

# Net-Zero Water: Energy-Positive Municipal Water Management

James D. Englehardt, Ph.D., P.E.

George Tchobanoglous, Ph.D.

Tingting Wu, Ph.D.

Lucien Gassie

Jay Garland, Ph.D.

Piero Gardinali, Ph.D.

Nichole Brinkman, Ph.D.

Jian Wang, Ph.D.

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**MS and undergraduate students:** (65)

**High school interns** (5)

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## REGULATORY AGENCIES

**Miami-Dade County Dept. Envir. Resources Mgmt.**  
**Miami-Dade County Dept. Health**  
**Florida Dept. Environmental Protection**  
**Coral Gables Building & Zoning**

# Motivations since 2003: Water, Energy, Chemicals

- Water

- California, Texas, Alaska
- Miami (60 in/y) → Landscape  $\leq 2$  days/week

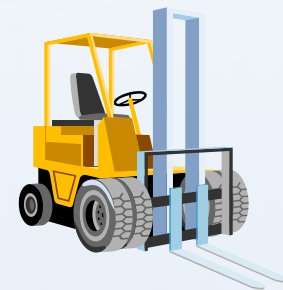
- Energy

- Sea level rise



# Third Challenge: Chemical Accumulation

- TRI releases: 6.2 billion lbs. (2001)
- US pesticide usage: 5 billion lbs. (2002)
- US surface + ground runoff: 1.8 trillion gpd
- Average 2000  $\mu\text{g/L}$  toxics → US waters



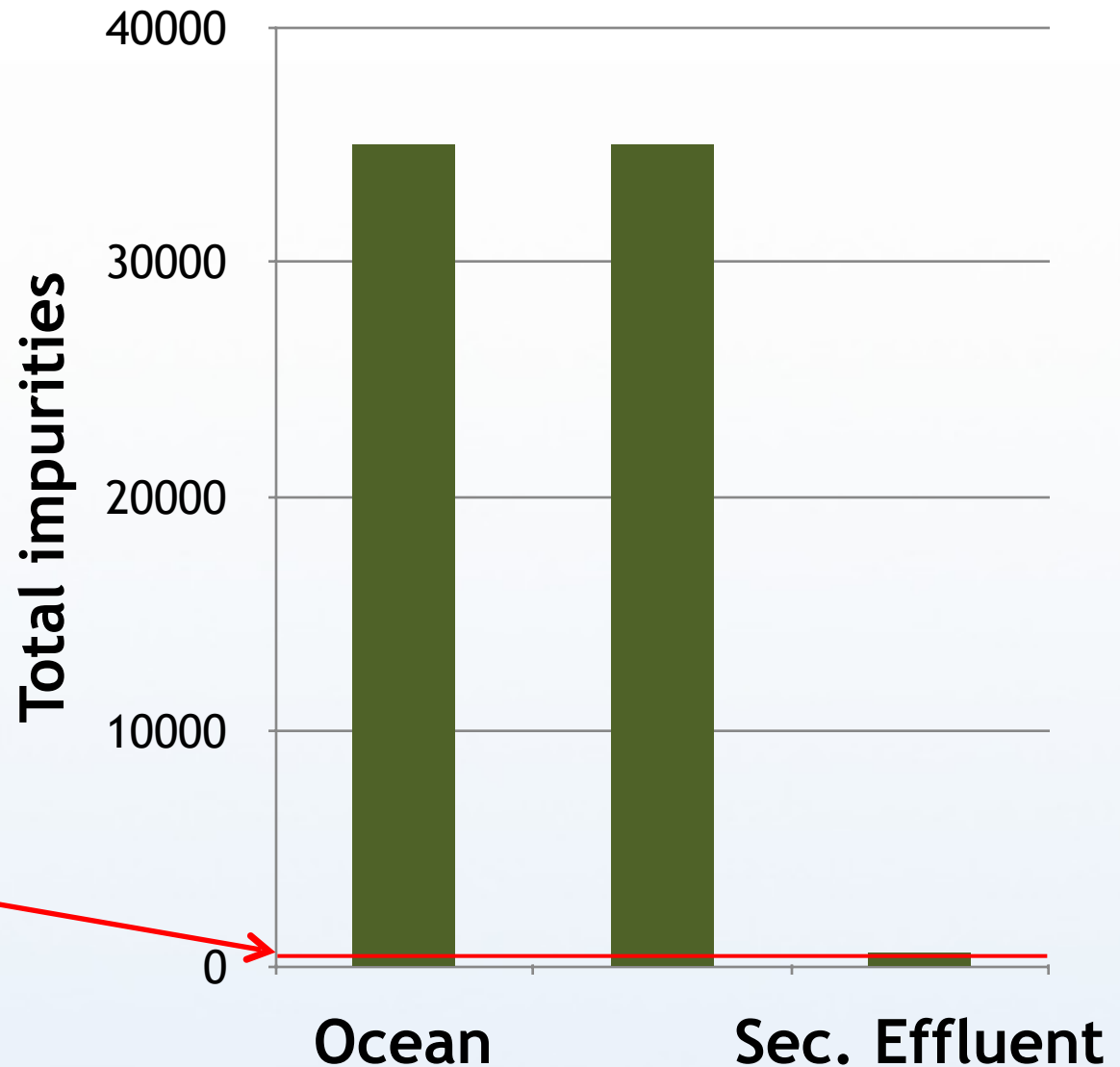
# Health and Environmental Effects

- US blood samples → toxics universal
  - (Thornton et al. 2002; CDC 2003)
- Wildlife/humans → endocrine disruption
  - 5% alligator fertility Lake Apopka



