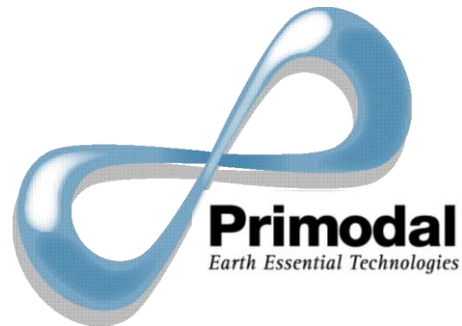


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When Grab Samples Just Won't Do: High-Quality High-Frequency Water Quality Monitoring



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Overview

- Project Objective
- Sensor Installation
- Experimental Plan
- Outcome
- Conclusion



Primodal

- Based in Hamilton, ON. (est. 2005)
- Expertise
 - Process Engineering, Design, Control, Uncertainty Analysis, Modelling and Monitoring
 - COMMON THEME → Data Evaluation
 - the need for accurate and representative data
- *PrecisionNow*[®] software suite (data collection & analysis)
 - DataDesk, DataPort & DataCentre



Project Objective

- **3 Goals**

- **Primary Goal**

- Demonstrate the benefits of the short-term installation of high-frequency sensors

- **Secondary Goals**

- Investigate what level of maintenance is required to improve the accuracy of the sensor readings
- Determine the magnitude of the error in laboratory sampling



Sensor Installation

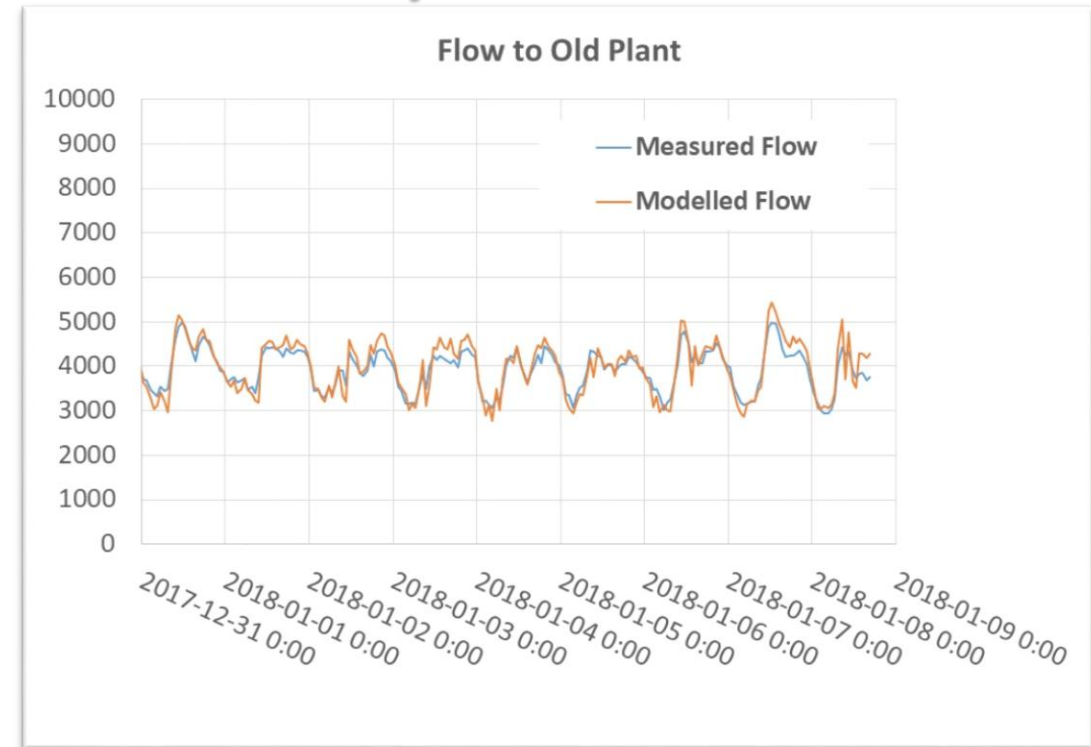
- Dundas Wastewater Treatment Facility
 - Combined sewers
 - Ave Q: 13,000 m³/d
 - Nitrifying plant
 - Common preliminary treatment



Sensor Installation

• Dundas Wastewater Treatment Facility

- Combined sewers
- Ave Q: 13,000 m³/d
- Nitrifying plant
- Common preliminary treatment
- Old and new sides
- Flow split model developed
 - Flow split not constant
 - Flow to old, function of total with remainder flowing to new side



Sensor Installation

- **Primary Effluent**

- Harsh environment
- Stochastic behavior
- Variable influent



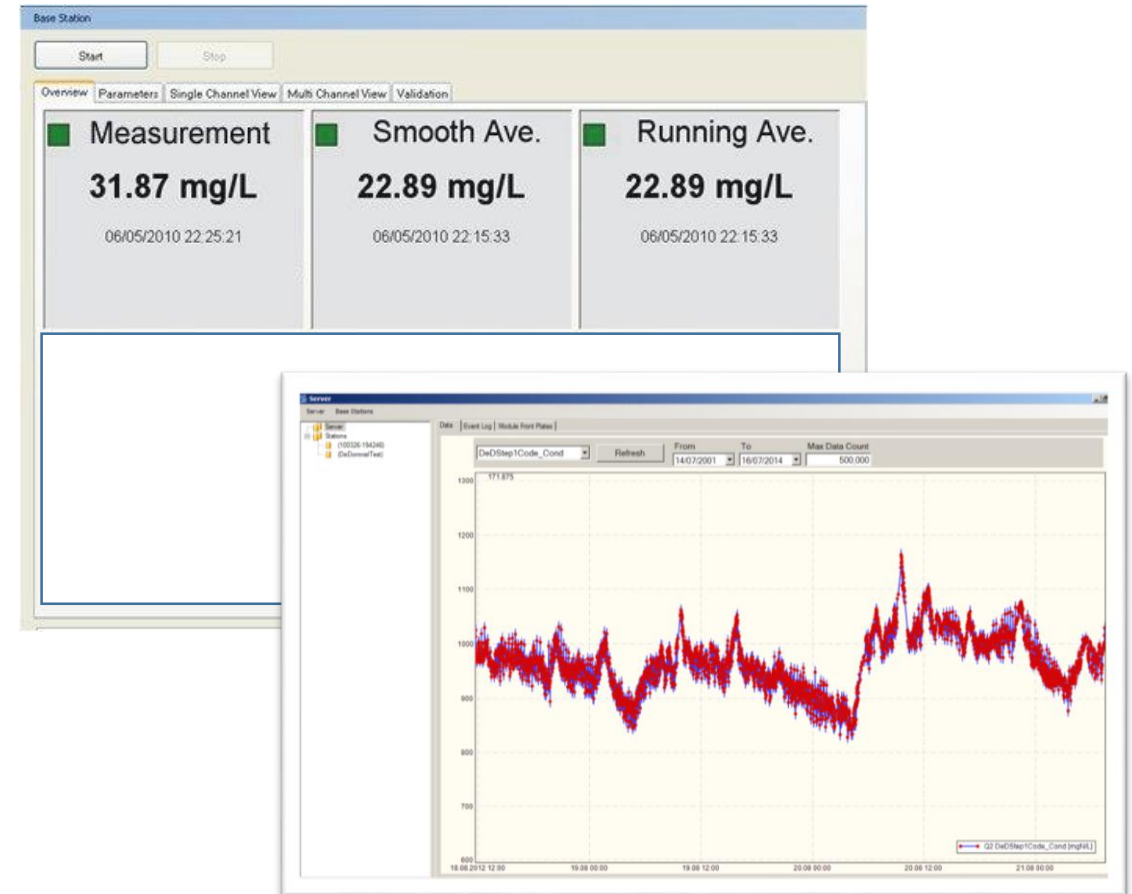
- **Monitoring System**

- RSM30 monitoring station
- 2 side-by-side YSI ISE ammonia sensors
- Cl and K compensation



