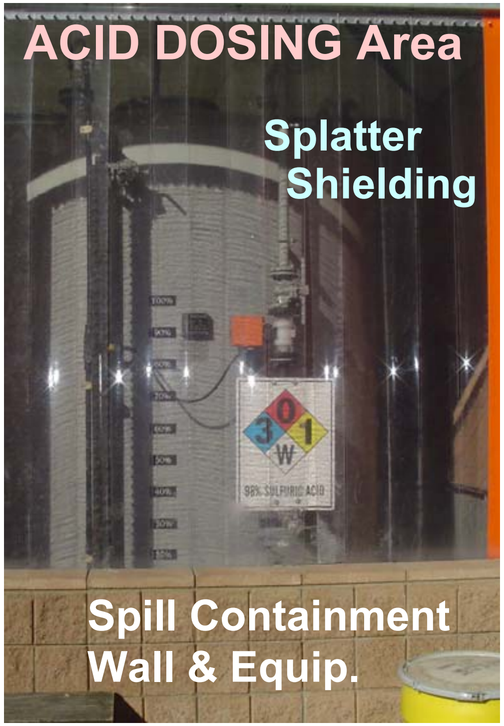
The "Good" FACILITY





The Basin Bottom is Visible:

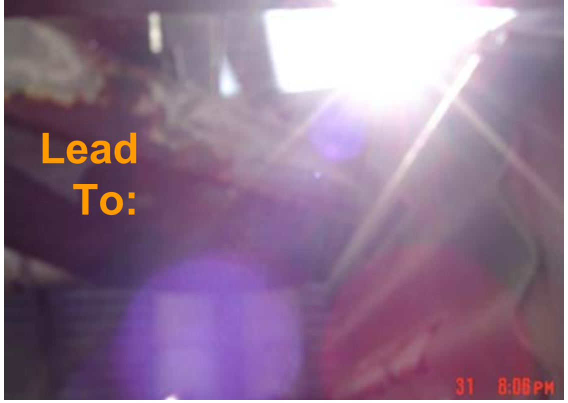
Through Water & Fine Sediments



The “Bad”

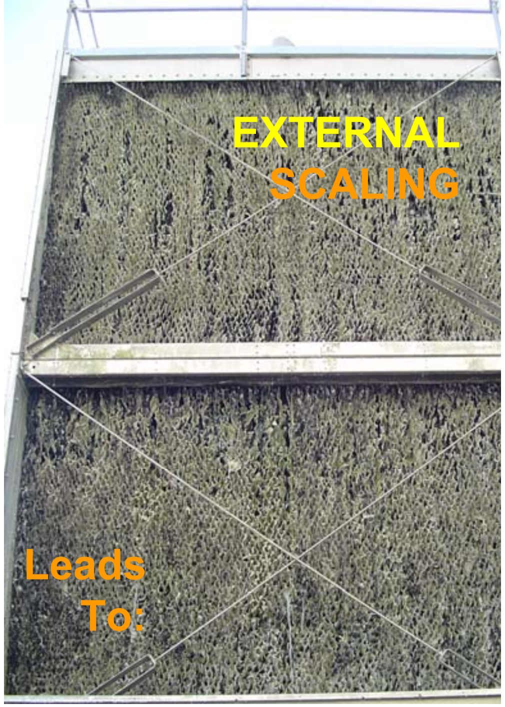

31 8:07PM


INTERNAL
LEAKS
DANGER
DANGER


Lead To:
31 8:06PM


DRIFT


Splash-Out


EXTERNAL SCALING
Leads To:

