ZAPS TECHNOLOGIES
www.zapstechnologies.com

Process Optimization Using Spectrophotometers

By Bud Dunbar
ZAPS Technologies
617-448-0440
robert.dunbar@zapstechnologies.com

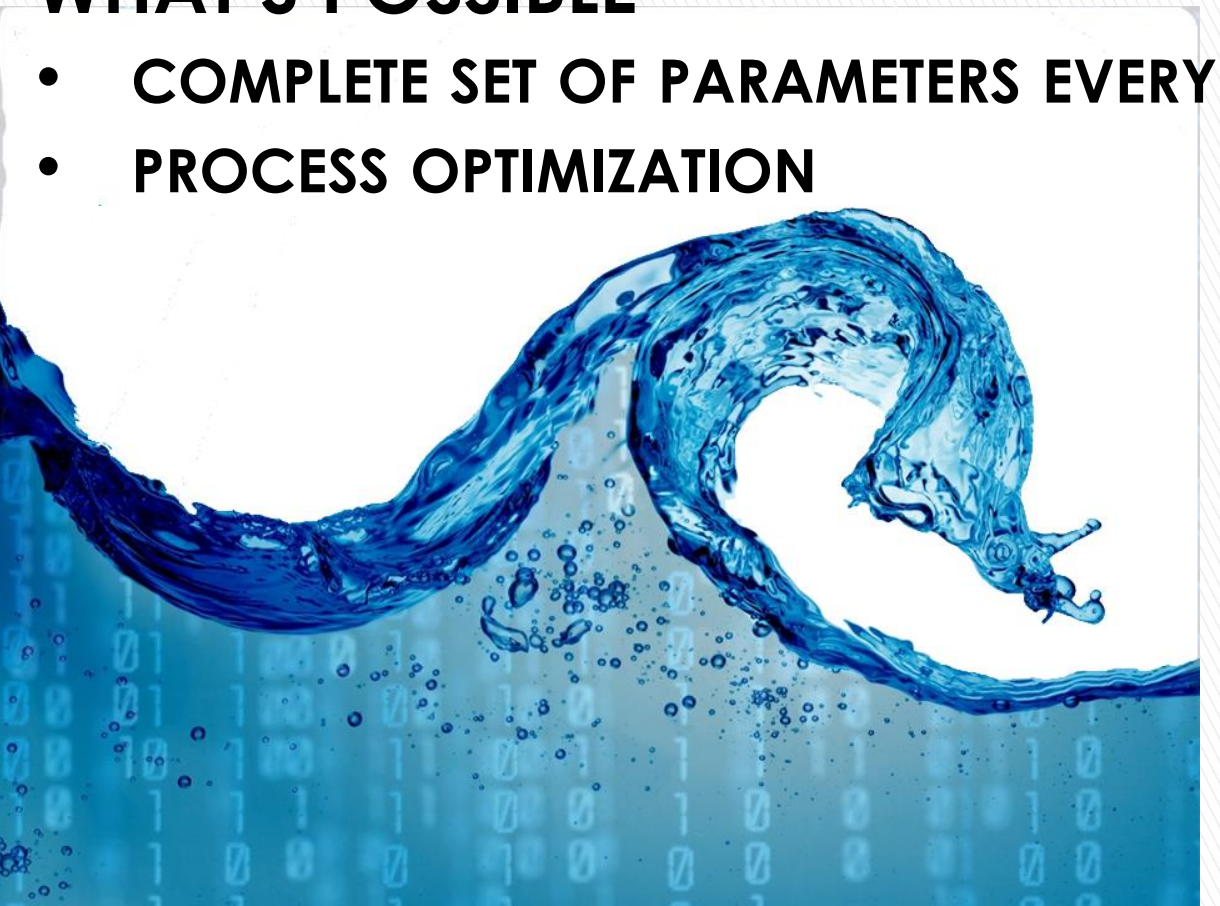
YOU CANT MANAGE WHAT YOU DON'T SEE

WHAT's CHANGED?

- INEXPENSIVE & POWERFUL PHOTON COMPONENTS
- POWERFUL COMPUTERS
- ANALYTICAL ALGORITHMS

WHAT'S POSSIBLE

- COMPLETE SET OF PARAMETERS EVERY 2 MINUTES
- PROCESS OPTIMIZATION

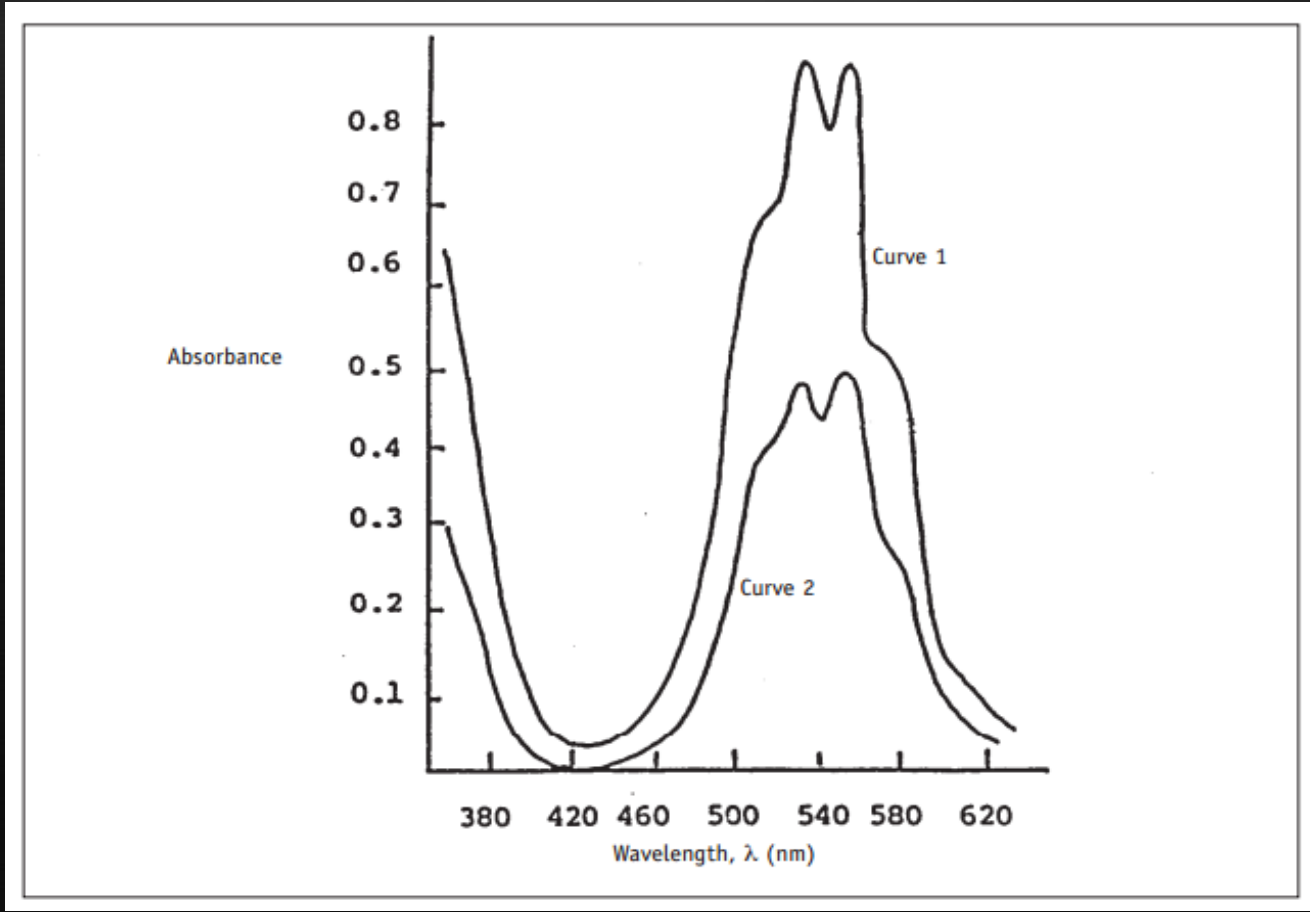


What is Spectrophotometry ?

Here is an example:

When certain frequencies of light hit Nitrogen Dioxide (common in air pollution) you get distinctive absorbance characterized by a reddish color

Absorbance vs Wavelength Potassium Permanganate (KMn04)– Sample 1 had a higher concentration than Sample 2



SPECTROPHOTOMETRY ENABLES:

- Multiple parameters at once
- Direct measurements
- In the natural matrix
- No reagents, no labor, no delay
- Much easier to maintain than in tank probes
  - Self cleaning
  - Self calibrating
- Digital, online, real time
- Highly accurate

Real Time, Online, Accurate

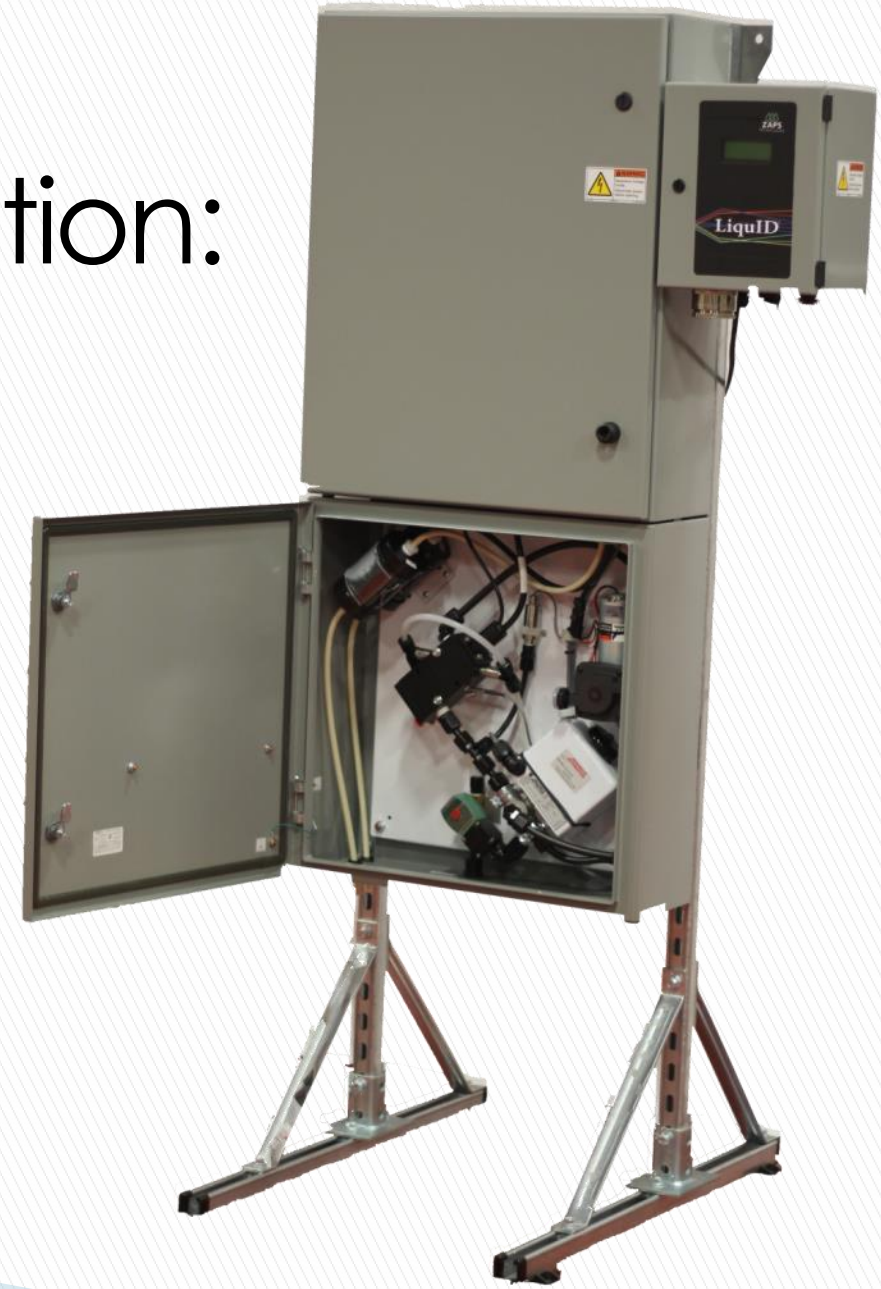
WASTEWATER		DRINKING WATER	
BOD	Biochemical Oxygen Demand	BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous BOD	CHLa	Chlorophyll-a
COD	Chemical Oxygen Demand	CHLb	Chlorophyll-b
ECOLI	Fecal Contamination	CHLORINE	Total Free Chlorine
FDOM	Fluorescent Dissolved Organic	COLOR	Color
NH3	Ammonia	ECOLI	Fecal Contamination
NO3	Nirate+Nitrite	FDOM	Fluorescent Dissolved Organic
T	Temperature	NH3	Ammonia
TKN	Total Kjeldahl Nitrogen	NO3	Nirate+Nitrite
TOC	Total Organic Carbon	OIL	Refined Hydrocarbons
TSS	Total Suspended Solids	PHYCO	Phycobilin Chromophore
UVA	UV 254 Absorbance	RHO	Rhodamine
UVT	UV 254 Transmission	SIZE	Relative Particle Size
VFA	Volatile Fatty Acids	SUVA	Specific UV Absorption
		T	Temperature
		TKN	Total Kjeldahl Nitrogen
		TOC	Total Organic Carbon
DO NOT SEE:		TOX	Disinfection Byproducts
	Phosphorus	TSS	Total Suspended Solids
	Disolved Oxygen	TURB	Turbidity (ATU)
	PH	UVA	UV 254 Absorbance
	ORP	UVT	UV 254 Transmission