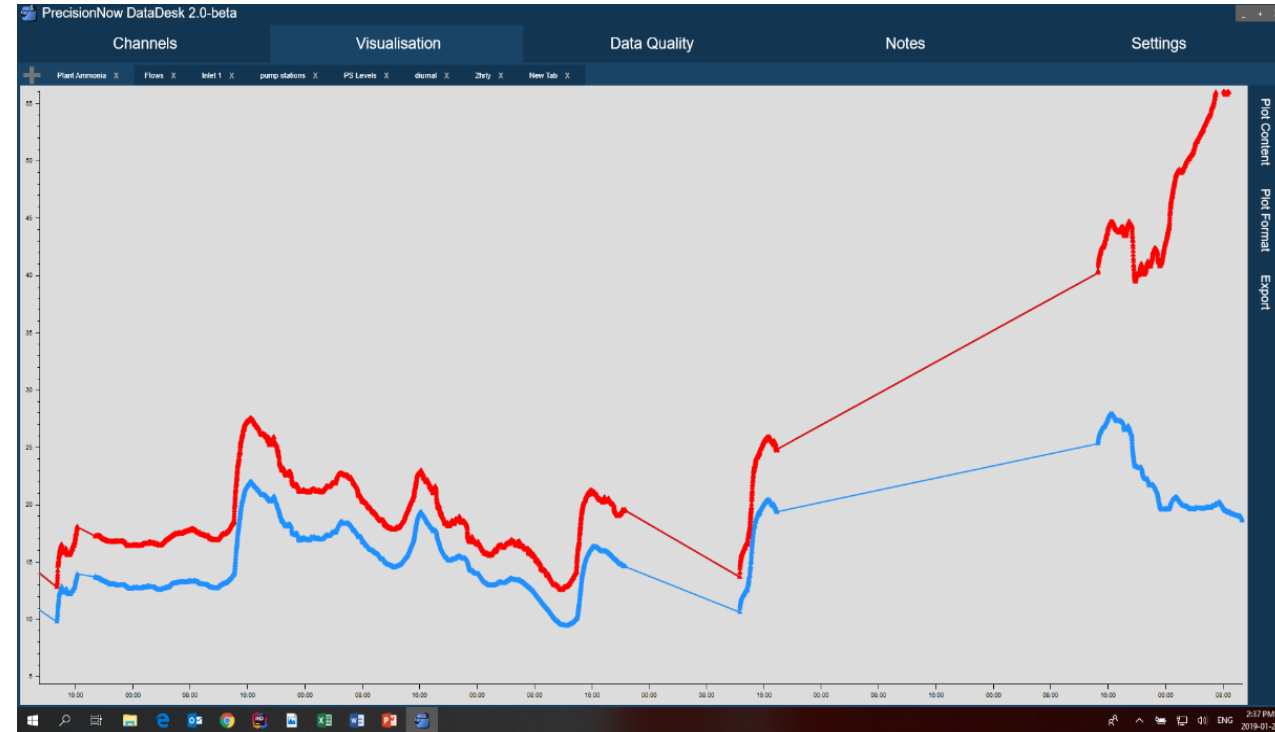
Sensor Installation

- RSM30 Monitoring Station
 - Stand-alone
 - Requires only 110v power
 - No long-term commitment
- *PrecisionNow*[®]
 - Data logging
 - Remote communication
 - Data visualisation
 - Real time data evaluation



Sensor Installation

- Probes
 - 2 identical and new probes
 - NH_4^+ , NO_3^- , Cl^- & K^+ sensors
- *Problem*
 - 1 probe excellent, 1 not
→ IMMEDIATE DRIFT