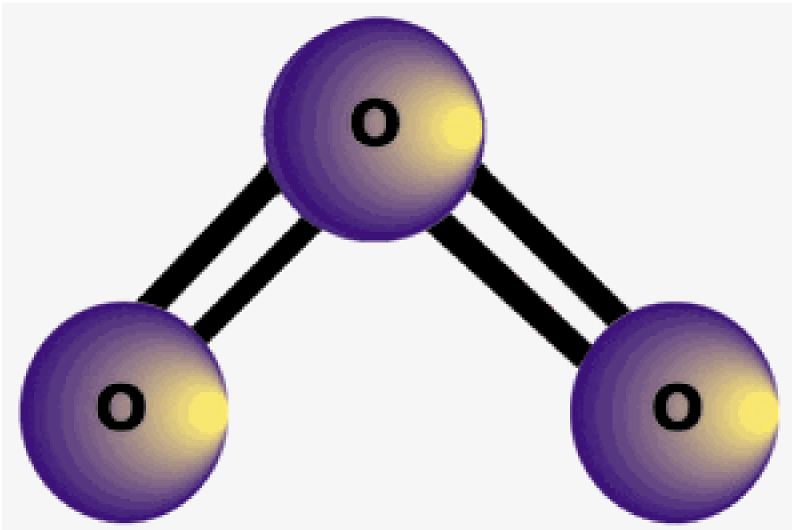
The 'UGLY' Tower…

Acid injection system

- Simple, established technology reengineered to almost continuously inject acid automatically to maintain an ideal pH to avoid both scaling and corrosion.
- Really just a highly developed extension of a typical treatment.
- Requires significant safety considerations and permitting.

Ozonation

Ozone (O_3)



Model of an Ozone Molecule.

- Commonly produced when an electical discharge spits O_2 and one of the remaining O atoms binds with another oxygen pair
- Unstable

  (half-life = 10 minutes)
- **Powerful biocide effects**

Ozonation

- Causes immediate rupture of bacterial cells (no opportunity for immunity development).
- This is fast! 1000s of times faster than Cl.
- Removes biofilm (slime) too (just 0.1 mg/L will remove 70-80% in 3 hrs.)
- **By removing biofilm, greatly reduce ability of scale to stick to surfaces and form deposits** (BUT DOES NOT

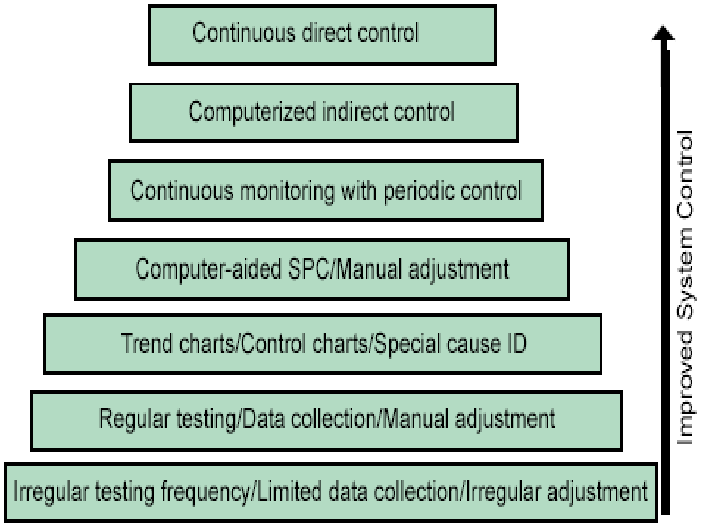
  IN-OF-ITSELF ELIMINATE SCALE DIRECTLY)

Caveats for Ozone Treatment

- Not for really hot water applications (>104°F basin H_2O).
- May or may not inhibit scale in any particular circumstance. Here in Southern Nevada probably does not eliminate use of chemicals for scale inhibition.
- ORP probe accuracy is crucial.
- Energy usage considerations.
- Corrosion considerations. Should use coupons.
- Not for high COD water

  (ex. may not be for petroleum processing facilities).
- Can produce negative discharge products.
- Must be located near tower and have multiple exit ports in basin.

