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The webinar will begin promptly at
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SERDP and ESTCP Webinar Series

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Building Energy and Water Efficiency Solutions

August 8, 2019

SERDP DOD • EPA • DOE | ESTCP

Welcome and Introductions

Heather Rectanus, Ph.D.
Webinar Facilitator

SERDP DOD • EPA • DOE | ESTCP

Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Heather Rectanus, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Mr. Timothy Tetreault, SERDP and ESTCP
- **Energy and Water Efficiency Improvements for Dishrooms in Military Dining Facilities** (25 minutes + Q&A)
  Dr. Frank Johnson, Gas Technology Institute
- **Hygroscopic Cooling Tower for Reduced Heating, Ventilation and Air Cooling Water Consumption** (25 minutes + Q&A)
  Dr. Christopher Martin, University of North Dakota
- **Final Q&A session**

In Case of Technical Difficulties

- Use a compatible browser (Firefox, IE or Edge)
- If material is not showing on your screen or if screen freezes
  - Key in Ctrl + F5 to do a hard refresh of your browser
- If connecting to computer audio
  - Click the arrow next to the “Join Audio” button
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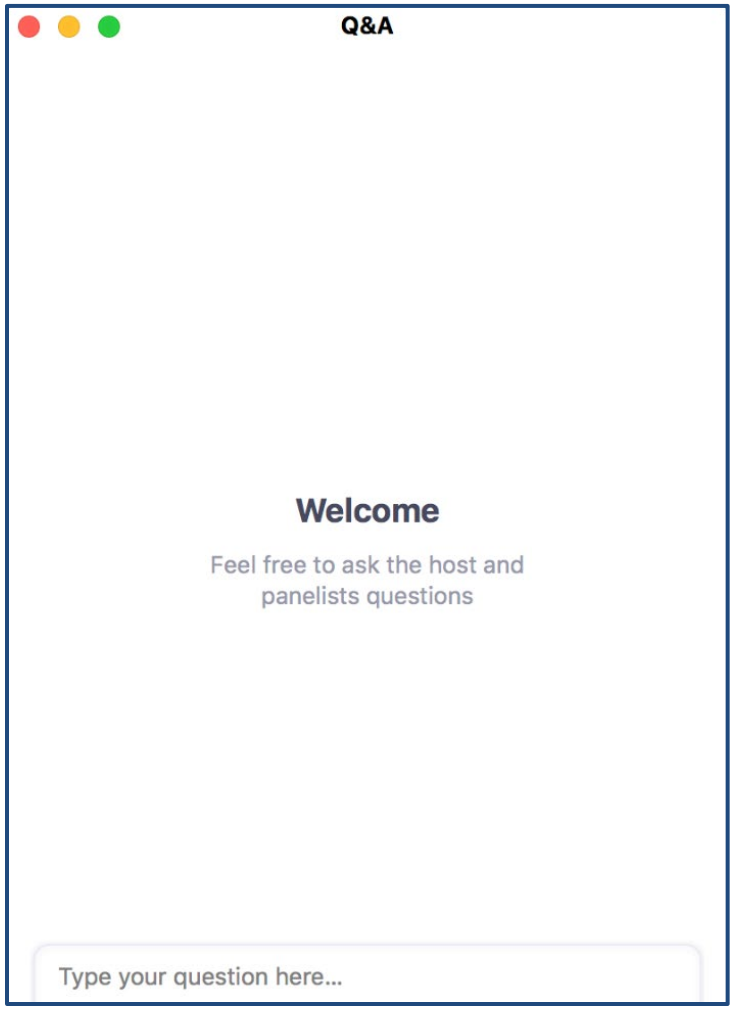
How to Ask Questions

- Find the Q&A button on your control bar and type in your question(s)
- Make sure to add your organization name at the end of your question so that we can identify you during the Q&A sessions



SERDP and ESTCP Overview

Timothy Tetreault
SERDP and ESTCP

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SERDP

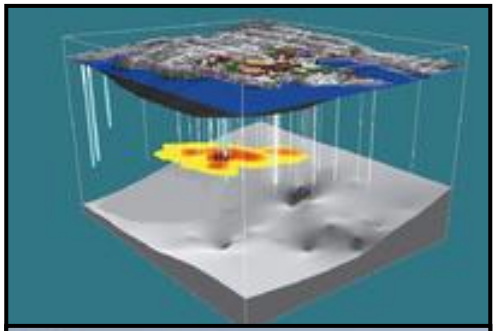
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

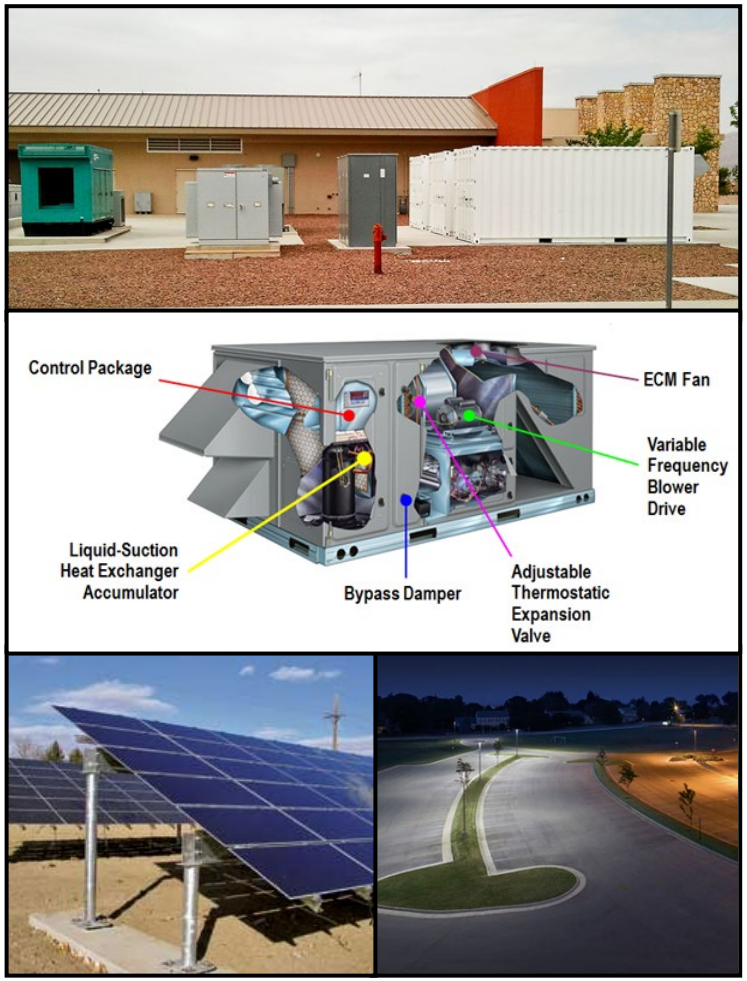
Program Areas

- Environmental Restoration
- Installation Energy and Water
- Munitions Response
- Resource Conservation and Resiliency
- Weapons Systems and Platforms



Installation Energy and Water

- Smart and secure installation energy management
  - Microgrids
  - Energy storage
  - Ancillary service markets
- Efficient integrated buildings and components
  - Design, retrofit, operate
  - Enterprise optimized investment
  - Advanced components
  - Intelligent building management
  - Non-invasive energy audits
- Distributed generation
  - Cost effective
  - On-site
  - Emphasis on renewables



SERDP and ESTCP Webinar Series

Date	Topic
August 22, 2019	Pacific Island Ecology and Management: Recovery of Native Plant Communities
September 5, 2019	The Use of Advanced Molecular Biological Tools in Groundwater Contaminated with Chlorinated Solvents
September 19, 2019	Life Cycle Assessment and Developmental Environment Safety and Occupational Health Evaluation: Tools for Sustainment and Health
October 3, 2019	Variation in Phenological Shifts: How do Annual Cycles and Genetic Diversity Constrain or Enable Responses to Climate Change?
October 17, 2019	Managing Aqueous Film Forming Foam (AFFF) Impacts to Subsurface Environments and Assessment of Commercially Available Fluorine-Free Foams

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

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Save the Date Announcement

SERDP • ESTCP
SYMPOSIUM

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

December 3-5, 2019

Washington Marriott Wardman Park

Registration is open!