# Water Impurity Levels (TDS)

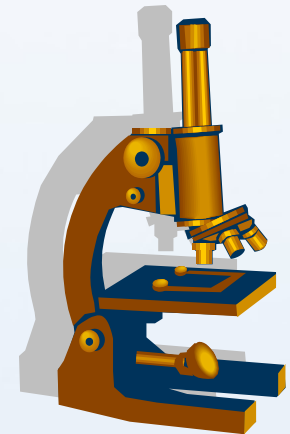
Secondary  
drinking water  
standard



# Treated Wastewater Quality (Average S. Florida)

Meets drinking water standards except:

- Antimony
- Total coliforms
- Secondary:
  - Color
  - Odor
  - TDS (551 mg/L)
  - foaming agents



# Current Water Recycling

- Wastewater segregation
  - Multiple conveyance and treatment systems
  - No water independence
  - Dry (composting) toilets
- Direct potable reuse: reverse osmosis
  - Continual concentrate disposal
  - Chemical constituents
  - Microbes

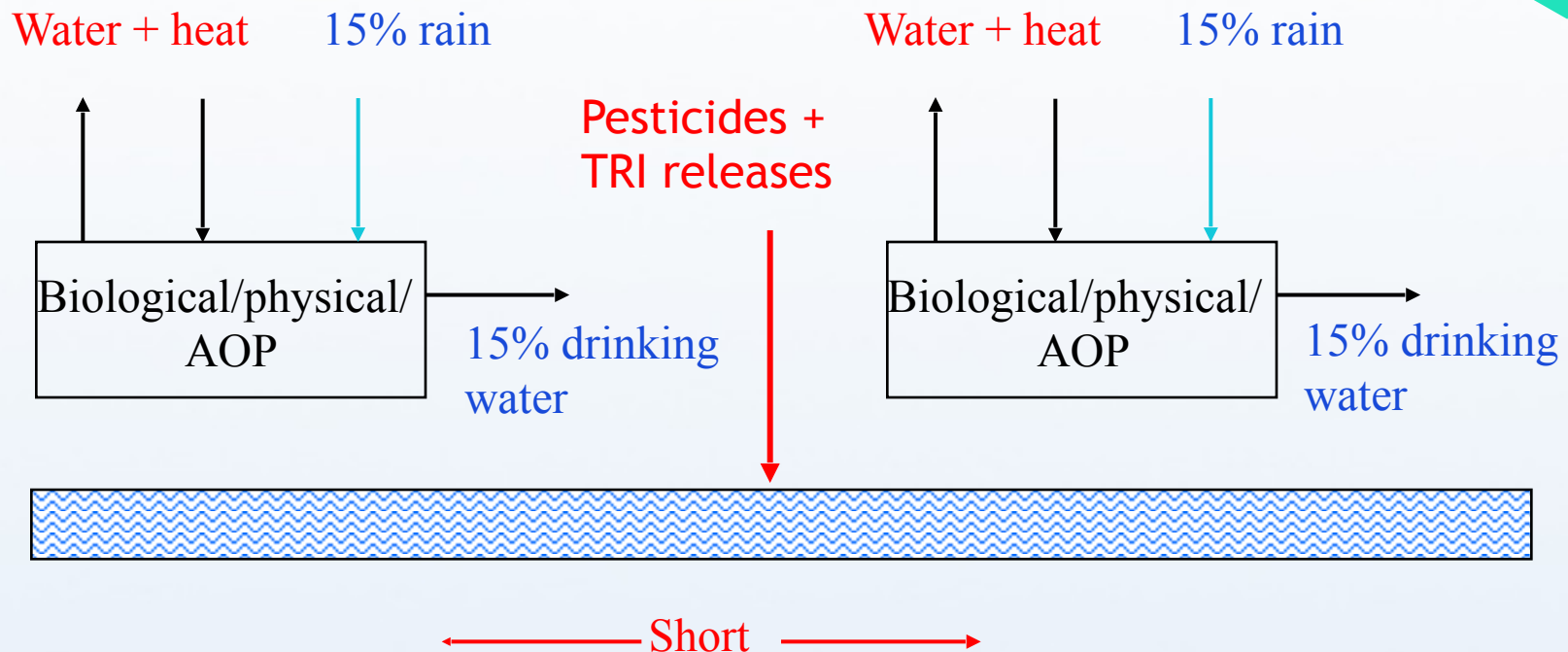




# DPR Water & Energy Recovery

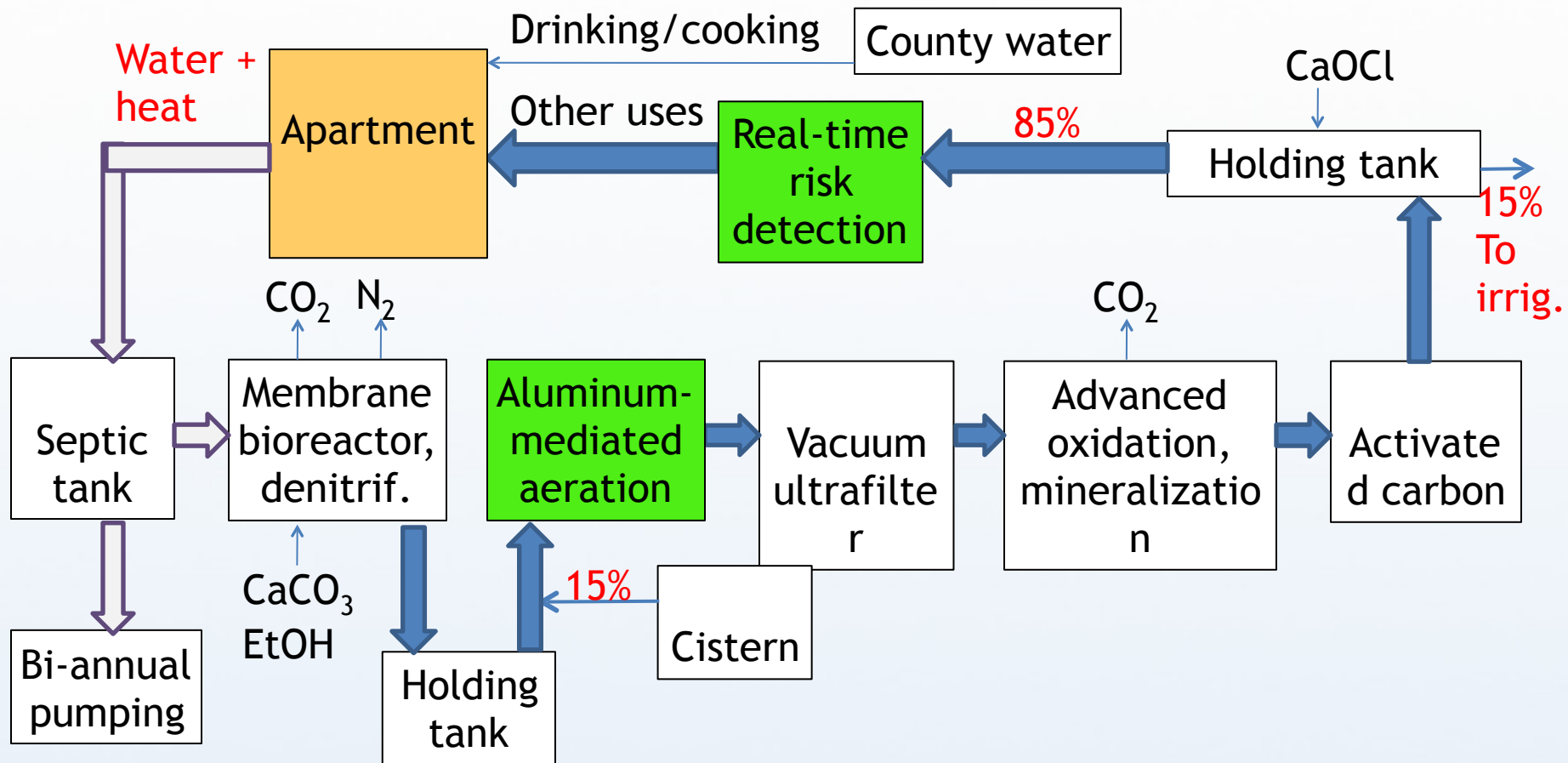
- Windhoek, Namibia: 20% recycle
- Big Spring, TX: 20%
- International Space Station: ~75% urine
- U of Miami Net-Zero Water system: 85%

