CHARACTERIZATION OF COTTON GIN PARTICULATE MATTER EMISSIONS STUDY

PRESENTATION TO THE USDA AGRICULTURAL AIR QUALITY TASK FORCE
COLLEGE STATION, TEXAS, AUGUST 2014

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USDA-ARS, Southwestern Cotton Ginning Research Laboratory
Mesilla Park, NM

Background

- 2006 – EPA implemented more stringent rules for $PM_{2.5}$
- Primary issues surrounding particulate matter regulations for cotton gins
  - 1) limited or lack of $PM_{2.5}$ data
  - 2) over-prediction of current dispersion models
  - 3) effects of sampler errors
- State Implementation Plans – Gin $PM_{2.5}$ emissions - further study and/or additional control measures
- All cotton gins eventually impacted
- National, California, Texas, Southern, and Southeastern associations…“urgent need to collect gin emissions data to address these issues".

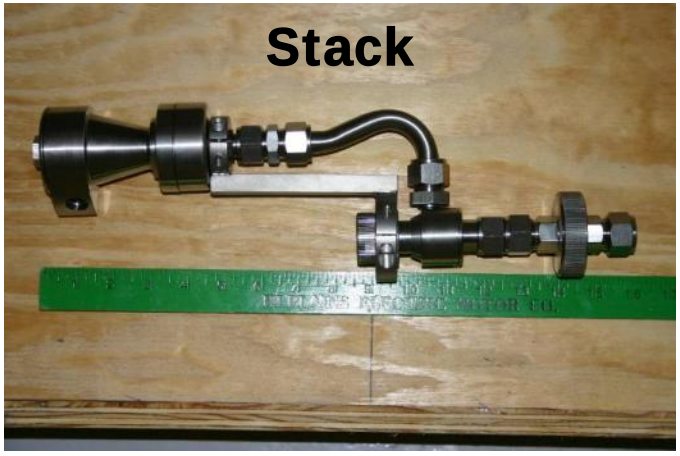
How much $PM_{2.5}$ is emitted from Cotton Gins?

Regulatory $PM_{2.5}$ Estimates ~ 36% of Total
USDA $PM_{2.5}$ Estimates ~ < 5% of Total

Dispersion Model Errors

Some models over-estimate PM concentrations by as much as 10x

Sampler Errors



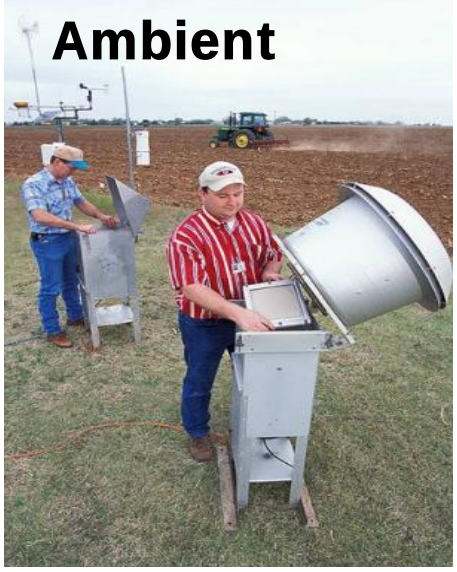
Study Results

Limestone	PM_{10} Over-Sampling	$PM_{2.5}$ Over-Sampling
Rate = 32 g/m^3	123%	700%
Rate = 148 g/m^3	133%	606%
Starch		
Rate = 32 g/m^3	477%	30000%
Rate = 148 g/m^3	444%	25316%

[i]Limestone - MMD = 7.0 μm ESD; GSD = 1.71; ρ = 2.62 g/cm^3

[ii]Starch - MMD = 15.1 μm ESD; GSD = 1.33; ρ = 1.26 g/cm^3

Source	PM_{10} Over - Sampling Rate
Cotton Gin	181 %
Cattle Feed Yard	185 %
Almond Harvesting	139 %



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National Collaboration

- USDA Gin Labs
  Derek Whitelock – Mesilla Park, NM
  Clif Boykin – Stoneville, MS
  Greg Holt – Lubbock, TX

Oklahoma State University
Michael Buser

- Texas A&M University
- Texas, California, Southern, Southeastern, and National Ginners Associations
- Cotton Incorporated
- Cotton Foundation
- Primary and alternate gins selected for the study
- California Air Resources Board
- San Joaquin Valley Air Pollution Control District
- Texas Commission on Environmental Quality
- Missouri Department of Environmental Quality
- North Carolina Department of Environmental Quality
- NRCS Air Quality and Climate Change Unit in Portland, OR
- USDA-ARS Aerial Application Unit in College Station, TX
- EPA (National, Region 9, and Region 4)

Advisory Groups

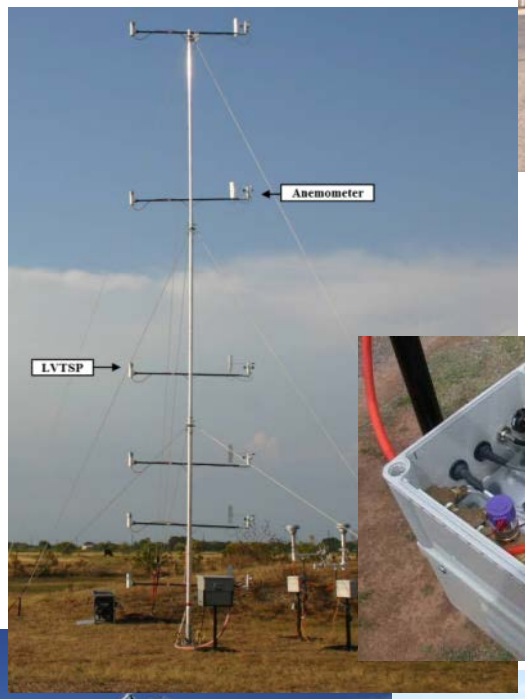
- Gin Advisory Group
  - 8 primary members
  - Gin Associations, Cotton Inc., and Texas A&M
- Air quality Group
  - 26 primary members
  - Gin Associations, Federal and State Regulatory Agencies, USDA ARS and NRCS

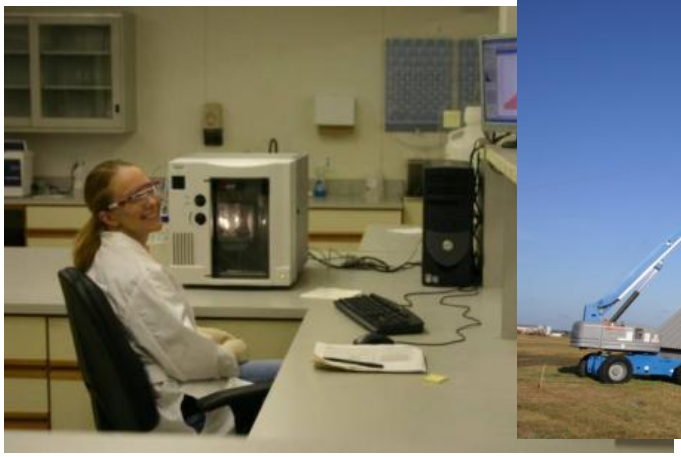
Project Objectives

- Gin emission factors
  - Develop $PM_{2.5}$
  - Verify current PM_{10} & TSP
- Characterize PM emitted from cotton gins

