

# particulate matter: mitigation strategies

brent w. auvermann  
associate professor and extension agricultural engineer  
amarillo, tx

# outline

- what drives PM emissions from dairies?
  - primary PM
  - secondary PM
- how much PM is emitted by dairies?
- what techniques are available to control PM?
  - source-reduction strategies
  - post-emission strategies

# what drives PM emissions from dairies?

- *primary* PM
  - animal hoof action on uncompacted manure
  - manure-harvesting operations
  - hay grinding and feed delivery
  - vehicle traffic on unpaved roads
  - associated with local nuisance conditions
- *secondary* PM
  - forms in the atmosphere from reactions of ammonia ( $\text{NH}_3$ ) with acidic gases ( $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$ )
  - generally not associated with local nuisances but may affect regional  $\text{PM}_{2.5}$  and/or visibility

# how much *primary* PM is emitted by dairies?

- credible research data for dairies are more elusive than for cattle feedyards
- 1<sup>ary</sup> researchers at the state level are CA and TX
- some current dairy emission factors
  - EPA – no official guidance (8.8 lbs PM<sub>10</sub>/1,000 hd-d proposed in 2001)
  - WRAP – 6.72 lbs PM<sub>10</sub>/1,000 hd-d (open lots)
  - CA – 6.7 lbs PM<sub>10</sub>/1,000 hd-d
  - OR – 11.5 lbs PM<sub>10</sub>/1,000-hd-d
  - NM
    - ✧ 4.4 lbs PM<sub>10</sub>/1,000 hd-d (CARB, 2003)
    - ✧ ordinarily requires use of most recent EPA emission factor

