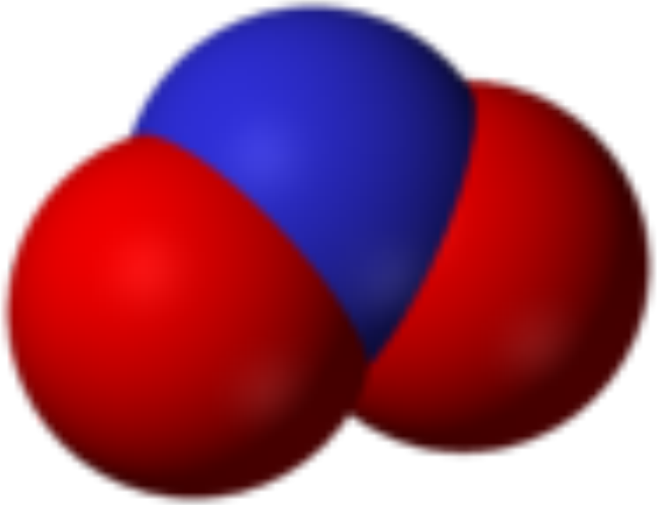
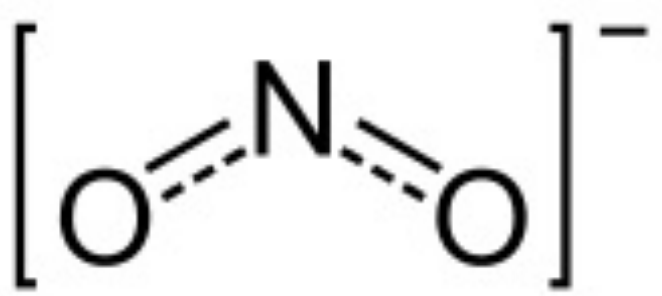
Nitrite monitoring with an online analyzer

hunting an elusive quarry for 20 years





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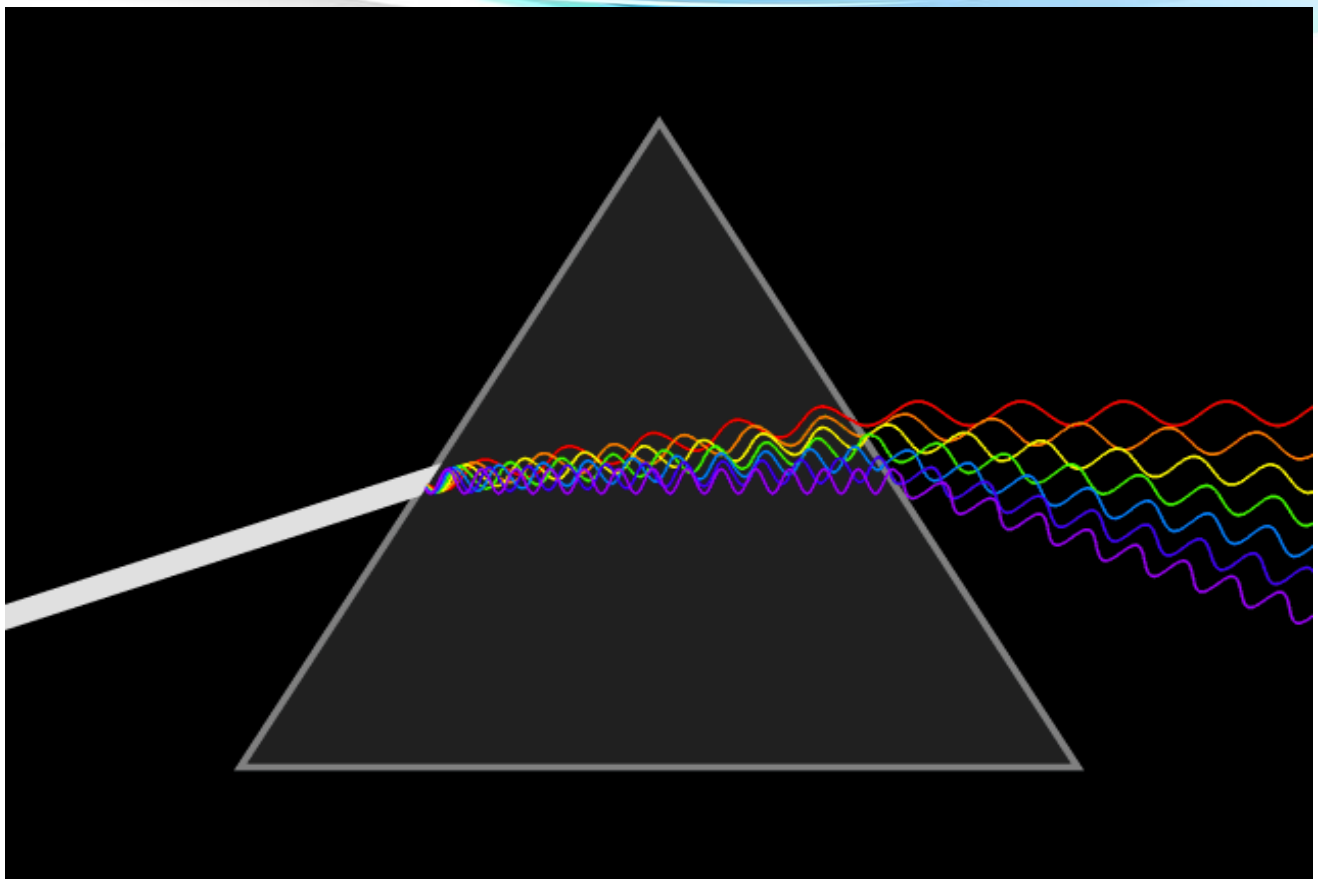
Online Monitoring for Process Optimization



Bruce Stevens – Regional Manager
Scott Kahle – VP Engg
Roy McKnight PhD – Lab Manager
Bernard Beemster – President

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Automated spectrometers provide reliable, accurate multi-parameter and multiple sample stream analysis

Single sample line photometers can do one parameter

Got started in 1993 after 7 years of NASA R+D via Biotronics

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“If You Want to Control Process Chemistry, Measure Constituents + Species DIrectly”

- **If a plant has nitrogen and/or phosphorus discharge limits …… then why measure anything other than NO2, NO3 + NH3 or PO4 for process control ?**
- **Surrogate parameters such as DO, ORP, MLSS or O.U.R do not provide any direct information about nutrient levels. pH, conductivity, and turbidity do not tell you if nitrification is happening either ?**
- **TN and TP analysers do not speciate, are cumbersome and difficult to maintain, so use B.A.T. for accurate, repetitive results ….**

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1980s was the Initial Research during Lunar Colonization Preparations

Hydroponic techniques—like those used to grow these onions, lettuce, and radishes in this plant growth chamber in Kennedy Space Center's Space Life Sciences Laboratory—may one day contribute to the development of a bioregenerative life support system.

Originating Technology/NASA Contribution

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EPCOT begin a new era in WWTFs

Reedy Creek Improvement District (RCID)

Manages water, waste water and reclaimed water for the Disney resorts

ChemScan demo in 1993 for effluent monitoring to RIBs

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City of Tampa – Hookers Point WWTF
Denitrification filter testing 1994

Excess iron salt use removed all the PO4 and no heterotrophs would not grow in the filters

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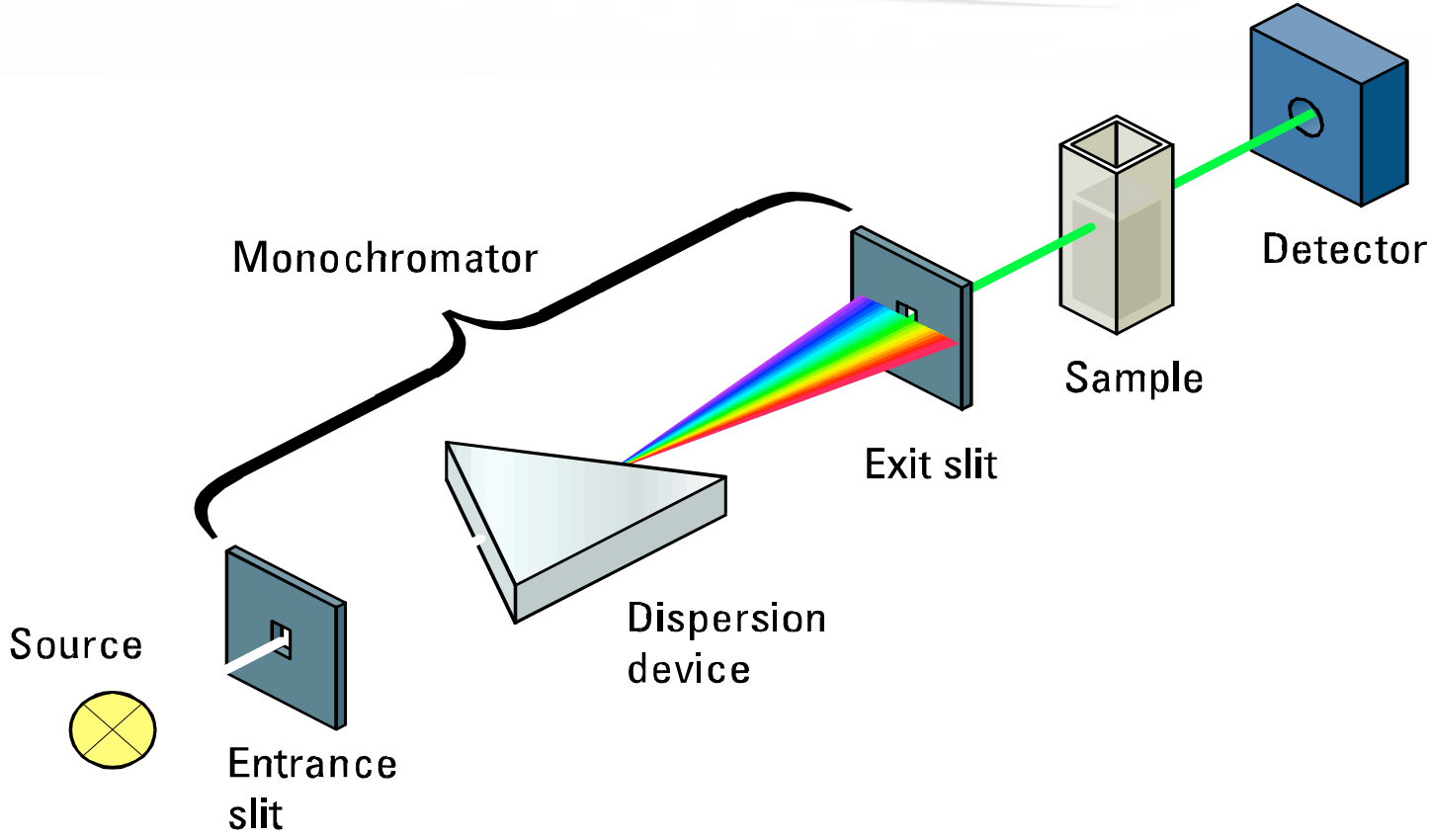
Lab spectrometer



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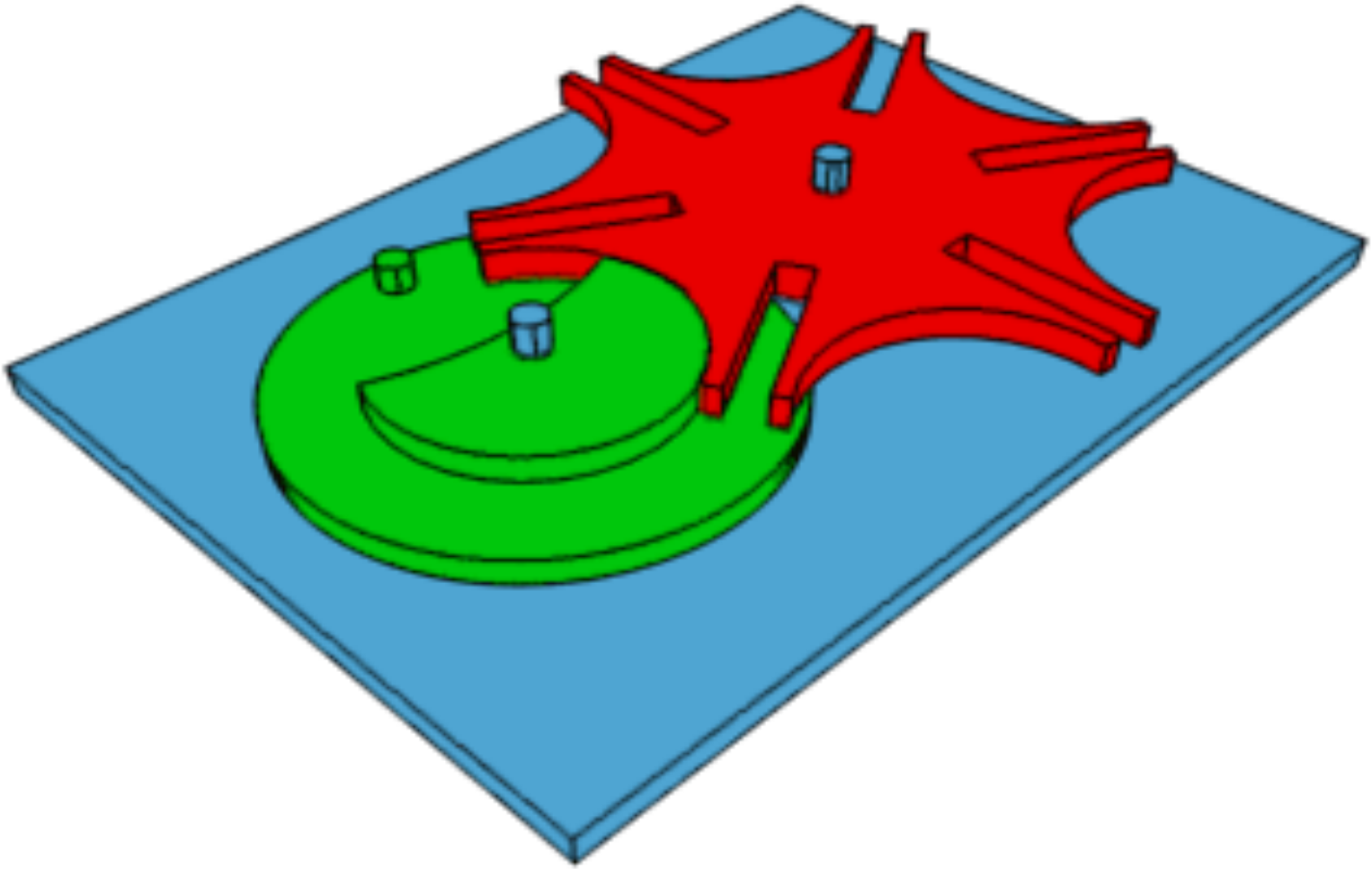
Automation is Applied

Sample delivery and preparation is Simplified



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ChemScan system with a proud operator happily showing off their 20 yr old NO_3 analyzer inside a climate controlled enclosure

