TURBIDITY AND DISINFECTION IN DRINKING WATER

CWWA, 2016
TRINIDAD TOBAGO

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BDM Latin America & Caribbean

Turbidity

5 NTU

3 NTU

1 NTU

Pathogens

Salmonella

E. coli

Protozoans

Cryptosporidium

Giardia

Trihalomethanes

Disinfection Byproducts

Haloacetic Acids

Emerging Contaminants

Personal Care Products

Ibuprofen

Acetaminophen

Endocrine Disruptors

Estrogens

It's Enough to Make You Sick!

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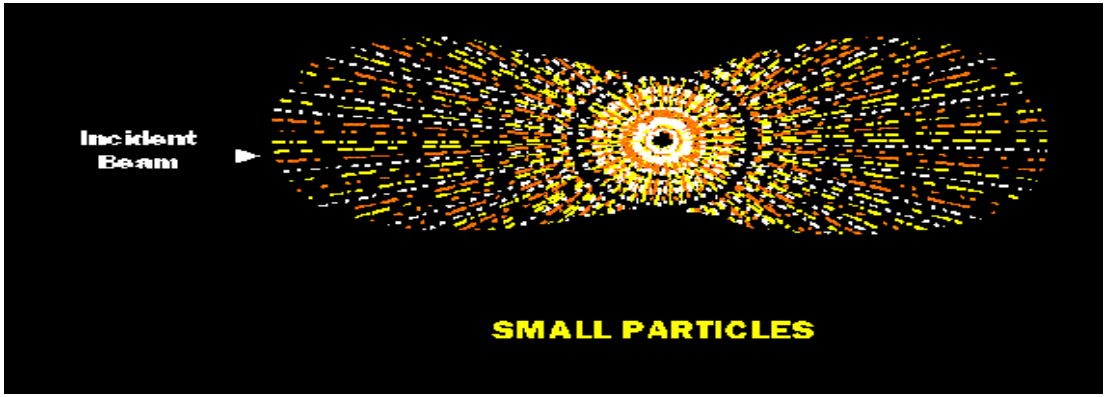
TURBIDITY AND WHAT IS IT

- Measure of light scattered from suspended solids in water



- Represents the clarity of water
  - turbid, cloudy,
- Composed of suspended and colloidal matter
  - organic matter
  - inorganic matter
  - biological organisms

TURBIDITY AND WATER QUALITY

Sources of Turbidity	Effects	Water Treatment Implications
Inorganic particles – carbonates, iron and manganese oxides	Changes in pH and zeta potential, cloudy appearance, source of micronutrients, taste	Difficulty in coagulation of particles, harbors and protects pathogens from chemical disinfection
Organic Particles – decomposed plant and animal debris, humic substances,	Energy and nutrients for bacteria and protozoans, pH, ion exchange, taste, precursor to DBs, zeta potential	Disinfection demand, and byproducts, increase in polymer dosing and coagulation times, inadequate disinfection,
Biological organisms – algae, zooplankton, pathogens, filamentous bacteria	Taste and odor, toxins, disease transmission, staining and discoloration, filter clogging	Increased disinfection demand, shortened filter bed life

TURBIDITY AND THE PRESENCE PATHOGENIC AND NON-PATHOGENIC ORGANISMS

- **Increases in turbidity**
  - growth of organisms most extensive on surface of particles and inside flocs
  - increased heterotrophic plate counts parallel with increases in turbidity
  - presence of coliforms after disinfection with turbidity ranges from 3 to 84 NTU
  - sub-optimal coagulation and breakthrough resulting in deterioration in *Cryptosporidum* removal
- **Optimal Turbidity**
  - 0.05 NTU
- **Optimal Chlorine Residual**
  - 2.0 mg/L Cl_2

