Algorithms in the Proactive Continual Monitoring of Source Water

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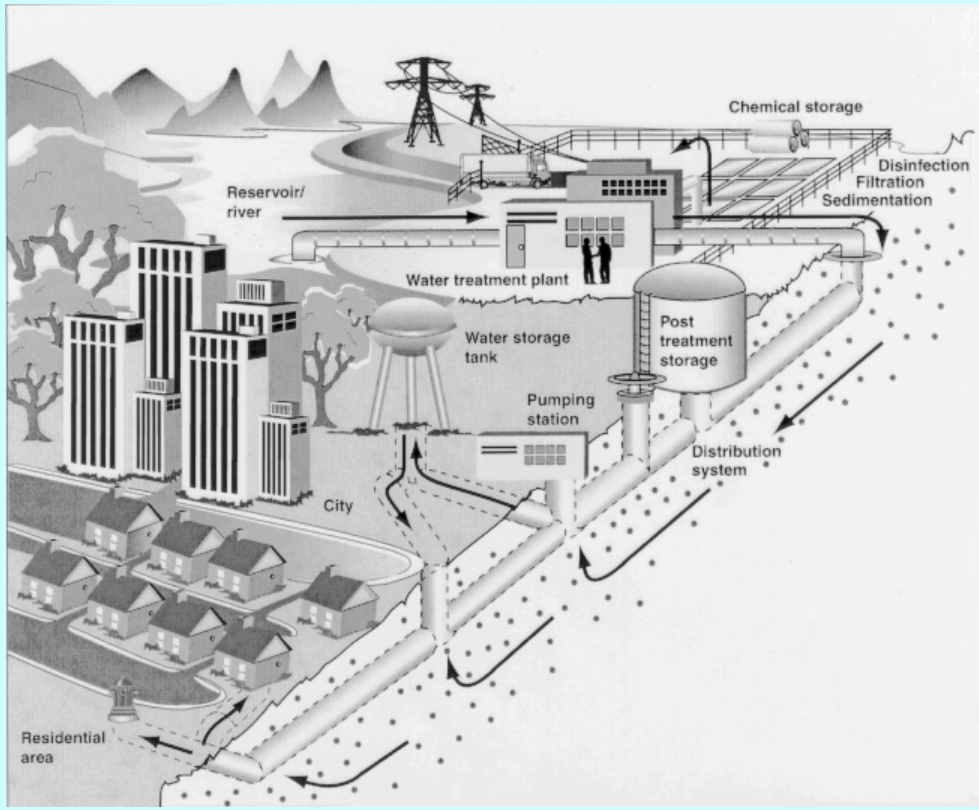
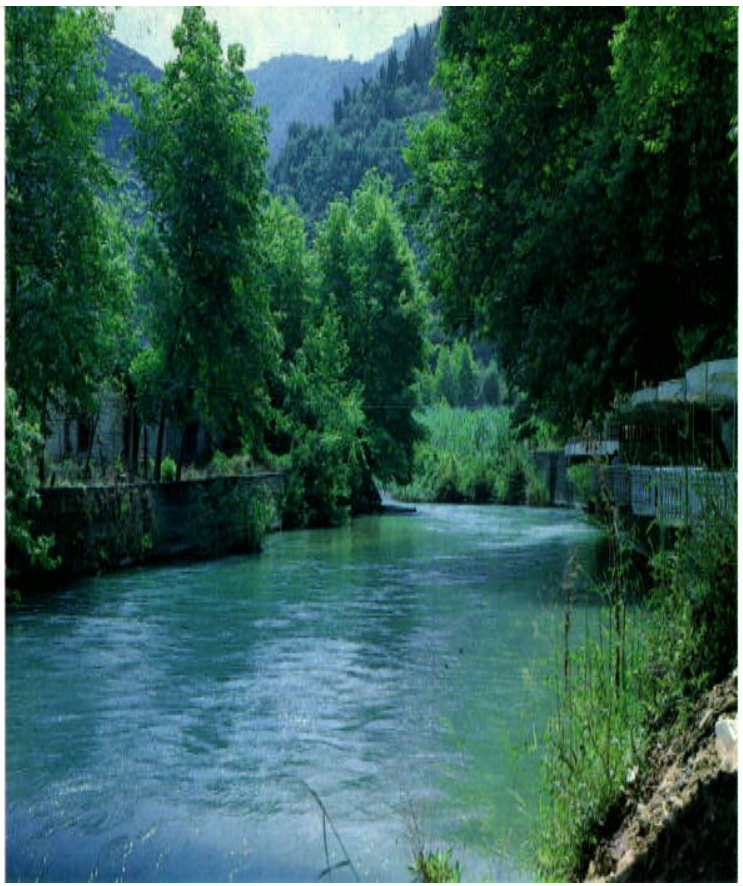
A Typical Water Supply System



Sites of Vulnerability

- Source water.
- Reservoirs
- Treatment Plants
- Finished Water Holding tanks
- Distribution System

Source Water



- Easy Access
- Requires Large Quantities due to dilution
- Many contaminant degraded by environment or removed by treatment plant

Reservoirs

- Access more difficult but not too hard.
- Requires Large Quantities due to dilution
- Many contaminant degraded by environment or removed by treatment plant

Treatment Plants

- Fairly Secure
- Dilution factor cut down.
- Could use chemicals already on site
- Insider problem

Finished Water Holding Tanks

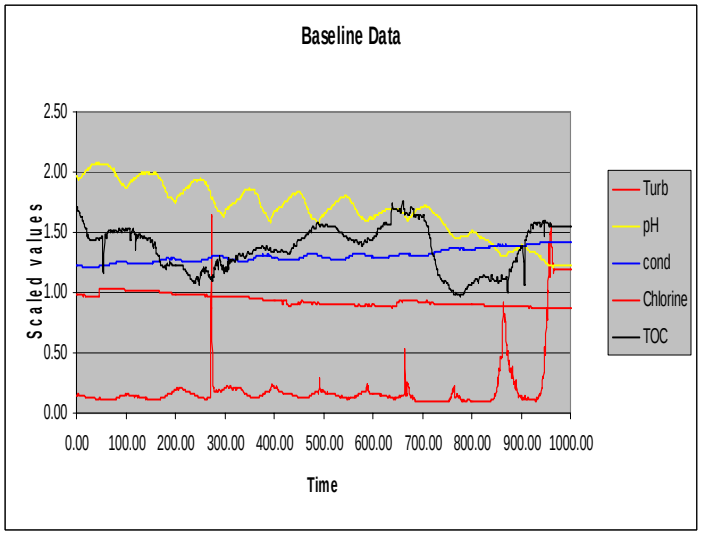
- Secure but not as secure as plants
- Dilution factor greatly reduced
- Post treatment

Distribution System

- Not at all secure
- Little dilution
- Specific areas can be targeted (Icon facilities, Military bases, etc.)
- Widely recognized as most vulnerable area

Distribution System: What is our vision?