Energy and Water Efficiency Improvements for Dishrooms in Military Dining Facilities

Frank Johnson, Ph.D.
Gas Technology Institute

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Agenda

- Problem of water usage in Dining Facilities (DFACs)
- Background on dish machine design
- Technical objectives/approach
- Results
- What we learned
  - Best practices guide
- Benefits to DoD

DFAC Background

- Problem
  - Excessive water and energy use to clean dishware in DFACs
  - Dishroom is 75% of energy and water load in DFACs

Dishroom Layout

Pre-Rinse Station

Background

- Commercial dish machines or warewashers
  - Clean and sanitize cookware and utensils
  - Primarily electric (very few natural gas units)
  - Types: flight, rack or conveyor and stationary door

Flight

Rack

Door

Technical Objectives

- Install new dish machine, heat recovery system and ventilation system
  - Replace existing steam system with natural gas system
- Develop optimal operational procedures for combined system
- Compare to existing baseline equipment and quantify savings
  - Goals: 75% water savings, 60% energy savings
- Develop standard procedures for installation at other locations
  - Best Practices Guide
  - Workshop PowerPoint

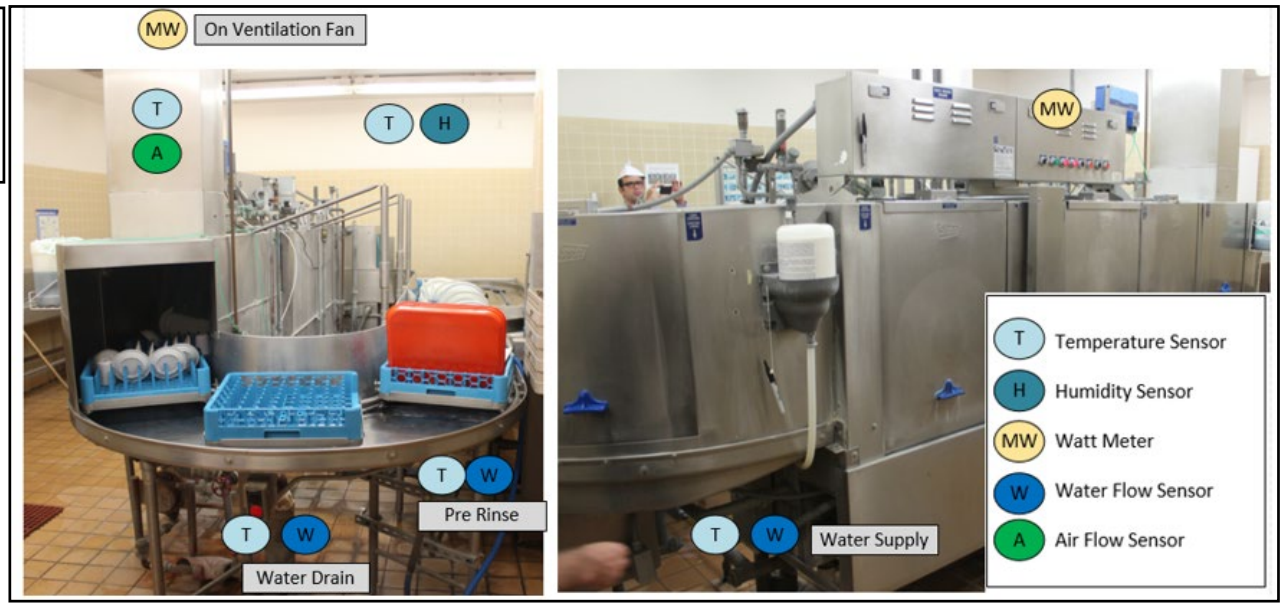
Technical Approach

- Methodology
  - Direct comparison of 6 months of performance and energy usage
  - Measure temperature, humidity, energy, racks cleaned, cleaning results
  - Baseline vs. new (dish machine, heat recover, ventilation)
- Location
  - U.S. Army Garrison Presidio of Monterey

Technical Approach

- Baseline – 6 months
  - Characterize existing system
    - Data points in image
    - Energy to produce steam for water heating from boiler

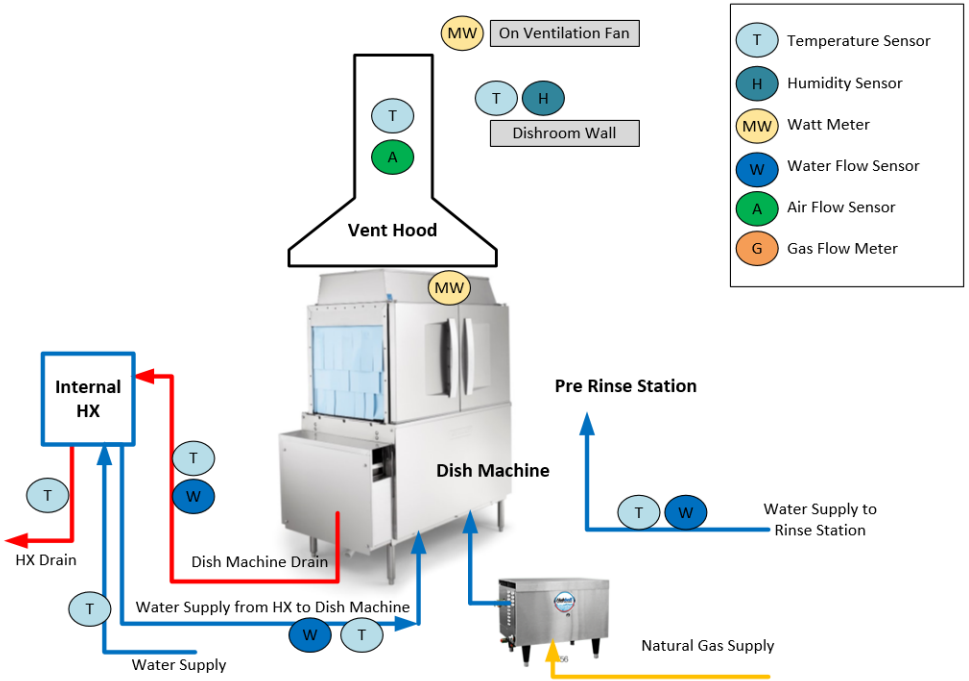
Baseline Dishroom at Belas Hall



Technical Approach

- Demonstration – 6 months
  - Replacement of baseline with integrated system
    - Dish Machine, HX (internal), Vent Hood, Booster Heater

Demonstration Dishroom at Belas Hall



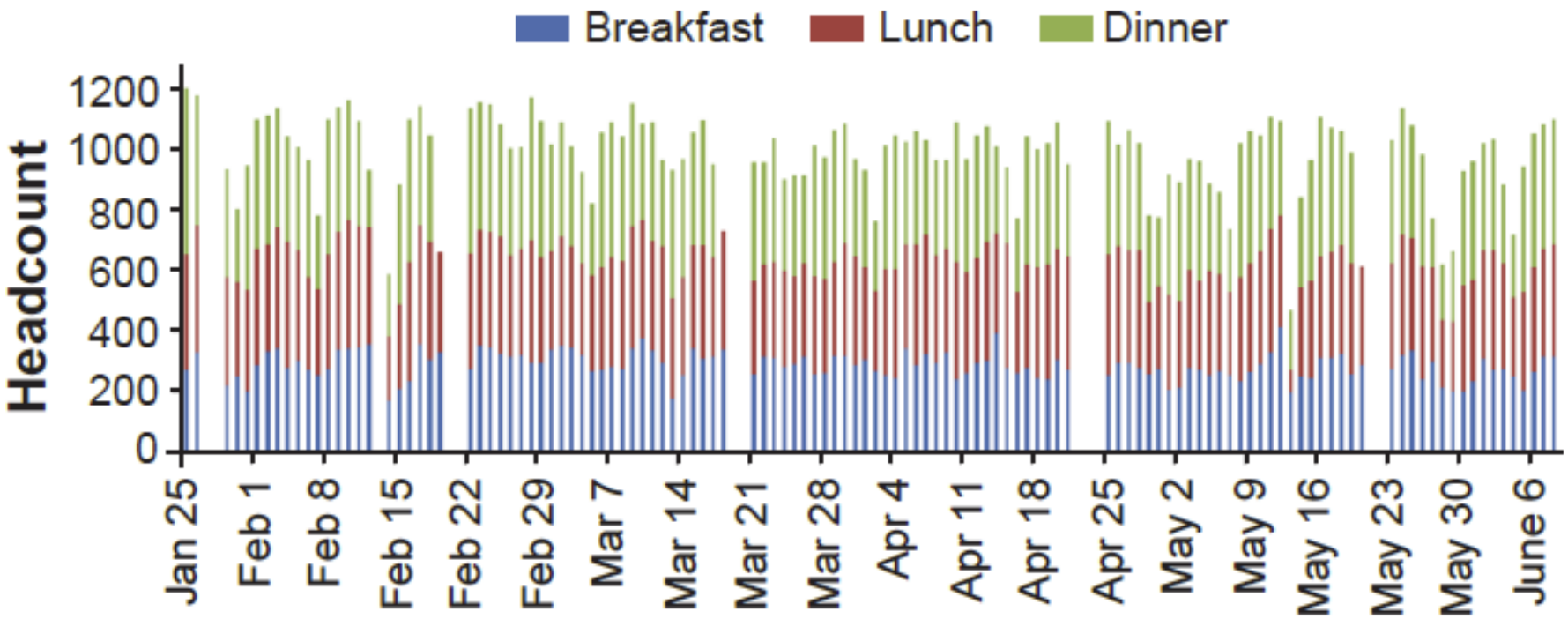
Technical Approach

- Specific performance objectives
  - Dish machine reliability
    - Direct measurement: operation time (hrs)
    - New heat source provides required water temperatures
    - In compliance with Tri-Service Food Code TM MED 350
  - Thermal comfort
    - Survey of operators
    - Direct measurement of temperature and humidity
  - User satisfaction – cleaning
    - Survey, images of cleaned dishware
    - In compliance with Tri-Service Food Code TM MED 350