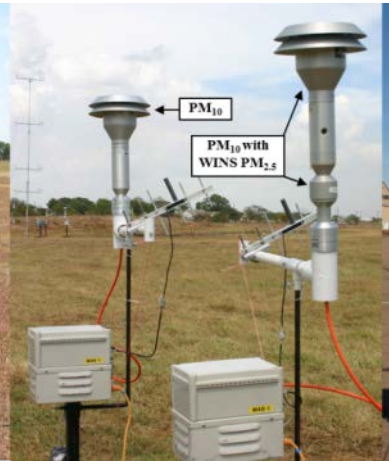
- Develop a robust PM dispersion modeling data set
- Quantify EPA PM_{10}, PM_{10}-$PM_{2.5}$, and $PM_{2.5}$ sampler performance characteristics

Resources


Anemometer
LVTSP

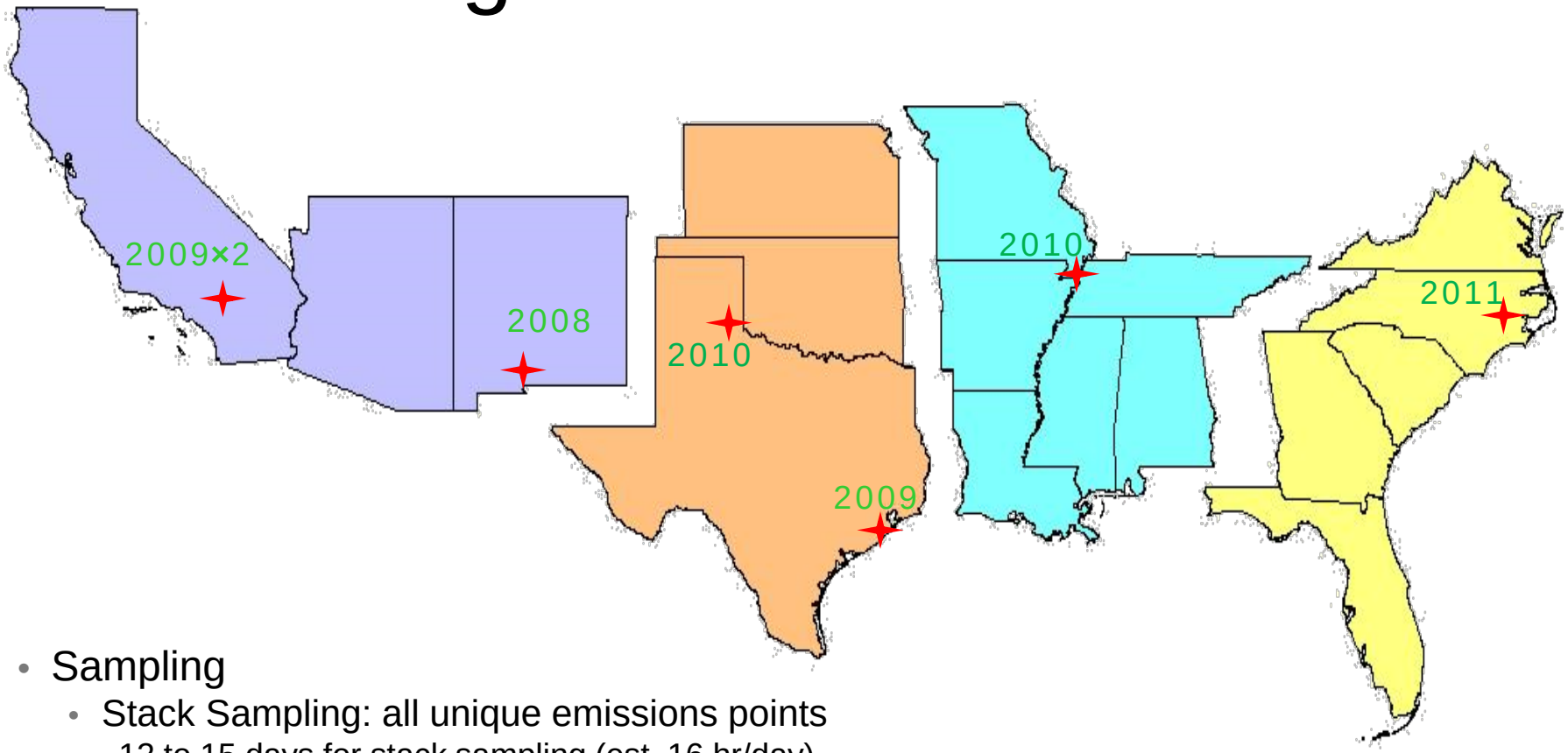



LVTSP


PM10
PM10 with WINS PM2.5

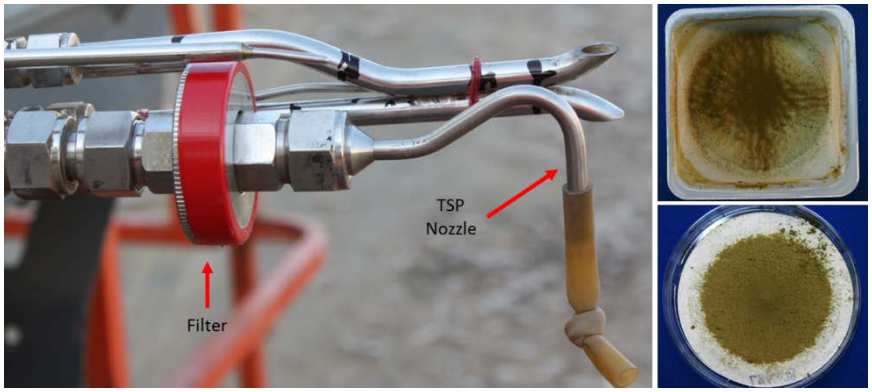

PM10 with VSCC PM2.5

Methodologies & Timelines

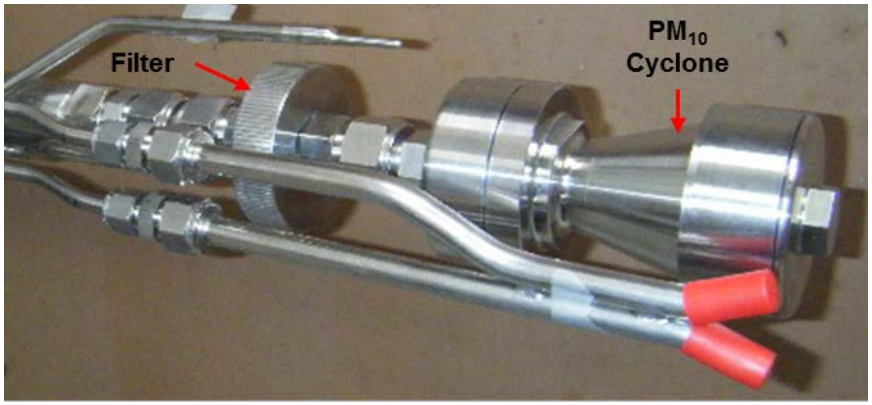


- Sampling
  - Stack Sampling: all unique emissions points
    12 to 15 days for stack sampling (est. 16 hr/day)
  - Ambient Sampling: 125 sampling point array
    - 10 to 15 days (~24 hr/day)
  - Ambient and stack sampling will overlap

