Measurements and Control Strategies

FUGITIVE DUST FROM CATTLE FEEDYARDS

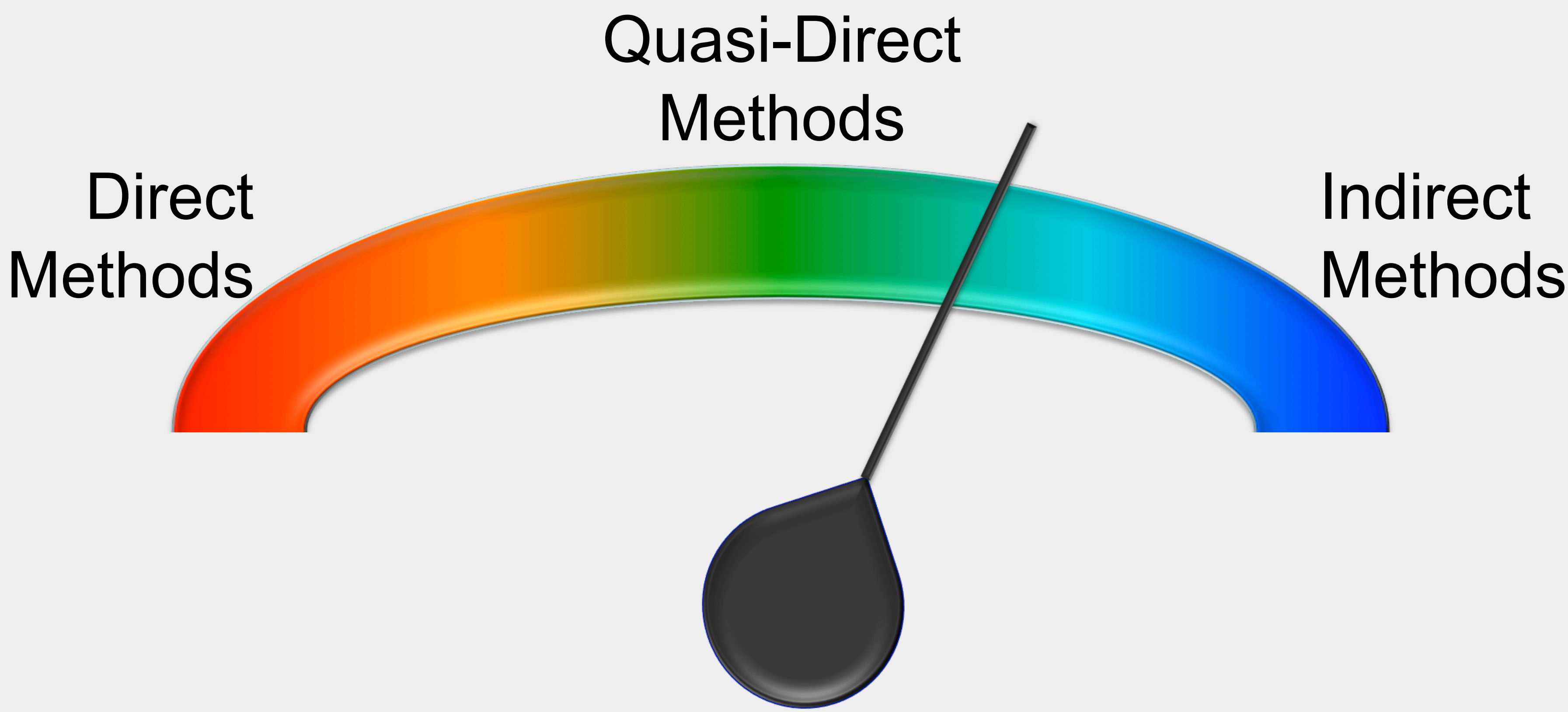
Air Quality

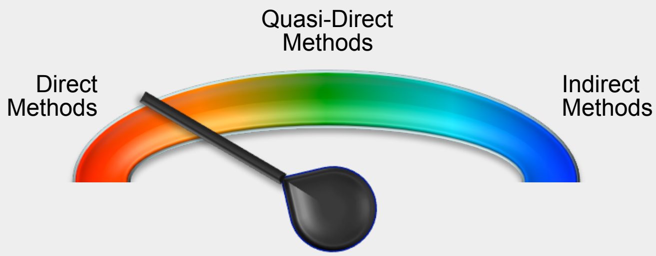
Odor, Dust and Gaseous Emissions

An agricultural research partnership of Texas AgriLife Research, WTAMU, Texas AgriLife Extension Service, KSU and USDA-ARS funded by USDA-CSREES (Award # 2005-34466-15703)

Ground Level Area Sources

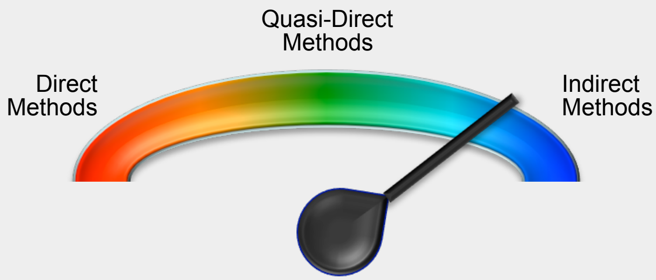
Measuring GLAS Emissions





Direct Methods

- Actually measuring the quantity of interest
- No such animal in the case of GLAS
- Methods that get closest:
  - Eddy accumulation
  - Flux chambers (!)



Indirect Methods

- Measuring something other than the quantity of interest (e. g., concentration)
- Inferring the emission rate from a model relationship
- Sensitive to errors in the measurements and the governing assumptions

