Determination of Hydraulic Retention Time for Passive Treatment System Oxidative Unit Using Rhodamine

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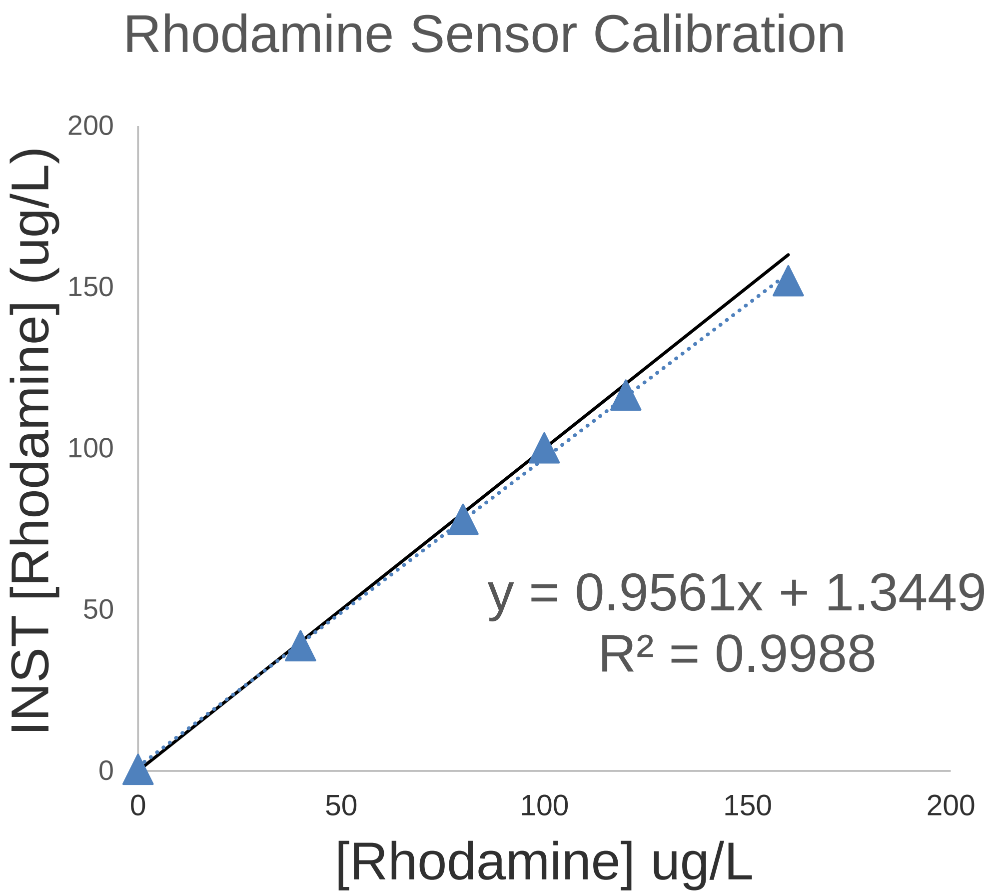
Objectives

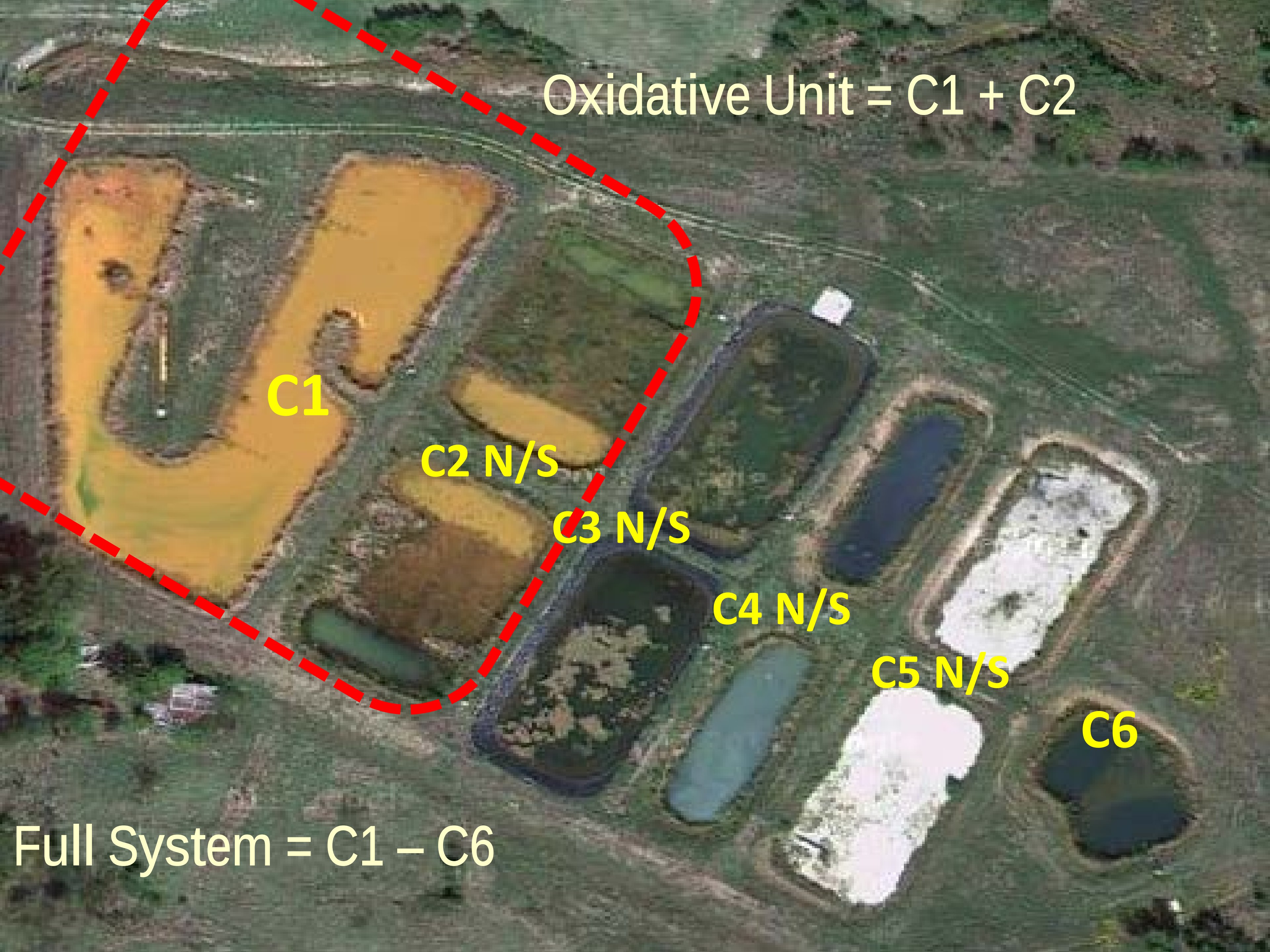
- Hydraulic Performance
  1. Time to Arrival, HRT, Concentration peak

