Seasonal Storm Induced Metals Transport Dynamics Between Oxidative Cells of a Passive Treatment System

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Passive Treatment: Design for Function

PHYSICAL

- Design treatment cells to optimize hydrology:
  - Storage / Surface Area
  - Hydraulic Retention Time
  - Elevation Change / Aeration

CHEMICAL

- Neutralize acidity
  direct and indirect
- Metals removal and retention
  oxidation / reduction
  ppt / sedimentation
- Alkalinity generation

Consideration of Storms in Design

ACUTE (SHORT TERM)

- Direct precipitation
- Surface runoff (system)
- Storm Drainage
- Construction Schedule

CHRONIC (LONG TERM)

- Changes in loading
- Erosion of berms
- Field work schedules
- Remote monitoring

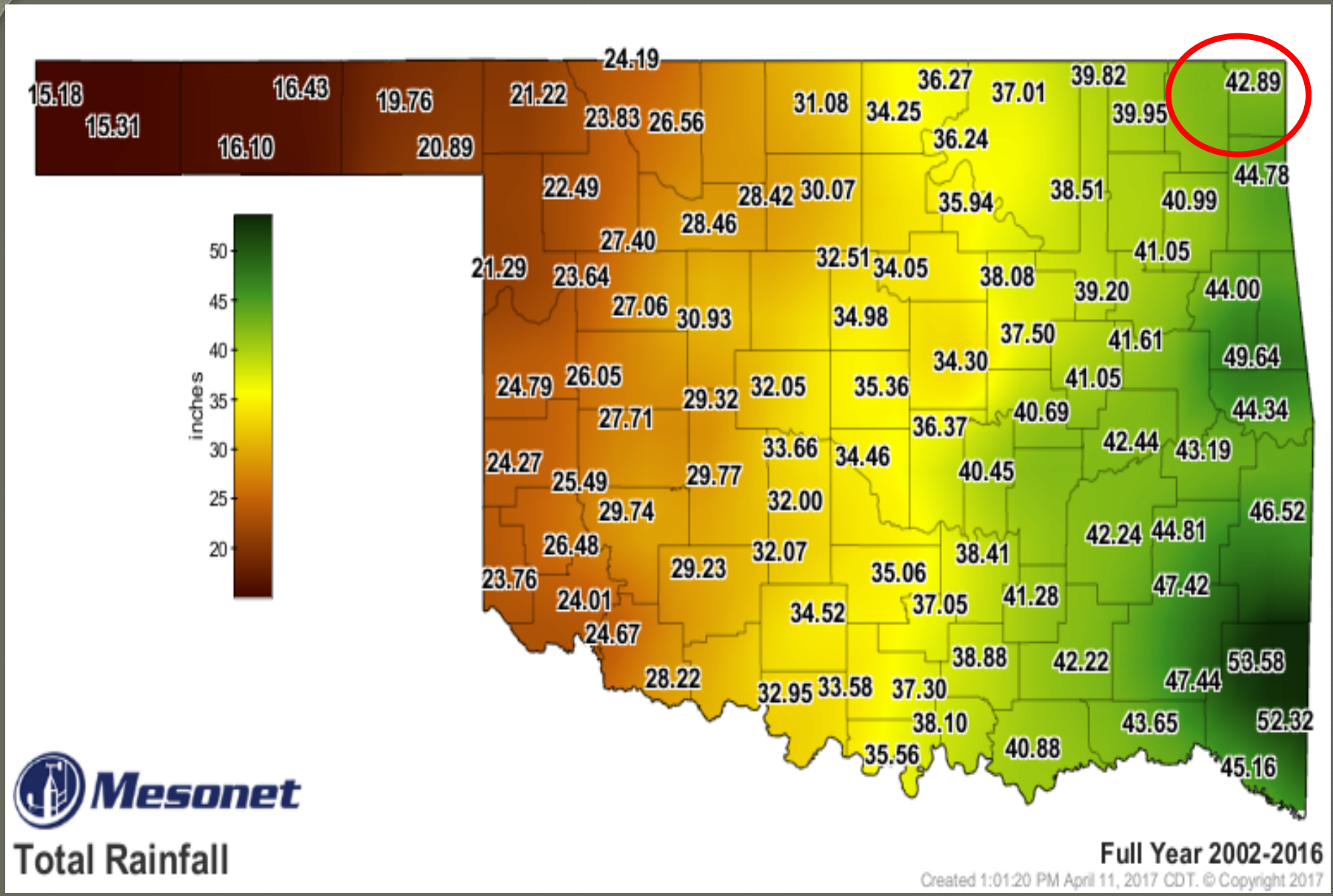
Objectives

ACUTE:

- To determine the relationship for rainfall intensity and total iron transport between the oxidative cells of a passive treatment system.

