Estimating the Impacts of Agricultural Best Management Practices in the Maricopa County PM_{10} Non-Attainment Area

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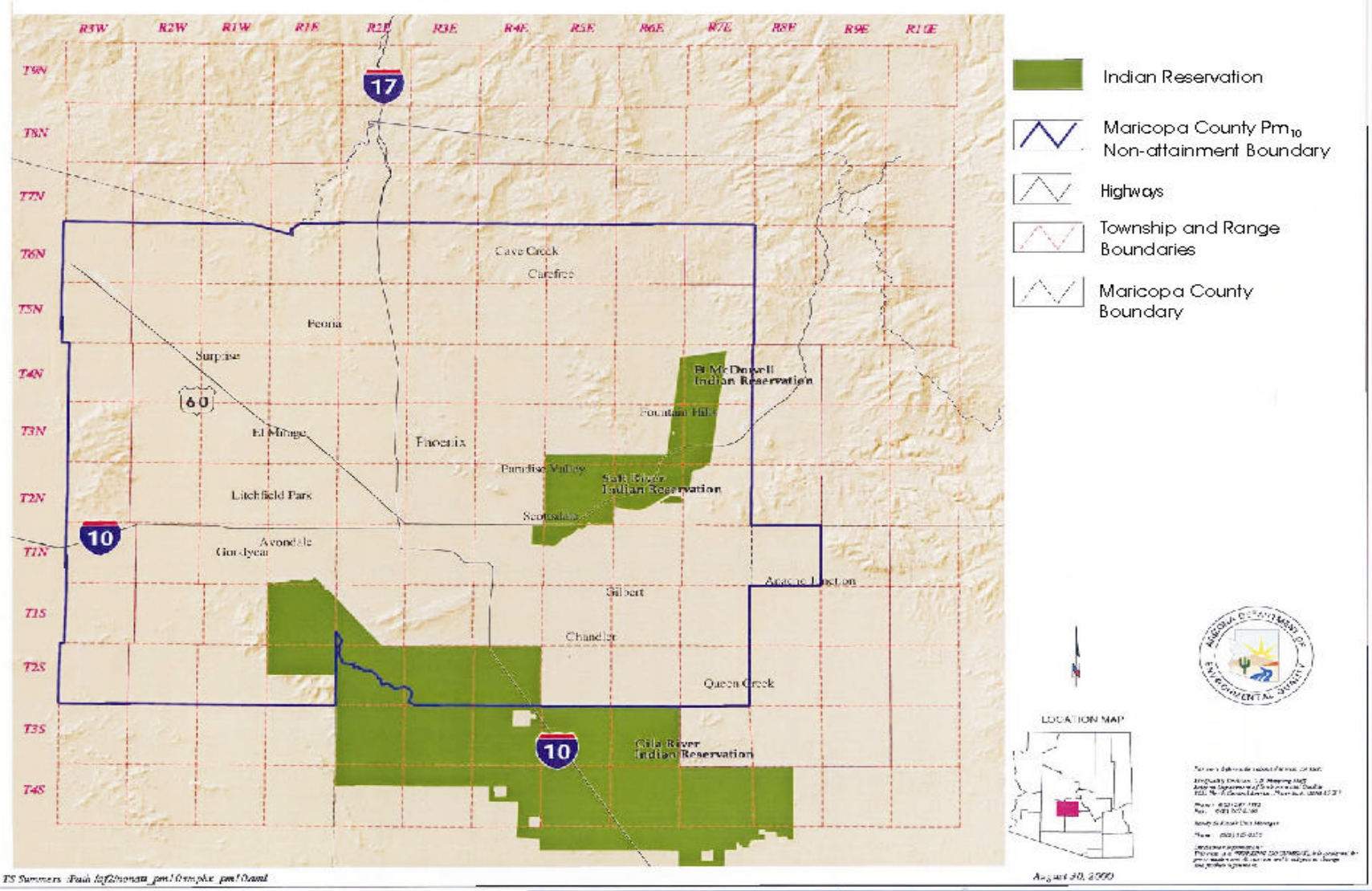
Overview of Today's Presentation