# Net Zero Water Management (85% Recycle)

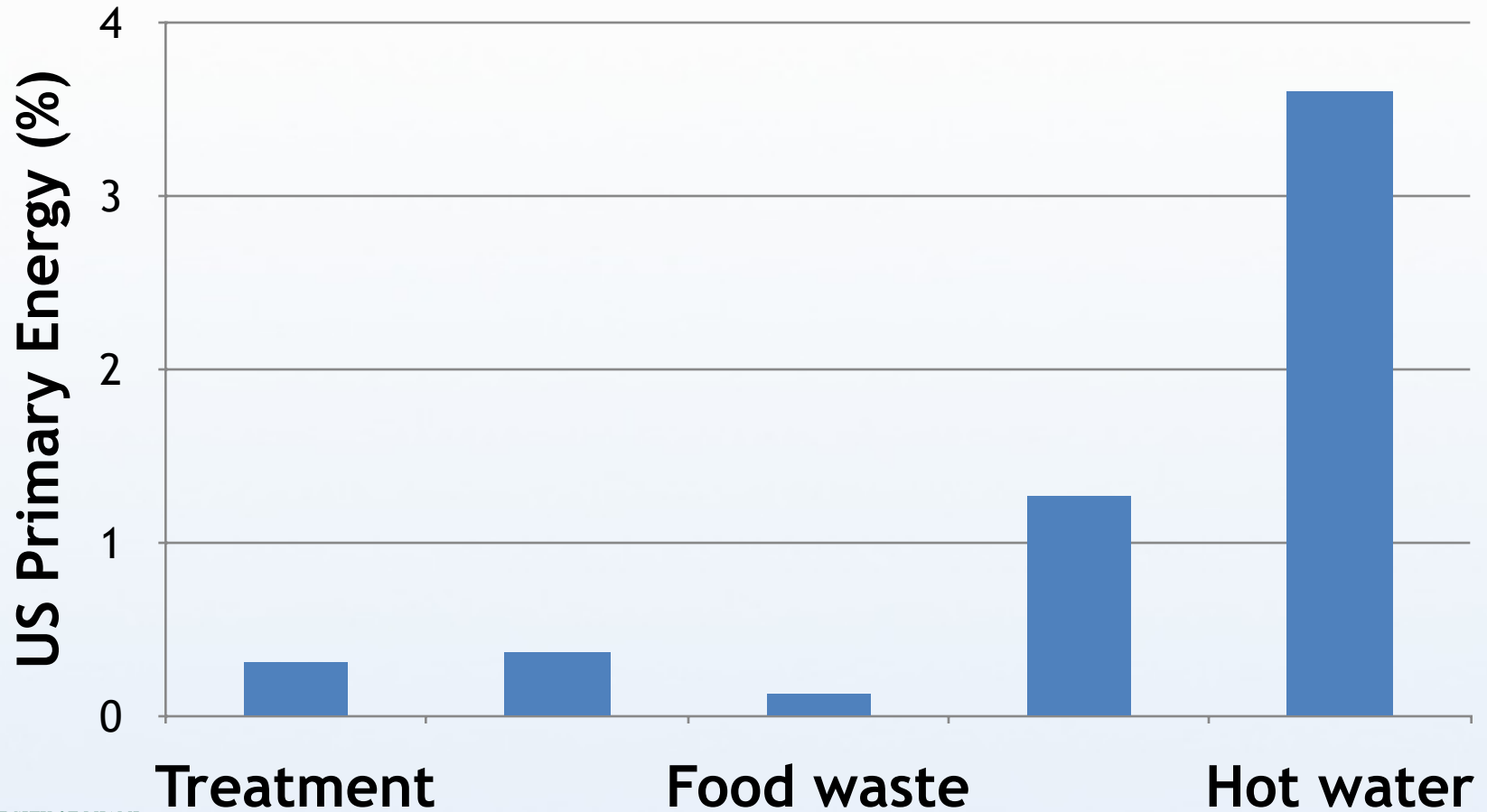


# Net-Zero Water:

## Nearly Closed-Loop Water/Energy Recycling



# Municipal Water Energy



# UM Urban Net-Zero Water System

- Save 56% of hot water energy
  - Equal to that used for treatment
- Water recycle: 85%
- No concentrate disposal
- Pump sludge every 1-2 years
- Meet potable reuse guidelines

# Residence Hall Site



← Auton.  
net zero  
water  
unit

# Treatment System

Above-ground



Aerobic/cistern





# Control Systems

## Master controls



## Peroxone & UV-peroxide







National Science Foundation (NSF)

April 26

University of Miami students are taking part in a water recycling research project just by living in the Autonomous NetZero Water Dorm - catch the story in our featured podcast line-up @Science360 Radio!