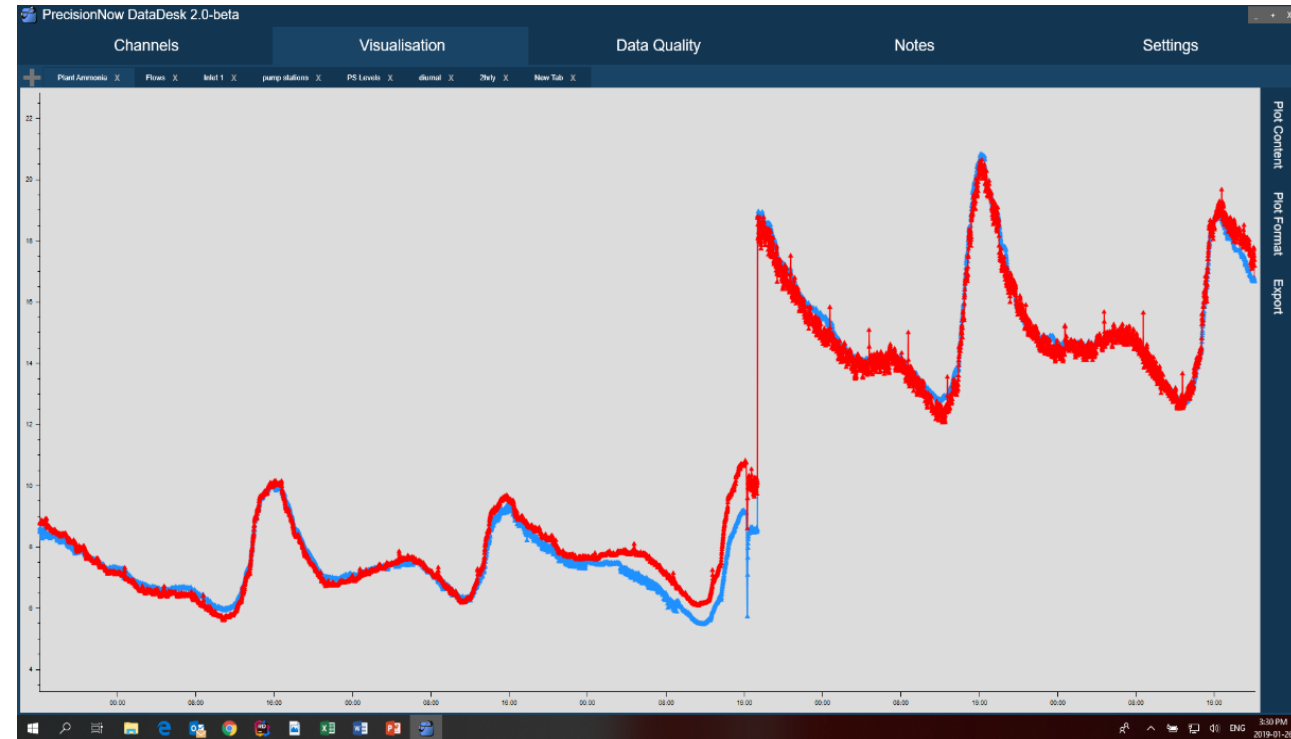
Sensor Installation

- **Probes**

- 2 identical and new probes
- NH_4^+ , NO_3^- , Cl^- & K^+ sensors

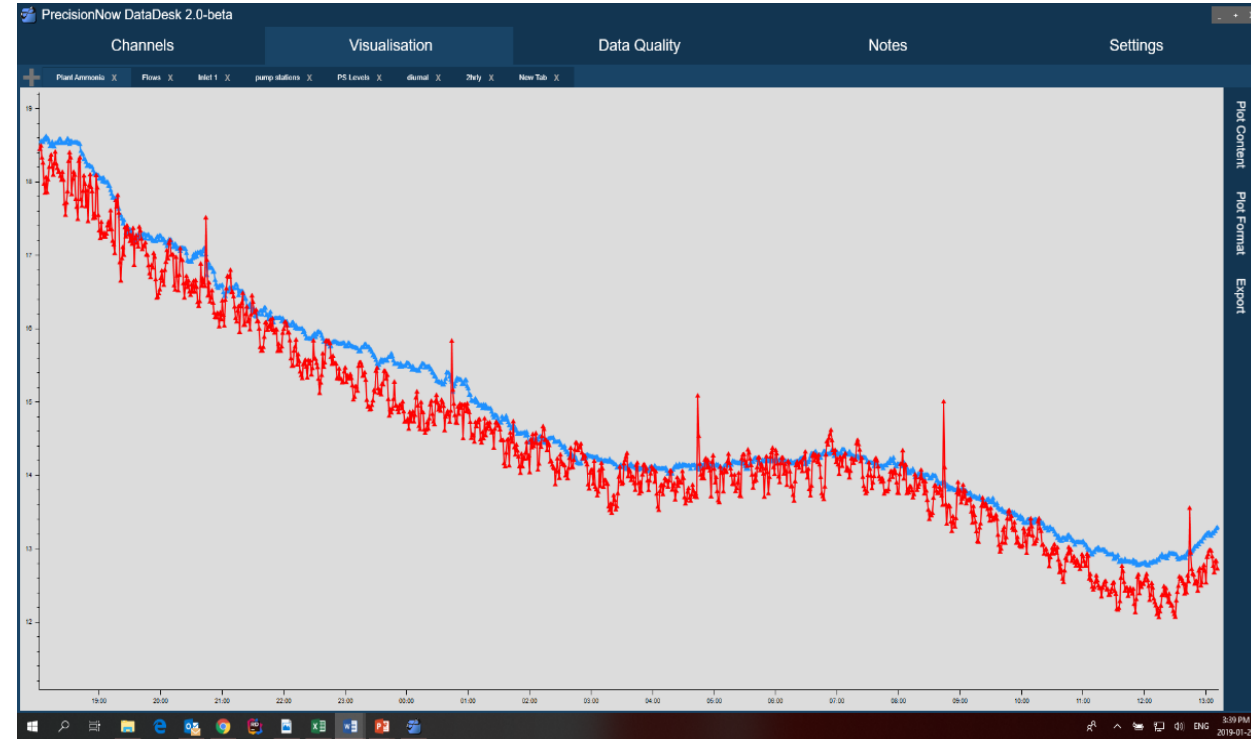
- ***Correction***

- 1 probe excellent, 1 not
- 7-month investigation
 - Sensors changed multiple times
 - Returned to depot (no issues found)
 - Eventually both probes returned similar results



Sensor Installation

- **Solution**
 - Even after correction, noise levels different due to age
- **Install Conclusion**
 - Results suggest that poor sensor performance might not be sufficient grounds to reject a sensor type or manufacturer.
 - Problem identification was only possible due to dual probes
 - Work with manufacturer if issues in your trial



Data Quality – Sensor Maintenance

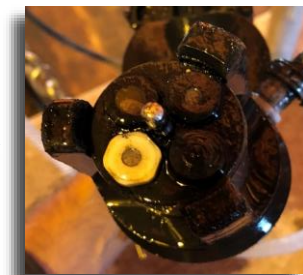
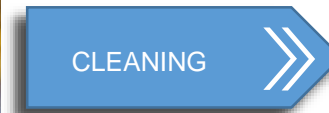
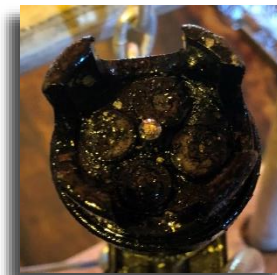
- **Sensor Care**

- Mechanically cleaned twice/wk
- 1 probe fitted with automatic air blaster (4hr interval)

Monday	Tuesday	Wednesday	Thursday	Friday
	clean			clean sample taken

- **Process Sample**

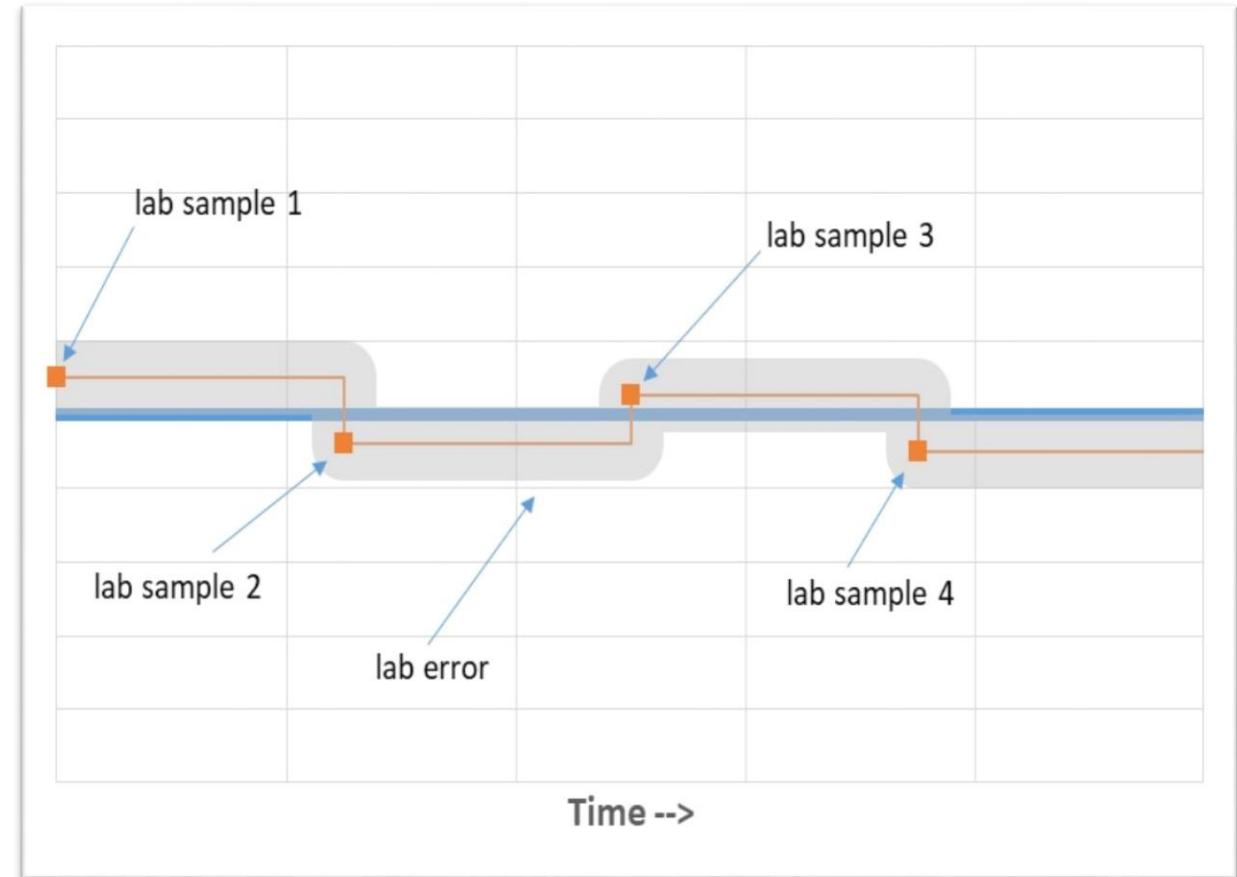
- Filtered on-site
- Same-day analysis (always within an hour of sampling)
- McMaster lab, using Hach TNT 832 Ammonia vials