- Discrete vs Continuous Sampling
  1. Method resolution / performance comparison
  2. Consideration of measurement bias

Rhodamine-WT and YSI (6130)

- Rhodamine Dye
  - 200 g/L
  - 555nm emission
- Sensors
  - 0.1-200 ug/L range
  - ±5% of value (error)
  - 0.1 ug/L LOD



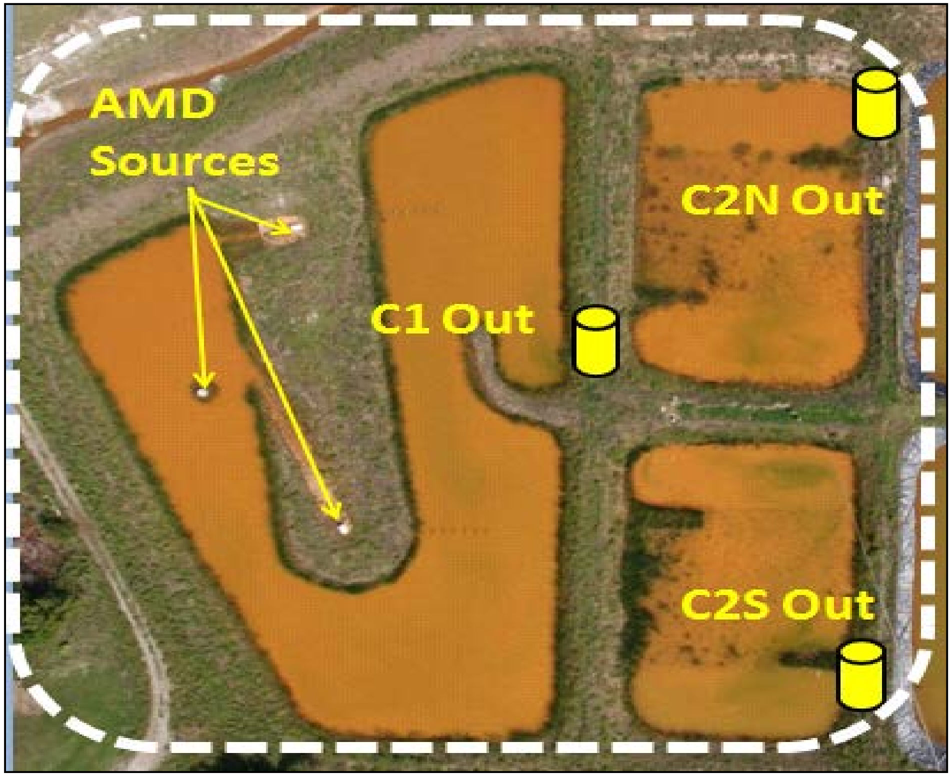

Oxidative Unit = C1 + C2
C1
C2 N/S
C3 N/S
C4 N/S
C5 N/S
C6
Full System = C1 – C6

Design Retention Times

Cell(s)	Cell Description	Targeted Parameter	Design Retention Time
1	Preliminary Iron Oxidation and Sedimentation Cell	Fe, trace metals sorption	7.7 days
2(N/S)	Surface Flow Wetlands (pond-marsh-pond design for additional iron oxidation and sedimentation)	Fe, solids retention	3.4 days