<http://go.usa.gov/kvXz>

## Toilet



## Drinking water



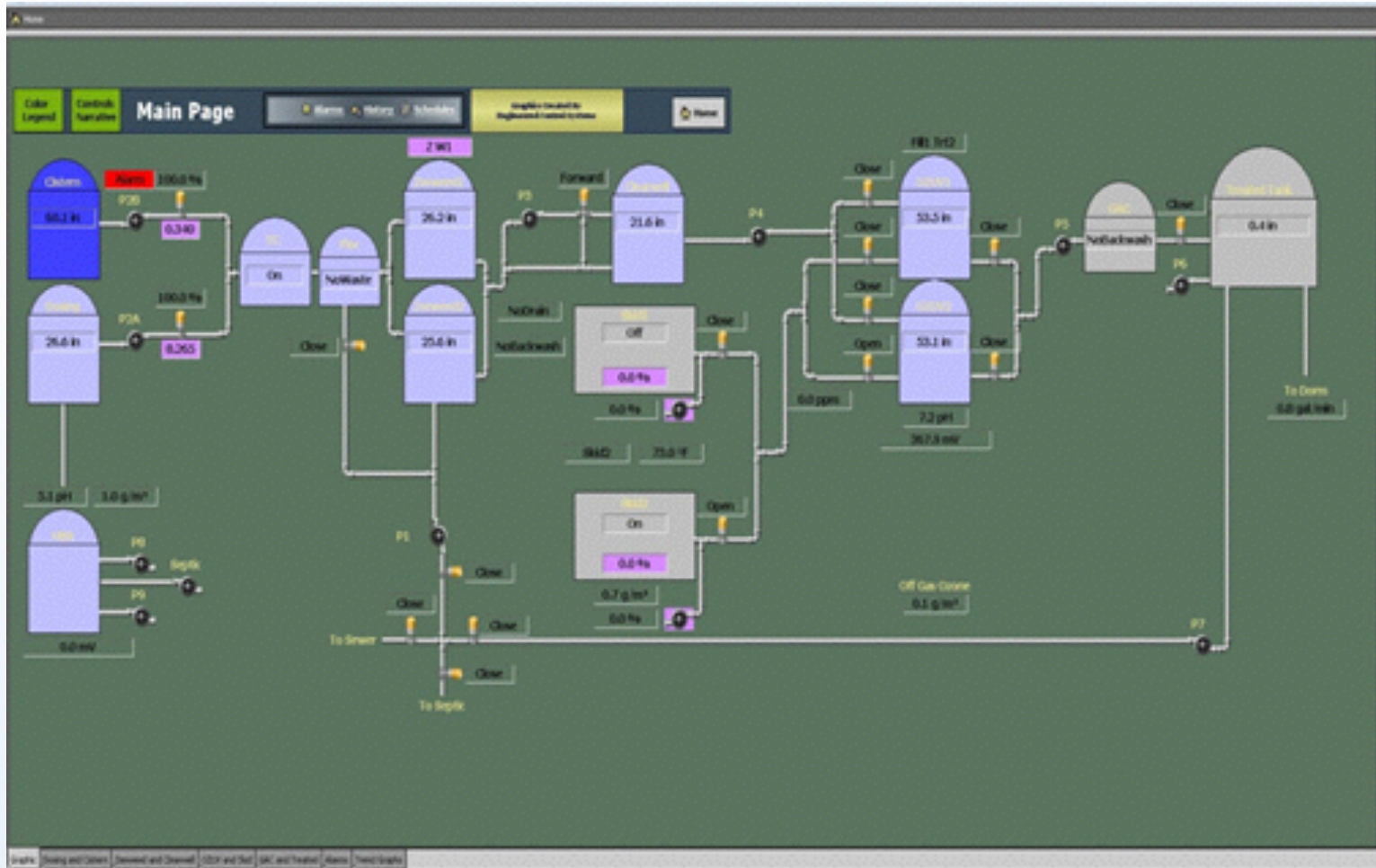
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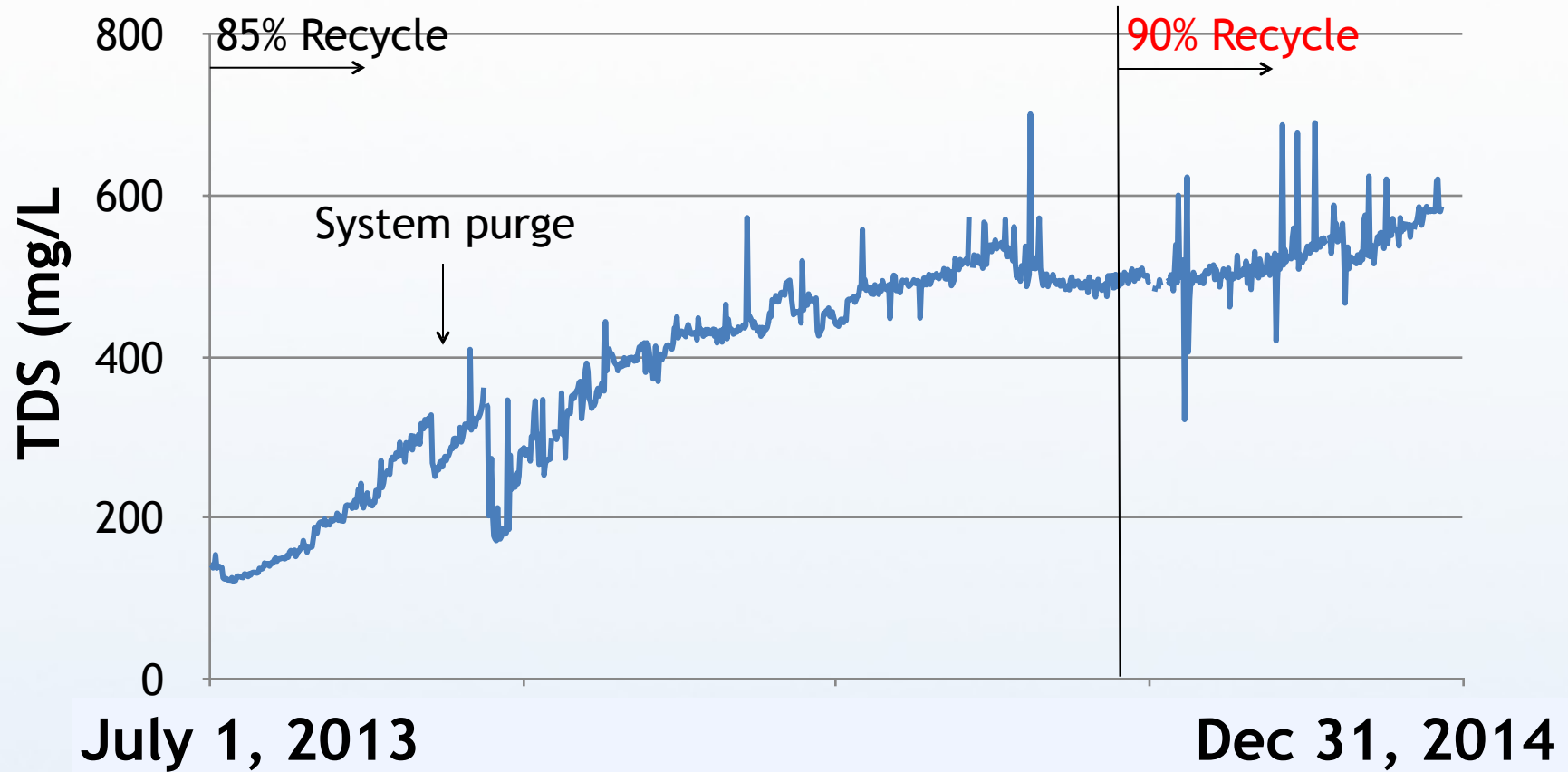