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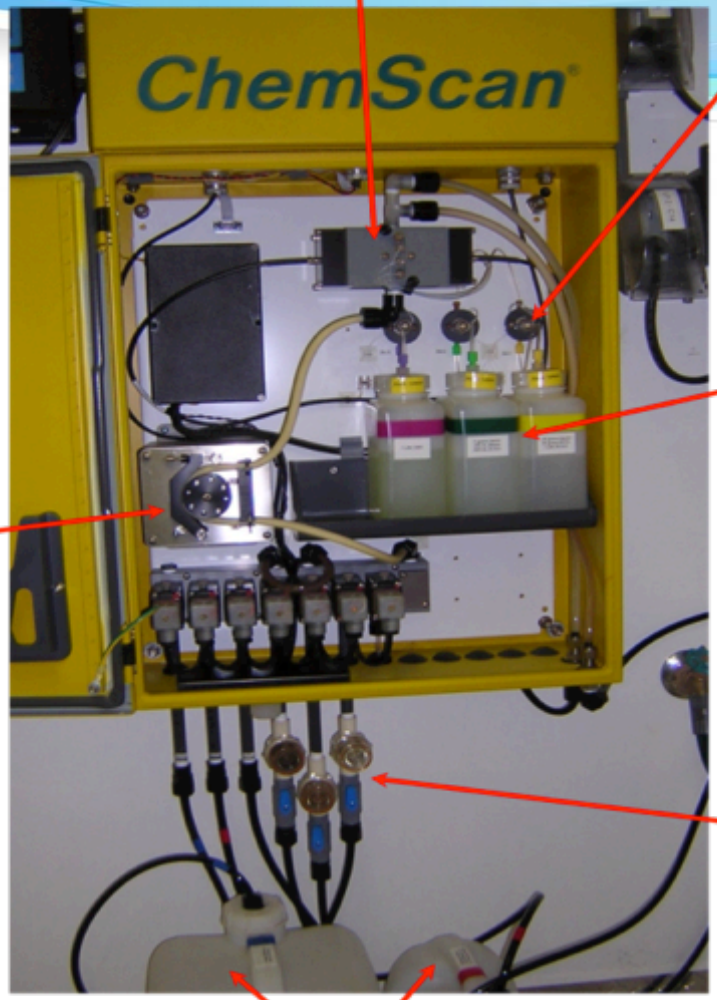
FlowCell



Reagent Injectors

Reagents

Internal Peristaltic Pump

Sample Inlets

Zeroing and Cleaning Solution Containers

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Demonstrated Results & Accuracy

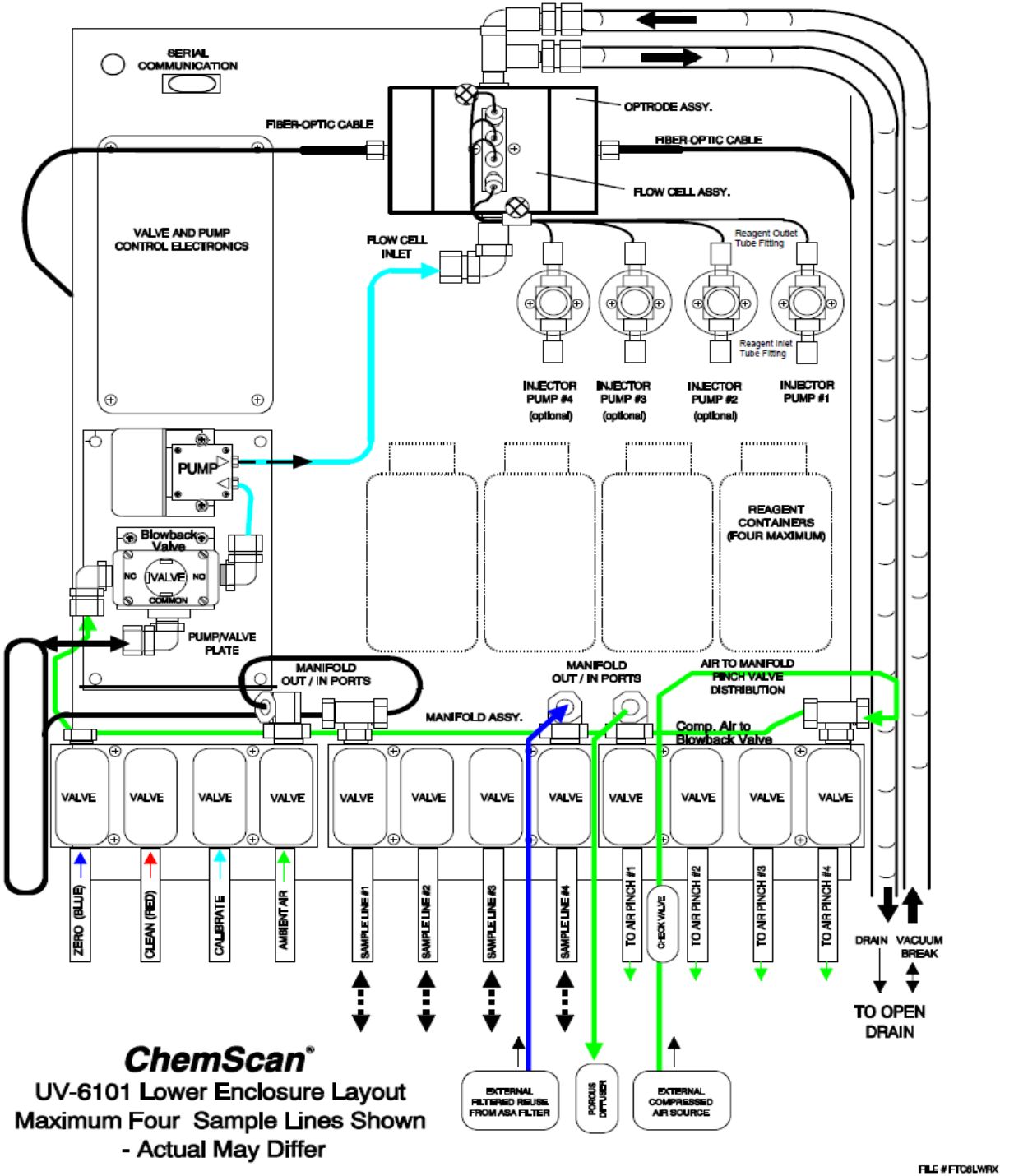
Optimized Performance

Standardized Components

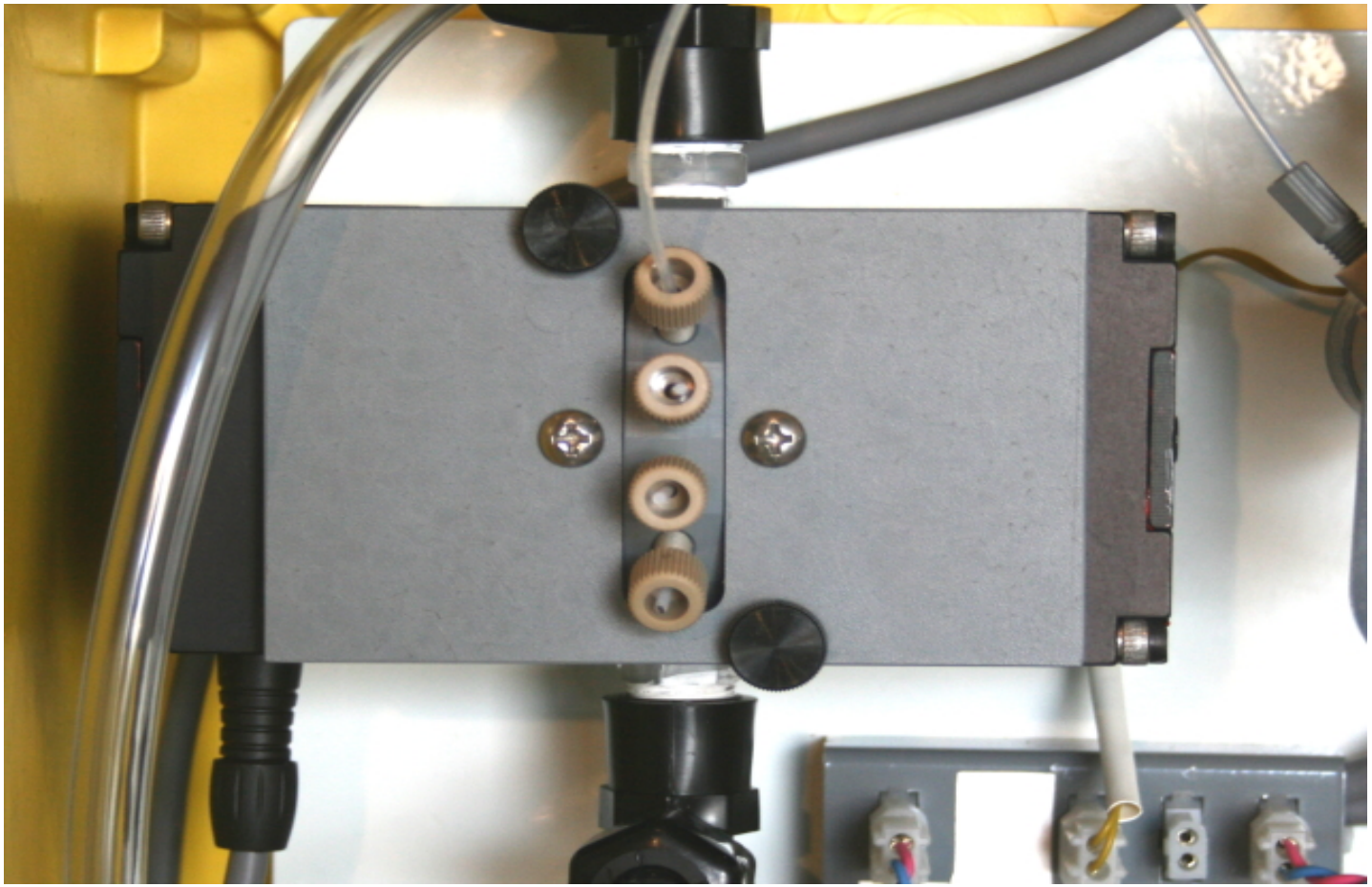
Long Life Cycle

Upgradable for Future Process Modifications

Hand Made in USA



Flow Cell



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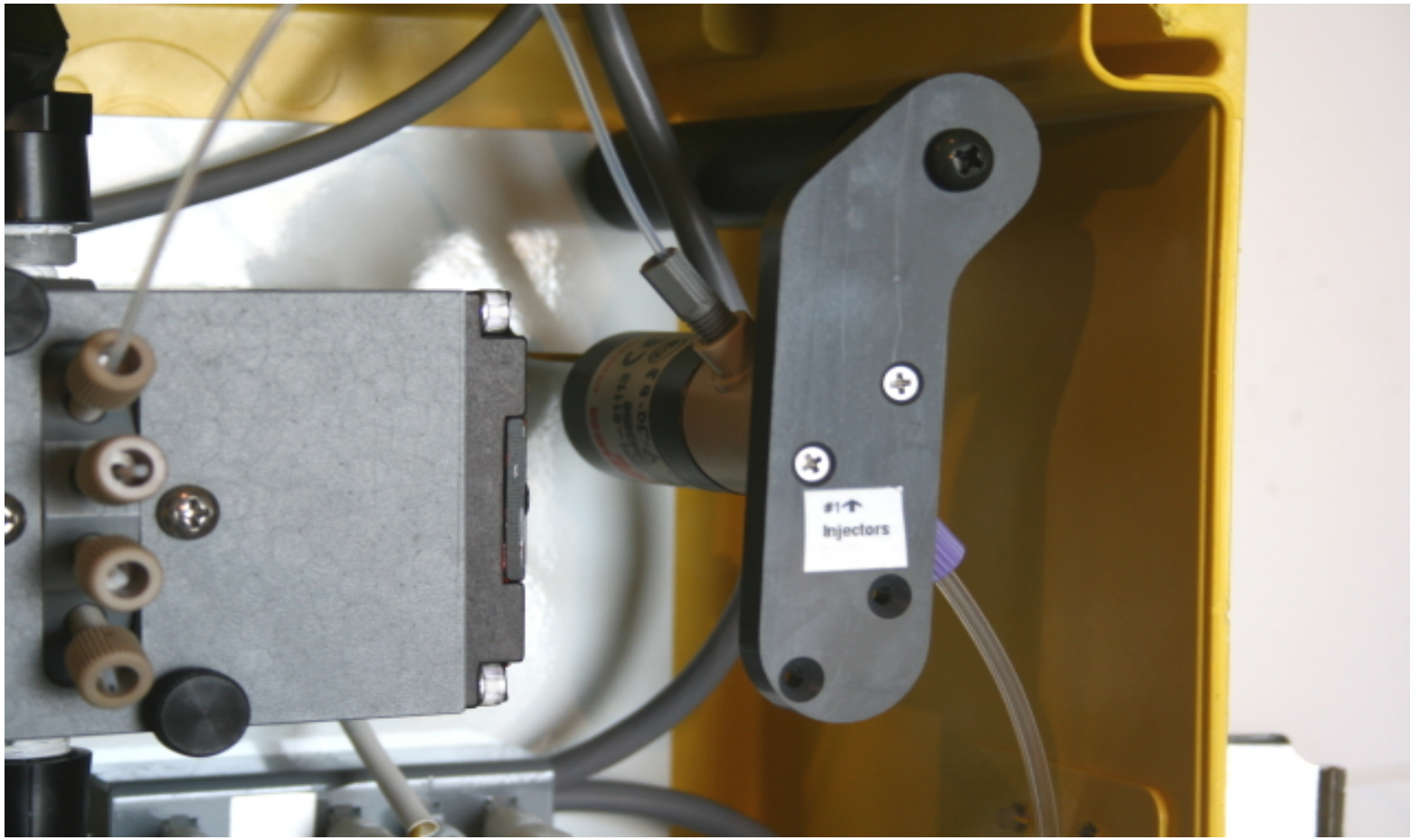
Reagent Injection



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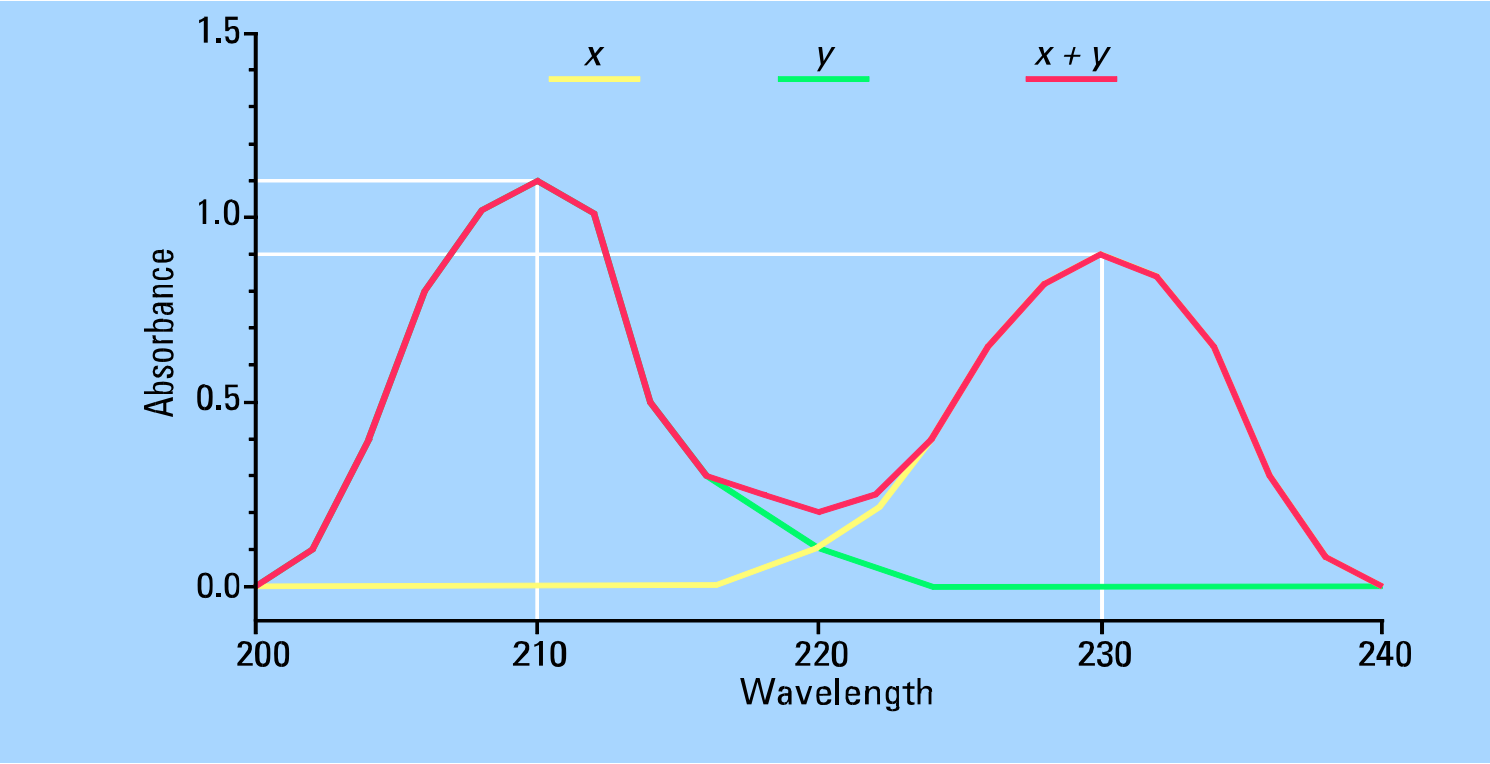
Two-Component Mixture