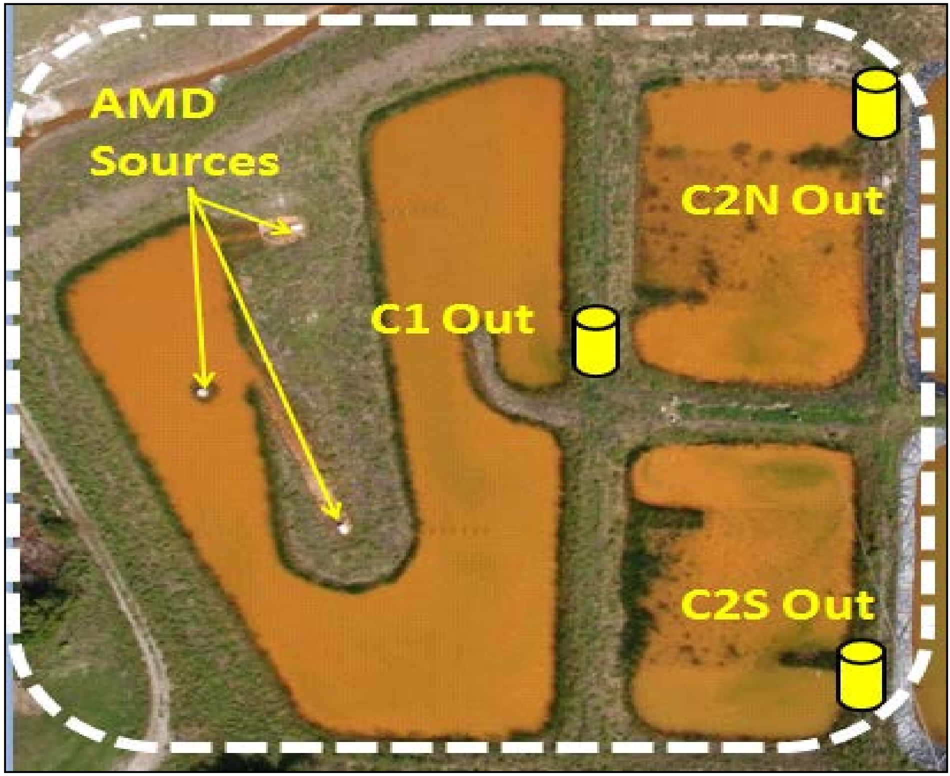
Instrumentation and Monitoring

- Continuous
  - Optical rhodamine sensors deployed at each effluent Agri Drain.
  - Sampling rate: One measurement every 15 min for 14 days.



Instrumentation and Monitoring

- Discrete
  - Optical rhodamine sensor used to measure autosampler collections
  - Sampling rate: One sample collected every hour for 24 hours