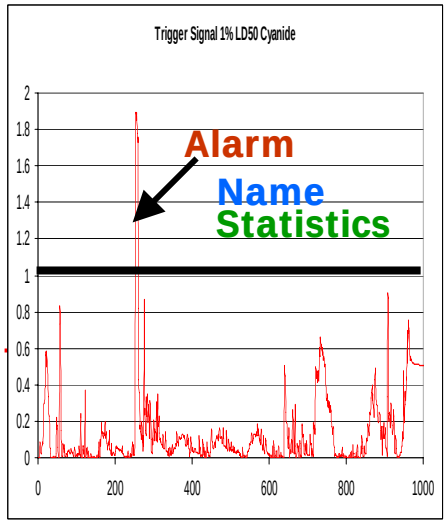
Input Five Parameter Signals



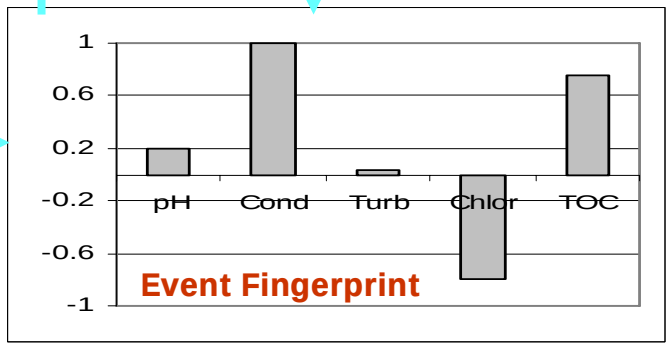
Analyze

Software

Output Single Signal



Learning



Plant / Agent Event Library

The Event Monitor analyzes plant data, alarms on significant deviations from baseline, reports the Event Name if found, and learns the event fingerprint if not already in the Plant Event Library.

Certificate of Conformance

This will certify that, on this date,

the United States Department of Homeland Security issued to

HACH COMPANY

a Delaware corporation

a **Certification** *for its*

Hach GuardianBlue™ Early Warning System

as an **'Approved Product for Homeland Security'** *under the*

Support Anti-terrorism by Fostering Effective Technologies Act of 2002 (the SAFETY Act).

Jay M. Cohen

Jay M. Cohen

Under Secretary for Science and Technology

10/31/2006

Date

Will this same approach work for source water?

Collaborative project with the USGS and Several Local Utilities

Source Water Monitoring

Modification of Basic Platform

Drinking water panel

Modified to Include:

- HR Turbidity
- pH
- Conductivity
- ORP
- Additional instrumentation
  - UV Organics Sensor
  - TOC Analyzer
  - Auto Sampler

Turbidity – higher range alternatives

- Solitax SC
  - 0-4000 NTU range
  - Accuracy ±1%
  - Resolution 0.001 NTU
  - Self cleaning
  - One point calibration
  - Dual beam IR detection
  - Independent of color

pH, Conductivity and ORP Sensors

- Differential pH probe for long term reliable operation
- Specific Conductance sensor
- Oxidation Reduction Potential
  - Platinum electrode
  - Range –2100 to 2100 mV

UV Organics sensor

- UV absorption measurement
- Self-cleaning wipers
- Spectral Absorption Coefficient at 254nm
- Available in a range of pathlengths

TOC and Autosampler

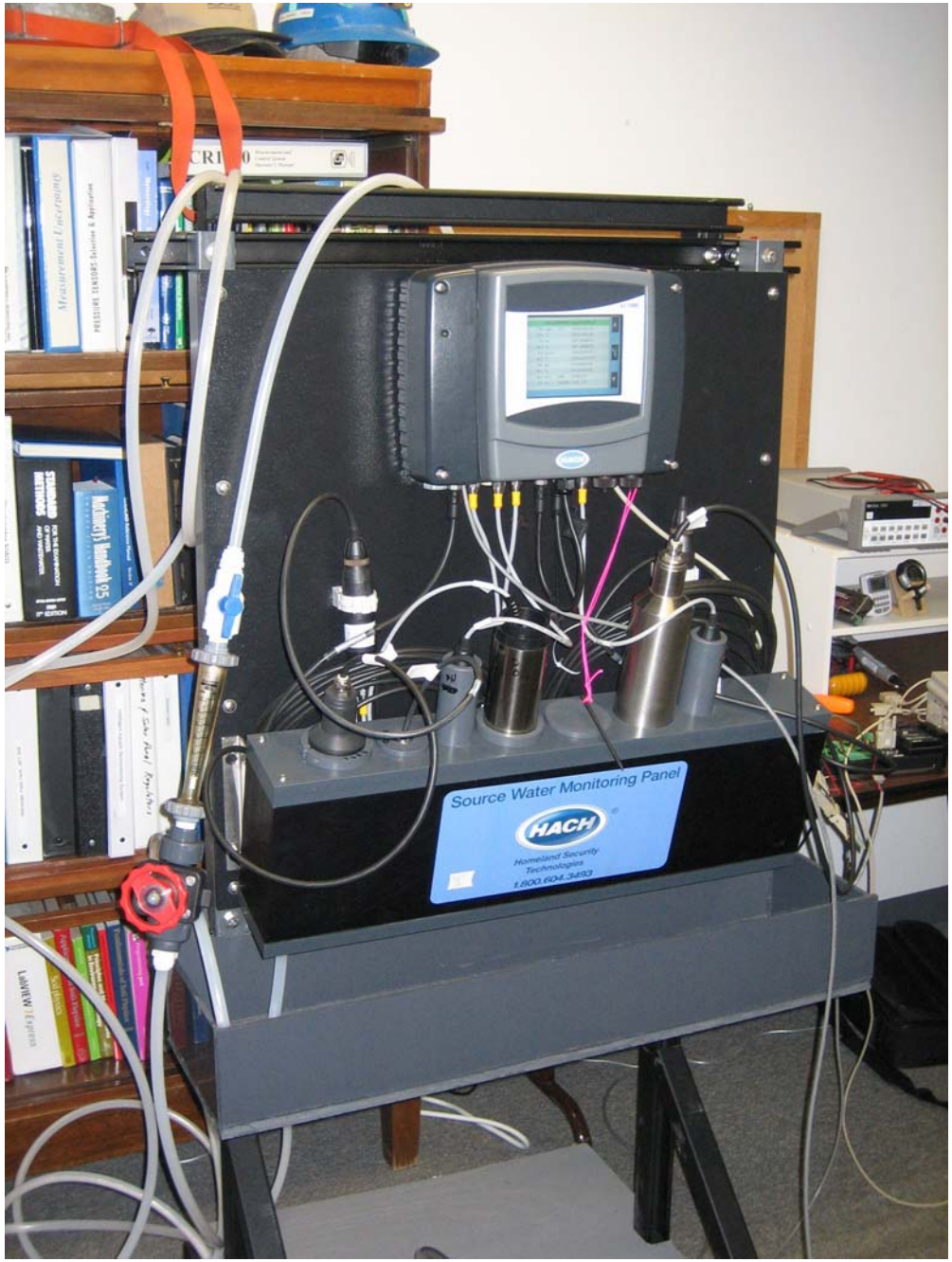
- *TOC for the broadest surveillance capability*
  - *UV Persulfate Method*
  - *Optimize sensitivity of system*

