SAND2008-7128C

Nanofiltration Treatment Options for Thermoelectric Power Plant Water Treatment Demands

28 October 2008

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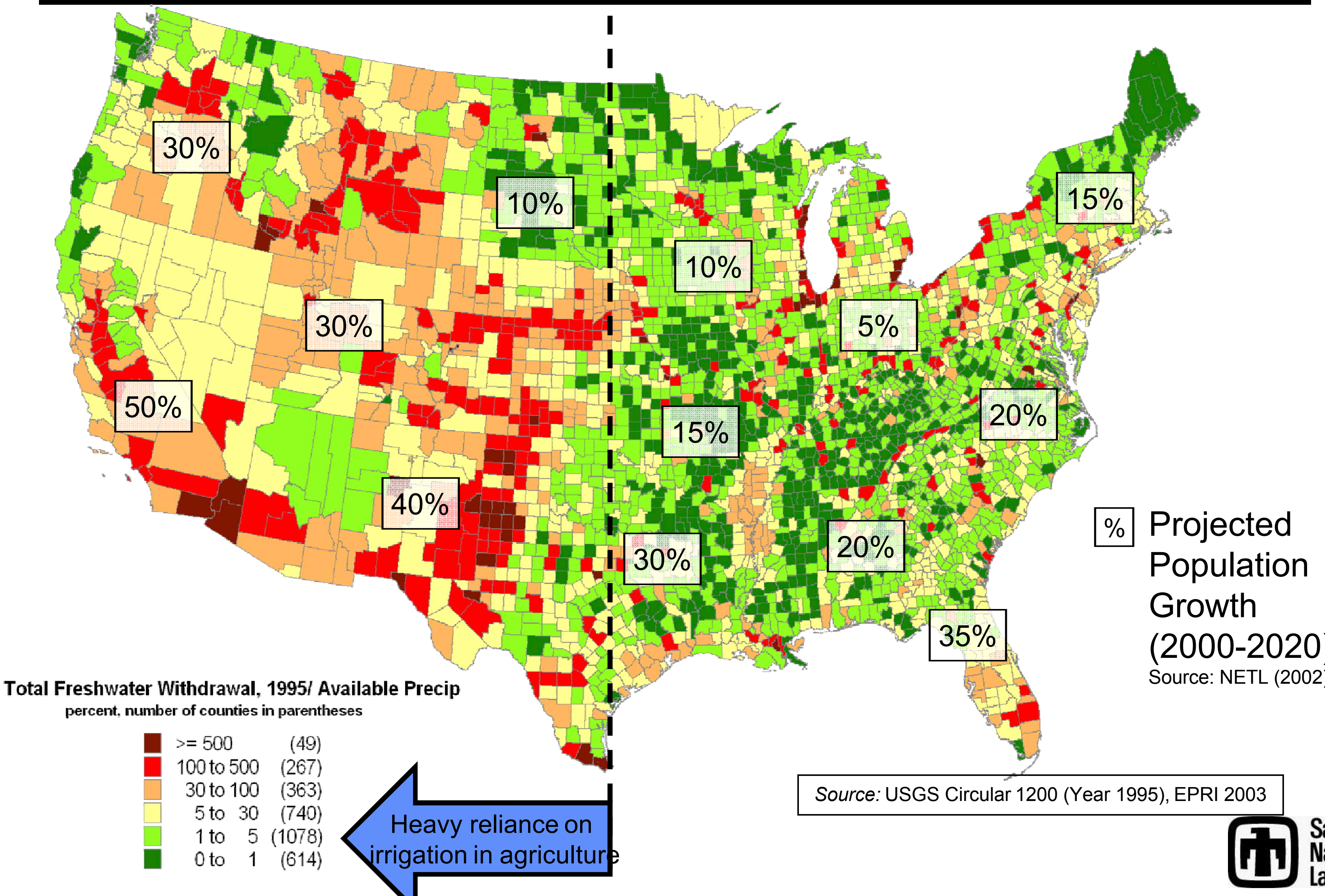
for the United States Department of Energy's National Nuclear Security Administration
under contract DE-AC04-94AL85000.