SNWA's Experiences – Advanced Control Technologies



- Go beyond simple TDS or pH. Typically have multiple sensors.
- HVAC Controls integrated with Total Building Control.
- CO_2 Sensors to predicatively manage tower loads.
- Fluorescent marked dispersal polymer – may allow a tower to go right to the "edge". (Real-time monitoring of system strain)

Tagged Dispersal Polymers*

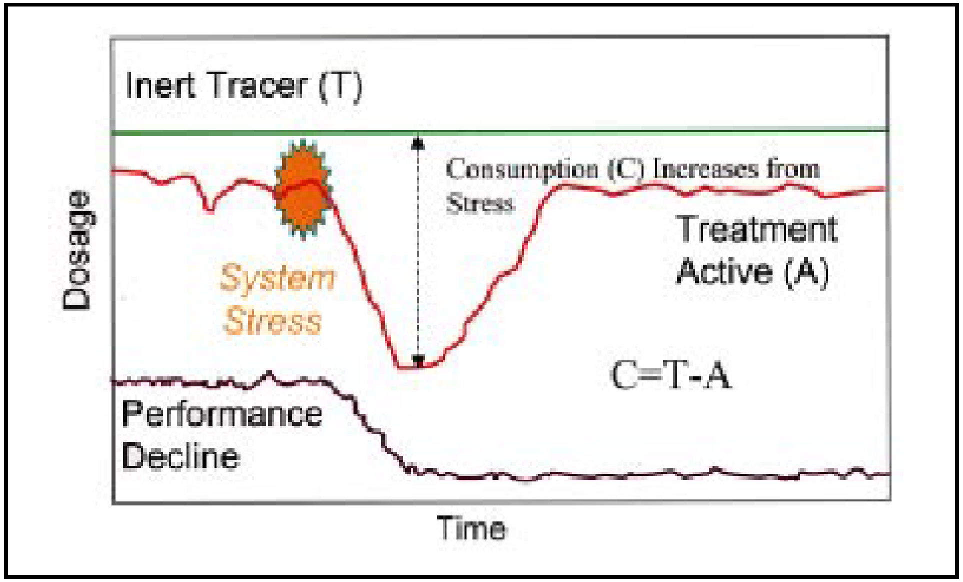
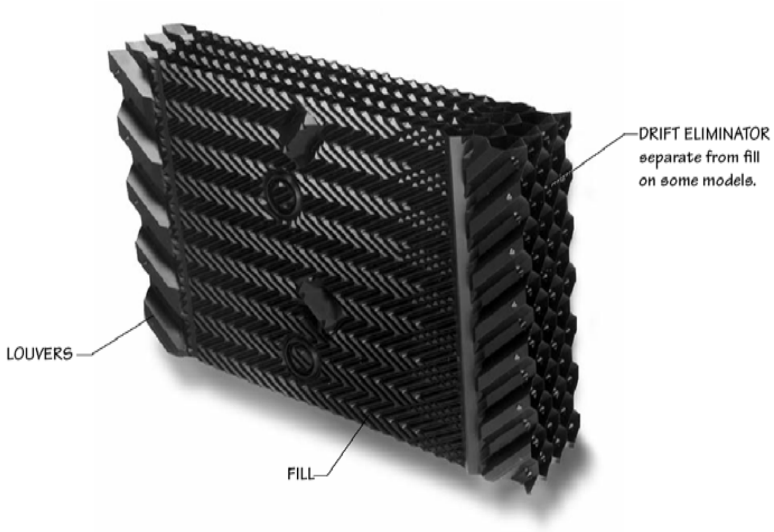


Figure 2 — ***Generalized representation depicting on-line measurement of actives consumption (resulting from high system stress). In this case, consumption precedes performance problems.***

* (Moriarty et al. 2001)

Drift Reduction

Drift Eliminator Section with Integrated Fill



- High-efficiency drift "elimination" technology.
- Unusual conservation initiative as most conservationists focus on reducing blow-down.
- But here in Southern Nevada it reduces our premium value consumptive use water.
- Drops drift losses to 0.005% of tower flow rate.