Results: Analysis

- Data correlated into meals/day
- Water usage locations and patterns
- Comfort levels in terms of temperature and humidity
- Energy usage locations and patterns
- Total energy usage
- Total water usage

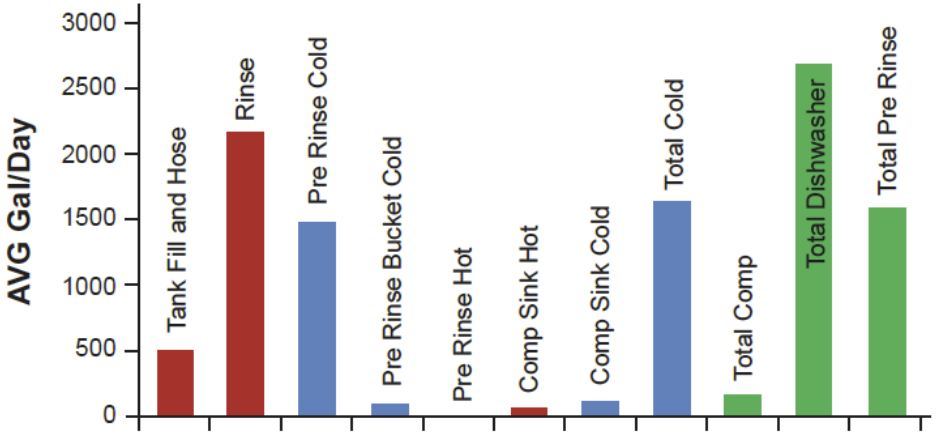
Results: Meals Served



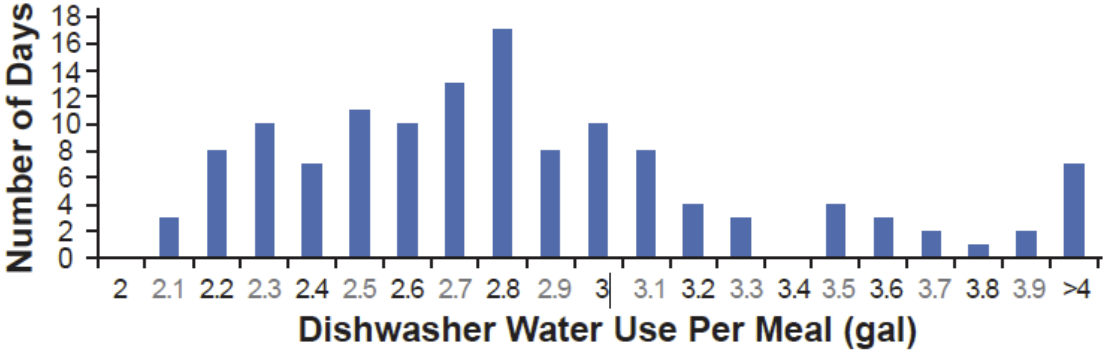
Shows consistent number of meals served per day

Results: Water Consumption

- Daily dishroom water consumption

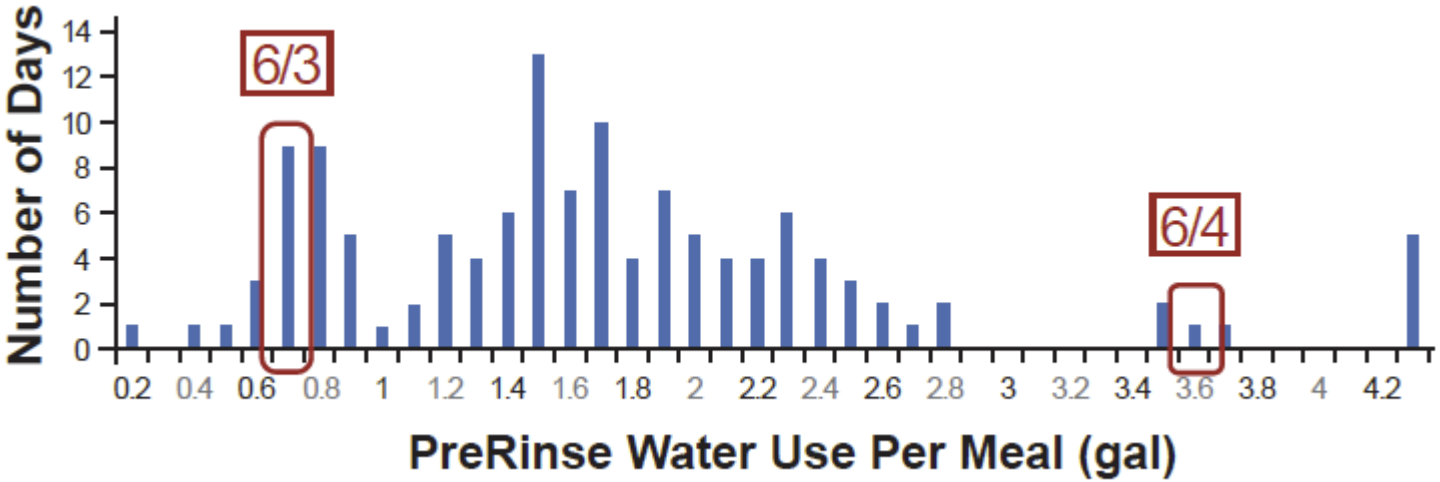


- Water use per meal*



*Shows inconsistent daily water usage rate

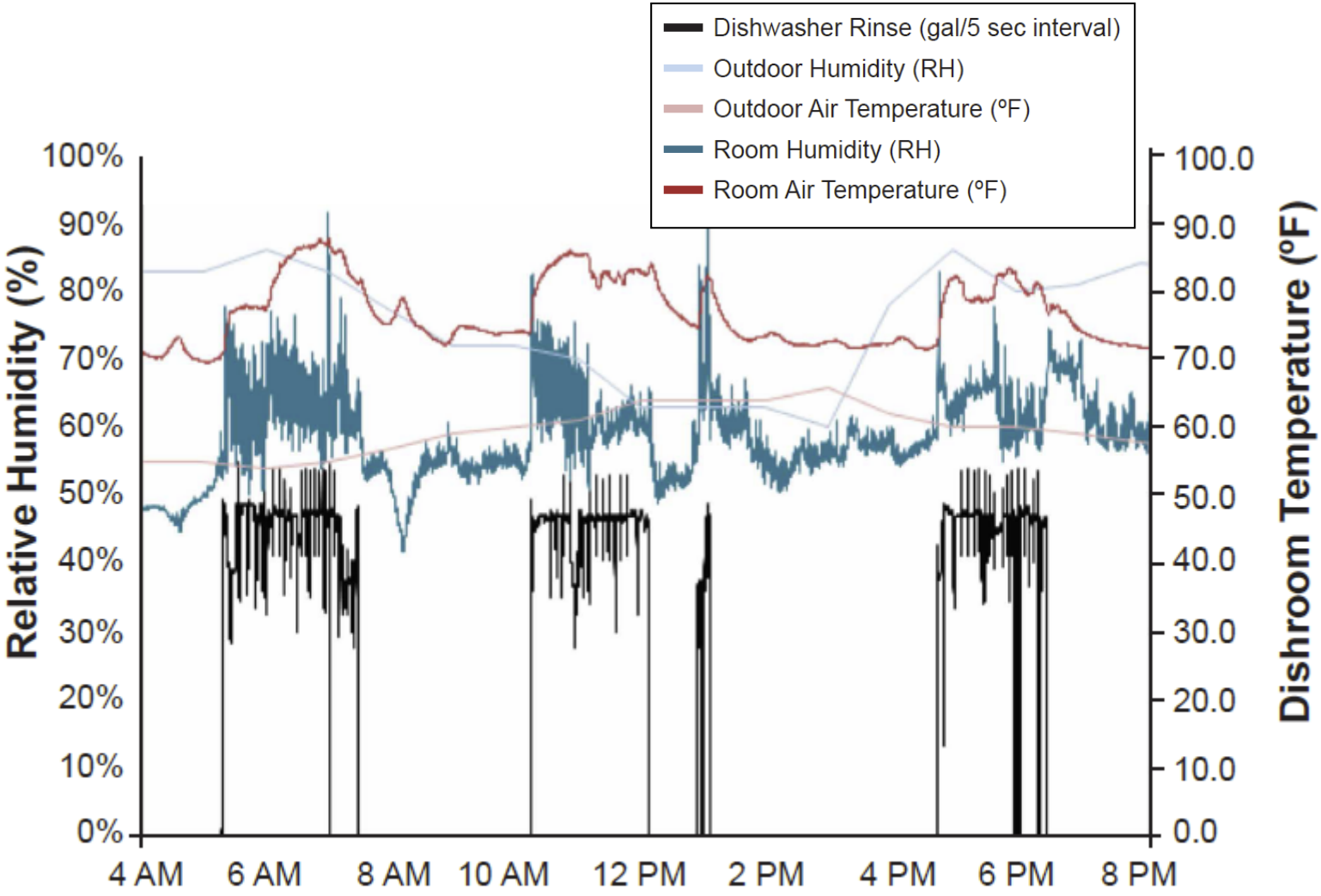
Results: PreRise Water Use



Results: Pre-Rinse Water Usage

- Procedural issues
  - Rinse water being left on
    - Hand scraping vs. water washing
    - Open hose to clean scrap bin
  - SOP for pre-rinse immediately implemented