State of the Art

- Measure several properties of light
  - Absorbance,
  - Florescence,
  - Reflectivity or Scattering
- Looking at very specific outgoing and incoming frequencies across a wide spectrum of frequencies
- Characterize normal underlying water matrix
- Using high energy photons
- Very sophisticated algorithms eliminate/separate noise, tss, turbidity, temperature, pressure, etc

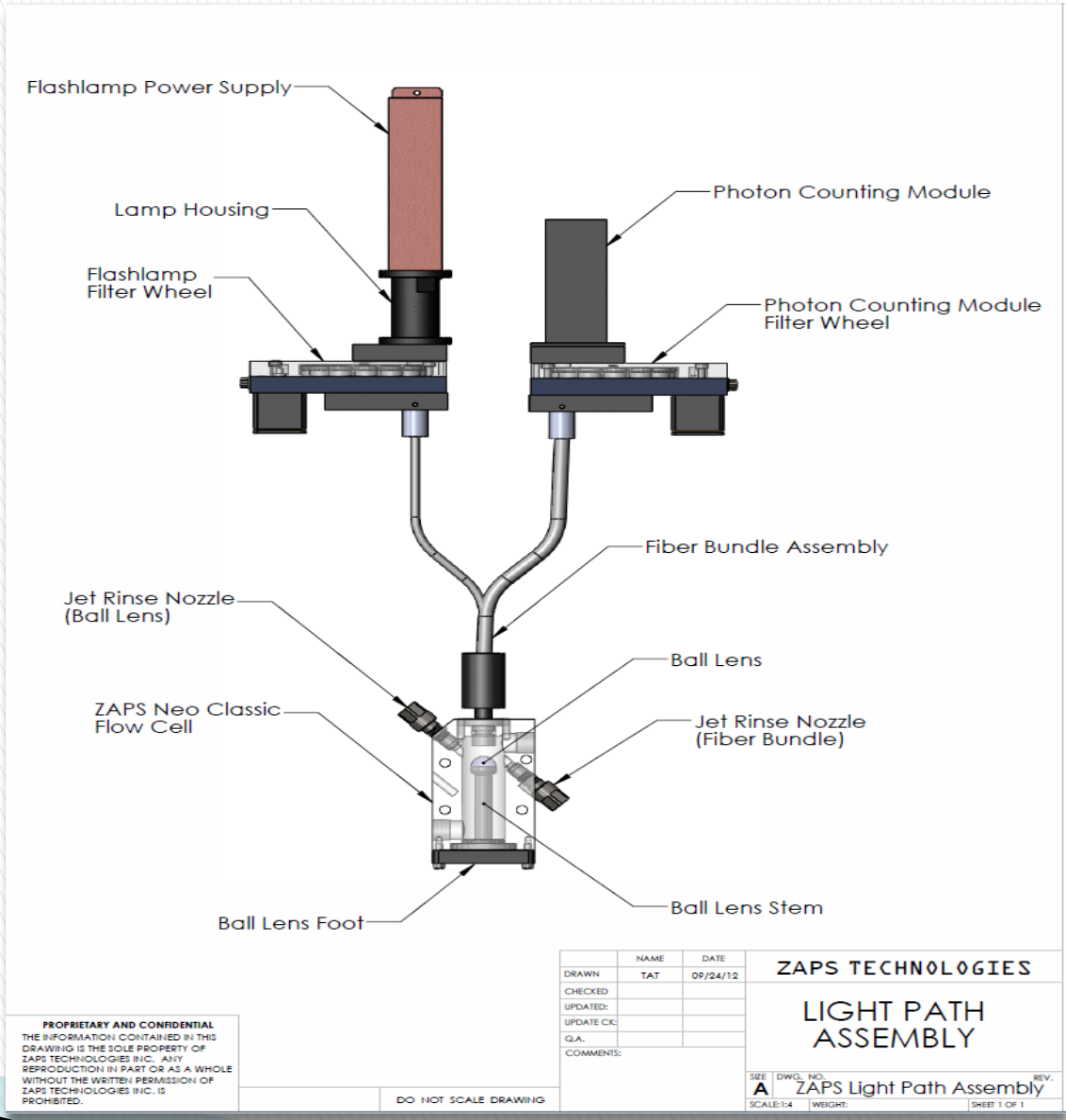
An implementation:

ZAPS

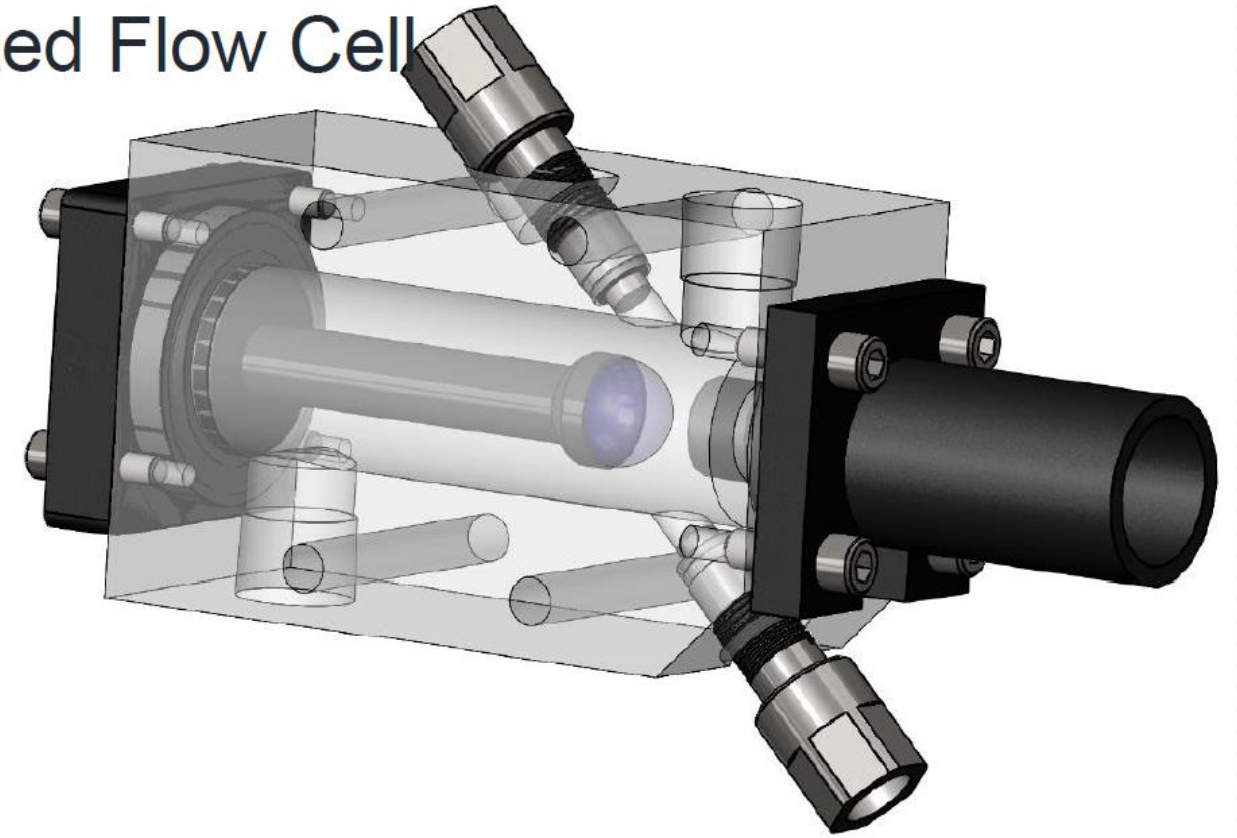


ZAPS LiquID Station : How it works

- High energy light passes from the lamp to the photon counter
- Multi-Spectral Frequencies
- - 2 Carousels of specific frequency filters one at the source and one at the detector
- Measure absorbance and florescence
- Reduction of spurious photons (noise) with proprietary optics
- Zero Angle Photon Spectroscopy (ZAPS)



Patented Flow Cell



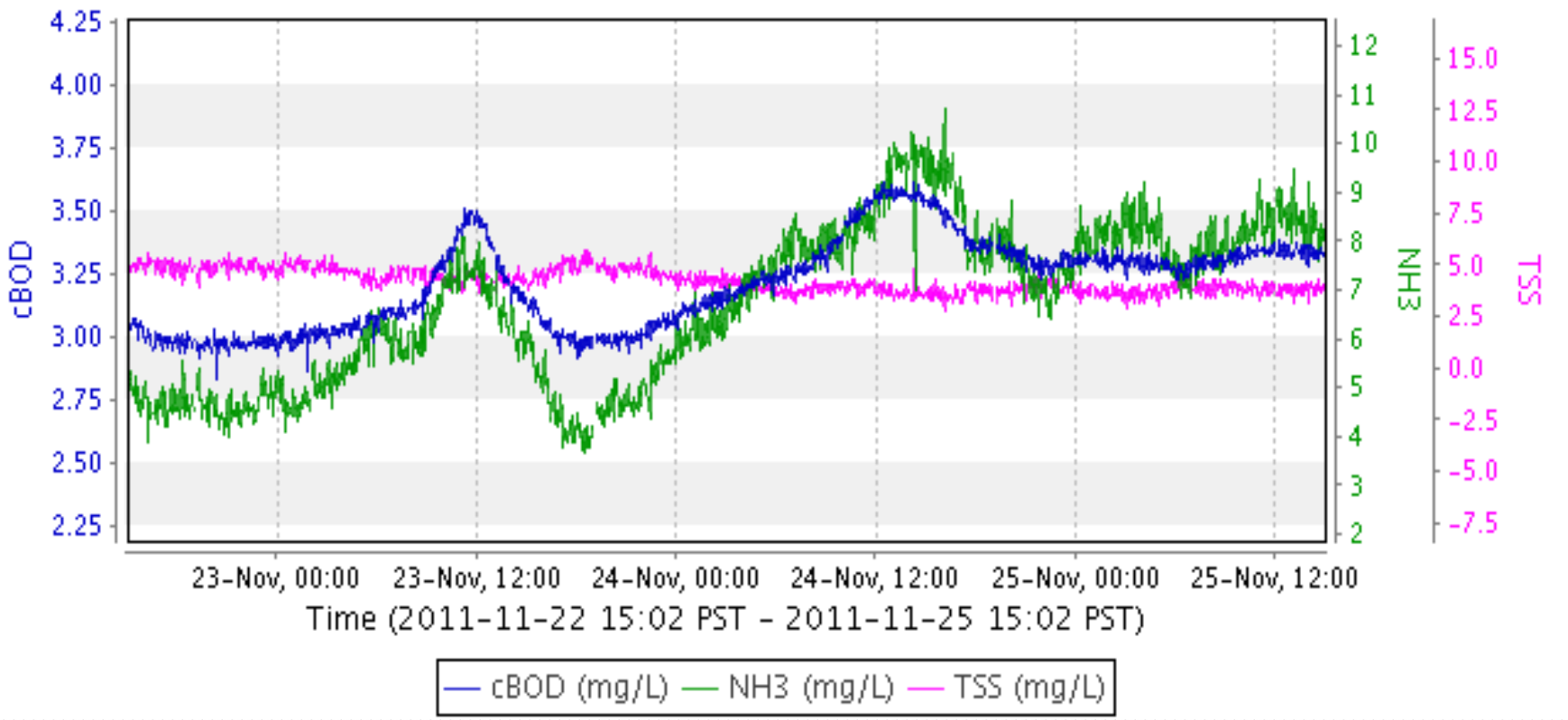
- Water Sample Flows through the Flow Cell
- Light passes through the water sample
- Optics are cleaned automatically
- Self calibrating
- No reagents, no labor, no time delay