Impact of Laboratory Error

- Why it matters

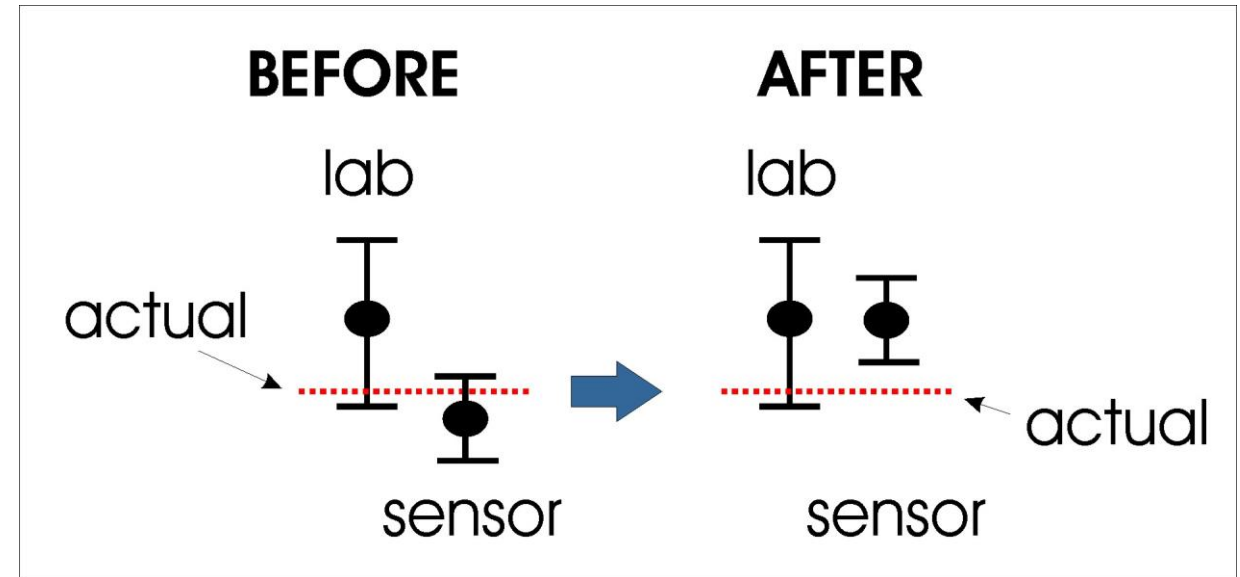
- Assume a constant concentration
- Consider the lab error
- Sensor adjusted to lab error



Impact of Laboratory Error

- **Why it matters**

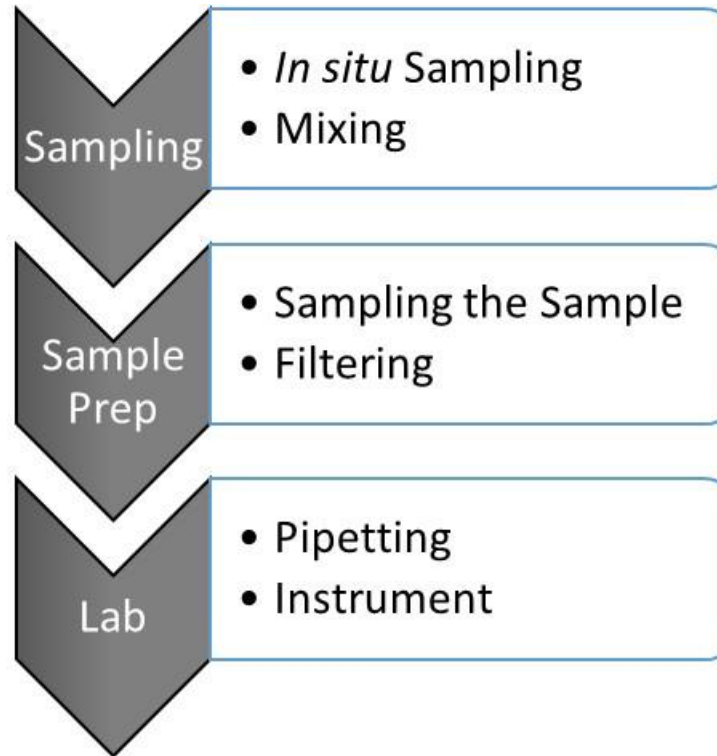
- Assume a constant concentration
- Consider the lab error
- Sensor adjusted to lab error
- **Situation worse when sensor error also not considered → 'over-calibration'**



Data Quality – Sampling & Laboratory Error

• Sampling Steps

1. Bucket dunk
2. Mix contents
3. Fill syringe
4. Filter
5. Pipette sample
6. Digest
7. Read



• Errors introduced at each step



Data Quality – Sampling & Laboratory Error

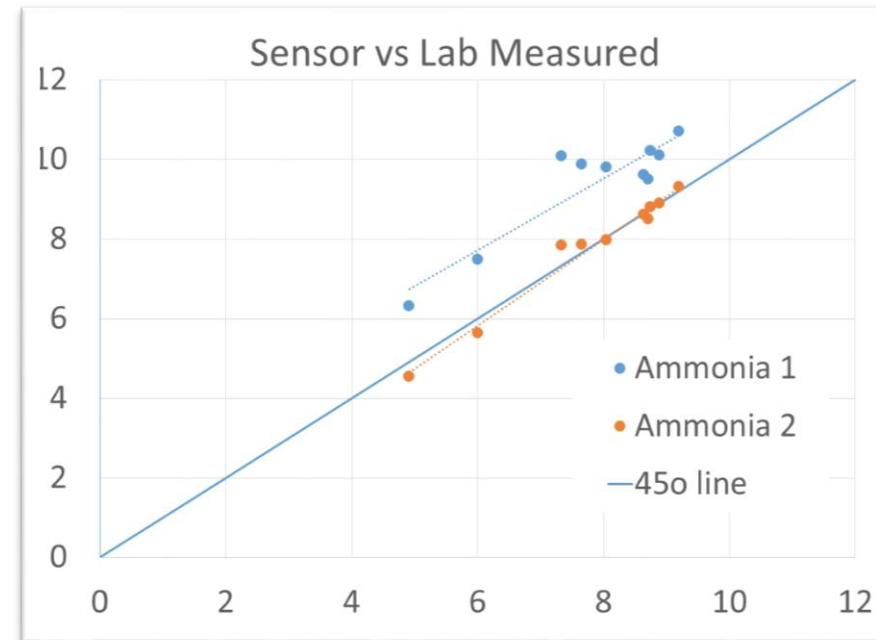
- Experimentally Designed Sampling
 - Multiple factors
 - 1 or 3 dunks
 - Mixed and unmixed in bucket
 - 1 or 3 syringe fills
 - New or used filter tips
 - 3 or 9 tubes loaded from a single sample vial
 - Different digestion times (various, 15-135 min.)
 - Different spectrophotometers