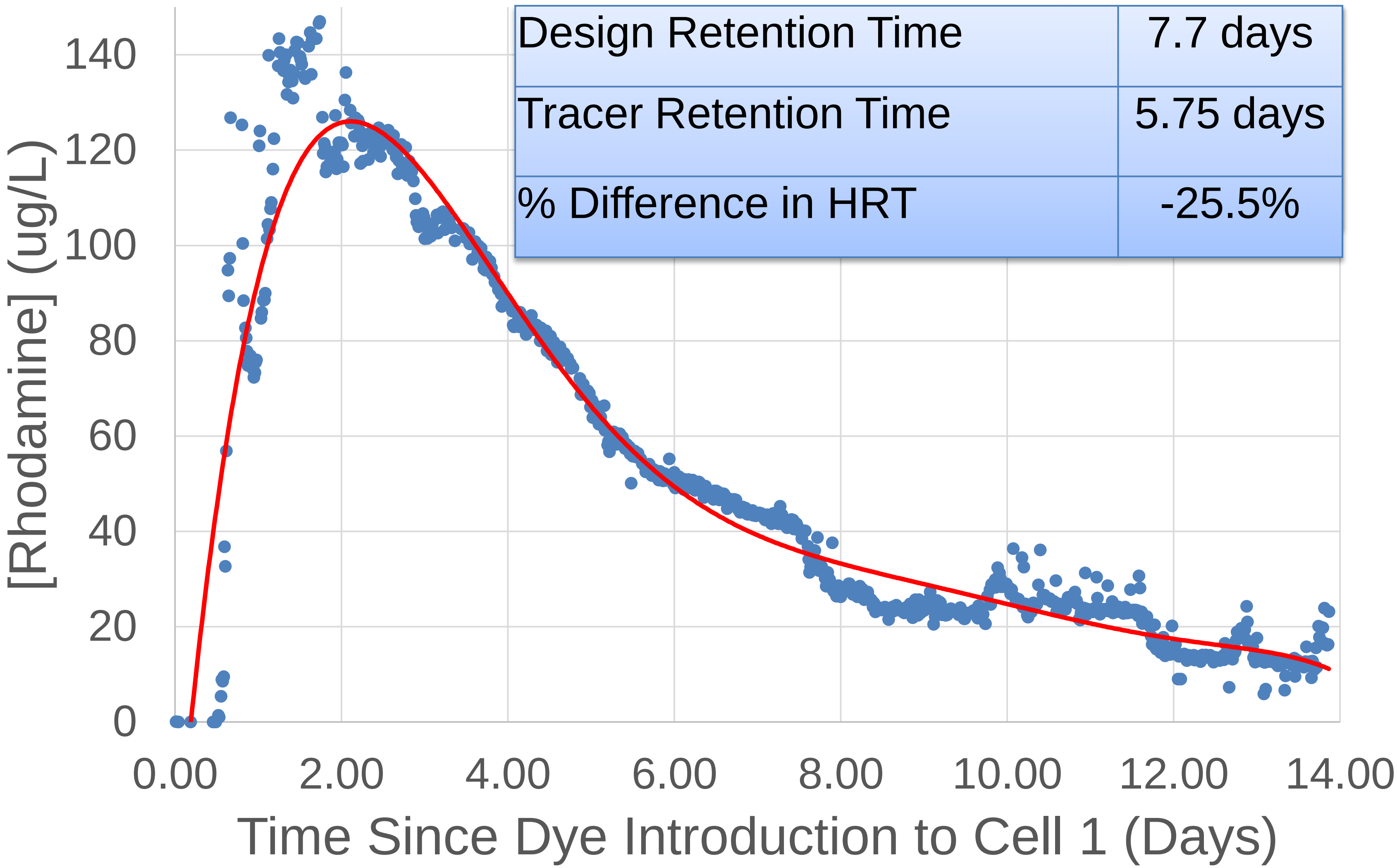


Time and Volume Scaled Rhodamine Dosing

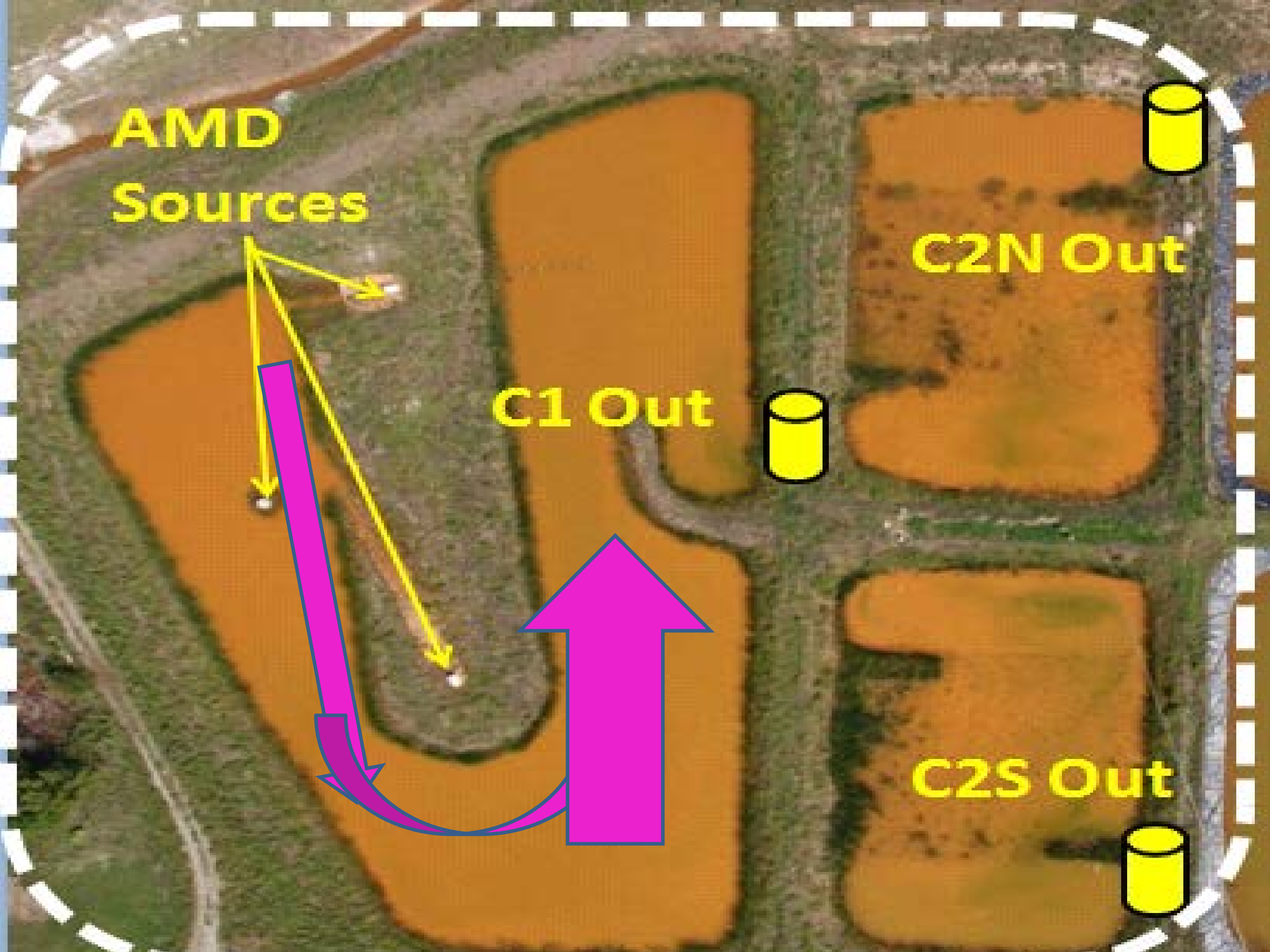
Flow (L/sec)	Seep A	Seep B	Seep D	Total Influent
Average (n = 6)	2.52 L/sec	4.41 L/sec	0.48 L/sec	7.41 L/sec
% Contribution	34%	59%	6%	100%
Dye Volume	900 mL	1800 mL	300 mL	3000 mL
Dye Mass Loading	180 g	360 g	60 g	600 g

- Flow rates were determined from six replicate measurements at each seep to calculate contribution.
- 3L of 200 g/L Rhodamine-WT was portioned based on percent contribution of each seep.
- All three rhodamine fractions were added simultaneously at all three seep locations.