Data Access

Secure Data Options

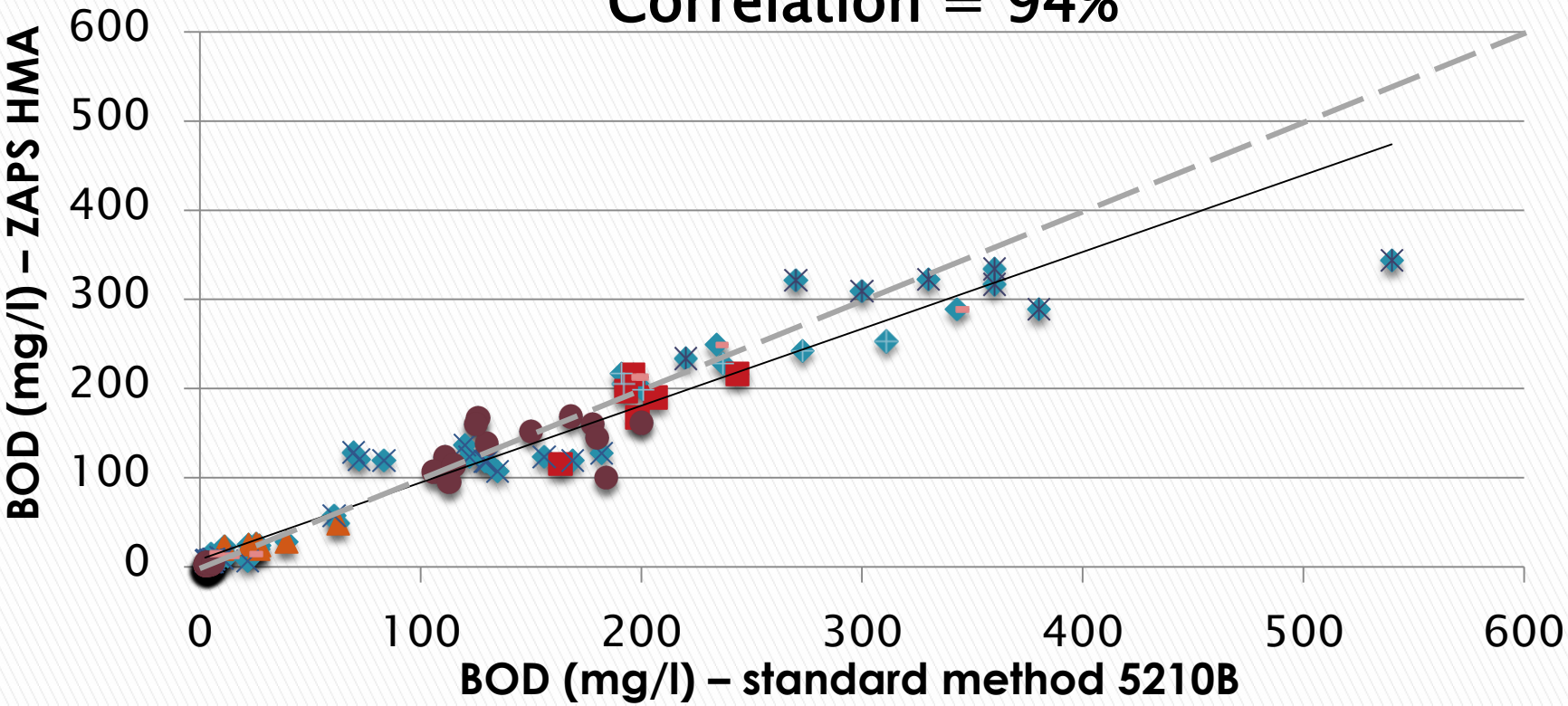
- Cellular uplink
- Ethernet connection (VPN)
- 4-20mA
- Digital connection to:
  - SCADA or
  - PLC

Graphical Web User Interface



ZAPS TECHNOLOGIES

Standard Lab Tests vs Spectrophotometry
Correlation = 94%

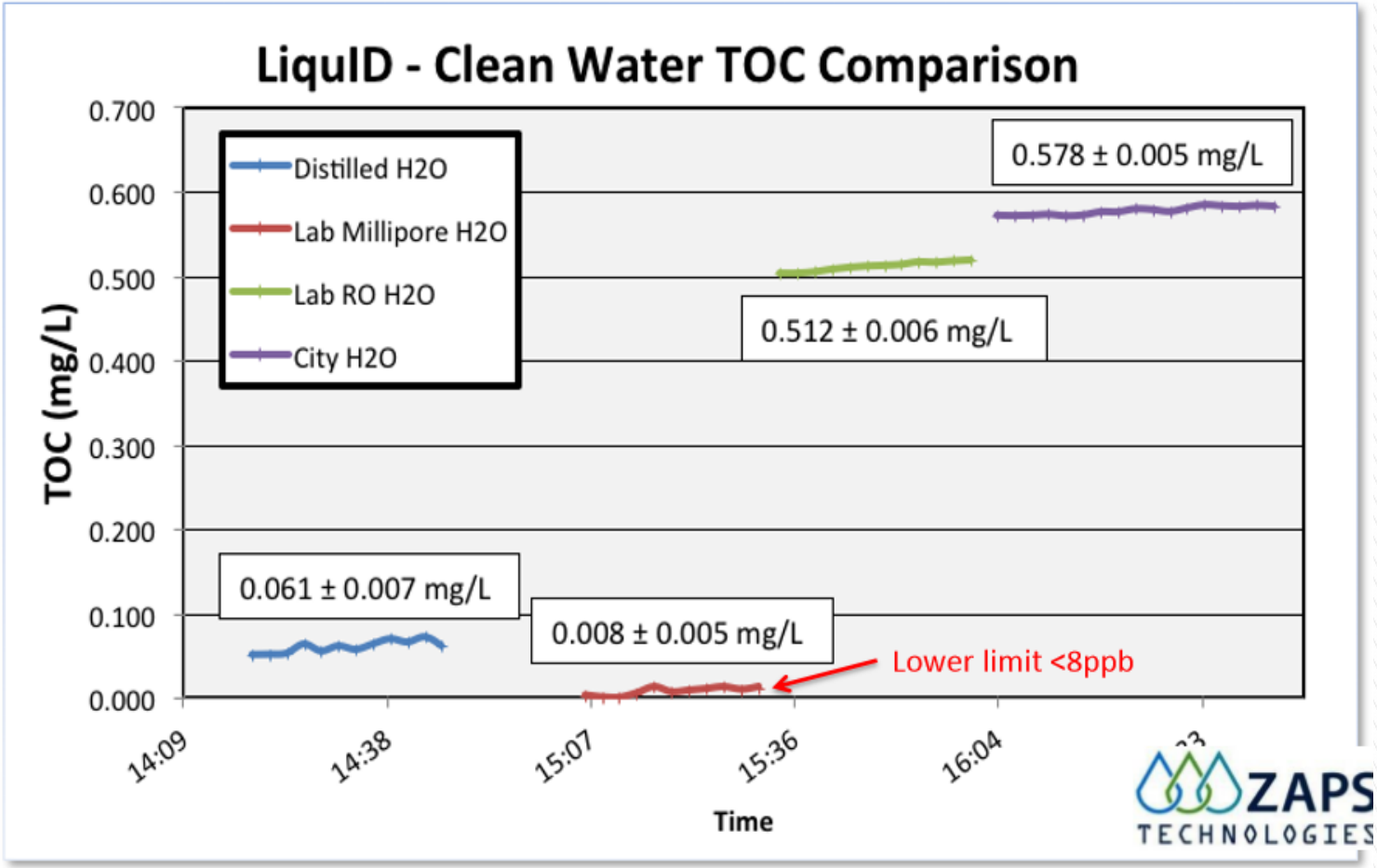


HMA Data vs Standard Method 5210B	
Installation Locations	7
Number of LiquID Stations	11
Grab Samples (N)	100
Correlation (R^2)	0.94

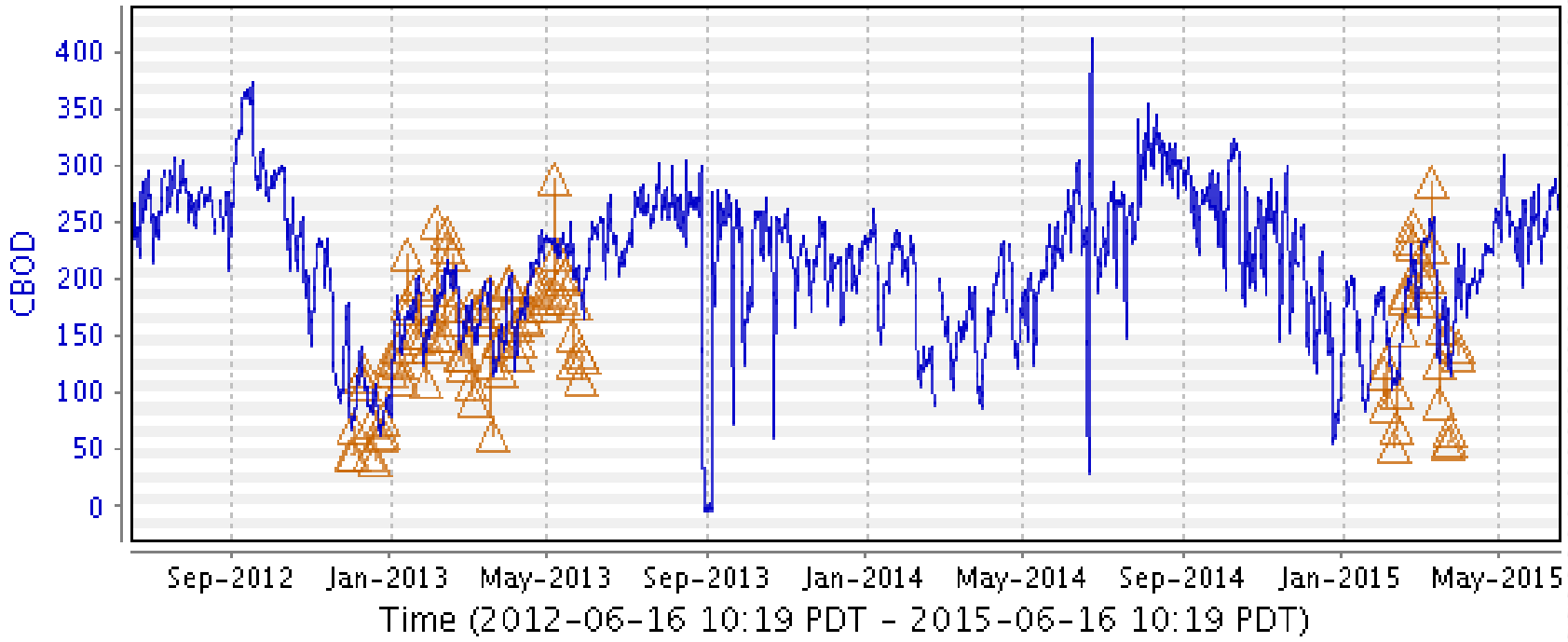
Parameters

Parameter	Detection Range/Sensitivity	Accuracy
Airplane Deicing Fluid	0.5 to 10000 mg ADF/L	±5%
Ammonia Gas (NH3)	0.2 to 100 mg-N/L	±8%
Biochemical Oxygen Demand (BOD)	0.2 to 700 mg/L	±8%
Carbonaceous BOD (cBOD)	0.05 to 600 mg/L	±8%
Chemical Oxygen Demand (COD)	0.7 to 1400 mg/L	±6%
Chloramine	0.01 to 11 mg/L	±5%
Chlorophyll a	0.3 to >100 ug/L	±5%
Chlorophyll b	3 to >100 ug/L	±5%
Color @440nm	2 to 1500 Pt/Co Unit	±5%
E. coli	0.1 to 23M MPN/100 mls	±10%
Fluid Temperature	-4 to 100 deg C	±3%
Fluorescent Dissolved Organic Matter (FDOM)	0.5 to >100 DFU	±5%
Nitrate+Nitrite (NO2+NO3)	0.03 to 50 mg-N/L	±9%
Phycobilin Chromophore	0.9 to >100 DFU	±5%
PTSA	0.5 >100 DFU	±5%
Oil – Refined Hydrocarbons	0.5 to >100 DFU	±5%
Rhodamine	0.5 to >100 DFU	±5%
Specific UV Absorption (SUVA)	0.06 to 5 L/mg-C•m-1	±10%
Total Kjeldahl Nitrogen (TKN)	0.2 to 100 mg-N/L	±8%
Total Organic Carbon (TOC)	0.02 to 100 mg/L	±5%
Total Free Chlorine	0.01 to 11 mg/L	±5%
Total Organic Halide (TOX)	2 to 6000 ug/L	+10%
Total Suspended Solids (TSS)	0.08 to 800 mg/L	±13%
Turbidity (ATU)	0.1 to 100 m-1	±10%
Ultraviolet Absorbance (UVA)	0.01 to 200 m-1	±5%
Ultraviolet Transmission (UVT)	0.2 to 100 %	±5%
Volatile Fatty Acids (VFA)	1 to 1000 mg/L	±10%

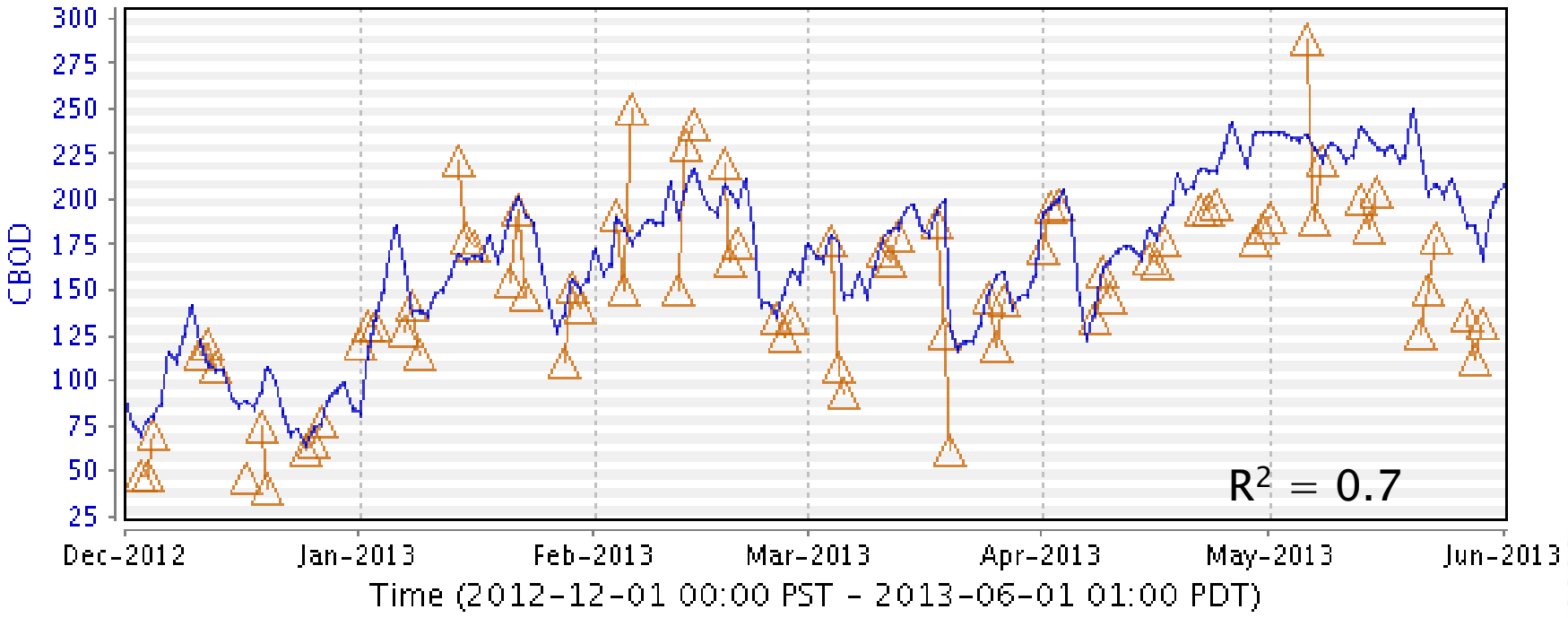
Accuracy: +/- 5 parts per billion (TOC)
As samples are exposed to air, carbon molecules infuse the samples in 20 minutes