Data Quality – Sampling & Laboratory Error

- Results

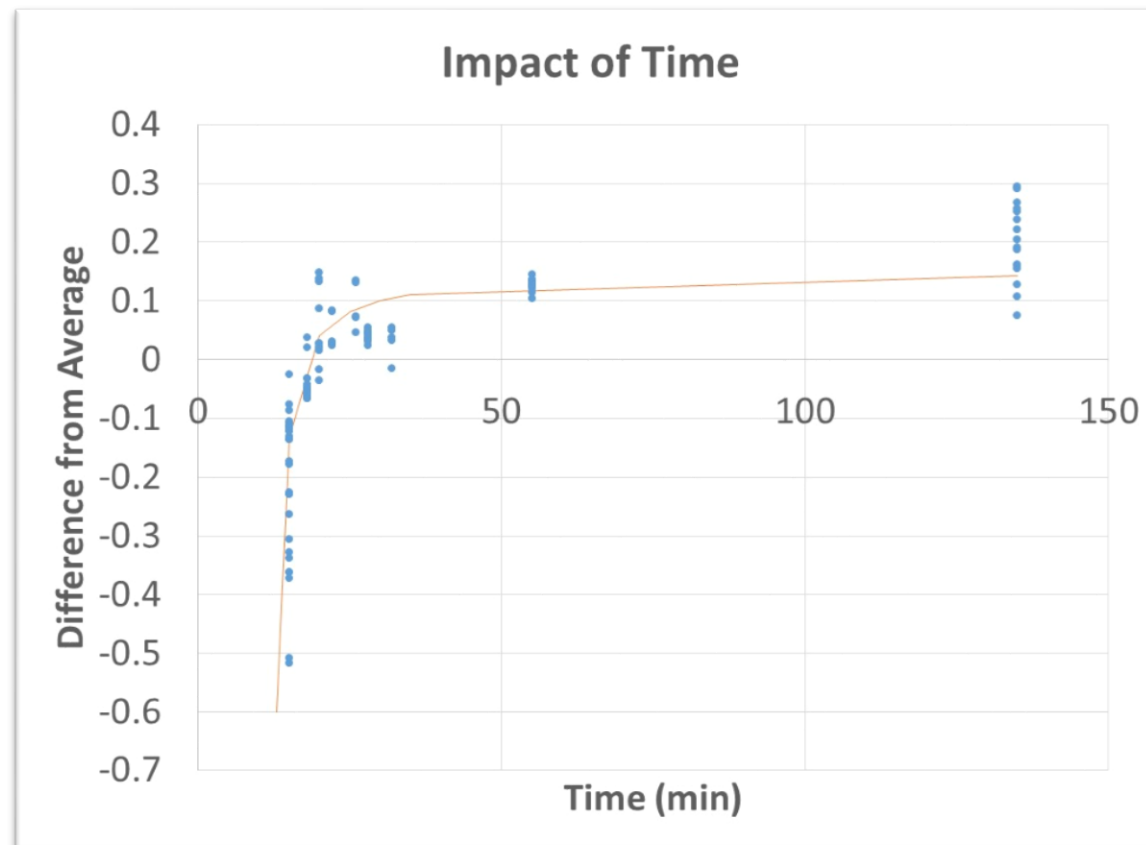
- One sensor showed agreement with lab values
- One showed constant offset