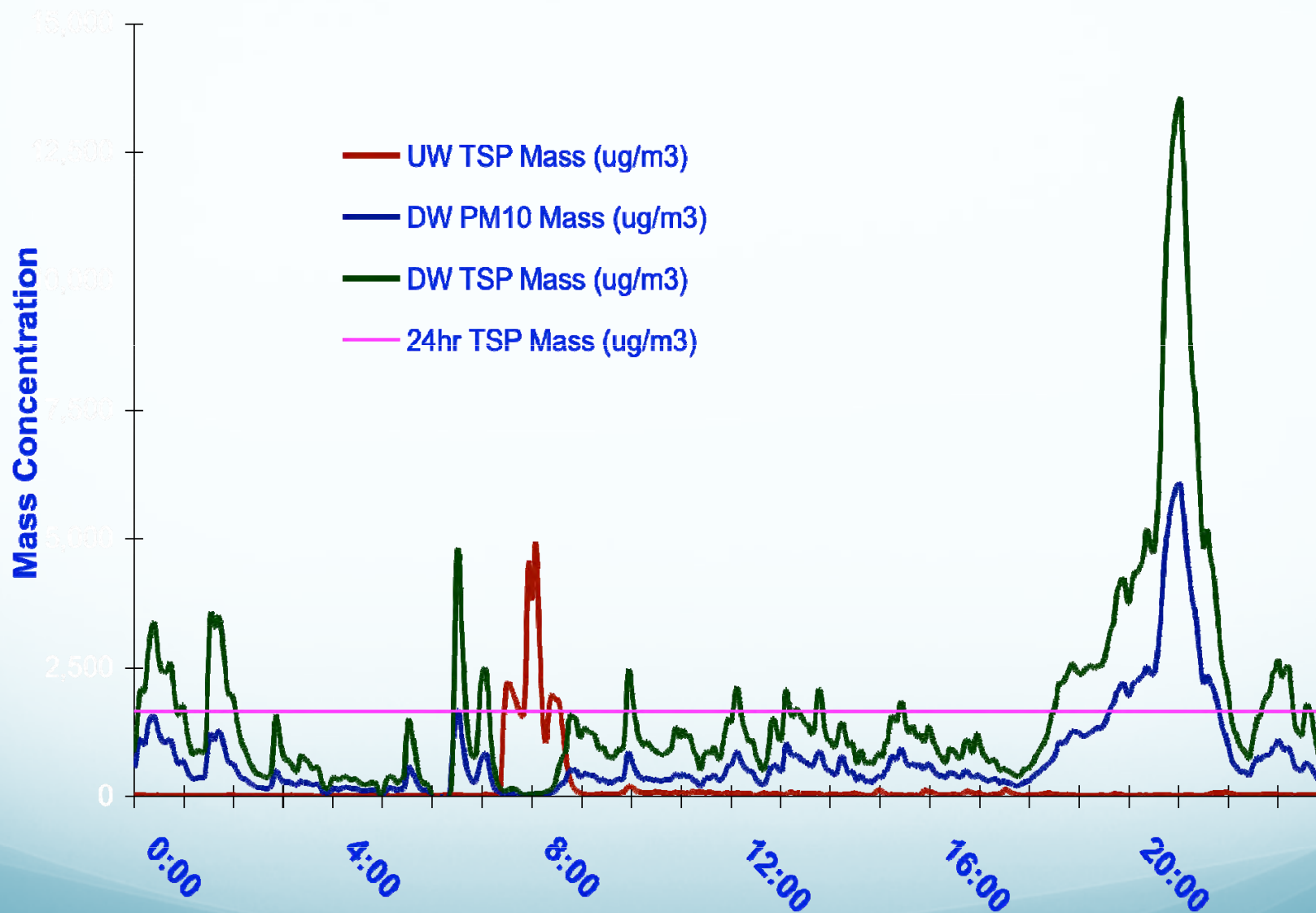
# PM abatement from open lots

- primary PM
  - moisture
  - compaction
  - manure harvesting
  - animal activity
  - mulches
- secondary PM
  - primary focus: ammonia emissions
  - that's "a whole 'nother story"





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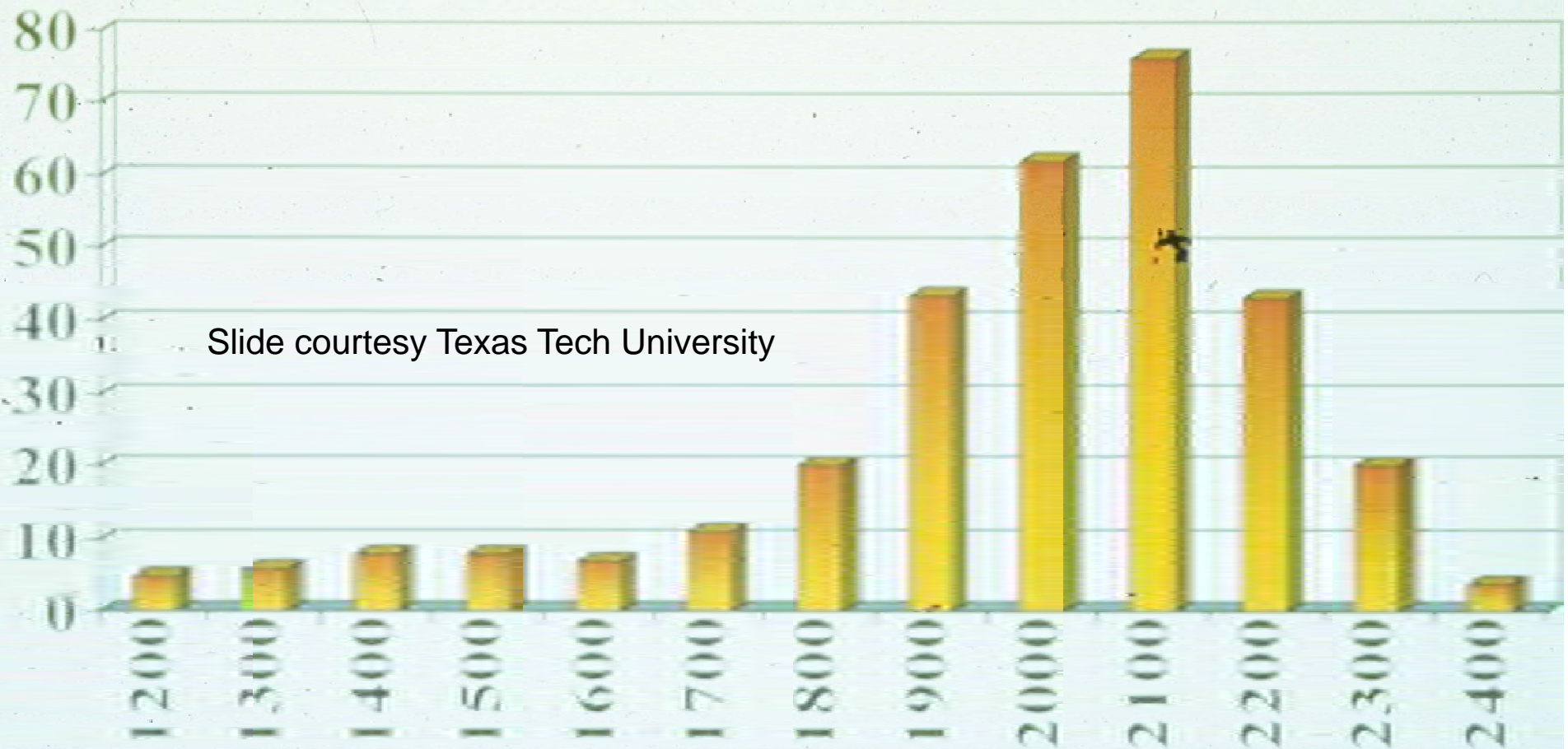