CHRONIC:

- Determine the significance of storm induced mass transport seasonally and annually with respect to baseline transport.


15.18
15.31
16.43
16.10
19.76
20.89
21.22
24.19
23.83
26.56
31.08
34.25
36.27
37.01
39.82
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39.95
36.24
44.78
22.49
28.42
30.07
35.94
38.51
40.99
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41.05
21.29
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Mesonet
Total Rainfall
Full Year 2002-2016
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Storm Classification

SAMPLING / MONITORING

- 10 years of storm data evaluated for sampling threshold values.

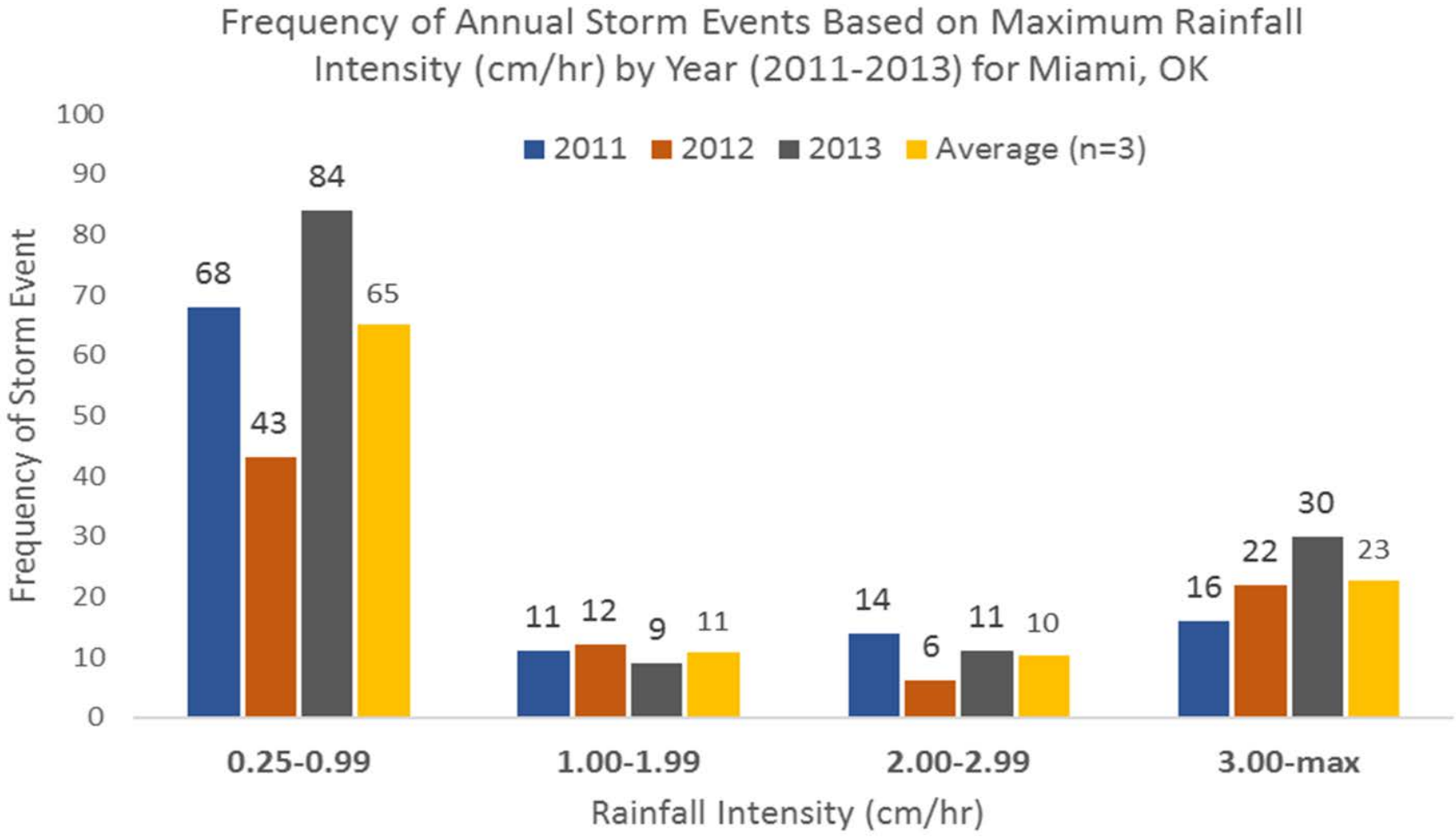
- Precipitation (yield)
- Duration (hours)
- Frequency (#)
- Intensity (yield / hour)