Data Quality – Sampling & Laboratory Error

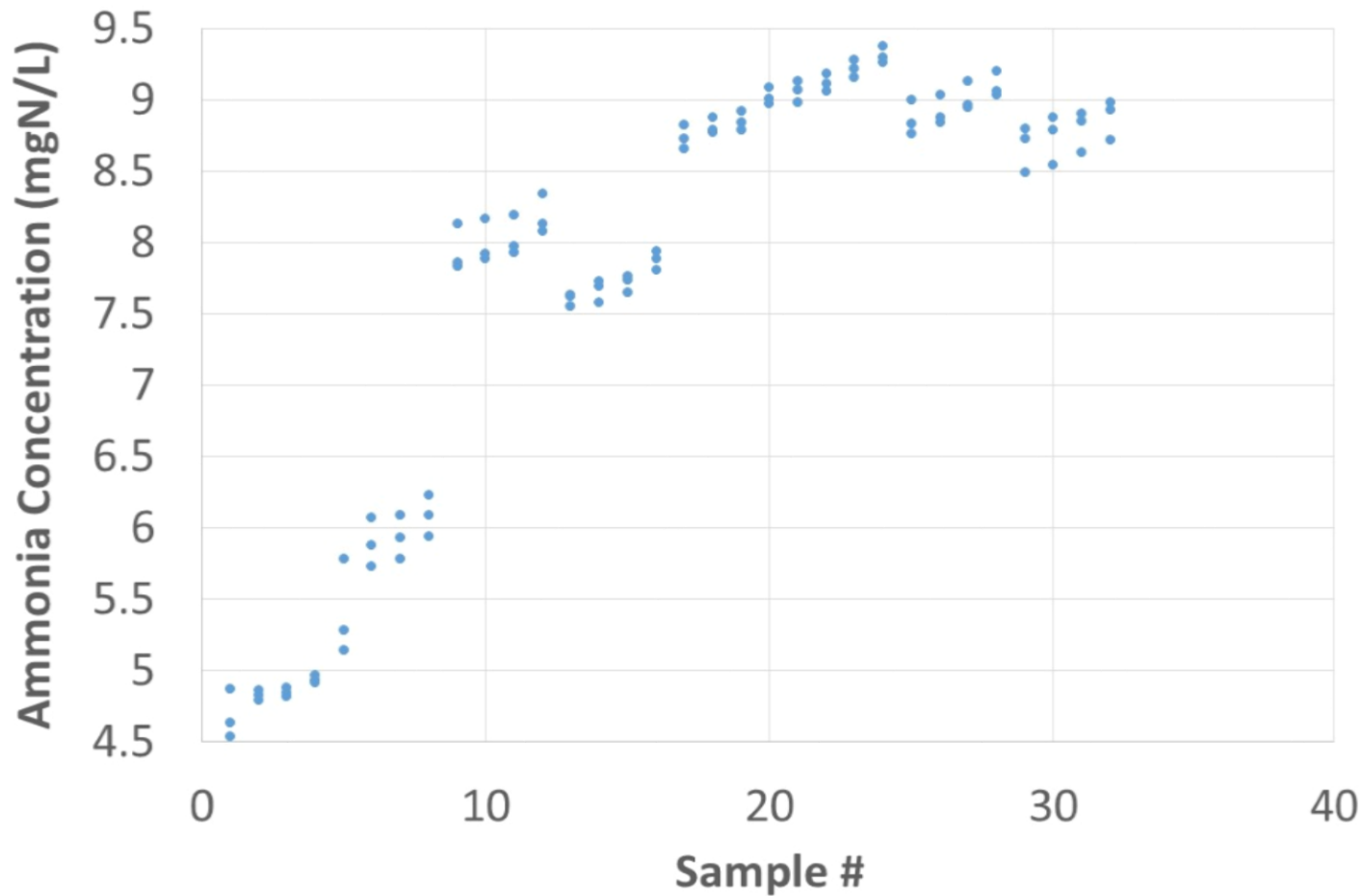
- Results

- Impact of digestion time on lab value



Data Quality – Sampling & Laboratory Error

Impact of Pipetting



• Results

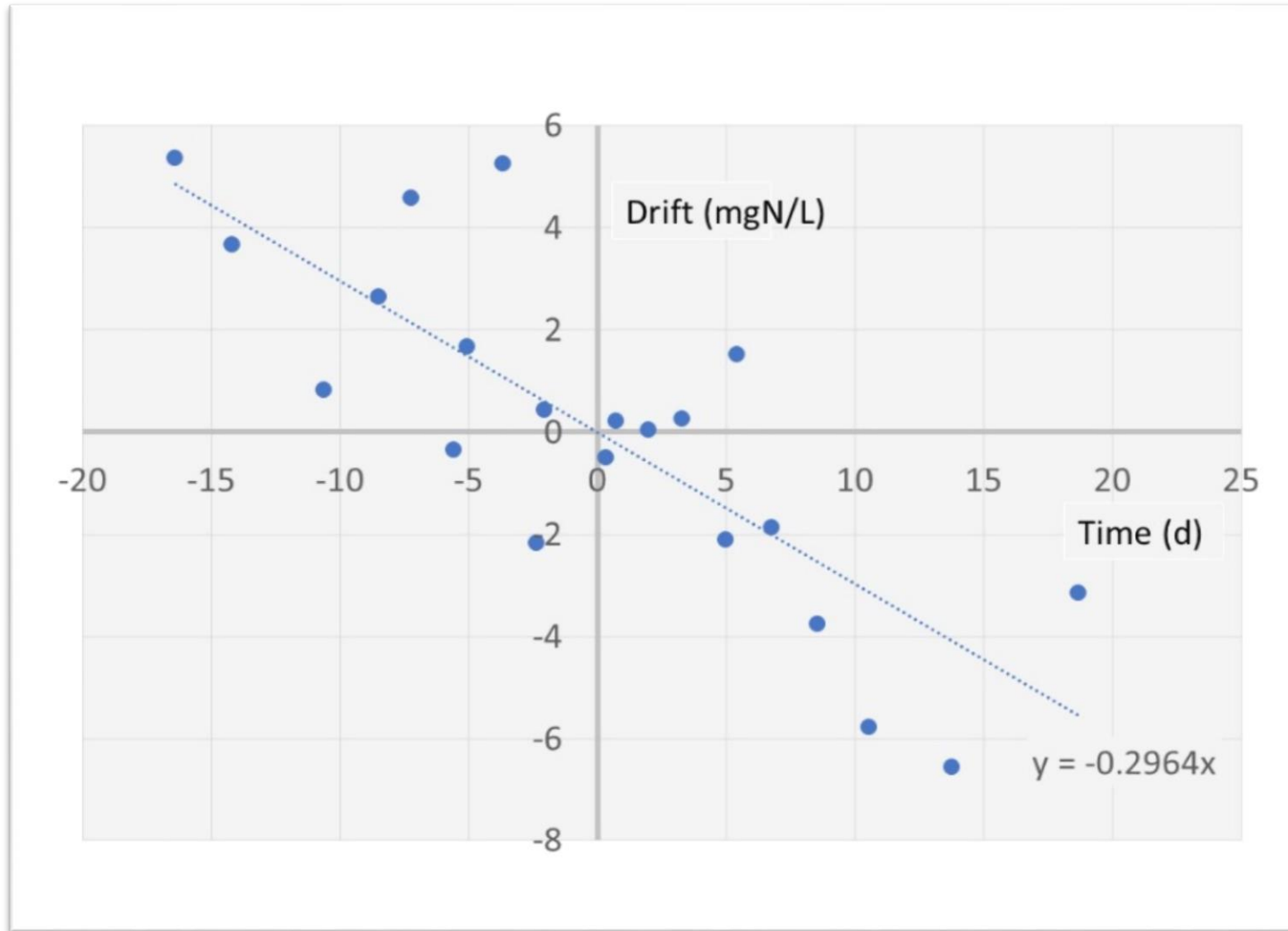
- Impact of pipetting and the tubes themselves

• Overall Lab Error

- Error estimated to be $\sim 0.45\text{mgN/L}$



Data Quality – Drift



- Drift Experiments
 - Parallel probes, one cleaned, one not
 - Ongoing, but results suggest about 0.3mgN/L/d drift if not cleaned (in that location)