Effects of Drought, Groundwater Pumping



Source: USGS Circular 1200 (Year 1995), EPRI 2003

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Energy-Water Issues

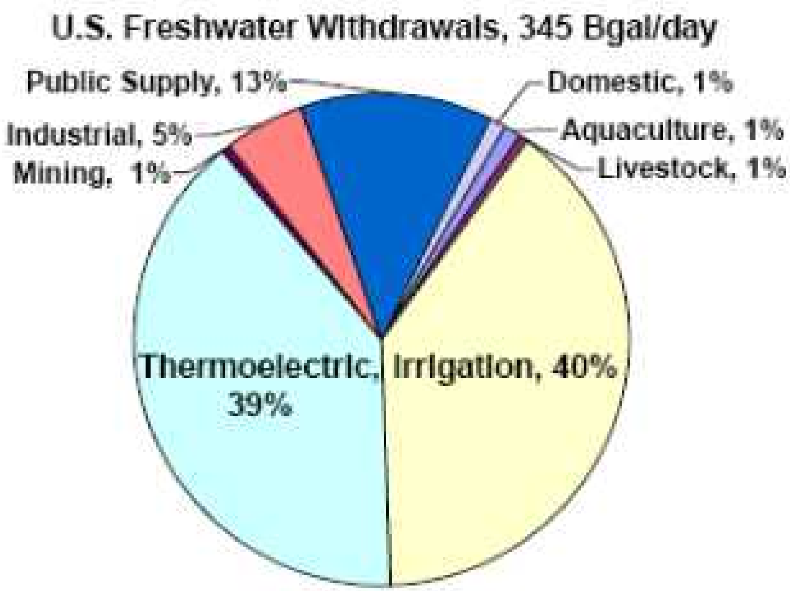

Figure II-1. Estimated Freshwater Withdrawals by Sector, 2000 (Hutson et al., 2004)

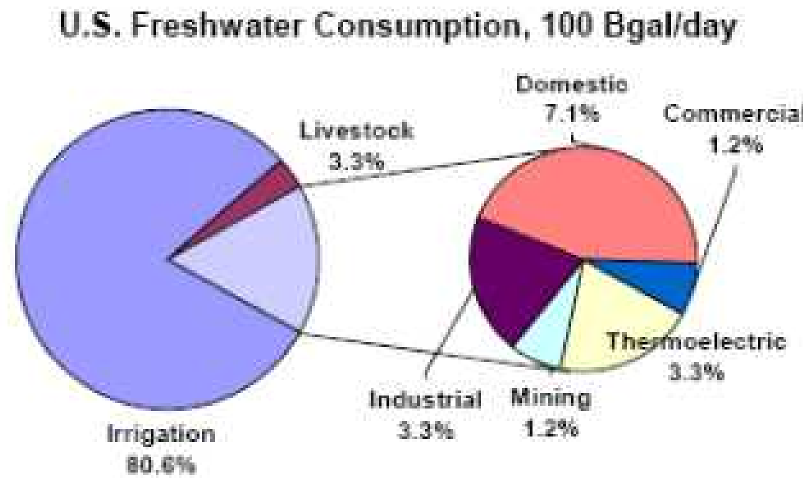

Figure II-4. Estimated Freshwater Consumption by Sector, 1995 (Solley et al., 1998)

Source: 2006 Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water

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Energy-Water Issues

- Population is increasing → electrical demand & water consumption is increasing
- Thermoelectric power generation is expected to grow at least 18% from 2005-2030 (EIA)
  - Water consumption likely to increase dramatically if current cooling tower designs continued
- Many parts of the US have experienced drought and/or are becoming water stressed
  - Different kinds of water consumers are in competition

Why nanofiltration?

- Nanofiltration membranes have a high rejection rate for divalent ions and are capable of knocking down TDS significantly.
- Nanofiltration membranes are more tolerant (in general) for fouling conditions, as compared to reverse osmosis.
- Nanofiltration membranes operate at lower applied pressures, as compared to reverse osmosis saves energy and $.
- …because it hasn't been done before!