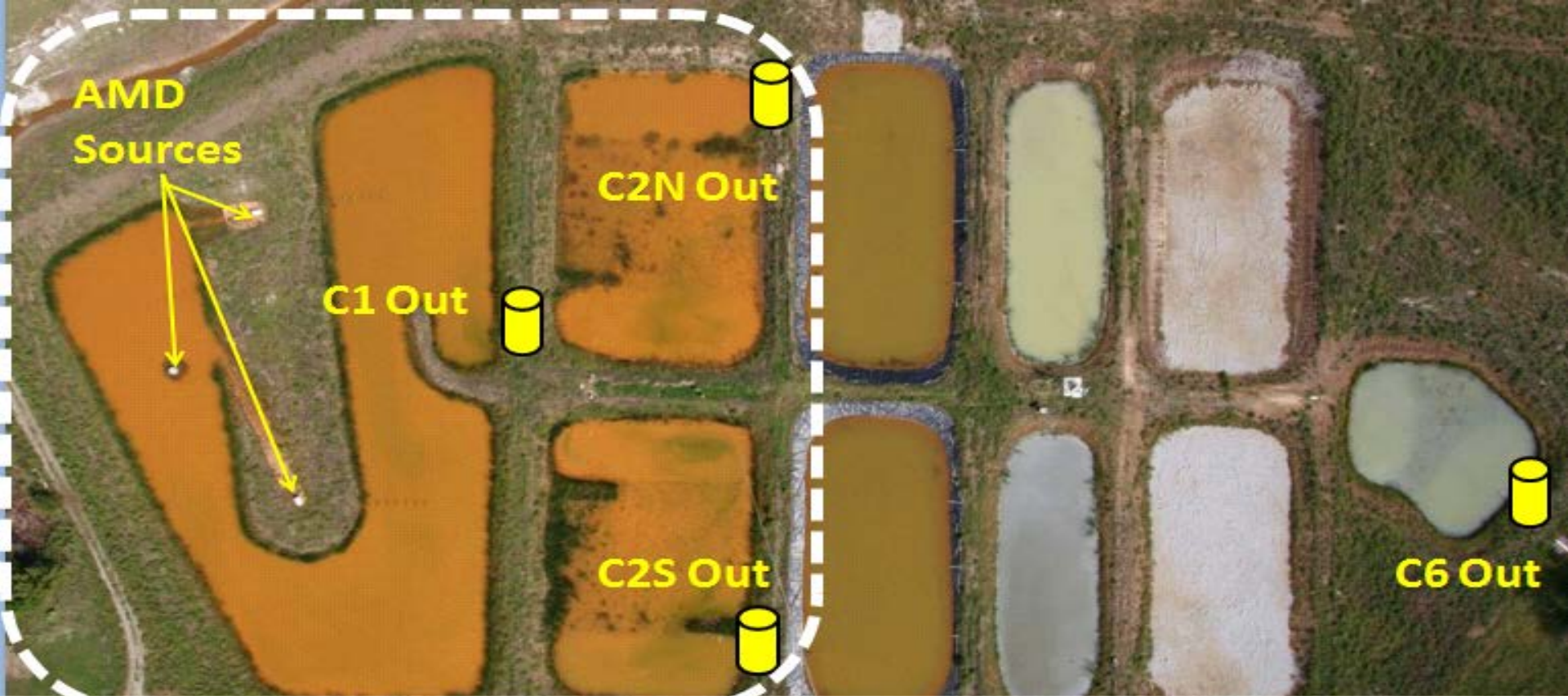
DATA INTERPRETATION

- 40 storms sampled over a three year period.

