An AERMOD SIP Application in Complex Terrain?

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Overall Approach

- Design Value and Exceptional Events
- Speciation/Precursors
- Emission Inventory
- Source Apportionment
- Aermod Modeling
  - To get "Effective Emissions" for transport of sources outside the Roll-Forward "Box" in a mountain valley.
  - Also provides Unmonitored Area Analysis
- Roll-Forward Model

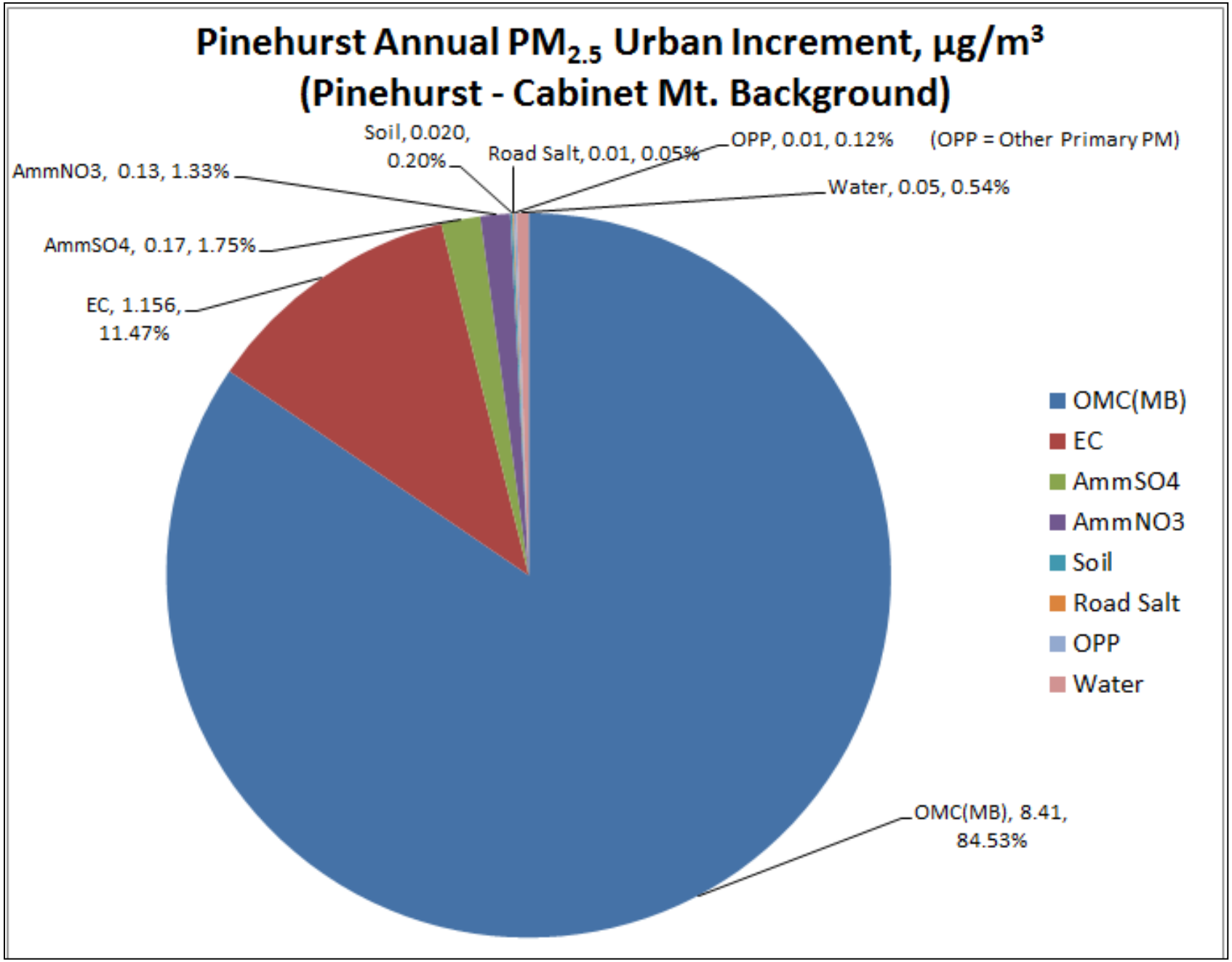
Speciated Linear Roll-forward Model Equation

$$C_i^f = \left(\frac{E_i^f}{E_i^b} \right) (C_i^b - bg_i) + bg_i$$

where E_i, C_i, and bg_i are the efffective emissions, concentrations, and background concentrations, respectively, of component *i*.