# Dust Generating Behaviors

(agonistic behavior, bullying and locomotion)



Slide courtesy Texas Tech University

Daytime

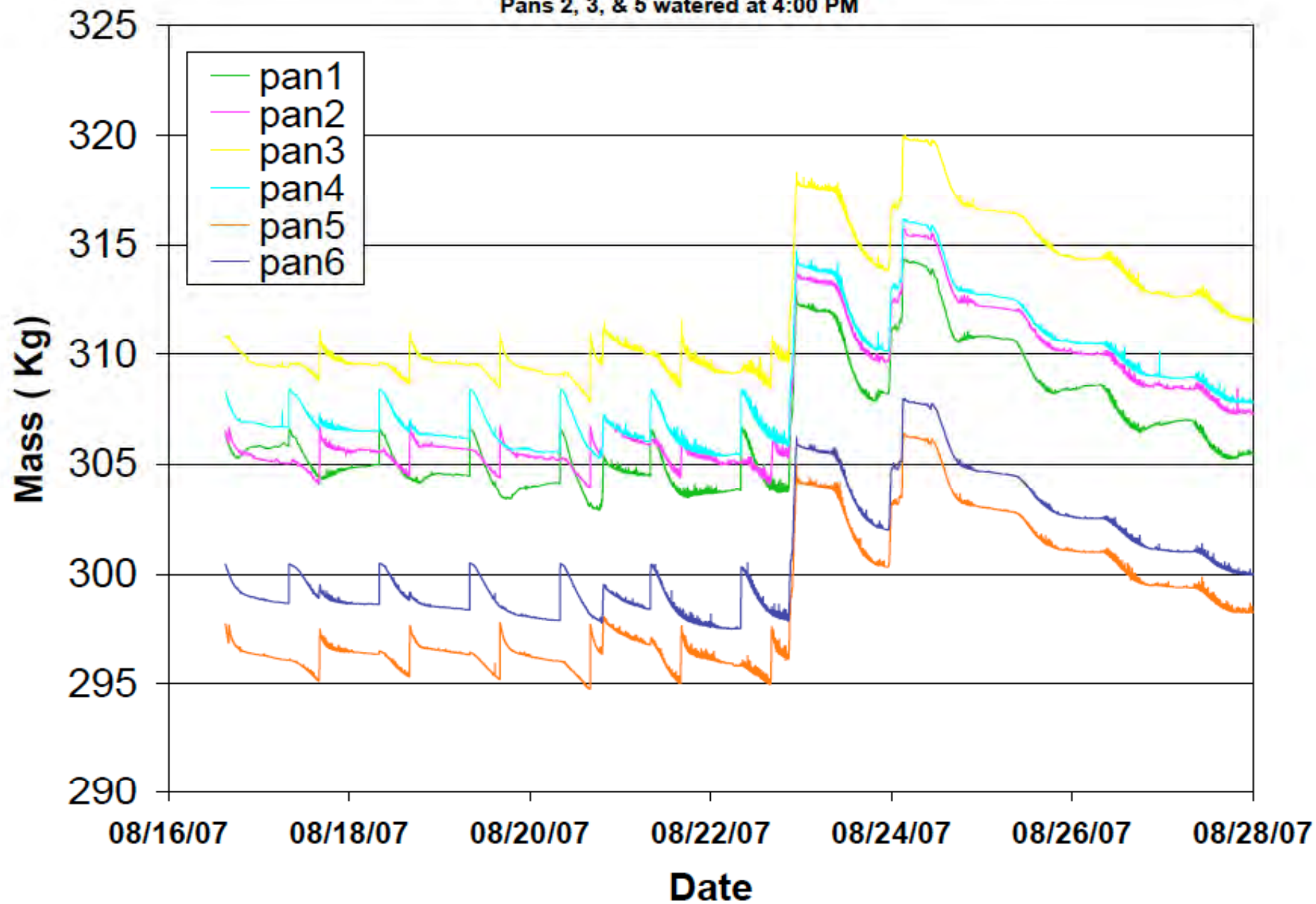




# Lysimeter Mass Over Time

Pans 1, 4, & 6 watered at 8:00 AM

Pans 2, 3, & 5 watered at 4:00 PM







# A Few Conclusions

- ◆ Manure harvesting and moisture control will have a synergistic effect
- ◆ Building mounds with dry manure doesn't work; needs 25-30% moisture for compaction
- ◆ Manure harvesting makes supplemental water go further
- ◆ Increasing stocking density might be worth trying on an open-lot dairy