- Intensity classification:
  - Low (0.25-0.99 cm/hr)
  - Moderate (1.00-1.99 cm/hr)
  - High (2.00-2.99 cm/hr)
  - Extreme (>3.00 cm/hr)

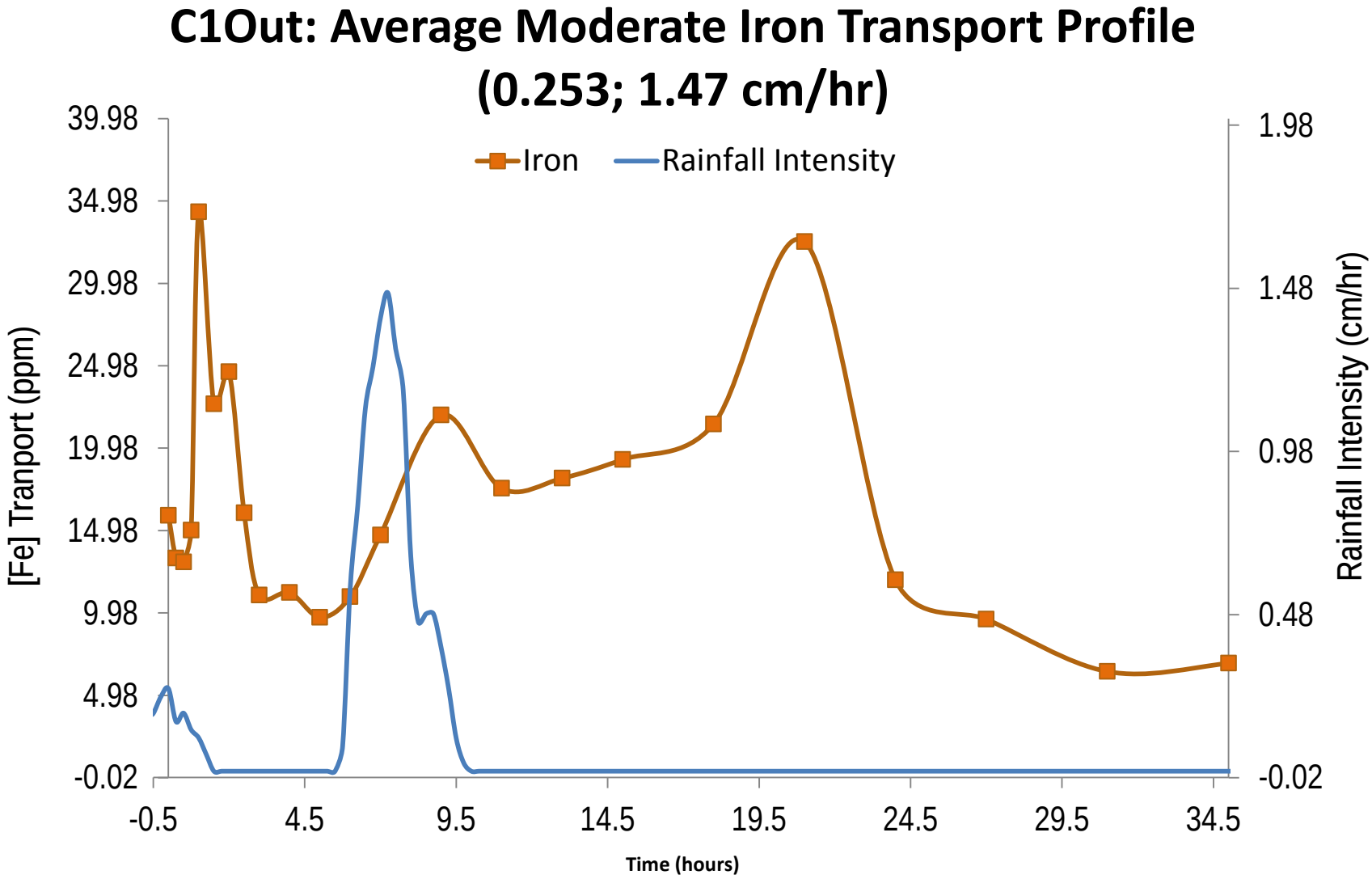
Storm Classification and Frequency





MRPTS Cell	Fe Loading (kg/year)	Total Fe Exported (kg/year)	Total Fe Retention (kg/year)	Surface Area Adjusted Removal Rate ($g/m^2/day$)	% of Influent Fe Exported in Effluent
Cell 1	36,036	7682	28,354	19.02	21.3%
C2N	7682	1381	6301	11.51	18.0%
C2S	7682	1358	6324	11.55	17.7%
Cell 6	317	107	210	0.53*	32.1%