The superscripts *f* and *b* indicate future (controlled) and base cases.

The ratio of future-year emissions and base-year emissions (E^f/E^b) is defined as the relative response factor (RRF).



Klamath Falls $PM_{2.5}$ Attainment Plan
Appendix 13
Effective Emissions

Submitted to: EPA

Context for AERMOD Dispersion Modeling

Effective Emissions

Introduction.

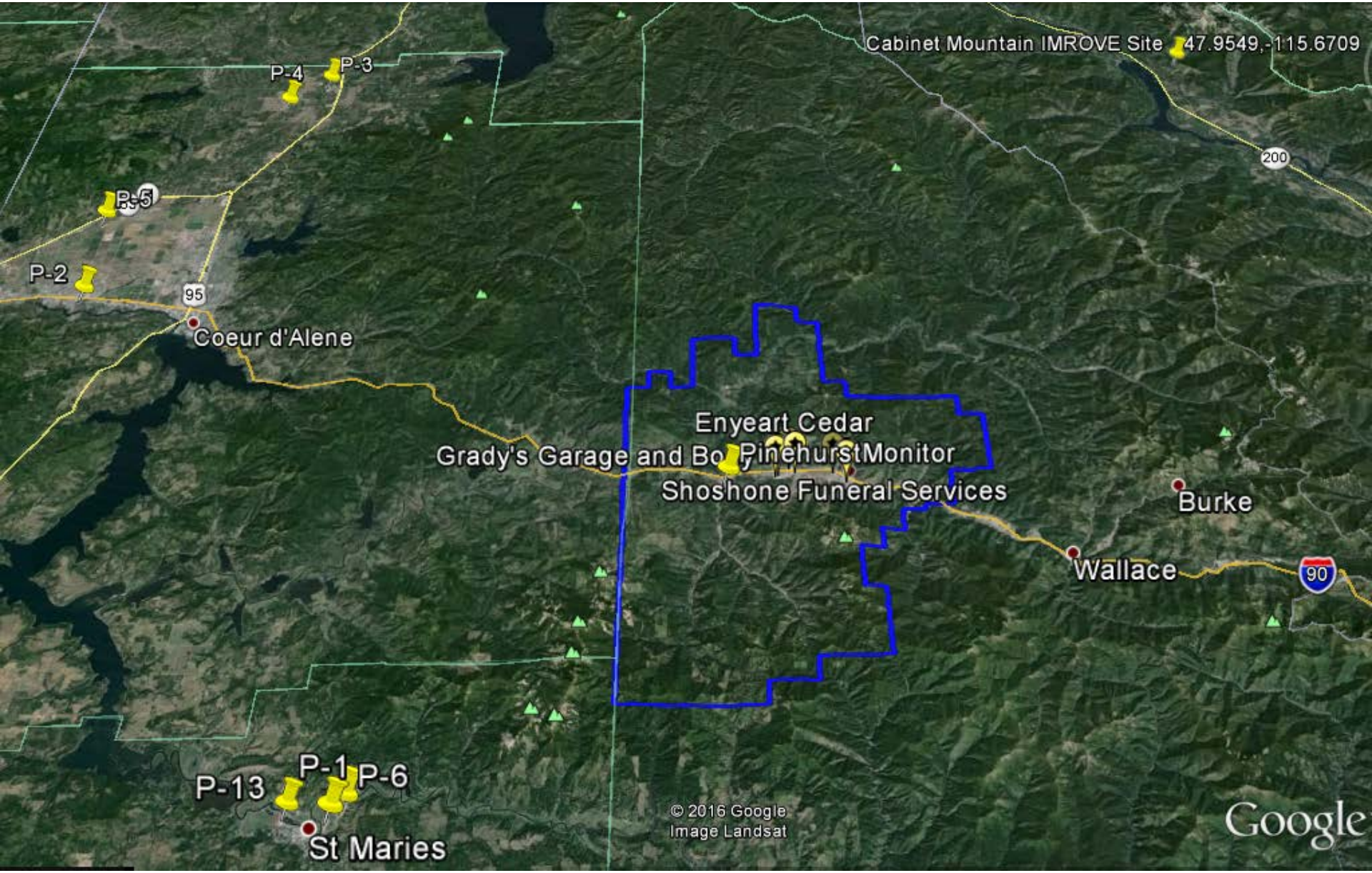
A rollback model is based on a correlation between emissions and ambient air concentrations, and assumes a relatively even distribution of emissions across a local air basin that results in relatively low concentration gradients. In Klamath Falls this assumption is considered generally representative with the exception of three emissions categories: industrial point sources, prescribed burning, and road dust. Two of these source categories are located at some distance from the FRM Peterson School monitor sited at the approximate center of the NAA: prescribed burning occurs outside of the NAA, and industrial sources are located near the western and northern edges of the NAA. Although these sources may have local high concentrations, their impact at the monitor is likely to be lower, with flat concentration gradients. Emissions from the third category, road and fugitive dust, appear high relative to the fugitive dust component of measured concentrations based on a Positive Matrix Factorization (PMF) analysis. The reasons for differences between emissions and concentrations for these three categories can be the result of plume dispersion, inaccurate emissions estimates, use of unrepresentative emission factors, or a combination of factors.