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Goals of Project

- Goal is to find "new water" for thermoelectric power plants
- Pilot operations will evaluate options for low cost desalination of two types of waters using nanofiltration:
  - Produced water (CBNG)
  - Cooling tower recirculating water
- Pilot operations end result:
  - Demonstrate a new treatment process to match needs of end use
  - Evaluate potential for new water for use in existing power plants

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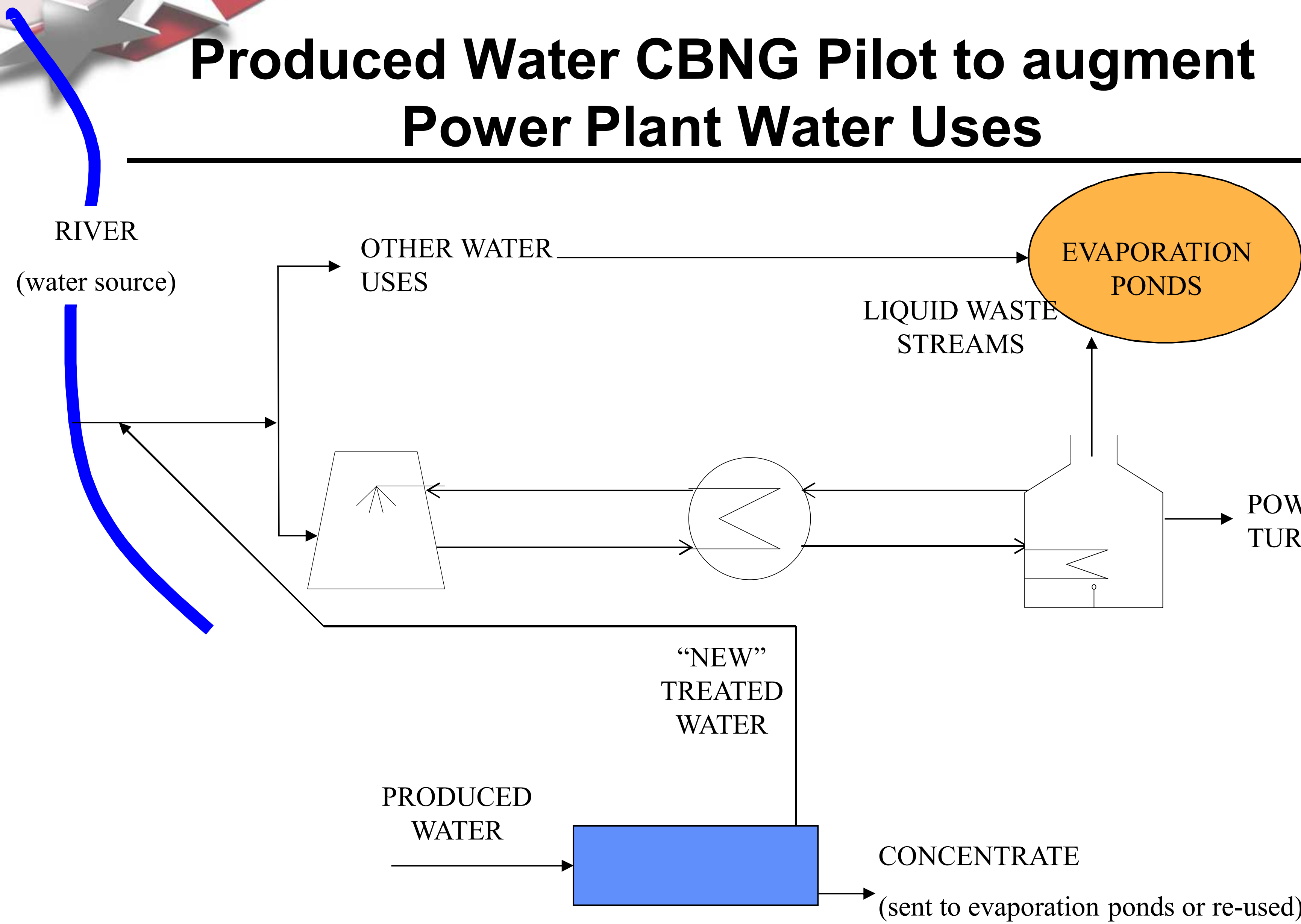
Produced Water CBNG Pilot to augment Power Plant Water Uses