Drift Savings Calculations Θ

Water Efficient Technologies Cooling Tower Conservation																
DRIFT: Per 1000 Tons Cooling Capacity ##						(Assumed Recirculation for 1000 Tons Capacity is 3000 GPM of Recirculating Water)										
Initial:	0.200%	:	6.00	GPM												
						ESTIMATED SAVINGS:										
STD:	0.050%	:	1.500	GPM												
						1.350		GPM	X	60	Min				81.0	GpH
Projected:	0.005%	:	0.150	GPM					X		24	Hr			1,944.0	GpD
									X			365	Days		709,560.0	GPY
						709,560.000		**GPY**		**per**			**1000**	**Tons**		
Capacity:																
Xxxx	Tons		*Total Nominal Capacity @* **Y** Tower Sets													
Zzzz	Tons	/	Tower Set													
Xxxx	**Tons**	/	1000	Tons												
	X.xxx	*	709,560	GPY	=		#VALUE!									
Duty Factor / Average Plant Load (APL)						70%	.70 * #VALUE	GPY Savings								
NOTES: ##	"Drift Rates:"															
Initial:	Is a generic rate for cooling towers in fair to poor condition															
STD:	Rate is per; Sandia Labs, June 2002 - For towers in fair to good condition w/ pre 1995 to 2000 packing designs															
Projected:	Is for newer packing designs that incorporate drift elimination or for separate drift eliminators;and varies per project...															
	{{Customer / Vendor to furnish Technical Documentation / Specifications to support Projected Drift Rate}}															
	Duty Factor / Average Plant Load (APL) Varies by Installation and Design - If Manufacturers Data is Unavailable; use 70%															

Θ As adapted from Sandia 2002;
See also NM State Engineer's Water Conservation Guide for CII Users 1999

OR Go simple with Good, Independent Maintenance Service Ψ

Table 2. Recommended Minimum Monitoring Schedule

Daily	• Visually inspect the equipment to verify that it is working properly. • Check to see if chemical supply is adequate. • Investigate anything which appears unusual or which may indicate changing conditions. • Record the daily volumes of makeup and blow down water. Significant variations in the daily flow may be indicative of system malfunctions or changed conditions.
Weekly	Check pH and conductivity. Significant variation from normal may indicate malfunctions or changed conditions requiring further investigation and/or chemical feed rate adjustment.
Monthly	Have a system expert: • Inspect the system, checking for proper equipment functions and physical evidence of corrosion or fouling. • Perform chemical testing on cooling system water to check water quality and report results and recommendations. • Check conditioning chemical dosages and adjust feed rates.
Semi-annually or annually	• Check and report corrosion rate.

Ψ (…CoolingTowerBMP: JEA 2005)

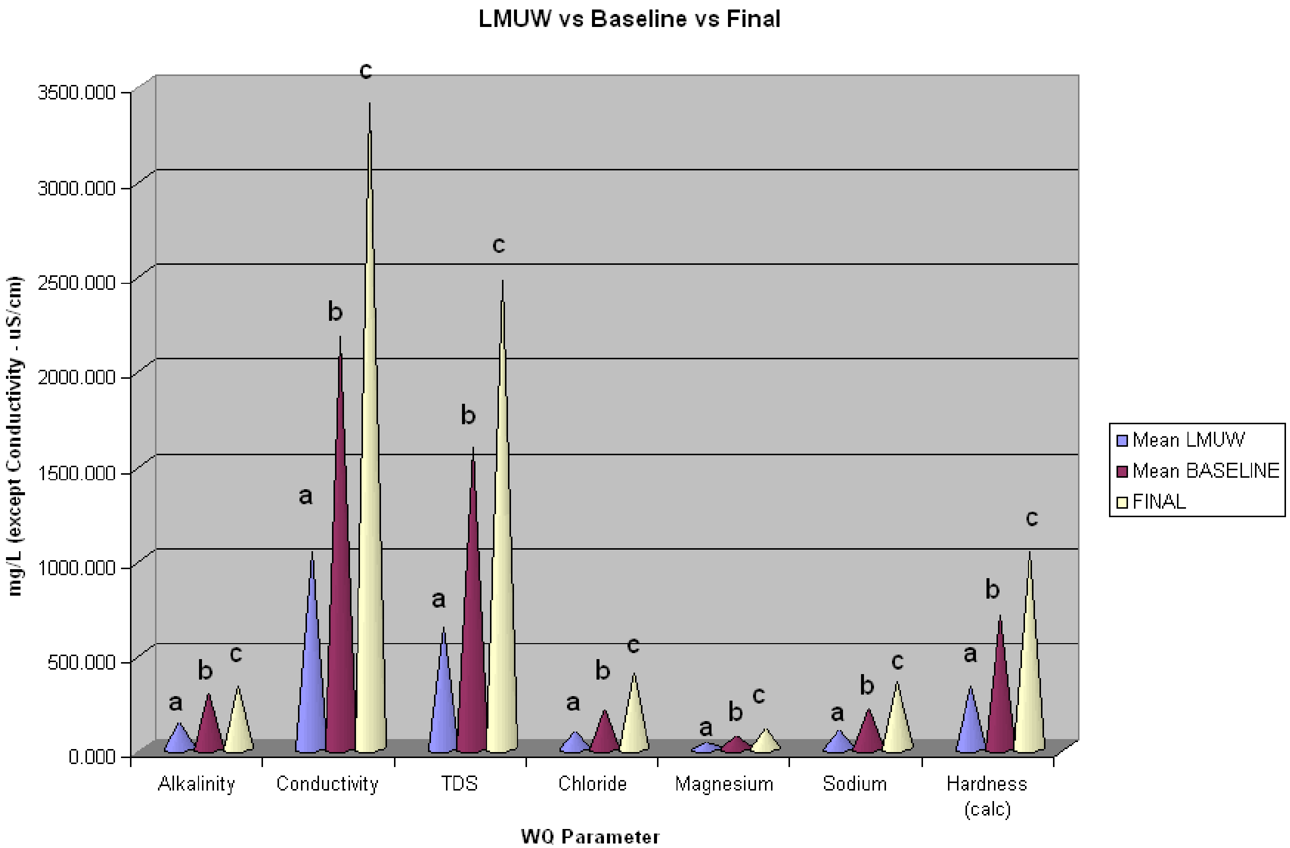
Additional Maintenance Service Suggestions