- Auto sampler
  - Triggered by system output when a deviation occurs
  - Configure w/24-1L sample bottles

Instrumentation / Site Requirements

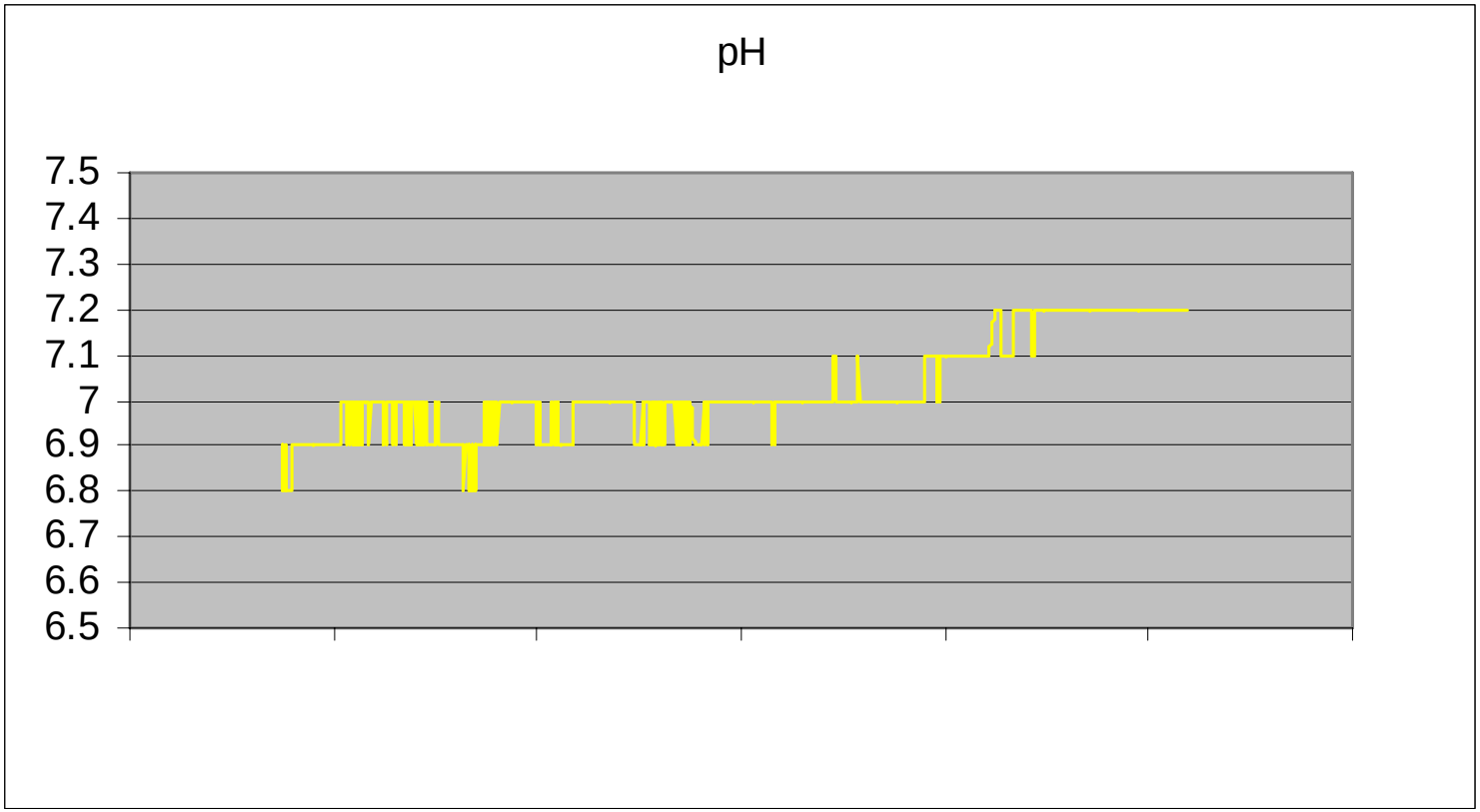
- 115 Vac required for all instrumentation
- UPS recommended
- Flow rate ~1L/min
- Sample pressure minimum 15-20 psi
  - Pump representative sample from river to monitoring station
- Operating temperature – 32 to 104 F
- TOC generates low pH waste stream – recommend discharge review
- Communication requirements based on desired data transmission


sc1000
533
18.3
0.0
20.0
HACH
Source Water Monitoring Panel
HACH
Homeland Security
Technologies
1.800.604.3493