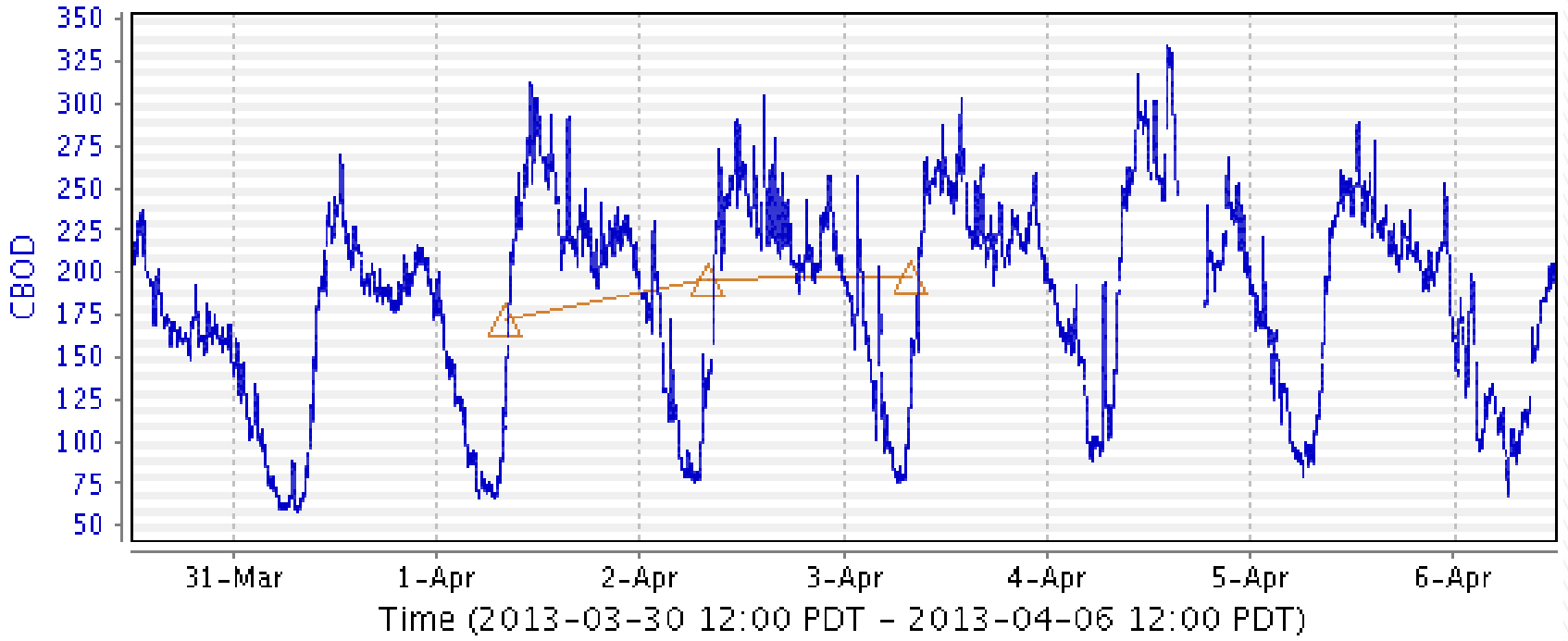
HMA: A microbe's view



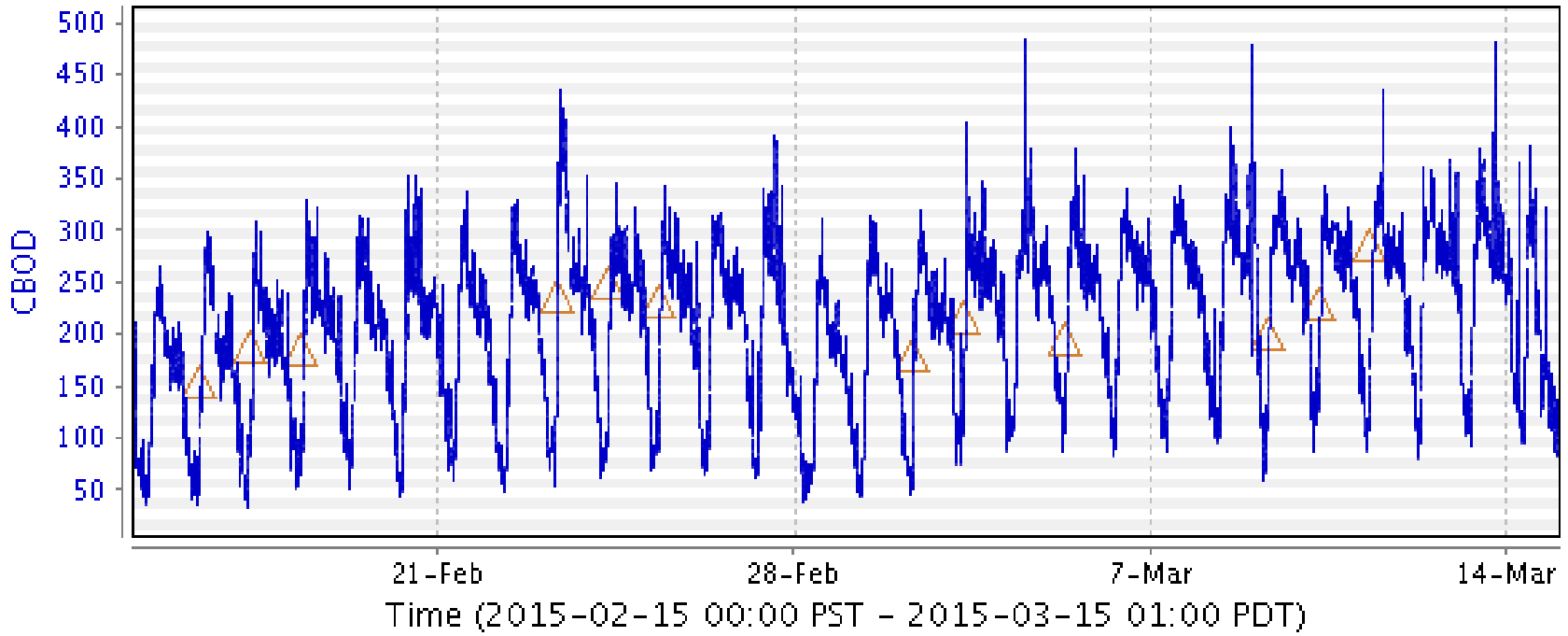
Technique	**ZAPS LiquID**
Report Type	Daily average
# of Days	1081 (99.5%)
# of Real-time Readings	677,244
Average Value (mg/L)	215 mg/L



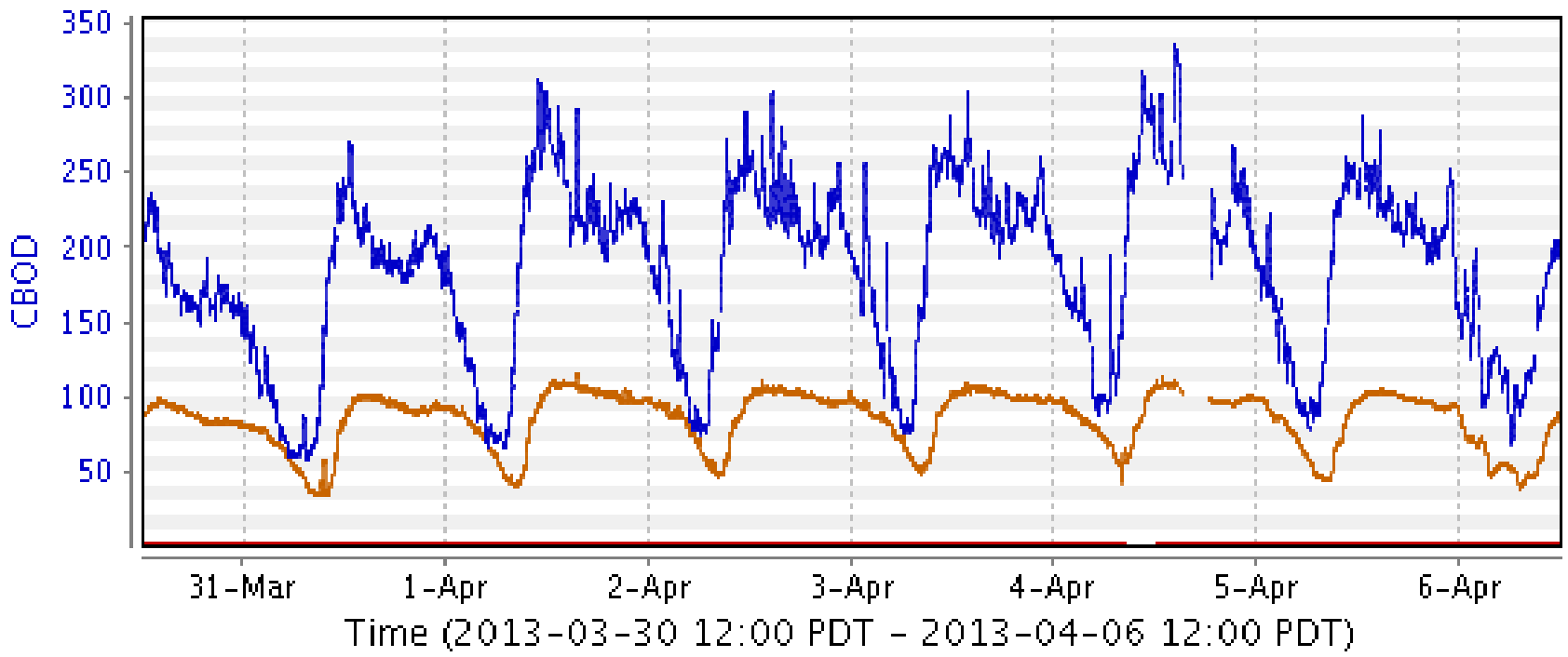
Technique	**Municipal Lab**	**ZAPS LiquID**
Report Type	Daily Composite	Daily average
# of Days	78 (43%)	181 (100%)
# of Real-time Readings	N/A	106,790
Average Value (mg/L)	145	157



Technique	**Municipal Lab**	**ZAPS LiquID**
Report Type	Daily Composite	Real-time
# of Days	3 (43%)	7 (100%)
# of Real-time Readings	N/A	4,687
Average Value (mg/L)	189	198