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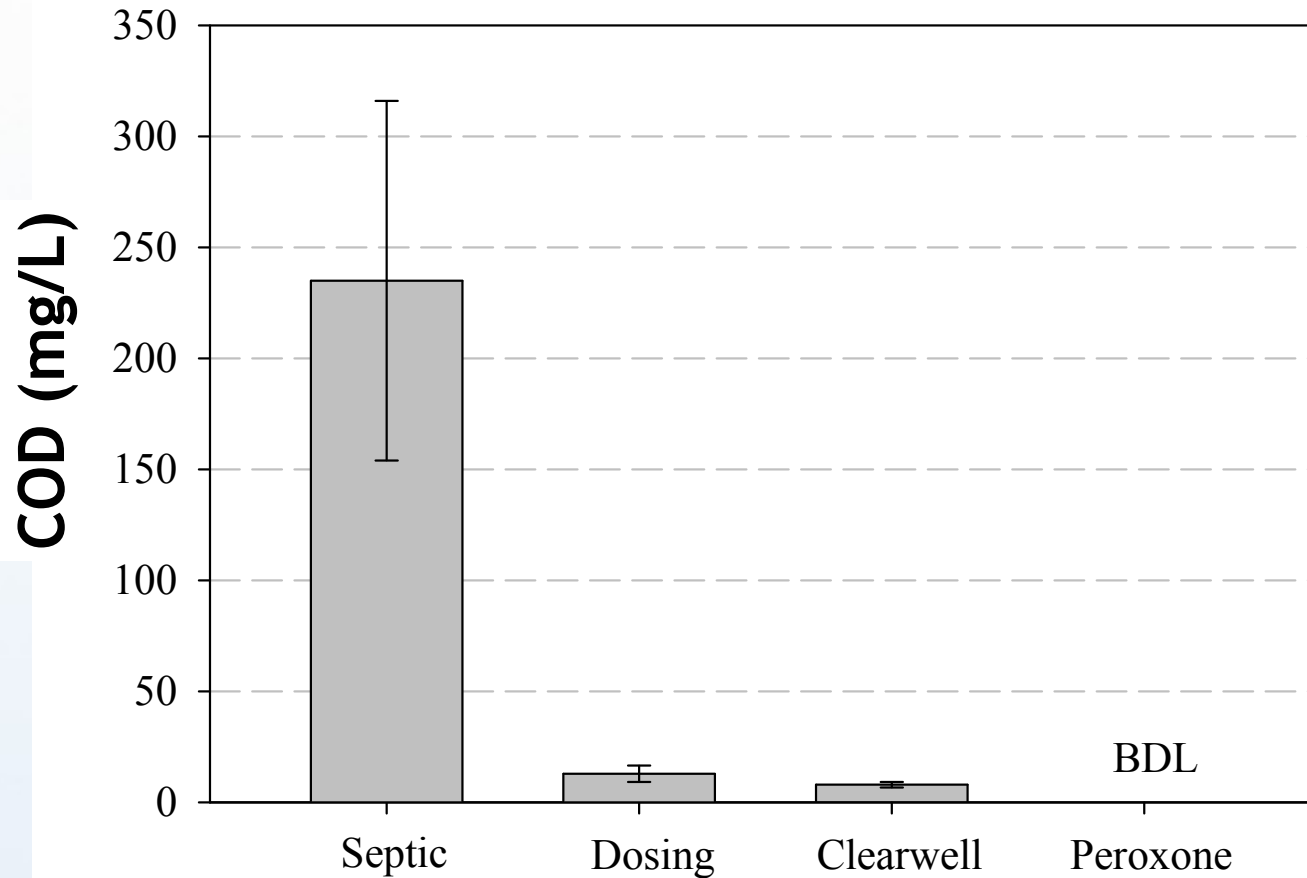
# Remote Process Control