Example of a two-component mixture with little spectral overlap

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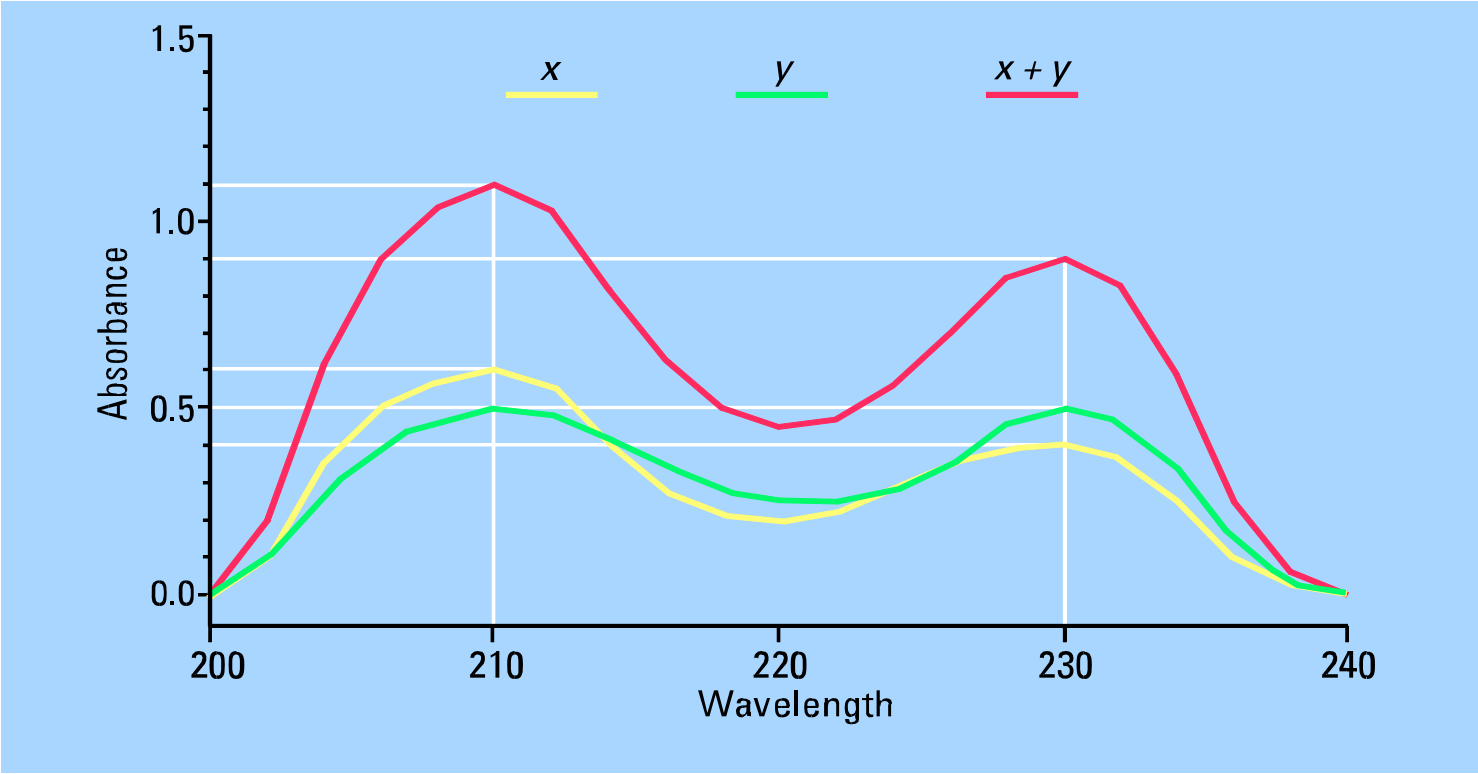
Differential Spectrometry to isolate the chemical specie nuances at low levels



Example of a two-component mixture with significant spectral overlap

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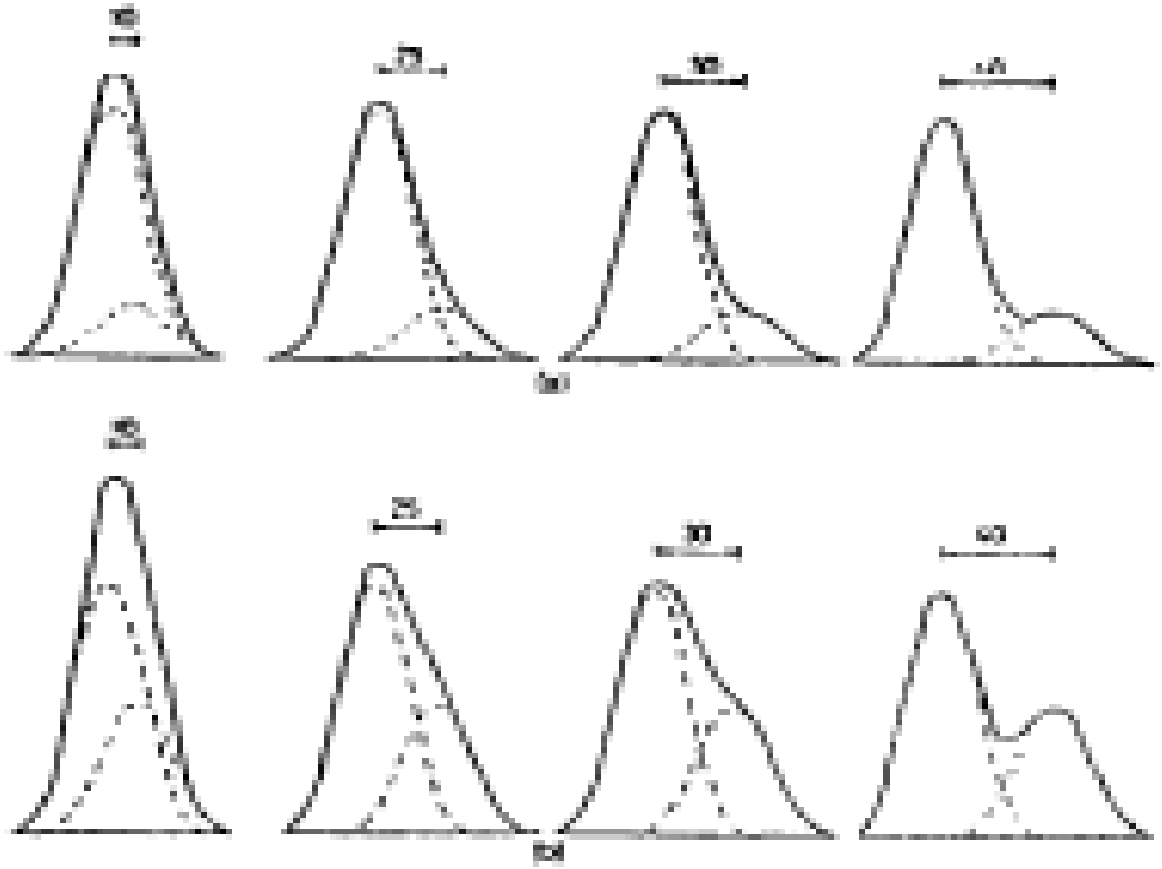
Pattern Recognition Software



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Chemometrics

3.1.3 Modes of Operation

1. On-line

   - Read samples
   - Calculate, store and display results
   - Output signals

2. Off-line

   - Perform calibration
   - Setup instrument parameters

3.1.4 Analytical Algorithms

1. Multiple variable regression analysis
2. Principal components preprocessing
3. First derivative preprocessing
4. Second derivative preprocessing
5. Principal components rotation preprocessing

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Deconvolution of raw data

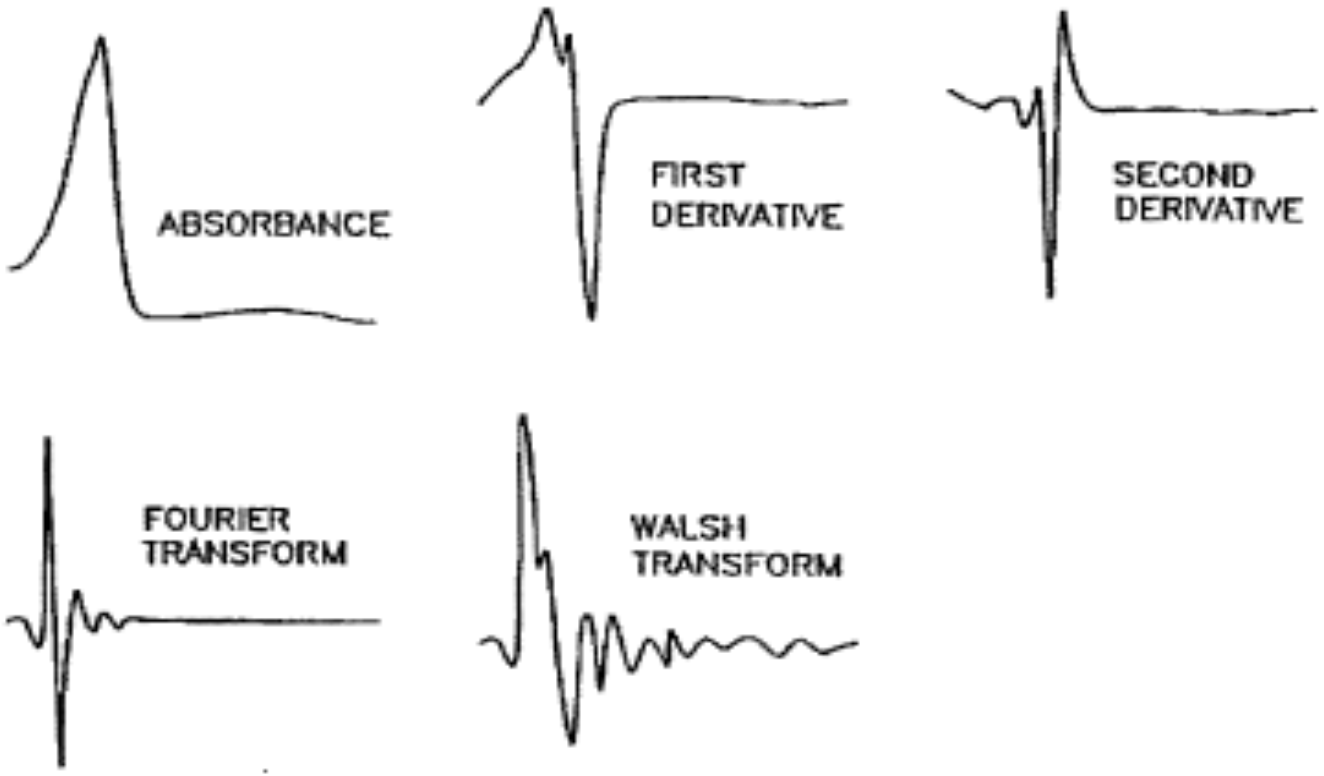

Figure 10. Preprocessed Spectra

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An Online Lab Grade Spectrometer

Capable of handling both reagent assisted and directly read samples

Calibration / Validation Port for grab sample analysis and site specific optimization

Capable of field modification and correlation with lab results to build confidence

Self Zeroing, self cleaning and future options or enhancements in time as needed

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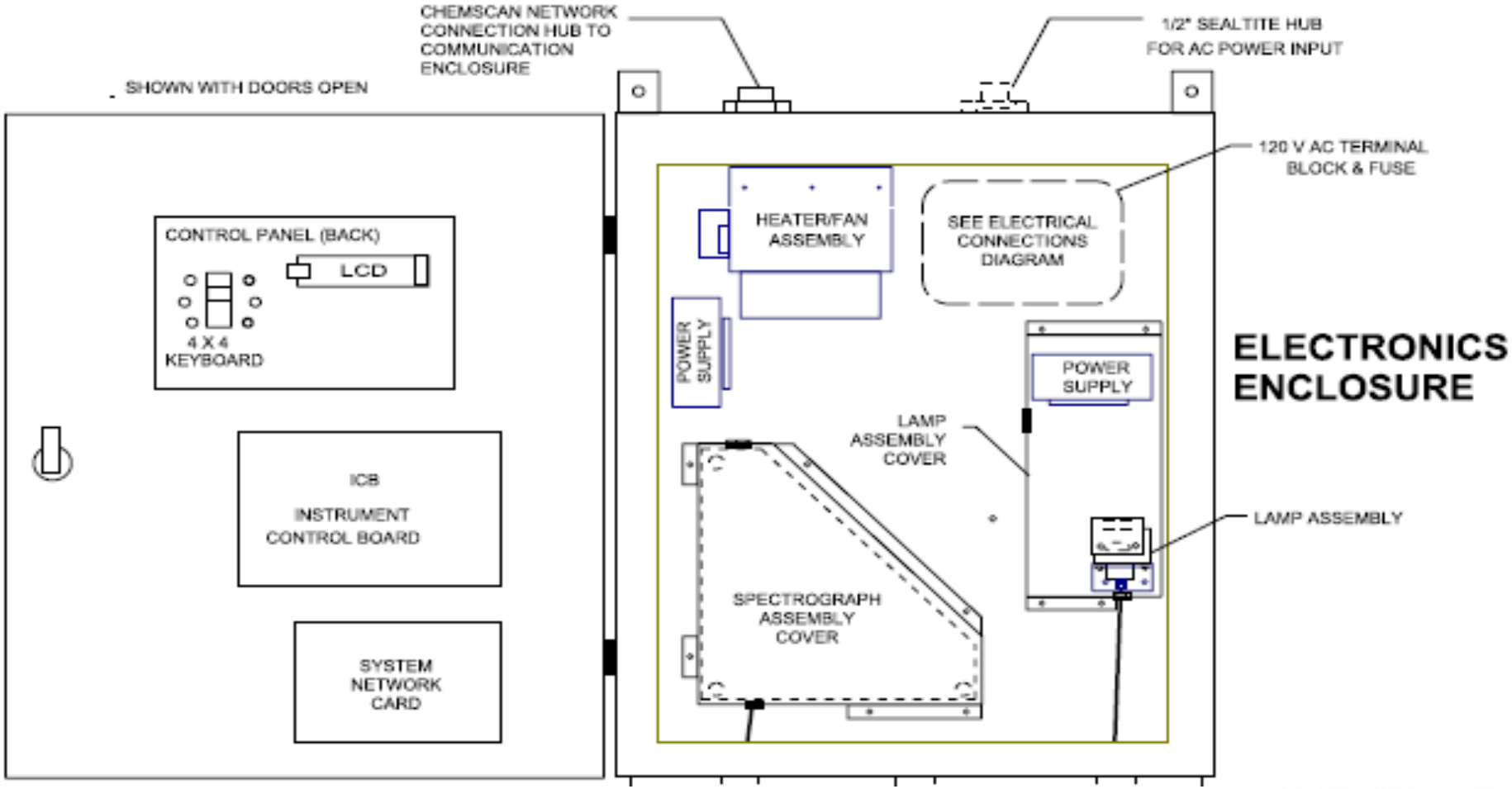
How we measure and control the analysis of liquid samples