$$Q = \frac{C}{AtmosphericDispersion}$$

PM_{10} Flux: Inverse Dispersion

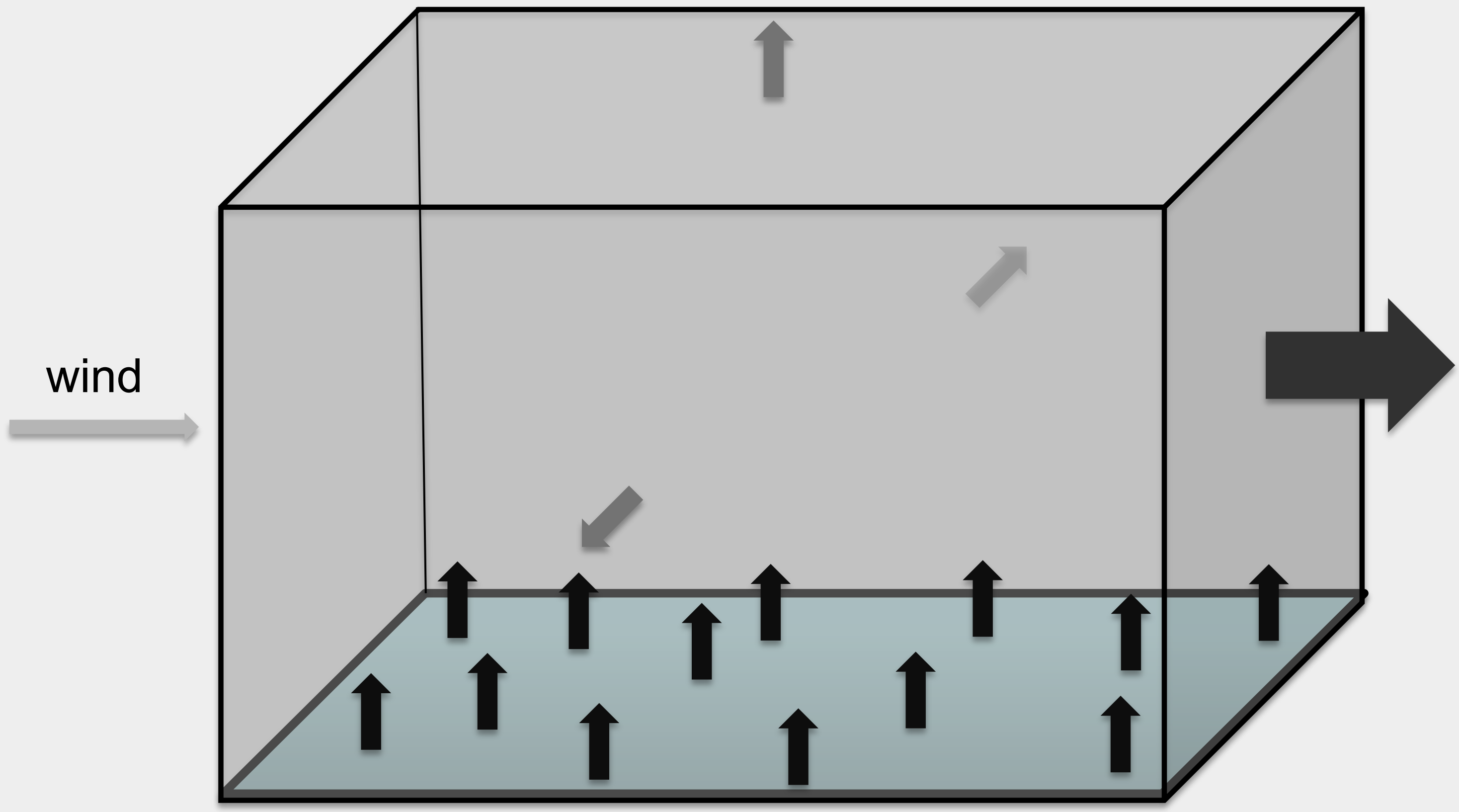
- AP-42: 280 x (PM_{10}/TSP) = 70 lb/1,000 hd-d
- S. Parnell et al. (1994): 9.2 lb/1,000 hd-d
- C. B. Parnell et al. (1999): 15 lb/1,000 hd-d
- CARB (2004): 29 lb/1,000 hd-d
- J. Lange et al. (2007):
  - 16±8 lb/1,000 hd-d (ISCST3)
  - 11±5 lb/1,000 hd-d (AERMOD)
- Wanjura et al. (2004): 42 lb/1,000 hd-d
  - Pen surface: 6 (14%)
  - Unpaved roads: 36 (86%)

Summary

- Direct measurement of fugitive emission rates from GLAS is difficult & expensive
- Many indirect methods available; no single method is best for all scenarios
- *Model contingency raises red flags*
- *Multiple independent methods should converge on a narrow range of estimates*

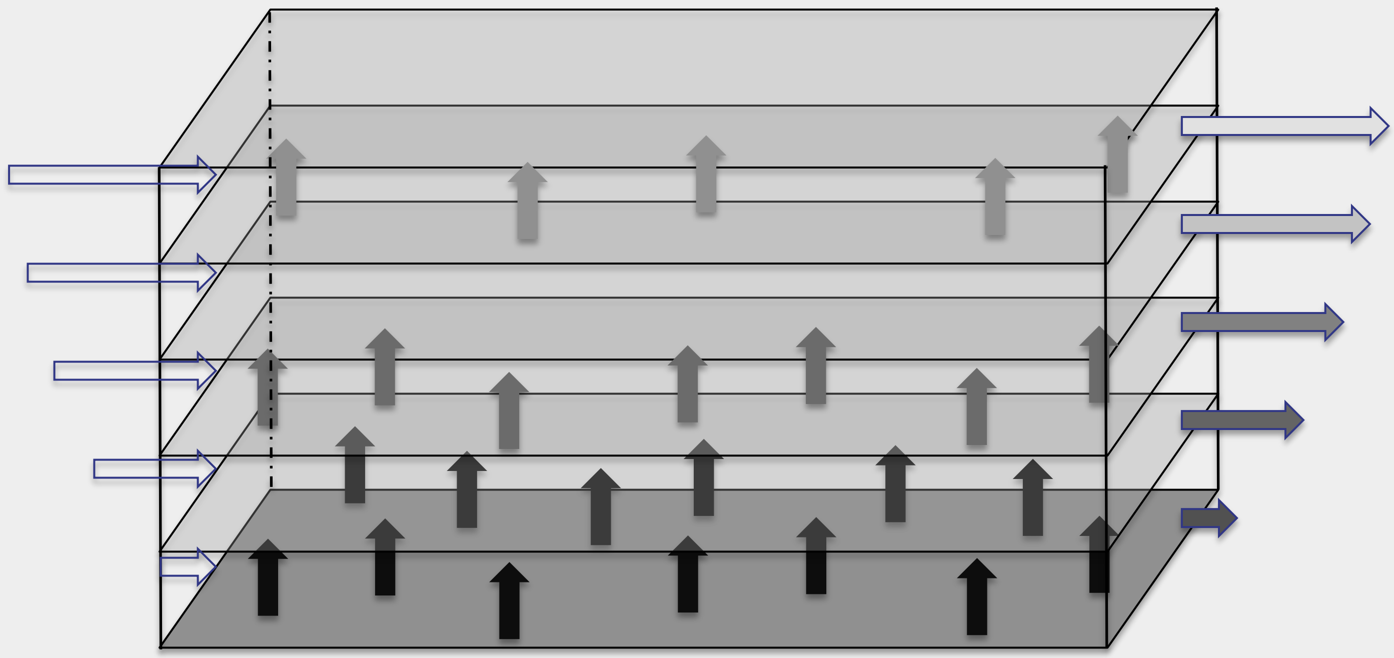
PM_{10} Flux: Other Methods

Box Model – The General Idea



Integrated Horizontal Flux

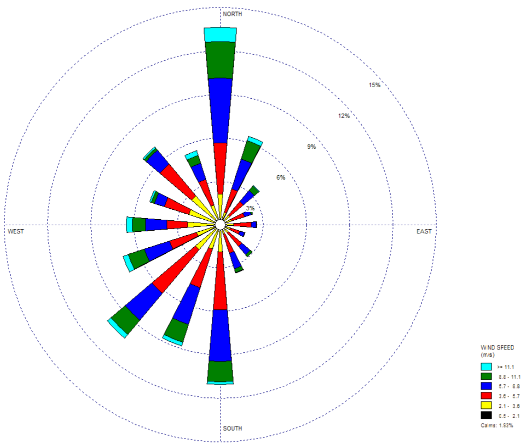
(a special case of the box model)



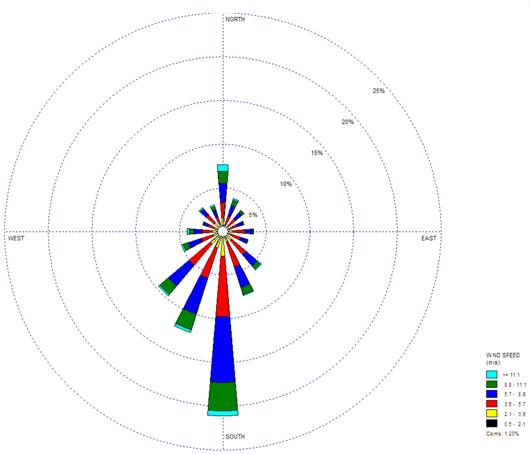
Both wind speed and mass concentration vary with elevation