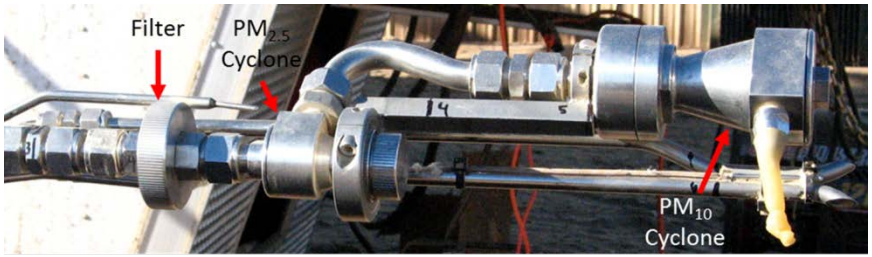
Stack Sampling

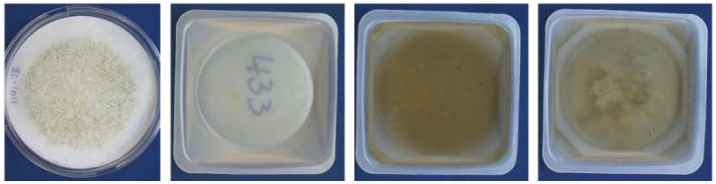


Total Particulate - Method 17



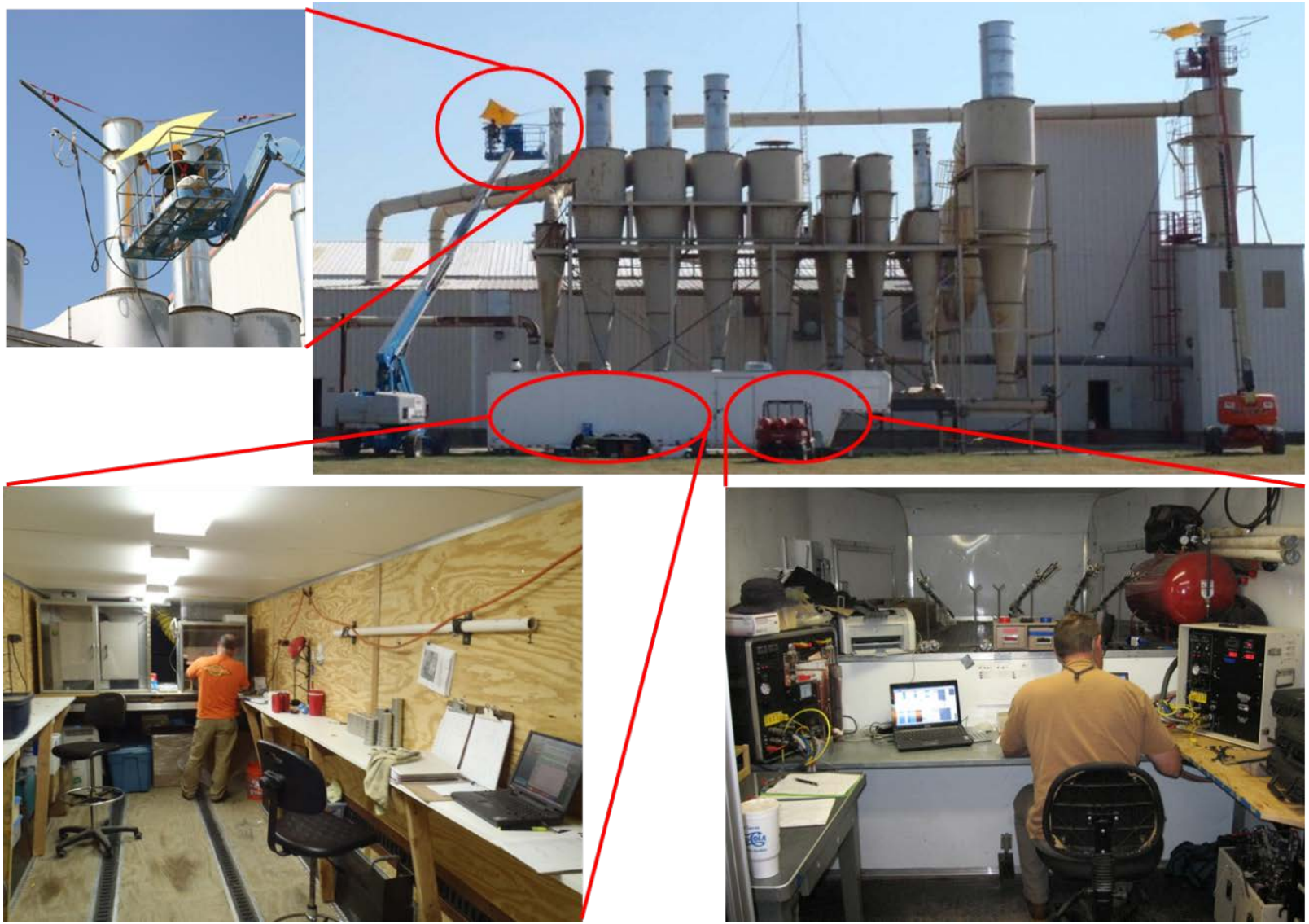
PM_{10} – Method 201A





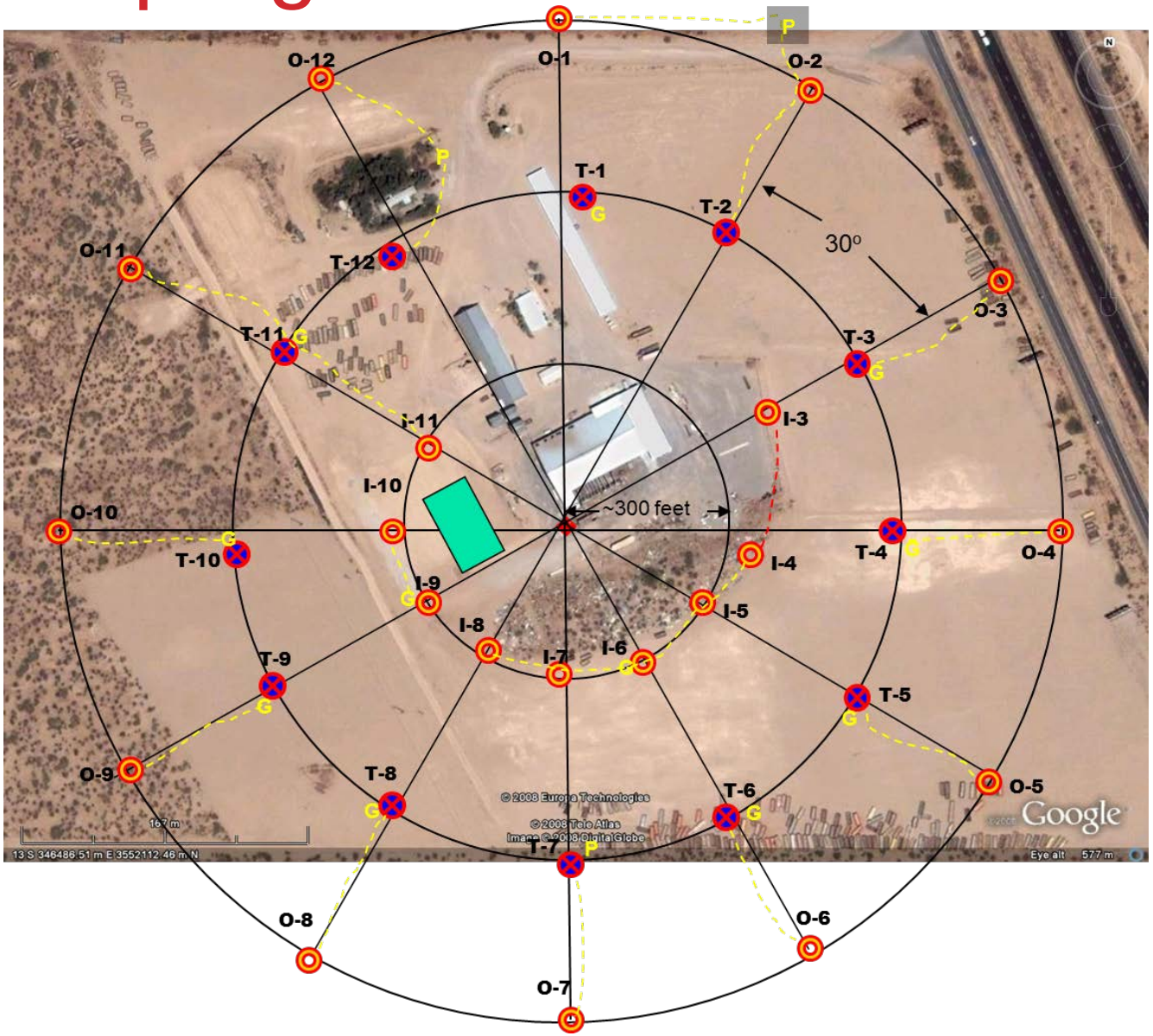
$PM_{2.5}$ – OTM 27

Stack Sampling



Ambient Sampling

- Tower Sampler
- Stand Alone Sampler



2 Tower Sites:
1 – TEOM
2 – PM10 Samplers
2 – PM2.5 Samplers
1 - Tower

2 Tower Sites:
1 – TEOM
1 – PM10 Sampler
1 – PM2.5 Sampler
1 - Tower

8 Tower Sites:
1 – PM10 Sampler
1 – PM2.5 Sampler
1 - Tower

24 Stand-alone Sites:
1 – TSP Sampler
1 – PM2.5 Sampler
1 - Tower

15

New Mexico

12 Systems Sampled
12 Days of Ambient
1800 total samples
6 weeks on site

South Texas

9 Systems Sampled
9 Days of Ambient