Results: Comfort Level



Results: Energy

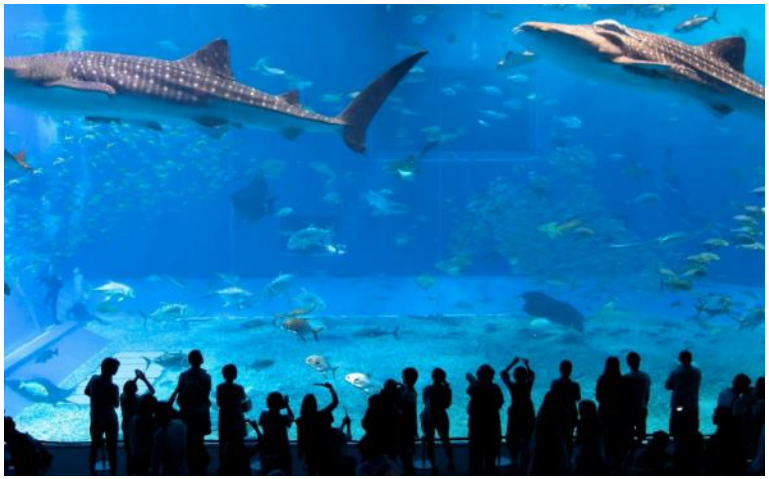
Performance Objective	Baseline	Demonstration	Savings	Savings
Total Natural Gas Use	6.7 MMBtu/day	4.6 MMBtu/day	2.1 MMBtu/day	31%
Electricity (Conveyor, Pumps, Motor)	28 kWh/day	17 kWh/day	11 kWh/day	41%
Boiler Room Energy Use	6.8 MMBtu/day	4.7 MMBtu/day 3.3 MMBtu/day*	2.1 MMBtu/day 3.5 MMBtu/day*	31% 51%

** After decommissioning of boiler system*

Results: Water

Performance Objective	Baseline	Demonstration	Savings	Savings
Total Water Usage of Dish Machine	5,805 gal/day	620 gal/day	5,185 gal/day	89%
Total Water Usage of Dishroom*	7,587gal/day	1,212 gal/day	6,375 gal/day*	84%

** Equates to 2,327,000 gallons per year water savings*

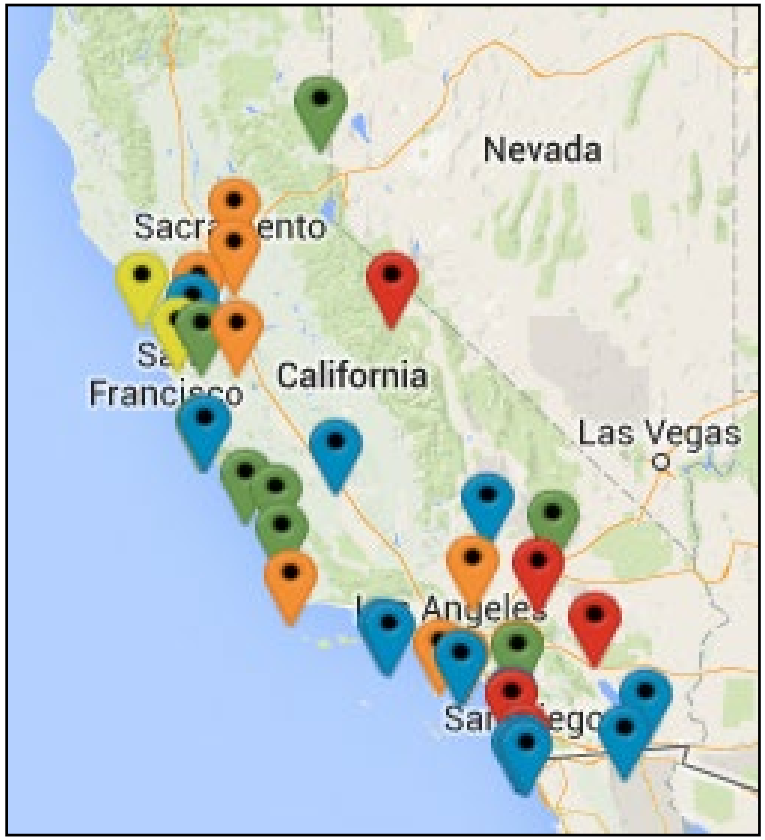


Best Practices Guide

- Project deliverable document*
  - https://www.serdp-estcp.org/Program-Areas/Installation-Energy-and-Water/Water-Conservation/EW-201518 (Labeled as Guidance Document)
- Current water usage patterns
  - Check for excess water usage
- Installation
  - Experienced contractors
- Kitchen design
  - Changes in the “flow of operation” of the dishroom
- End user buy-in
  - Changing the existing workflow in the dishroom

Technology Applicability at Other DoD Installations

- Target audiences
  - DoD-DFACs
  - Commercial end-users
    - Universities
    - Commercial Foodservice Facilities
      - Restaurants
      - Cafeterias
      - Casinos



Military Bases in California

Technology Applicability at Other DoD Installations

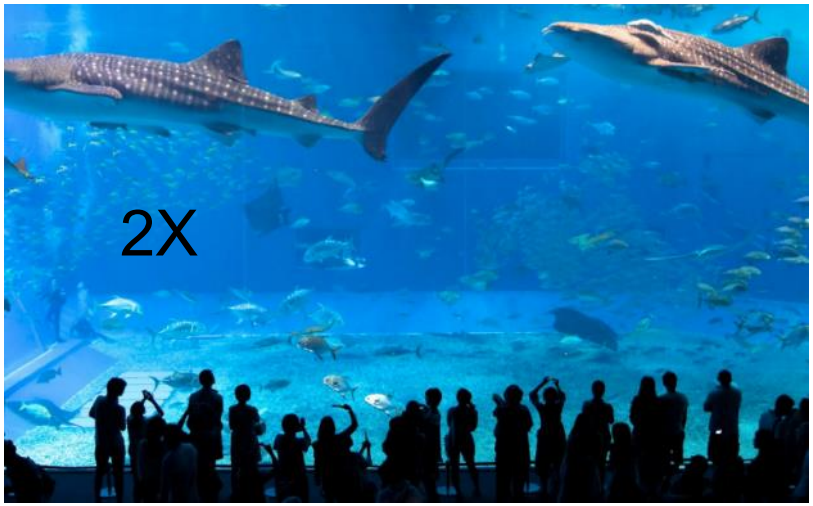
- Conduits to the marketplace
  - Gas utilities
    - Emerging Technology Programs (ETP)
    - Federal Utility Energy Service Company (UESC)
  - Consortium for Energy Efficiency (CEE) – Energy Star
  - Manufacturers – dish machines, ventilation systems
  - Publications – ASHRAE, symposiums
  - Social media

Conclusions

- Significant energy and water savings from dishroom modernization
- Operational procedures matter
  - Understand water usage patterns
  - End-user buy in
- Kitchen design matters
  - Experienced kitchen design expert and installer

Benefits to DoD

- Results
  - Energy savings – 51%
  - Water savings – 84%



- Best Practices Guide
  - Current water usage patterns
  - Installation
  - Kitchen design
  - End-user buy in

Acknowledgments

- Alexander Zhivov, U.S. Army Corps of Engineers
- Don Fisher, Fisher Consultants
- David Zabrowski, Frontier Energy
- Jay Tulley, Energy Manager, U.S. Army Garrison Presidio of Monterey
- Hobart – Dish machine manufacturer
- Hubbell – Booster heater manufacturer

For additional information, please visit
https://www.serdp-estcp.org/Program-Areas/Installation-Energy-and-Water/Water-Conservation/EW-201518

Speaker Contact Information

frank.johnson@gastechnology.org; 847-768-0670

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Q&A Session 1

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Hygroscopic Cooling Tower for Reduced Heating, Ventilation and Air Cooling Water Consumption