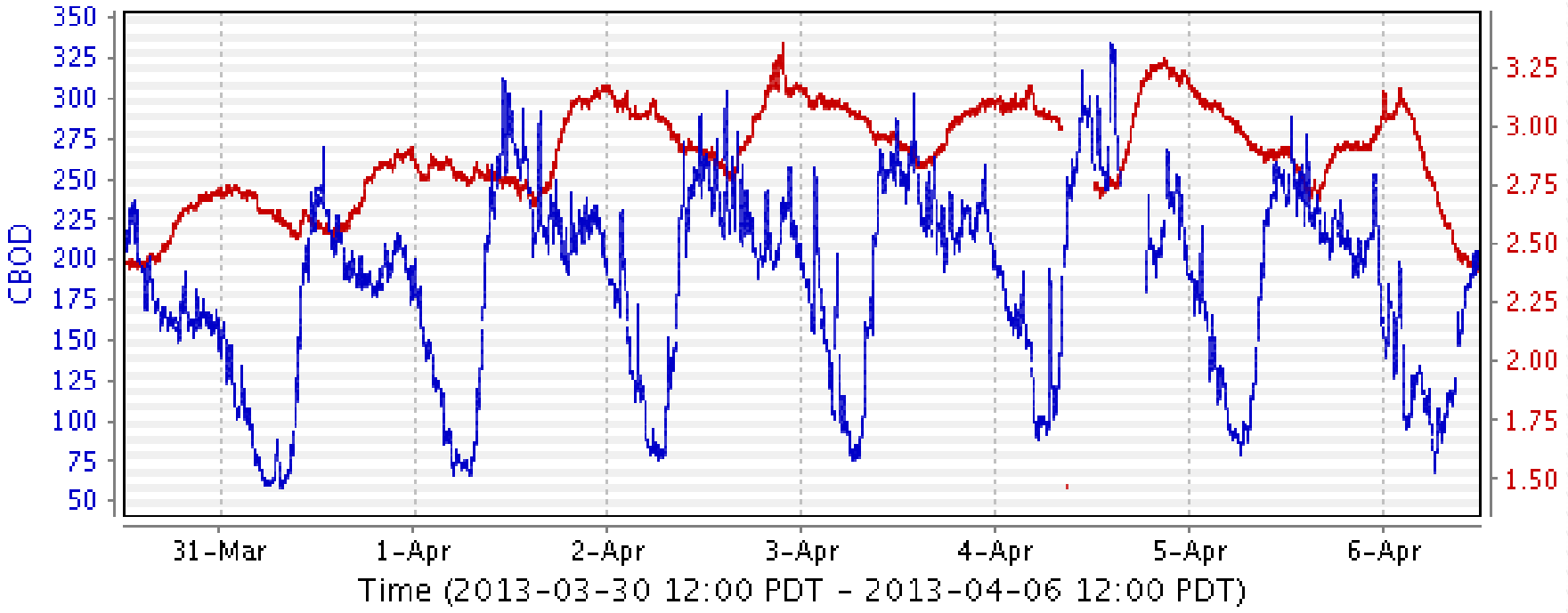


Technique	**Municipal Lab**	**ZAPS LiquID**
Report Type	Daily Composite	Real-time
# of Days	12 (43%)	28 (100%)
# of Real-time Readings	N/A	18,116
Average Value (mg/L)	213	212



Raw Influent – Primary Effluent – Final Effluent

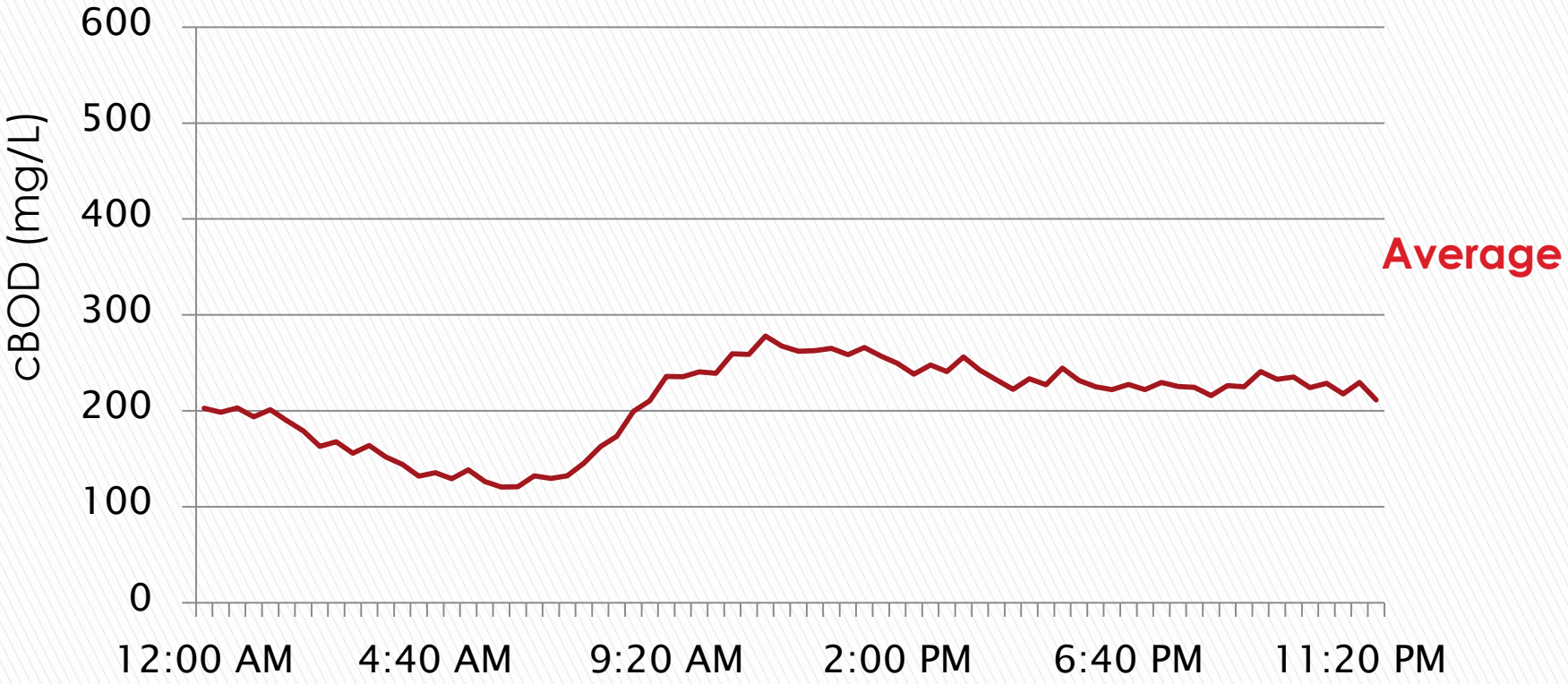
4,700 cBOD readings per series.



Raw Influent **Final Effluent**

4,700 cBOD readings per series.

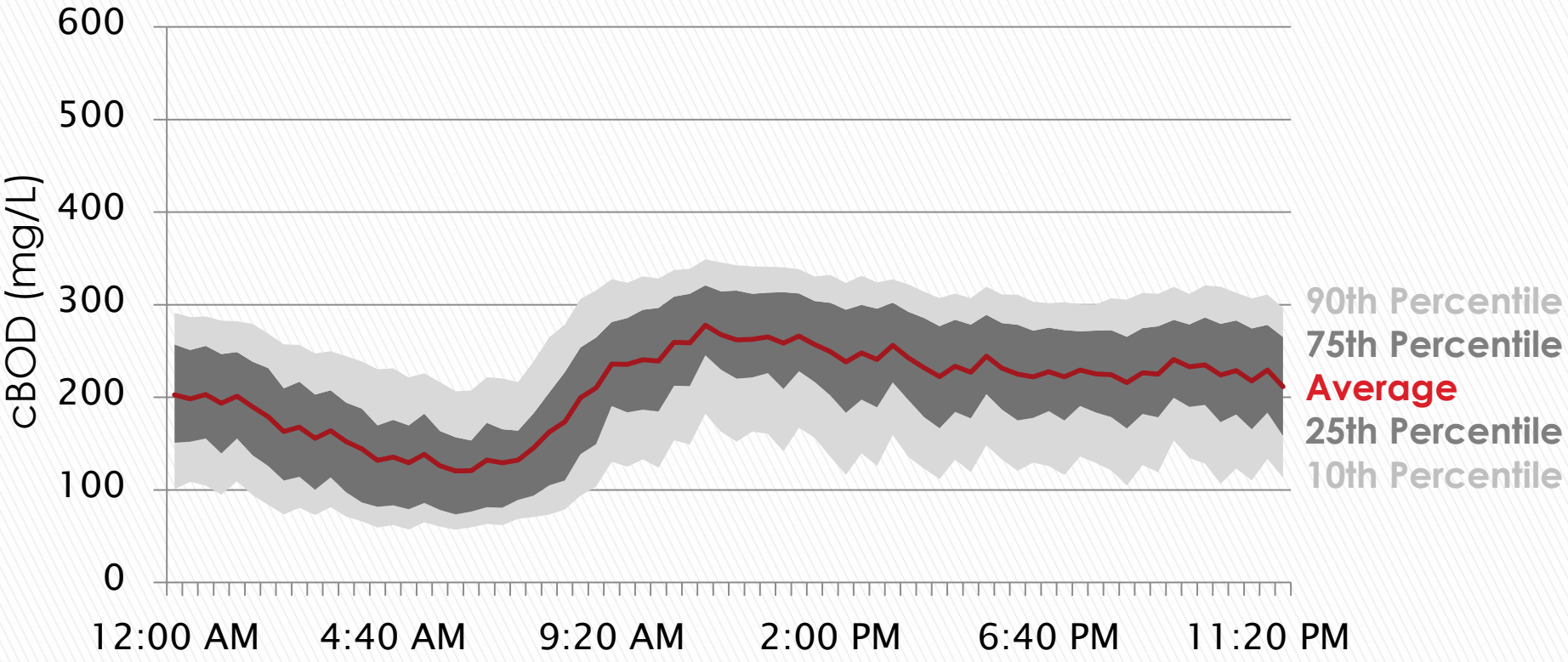
Calculate an average every minute of the day From 365 days of data



Diurnal Cycle – one year of data

213,642 cBOD readings

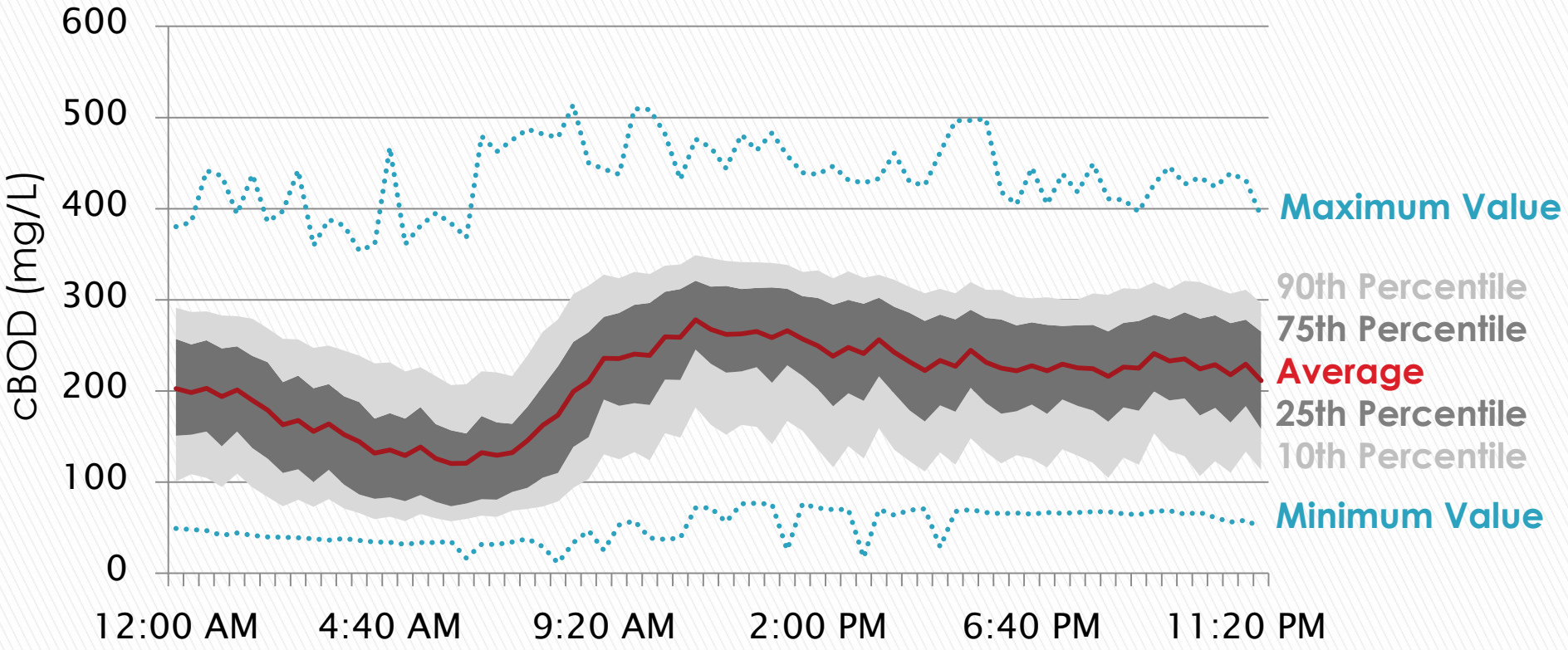
Look at the variance from those averages