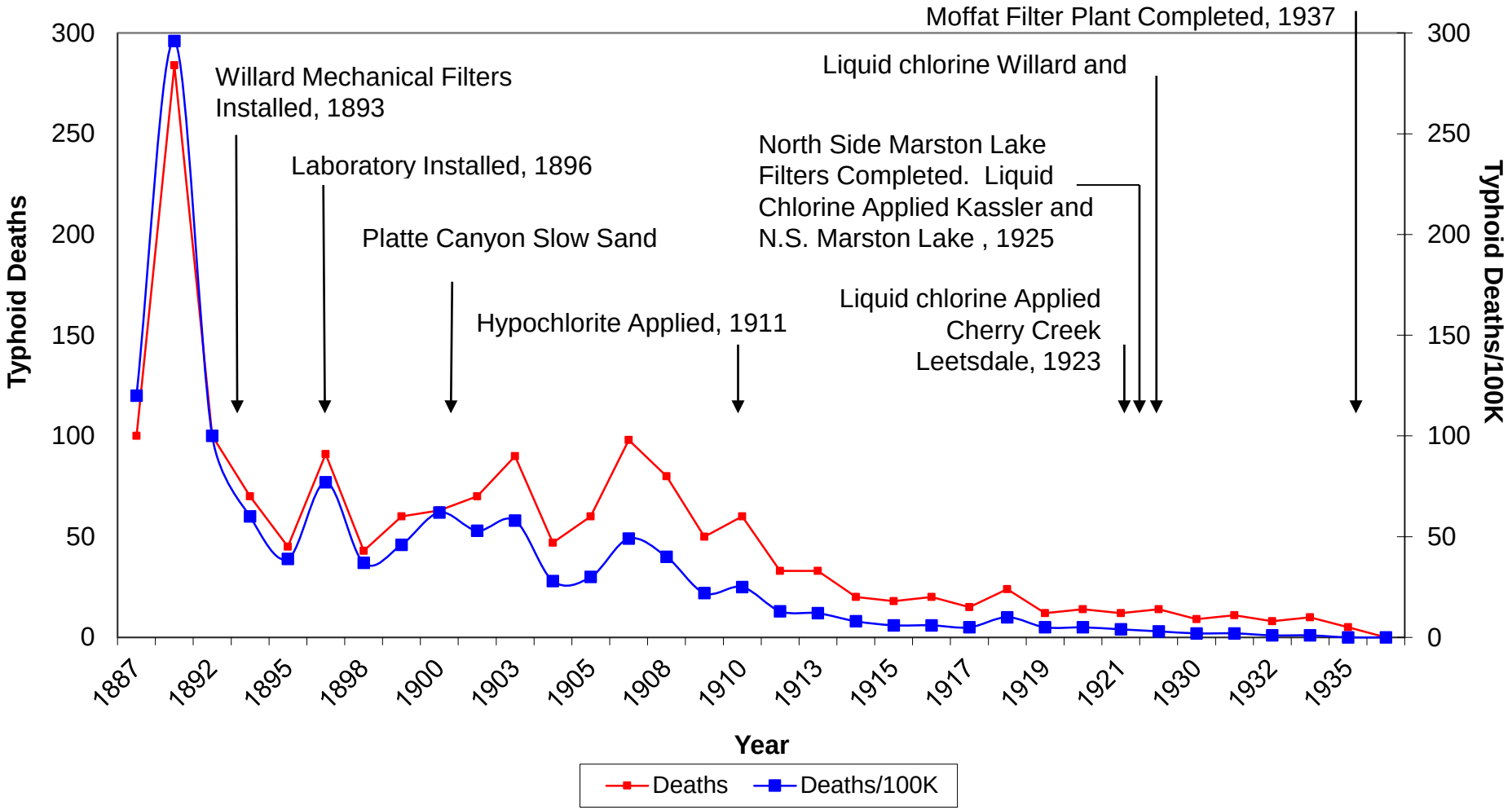
EFFECT OF TURBIDITY ON DISINFECTION

- **Chlorine Demand**
  - water with high turbidity gives rise to a substantial chlorine demand
  - chlorine demand results in a reduction of free chlorine residual and loss of protection from recontamination, and increased costs of disinfection
  - increased pre-chlorination dosage requirements
    - study shows 180% increase in chlorine demand for a turbidity increase from 1.0 to 5.0 NTU
    - increase in turbidity from 1.0 to 10 NTU results in an eight-fold decrease in disinfection efficiency at a fixed chlorine dose
    - viruses and coliforms that adsorbed to organic matter are more resistant to disinfection

Denver, Colorado Typhoid Deaths 1887-1940.