Feedyard A
17-20,000 head

Amarillo Dec – Feb

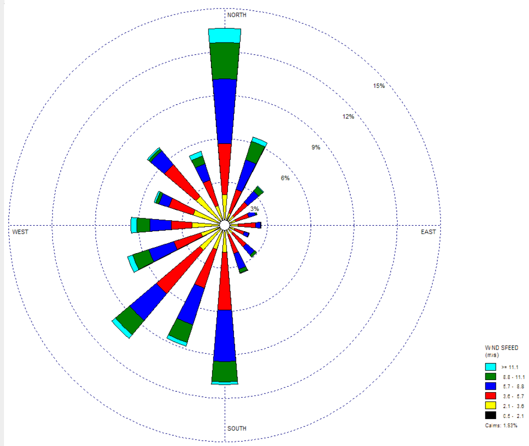


Amarillo Mar – Nov

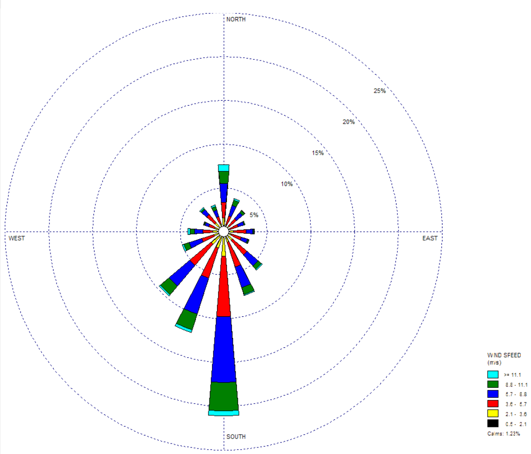


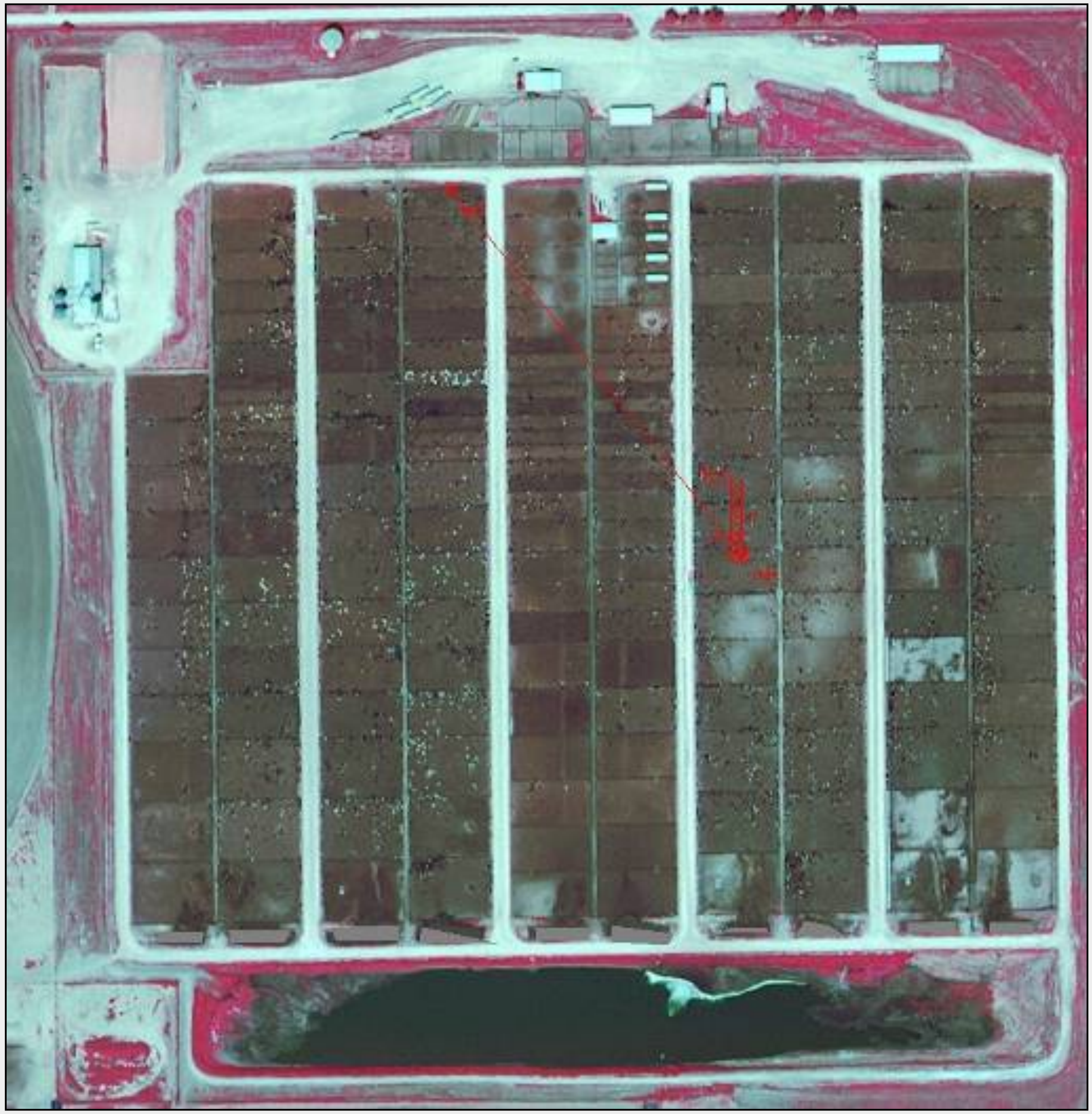
Feedyard E
17-24,000 head

Amarillo Dec – Feb



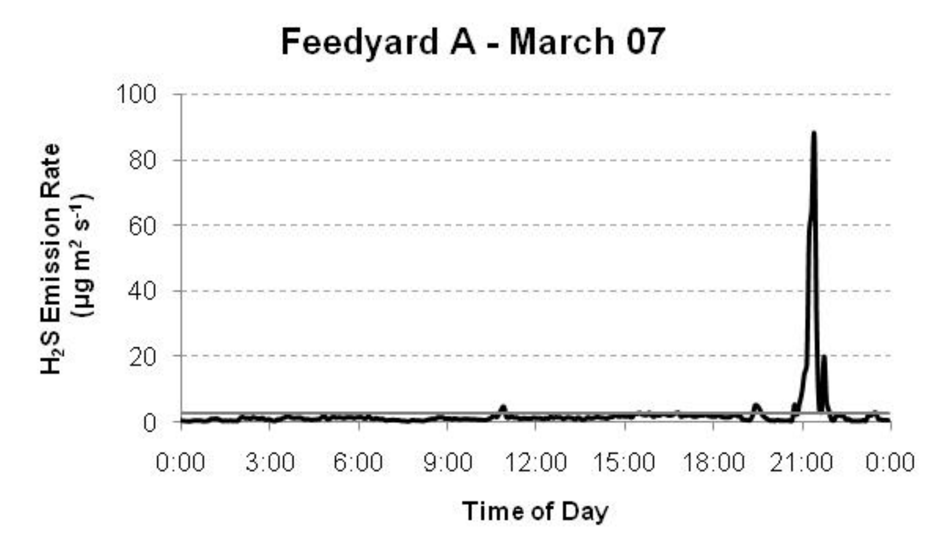