Diurnal Cycle – one year of data

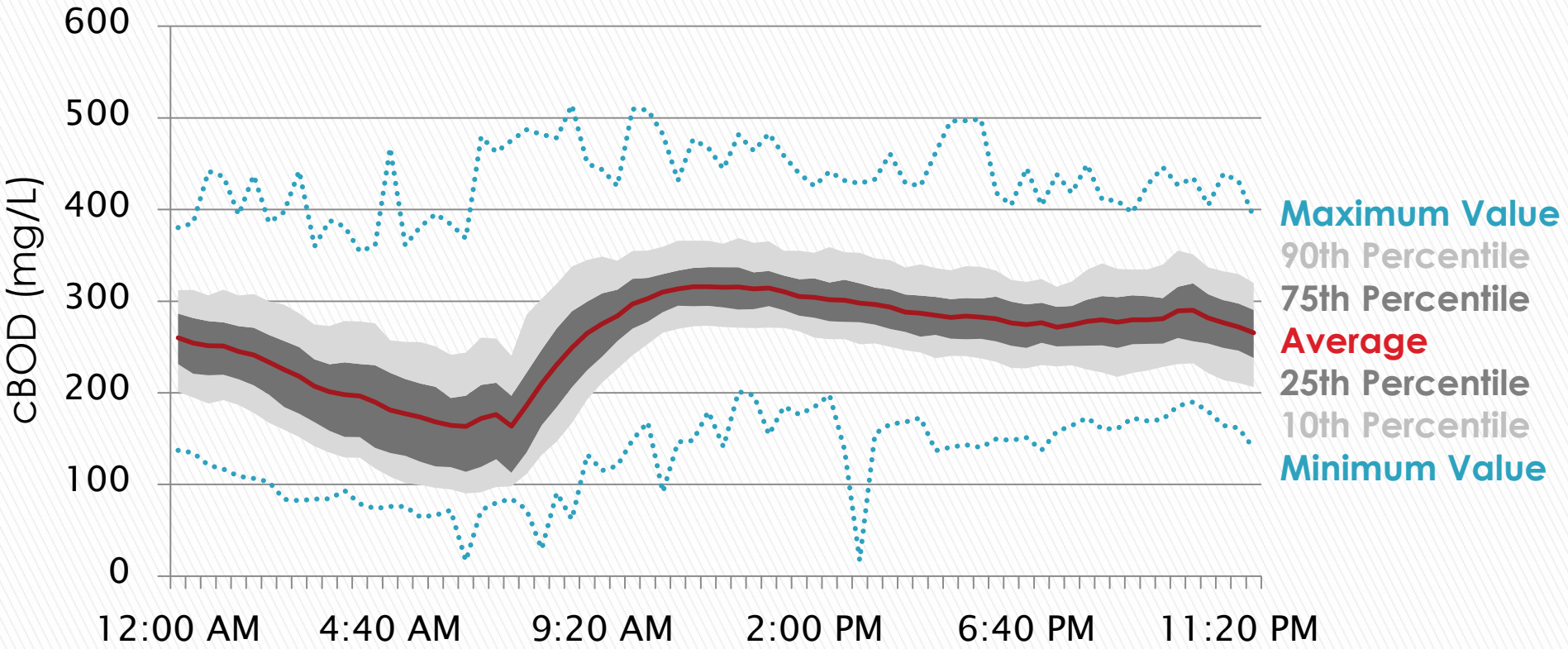
213,642 cBOD readings

We manage our plants based on conservative assumptions for maximum, minimum, and average loads



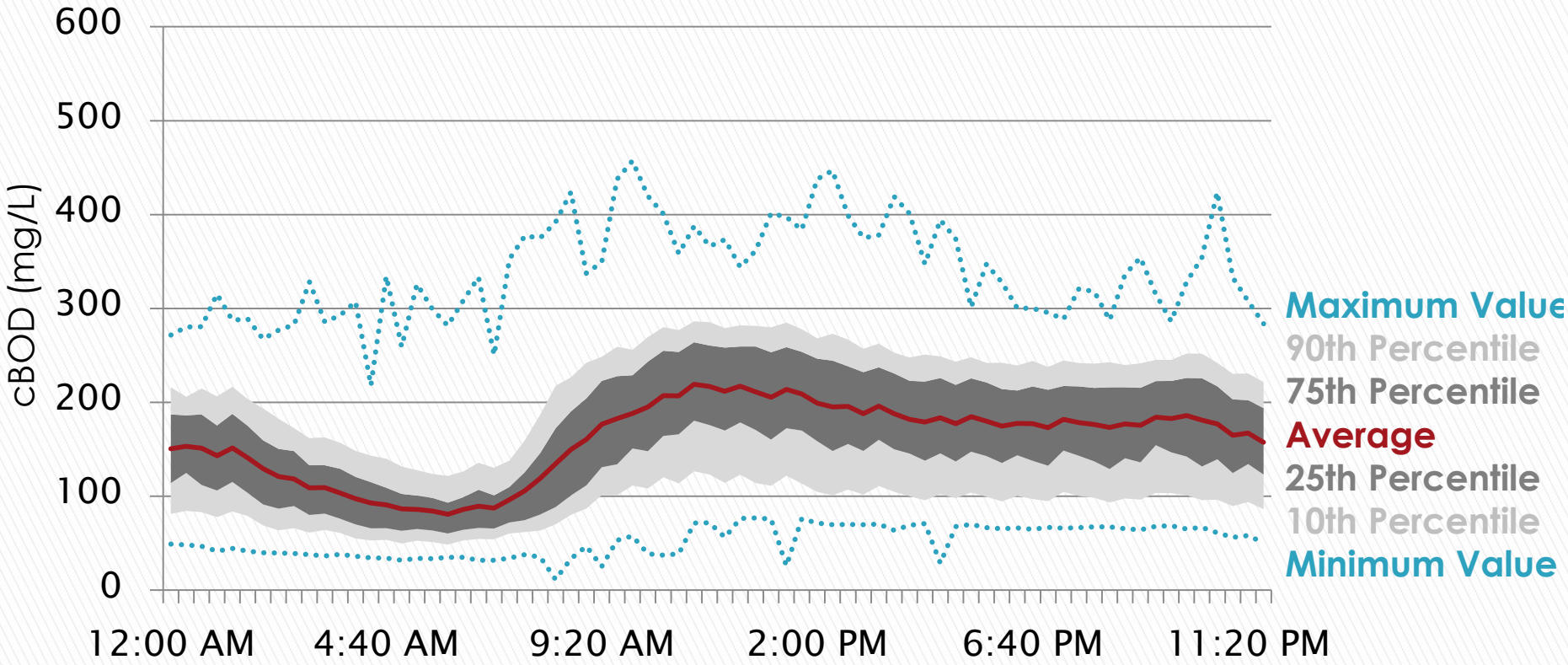
Diurnal Cycle – one year of data

213,642 cBOD readings



Summer Season – Diurnal Cycle – one year of data

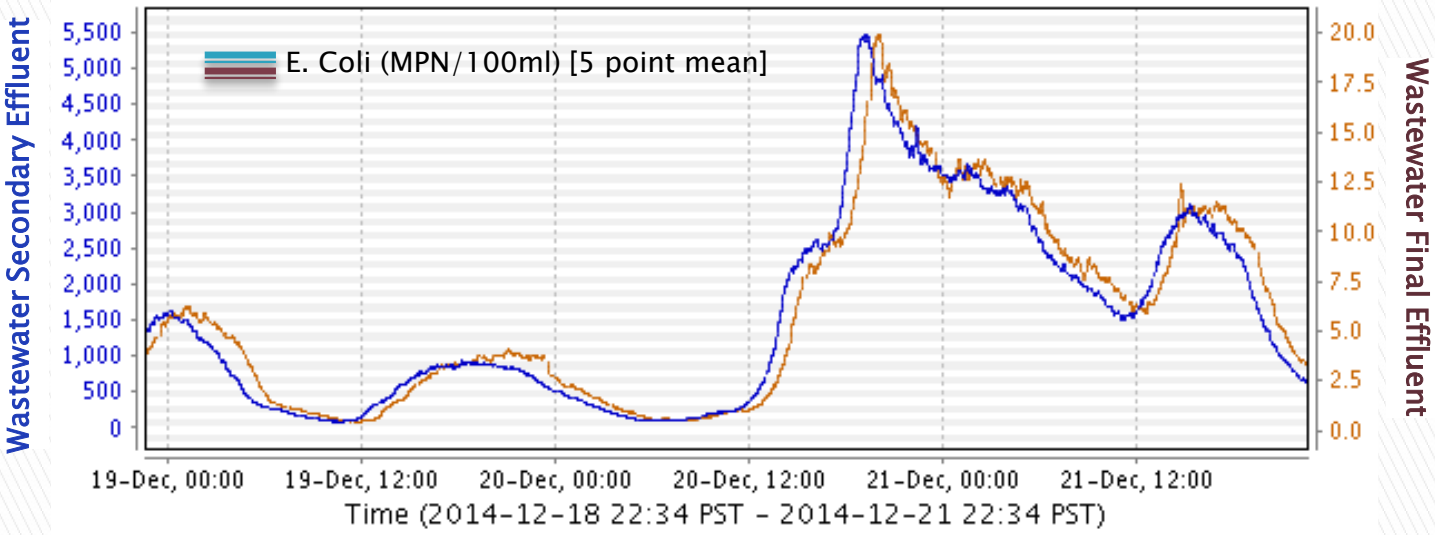
106,525 cBOD readings



Winter Season – Diurnal Cycle – one year of data

107,117 cBOD readings

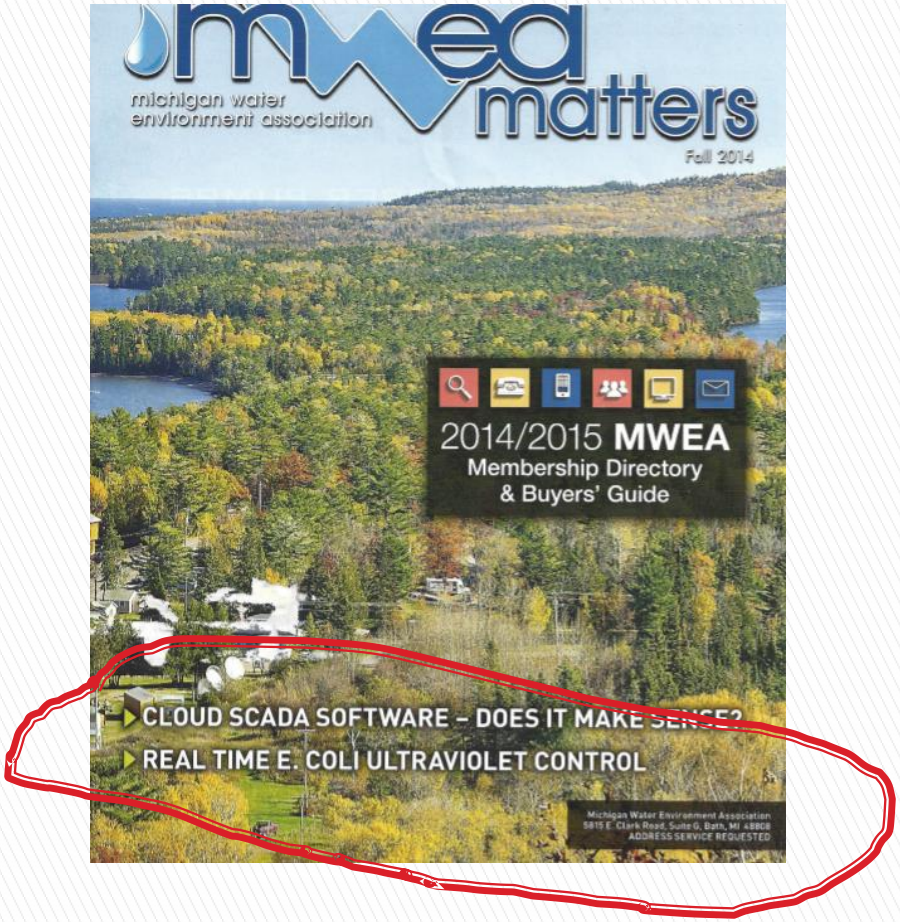
Measuring Activated Ecoli to Optimize Disinfection



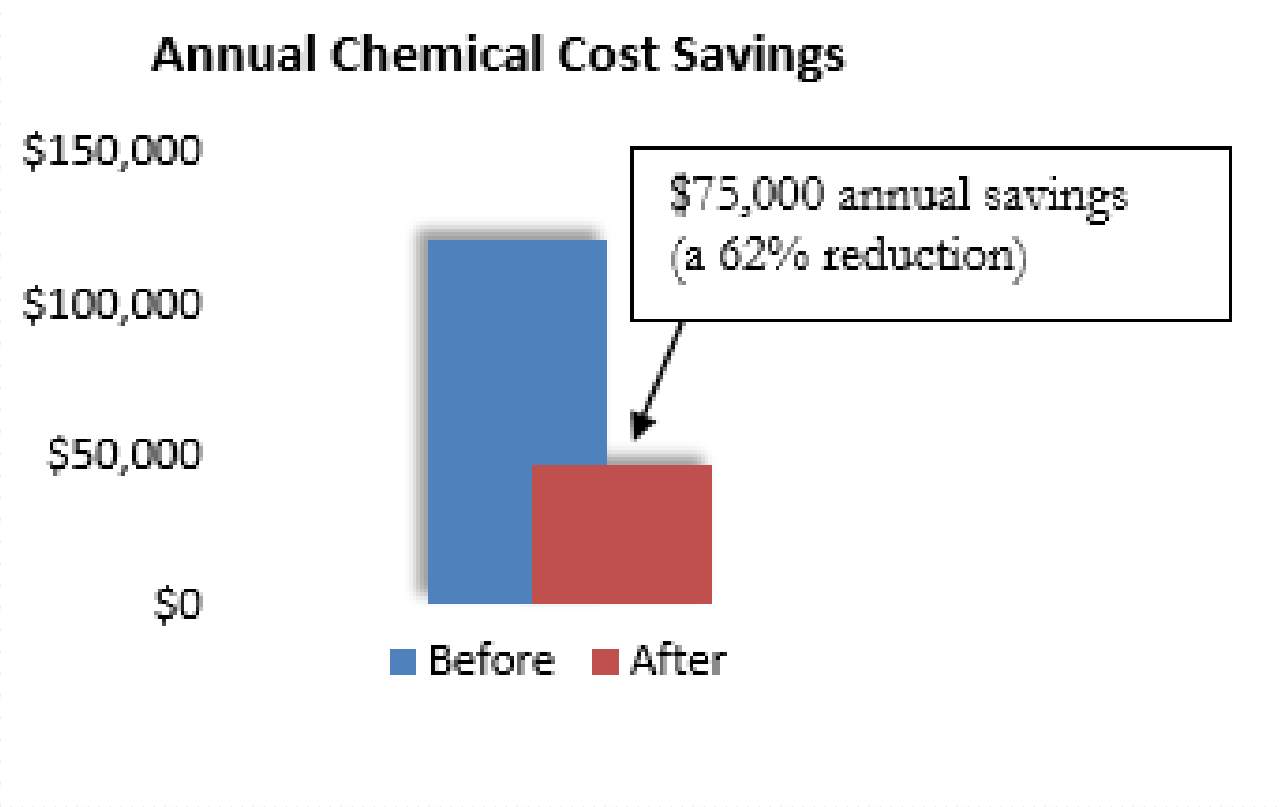
- Customer documented savings in chlor/dechlor and UV
- Typically 50% of chemical and energy costs
- Technology differentiates activated from deactivated Ecoli