- Project Background
- Project Scope
- Technical Approach
- Results

Maricopa County PM_{10} Non-Attainment Area



Project Background

- Serious PM_{10} non-attainment area
- Previously unregulated sources included unpaved roads and lots, and agricultural activities
- Micro-scale study focused on impacts at two monitoring sites
- Key stakeholders: Governor's Ag BMP Committee, EPA Region IX, ADEQ, Farm Bureau, UA Extension, USDA/NRCS

Project Scope

- Maricopa County PM_{10} Non-Attainment Area
- Three agricultural source types
  - Tillage and harvest
  - Non-cropland (wind erosion and unpaved roads/areas)
  - Cropland (wind erosion)
- PM_{10} emissions for April 1995 design day
- Impacts from 30+ BMPs identified by the Governor's Committee

Methodology for Agricultural BMP Analysis

Step 1: Determined applicability of BMPs based on crop type

Step 2: Ranked BMPs based on likelihood of implementation

Step 3: Determined range of control efficiencies by crop type

Step 4: Established an implementation scenario as the basis for estimating emission reductions

- BMPs most likely to be implemented
- Compliance factor of 80%
- Relevancy factors based on crop type
- Net control efficiencies for each BMP by crop type

BMP Applicability and Ranking - Tillage and Harvest

BMP	Ranking	Applicable Crop						
		Cotton	Wheat	Barley	Corn	Alfalfa/ Other Hay	Vegetables	Citrus
Chemical irrigation	1-4	T			T			
Combining tractor operations	1	T	T	T	T		T	T
Equipment modification	3-5	T	T	T	T	T		
Limited activity during high-winds	1-3	T	T	T	T	T	T	T
Multi-year crop	1	T	T	T	T			
Planting based on soil moisture	1	T	T	T	T		T	
Reduced harvest activity	1	T				T		
Reduced tillage system	4	T	T	T	T			
Tillage based on soil moisture	2		T	T	T			
Timing of tillage operation	1	T	T	T	T			

BMP Applicability and Ranking - Non-Cropland

BMP	Ranking	Applicable Crop						
		Cotton	Wheat	Barley	Corn	Alfalfa/ Other Hay	Vegetables	Citrus
Access restriction	1	T	T	T	T	T	T	T
Aggregate cover	3	T	T	T	T	T	T	T
Artificial wind barrier	10	T	T	T	T	T	T	T
Critical area planting	5	T	T	T	T	T	T	T
Manure application	1	T	T	T	T	T	T	T
Reduced vehicle speed	1	T	T	T	T	T	T	T
Synthetic particulate suppressant	7	T	T	T	T	T	T	T
Track-out control system	5-7	T	T	T	T	T	T	T
Tree, shrub, or windbreak planting	9	T	T	T	T	T	T	T
Watering	3	T	T	T	T	T	T	T

BMP Applicability and Ranking - Cropland

BMP	Ranking	Applicable Crop						
		Cotton	Wheat	Barley	Corn	Alfalfa/ Other Hay	Vegetables	Citrus
Artificial wind barrier	10					T	T	T
Cover crop	4	T	T	T	T		T	T
Cross-wind ridges	3	T	T	T	T		T	
Cross-wind strip cropping	10		T	T	T	T	T	
Cross-wind vegetative strips	10	T	T	T	T		T	
Manure application	3	T	T	T	T			
Mulching	10	T						T
Multi-year crop	1	T	T	T	T			
Permanent cover	8							
Planting based on soil moisture	2	T	T	T	T		T	
Residue management	1	T	T	T	T			
Sequential cropping	5	T	T	T	T		T	
Surface roughening	2	T	T	T	T		T	
Tree, shrub, or windbreak planting	9	T	T	T	T	T	T	T

Control Efficiencies for BMPs Most Likely to be Implemented

BMP				
		Control Efficiency		
Category	Action	Minimum	Maximum	Mid-point
Tillage	Combining Tractor Operations	35%	50%	43%
	Limited Activity During High-Wind Events	25%	25%	25%
	Multi-Year Crops	50%	75%	63%
Harvest	Combining Tractor Operations	35%	50%	43%
	Reduced Harvest Activity	29%	71%	50%
Non-Cropland	Access Restriction	0%	3%	2%
	Reduced Vehicle Speed	7%	77%	42%
Cropland	Multi-Year Crops	50%	75%	63%
	Residue Management	39%	92%	65%
	Timing of Tilling Operations	50%	60%	55%