1200 total samples
3 ½ weeks on site

California

2 Gins
26 Systems Sampled
14 Days of Ambient
2600 total samples
4 ½ weeks on site

Missouri

9 Systems Sampled
10 Days of Ambient
1500 total samples
3 ½ weeks on site

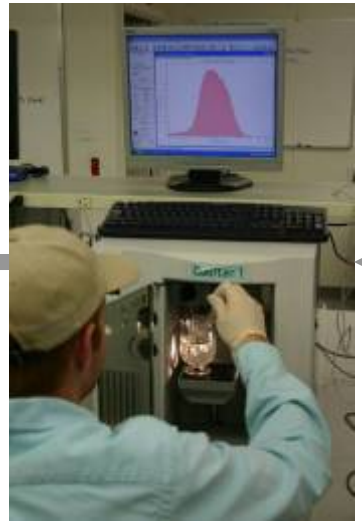
West Texas

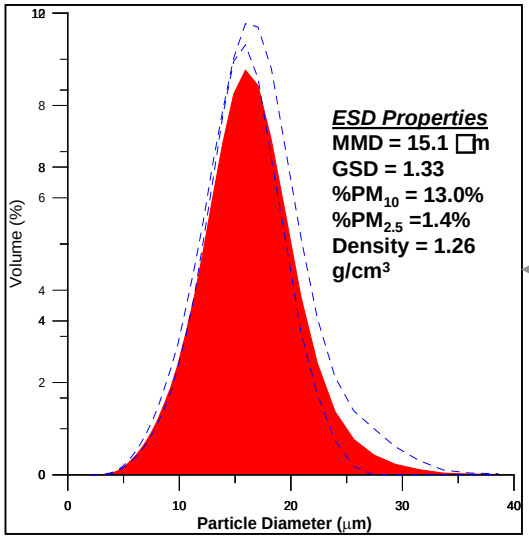
10 Systems Sampled
10 Days of Ambient
1500 total samples
2 ½ weeks on site

North Carolina

7 Systems Sampled
10 Days of Ambient
1600 total samples
4 weeks on site

Laboratory Analyses





Current Status

- Field work – COMPLETED
  - 7 Gins
  - 73 Stacks x 3 Methods
  - 65 days Ambient x 125 Samplers
- Laboratory analysis – COMPLETED
  - ~10,000 Samples
- Data compilation and QC
  - Stack sampling – COMPLETED
  - Ambient sampling – COMPLETED