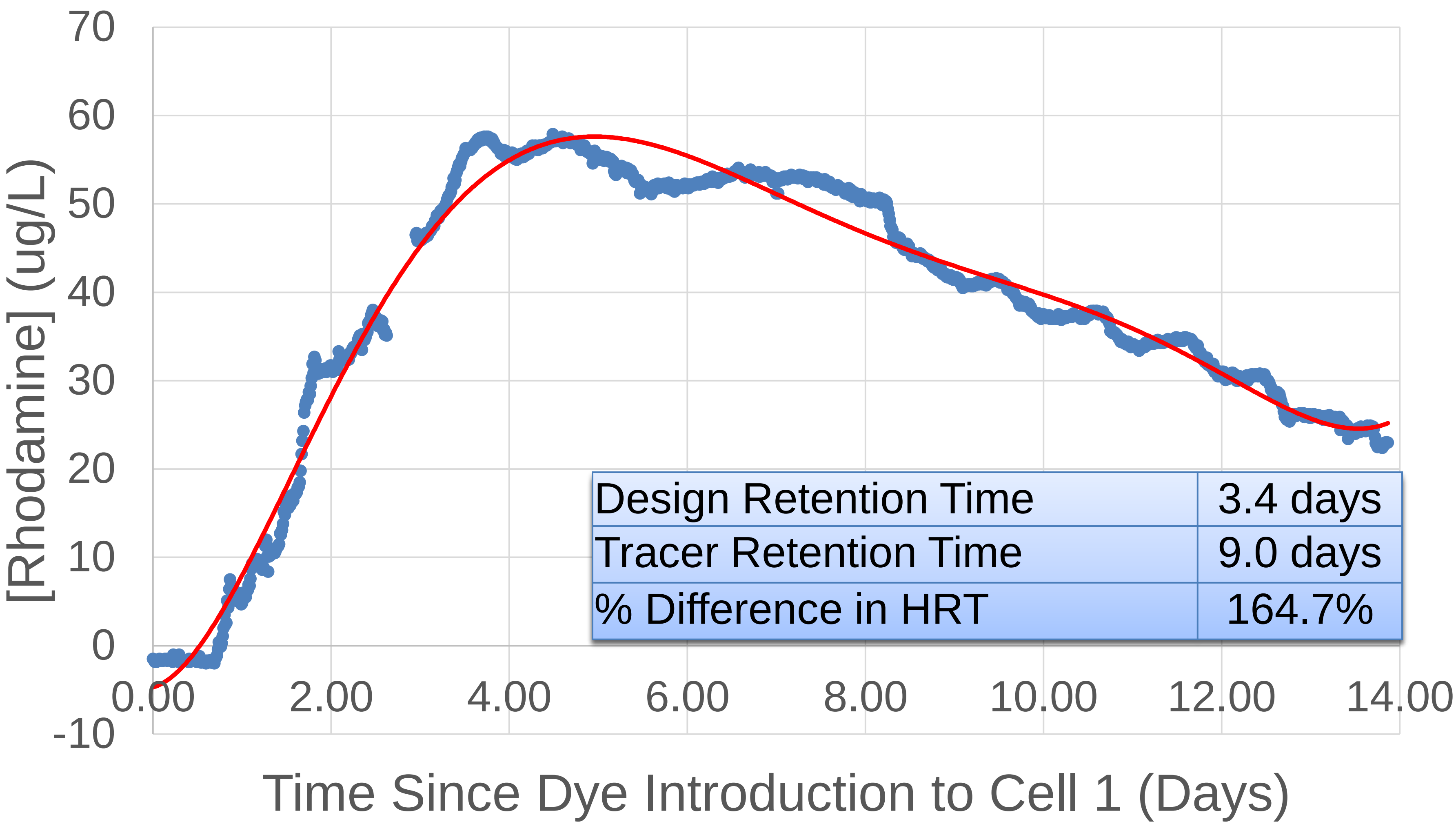
C1Out Rhodamine Transport Profile



Design Retention Time	7.7 days
Tracer Retention Time	5.75 days
% Difference in HRT	-25.5%