Simplified Diagram of San Juan Generation Station

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Produced Water CBNG Pilot

- **Existing CBNG Produced Water Pilot**
  - **~12,000 mg/L TDS produced water, primarily Na, HCO_3, Cl**
  - **Currently Producing 1-3 gpm of <100 mg/L TDS treated water**
- **NF membranes will replace RO membranes shown at the CBNG Pilot for the current study.**

Produced Water CBNG Pilot

- Actual RO Pilot Data:
  - 500-550 psi pressure to RO (primarily due to lack of UF pre-treatment)
  - Operated at ~480 psi with UF pre-treatment
  - Permeate quality is pH 5.6 & 100-150 mg/L TDS
  - Partnering with ConocoPhillips, B.EST., NMSU, BLM, OCD
- Predicted (ROSA©) Nanofiltration Data:
  - Operate at <300 psi to NF system
  - Permeate quality to be pH 7.0 &1500 mg/L TDS
  - Acceptable to blend with lower TDS water for cooling tower

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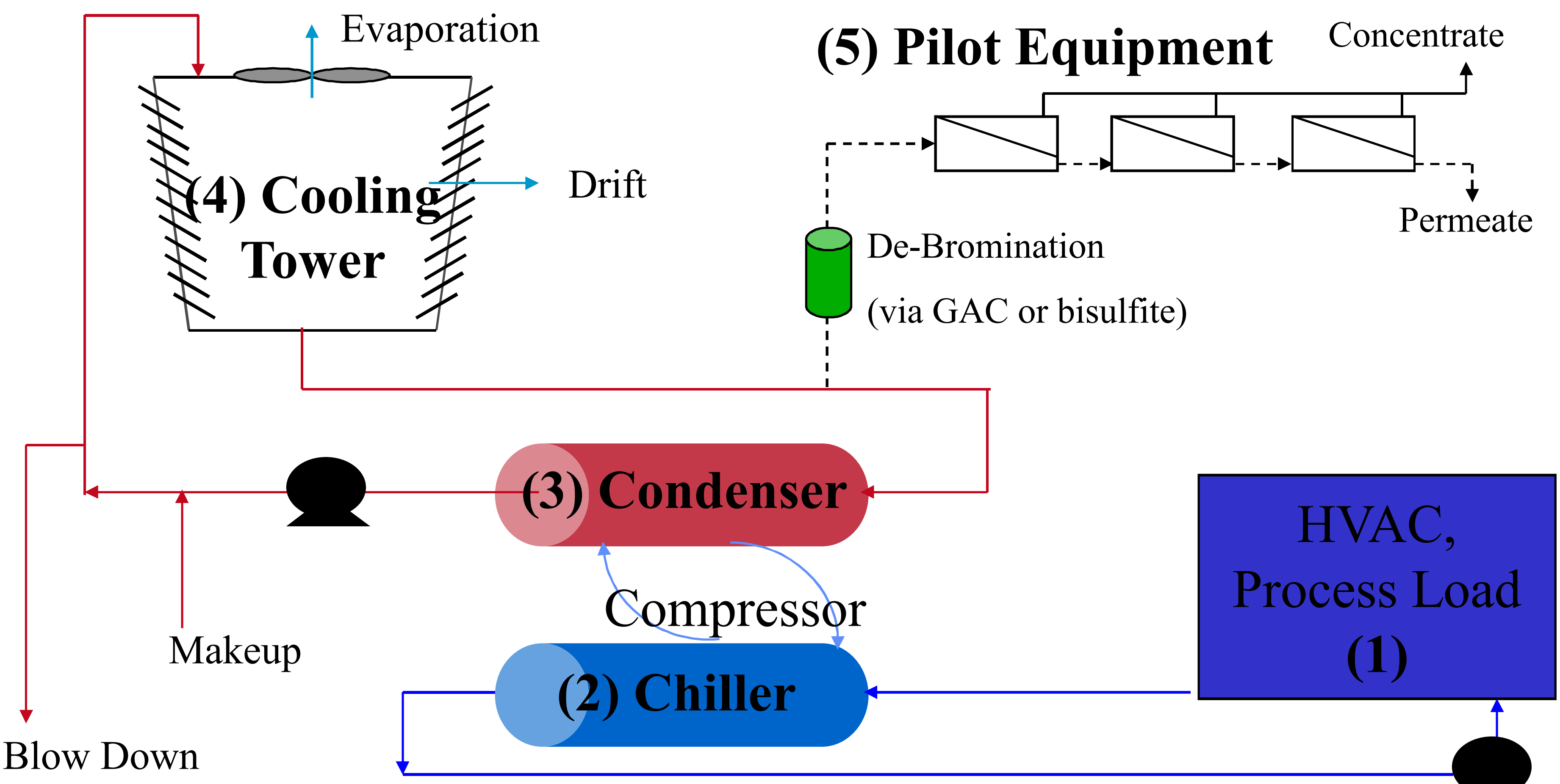
Produced Water Pilot – Predicted Chemistry (ROSA©)