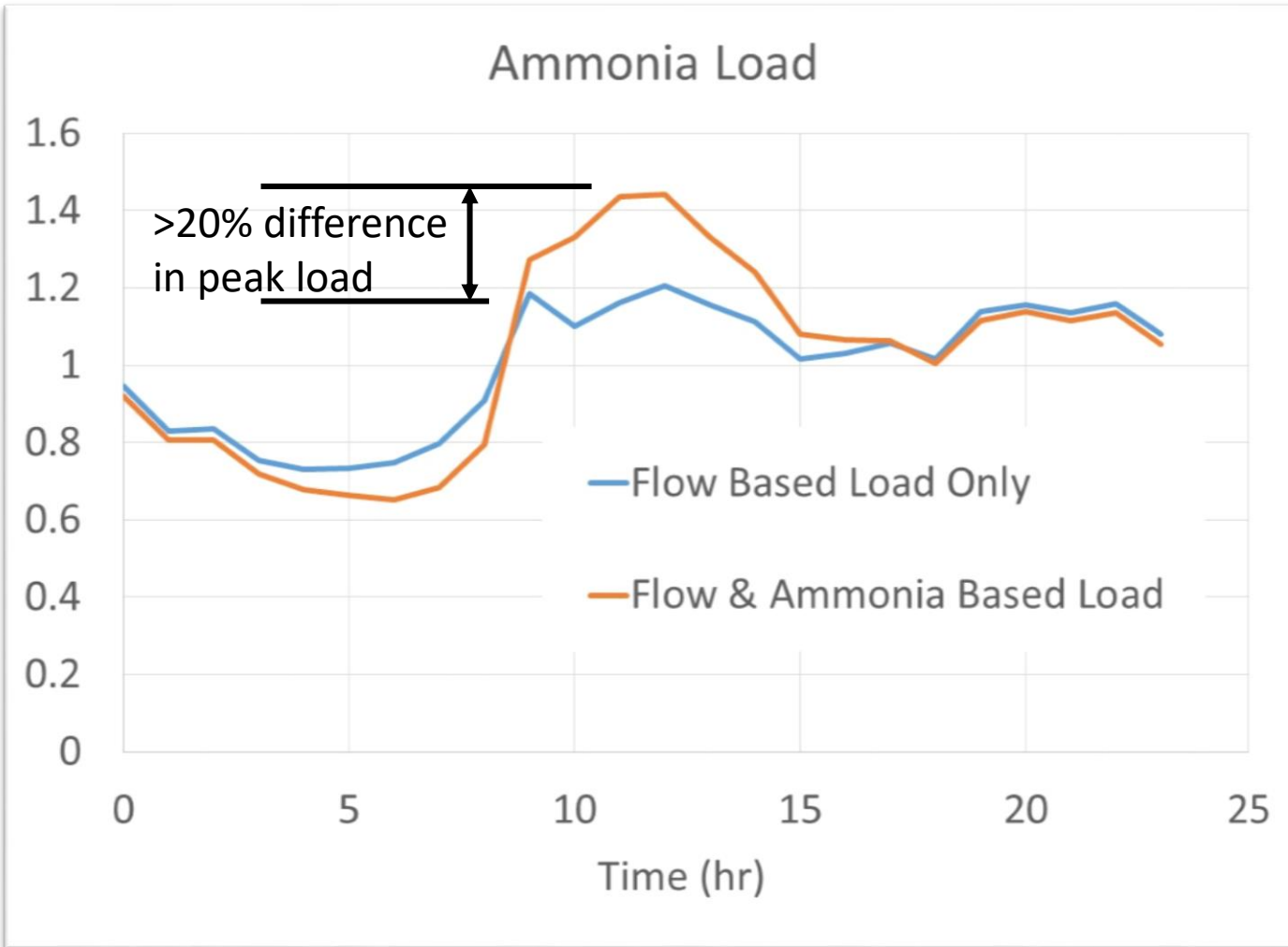
High Frequency Data



- Diurnal Ammonia
 - Determination of diurnal changes influent ammonia



High Frequency Data

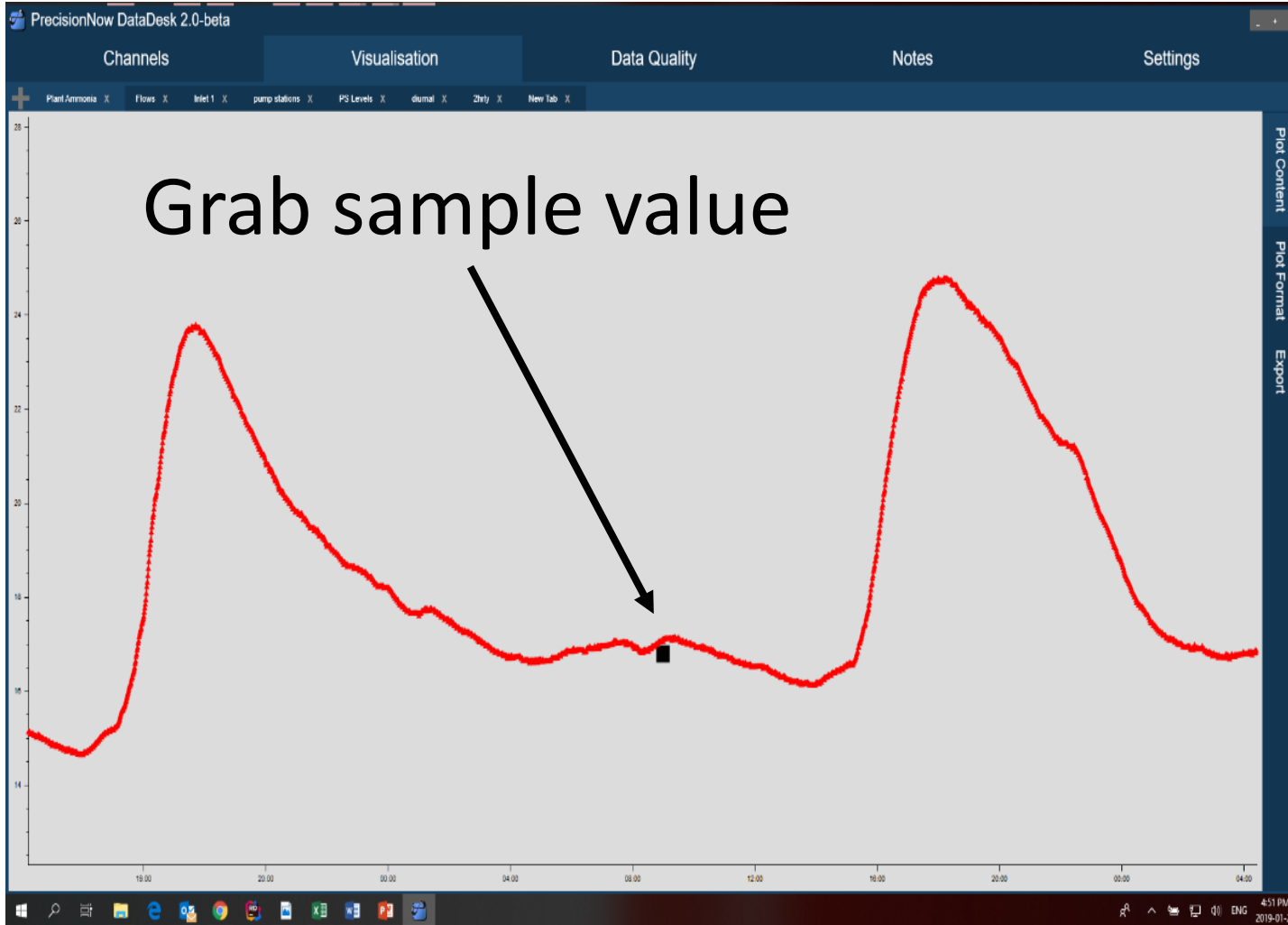


- **Diurnal Load**

- Not considering diurnal conc. can lead to significant underestimation of load
- Implications for blower design and DO control