Source of information: Denver Water

Deaths from Typhoid 1890 - 287; 1940 - 0



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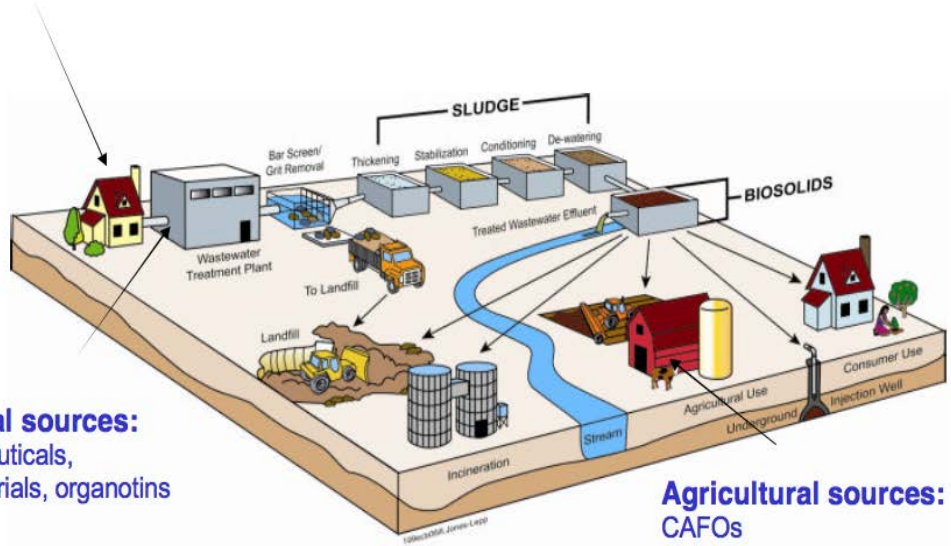
EMERGING CONTAMINANTS

- Chemicals are being discovered in water that previously had not been detected or are being detected at levels that may be significantly different than expected.

Consumers: Pharmaceuticals, nanomaterials in personal care products (e.g., sunscreens), personal care products (e.g., NPEOs, synthetic musks), detergents (fluorescent brighteners), PVC pipe (organotins)



Industrial sources: pharmaceuticals, nanomaterials, organotins

Agricultural sources: farming, CAFOs

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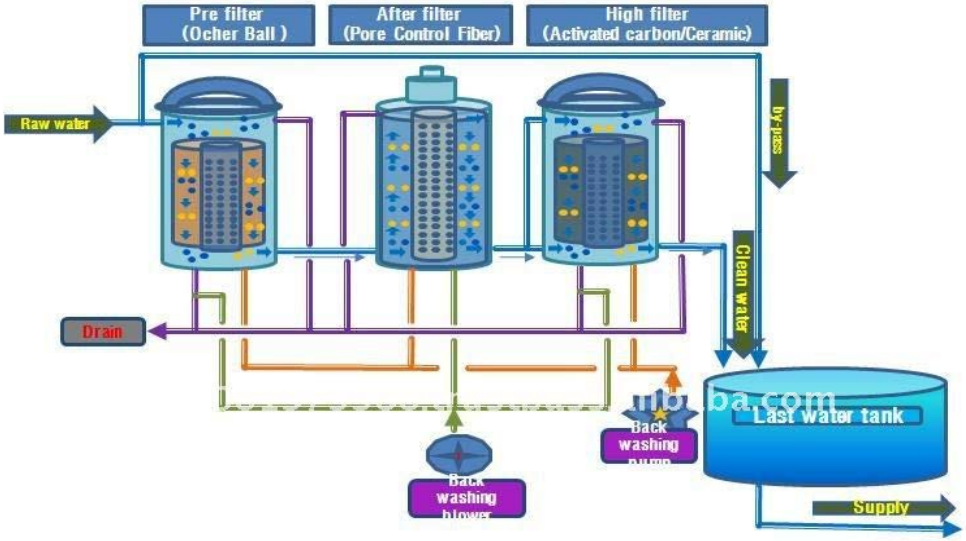
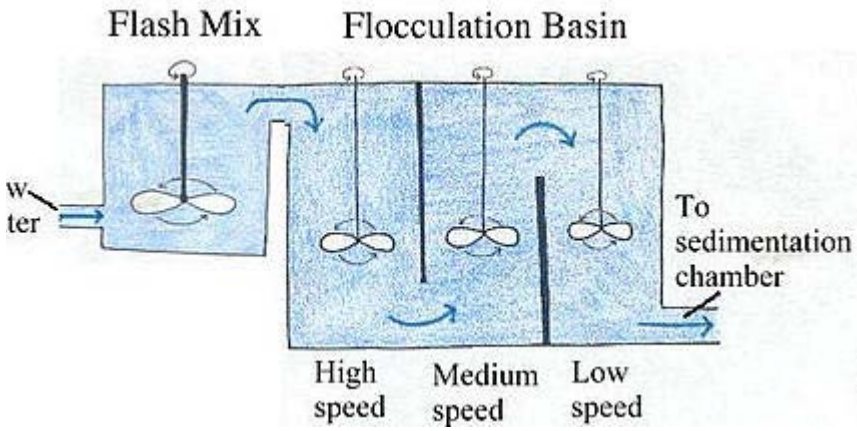
TREATMENT AND MONITORING TECHNOLOGIES