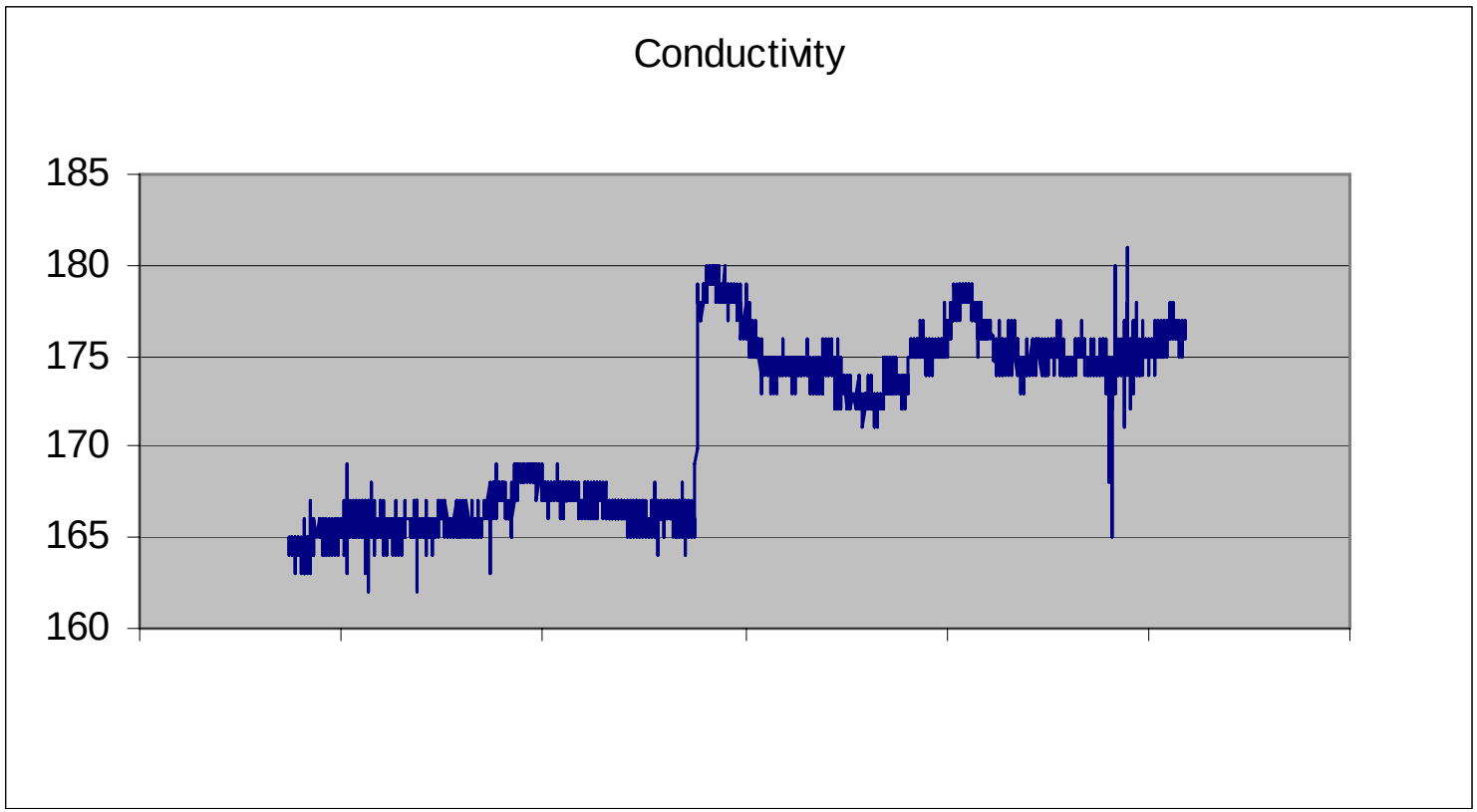


- System installed in a monitoring station
- Running for over a year
- Most sensors functioned well
- Some problems with ORP which may be redundant anyway