- **Install a Sampling Station work area w/ sink, log book, and storage near system controller. (A Diagrammatical 'backboard' is desirable too.)**
- **Install / Maintain Trash Screens over all exposed flow-areas of tower structure, to reduce nuisance objects becoming flow clogging devices and biological growth sites…**
- **Shade Structures over and Louvers around installation, control solar nuisance heat and scale deposition sites on outside of packing/fill media.**
- **Cover exposed areas to prevent direct sun exposure and its contribution to algal growth… I.e. Bottom of fill media and basin interface in Cross-Flow tower designs.**

  (One advantage of Counter-Flow tower designs is a shielded basin.)

Avg. Post-program Water Quality

(are we being effective?)



Yes!

Post Improvements CR_{avg} = 3.45

CR Improvements Observed (DRAFT)

Measure	Start CR	End CR	Improved
Acid Injection	2.33	3.91	1.58
Ozonation	2.15	3.17	1.02
Advanced Controls	1.85	3.25 – 4.5*	1.40
Improved Mgmt. Only	3.19	3.70	0.51 (at least?)

* Tagged Dispersal Polymer-based Control

Conclusions

- SNWA's efforts to facilitate improvements in the water efficiency of cooling towers appears to be successful.
- For those properties partnering with SNWA, CR has gone from 2.22 up to 3.45 (an improvement of 1.23).
- This represents an annual savings of approximately 673,760 gallons *for each 100 tons of cooling capacity*.
- **For the average facility visited, this equates to an average savings of 17,718,414 gallons annually.**
- **This a 45% savings in blow-down water.**

Conclusions

- Drift Reduction retrofits are a viable way to conserve valuable consumptive use water in Southern Nevada.
- Typically reduces drift from a starting loss of 0.2% to 0.05% of tower flow rate down to 0.005% to 0.001%.
- This represents an annual savings of approximately 70,960 gallons *for each 100 tons of cooling capacity*.
- **For the average facility visited, this would equate to an average savings of 1,866,093 gallons annually.**
- **This is a reduction of 10x to 200x in drift losses.**

Additional Future Directions

- More recapture and cleanup of onsite wastewater for use in cooling towers in industrial settings (ex. laundry facilities, bottling plant).
- Hybrid cooling towers to reduce evaporative demands.
- Ground source heat pumps used for “geocooling”! (School District is piloting).

Questions?

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➢ Also see: http://www.hpac.com

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