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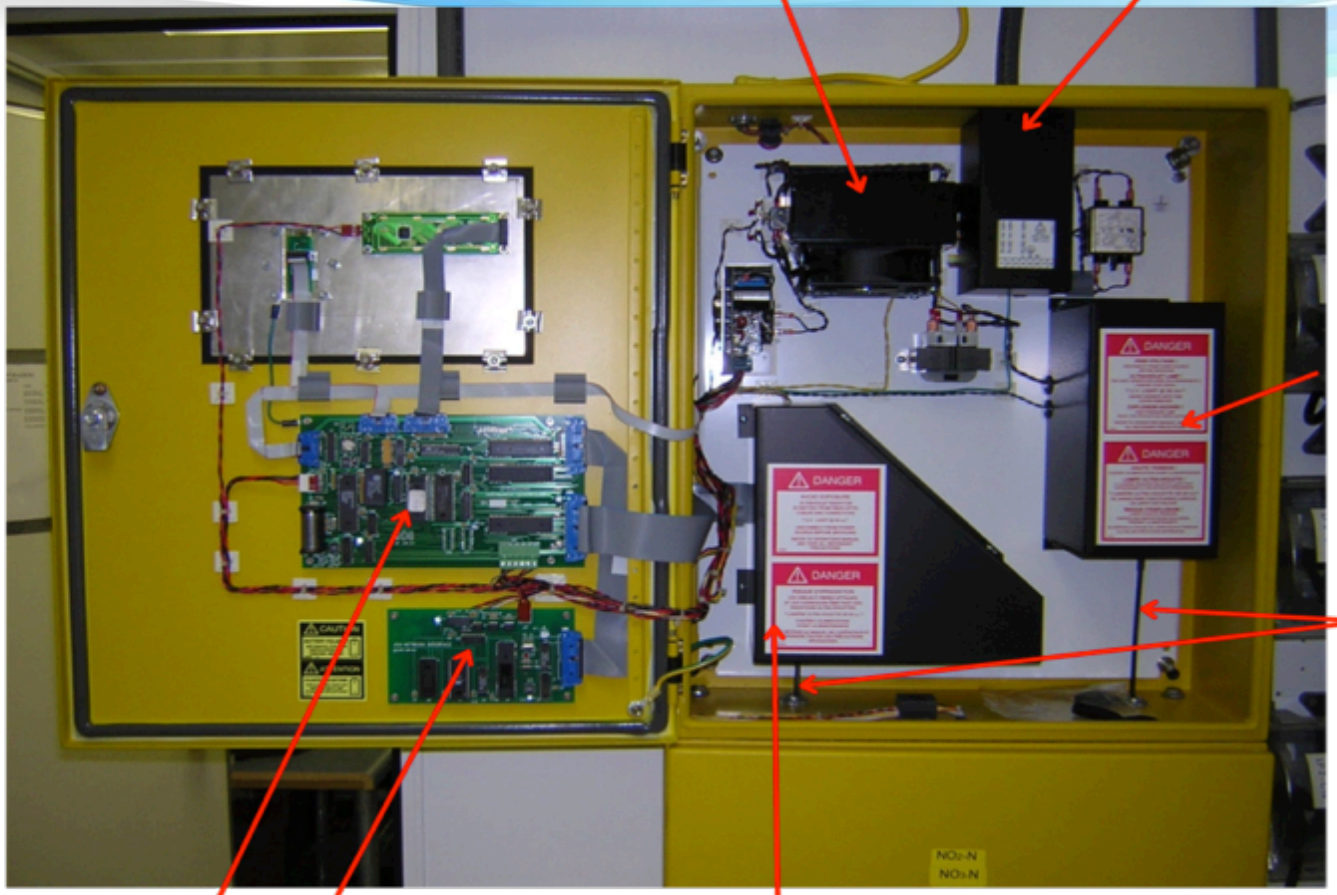

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An optical instrument - not a control panel

- Light projected from a broad beam Xenon flash lamp thru a fiber optic cable to a hand built spectrograph that reads …..

  every 2 nanometers across a 260 nM UV-Vis spectrum

- Expansion, contraction, corrosion, humidity and physical positioning of the instrument affect the performance
- It is not a solid state box that you can place anywhere and in any position that you find convenient.
- UL Listing is custom adder for each project if needed

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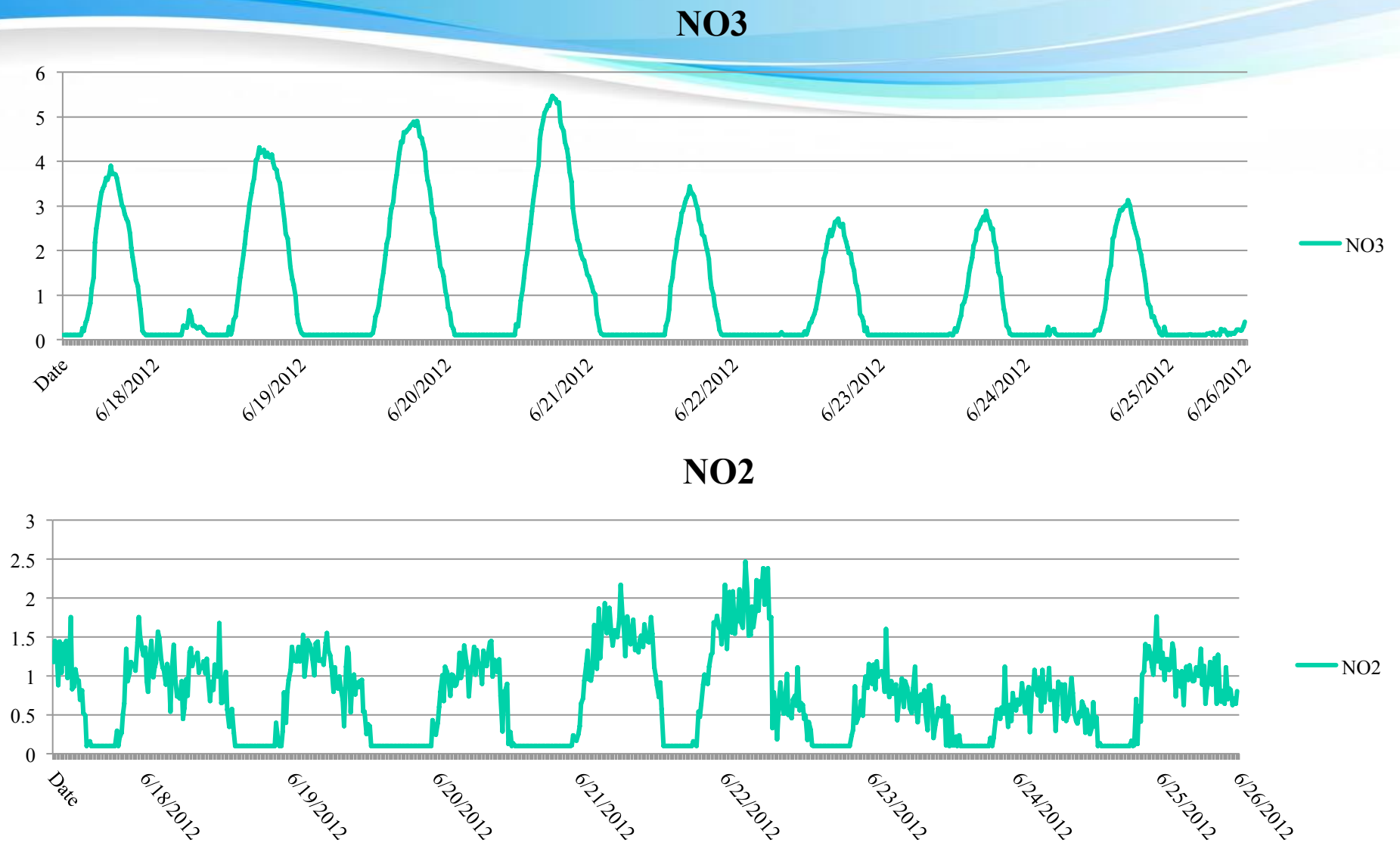
A tool for effluent monitoring or BNR process decision making



Fairfax County , VA demo test Fall 2012

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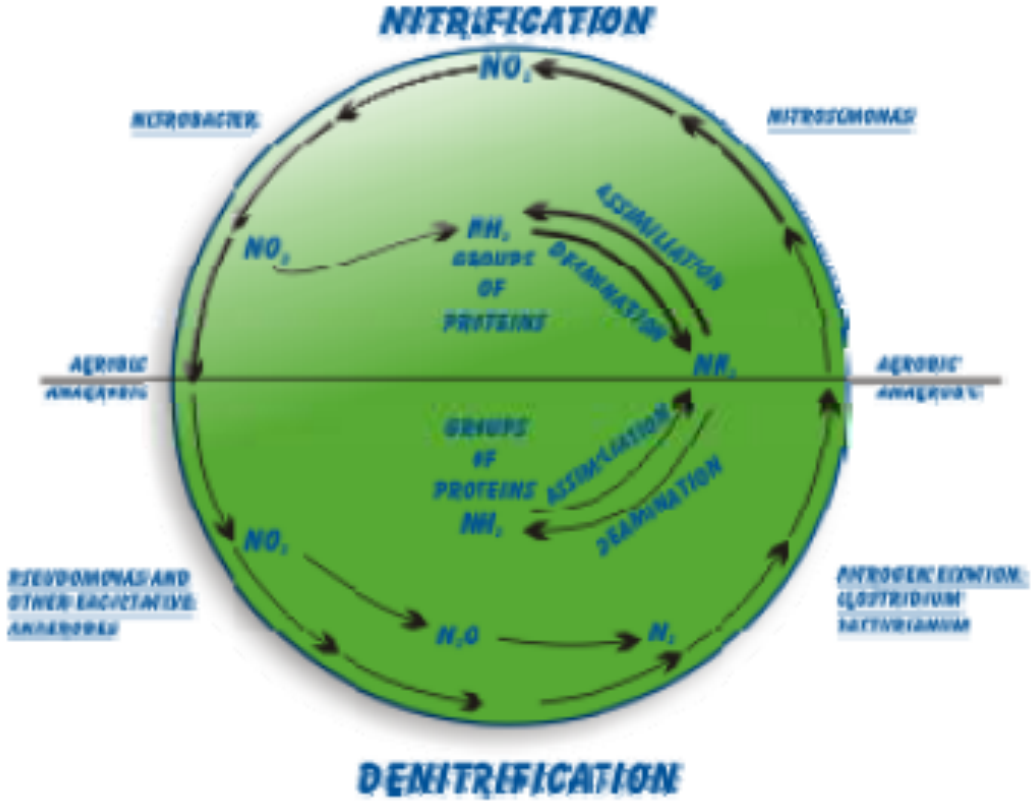

- Nitrospira
- Nitrobacter
- Nitrococcus
- Nitrospina
- Anammox

All species convert NO2 to N2 gas and can enable denitrification

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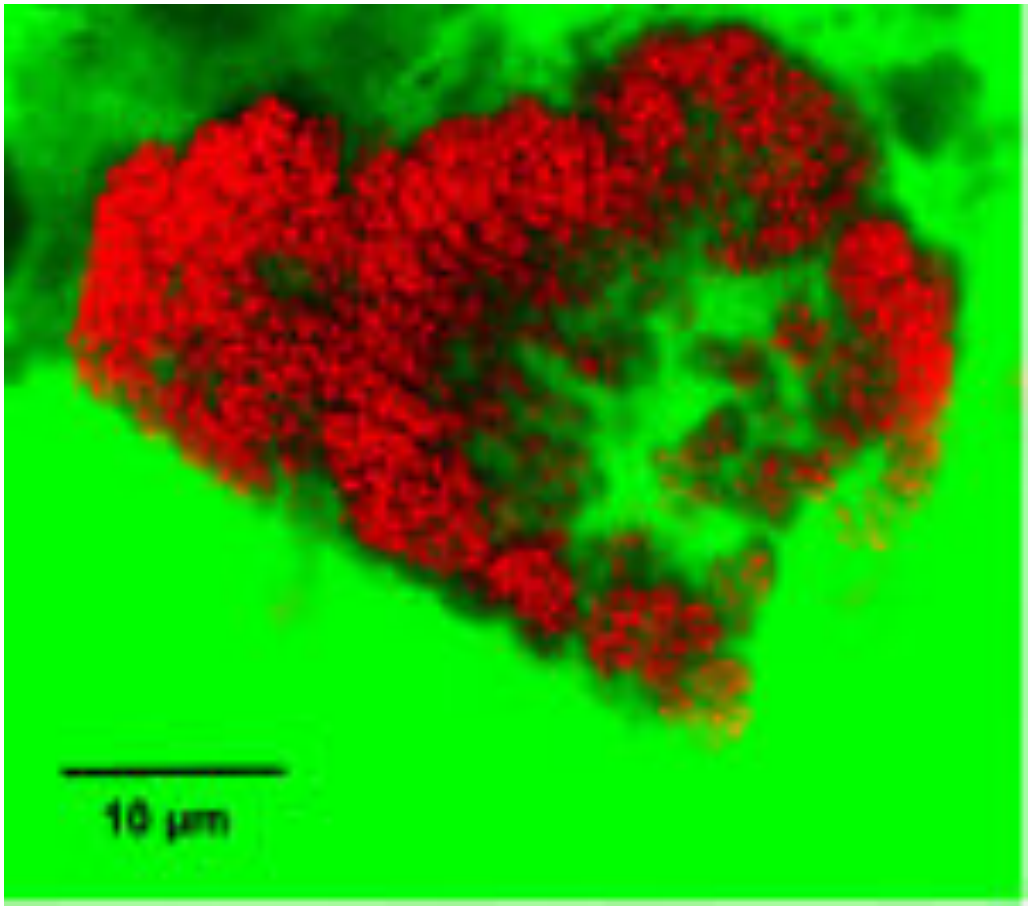
Nitrite is a spurious compound in a biological treatment system that acts as an intermediary product and promulgator of reactions varying in concentration



Nitrospira

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How important is NH3 + NO2 removal to costs ?

What about N2O …. Does this GHG play a role in BNR ?