Example Iron Transport Profile



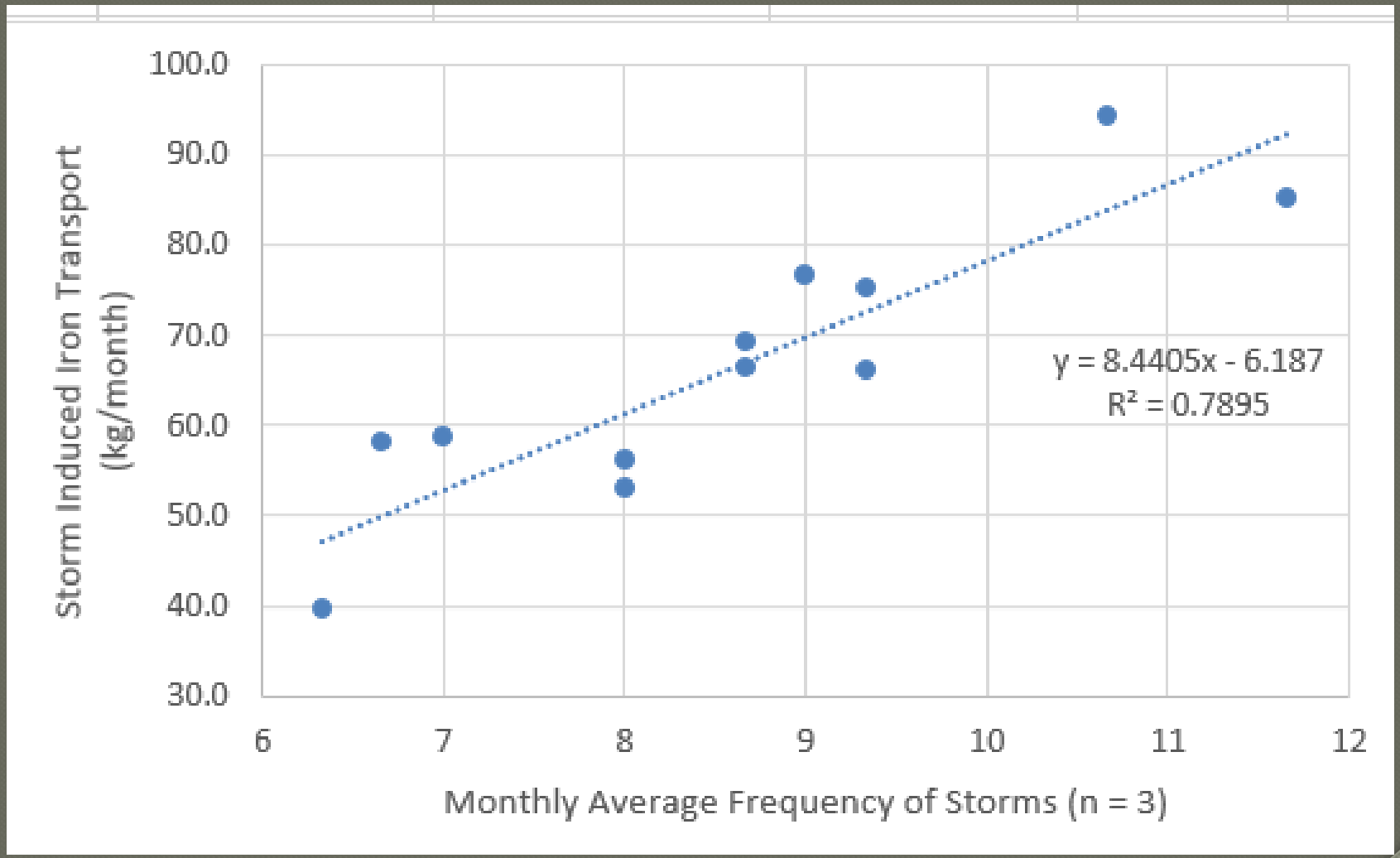
Cell 1: Fe Transport for Individual Storms

	Average Transport (kg/storm) ± σ					
Location	Storm Induced	Baseline	df	t Stat	T Critical	Interpretation
Cell 1	8.69±5.76	2.49±1.74	12	3.42	1.78	Significant
Cell 2N+S	0.96±0.47	0.44±0.50	20	1.9	1.72	Significant
Cell 6	0.33±0.27	0.13±0.08	12	2.56	1.78	Significant