# Minerals (mg/L TDS)

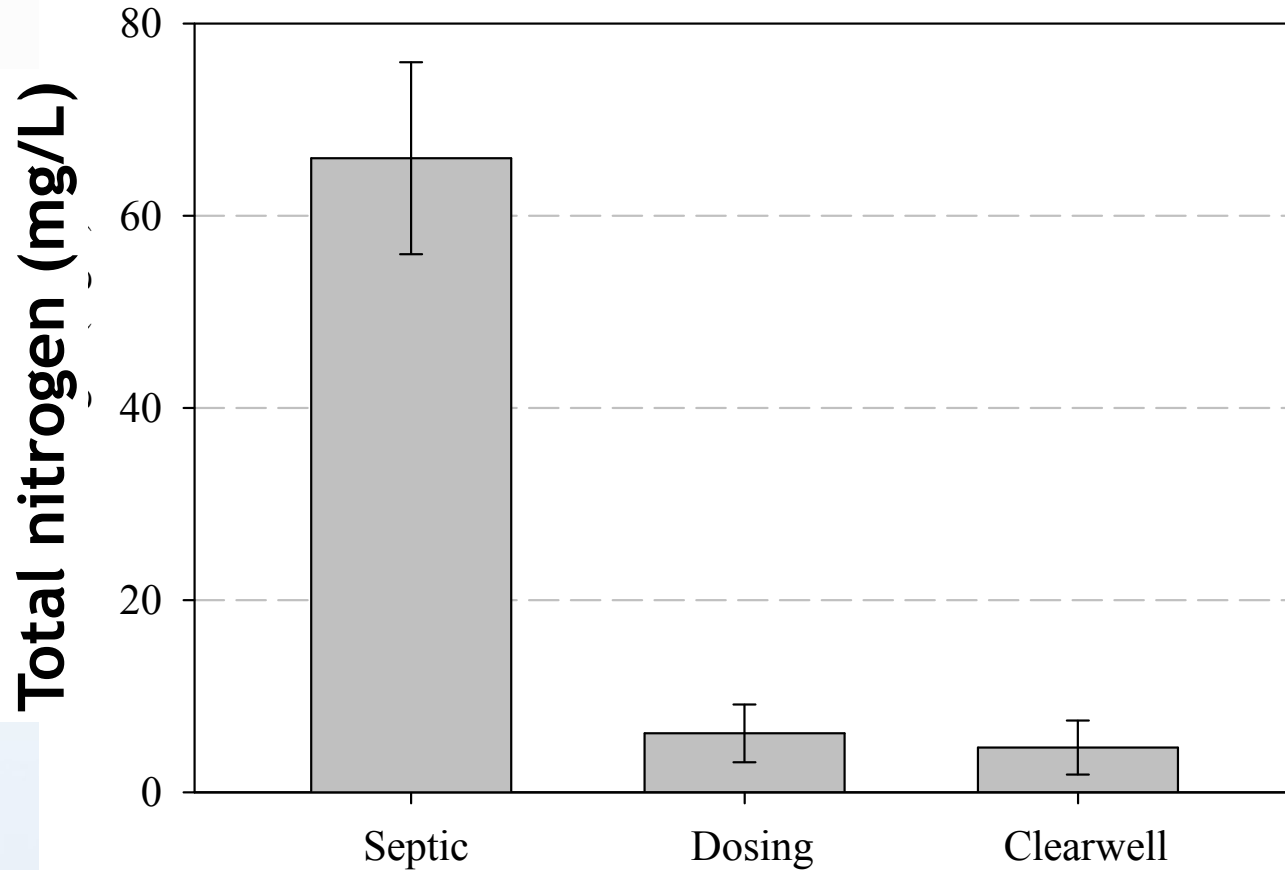


# Organics Reduction through System

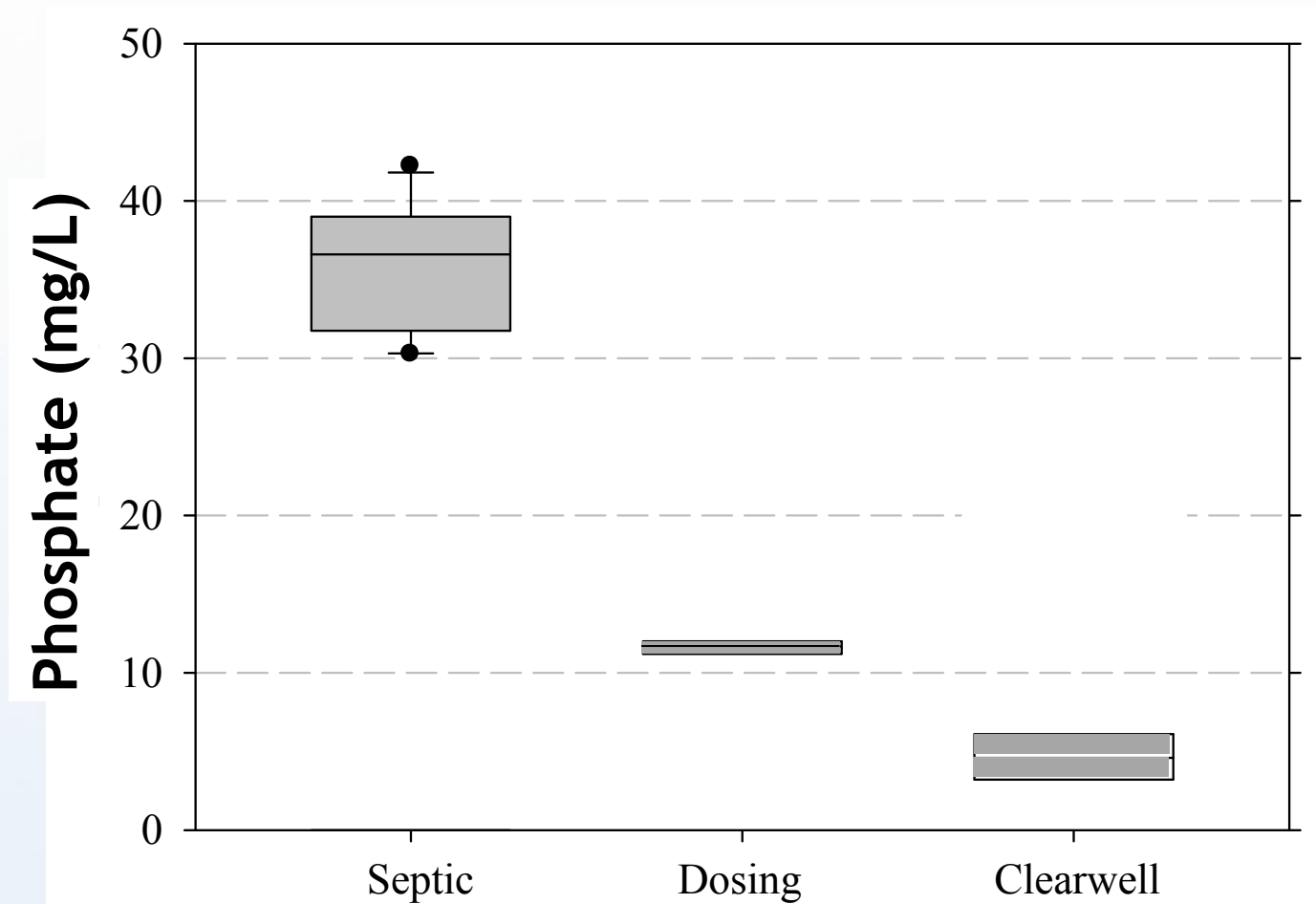


# Reduction of Nitrogen Species

(Jul., 2013 - Dec. 2013)



# Phosphate Reduction through System



# Chemicals

- 1006 emerging constituents tested
- Influent: 56
- Effluent: 50 removed >90%
  - 50 removed >90%
  - 3 increased including DEET
  - 97 of 97 pharms, hormones, personal care products undetected

# Microbes

- MS coliphage: **none**
- Somatic coliphage: **none**
- Adenovirus: **one** qPCR signal
- Cryptosporidium: **none**
- Giardia: **none**
- Fecal coliform: **8 positive** of 136 daily plates