Amarillo Mar – Nov

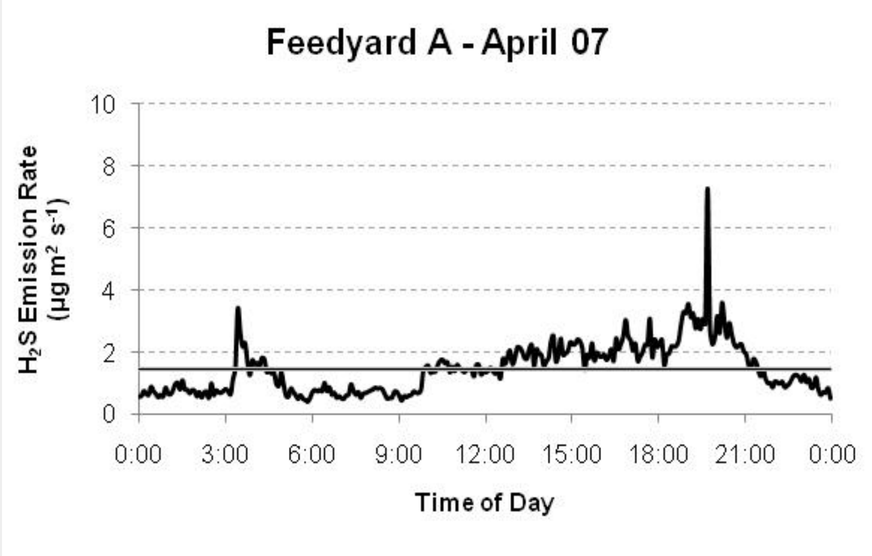


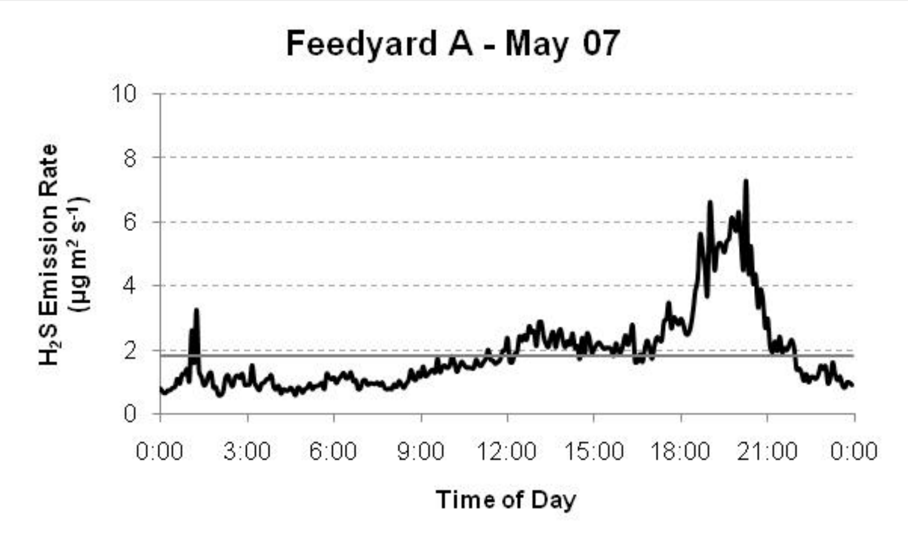


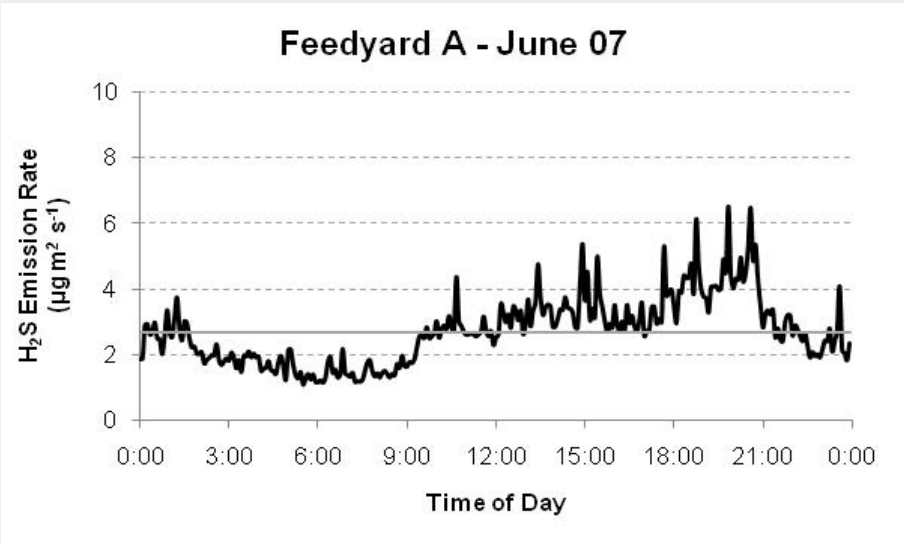
Feedyard A - H_2S Emission Rate from Pens

Diurnal Emissions Pattern

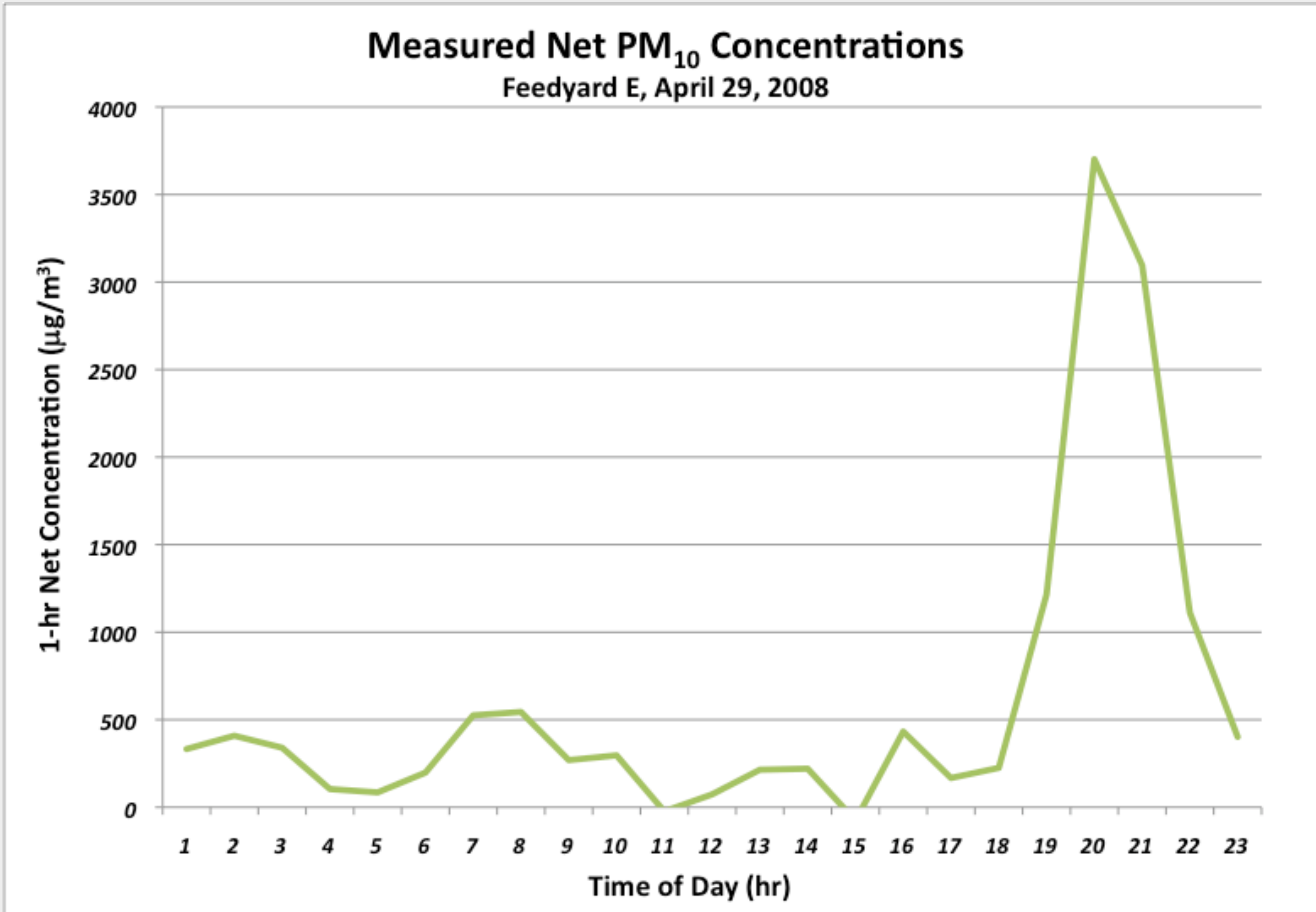








Is the Emission Flux Constant?