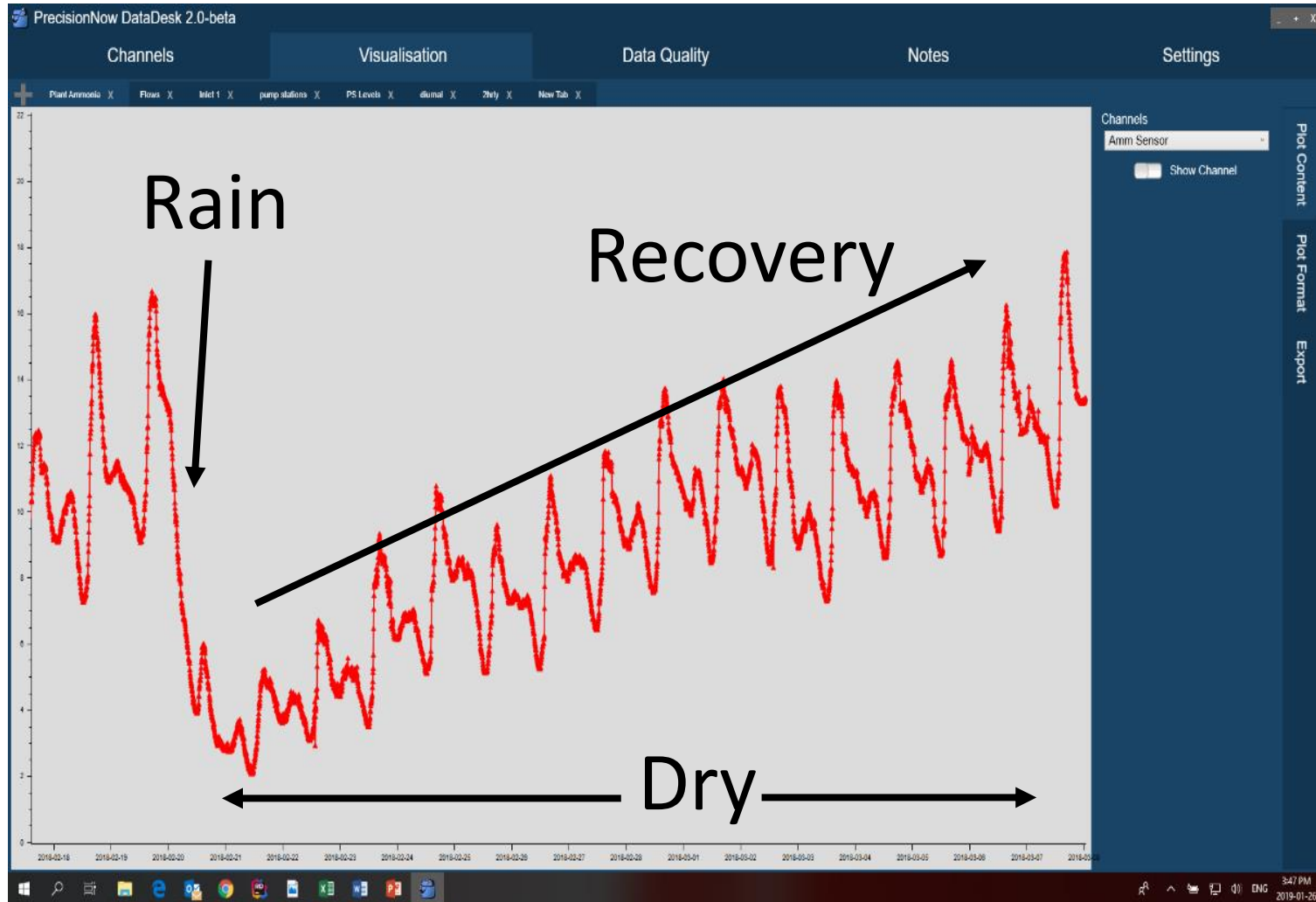
High Frequency Data



- Issue with Grabs
 - Problem exacerbated if concentration is not representative
 - Same site, daily grabs taken, clearly underestimating the dry conc.



High Frequency Data

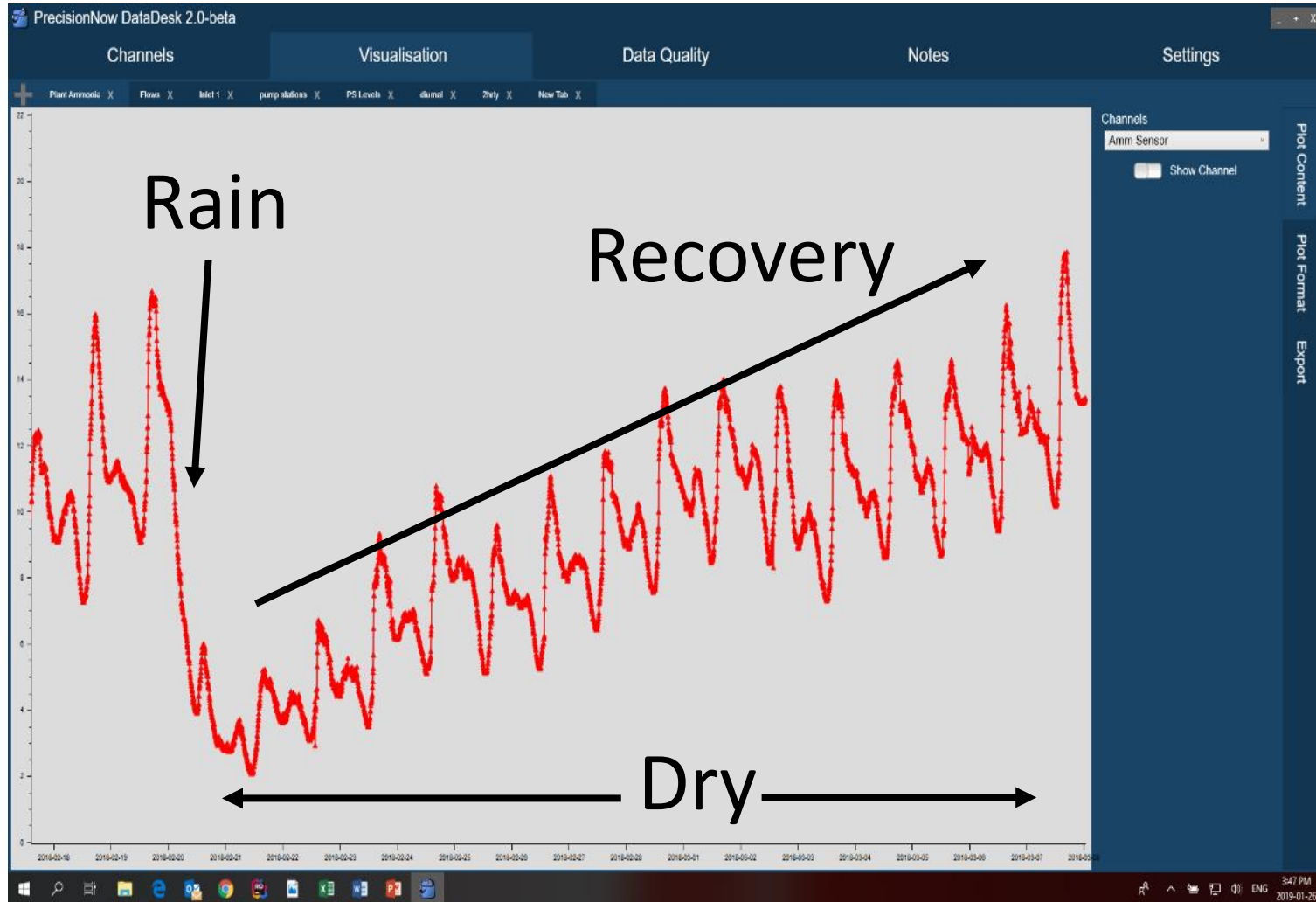


- **Unexpected Behaviour**

- Unexpected long recovery time from a rain event
- Still investigation cause, but infiltration suspected



High Frequency Data



- Unexpected Behaviour

- Implications for the process control apparatus and possible planning for wet weather events, and/or multiple events



Conclusion

- **High-Frequency Data**

- Necessary and recommended for advanced process understanding including things like min and max blower demand, DO control in general and wet weather planning
- Options available for short-term high-frequency monitoring when a long-term commitment is fiscally not possible or is unnecessary



Conclusion

- **High-Frequency Data**

- Data Quality is essential

- You've invested in the equipment, so spending the time and money ensuring the sensor data quality will help realise the benefits

- Maintenance

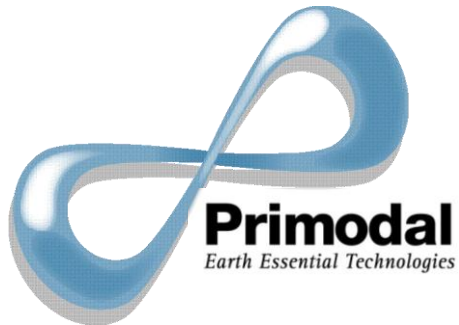
- Understanding when and how often maintenance is required saves money (avoid ad hoc estimates)

- Lab and Sensor Errors

- Estimating the various errors will help avoid over-calibration



Thank-you !



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