## Log Reductions – if we could extrapolate treatment response linearly

Organism	Virus	Giardi a	Crypto
NZW: Peroxone	44	89	40
NZW: UV/H <sub>2</sub> O <sub>2</sub>	164	32	30

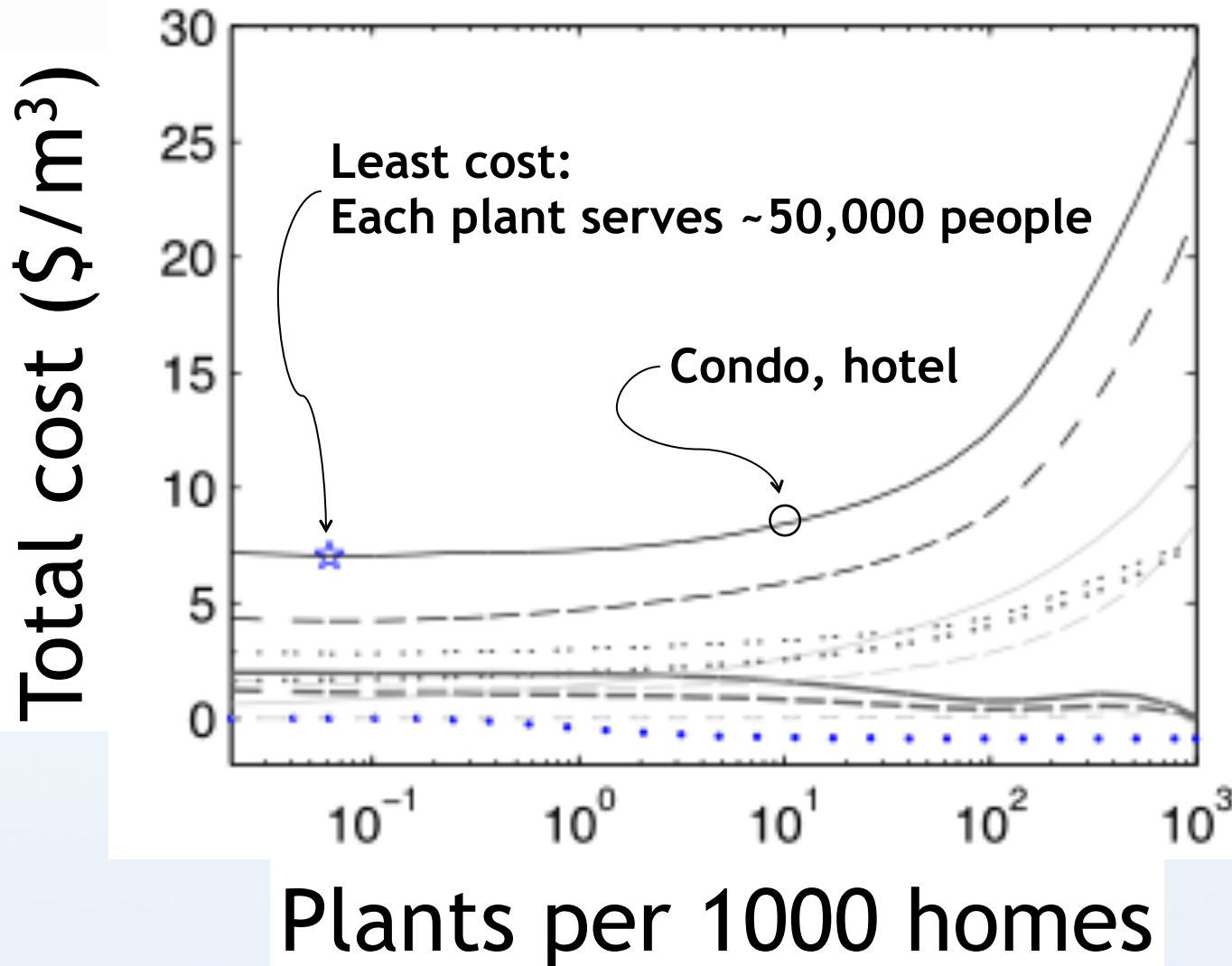
# Compliance

- 115 of 115 drinking water stds met:
  - 10/15/2013 – 7/3/14
- 114 of 115 drinking water stds met:
  - 7/3/14 – 12/3/2014
  - Bromate: 20 µg/L

# Process Control

- Bromate → Backwash water disposal
- FC → catalytic GAC
  - Remove hydrogen peroxide residual
  - Maintain chlorine residual

# Cost versus Plant Scale



# Energy Demand: 1 MGD Plant (kWh/m<sup>3</sup> primary energy; EPRI 2002)

Treatment total:	-9.12
• Wastewater:	-2.39
• Water:	-2.10
• Peroxone mineralization:	-6.52
Hot water savings:	13.25
• Hot water:	23.81
• Losses:	10.56
Energy Saved:	<hr/> 4.13
Conveyance Energy:	-0.99

# Conclusions: NZW

- Mineralization energy: \$8/1000 gal
  - Total cost 45% lower than San Francisco
- Water independence
- Energy retained in closed loop
- No concentrate disposal
- 15% drinking water disposed
- 1-2 year sludge pumping

# Recommendations: NZW

- Remote automated process control
- Local monitoring, maintenance
- Skilled technician on call
- Information:
  - Google: net-zero water miami
  - jenglehardt@miami.edu

# Goundbreaking in Miami

Working ...



... for the  
next  
generation, in  
Alaska  
**Thank you**