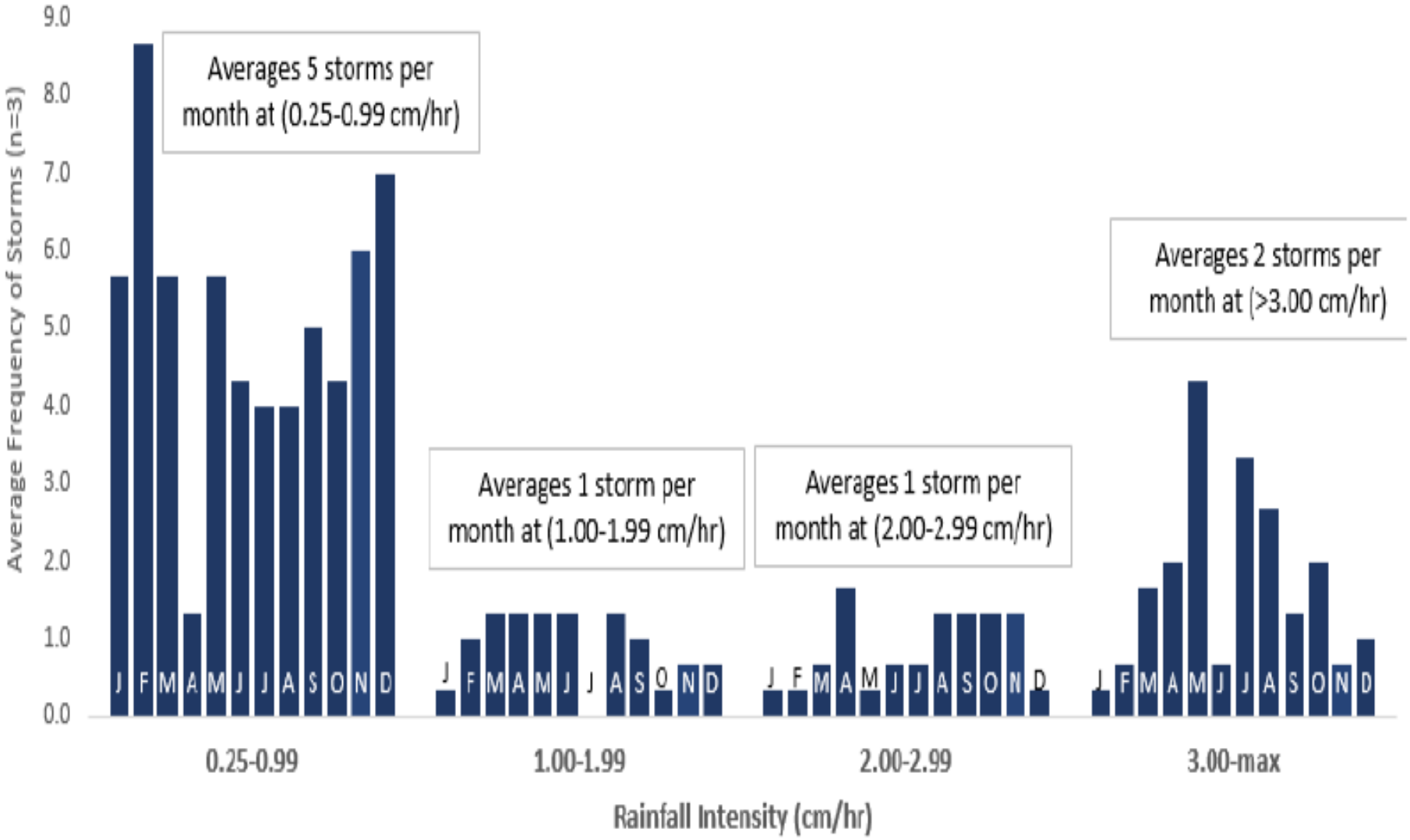
The amount of iron transported does not correlate to rainfall intensity, duration, or storm yield.

Rainfall events induced significant iron transport over baseline during the 30+ hour monitoring period.

