

Utilizing Continuous Water Quality Monitoring Data for Regulatory Assessment and Discharge Permit Development Along an Effluent-Dominated Segment of the South Platte River



Jordan Parman, Metro Wastewater Reclamation District, Denver, CO

Jim Dorsch, Metro Wastewater Reclamation District, Denver, CO

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Monitoring Programs

- Biweekly sampling of South Platte River
- Biweekly sampling of Barr Lake and Milton Reservoir
- Quarterly groundwater monitoring
- Biological/physical
- Special studies



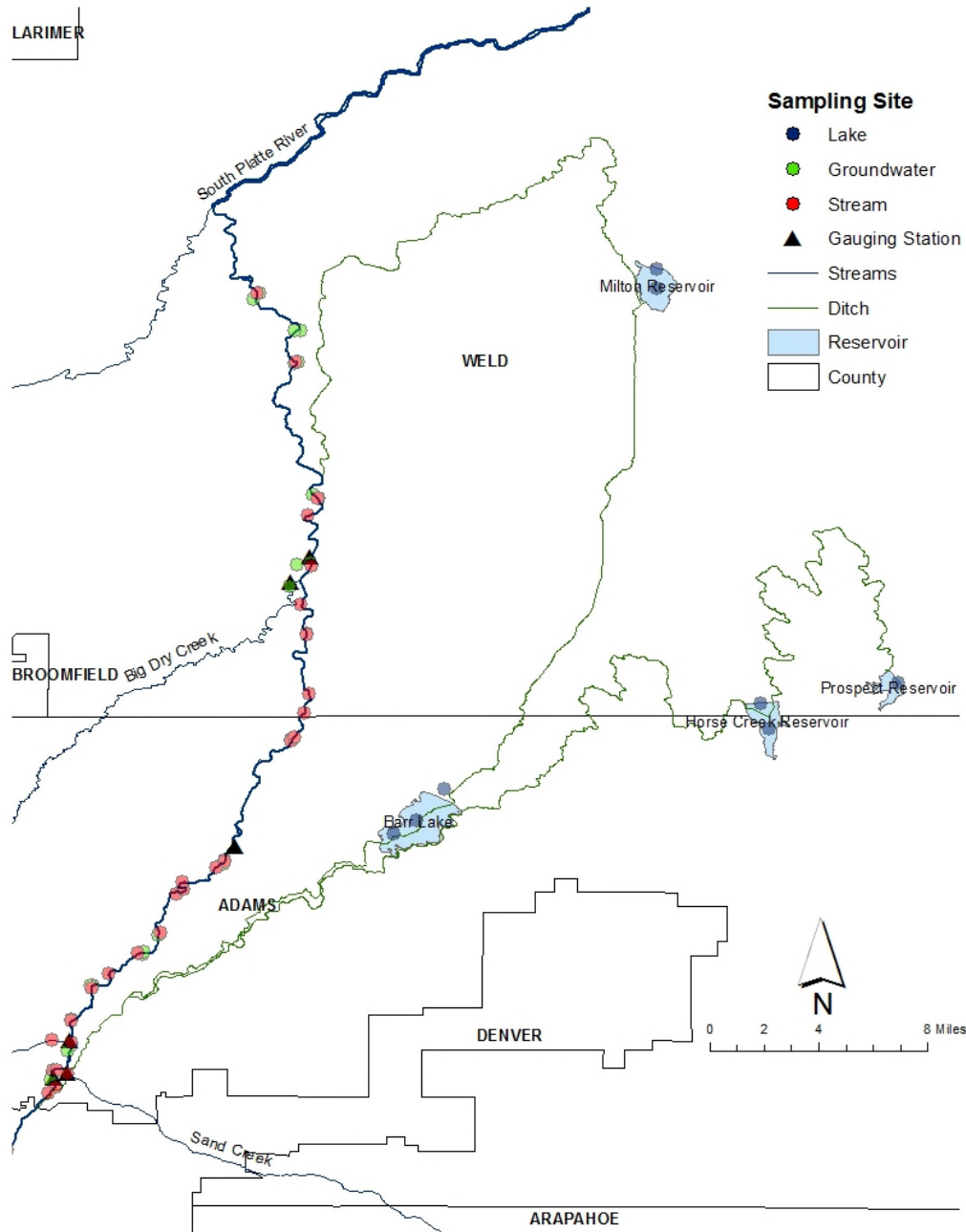
South Platte River at Brighton, CO

Monitoring Equipment

- In-Situ Multiparameter 9500 water quality probes with dissolved oxygen, turbidity, pH, conductivity, temperature
- HOBO[®] U22 Water Temp Pro thermistors
- Cooperator with USGS stream gages

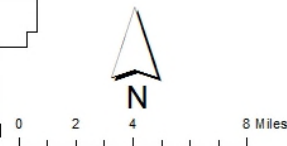
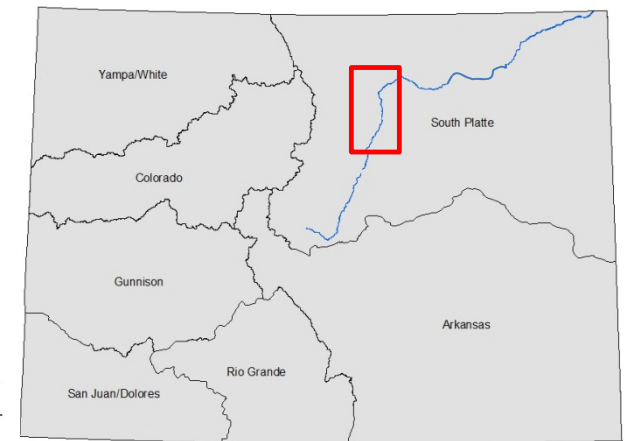


Map of Sampling Sites and Gauges



Sampling Site

- Lake
- Groundwater
- Stream
- ▲ Gauging Station
- Streams
- Ditch
- Reservoir
- County



South Platte Water Quality Model

- Unique site-specific water quality model designed to evaluate water quality standards and development of permit limits for clean water agencies