Christopher Martin, Ph.D.
University of North Dakota

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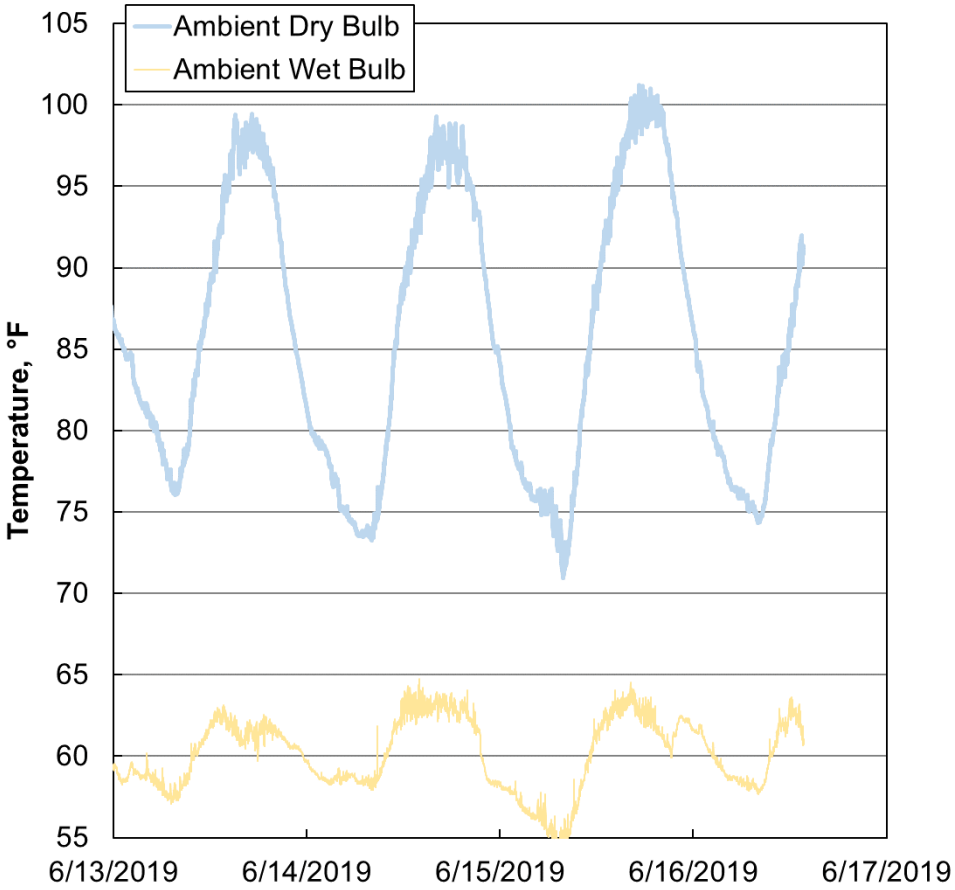
Agenda

- Wet cooling background
- Cooling towers within DoD
- Hygroscopic cooling technology
- ESTCP demonstrations
- Comparison of water-saving alternatives
- Early conclusions

Wet Cooling Features Compared to Dry Cooling

- Dry, sensible
  - Pro: No water consumption; minimal maintenance
  - Con: Limited to dry bulb temperatures
- Wet, evaporative
  - Pro: Consistent, cooler wet bulb approach temperature
  - Con: Ongoing water consumption and maintenance



Ambient conditions measured at Ft. Irwin, CA

Barriers to Efficient Wet Cooling

Improved Operating Efficiency

Chiller Type	ASHRAE 90.1 Standard; >150 tons	Common Basis, kWth/kWe
Air-Cooled	10.10 Btu/W-hr	3.0
Water-Cooled Centrifugal	0.610 kW/ton	5.7

Regulatory Enforcement

California 2019 Building Energy Efficiency Standards; Limitations of Air-Cooled Chillers:

> *Chilled water plants shall not have more than 300 tons provided by air-cooled chillers.**

**Section 140.4 – Prescriptive Requirements for Space Conditioning Systems; Subsection (j)*

- Despite energy advantages, wet cooling has been more difficult to implement
  - Water intensive
  - Ongoing maintenance of water chemistry
  - Potential health liability from microbial growth

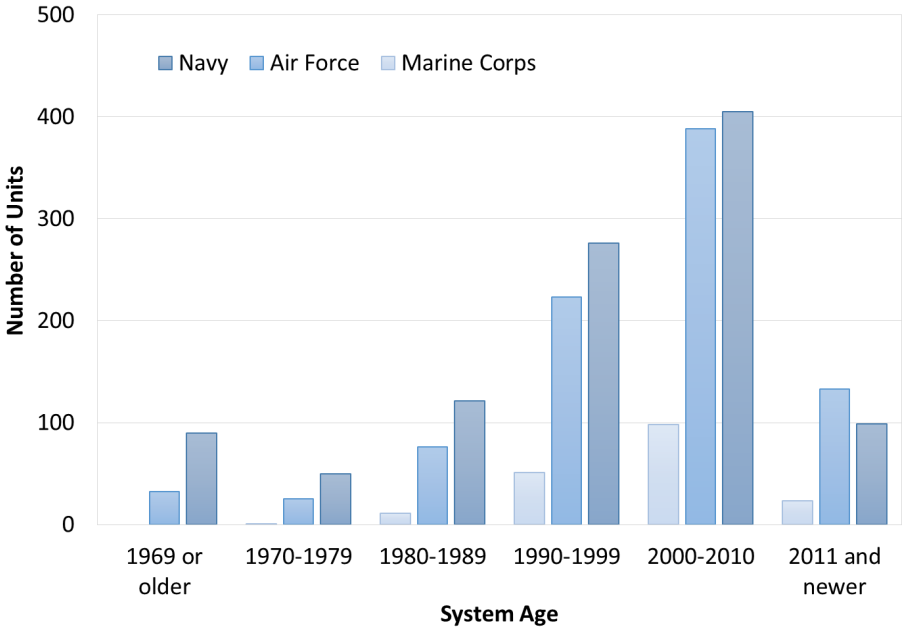
Existing DoD Cooling Towers

- CERL's BUILDER™ Sustainment Management System (SMS) used to gage DoD's cooling tower inventory

Rounded cooling tower totals for each service

Air Force	1400
Navy	1200
Marines	200
Army*	1300
Approximate Total	**4200**

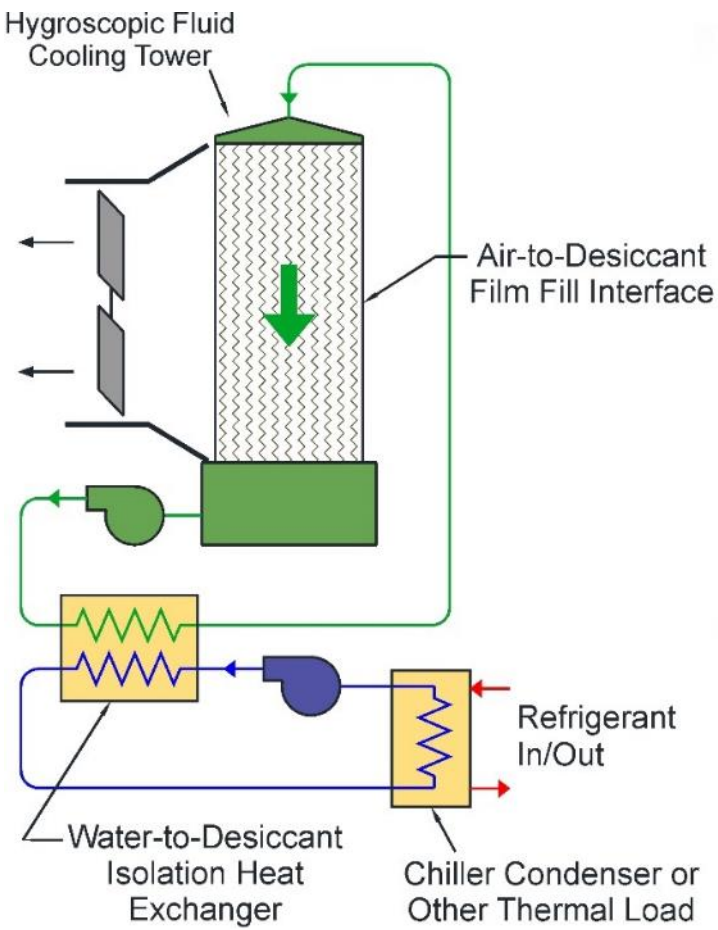
** Inventory of Army units is underway; 1300 estimated from known numbers at individual sites*