Compliance Factor

- Percentage of farms expected to comply (i.e., implement at least one BMP from each category)
- EPA default = 80%
- Percentage of farm land on farms >10 acres = 99.8%
- Overall compliance factor = 80%

Relevancy Factor

- Percentage of compliant farms expected to implement a given BMP, by crop
- Example: Tillage emissions from cotton
  - Combining tractor operations (23%)
  - Limited activity on high-wind days (47%)
  - Multi-year crops; switch to alfalfa (30%)

Net Control Efficiency

Net Control Efficiency = Control Efficiency × Compliance Factor × Relevancy Factor

Summary		Net Control Efficiency by Applicable Crop (%)						
Category	**BMP**	**Cotton**	**Wheat**	**Barley**	**Corn**	**Alfalfa/Hay**	**Vegetables**	**Citrus**
Tillage	Combining Tractor Operations	7.9	7.9	7.9	7.9	N/A	11.2	11.2
	Limited Activity During High-Wind Events	9.3	9.3	9.3	9.3	20.0	13.2	13.2
	Multi-Year Crops	15.8	15.8	15.8	15.8	N/A		
Harvest	Combining Tractor Operations	17.0	33.9	33.9	33.9	N/A	33.9	33.9
	Reduced Harvest Activity	20.0	N/A			39.9	N/A	
Non-Cropland	Access Restriction	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Reduced Vehicle Speed	16.8	16.8	16.8	16.8	16.8	16.8	16.8
Cropland	Multi-Year Crops	23.9	23.9	23.9	23.9	N/A		
	Residue Management	12.2	18.3	18.3	12.2			
	Timing of Tilling Operations	10.2	15.4	15.4	10.2			
	Planting Based on Soil Moisture	5.6	N/A		5.6			

N/A= Not applicable.

Methodology for Estimating 1995 Design Day Emissions

- Determined emission estimating technique (EET)
- Collected activity data
- Determined percentage of county farmland within non-attainment area = 62.8%
- Developed spreadsheets and performed calculations
- Quality-assured spreadsheets

Emission Estimating Technique - Tillage

$$EF = k(4.8)s^{0.6}$$

where:

EF	=	tillage emission factor (lbs PM_{10}/acre-pass);
k	=	particle size multiplier (value of 0.15 for PM_{10}); and
s	=	soil silt content (percent).

$$Tillage_{Crop} = EF \times AP_{Crop} \times A_{crop} \times AF \times F$$

where:

$Tillage_{Crop}$	=	tillage emissions for each crop type (lbs PM_{10});
EF	=	tillage emission factor (lbs PM_{10}/acre-pass);
AP_{Crop}	=	number of tillage acre-passes per acre for each crop type;
A_{Crop}	=	total number of tilled acres for each crop type (acres);
AF	=	fraction of annual activity occurring on April 9; and
F	=	fraction of Maricopa County farmland within non-attainment area.

Emission Estimating Technique - Harvest

$$\mathbf{Harvest_{Crop} = EF \times A_{Crop} \times F}$$

where:

$Harvest_{Crop}$	=	harvest emissions for each crop type (lbs PM_{10});
EF	=	harvest emission factor (lbs PM_{10}/acre);
A_{Crop}	=	total number of reported acres for each crop type (acre); and
F	=	fraction of Maricopa County farmland within non-attainment area.

Emission Estimating Technique - Wind Erosion

$$EF = 0.0125 \times I \times C \times K \times L_N \times V_N$$

where:

EF	=	PM_{10} emission factor (tons/acre/year);
0.0125	=	fraction of suspended particles that are PM_{10};
I	=	soil erodibility (tons/acre/year);
C	=	climatic factor (unitless);
K	=	surface roughness factor (unitless);
L_N	=	unsheltered field width factor (unitless); and
V_N	=	vegetative cover factor (unitless).

$$\text{Wind Erosion}_{Crop} = EF \times \text{Acres} \times F$$

where:

$\text{Wind Erosion}_{Crop}$	=	wind erosion emissions for each crop type (lbs PM_{10}/year);
EF	=	wind erosion emission factor (lbs PM_{10}/acre/year);
Acres	=	acres of cropland or non-crop land (acres);
F	=	fraction of Maricopa County farmland within non-attainment area.