- **Turbidity**
  - Chemically Assisted Filtration - 0.3 NTU
  - Slow Sand Filtration – 1.0 NTU
  - Diatomaceous Earth Filtration – 0.95 to 2.5 NTU
  - Membrane Filtration - < 0.10 NTU
  - Polymer Coagulation





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WHY IS TURBIDITY IMPORTANT?

Turbidity is the report card by which drinking water production is measured.

Low turbidity signifies:

- Safe water (minimal microbiological risk and maximum disinfectant effectiveness)
- No taste and odor issues
- Controlled turbidity indicates a well-run process and plant

WHAT ARE TODAY'S CHALLENGES IN TURBIDITY?

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HACH AND DR. LANGE: LEADERS IN TURBIDITY MEASUREMENT FOR OVER 50 YEARS

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The TU5 Series was built so you can be sure that a change in your turbidity reading is a change in your water.

- Groundbreaking 360° x 90° Detection™ Technology
- Matching lab and online results
- Everything about turbidity – faster
- No Surprises

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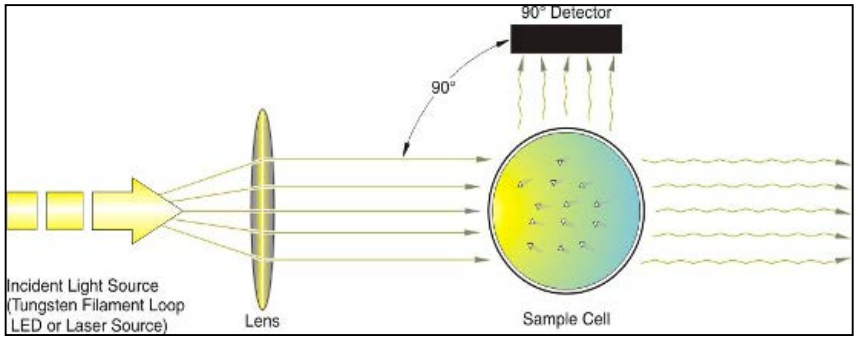
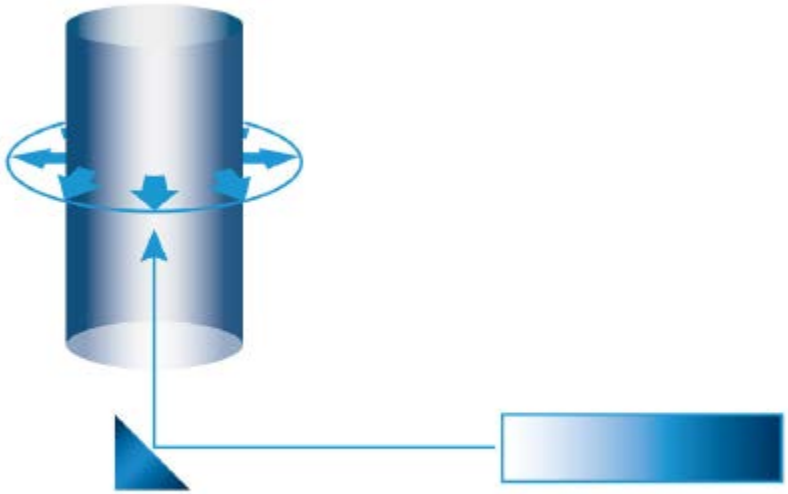
GROUNDBREAKING 360° x 90°MEASUREMENT TECHNOLOGY