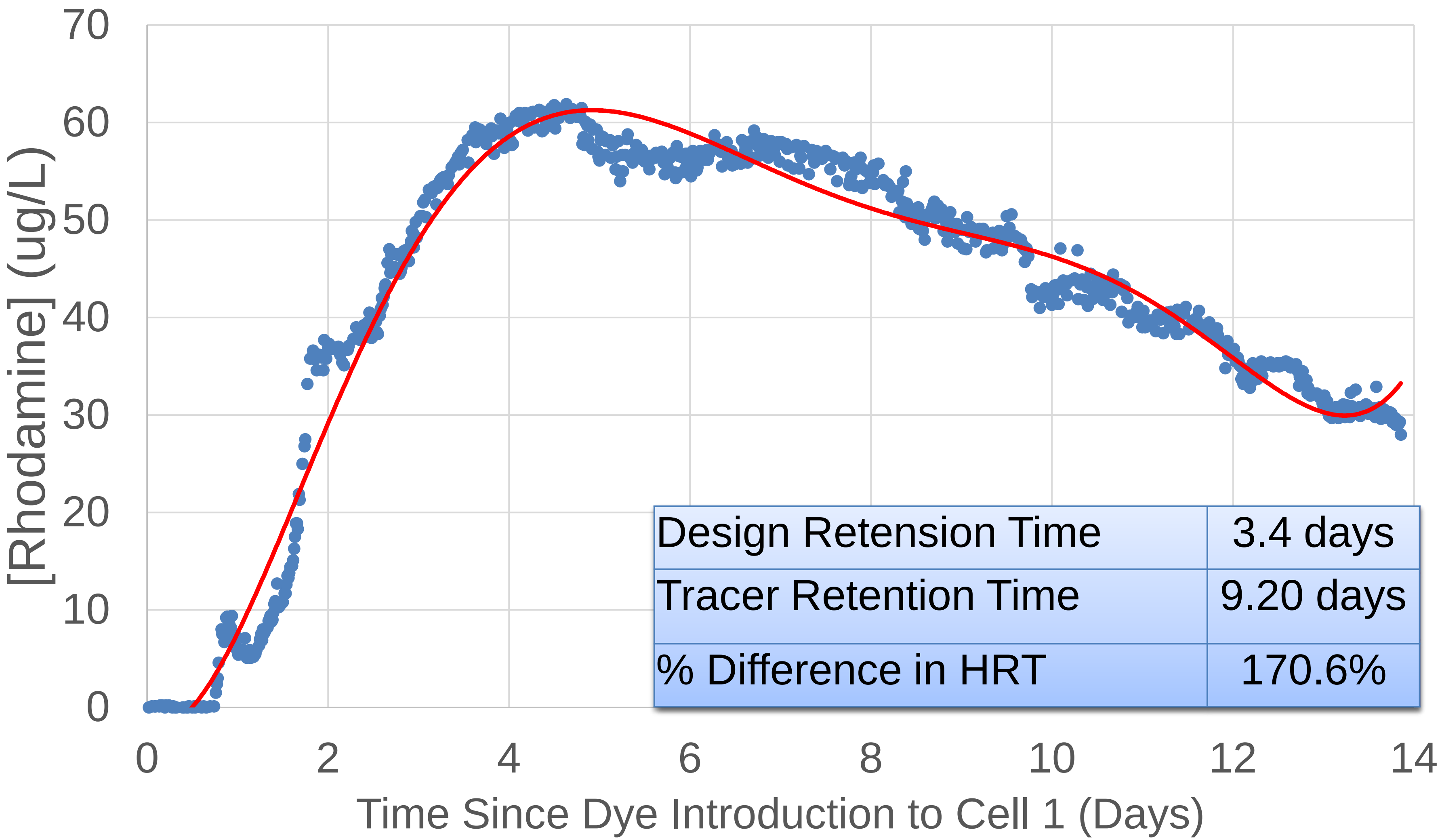

AMD
Sources
C1 Out
C2N Out
C2S Out

C2Sout Rhodamine Transport Profile

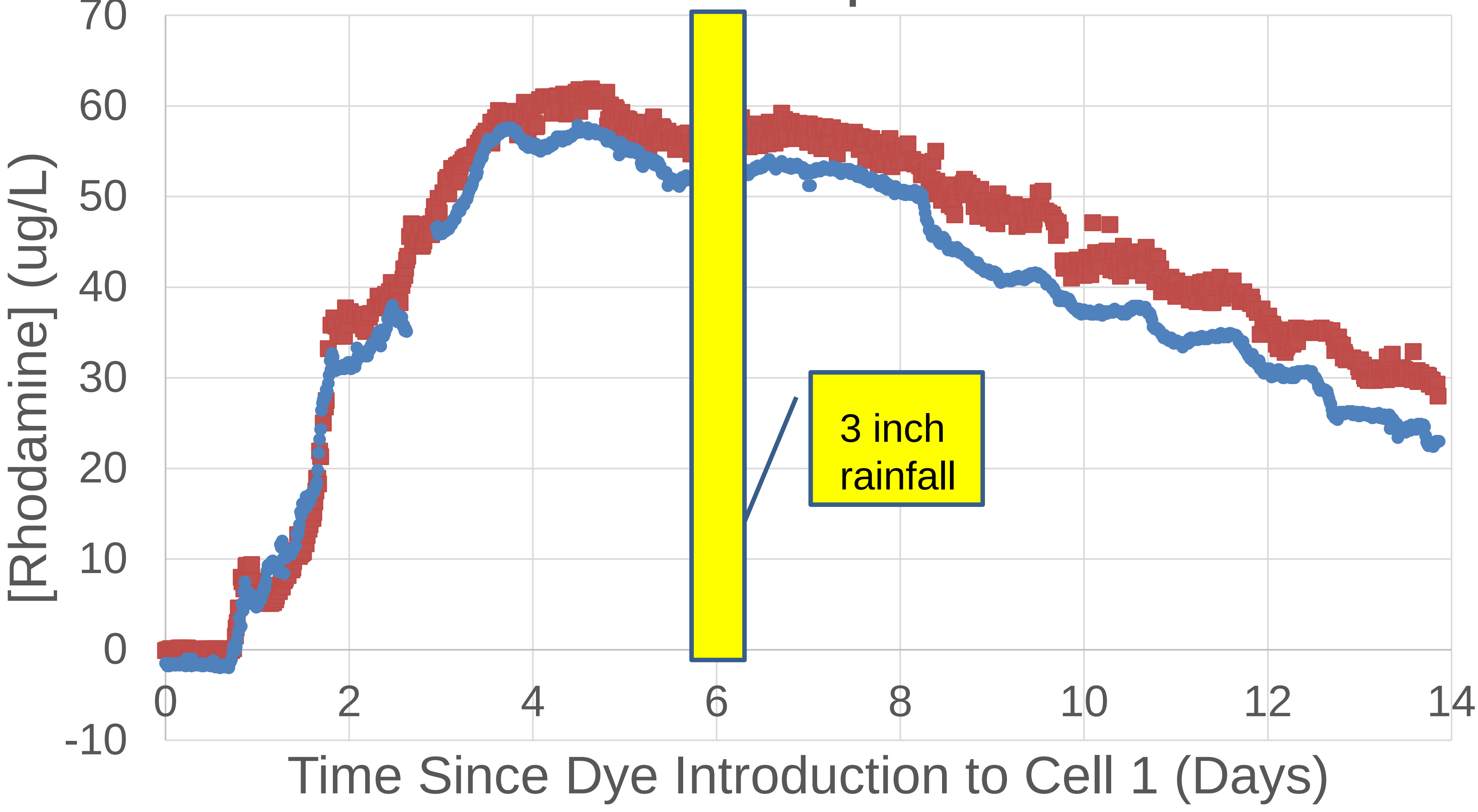


Design Retention Time	3.4 days
Tracer Retention Time	9.0 days
% Difference in HRT	164.7%