Current Status

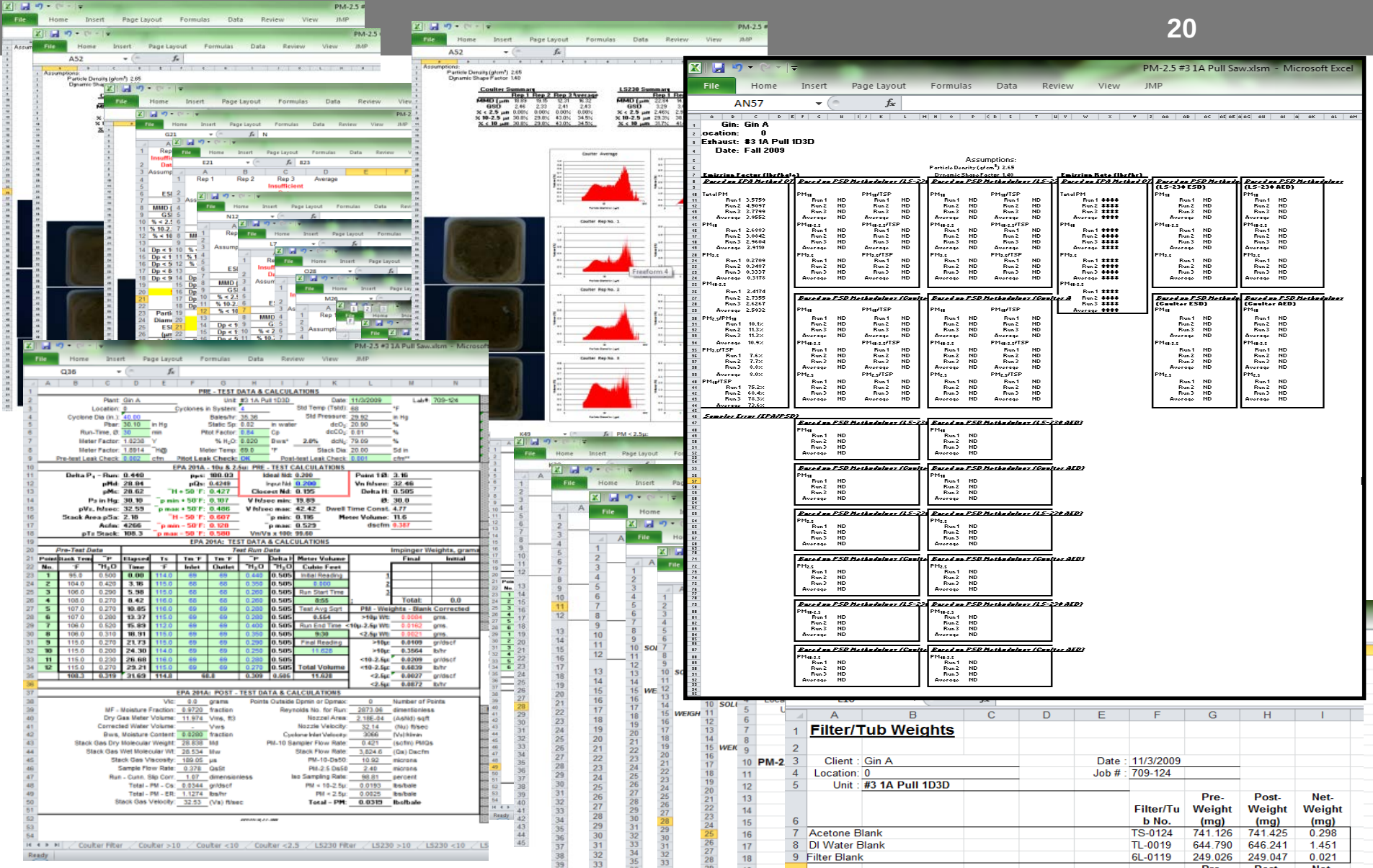
- Reporting
  - Project Plan Manuscript
    - Published in Journal of Cotton Science - April 2012
  - Emissions Data Manuscripts
    - Journal of Cotton Science (http://www.cotton.org/journal/)
    - Stack sampling (EPA approved sampling methodologies)
    - 17 unique gin systems

      $PM_{2.5}$ – published Dec 2013

      PM_{10} – accepted Jan 2014

      Total PM – in revision

      PSD – submitted Jul 2014
  - Technical Reports
    - Stack sampling (EPA approved sampling methodologies)
    - All background and sampling data
    - buser.okstate.edu/air-quality/national-cotton-gin-technical-reports/



Filter/Tub Weights

Client : Gin A — Date : 11/3/2009
Location: 0 — Job # : 709-124
Unit : #3 1A Pull 1D3D

	Filter/Tub No.	Pre-Weight (mg)	Post-Weight (mg)	Net-Weight (mg)
Acetone Blank	TS-0124	741.126	741.425	0.298
DI Water Blank	TL-0019	644.790	646.241	1.451
Filter Blank	6L-0119	249.026	249.047	0.021

No.	Cyclone Name	Method	Run No.	Sample Location	Filter/Tub No.	Pre-Weight (mg)	Post-Weight (mg)	Net-Weight (mg)
3	#1A Pull	27	1	< 10	TS-0866	638.283	651.772	13.489
3	#1A Pull	27	1	< 2.5	TS-0867	674.101	674.352	0.251
3	#1A Pull	27	1	> 10	TS-0865	658.131	663.144	5.014
3	#1A Pull	27	1	Filter < 2.5	8L-1481	299.856	301.141	1.285
						655.348	671.683	16.336
						682.656	682.879	0.223
						681.953	690.542	8.589
						303.259	305.141	1.882
						628.370	642.902	14.533
3	#1A Pull	27	3	< 2.5	TS-0875	697.169	697.592	0.423
3	#1A Pull	27	3	> 10	TS-0873	690.145	694.763	4.618

Stack Sampling Data

buser.okstate.edu/air-quality/national-cotton-gin-technical-reports/

Emission Factors for AP-42 Typical Gin

Unloading, 1st & 2nd Stage Seed Cotton Cleaning, , Overflow, Lint Cleaners, Mote Fan, Battery Condenser, Master Trash

	Total	PM10		PM2.5	
Gin PM Study EPA Methods	**1.743**	**0.987**		**0.148**	8.5% of Total
AP-42	**2.4**	**0.82**	**CA Est.**	**0.861**	
Difference EPA - AP-42	**-27%**	**20%**	**Difference EPA – CA Est.**	**-83%**	
Gin PM Study PSD Methods		**0.660**		**0.044**	
Difference PSD – EPA		**-33%**		**-70%**	
Difference PSD – AP-42		**-20%**	**Difference PSD – CA Est.**	**-95%**	