Grand Rapids saved $54,000/year

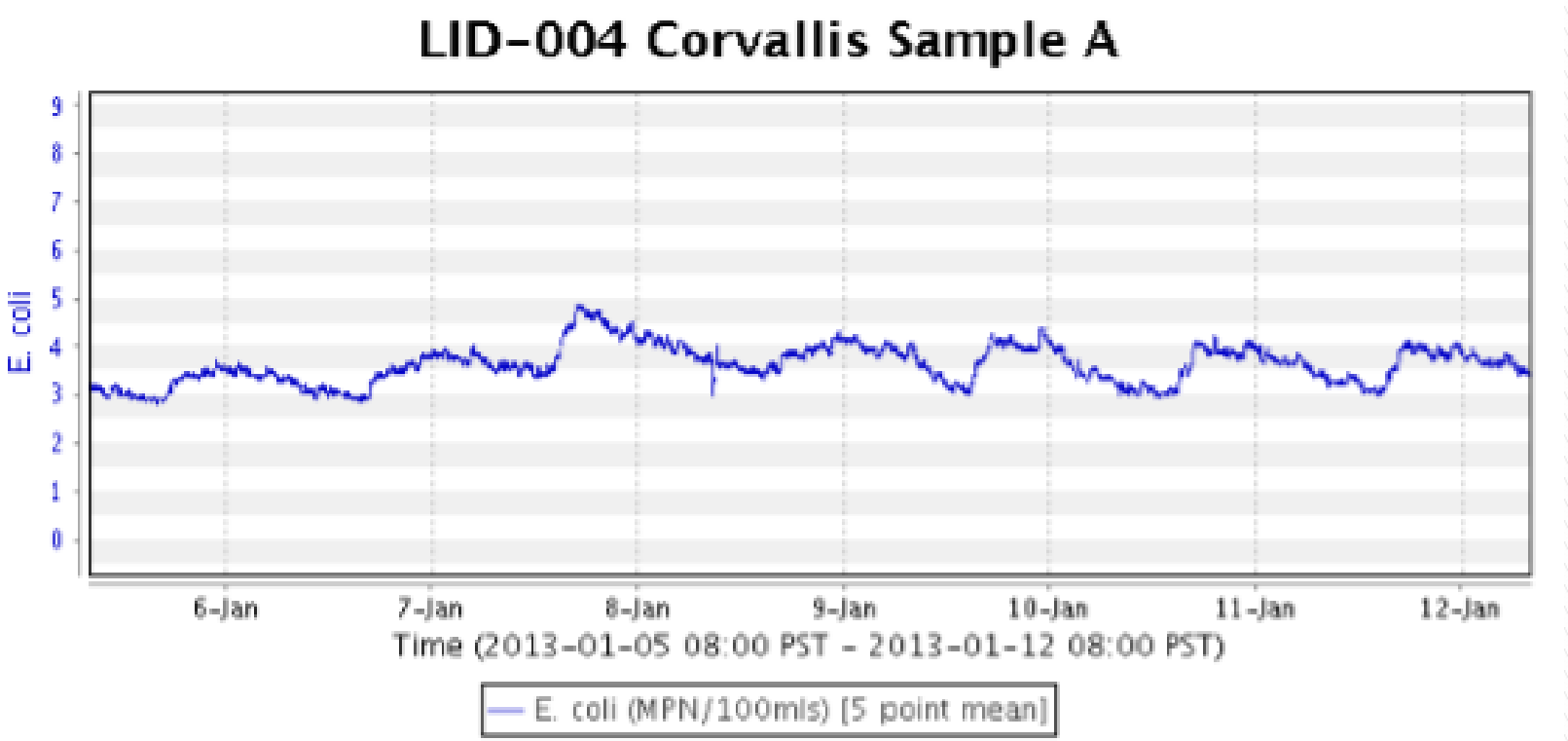
- Back off disinfection until you start to see some activated Ecoli come through
- Machine sees activated Ecoli vs deactivated
- Customer wrote this article
- Using machines for four applications
- Monitoring final effluent helps see the effect of other changes to process



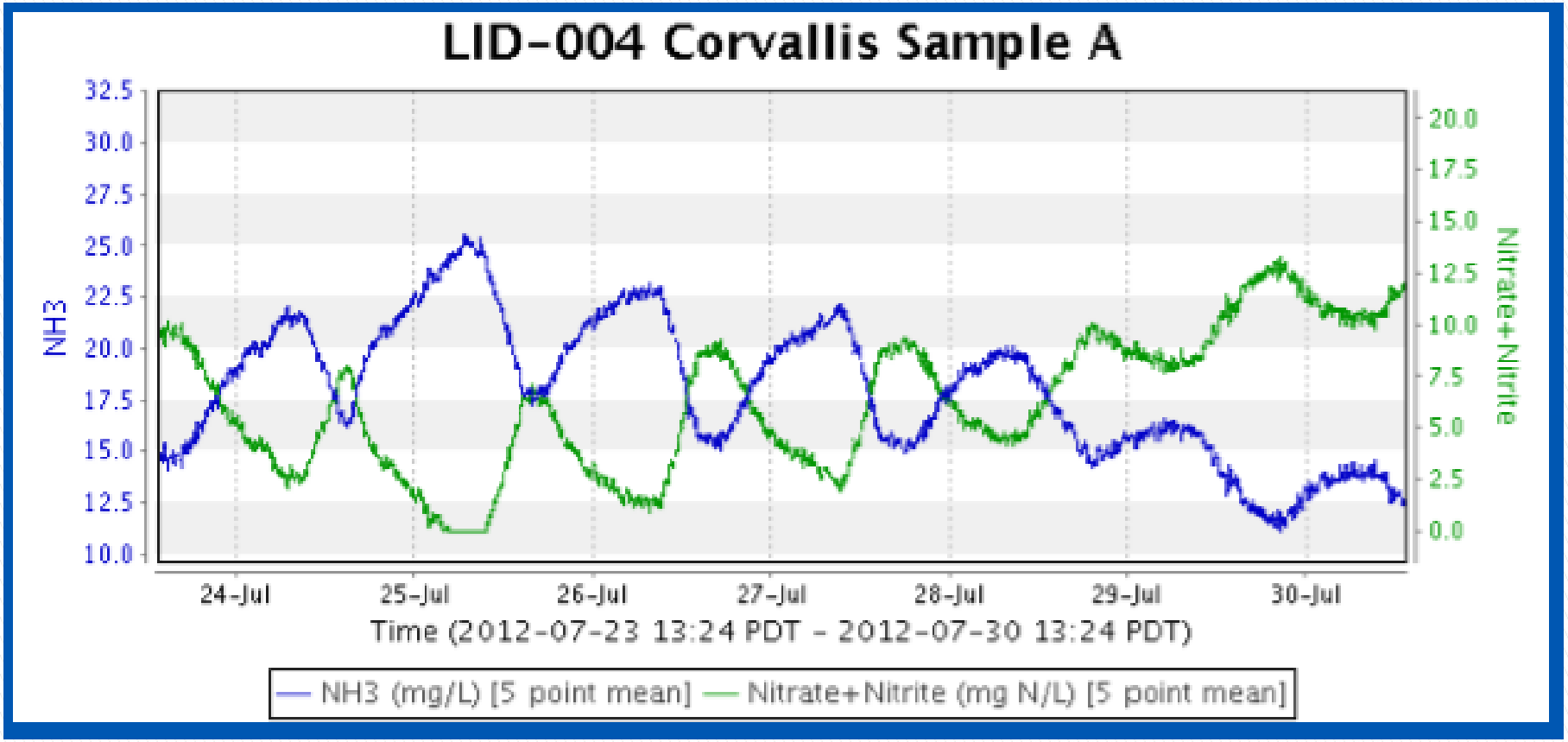
Corvallis saved 62% of their chemical cost