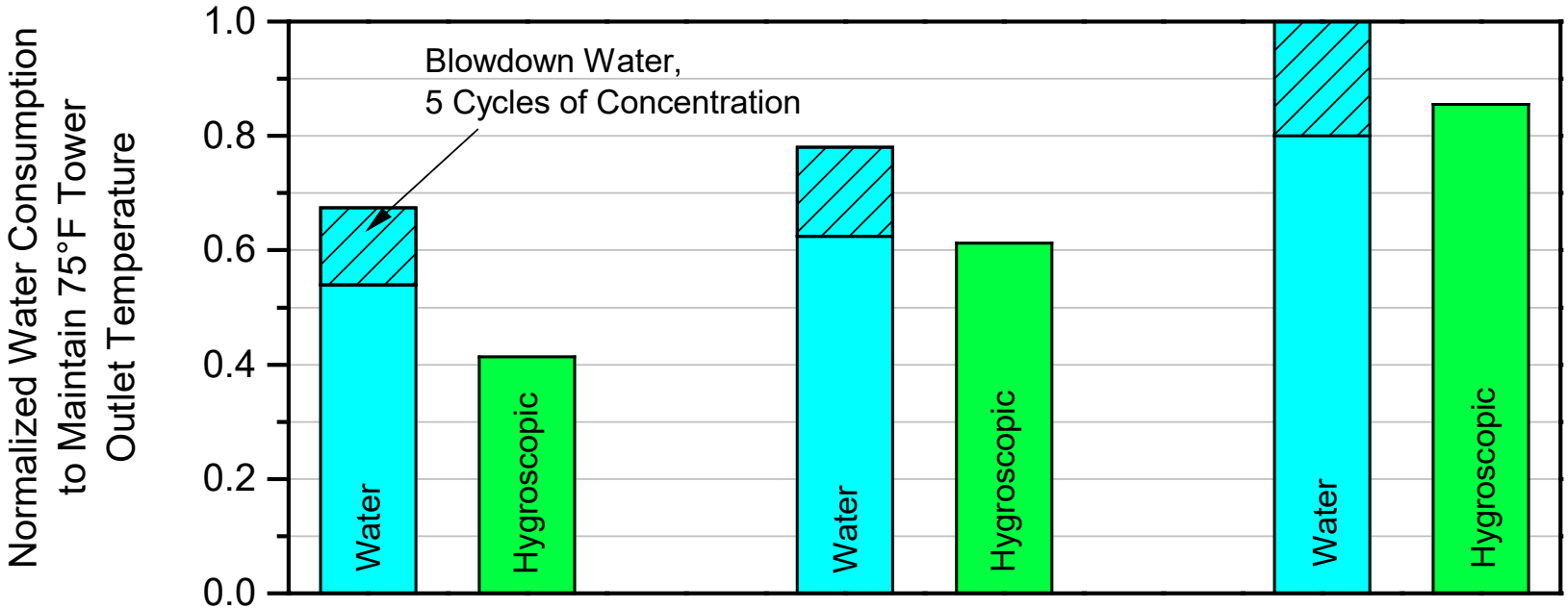
- 80% of the known towers are newer than 1990
- Replacement rate of ~130 towers per year assuming a 20 to 25 year service life
- Unit sizes range from 60 to 1000 tons

Hygroscopic Cooling Technology

- Concept
  - Substitution of a liquid desiccant for pure water
- Water is conserved via two mechanisms
  - Increased sensible heat transfer during cool weather
  - Blowdown eliminated, all makeup water is evaporated for cooling



Water Saving Potential with Hygroscopic Cooling



Conditions	**Cool**	**Neutral**	**Hot**
Dry Bulb Temp.	60°F	75°F	90°F
Wet Bulb Temp.	54°F	63°F	67°F
Relative Humidity	70%	50%	30%

Operational Benefits of the Hygroscopic Fluid

- The hygroscopic fluid is a solution of $CaCl_2$ and water

Natural $CaCl_2$ brine concentration; Amboy, CA; Peter Thody

- Characteristics of a cooling tower working fluid
  - Tolerant of poor quality makeup water
  - Virtually freeze proof for year-round operation
  - Microbe inhibiting
- $CaCl_2$ is also non-toxic, inexpensive and widely available

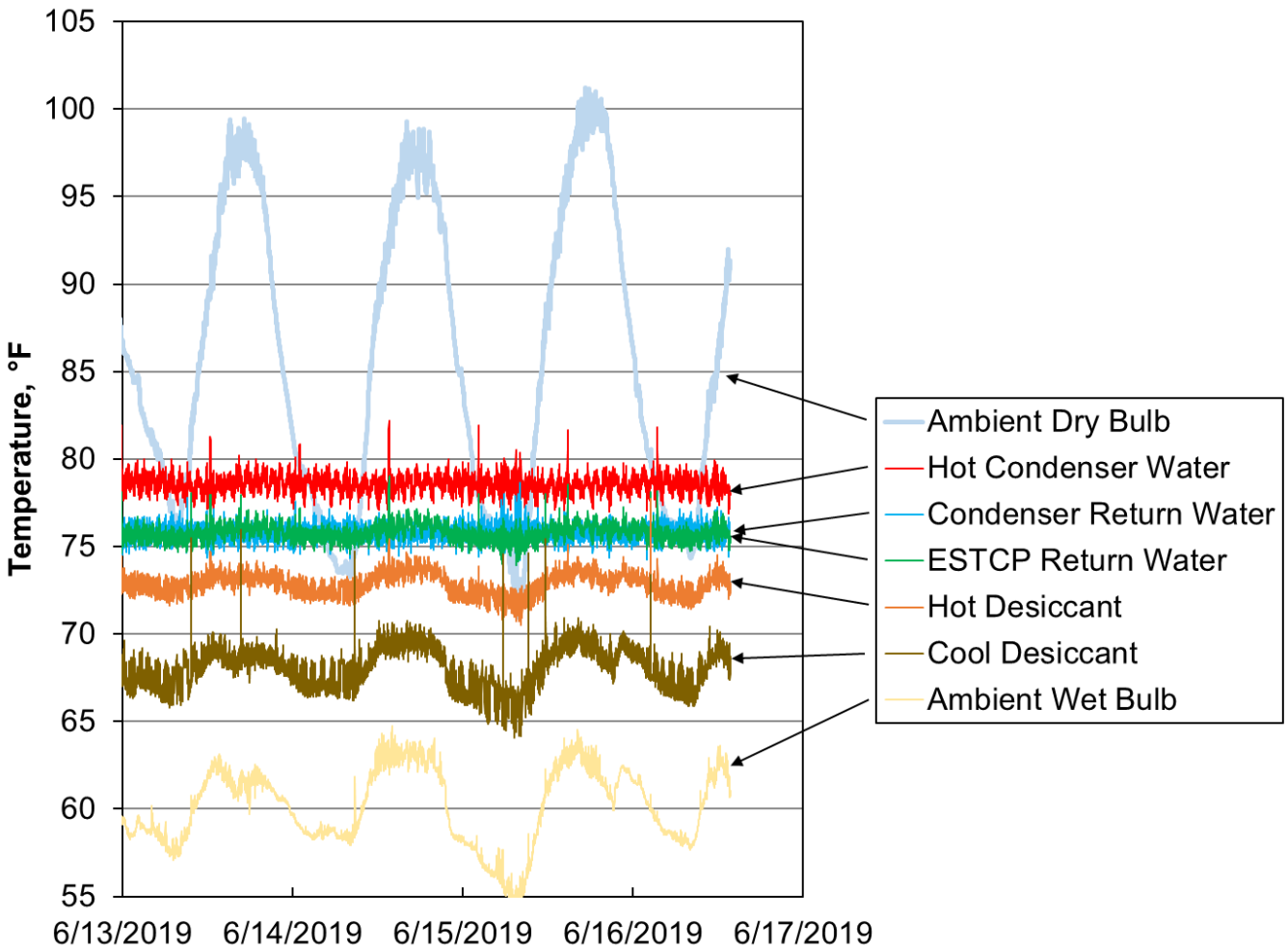
ESTCP Demonstration Sites

- National Training Center, Fort Irwin
  - Central heating and cooling plant
  - Existing tower cools a 325 ton chiller
  - Demonstration started July 2018
- DoD Center Monterey Bay
  - Existing tower cools 190 and 120 ton, staged chillers
  - Demonstration started March 2019