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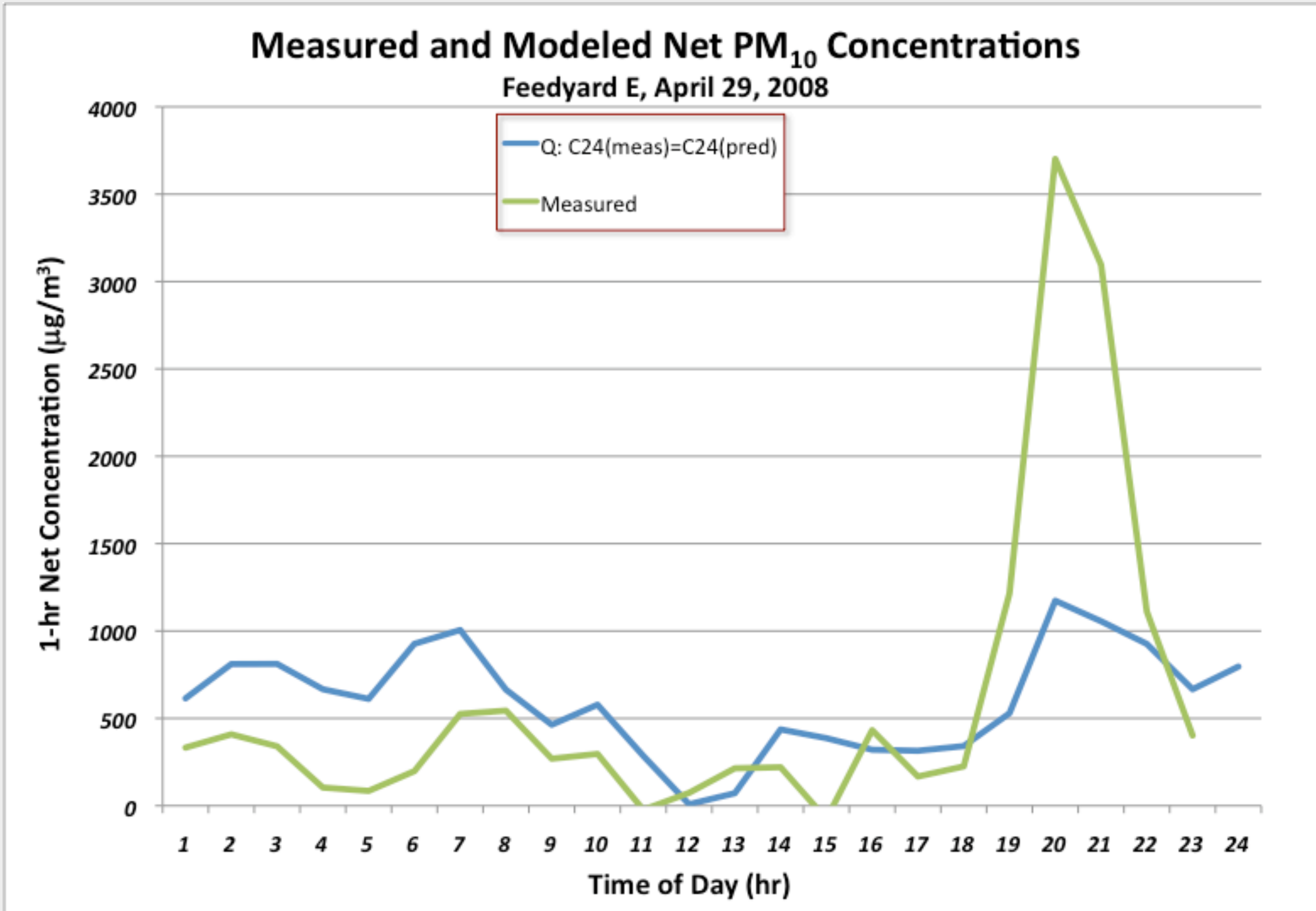

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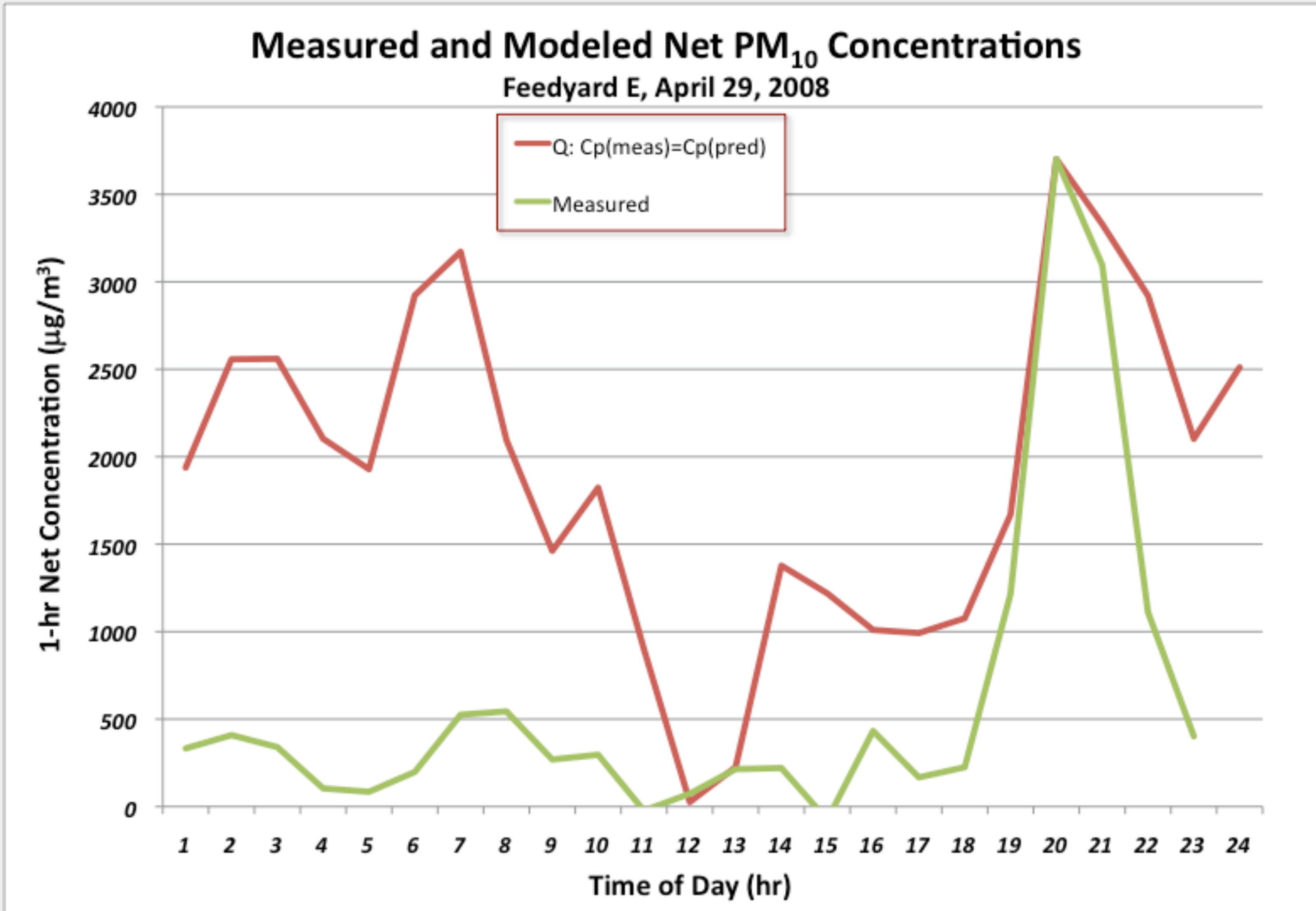