- Detailed hydrology (surface water flows, WWTP discharges, ditch withdrawals, groundwater seepage)
- Uses biweekly data as well as special 24-hour studies (instream biological processes, i.e. respiration)
- Dissolved oxygen, nitrogen species, total phosphorus, temperature
- Estimation of permit limits for total ammonia (aquatic life)

Calibration Procedures

- Methods
- Frequency
- Acceptable ranges

Sensor	In-Situ Recommended Calibration Frequency	MWRD Calibration Frequency
Dissolved Oxygen (RDO)	2-4 weeks	Every Deployment
pH	1-2 months	Every Deployment
ORP	1-2 months	
Conductivity	2-3 months	Every Deployment
Pressure	1 year (factory)	Varies
Turbidity	5+ years	Every Deployment

Sensor	Acceptable Calibration Ranges
pH	Slope of -54 to -62 mV/pH, offset between 350 and 450 mV
Conductivity	K-Cell between 0.30 and 0.39 cm^{-1} (low range sensor)
Dissolved Oxygen (RDO)	Slope of 0.9 – 1.1, % Saturation between 90%-110%
Turbidity	$\pm 5\%$ or ± 2 NTU, whichever is greater, from 0-200 NTU
Temperature	No option for calibration
Pressure	Can “zero” when necessary

Attended vs. Unattended Deployments

- Attended monitoring
 - Higher quality data
 - Labor costs
 - Unable to assess diel variation
- Unattended monitoring
 - Reduced labor effort
 - Continuous data, user-set logging
 - Vandalism
 - Biofouling (especially DO and turbidity)