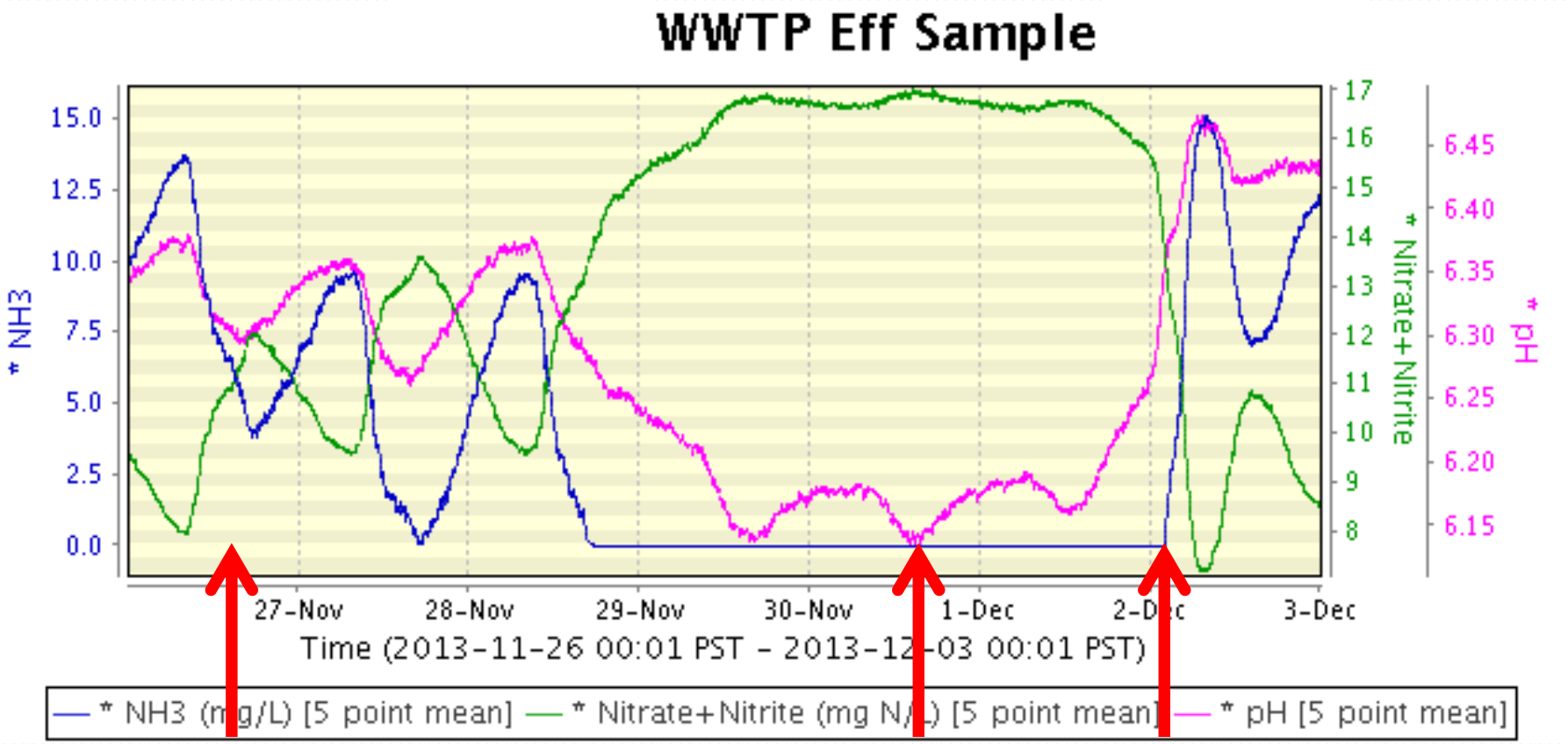
Much tighter control of disinfection



Optimizing Nitrification



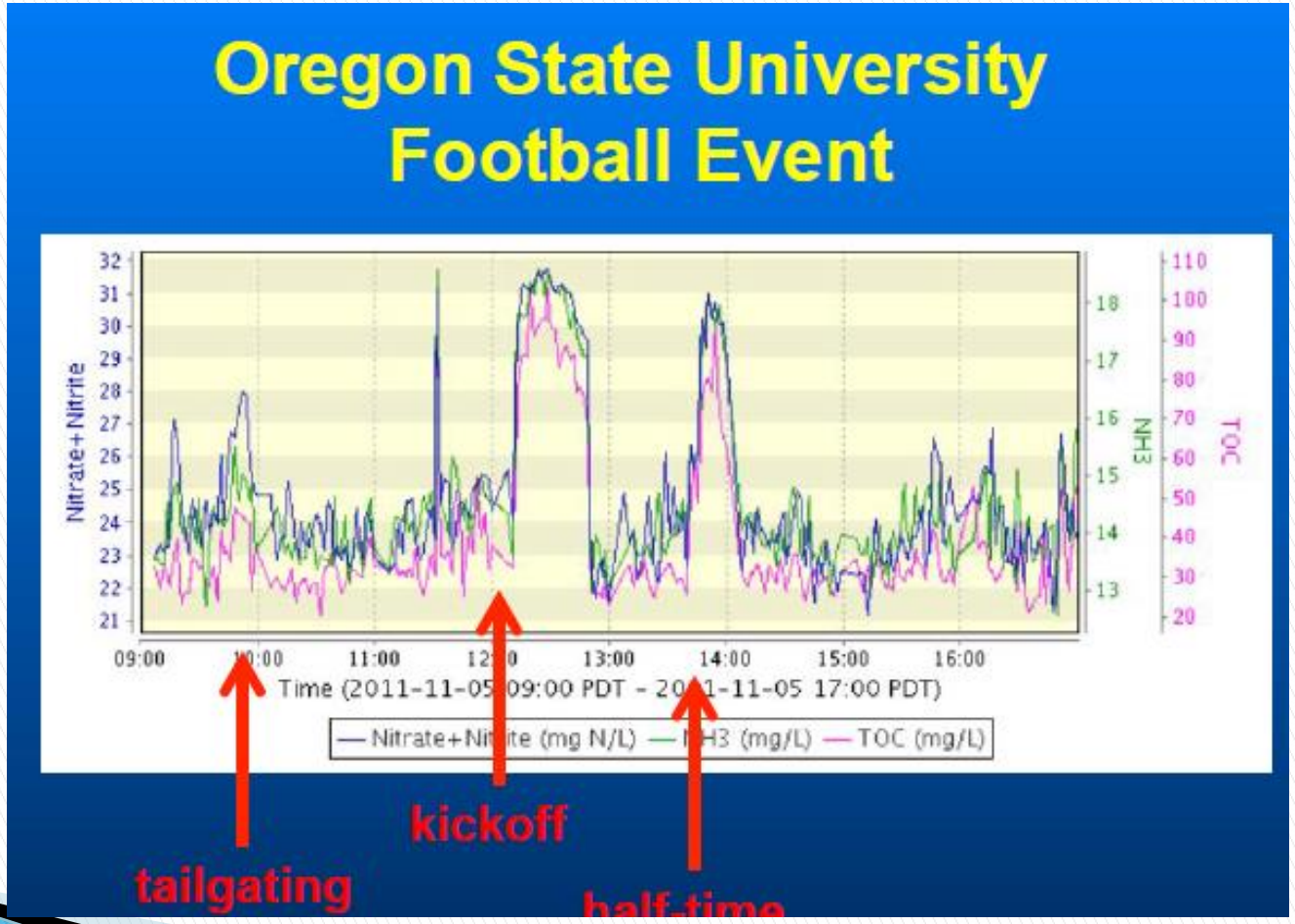
Observing the interdependence between parameters



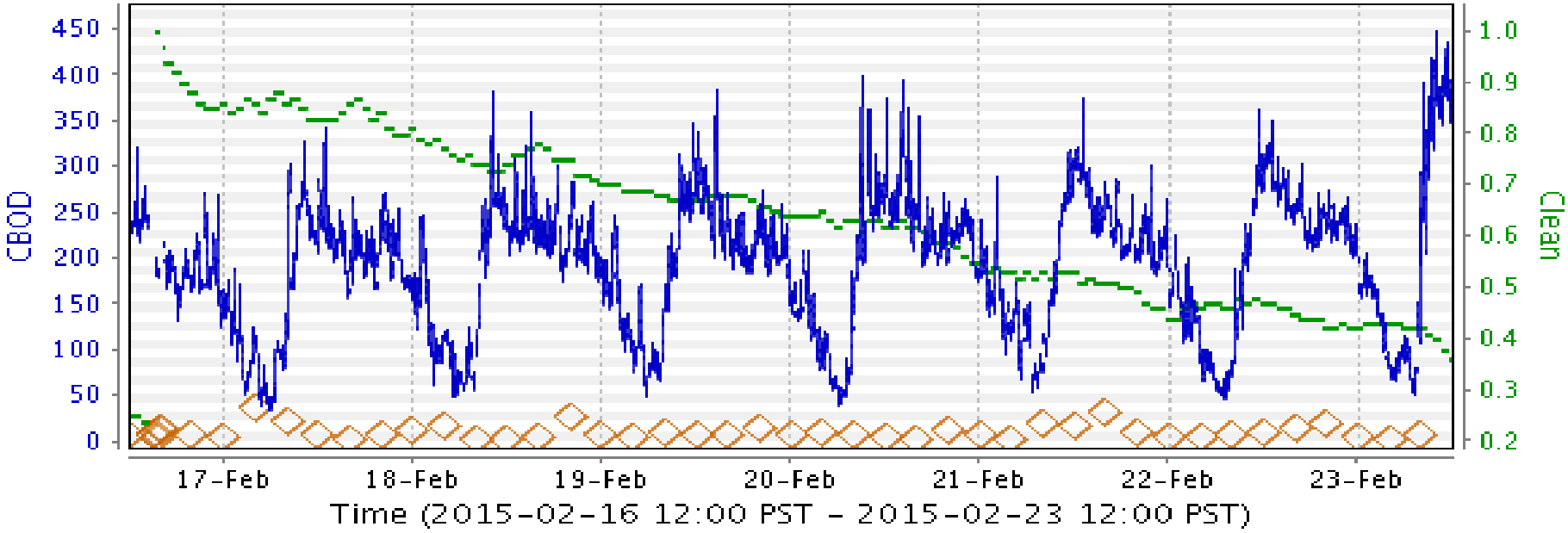
rain event

Low pH 11.2^{0}C

BETTER UNDERSTANDING LOADS



Self Cleaning and Self Calibrating Online maintenance indicators



LiquID cBOD – 'Clean' Parameter – Automated Calibrations

Automated Processes	Total	Per Day
Days	7	
Automated Cleaning Cycles	219	31
Automated Calibration Checks (plotted)	47	7
cBOD Parameter Readings (plotted)	4,529	647
Manual Optics Cleans	1	

ZAPS TECHNOLOGIES

LiquID™ Station

USER INTERFACE

Print

Quick Glance | Monitor | Data | Quick Review | Alerts | Control | Grab Sample

Station: WWTP Inf view

Status: ONLINE

Last transmission received: 2015-06-17 10:27AM PDT

Start: 2013-03-31 00:00

Ex. [2015-06-28 16:00], or leave empty for current time.

<< < [] > >>

Scale: 1 week

Metric 1: CBOD

Metric 2: Sample Temperature

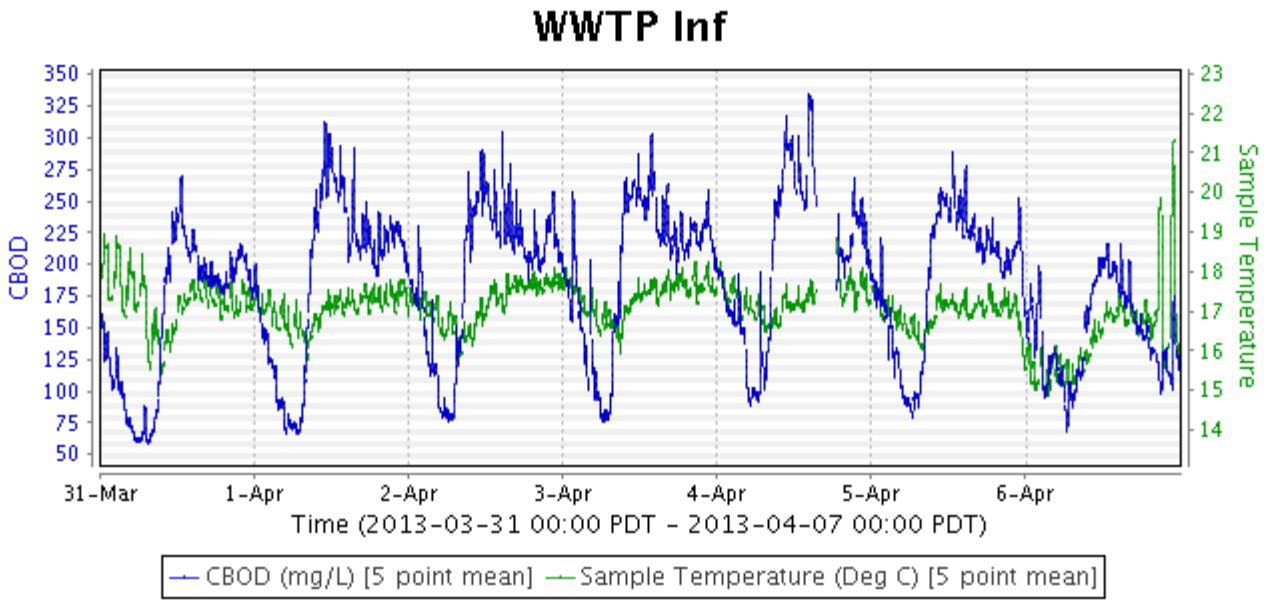
Metric 3: -- Select --

Statistic: 5 point mean

Updates: None Go

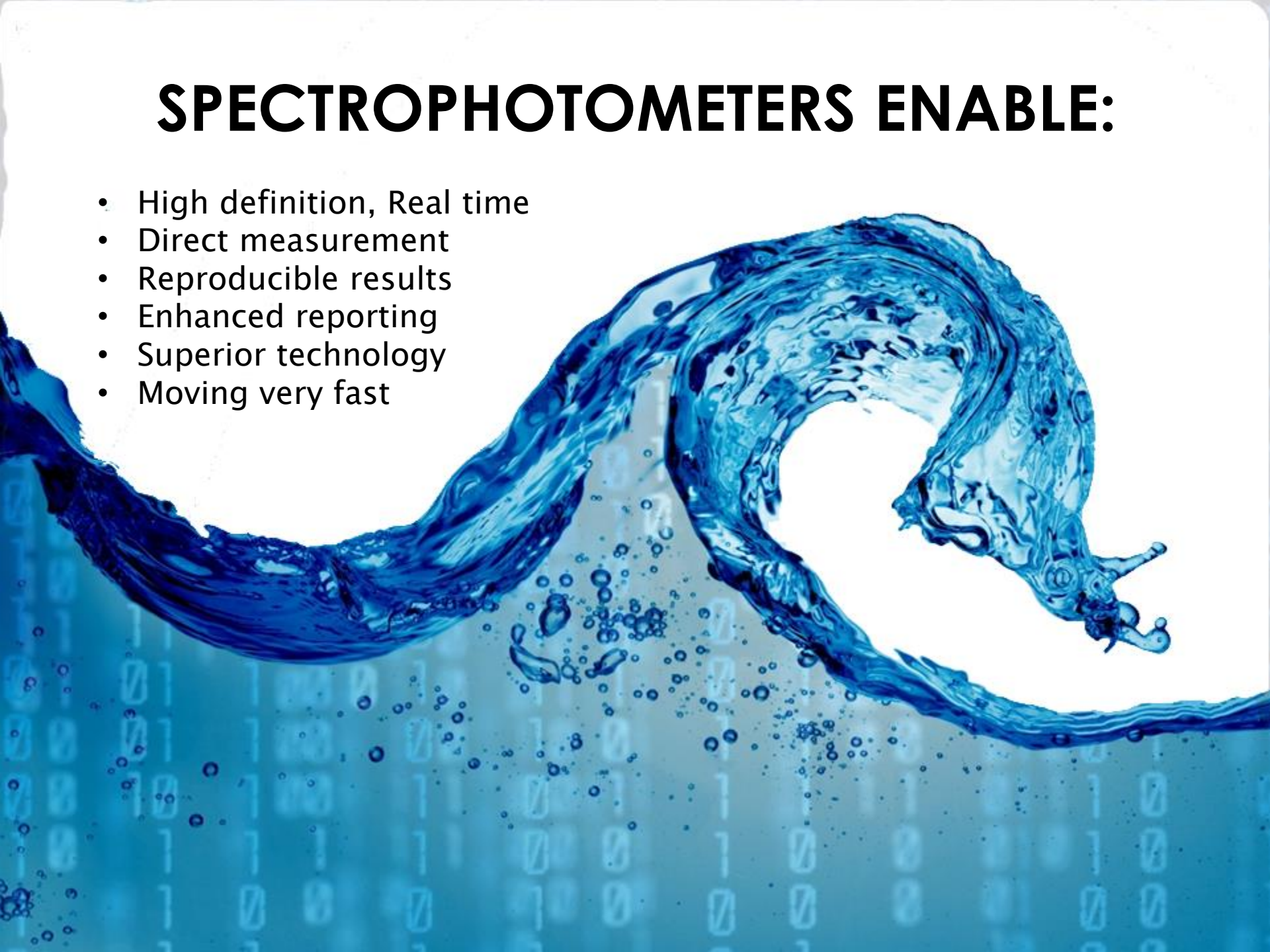
⊞ Metrics

⊞ Filter Options



SPECTROPHOTOMETERS ENABLE:

- High definition, Real time
- Direct measurement
- Reproducible results
- Enhanced reporting
- Superior technology
- Moving very fast



The value of data is determined by:

- how timely it is
- how much analysis was done on it

www.zapstechnologies.com

robert.dunbar@zapstechnologies.com
617-448-0440

ZAPS TECHNOLOGIES