C2Nout Rhodamine Transport Profile



Cells 2 N and S Rhodamine Transport Profile Comparison



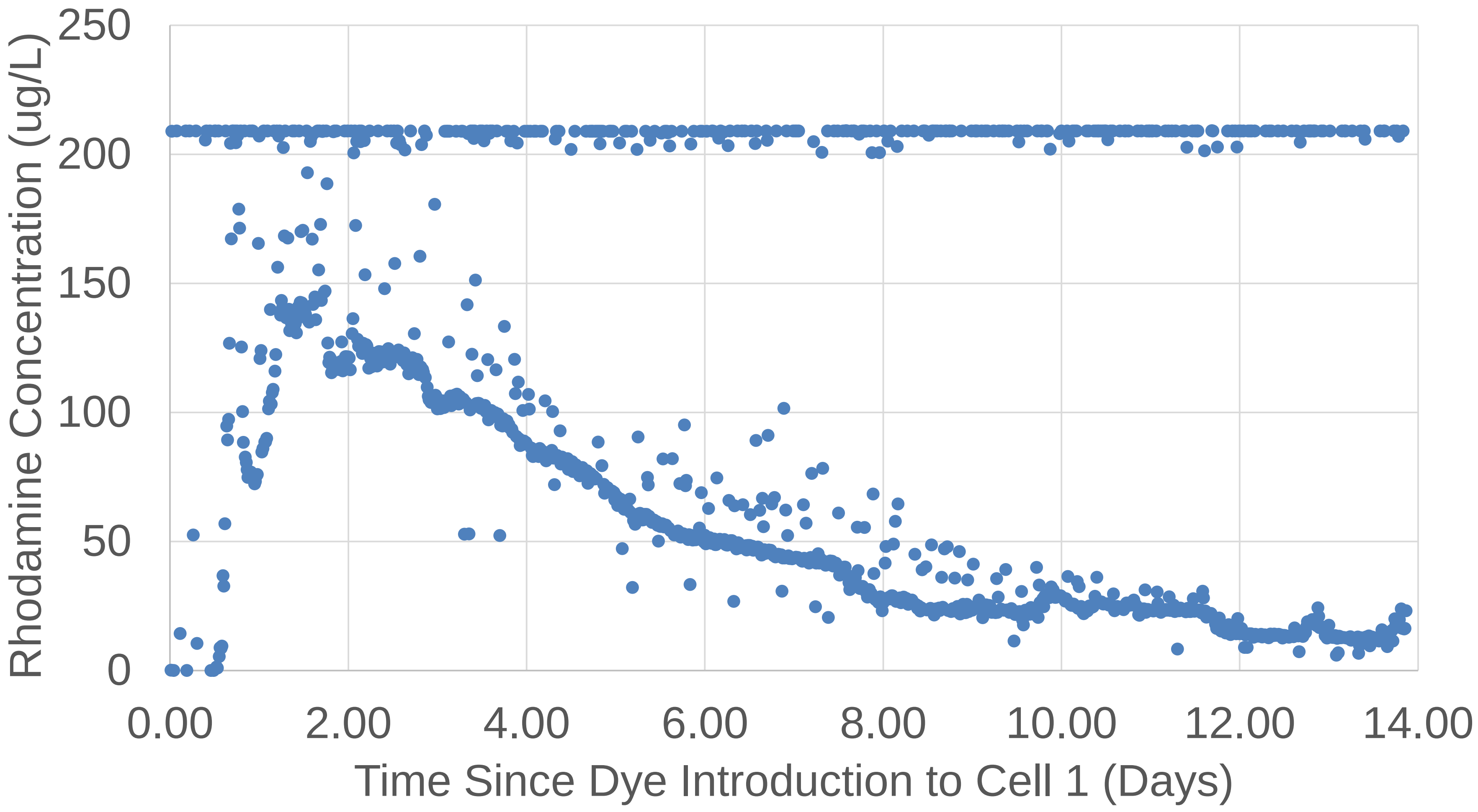
Transport Results Summary

Cell 1 HRT is less than anticipated by design – Short Circuiting.

Cell 2N and Cell 2S are consistent in HRT indicating equivalent flow splitting.

Cell 2 HRT is greater than anticipated by design due to Cell 3 (VFBR) flow restriction during periods of rainfall.