Current Impact

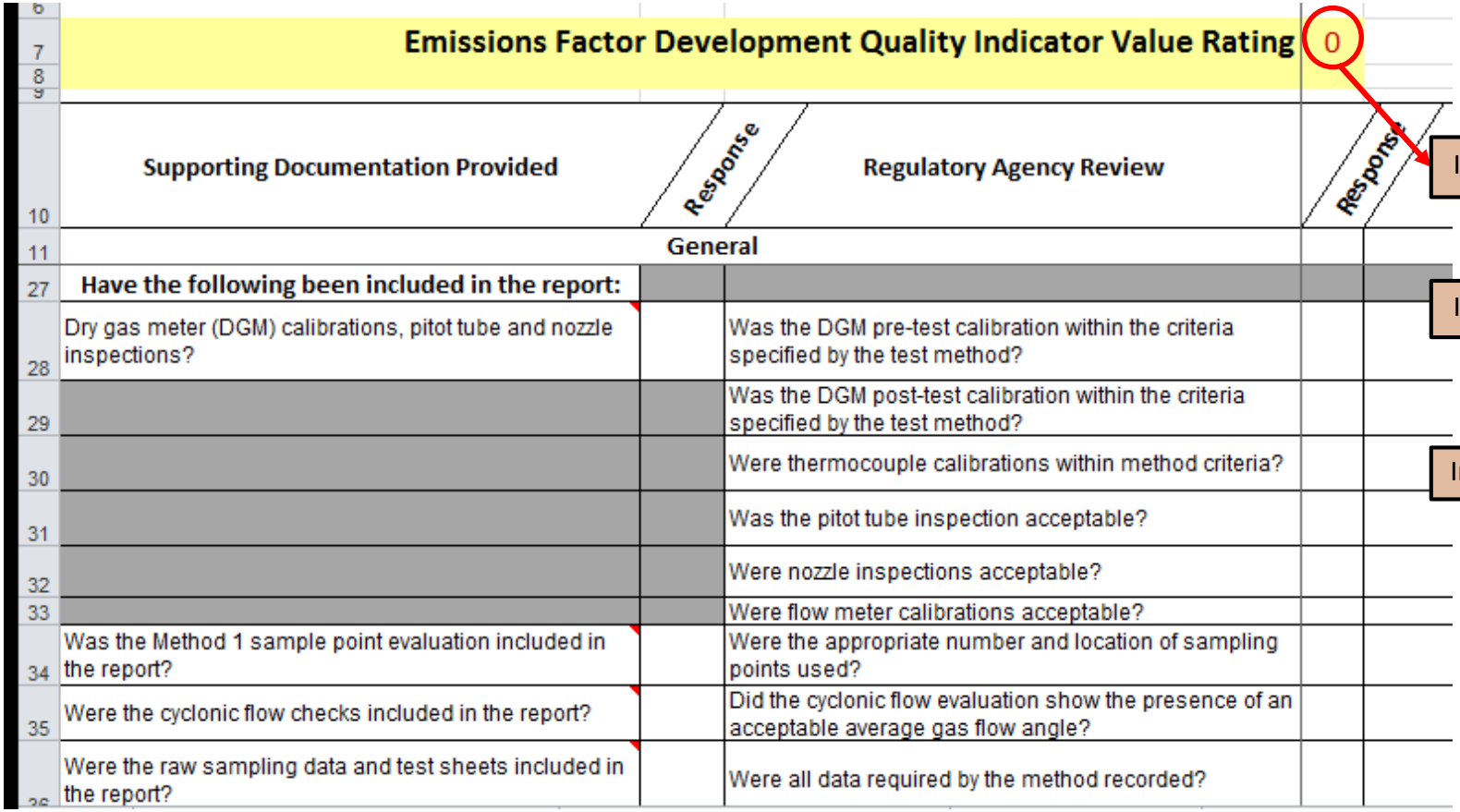
- California
  - SJVAPCD $PM_{2.5}$ Implementation Plan – Based on the Project data recommends not additional regulatory actions for gins
- Texas
  - Completely revised its cotton gin permitting rules utilizing the Project data

Current Work

- Thomas Moore
  - Michael Buser - Biosystems & Agricultural Engineering, Oklahoma State University
- Use National Study data and current AP-42
- New EPA emission factor guidelines (Aug. 2013)
  - Develop $PM_{2.5}$ emission factors and quality ratings
  - Update PM_{10} emission factors and quality ratings
- Package data for submittal to EPA
- Assistance from Ron Myers, EPA Measurement Policy Group

Source test quality ratings

Supporting documentation and regulatory agency review questions



	Emissions Factor Development Quality Indicator Value Rating	0		
10	Supporting Documentation Provided	Response	Regulatory Agency Review	Response
11	General			
27	**Have the following been included in the report:**			
28	Dry gas meter (DGM) calibrations, pitot tube and nozzle inspections?		Was the DGM pre-test calibration within the criteria specified by the test method?	
29			Was the DGM post-test calibration within the criteria specified by the test method?	
30			Were thermocouple calibrations within method criteria?	
31			Was the pitot tube inspection acceptable?	
32			Were nozzle inspections acceptable?	
33			Were flow meter calibrations acceptable?	
34	Was the Method 1 sample point evaluation included in the report?		Were the appropriate number and location of sampling points used?	
35	Were the cyclonic flow checks included in the report?		Did the cyclonic flow evaluation show the presence of an acceptable average gas flow angle?	
36	Were the raw sampling data and test sheets included in the report?		Were all data required by the method recorded?	

Individual Test Rating

Gin 1 Test

Individual Test Rating

Gin 2 Test

Individual Test Rating

Gin *N* Test

Submitter questions- 16

Regulatory review questions- 47

Factor Calculation

- Use ITRs to calculate Composite Test Rating (CTR)

$$CTR = \left[\frac{\sum_{i=1}^{n}\left(\frac{1}{ITR}\right)^{2}}{N}\right]^{-0.5}$$

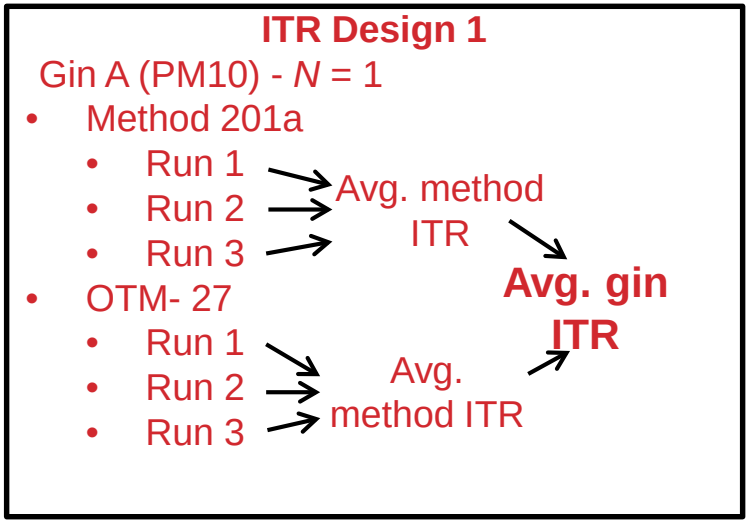
- Use CTR to calculate Factor Quality Index (FQI)