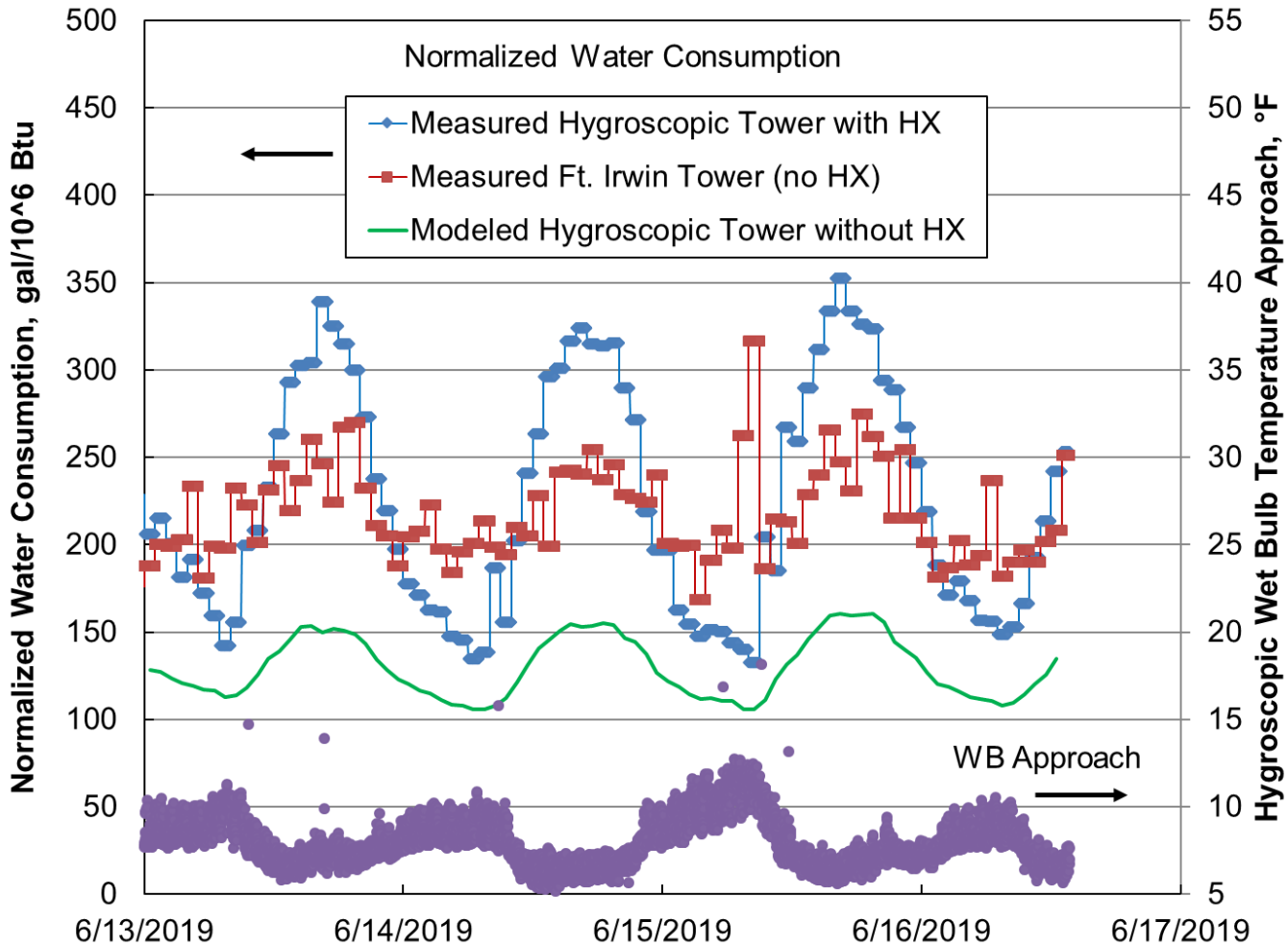
DoD Center Monterey Bay

National Training Center, Fort Irwin

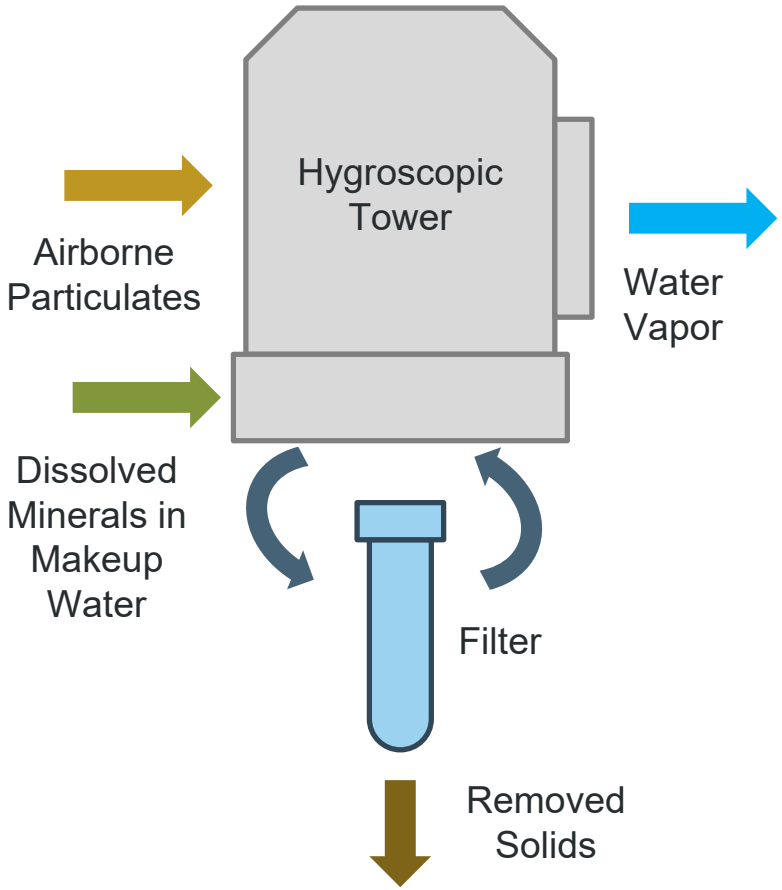
Fort Irwin Operating Temperatures



Fort Irwin Normalized Water Consumption



Blowdown Elimination



- Significant water savings comes from eliminating the blowdown stream
- Mineral balance is achieved through forced precipitation

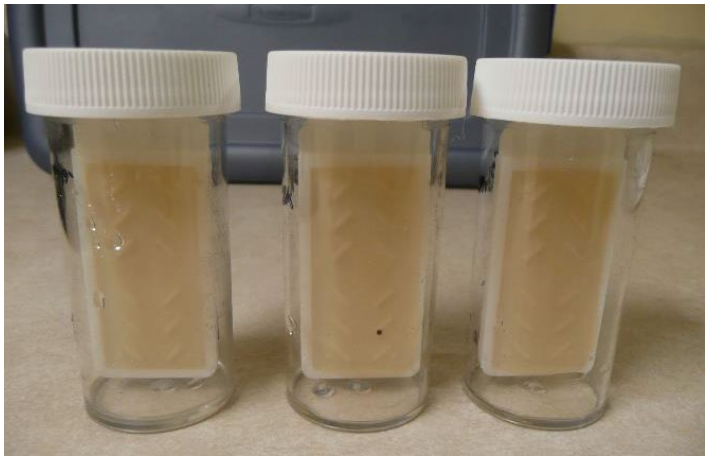
Precipitates and filter collected at Ft. Irwin, 8/27/18

Precipitate Hazard Analysis

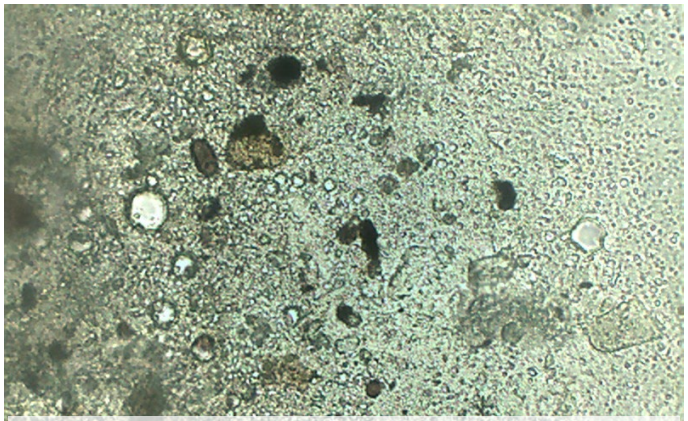
RCRA Metals	Measured Solid Conc. mg/kg	California Total Threshold Limit Conc., mg/kg	Maximum Leachate Conc. mg/L (20:1 dilution)	Federal Regulatory Leachate Limit, mg/L (20:1 dilution)
As	5.76	500	0.288	5
Ba	57.5	10,000	2.88	100
Cd	<0.05	100	0.0025	1
Cr	16.9	2,500	.845	5
Pb	1.58	1,000	0.079	5
Hg	0.0082	20	0.0004	0.2
Se	0.37	100	0.02	1
Ag	<0.05	500	0.0025	5

Microbial Control

- Reduced water activity of the desiccant inhibits microbe growth
- Bacterial dip slides
  - Readings <100 to 100 cfu/ml for the hygroscopic fluid
  - Indicates “system under control”
- Microbiological examination
  - Floating debris submitted for optical microscopy
  - No signs of single cell bacteria, algae, or higher life forms