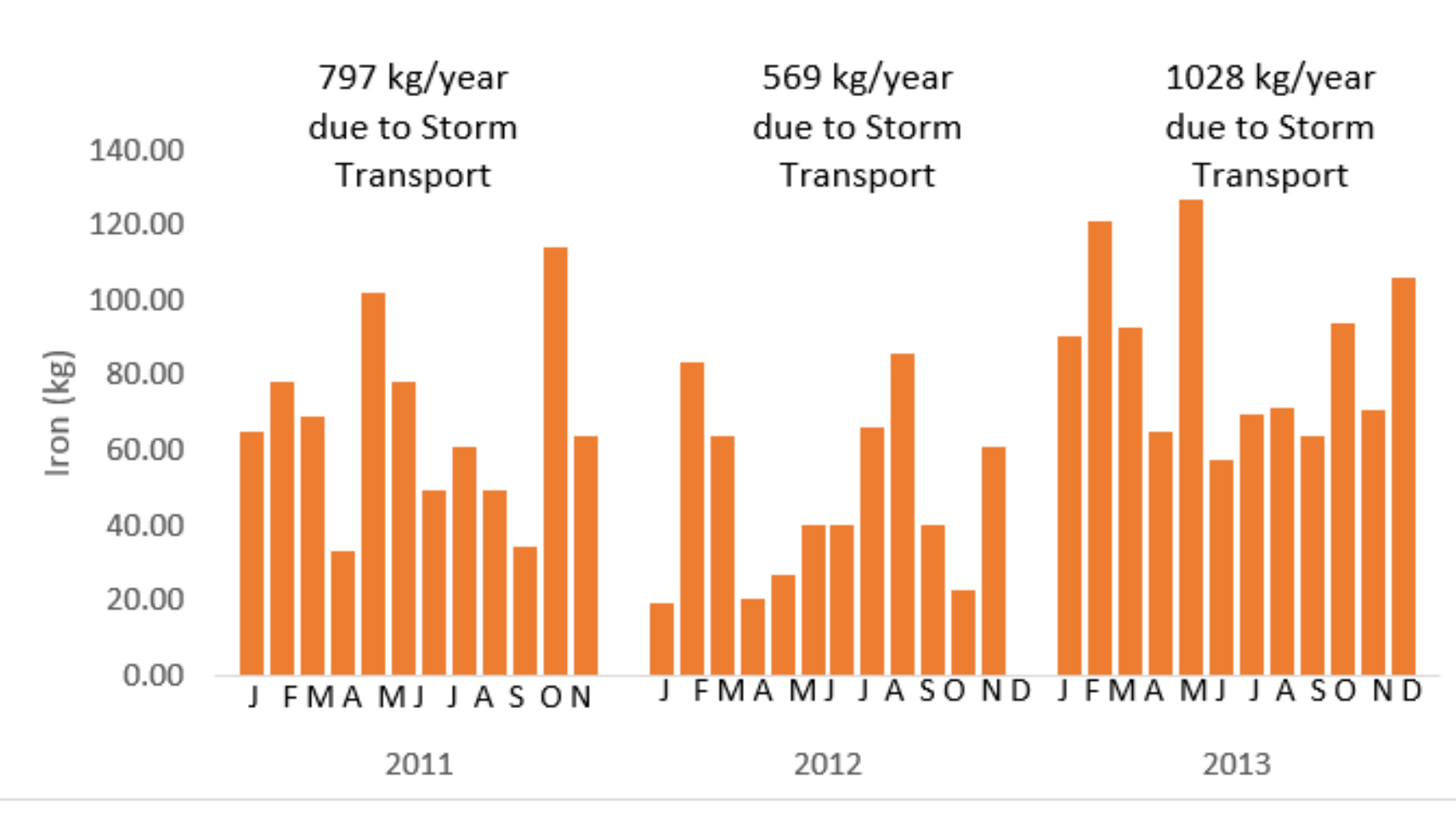
Frequency of Storms is Directly Proportional to Iron Transport