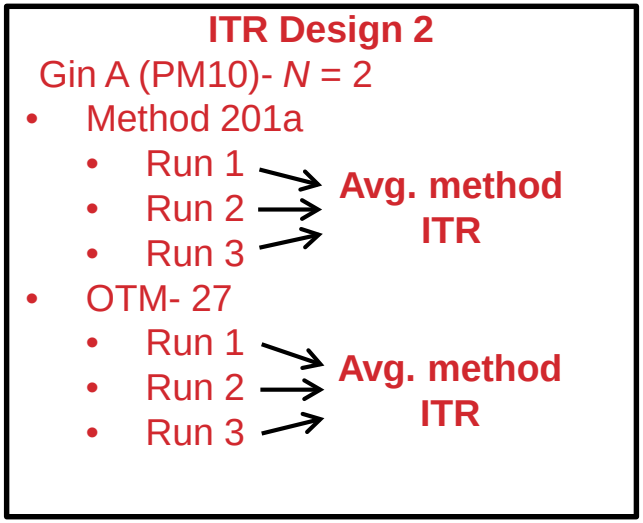
$$FQI = \frac{100}{CTR * N^{0.5}}$$

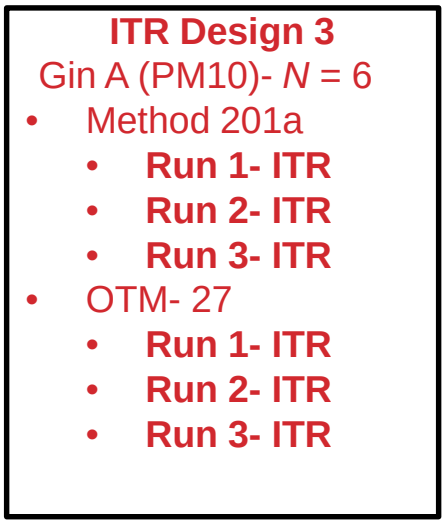
- Use FQI to determine factor representativeness
  - Poorly representative: FQI > 0.5774
  - Moderately representative: 0.3015 < FQI < 0.5774
  - Highly representative: FQI < 0.3015

EPA Guidelines

- ITR determination is open to interpretation. What is a “test”?







Proposed $PM_{2.5}$ Emission Factors

System	Emission Factor (lbs/bale)	Representativeness	No. of Systems Tested	No. of Test Runs	*N* needed for moderate	*N* needed for highly
Unloading	0.0488	Poorly	3	9	1	9
1st Stage Seed Cotton Cleaning	0.0178	Moderately	7	21	0	5
2nd Stage Seed Cotton Cleaning	0.0080	Moderately	4	15	0	8
3rd Stage Seed Cotton Cleaning	0.0088	Poorly	2	6	2	10
1st Stage Lint Cleaning	0.0188	Moderately	4	12	0	8
2nd Stage Lint Cleaning	0.0106	Moderately	4	12	0	8
Combined Lint Cleaning	0.0303	Poorly	3	9	1	9
1st Stage Mote	0.0085	Moderately	5	15	0	7
2nd Stage Mote	0.0048	Moderately	5	14	0	10
Combined Mote	0.0209	Poorly	2	6	2	10
Battery Condenser	0.0077	Moderately	5	18	0	6
Cyclone Robber	0.0035	Poorly	4	12	1	9
Mote Cyclone Robber	0.0094	Poorly	2	9	1	10
Master Trash	0.0098	Moderately	5	15	0	7
Overflow (Distributer)	0.0091	Moderately	3	9	0	8
Mote Cleaner	0.0287	Poorly	1	3	2	10
Mote Trash	0.0024	Poorly	2	6	2	10

- Tests needed (assuming constant CTR)
  - Moderately representative: $N = 30{,}000 * CTR^{-2}$
  - Highly representative: $N = 110{,}000 * CTR^{-2}$

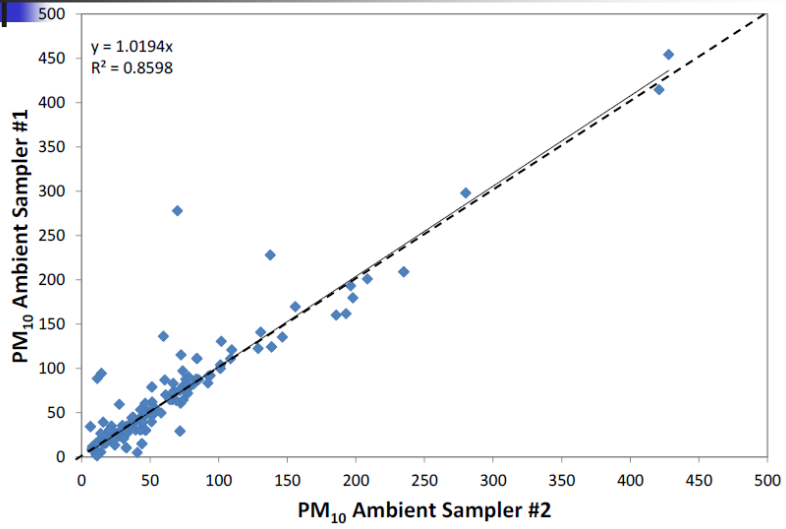
Additional Work

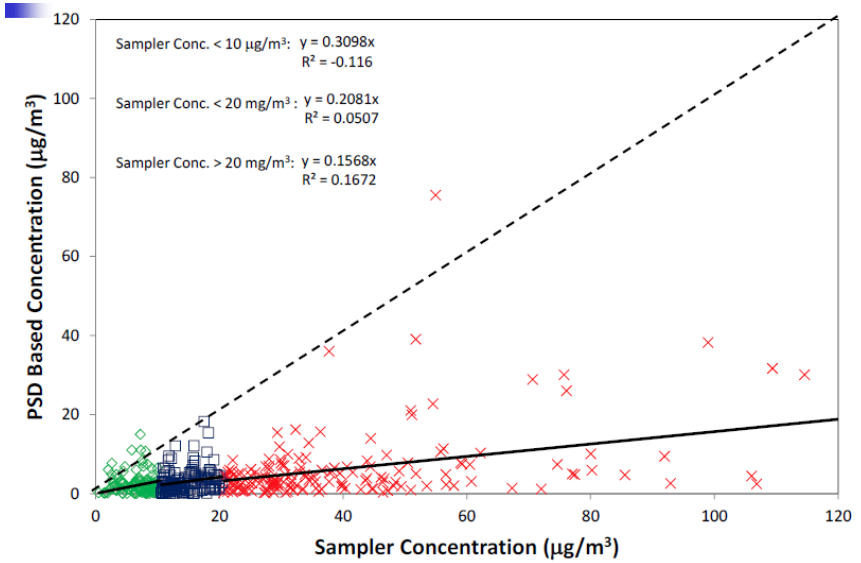
- Incorporate additional data into rating process
  - Re-rate current AP-42 data
  - Stack sampling compliance tests
    - California
    - Missouri
    - New Mexico
  - Particle size analysis data
- Organization of supporting documentation for EPA submission
  - Annotated technical reports
  - Gin layouts
  - Chain of custody
  - Target submission date: September 2014