The TU5 Series employs a unique optical design that sees more of your sample than any other turbidimeter, delivering the best low level precision and sensitivity while minimizing variability from test to test.



Traditional Turbidity Measurement 90°



New 360° x 90°measurement technology

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MATCHING LAB AND ONLINE RESULTS

For the first time you will be able to remove the uncertainty of which measurement to trust, thanks to **identical 360° x 90° Detection Technology** in both instruments. Sample Tracking* and compare wizard supports the user in the evaluation of matching or non matching result.

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EVERYTHING ABOUT TURBIDITY – FASTER MAINTENANCE

- 95% less online sample surface area to clean.
- Unique sealed vials for calibration of process and lab instrument.
- No need for indexing and silicone oil in the lab.

Old: 10 Minutes

New: 1 Minute

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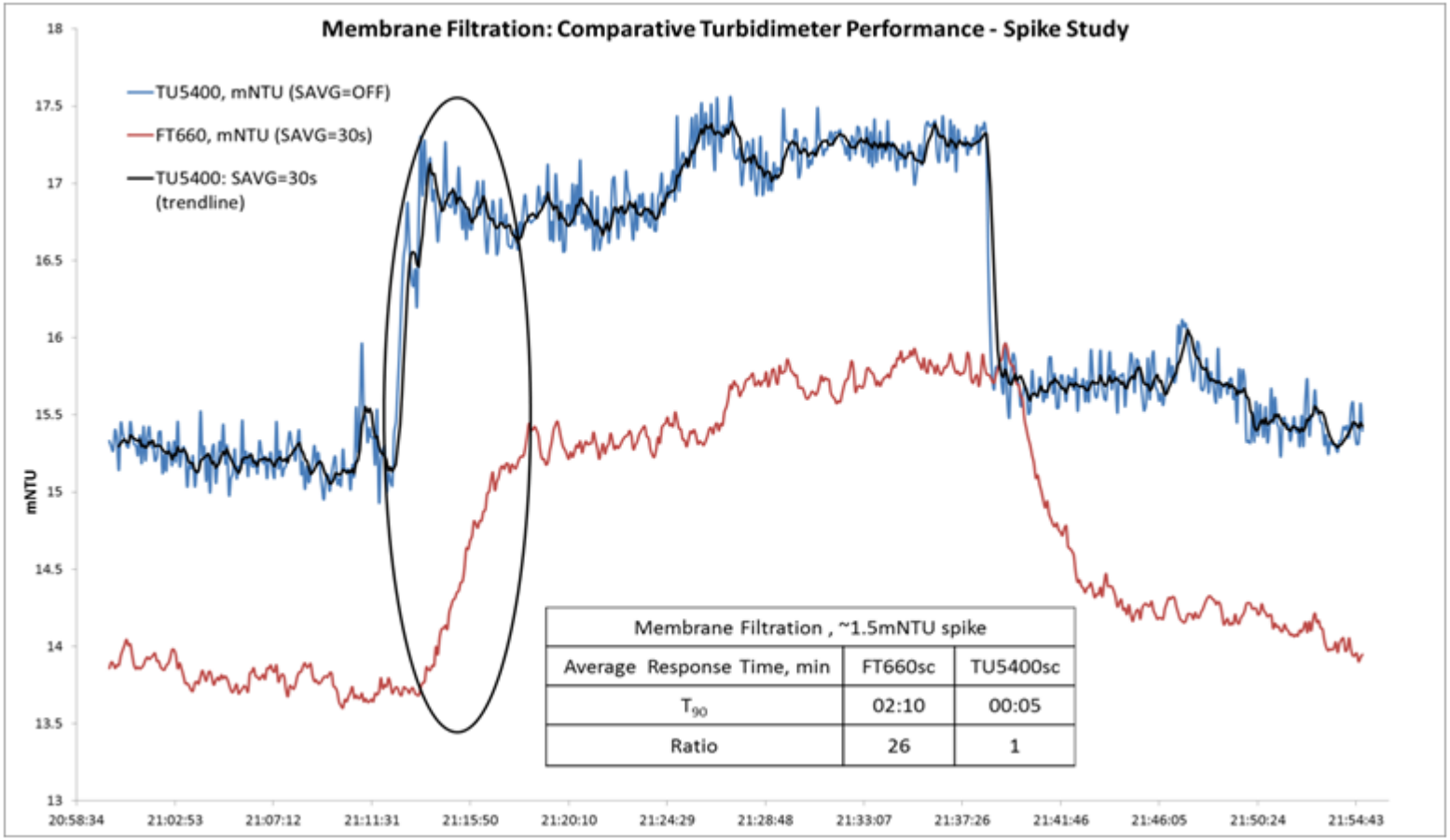
EVERYTHING ABOUT TURBIDITY – FASTER EVENT DETECTION