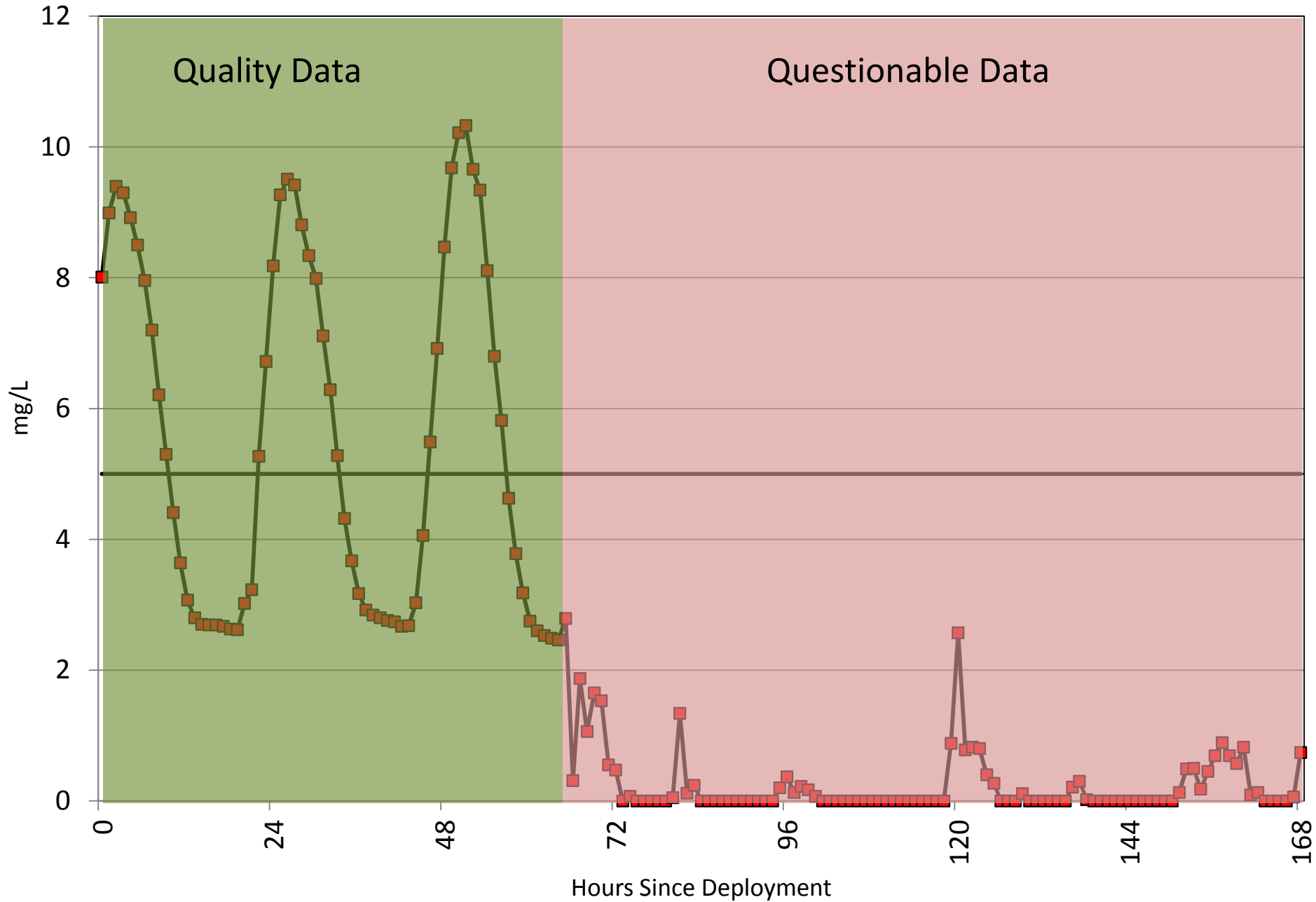
Fulton Pool Deployment



Fulton Pool Deployment



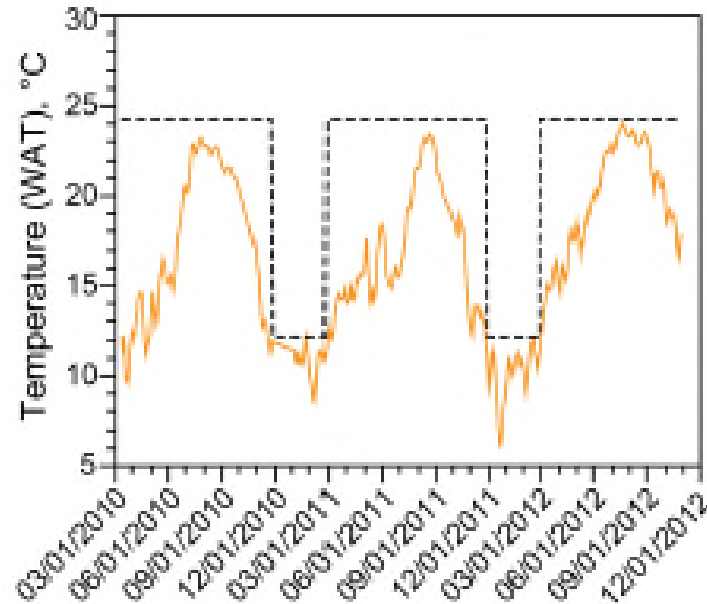
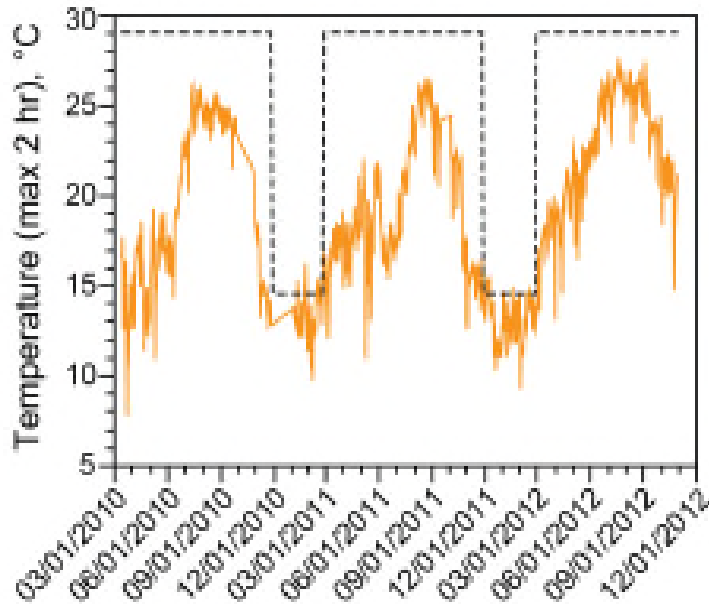
Fulton Pool Dissolved Oxygen (June 4-11, 2012)



Biofouling



Temperature Standards and Monitoring



River temperatures at 88th Avenue. The dashed lines show temperature standards.