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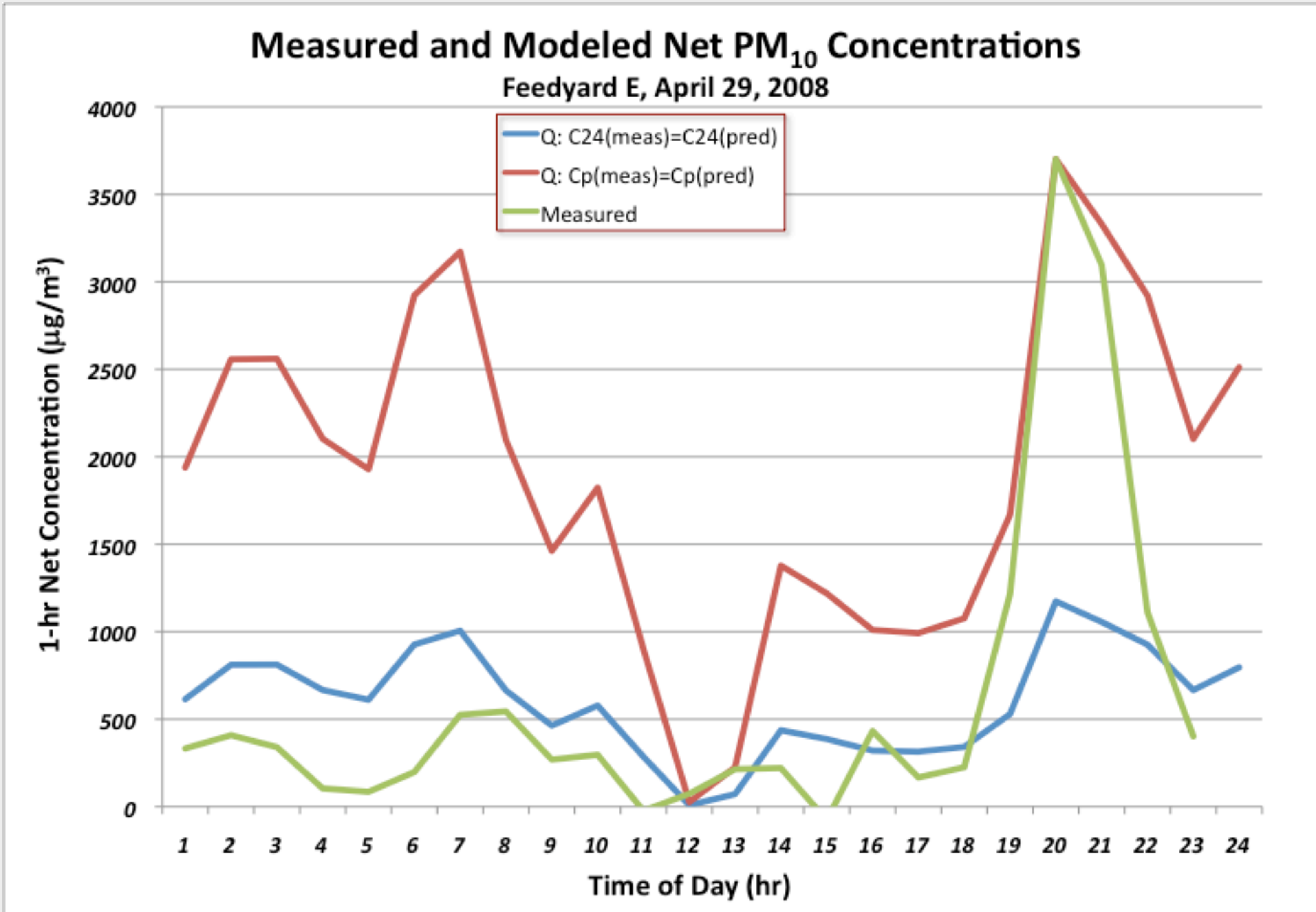


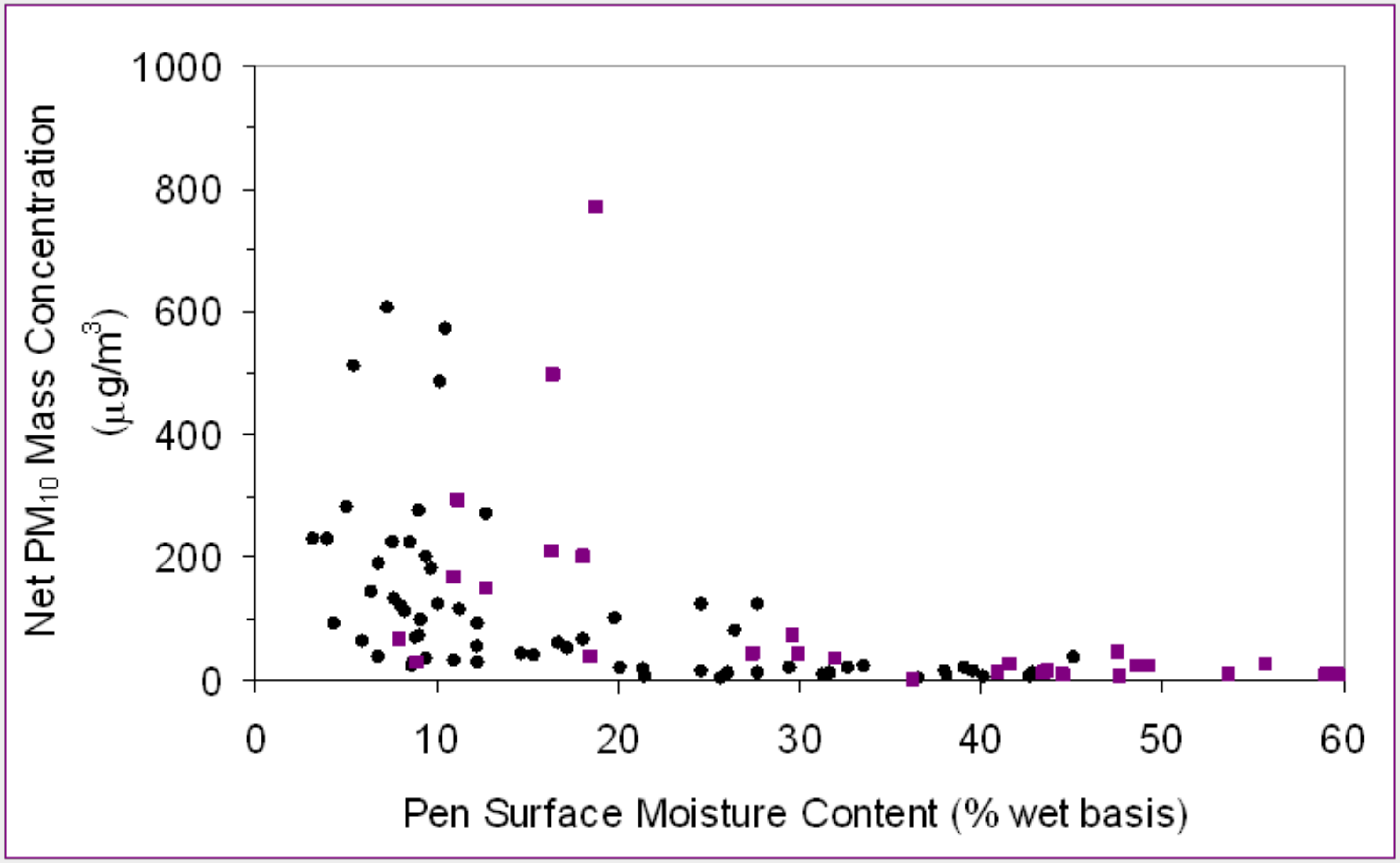
Modeling Flux: Achilles' Heel

- Under normal circumstances, no single value of PM_{10} emission flux will reproduce measured concentrations exactly
  - Matching the 24-hr average, $C_{meas,24}$, underpredicts C_{peak}
  - Matching C_{peak} overpredicts $_{Cmeas,24}$
- Even if we must have a 24-hr emission factor, we shouldn't use it for dispersion modeling

Fugitive Dust Control Strategies

- Source control techniques
  - Moisture management
    - Pen surface sprinkling
    - Stocking density manipulation
  - Manure harvesting
  - Surface amendments (mulches, binders, etc.)
- Edge-of-feedyard or downwind control techniques
  - Water curtain
  - Shelterbelts

Moisture Management
Target Moisture Content?