Name	Feed	After Recycle	NF Concentrate	**NF Permeate**	RO Rejection
Na	6158.38	8422.86	497.15	**497.15**	89%
Mg	8.34	11.58	0.24	**0.24**	96%
Ca	37.97	52.73	1.09	**1.09**	96%
Ba	39.1	54.29	1.11	**1.11**	96%
CO3	311.55	498.2	0.9	**0.9**	100%
HCO3	10825.82	14664.3	912.44	**912.44**	88%
NO3	4.12	5.26	1.27	**1.27**	61%
Cl	2941.84	4023.51	237.63	**237.63**	89%
F	1.01	1.37	0.09	**0.09**	88%
SO4	4.01	5.6	0.05	**0.05**	98%
SiO2	13.65	18.86	0.61	**0.61**	94%
TDS	20345.79	27758.57	1652.59	**1652.59**	89%
pH	7.86	7.8	7.04	**7.04**	11%

Cooling Tower Pilot



Cooling Tower Pilot

- Install small nanofiltration system on circulation loop
- Partnering with Facilities Engineering group at SNL
- Monitor removal of scale-forming constituents
- All treated, wastewater to drain
- Proof of concept approach

Cooling tower for pilot:
600-1800 gpm
Installed in 1999

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Predicted Cooling Tower Pilot Chemistry (ROSA©)

Name	Feed	After Recycle	Concentrate	Permeate	RO Rejection
Na	176	219	326	27.2	84%
Mg	33	42	64	2.1	94%
Ca	130	165	252	8.1	94%
CO_3	54	69	107	2.1	96%
HCO_3	476	601	912	39.8	92%
Cl	232	289	429	36.0	85%
SO_4	34	43	67	0.8	98%
SiO_2	125	158	239	10.9	91%
TDS	1260	1586	2397	127.0	90%
pH	9.0	9.0	8.9	8.91	N/A

- Reduce/Eliminate feed (well water) with permeate mixture
- Run at higher cycles – conserve water & chemicals (?)