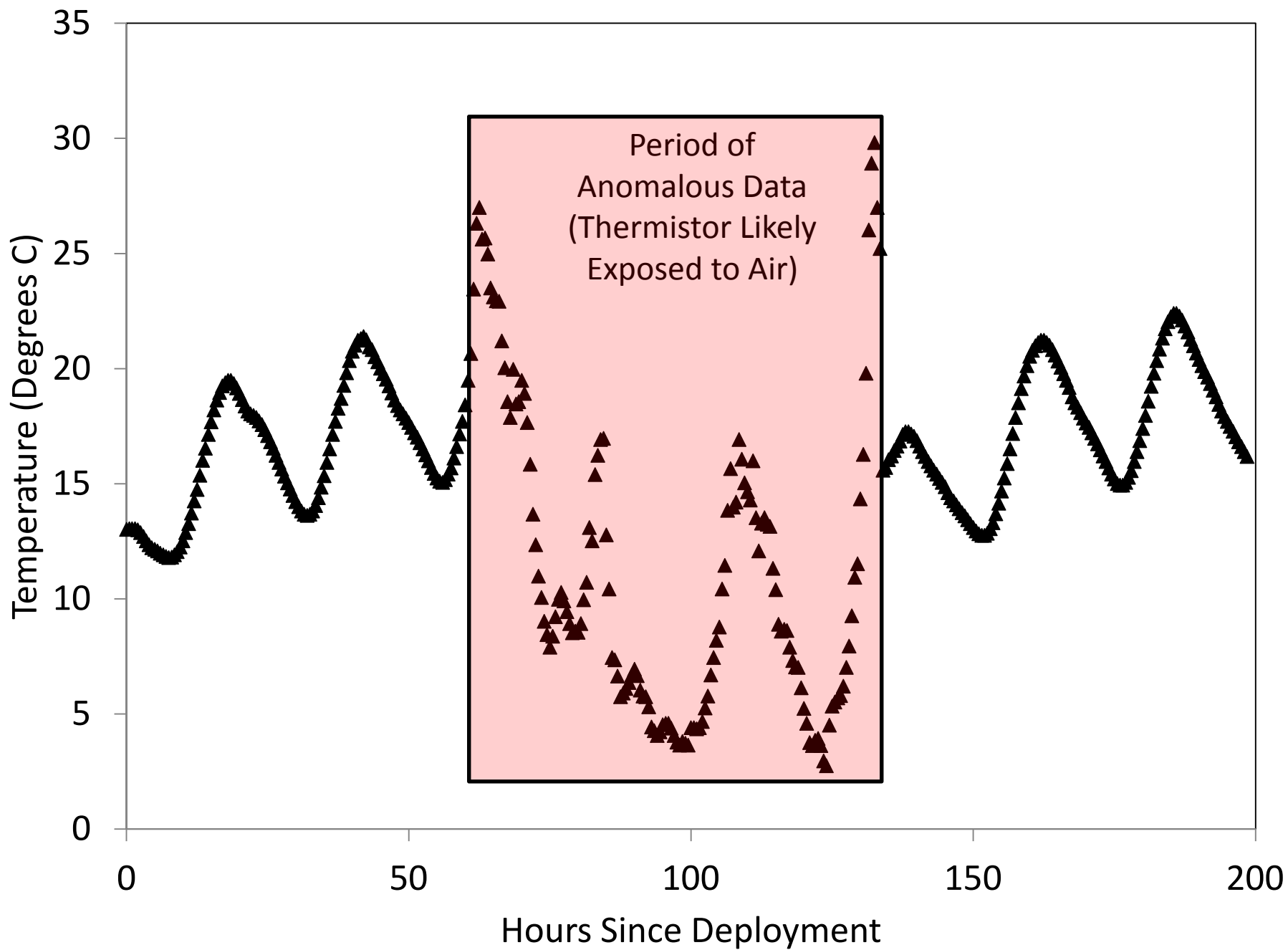
- Temperature data analyzed to determine DM and MWAT consistent with once-in-three-year exceedance frequency
- Low flow and high air temperature exclusions
- Even with exclusions, temperature standards are exceeded in locations below treatment facility in wintertime