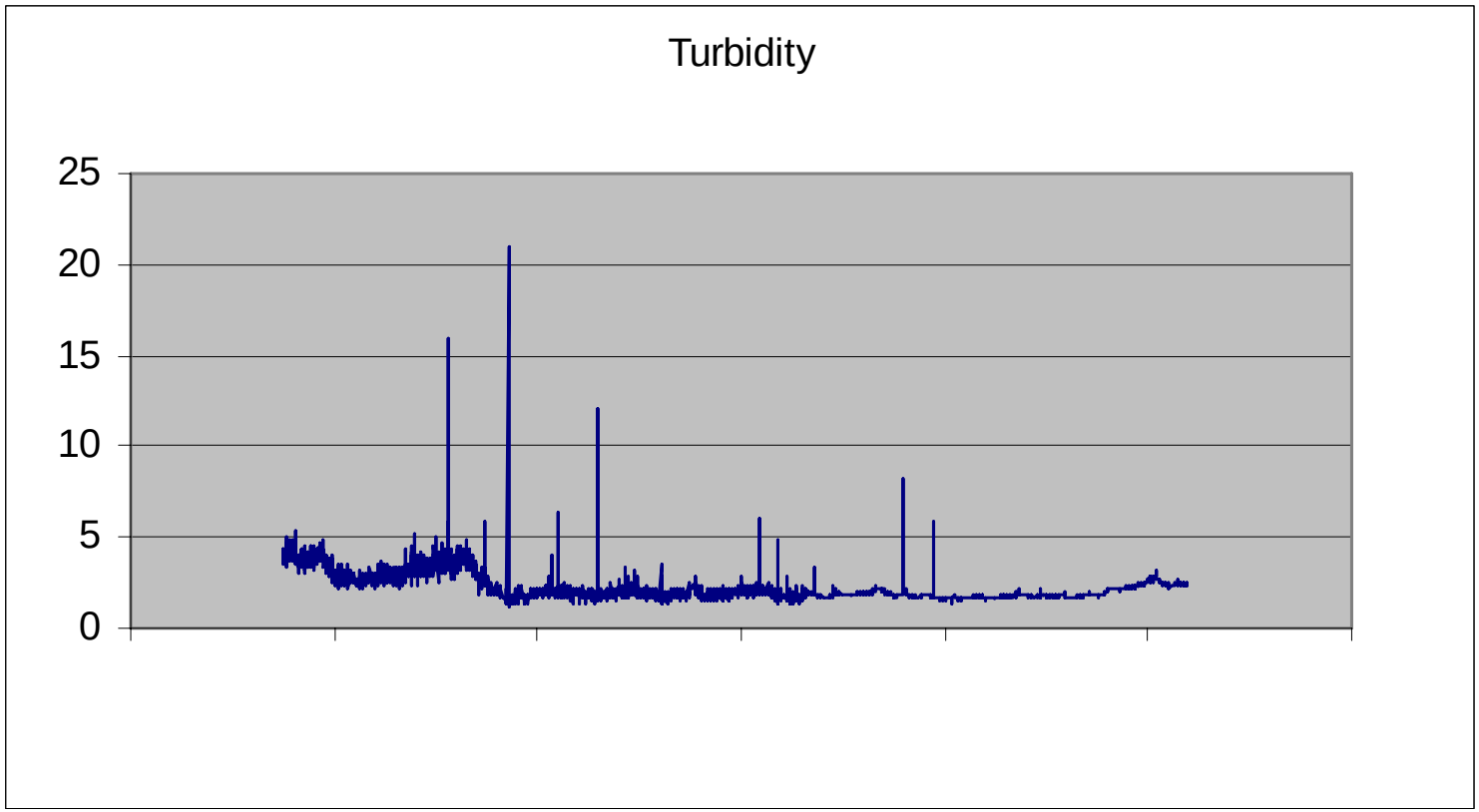
Source Water pH



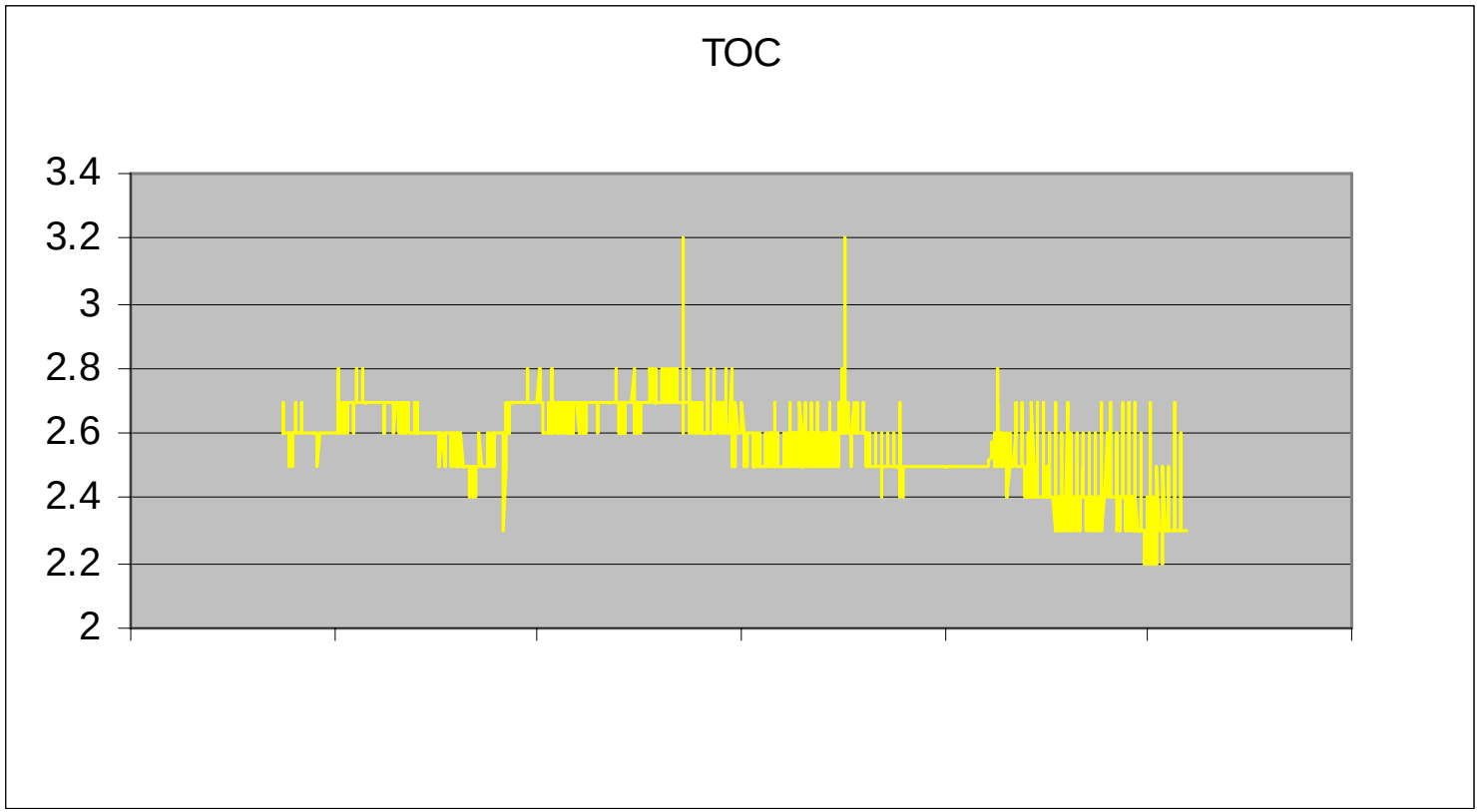
Source Water Conductivity



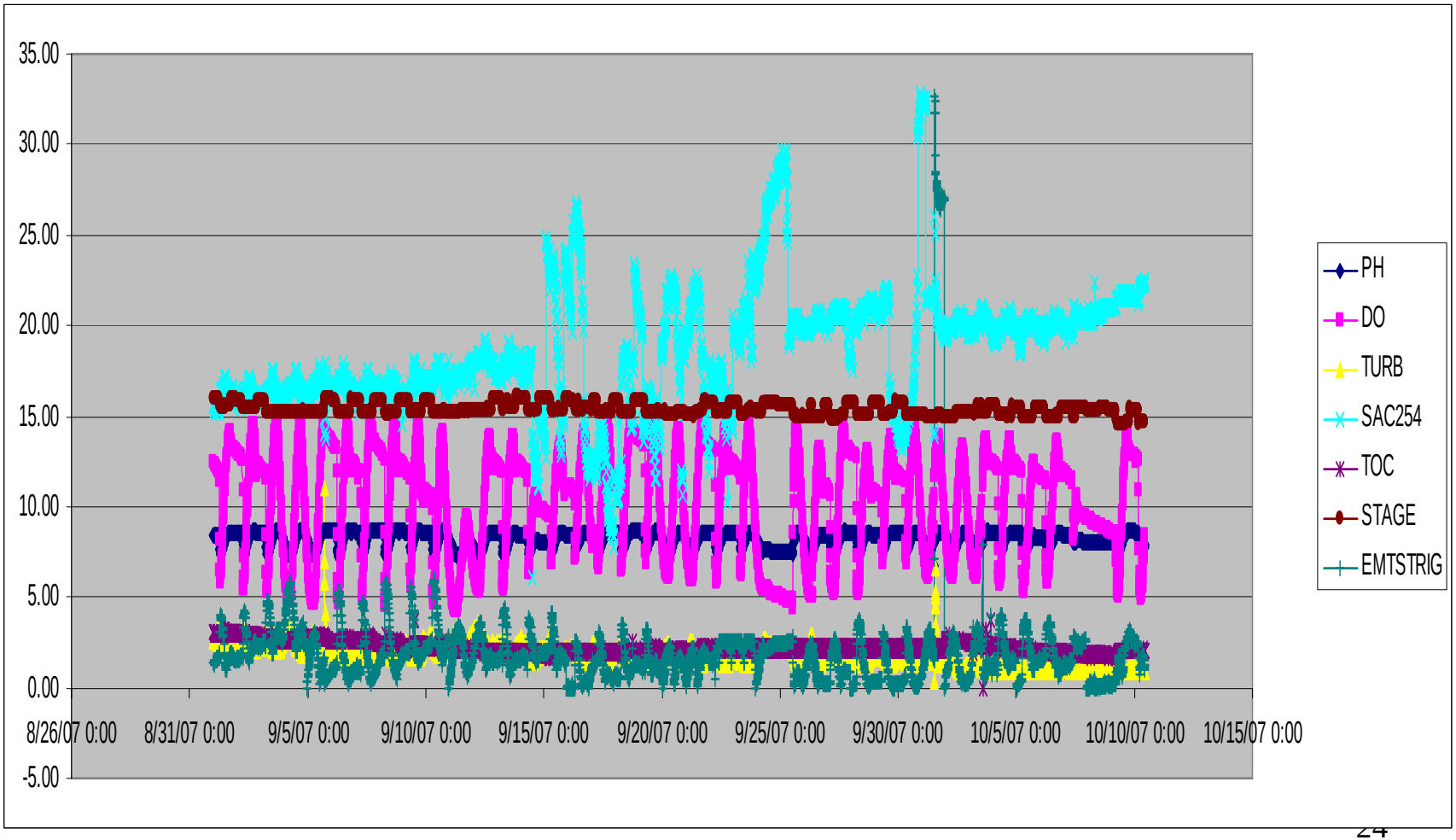
Source Water turbidity



Source Water TOC



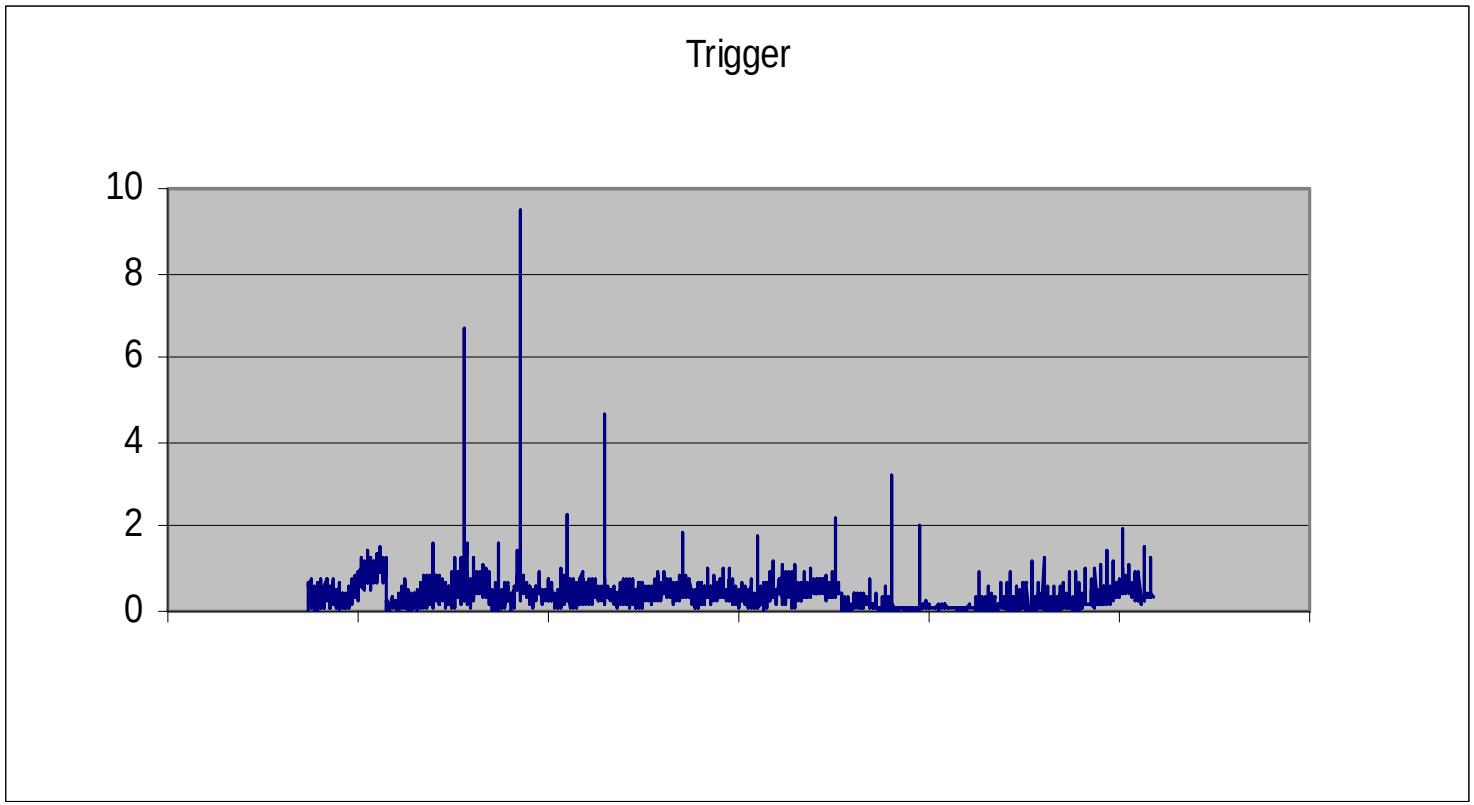
6 Weeks of Data From 1 Site



Adaptive Tuning

- A new tuning function was added to the software package to compensate for the noise. Utilizing the new algorithm, the software for the detection system continually adjusts its sensitivity based on the recent noise level in the multiple parameter readings. This adjustment helps to compensate for changes in baseline conditions over time. If the parameter readings become noisier, the system reduces its sensitivity, and increases its sensitivity should readings become less noisy. Result is a sensitive system with few false alarms

Adaptive Tuning



Reasons to Test Source Water

- Regulation
  - LT2 Enhanced Surface Water Treatment Rule
    - Purpose is to decrease Cryptosporidium
    - Monitor source water to determine treatment requirements
    - 2 years monthly sampling for crypto
    - Smaller systems can test for e. coli
  - D/DBP – TOC, Alkalinity
    - Monitor for organics that will cause DBP to form
    - Removing Organics
    - Monitoring and reducing residuals