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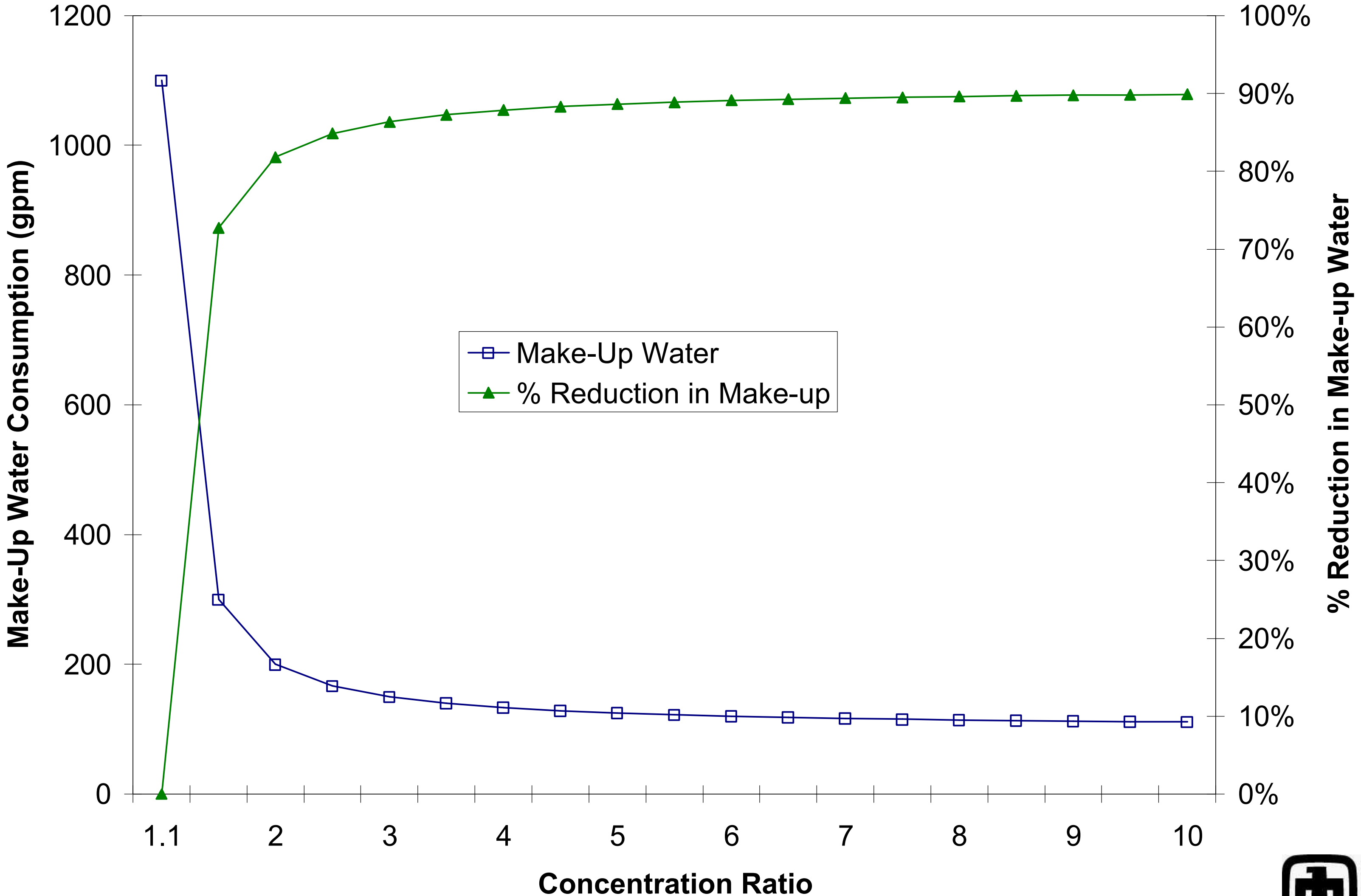
Effect of Cooling Tower Pilot



Project Timeline

Oct-Dec 2008	Install & Operate NF membranes at CBNG Pilot Location – Operate for 1 week in November – Status Report of Operations
Jan-Mar 2009	Install NF system at SNL cooling tower – Equipment and Modifications to existing HVAC system
April-July 2009	Operate NF pilot at SNL cooling tower –Operate for 2-3 months –Status Report of Operations
Aug-Sept 2009	Write Report –Cost/Benefit Analysis of both pilots' results

Thank you for your attention.

Questions?

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