Membrane Filtration , ~1.5mNTU spike		
Average Response Time, min	FT660sc	TU5400sc
T_{90}	02:10	00:05
Ratio	26	1

A smaller online sample volume means you will detect events almost immediately.

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NO SURPRISES

- Prognosys™ predictive diagnostics monitors a TU5 Series online instrument, proactively alerting users to maintenance and service needs before a measurement becomes questionable.
- Onboard troubleshooting in the TU5 Series laboratory instrument allows for easy resolution of issues

PROGNOSYS™

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ADDITIONAL SLIDES – SUPPORTING TREATMENT

TREATMENT AND MONITORING TECHNOLOGIES

- **Chlorine Disinfection**
  - Hypochlorite and Hypochlorous Acid
    - $Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$
    - $HOCl \rightarrow H^+ + OCl^-$
  - Chlorine dioxide (ClO_2)
    - $ClO_2\,(aq) + e^- = ClO_2^-$
  - Monochloramine (NH_2Cl)
    - $NH_3 + HOCl \rightarrow NH_2Cl + H_2O$

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ON-LINE MONITORING OF CHLORINE DISINFECTION RESIDUAL – AMPEROMETRIC VS COLORIMETRIC

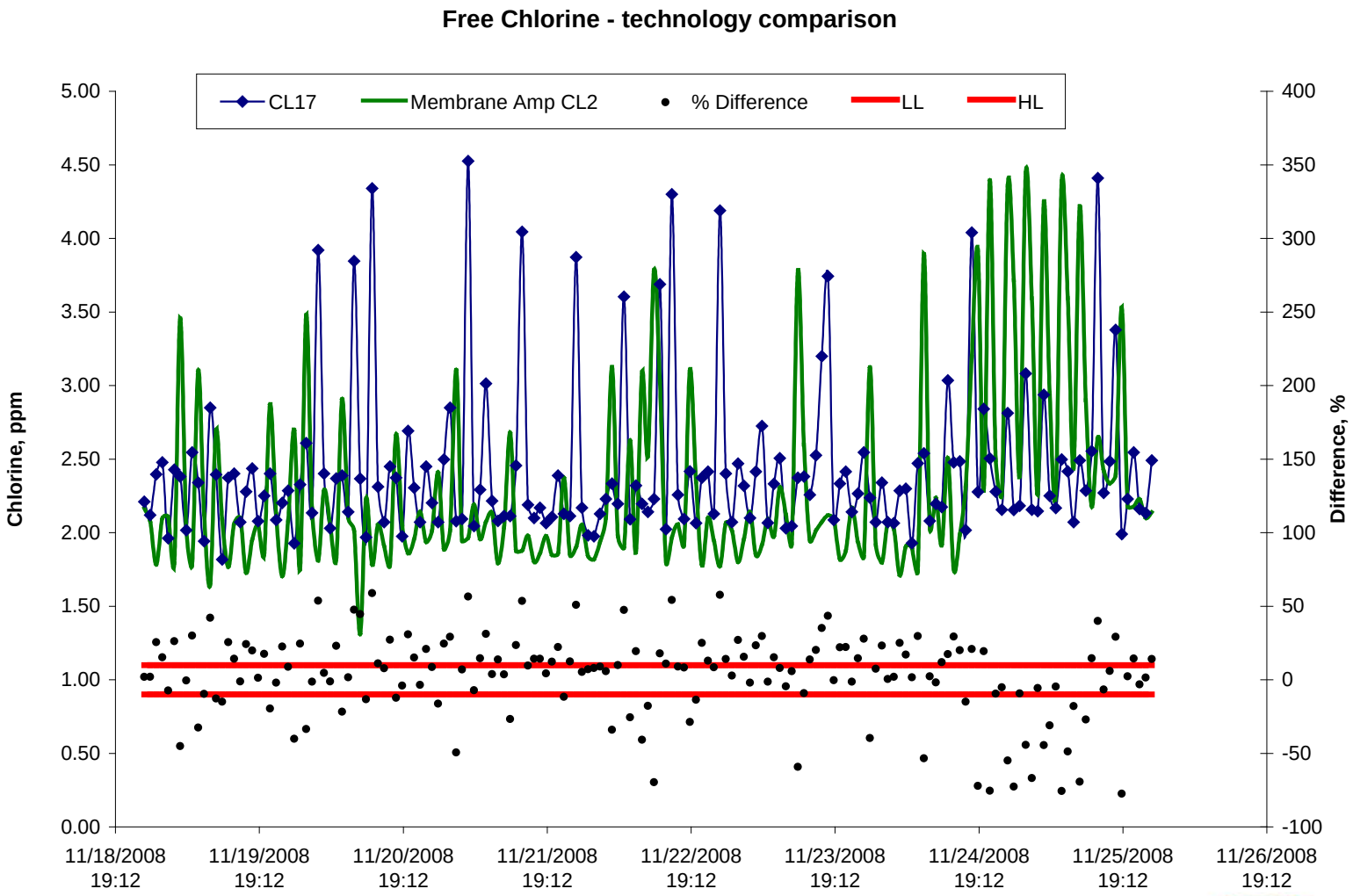
Amperometric