Regulated Parameters

- Fluoride – Source water with natural fluoride
- Turbidity – Measured throughout the plant
- TOC – Monthly TOC removal
- pH – Adjusted throughout the plant to optimize processes
- Nitrate – Source water with Nitrate

Plant Operation Efficiency

- Monitor raw water to optimize chemical usage
  - Coagulation chemicals are dosed based on incoming water
  - In most cases turbidity is used to dose coagulants
  - In high TOC source waters, UVAS is a better measure of coagulant feed
  - pH control is critical to efficient coagulation
- Adjust process to blend multiple sources
  - High nitrate waters are blended with low nitrate waters to meet final effluent requirements

Detect Changes in Water Quality

- Adjust blending of multiple sources
- Intrusion of another source
  - Spring run-off / flooding
  - Municipal or industrial waste
  - Acid mine drainage
  - Produced water from oil and gas drilling operations
  - Algal blooms
  - Reservoir stratification
- Storm events
- Dissolved organic matter
- Protect treatment facility from accidental or malicious contamination of the source water

Turbidity/Suspended Solids

- Turbidity measurement is used to optimize the solids removal process
- Security – Sources of Turbidity that is added through intentional sources
  - Chemical compounds
  - Increased bacterial levels
  - Fertilizers
  - De-icing salts

Turbidity/Suspended Solids

- Natural turbidity
  - Inorganic suspended solids – clay, silt, mineral particles from soil – largest source of turbidity
  - Decaying plant matter
  - Urban runoff – construction sites or parking lots
  - Soil erosion
  - Thermal changeover resulting in algae blooms
  - Rain events from fire destroyed areas upstream
  - Rain events causing combined sewer overflows
  - Microorganisms
- May have to increase chemical dose, lengthen settling time, divert flow to avoid filter failure

UV Organics

- Security - intrusion of an organic nature such as diesel fuel
- Natural Organics
  - Low turbidity water may have high TOC
  - Algae blooms due to thermal inversion
  - During periods of high rainfall, source waters may see an increase in decaying organic mater which will show up on the UVAS probe
  - Absorbance at 254nm may correlate with THM formation at chlorination, COD, BOD or TOC concentrations
- May have to increase chemical dose, lengthen settling time, divert flow to avoid filter failure
- Stage 2 D/DBR dated Jan 2006 lists UV254/SUVA method as an approved method for enhanced coagulation control

pH

- Acid/base relationships within water
- Critical to processes in the plant – measured at source to aid coagulation
- Security – Chemical addition
- Natural pH
  - Natural particulates that change turbidity can also change pH
  - Acid mine runoff
  - Accidental chemical runoff
- Change pH to optimize coagulation chemical feed

Dissolved Oxygen

- For the day to day running of a plant, DO can be directly correlated to water quality.
- Security
  - Water quality indication of toxic conditions
- Natural DO changes
  - Sudden change may indicate toxic conditions that effect algal respiration or increased levels of bacteria using up the oxygen
  - Thermal overturn of reservoir and bring anoxic water to the treatment plant
- Changes characteristics of coagulation dosing

Conductivity

- Measures total ionic concentration in water
- Security
  - Harmful ionic species
- Natural conductivity/TDS
  - Common indication of wastewater incursion
  - Increased inorganic components
  - Salts
  - Saline incursion
  - Iron/chlorides
  - Aluminum from dosing chemicals

Nitrate/Ammonia/ORP

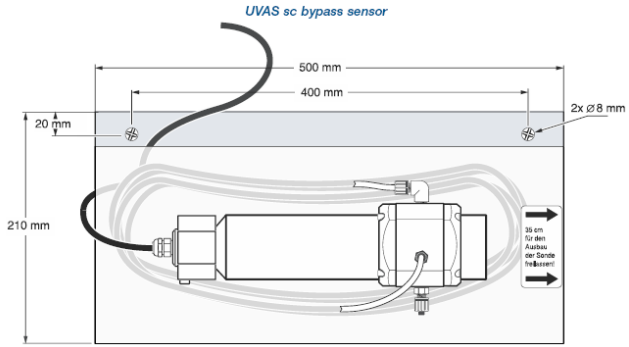
- ***Nitrate:*** Nutrient level within water; agricultural runoff. If the incoming water exceeds 10 ppm, the plant will need to treat the water through blending, ion exchange or membrane filtration
- ***Ammonium*** May indicate presence of pesticides or other biological degradation of organic matter. Detects sewer collection backup due to heavy rains. It is also critical for systems that add chlorine. Chlorine and ammonia combine to form chloramines. That ratio of chlorine and ammonia is important to controlling the various species of chloramines and understanding breakpoint chlorination
- ***ORP Sensor:*** May indicate sudden changes for oxidative or reducing species introduced into the water or thermal turnover

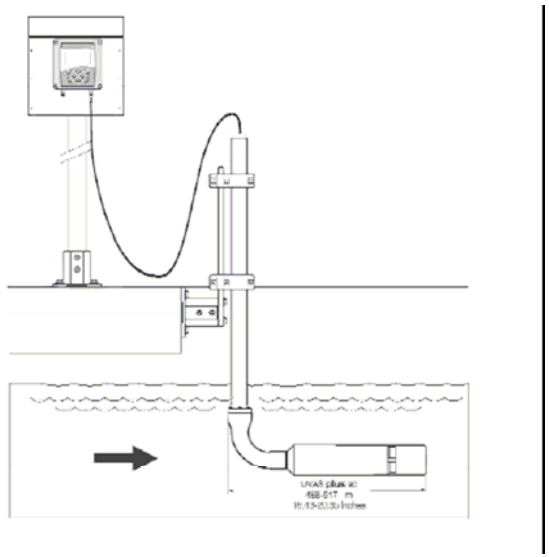
Coagulation Control Using Source Water Monitoring

- In the discussion of source water monitoring, the real issue is the day to day running of a WTP.
- The first line of defense for the water treatment plant is coagulation control
- It is also the most cost effective may to reduce treated water turbidity and organics
- Removing organics is the best measure of removing DBP

Coagulation Control Using Source Water Monitoring

- The 2 main instruments used to pre-dose coagulants are turbidity and UV Organics or UVAS.
  - Turbidity – The best pre-dose instrument for organic under 2 L/mg-m. Below these ranges most of the turbidity is caused by inorganic matter such as clay, silt, etc.
  - UVAS – More accurate instrument for coagulation control when organics increases past 2 L/mg-m