- BOD removal ~~~ 2# O2 / # BOD
- NH3 removal ~~~ 4.57# O2 / # NH3

- NO2 Lock = 5 lbs CL2 per lb of NO2 in effluent

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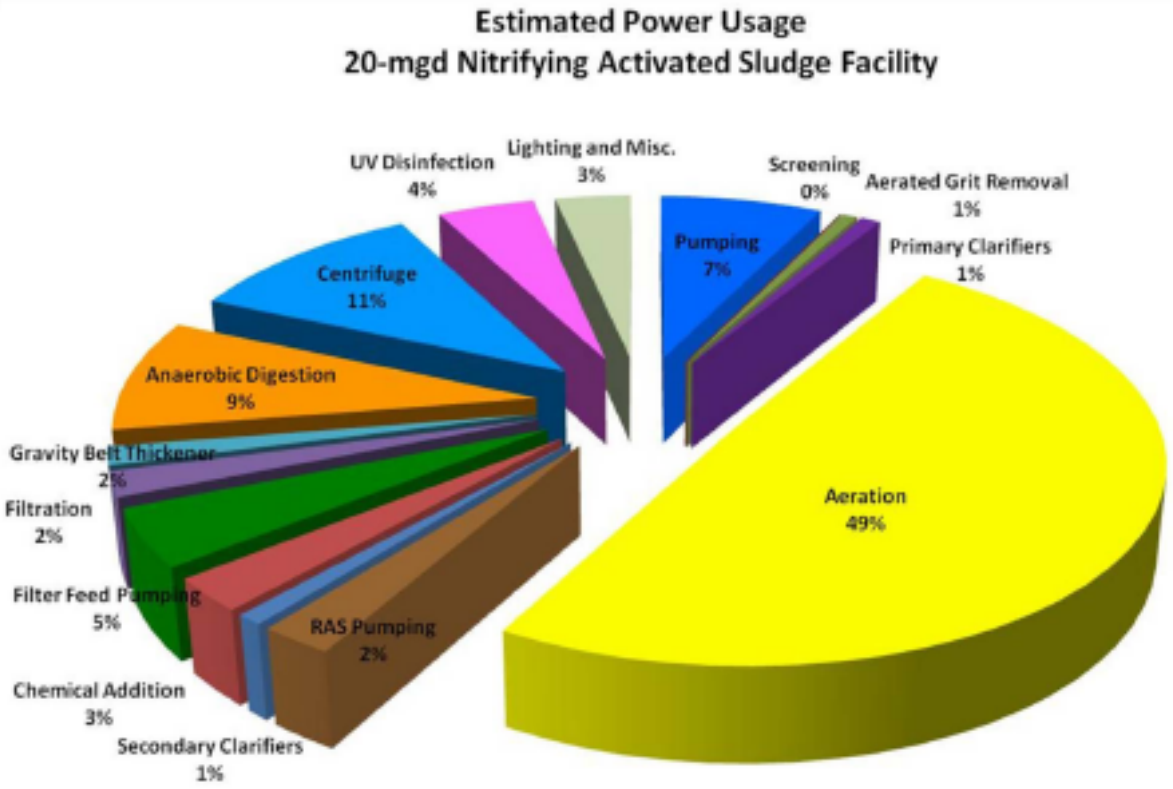
Half of the energy in the facility

Benefits: Aeration costs



Source: "Energy Conservation in Wastewater Treatment Facilities" – Manual of Practice – No. 32, Water Environment Federation – Copyright 2009

EnviroSim ASSOCIATES LTD.

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BNR Sample Locations

- Primary Effluent
- Anaerobic Selector
- Anoxic Zone
- Aeration Tanks
- Post Anoxic Denite
- Re-Aeration Chambers
- Clarifier Splitter Boxes
- Filter Feed Channels
- Effluent CL2 Contactors
- UV Disinfection Reactors

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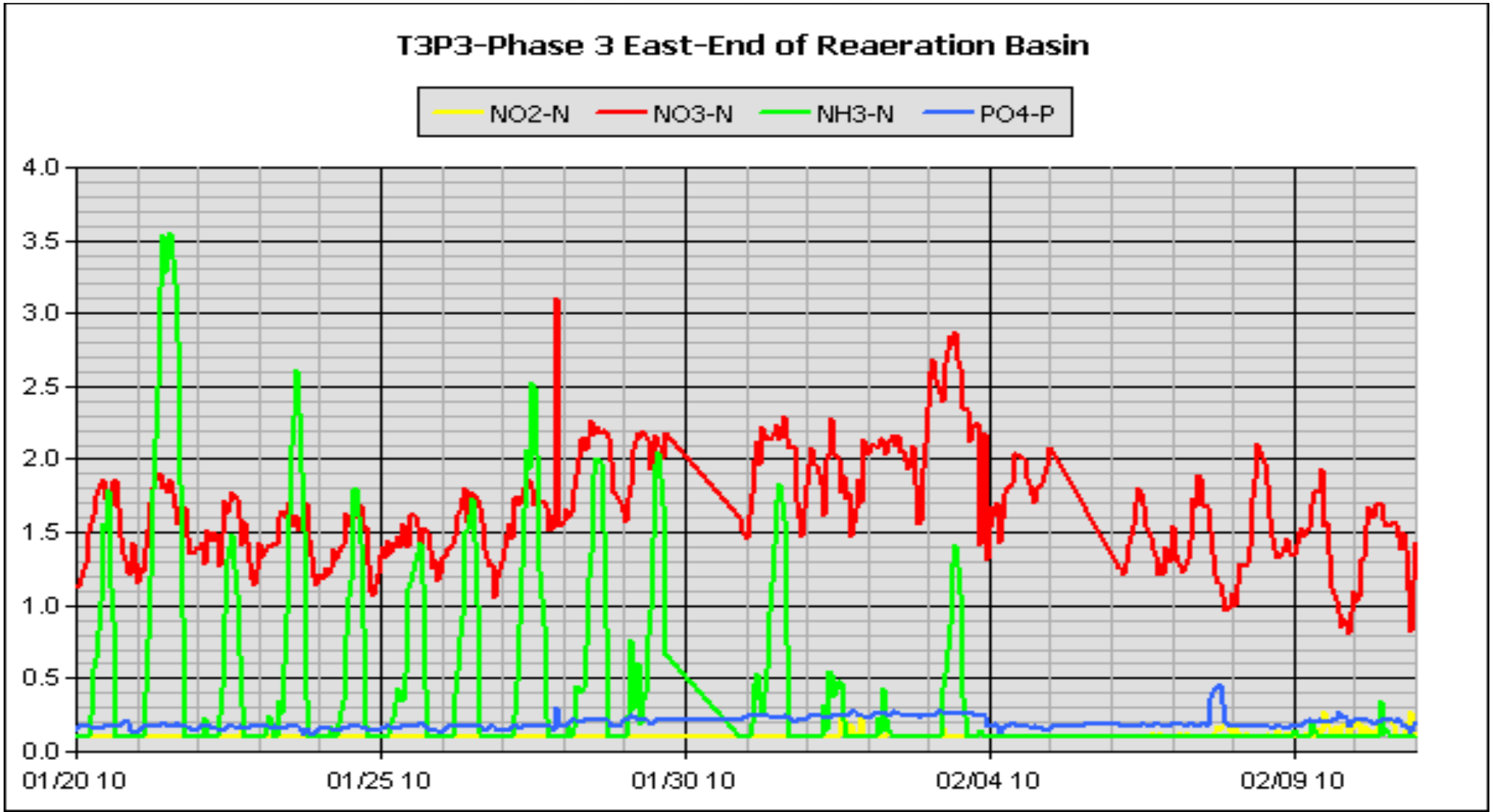
The Iron Bridge Bardenpho System… A Great Process Made Better!

Roy A. Pelletier, David S. Sloan, and Thomas L. Lothrop



ChemScan w MLSS filter loops

Enclosed system under cover

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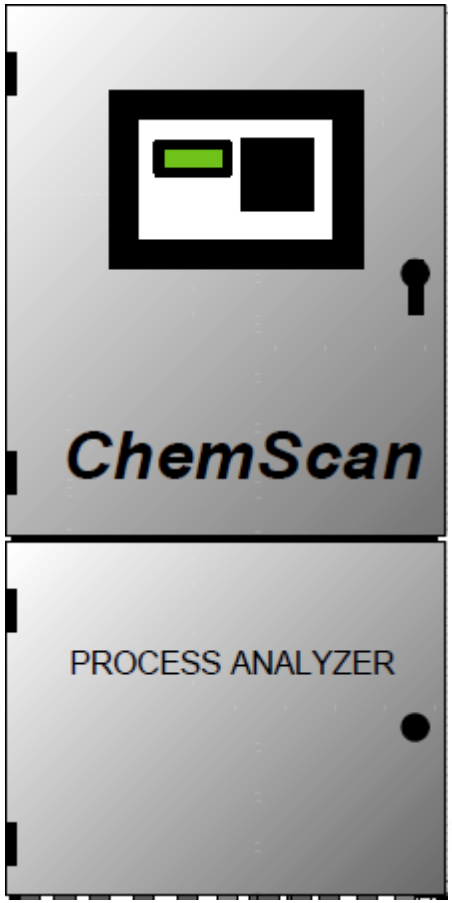
It can measure NO2 separately from NO3

(and confirm it w reagent rxn NO2 method)

introducing the

316L S/S ***UV-4100 MOX***



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Separation of NO2 + NO3 is not easy

- Natural Absorbances from 210-230 nM and overlapping curves due to ratios of NO3 to NO2
- Sharon process ranges can be 200-300 mg/l NO2
- Demon / Anita Mox can be 20-50 ppm NO2 with very low NO3 which is reverse of current nite - denite ratio data we have worked with …but there is promise

- Most operating data shows relatively good NO3 to NO2 ratios < 10/1

- Higher ratios make it difficult to detect the low level analyte thru the noise of the primary component in the mixture

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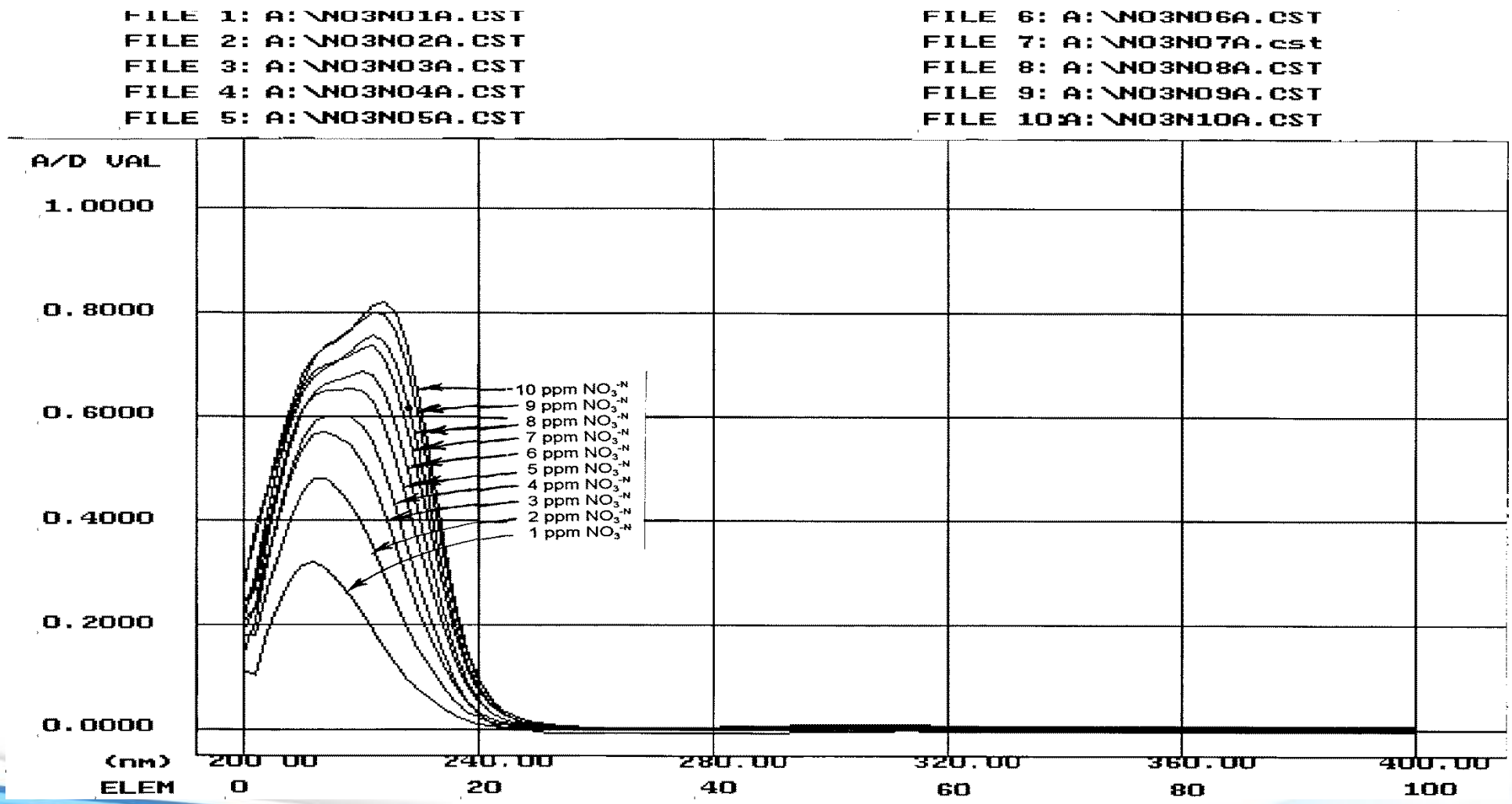
ChemScan's original nitrate spectra