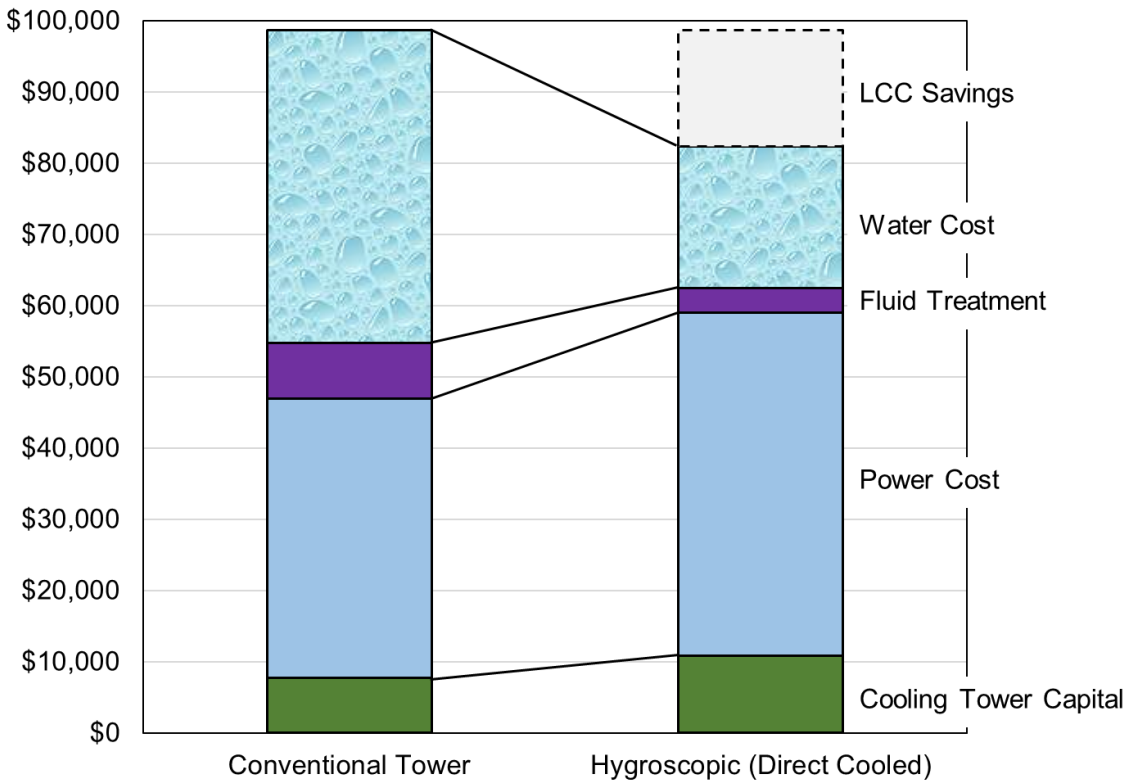
Sani-Check B slides after 48 hr incubation period. Ft. Irwin hygroscopic samples, 8/27/18



Sample microscopy image of material collected at Fort Irwin, 6/7/19

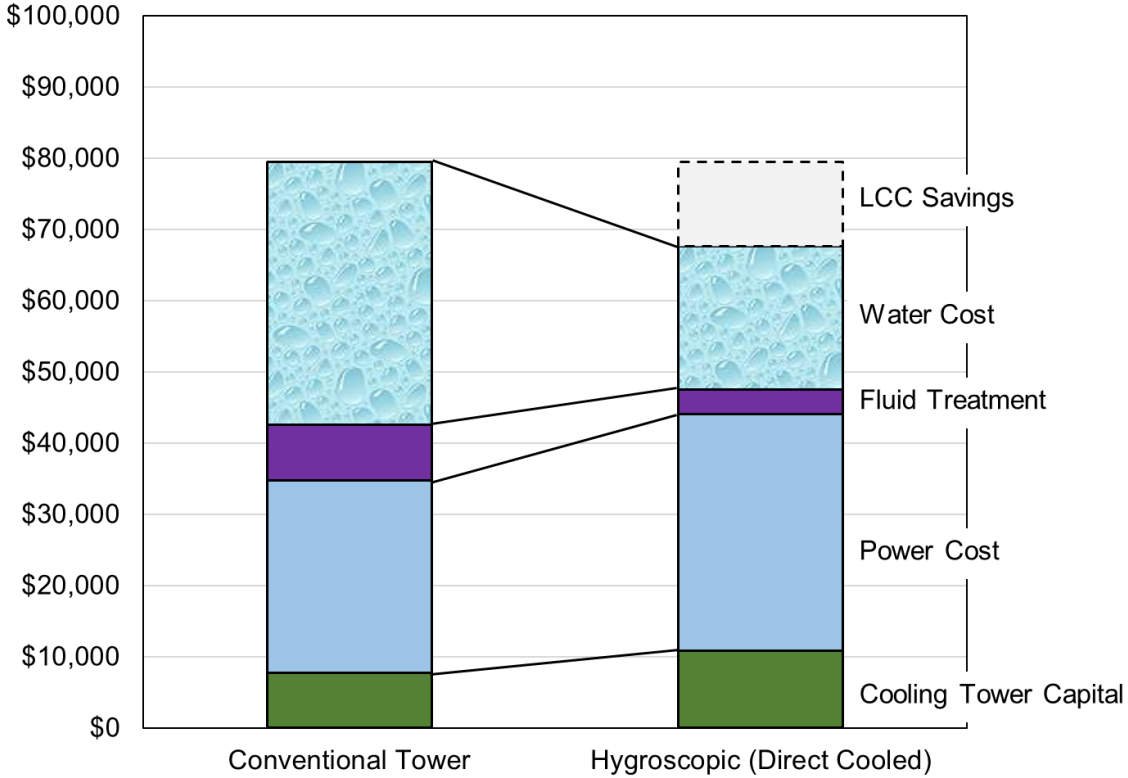
Payback Potential: Fort Irwin

- 58 ton cooling tower example (size of demonstration unit)
- $14.00 per kgal combined water and sewer rate
- Estimated 6.2 savings to investment ratio; 3 year simple payback



Payback Potential: Monterey

- 58 ton cooling tower example (size of demonstration unit)
- $11.80 per kgal combined water and sewer rate
- Estimated 4.7 savings to investment ratio; 4 year simple payback



Comparison to Other Cooling Tower Improvements

Method	Baseline	Use Reclaimed or Recycled Water	Increase Cycles of Concentration (COC)	Hygroscopic Cooling
Considerations	Existing system	Availability and quality of supply	Mandated limits in some locations	New system, not a retrofit
Key Cost Elements	None	Added piping infrastructure to reach tower	Feedback controller; added water treatment	New tower investment
Comparison Basis	Baseline, 500 kgal/year with 3 COC	Substitute lower cost reclaimed water	Increase COC from 3 to 5	30 to 50% targeted water savings
Makeup Water, kgal/year	500	500	417	250 – 350
Water to Sewer, kgal/year	167	167	83.3	0
Total Water Charge*, $/year	$4870	$2000	$3778	$2015 – $2821
Water Cost Reduction, %	0	58.9	22.4	42.1 – 58.6

* Water costs based on City of San Diego posted rates for industrial and irrigation customers (https://www.sandiego.gov/public-utilities/customer-service/water-and-sewer-rates/):
Potable water supply: $8.06/kgal; reclaimed water supply: $2.32/kgal; sewer charge: $5.04/kgal

Early Conclusions

- Hygroscopic cooling
  - Significant water savings potential without compromising cooling performance
  - Simplified control of water quality and microbial growth
- Outlook
  - Appears competitive today for favorable sites
  - Key factors: water cost, water quality, and annual run time
  - Consuming otherwise unusable waste waters might be even more cost effective

Next Steps for the Demonstrations

- Operate field tests through 2019
- Post demonstration analysis
  - Corrosion coupons
  - Dissolved solids control
- Cost assessment
  - Develop equipment costing
  - Update payback analyses

Benefits to DoD

- Free cooling with cooling towers
  - Bypass chiller, cool directly with tower
  - Potential low power backup cooling for emergency or resilience planning

Device	ASHRAE 90.1 Standard; >150 tons	Common Basis, kWth/kWe
Air Cooled Chiller	10.10 Btu/W-hr	3.0
Water Cooled Centrifugal Chiller	0.610 kW/ton	5.7
Cooling Tower	40.2 gpm/hp*	79

- Addition of hygroscopic cooling
  - Reduced inputs; fewer restrictions on water quality
  - Simplified operation for remote and/or emergency operation

**Based on a 10°F temperature range and a 10°F wet bulb approach*

Acknowledgments

- Partnering organization
  - Mr. Scott Lux; U.S. Army Engineer Research and Development Center Construction Engineering Research Laboratory (ERDC-CERL)
- Host sites
  - Mr. Christopher Woodruff; National Training Center and Fort Irwin
  - Mr. John Wallingford; DoD Center Monterey Bay, Presidio of Monterey
- Technical contributor
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For additional information, please visit https://www.serdp-estcp.org/Program-Areas/Installation-Energy-and-Water/Water-Conservation/EW-201723

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Q&A Session 2

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The next webinar is on August 22, 2019

Pacific Island Ecology and Management: Recovery of Native Plant Communities

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