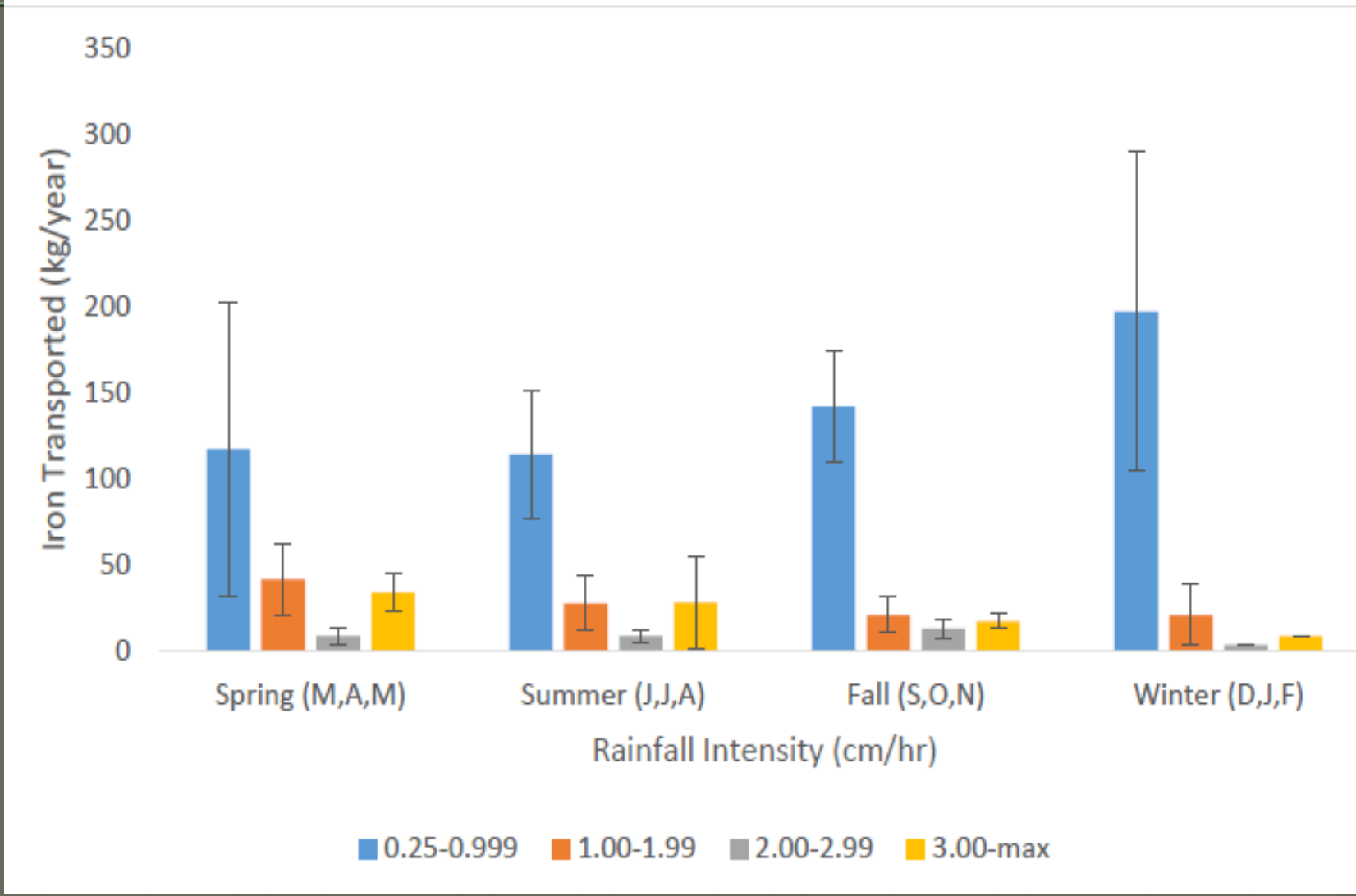
Storm Frequency and Intensity



Cell 1: Fe Transport for Monthly Storms



Cell 1: Seasonal Storm Transport



Average Annual Transport Summary

	Loading Fe (kg/year)	Total Transported Fe (kg/year)	Storm Induced Fe Transport (kg/year)	% of Transport Storm Induced (%Net Transport)
C1Out	34767	7862	1067	13.6%
C2N	7862	1220	165	13.5%
C2S	7862	1019	113	11.1%
C6Out	301	152	49	34.8%

Transport Mechanism

RESUSPENSION

- Not likely due to depth of treatment cell (>1.5m)
- No observable trend between transport and intensity.
- Resuspension is not supported.

SETTLING DISRUPTION

- Iron transport peaks ~15 hours after a rainfall event.
- Floc fragmentation and mixing of surface zone.
- Settling disruption supported by Stokes Law calculations.

Conclusions

- Storms transport Fe between cells in the oxidation unit independent of rain fall intensity, duration, and yield.
- Storms do not induce export of Fe from the treatment system due to oxidative cell placement early in the treatment series.

Conclusions

- There is no significant difference between seasons for storm induced iron transport.
- There is no significant difference between years and storm induced iron transport.
- Transport mechanism is disrupted sedimentation rather than resuspension

Future Work

- Impact of the temporal distribution of storms on mass transport.
  - # of storms per transport event
  - # and frequency of storms preceding event
- Transport profiles for trace metals
  - (Cd, Pb, Zn, and more)
  - Correlation to iron via surface sorption

Acknowledgements

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Comments / Questions?