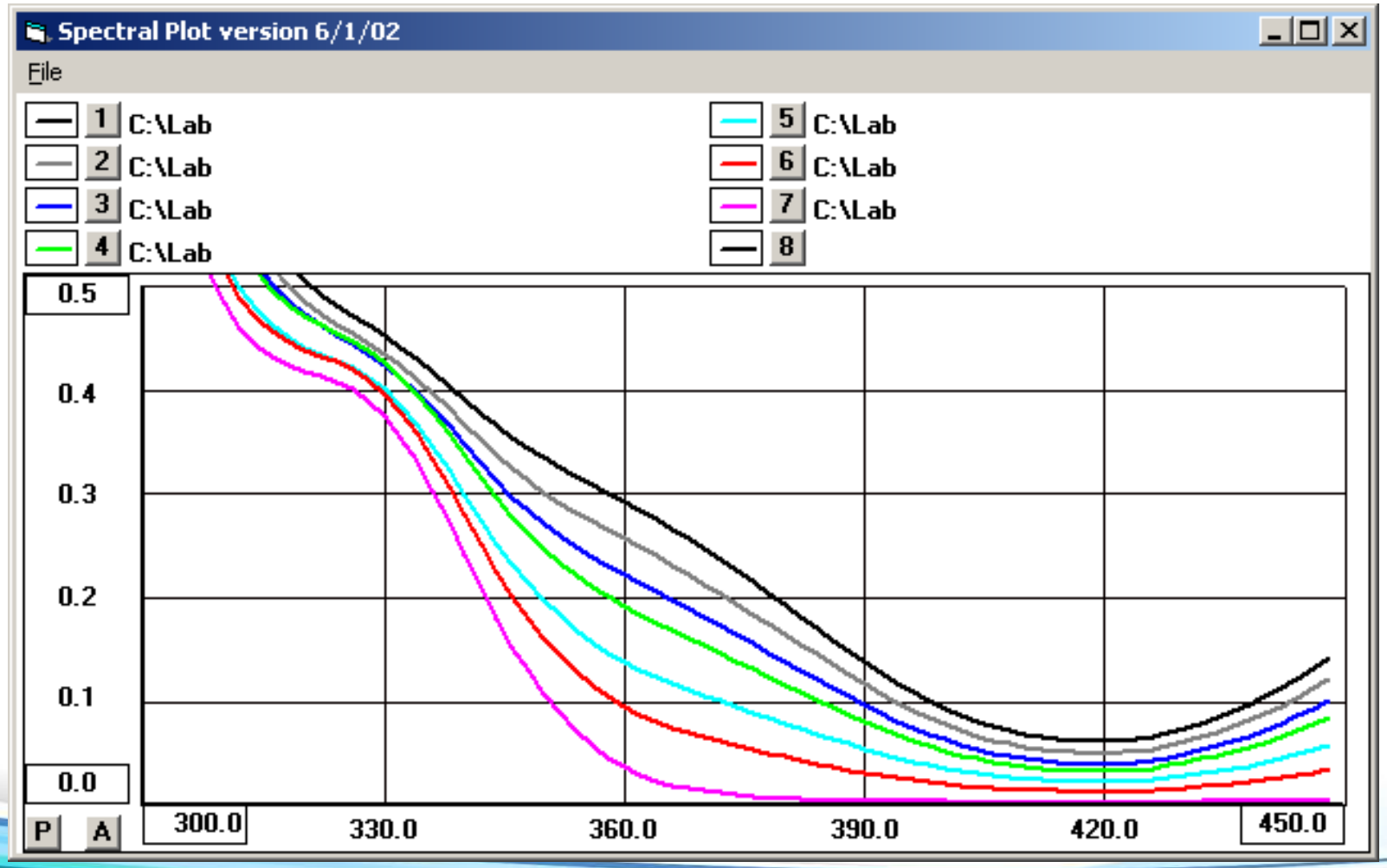


Spectral Signatures for NO_2 using NED

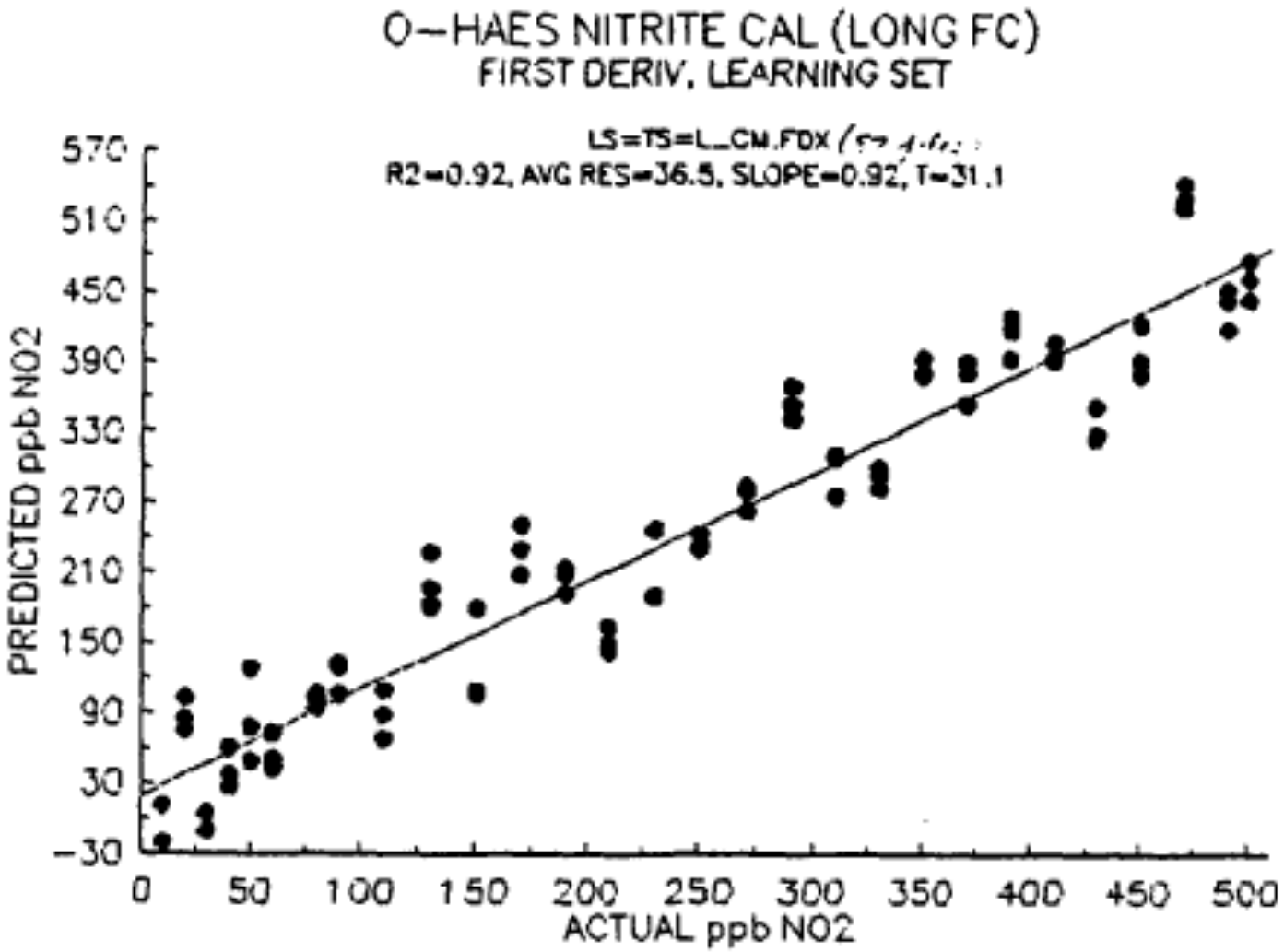
320nm to 420 nm

Concentrations [mg/L NO_2-N]:

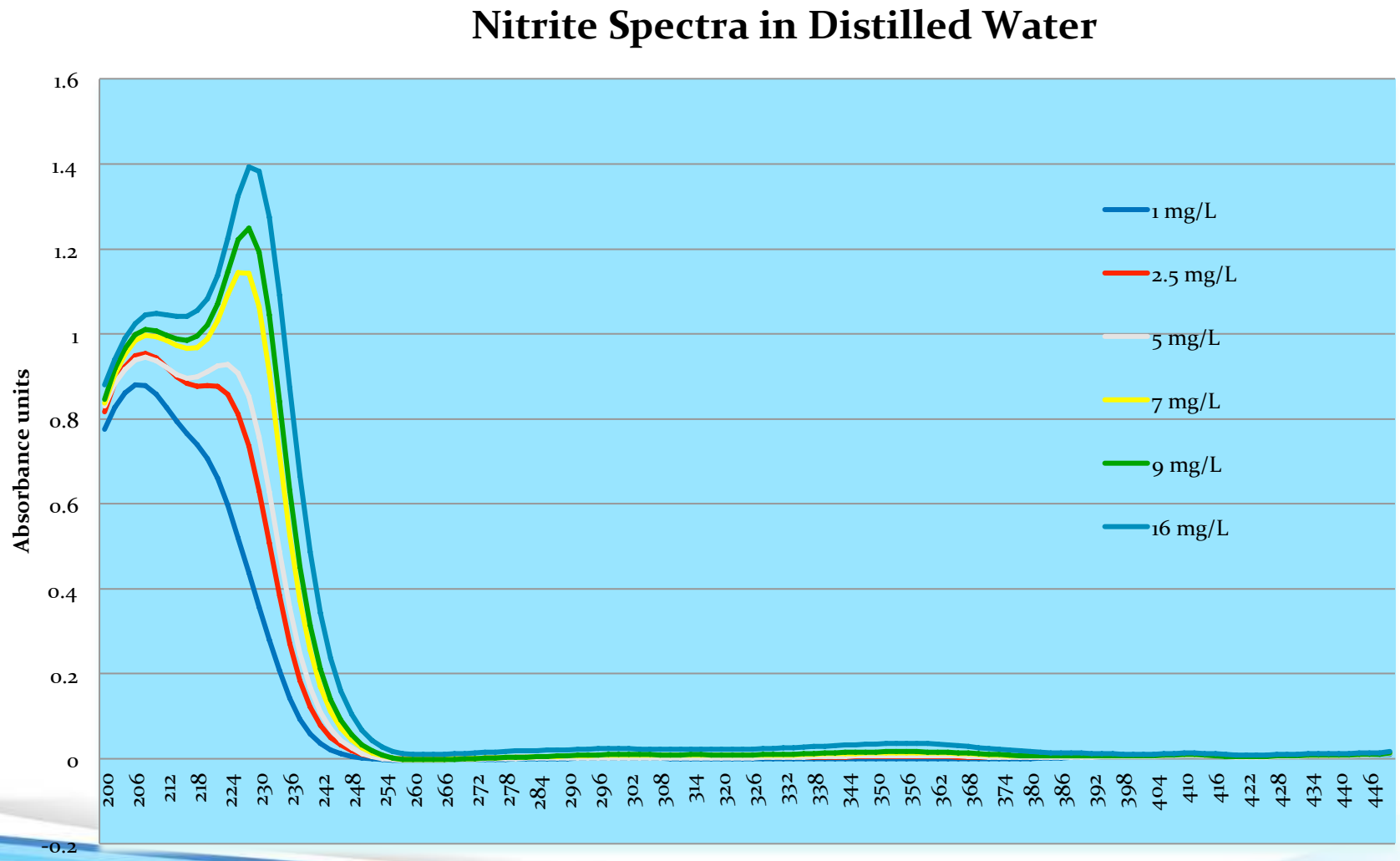
Black – 0.30; Gray – 0.25; Blue – 0.20; Green – 0.15; Lt Blue – 0.10; Red – 0.05; Mauve – 0.00