Future Work

- Field Evaluation of EPA Samplers
- PM_{10} and $PM_{2.5}$
- Particle Size Distribution with TSP samples

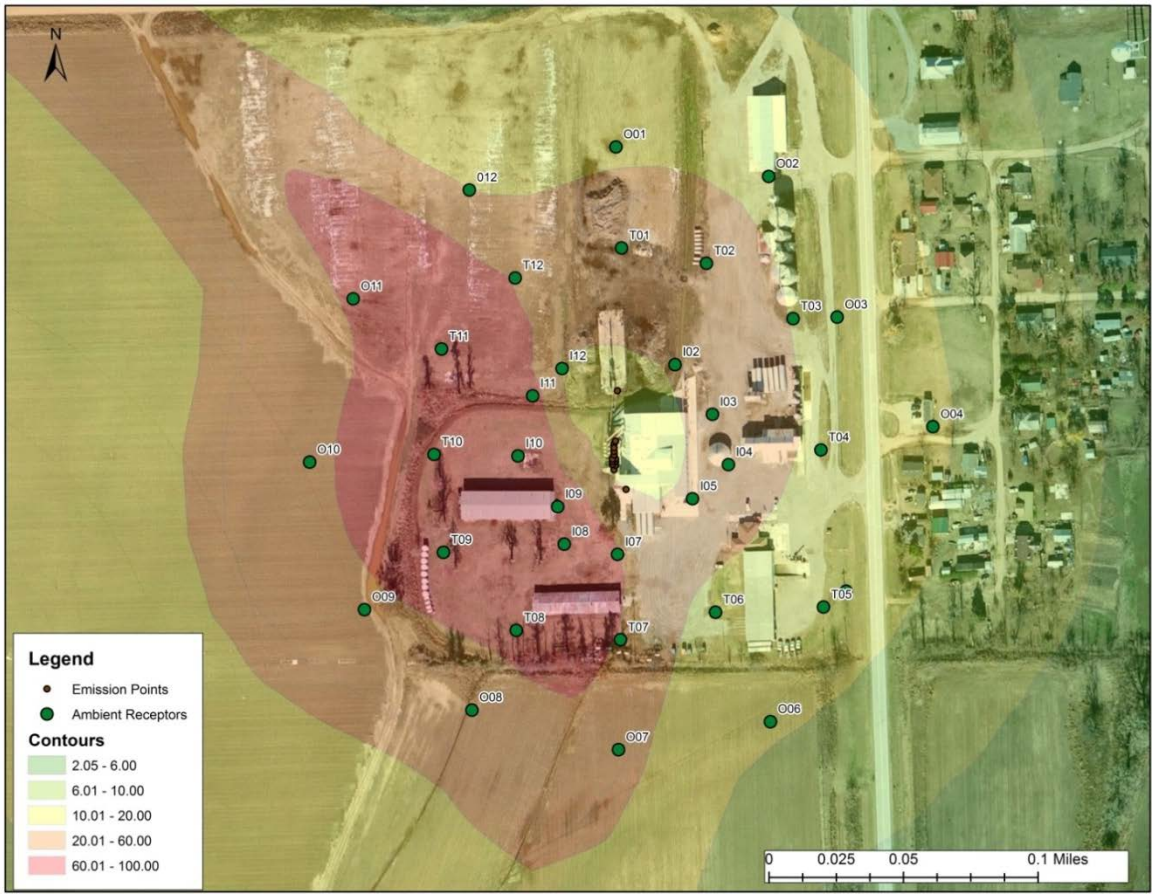
PM_{10} Collocated Samplers





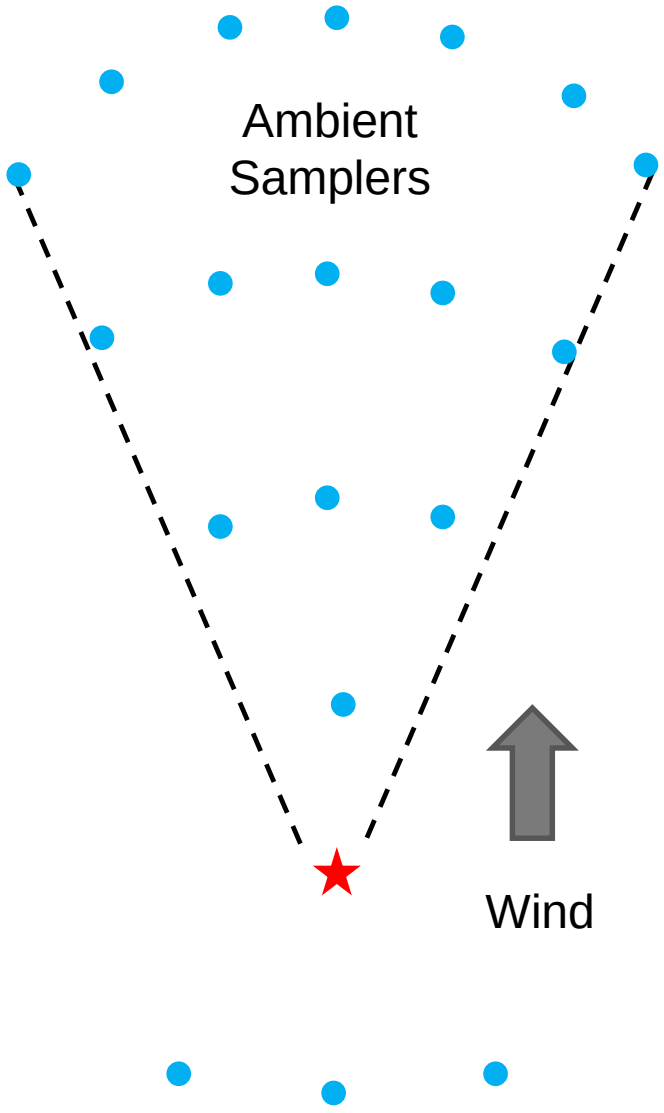
Future Work

- Ambient Data & Model Analyses
  - Point-by-point comparison
    - Ambient Sampler Concentrations
    - Model Output using measured emissions



Future Work

- Modeling Dataset
- Controlled Release Study
- Location
  - Few outside influences
  - Consistent wind direction
- Particulate
  - Known Characteristics & Concentration
- Varied Release Heights



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