Emission Estimating Technique - Travel on Unpaved Roads

$$EF = (0.36)(5.9)(s/12)(S/30)(W/3)^{0.7}(w/4)^{0.5}$$

where:

EF	=	re-entrained unpaved road dust emission factor (lbs/VMT);
0.36	=	aerodynamic particle size multiplier for PM_{10};
5.9	=	constant;
s	=	silt content of road surface material (percent);
S	=	mean vehicle speed (mi/hr);
W	=	mean vehicle weight (ton); and
w	=	mean number of wheels (unitless).

$$\text{Unpaved} = EF \times VMT \times F$$

where:

Unpaved	=	emissions (lbs PM_{10}/day);
EF	=	emission factor (lbs/VMT);
VMT	=	VMT estimate (VMT/day); and
F	=	fraction of Maricopa County farmland within non-attainment area.

1995 Design Day Emissions

Category	Activity	Design-Day Emissions (lbs/day)	Percentage of Total
Tillage and Harvest	Tillage	54,667	1.6%
	Harvest	0	0.0%
Non-Cropland	Wind Erosion	325,895	9.4%
	Unpaved Road Travel	41,561	1.2%
Cropland	Wind Erosion	3,042,794	87.8%
Total		**3,464,917**	**100.0%**

Methodology for Estimating 2006 Design-Day Emissions and Reductions

- Estimated percentage of land expected to go out of production between 1995 and 2006 = 37%
- Applied 37% land use factor and mid-point BMP control efficiencies to 1995 design day emissions to obtain 2006 design-day emissions
- Applied 37% land use factor and range of BMP control efficiencies to obtain range of emission reductions

2006 Projected Design Day Emissions

Category	Activity	Projected Emissions (lbs/day)	Percentage of Total
Tillage and Harvest	Tillage	23,467	1.7%
	Harvest	0	0.0%
Non-Cropland	Wind Erosion	204,186	14.8%
	Travel on Unpaved Roads	21,528	1.6%
Cropland	Wind Erosion	1,126,101	81.9%
Total		**1,375,282**	**100.0%**

Potential Emission Reductions from BMP Implementation

Category	Activity	Total Design-Day Emissions (lbs/day)	Land Use Reduction (lbs/day)	BMP Implementation Scenario		Total Reduction (lbs/day)
				BMP	BMP Reduction	
Tillage and Harvest	Tillage	54,667	20,416	Combining Tractor Operations	2,910	31,200
				Limited Activity During High-Wind vents	3,423	
				Multi-Year Crops	4,450	
	Harvest	0	0	Combining Tractor Operations	0	0
				Reduced Harvest Activity		
Non-Cropland	Unpaved Road Travel	41,561	15,521	Access Restriction	156	20,034
				Reduced Vehicle Speed	4,357	
	Wind Erosion	325,895	121,709	N/A		121,709
Cropland	Wind Erosion	3,042,794	1,136,362	Multi-Year Crops	359,556	1,916,693
				Residue Management	183,068	
				Timing of Tilling Operations	153,810	
				Planting Based on Soil Moisture	83,897	
Total		**3,464,917**	**1,294,008**		**795,627**	**2,089,636**

Conclusions

- Design-day emissions based on best available data
- A reduction of 57.5% to 63.0% (mid-point = 60.3%) in agricultural emissions is expected by 2006 from implementation of agricultural BMPs and land going out of production
- Actual reductions may be more or less than predicted due to
  - Selection of BMPs in implementation scenario
  - Compliance rate
  - Relevancy factors
  - BMP control efficiencies

Significant Accomplishments

- Stakeholder involvement in process and buy-in of results
- PM_{10} SIP shows attainment by 2006
- Technically rigorous analysis that can be used in areas where agricultural emissions need to be controlled