# what about unpaved roads?

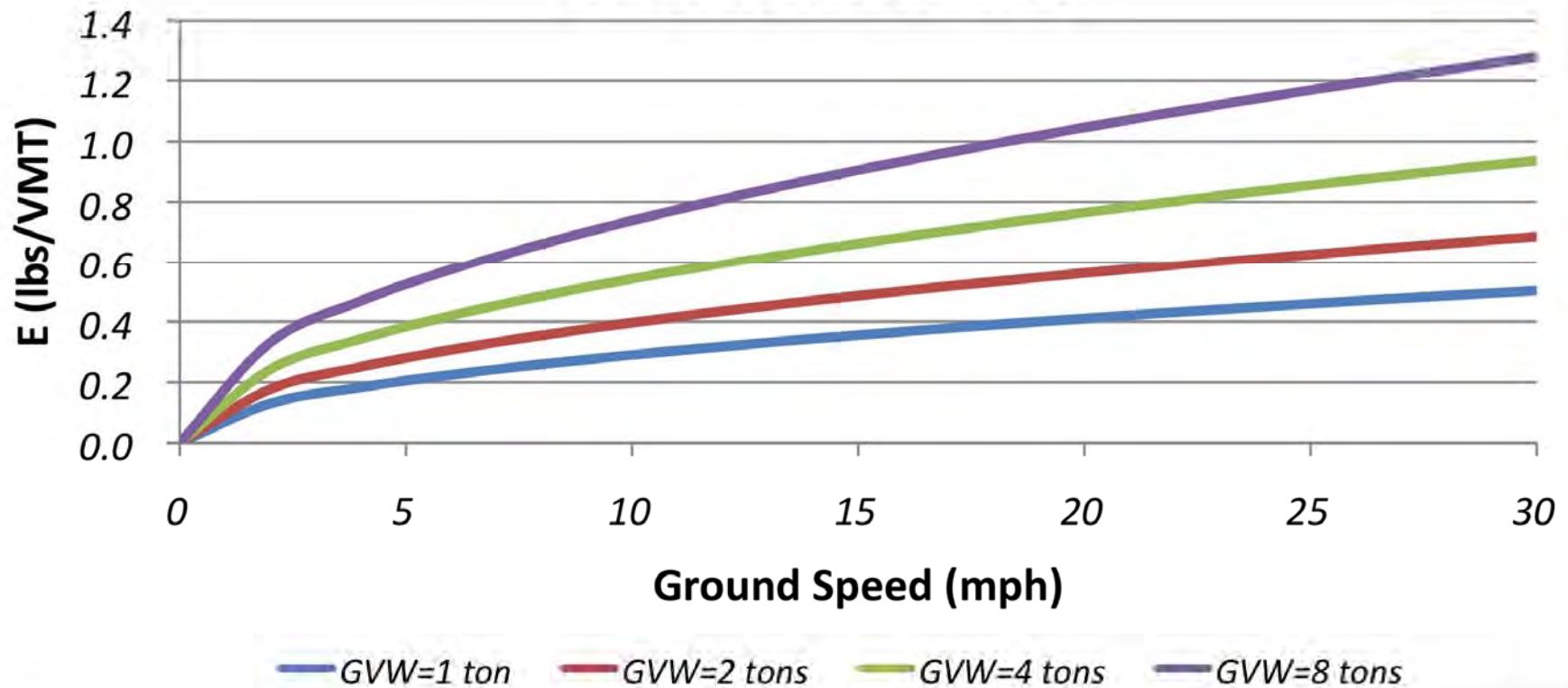
- varies with silt content, GVW, road speed, and moisture content

$$E(lb / VMT) = 1.5 \left( \frac{s}{12} \right)^{0.9} \left( \frac{W}{3} \right)^{0.45} \left( \frac{S}{30} \right)^{0.5} \left( \frac{M}{0.5} \right)^{-0.2}$$

# what about unpaved roads?

## Unpaved Road Emissions

12% silt, 10% moisture



# PM abatement on unpaved roads

- reduce vehicle speeds via speed limits, speed bumps
  - 50% redux via speed reduction from 20 to 5 mph
  - more important for heavier vehicles (AOTBE\*)
- increase moisture content using lagoon wastewater or fresh water
- consider chemical amendments
  - $\text{MgCl}_2$
  - petroleum resins

\*all other things being equal