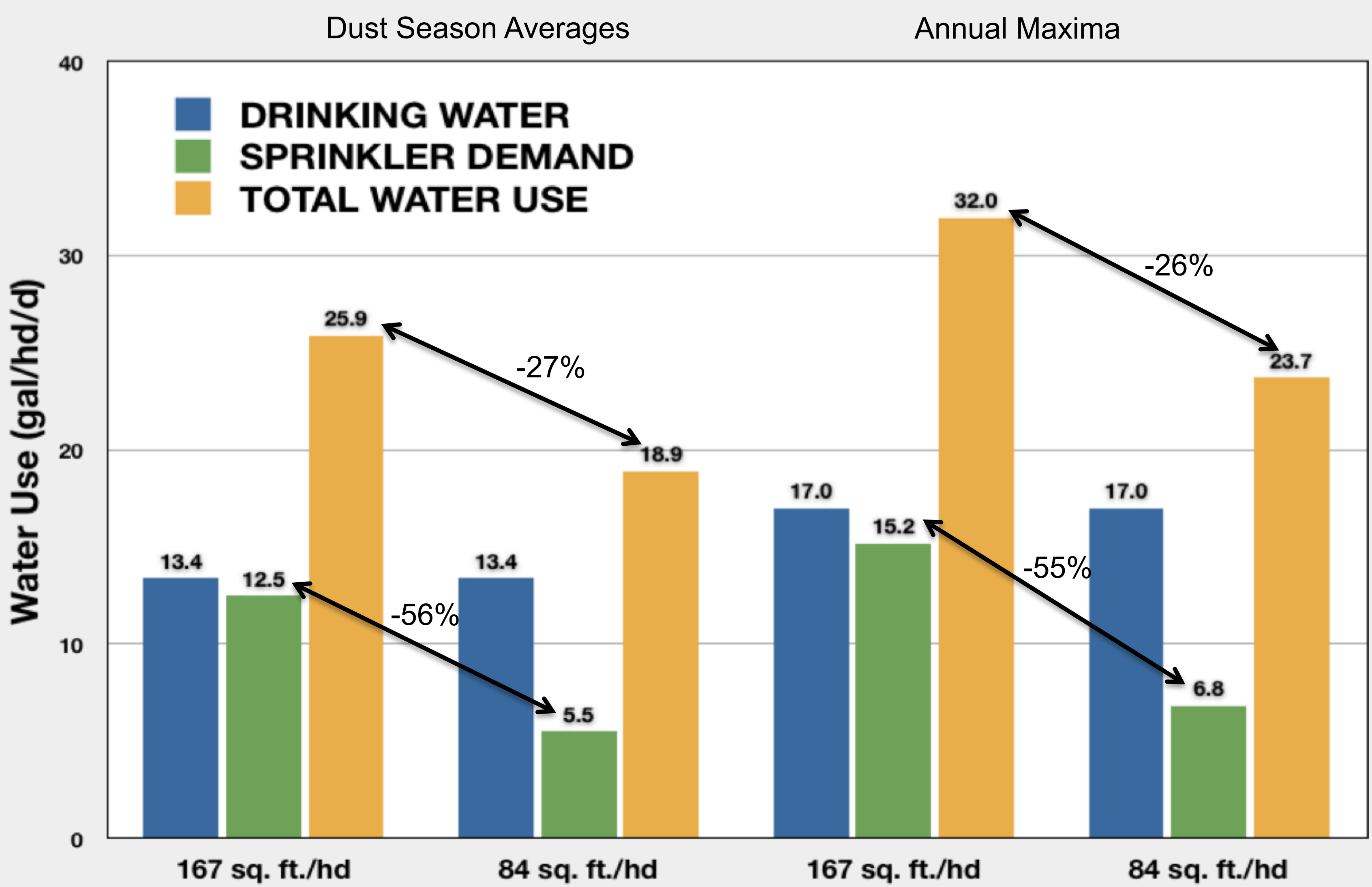


Net PM_{10} Concentrations vs. Pen Surface Moisture Content.

Pen Surface Sprinkling

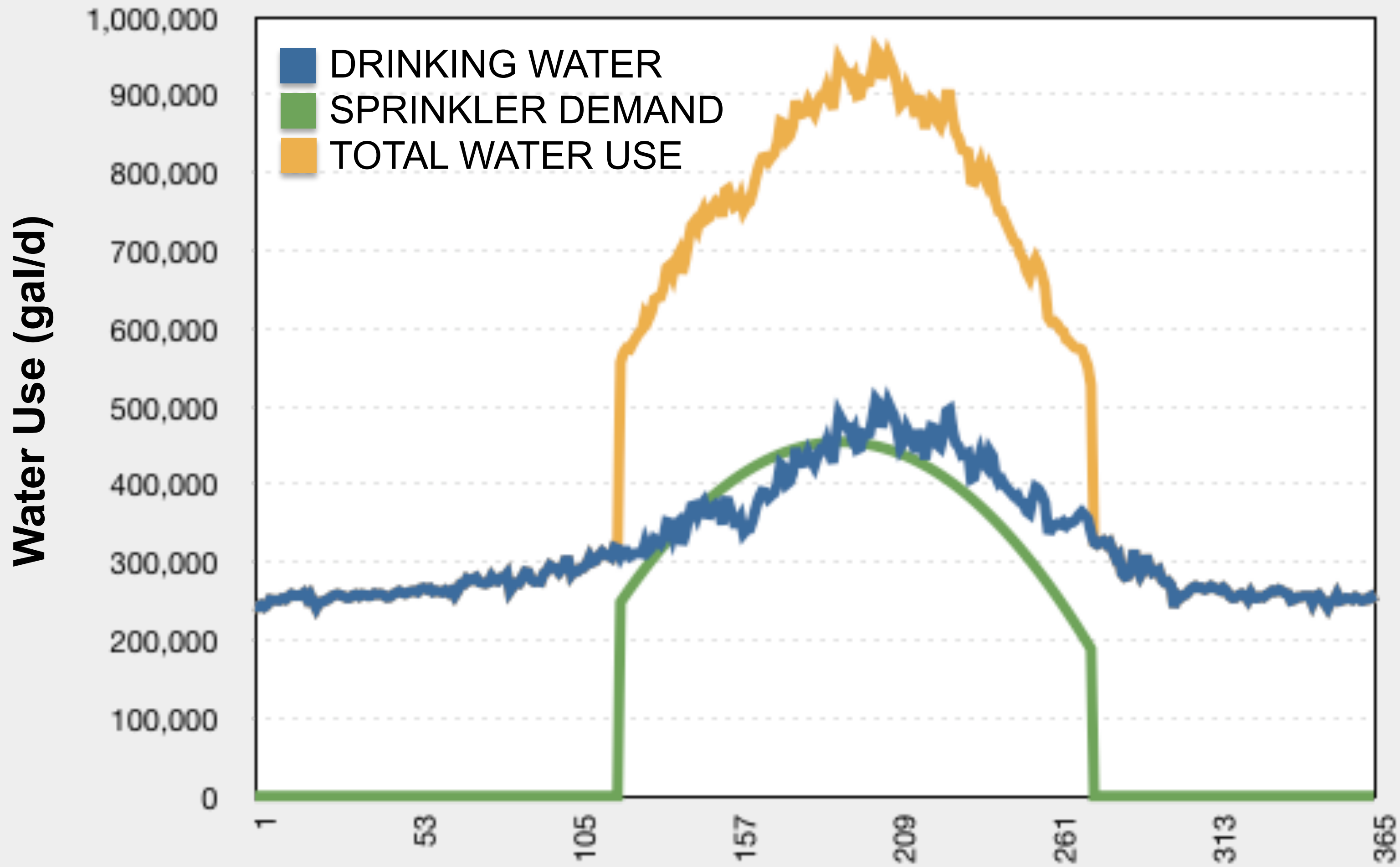
- Application of water to pen surfaces (solid-set, tanker-mount, “reel rain”)
- **Efficacy**
  - Reduced net PM_{10} concentration by 30 to 55%
- **Readiness for adoption**
  - Ready for producer implementation
  - Need to refine design and management procedures