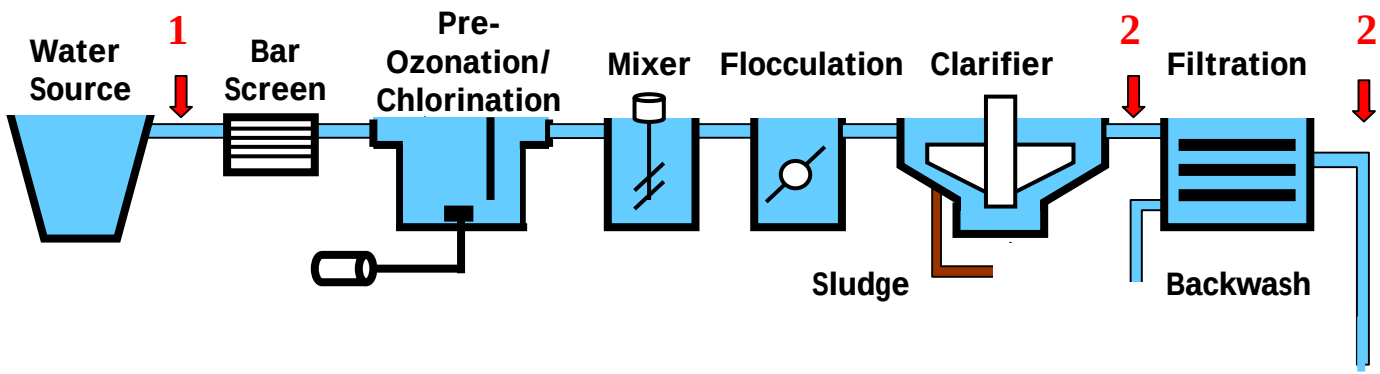


Coagulation Control Using Source Water Monitoring

- Organics measured by UV typically have double bonds with free electrons that ready bond with molecules around them.
- This results in increased formation of DBP and consumes coagulants at a faster rate than other molecules
- By using UVAS at the source and before filtration, the coagulant is dosed to provide maximum removal
- The relationship between turbidity and organics changes independently. While coagulation is initially dosed using turbidity, UVAS can determine if additional dosing is needed in the case of higher organic content.

Coagulation Control Using Source Water Monitoring

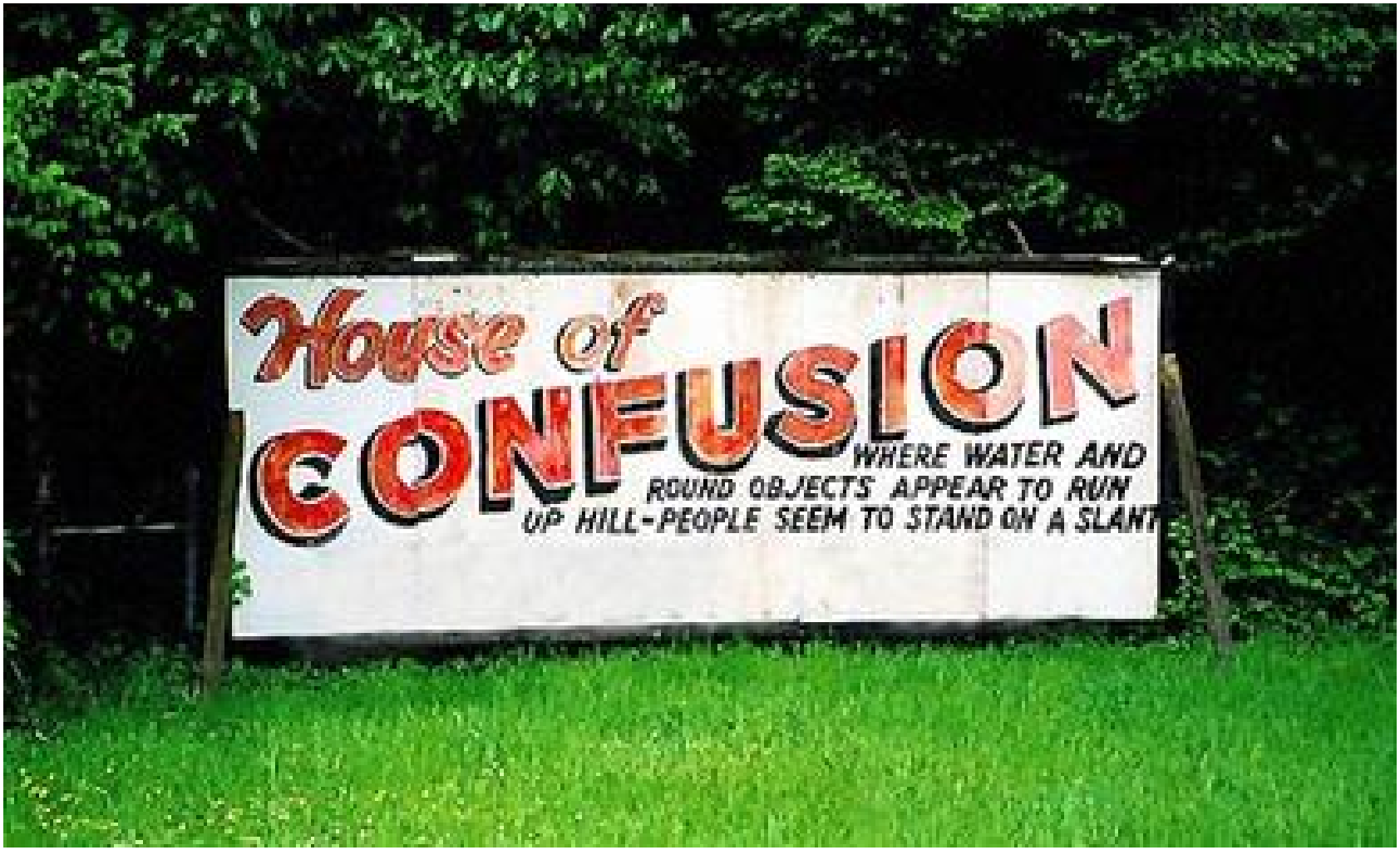
- 1. Source water monitoring to forward feed coagulation dose
- 2. Post clarification or post filtration to monitor effectiveness of coagulation and backfeed dosing/settling time



Coagulation Control Using Source Water Monitoring

- While UVAS and turbidity are common parameters to control coagulation, there are studies showing the relationship of other parameters as part of an algorithm to control dosing.
- These same parameters provide effective security monitoring as shown earlier

Questions?


House of
CONFUSION
WHERE WATER AND
ROUND OBJECTS APPEAR TO RUN
UP HILL-PEOPLE SEEM TO STAND ON A SLANT