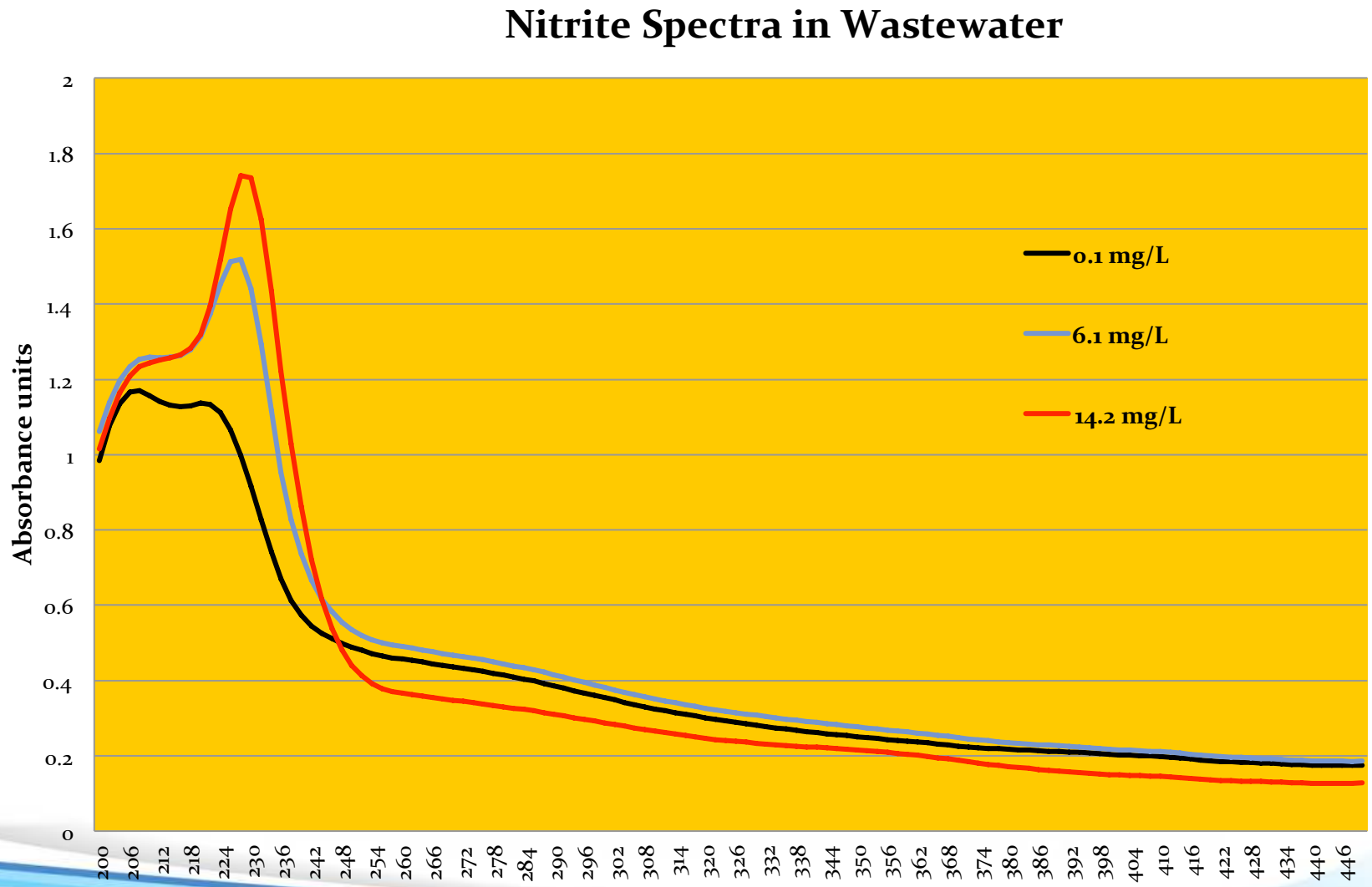
ChemScan's Original Low Level NO2 data



R+D with spikes in distilled water



R+D with spikes in a waste water matrix



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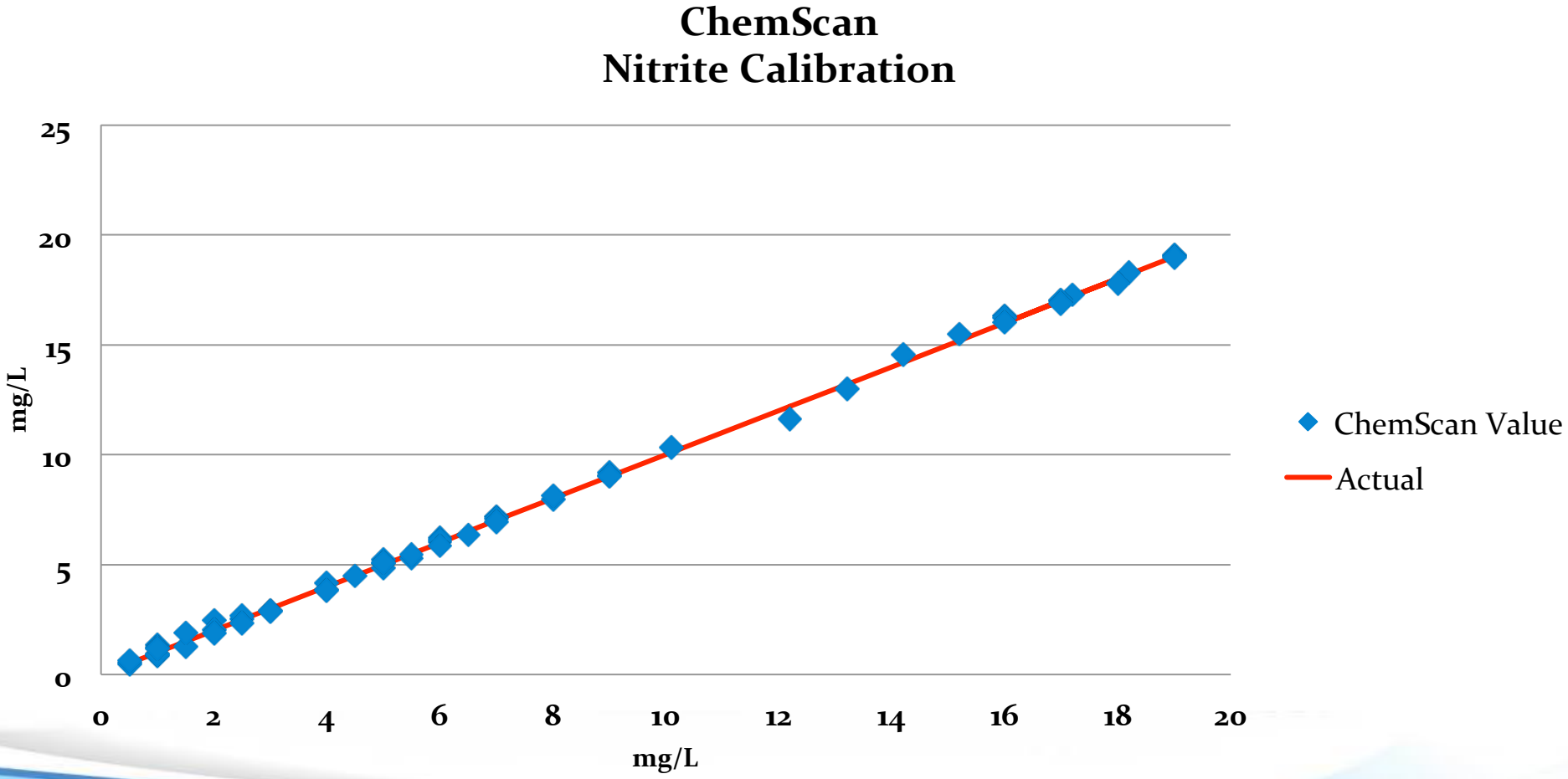
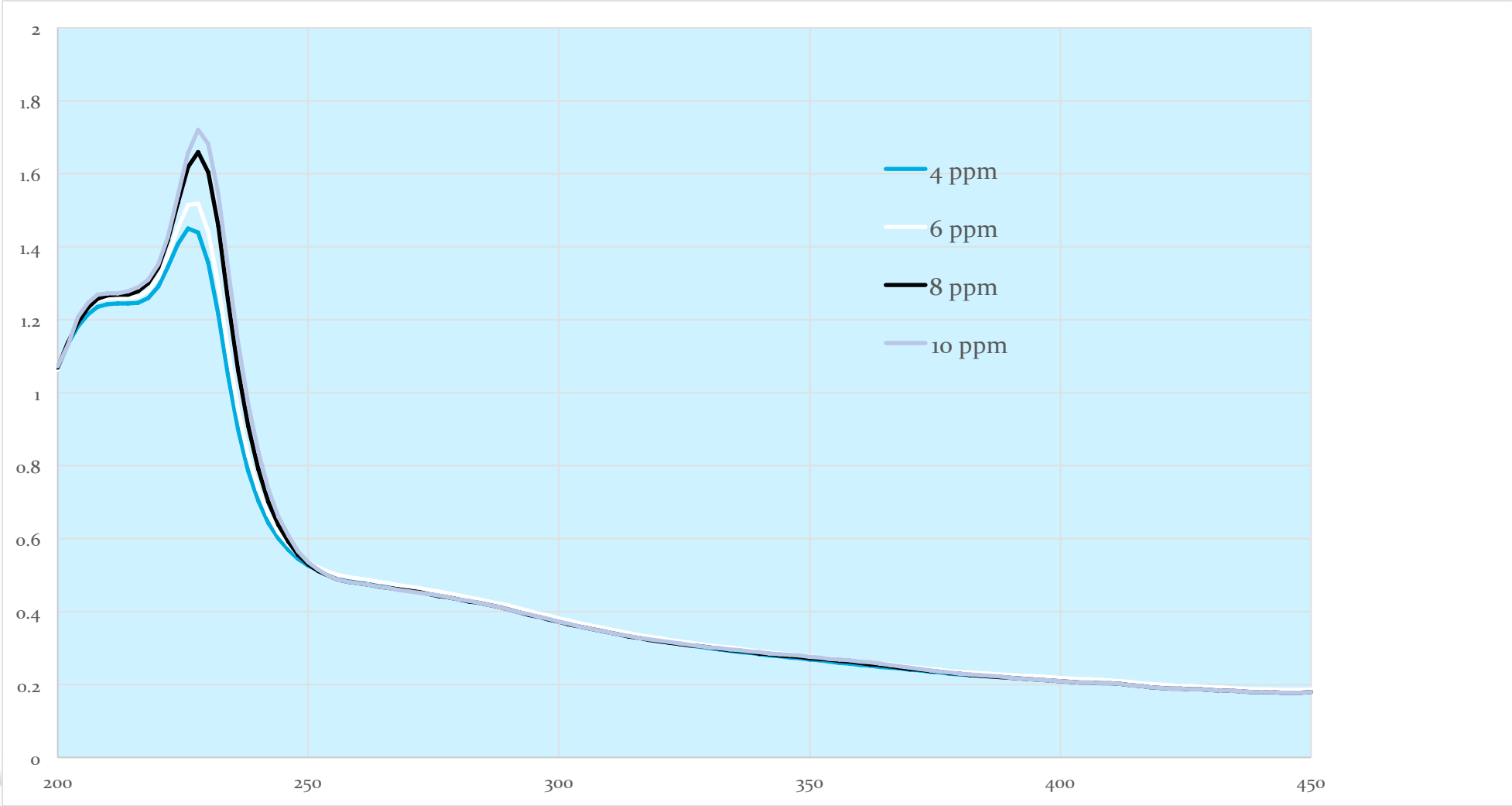
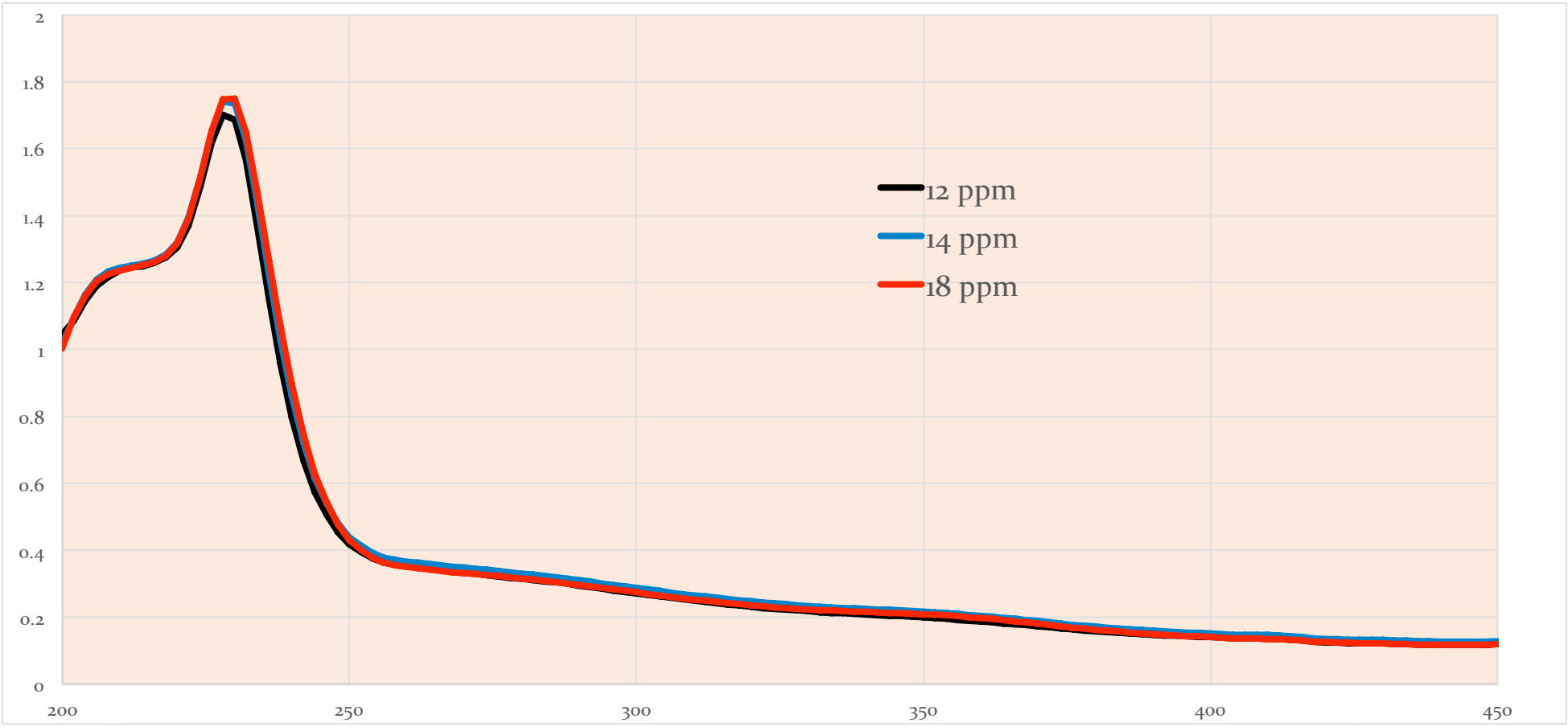
East Greenwich, RI WWTF
Full Scale COLOX NO2 Shunt demonstration



Field generated spectra for WWTFs



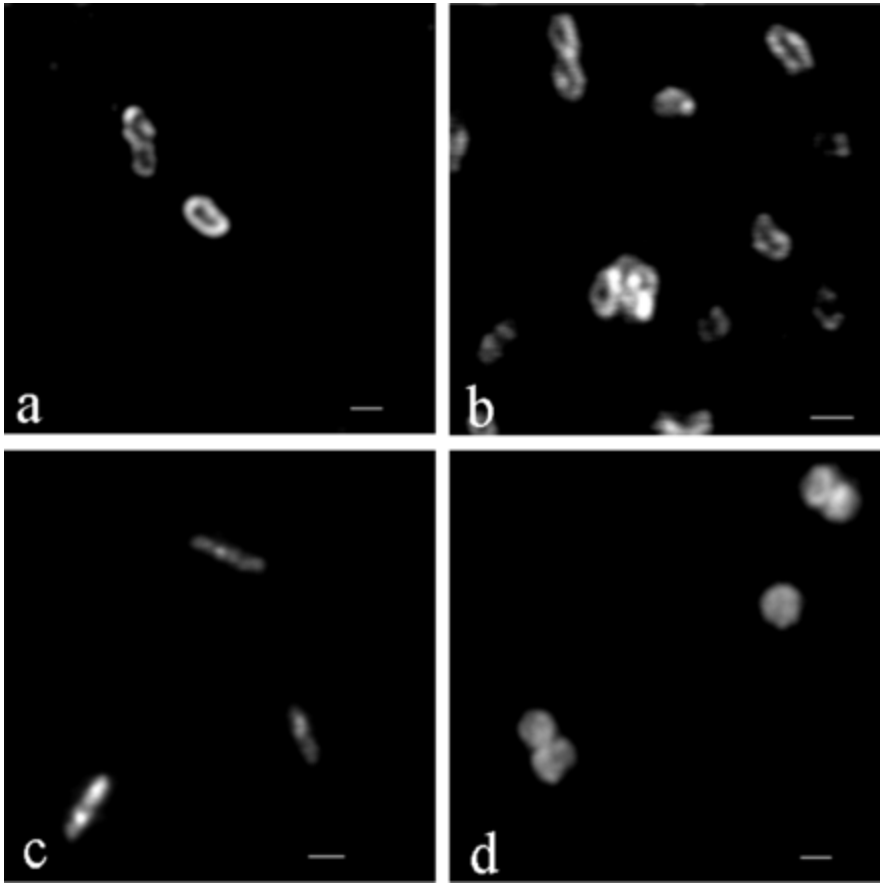
Higher range spikes add to pattern recognition



Research continues

Nitrospira

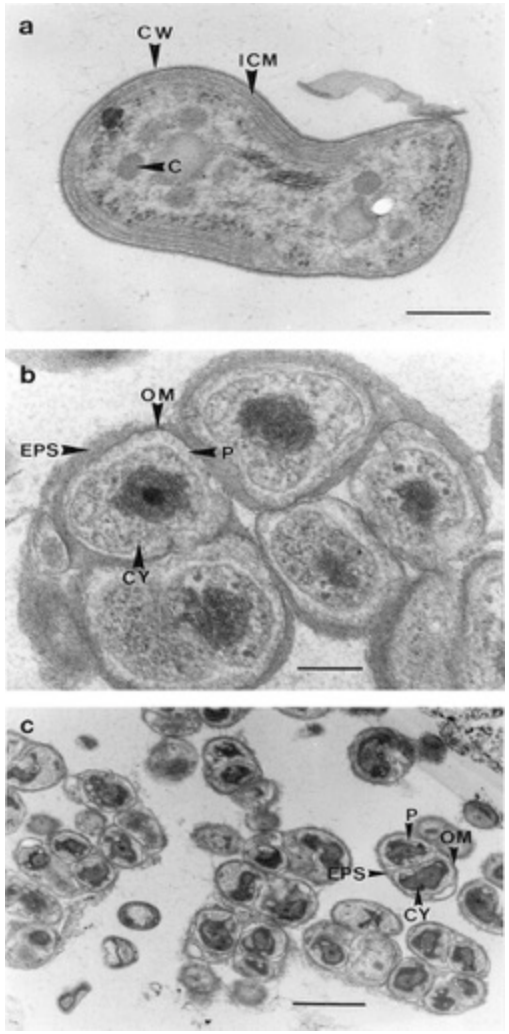
Nitrobacter



Nitrospina

Nitrococcus

Electron micrographs of ultrathin sections of activated sludge and enrichment cultures containing nitrite oxidizers.

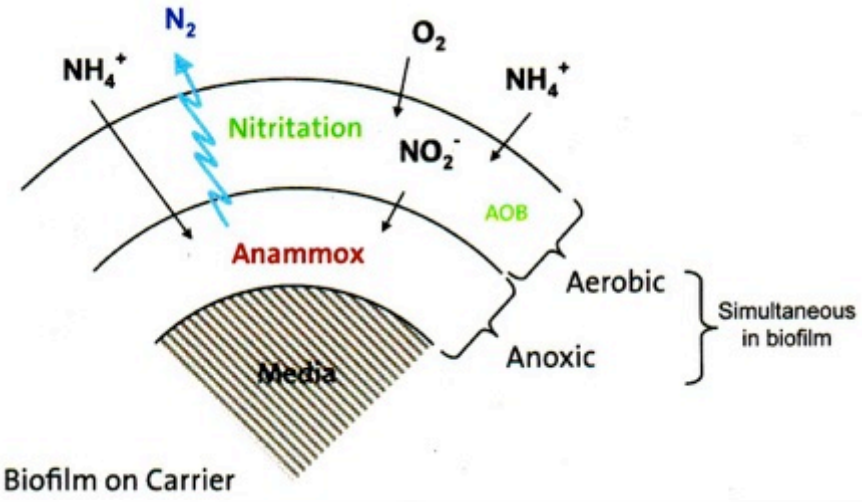


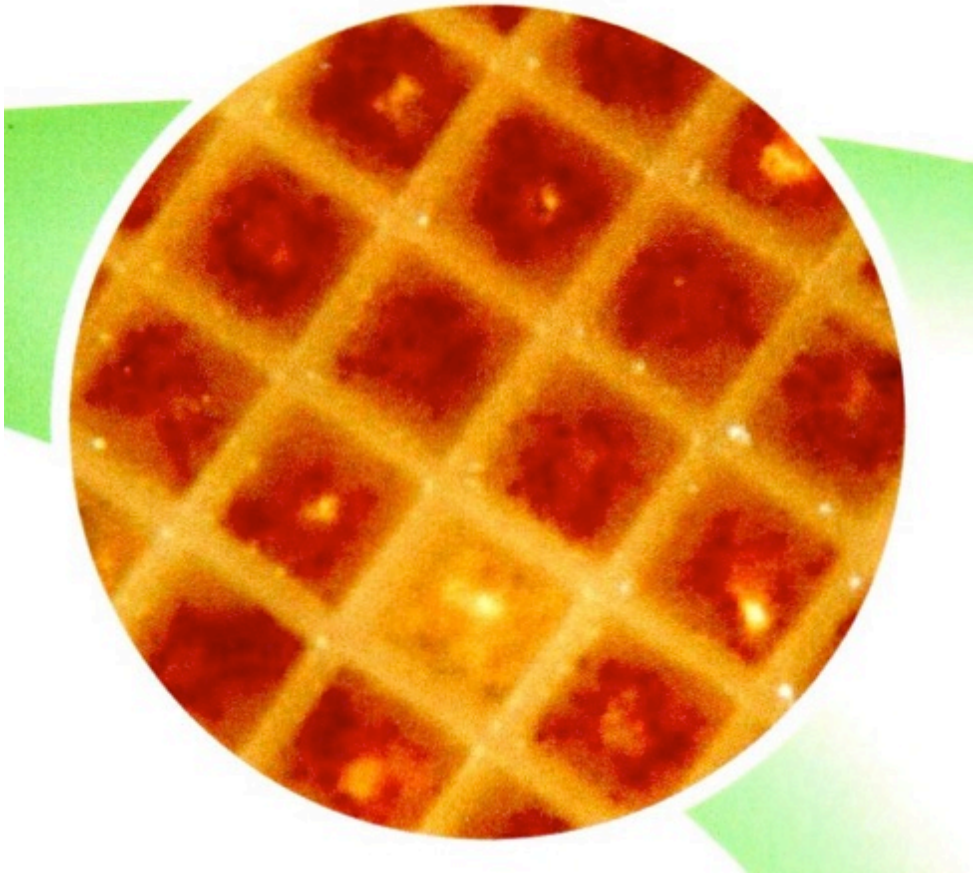
Sabine Bartosch et al. Appl. Environ. Microbiol. 1999;65:4126-4133

Old bugs are back in style after millions of years

AnoxKaldnes ANITA™ Mox

This configuration combines nitritation and anommox reactions in an MBBR biofilm process using a single reactor. The reactions are maintained by control of DO in the reactor. This arrangement provides an energy and cost efficient method to remove total nitrogen from wastewater with high ammonia concentrations, such as anaerobic digester supernatant.