- Continuous Readings
- Reagentless when measuring for free chlorine, requires reagents for total chlorine.
- Requires stable water without large changes in pH, temperature, and dissolved organic carbon for accurate measurements.
- Subject to membrane fowling in water that contain levels of iron and manganese
- Membrane replacement averages 2 or more times per year ($600 per replacement).

Colorimetric

- Continual Readings – every 2.5 minutes
- Requires reagents every 30 days
- Stable and most accurate measurements in all waters with large changes in pH, temperature, and dissolved organic carbon.
- Very low maintenance required
- Golden standard for chlorine measurements. Most accurate, most precise.

COMPARISON OF AMPEROMETRIC AND DPD ONLINE TECHNOLOGY



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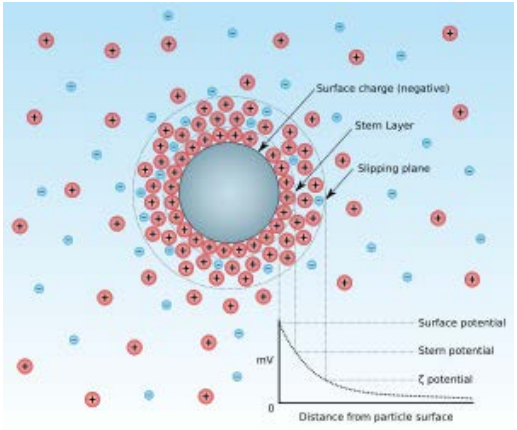
TREATMENT AND MONITORING TECHNOLOGIES

- **Dissolved Organic Carbon (DOC)**
  - **DOC (humic acids) + alkalinity**
    - **Reduces DOC and disinfection byproduct formation**
- **Streaming Current (zeta potential ζ)**
  - Optimization of polymer for turbidity coagulation



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