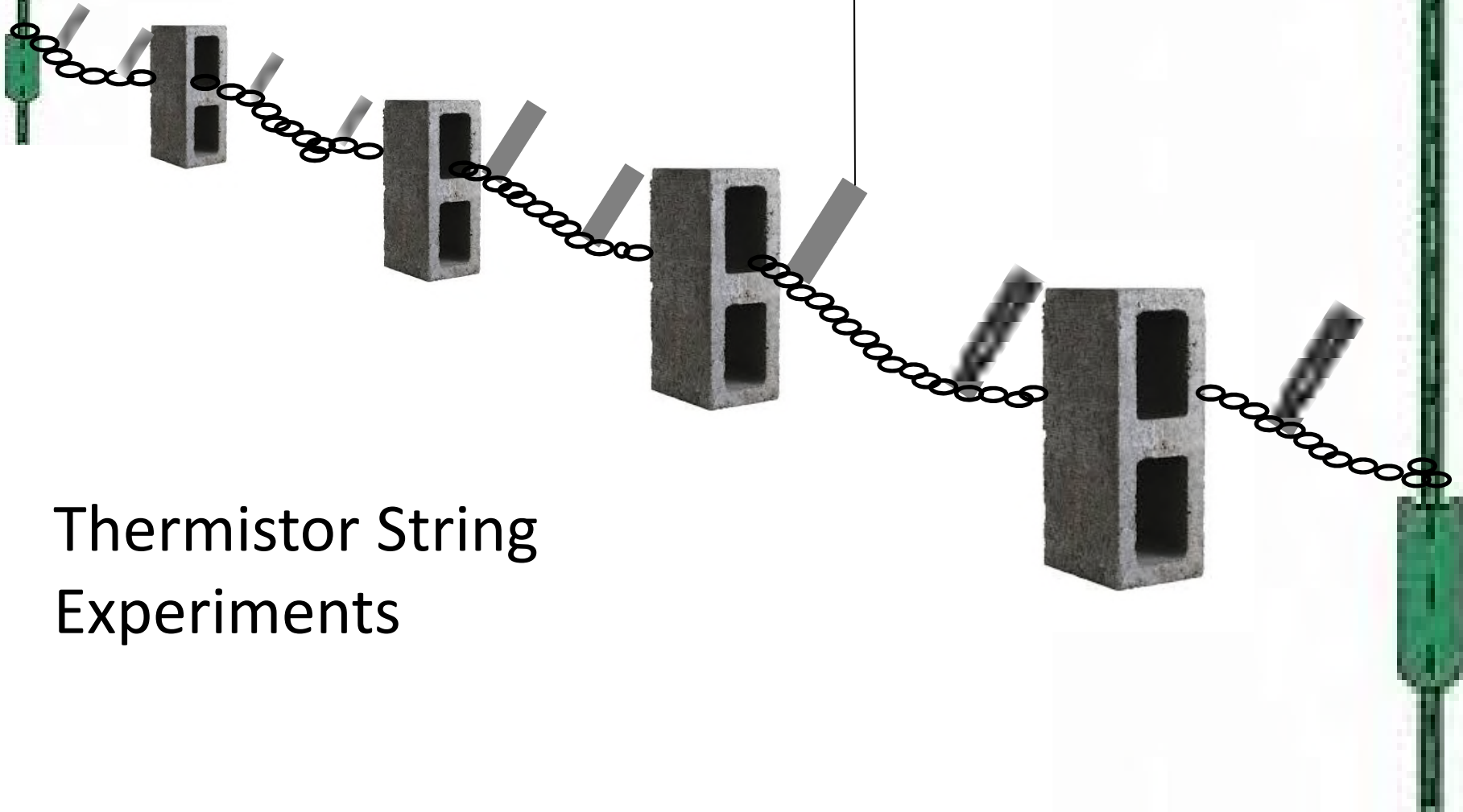
Temperature Mixing Issues

- Modeling results: complete mixing of upstream flow, with discharge from WWTP, and other downstream tributaries does not occur until 11.2 miles downstream
- Temperature gradient of up to 5 degrees C, portions of the segment may be in attainment of standards upstream of completely mixed thermal conditions
- Lower portions of segment are not in attainment with summertime temperature standards, a result of wide shallow stream channel, low-flow conditions and a lack of shading



South Platte River at Weld County Road 28
during low-flow conditions





Thermistor String
Experiments

Deployment #1

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Google earth

1994

Imagery Date: 10/7/2012 lat 39.813689° lon -104.953007° elev 5120 ft eye alt 6193 ft