Stocking Density Effect on Water Balance



Projected Water Use (30k hd)

(Pacific Northwest rain shadow)



Sprinkler Water Demand: Summary

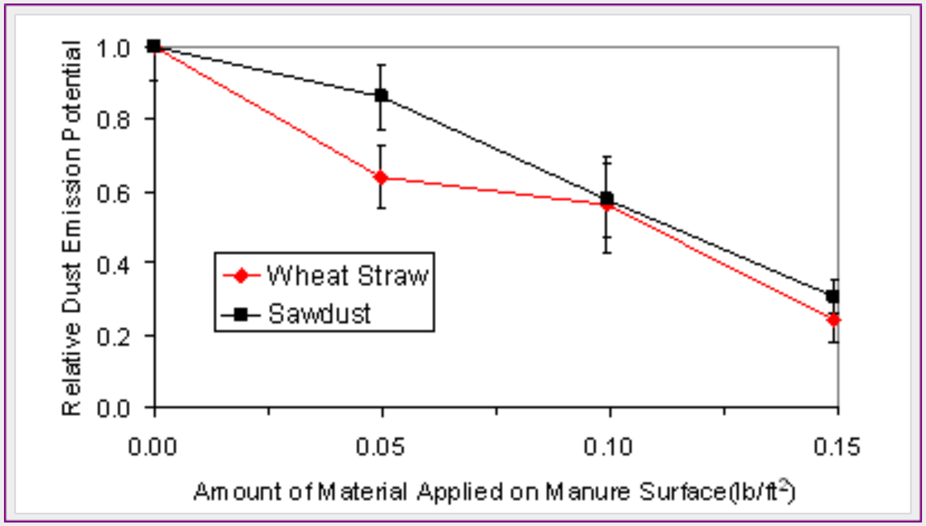
- Spreadsheet exercise ONLY
- Assumed ET_{fy}=0.35 ET_o
  - Marek thesis: ET_{fy}, Et_o not well correlated
  - Feedyard evaporation is water-limited, not energy-limited
  - Bottom-line sprinkler demand figure of 1/8”/d is artificially low
- 2x stocking density effect on WB appears minimal

Manure Harvesting

- Frequent removal of the uncompacted surface layer
- **Efficacy**
  - Dust emission potential of manure layer decreases with decreasing manure depth
  - Manure harvesting can reduce the amount of water needed for dust control
  - Yields highest fuel value
- **Readiness for adoption**
  - Ready for producer implementation
  - Need to refine management procedures
  - Law of diminishing returns

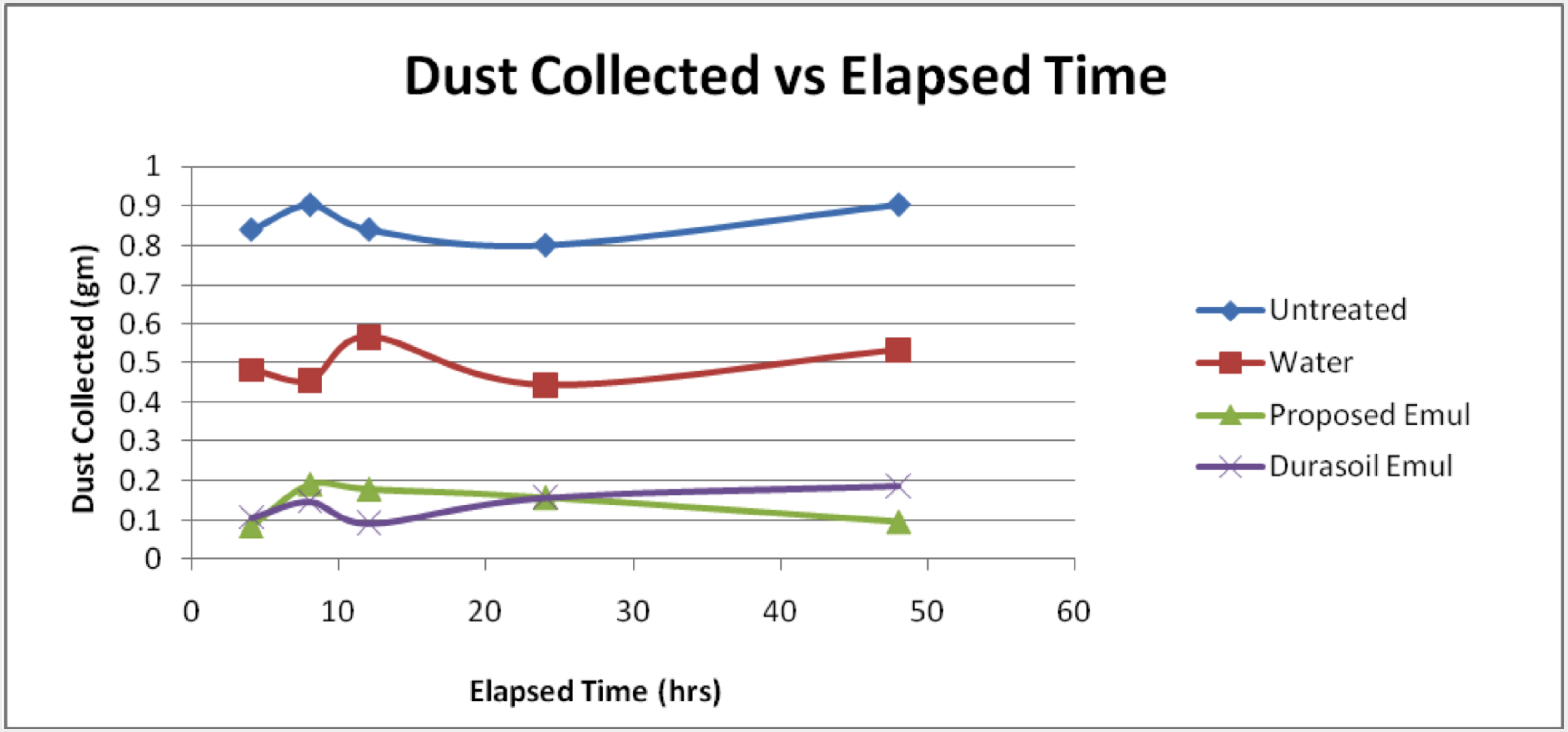
Surface Amendments

- Surface application of crop residue or other materials
- **Efficacy**
  - Application of wheat straw or sawdust reduced the dust emission potential of a manure surface
- **Readiness for adoption**
  - Promising but needs to be validated at the field level



Oil-in-Water Emulsions

- Water is the “continuous phase”
- “Oil” at $2.05/gal, 20% v/v, 0.25” applied



Stocking Density Manipulation

- Cross-fencing (solid or electric)
- Preserve 100% of bunk space
- **Efficacy**
  - Doubling the effective stocking density reduced net PM_{10} **concentrations** at the corral fence line by 20%
  - No conclusive proof of reduced emission **rate**
  - Anecdotal evidence from producers

Water Curtain

- Open-air wet scrubber
- **Efficacy**
  - Prototype reduced near-field PM_{10} concentration 20-40%
  - Used as much water as a solid-set sprinkler system (1 gpm/ft)
- **Readiness for adoption**
  - Is not cost-effective

Shelterbelts

- Vegetation system downwind of a facility
- **Efficacy**
  - Effective in mitigating odor and dust generated from swine facilities and roads
- **Readiness for adoption**
  - Promising but needs field evaluation

Summary

- A surface moisture content of 20% may be a critical threshold for dust control.
- Strategies ready for producer implementation but need refinement
  - Pen surface sprinkling
  - Frequent manure removal
- Promising strategies that need further development or evaluation
  - Pen surface treatments
  - Shelterbelts
  - Increased stocking density with pen surface sprinkling