Continuous Datasets Plagued by Particulate Interferences



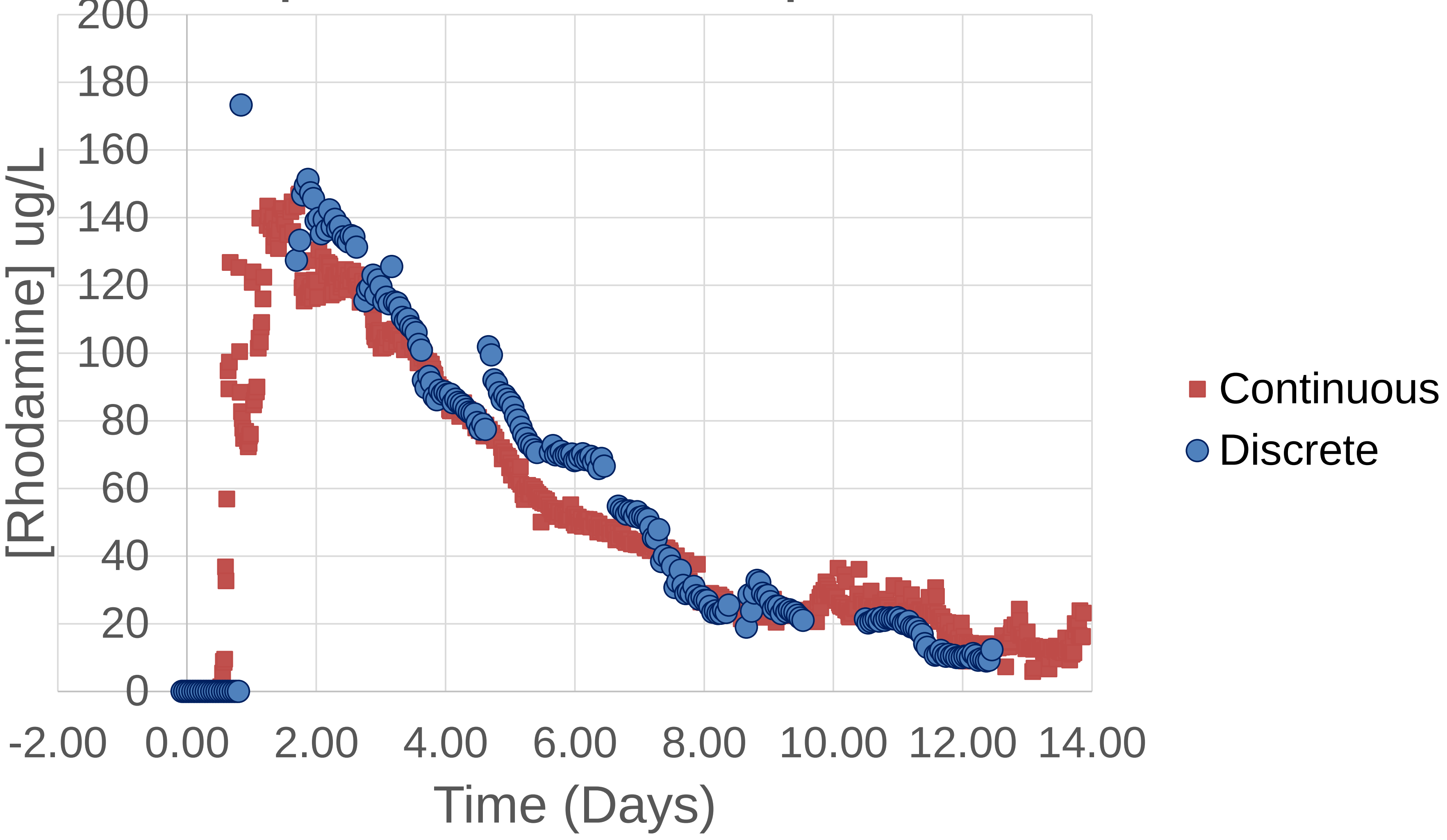
Drawbacks to Continuous Approach

- High sampling rate needed to compensate for particulate interferences without loss of data resolution.
- High sampling rate decreases battery life.
- Extensive data processing post collection.

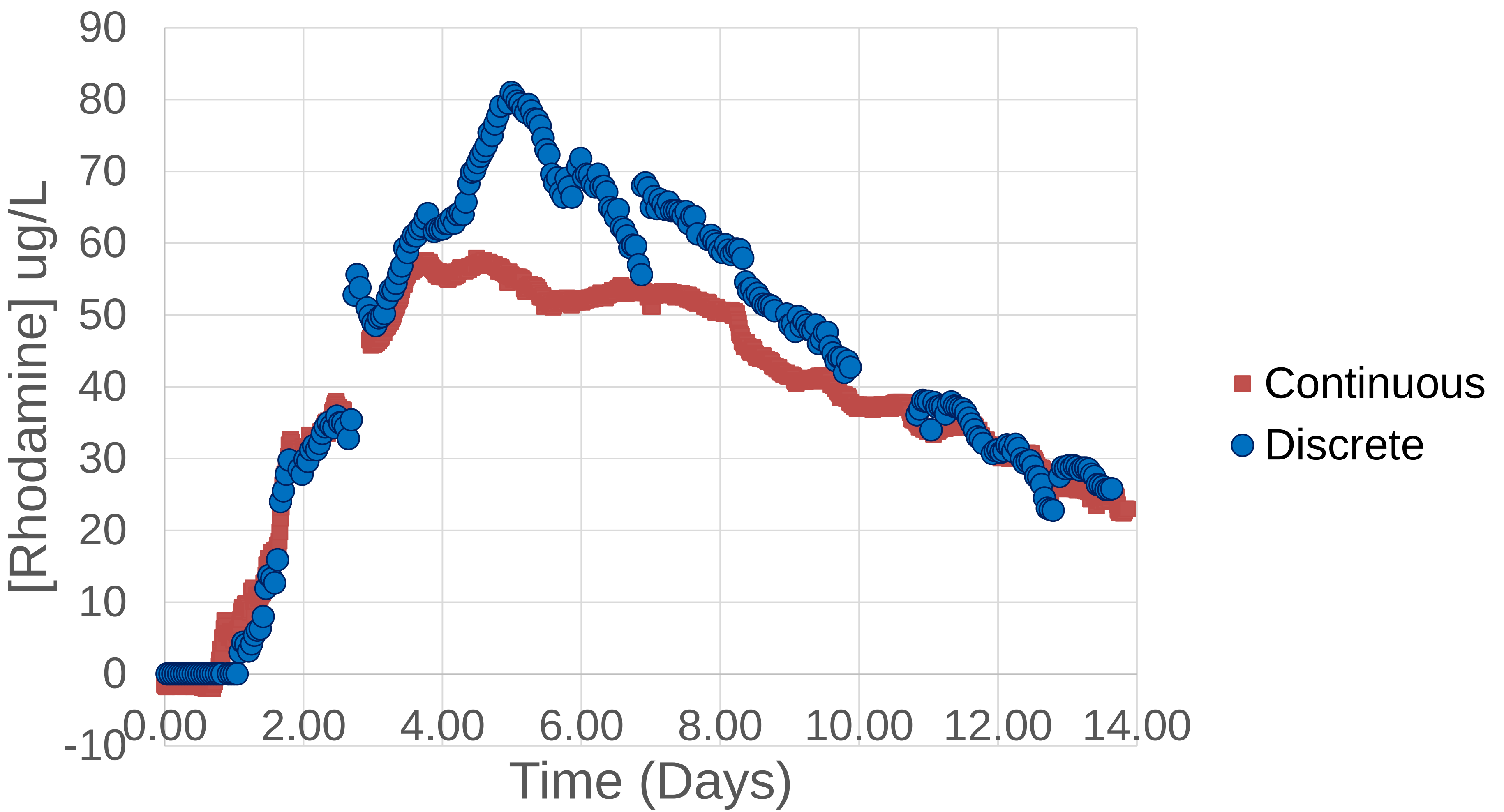
Discrete Monitoring

- Samples collected every hour for 24 hours.
- 4 samples a day were filtered to removed suspended iron ppt. as an interference correction

C1OUT: Discrete Rhodamine Transport Profile Comparison



C2Sout: Discrete Rhodamine Transport Profile Comparison



Discrete Sampling Results

- HRT consistent between sampling methods (continuous vs discrete)
- Daily calibration corrects for drift / signal attenuation concerns
- Monitor qualitative progress of dye and Report on daily progress in real time
- Mitigation of outliers due to autosampler

Drawbacks to Discrete Approach

- Autosampler failure can lead to gaps in dataset.
- Delayed measurements by up to 24 hours.
- Commitment of personal for the duration of the project.

Summary

- Tracer studies of iron oxidation cells using rhodamine are possible despite expected sorption losses.
- Continuous or discrete sample collection methodologies may be used for quantitative analysis.
- One must consider equipment and team resource availability on a case by case basis.

Questions / Comments

C2Sout Rhodamine Transport Profile Comparison (2015 vs 2009)