At-Tank Analysis System

Shelters are beneficial for long term operations
+ maintenance effectiveness

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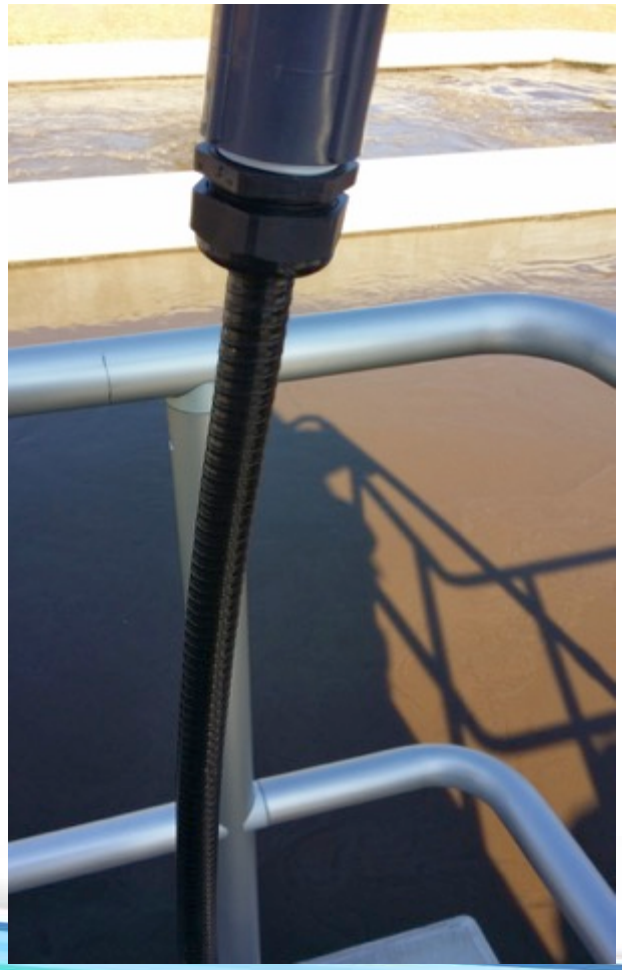
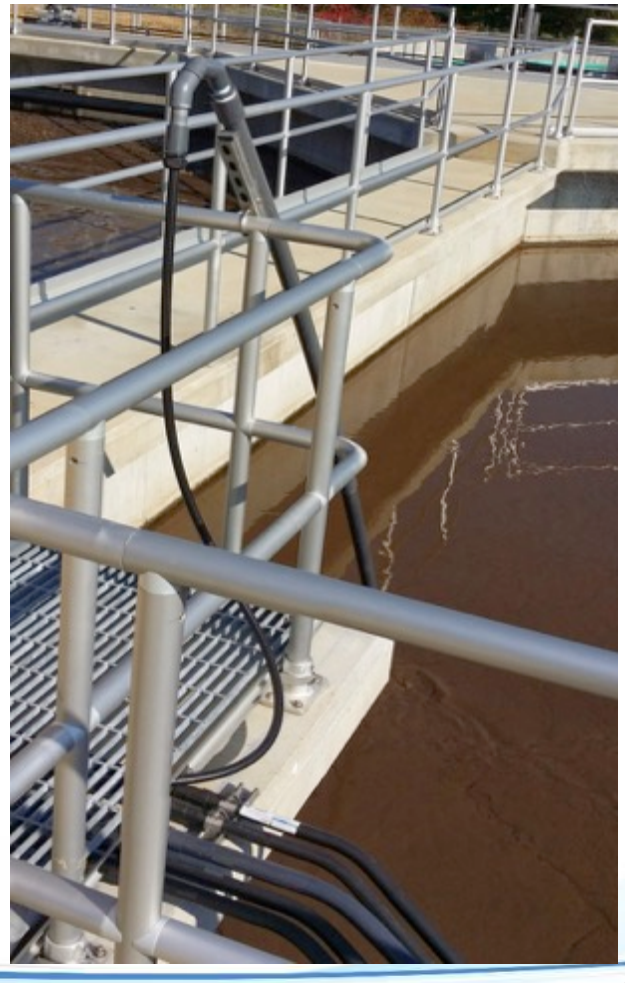
Heat Traced Sample Lines
for Cold Weather Operations





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Flow Thru Cyclic Design

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Long Distance MLSS - Option II

New Membrane Filter Development that combines
the Benefits of Cyclic Filter with Long Distances Between Samples

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N2O sensor - Option III

- **Combining the latest real time sensor technology from Europe with our UV-4100 spectrometer**

  - Up to 2 Sample Locations per controller
  - Low Maintenance (1 Hour / month)
  - Over 5 years of Proven Reliability
  - 25 units installed for Anammox and other BNR process
  - Appears to correlate very well with NO2 data

WORLD'S ONLY SENSOR FOR DISSOLVED N_2O

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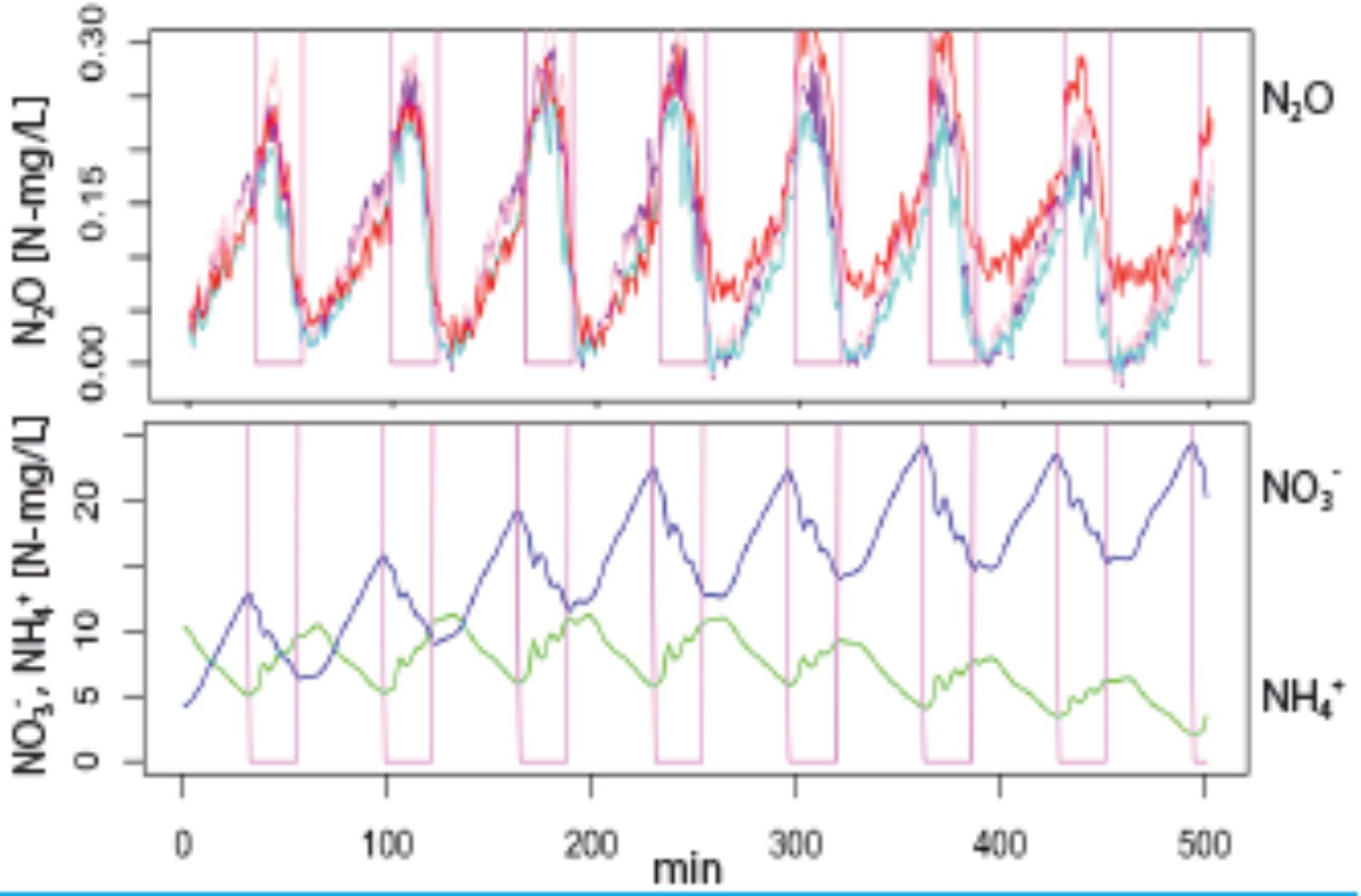
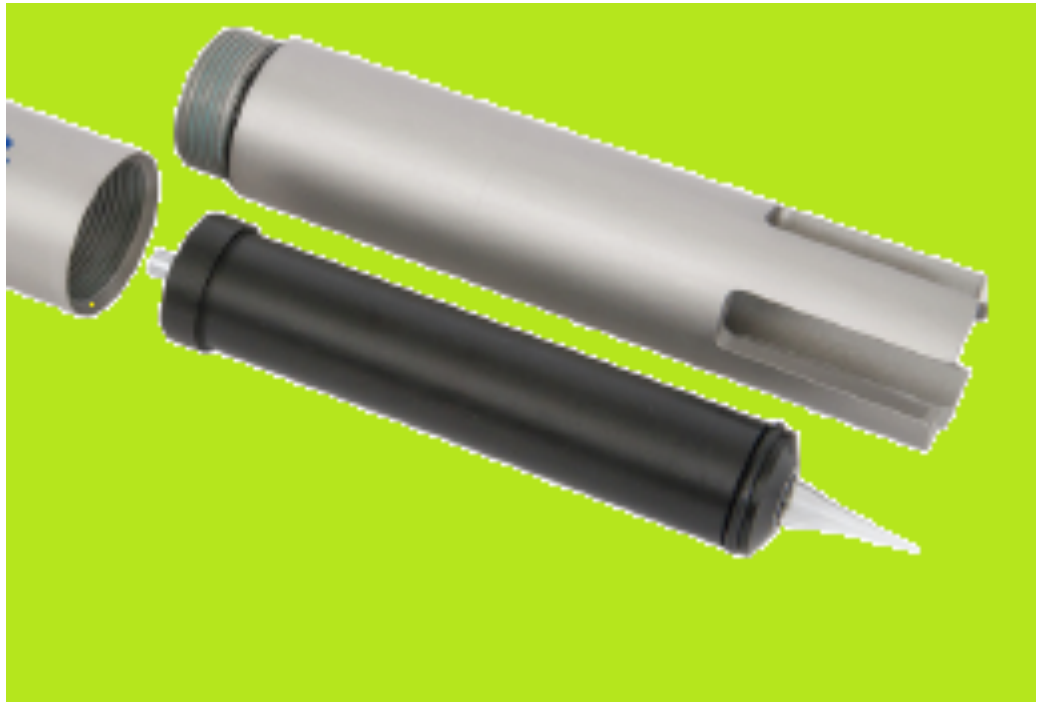
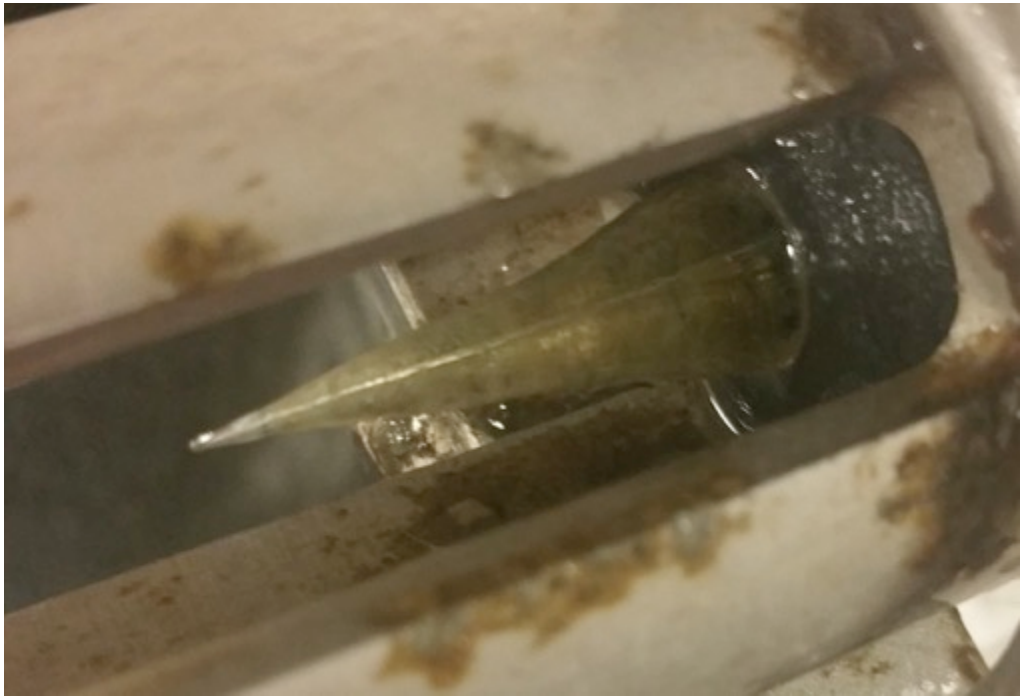
the development of the technology in Europe



A unique silicone membrane with a special tip shape to focus gas for analysis





and optimize aeration energy as well as carbon feed

MEASURE

Monitor your nitrogen removal processes
Know your N_2O production and emission

UNDERSTAND

Take a look at the complete nitrogen cycle
Gain new knowledge around nitrogen removal

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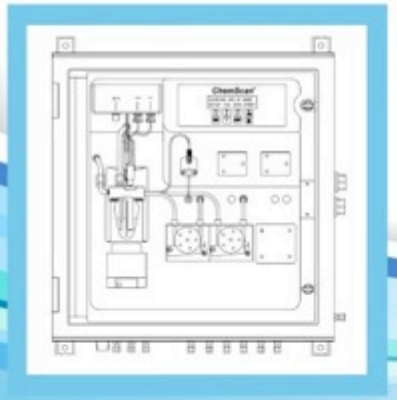
Last but not least ….
a new online system
for nitrification plants

contact info
Bruce Stevens
207 557- 2789
bps@chemscan.com

INTRODUCING

ChemScan®
Titration Analyzer
For Alkalinity Analysis



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