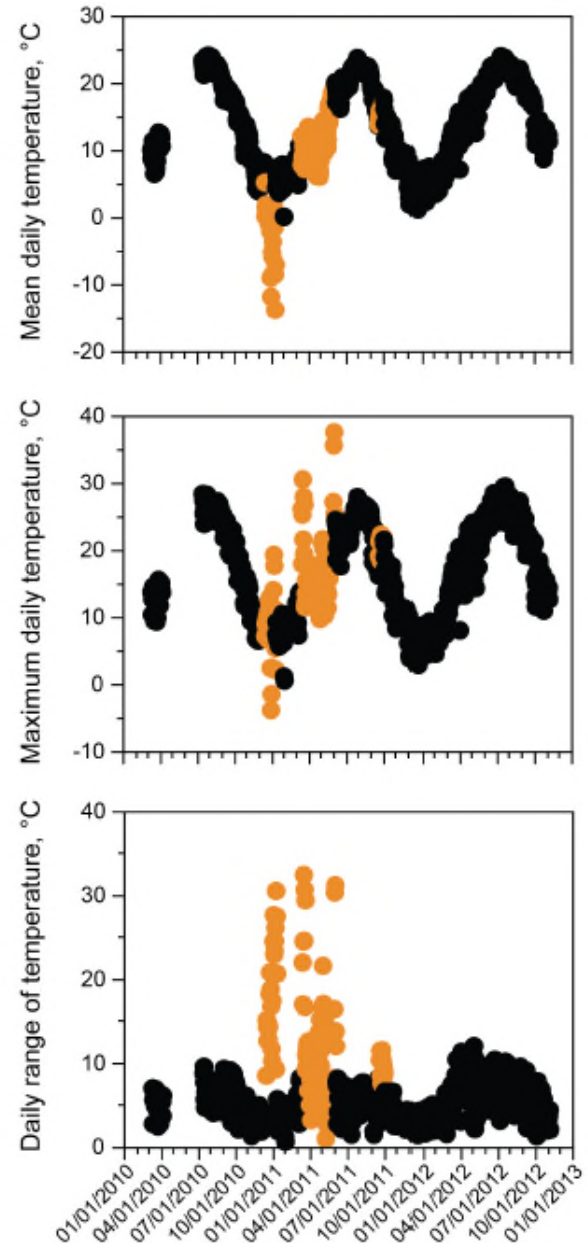
Deployment #1 Temperature Gradient

Site #	Distance (m)	Depth (cm)	Mean Temperature (Degrees C)
1	3.0	10	20.72
2	6.0	12	20.85
3	9.0	21	20.85
4	12.0	23	20.8
5	15.0	32	20.85
6	18.0	32	20.79
7	21.0	40	20.59
8	24.0	47	20.17
9	27.0	60	19.53
10	30.0	68	17.21
11	33.0	72	16.28
12	36.0	14	16.26

Thermistor Data Removal Procedures

- Remove known data before/after deployment
- Remove periods where temperature changed more than 2°C in an hour
- Plot daily mean, maximum and range to identify other potential anomalies
- Flag data in days with air temperature excursions or low flow exemptions

(Figure adapted from Lewis and McCutchan, 2012)



Maintenance Needs and Concerns (Thermistor)

- Need for careful QA/QC
- Monthly download to avoid anomalous readings
- Be aware of seasonal flow variations and flood events
- Simple and understandable database structure is important with large dataset



Ongoing and Future Work

- Continue string experiments to determine seasonal patterns of mixing
- Select location for standard compliance
- Explore linkages between temperature and aquatic life (fish and macros)



Conclusions

- Sampling has evolved over years to adapt to address regulatory concerns
- In-Situ probes provide high quality data for attended monitoring of water quality, unattended monitoring data must be more closely analyzed, especially within regulatory context
- HOBO® thermistors provide excellent continuous temperature records and are relatively simple to deploy
- QA/QC methods must be developed and closely followed to ensure validity of the continuous datasets, especially when assessing data from unattended monitoring in biologically active aquatic environments



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Review of 2013 End-Calibration Data

-137 separate deployments

-3 instances when the end-calibration values were outside the acceptable error range (2 turbidity for Fulton Pool probes, 1 malfunctioning RDO sensor)

Sensor	Calibration Standard	Average Absolute Deviation	% Deviation
pH	7*	0.07	0.96%
pH	10*	0.08	0.76%
Conductivity	704 $\mu\text{S}/\text{cm}$	7.55 $\mu\text{S}/\text{cm}$	1.07%
Turbidity	40 NTU	0.66 NTU	1.65%
% DO	100%	2.13%	2.13%

* Either pH 7 or 10 calibration solution is used for end-calibration, not both

South Platte River Temperature Monitoring: A Moving Target