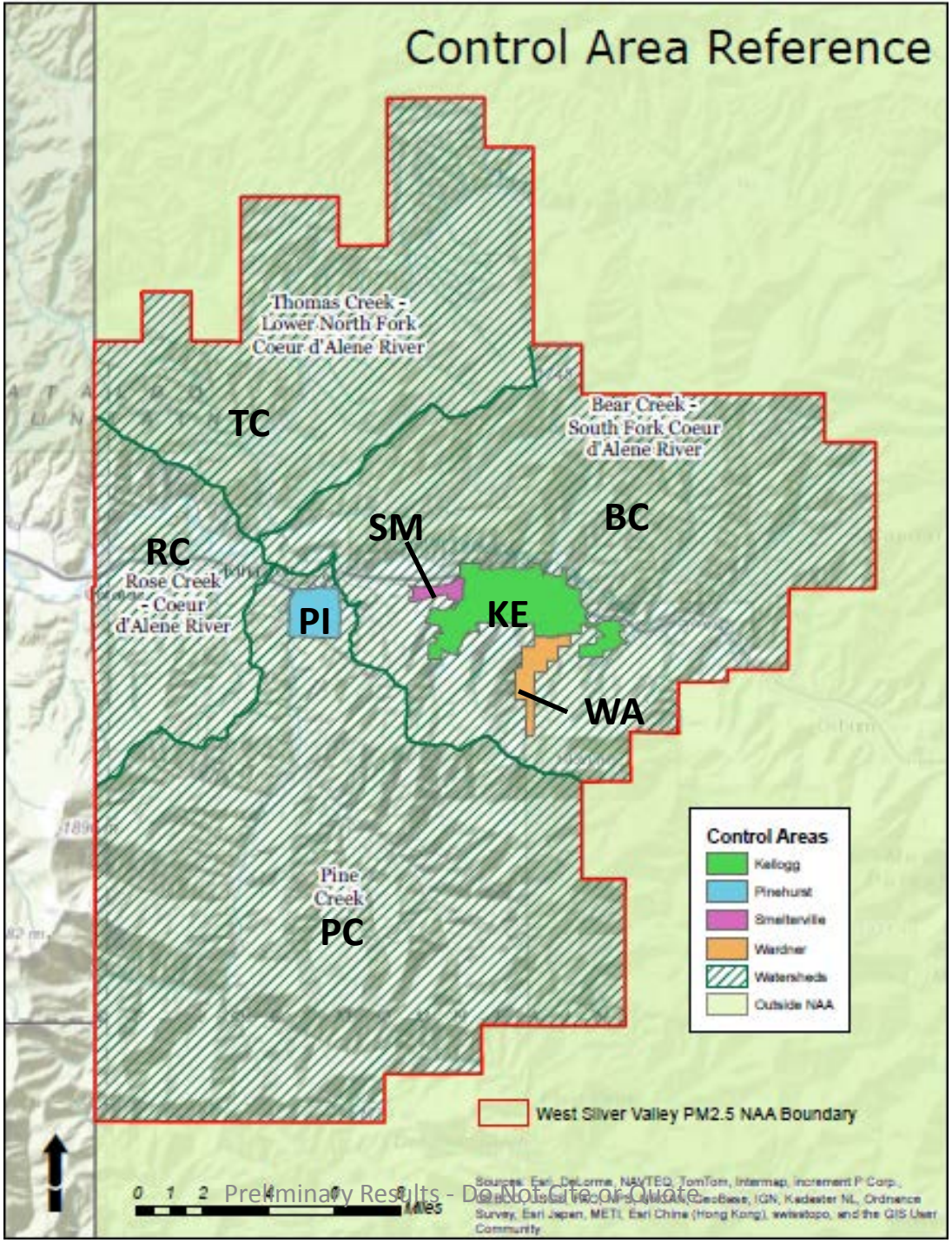
In order to better provide a correlation between emissions and their contribution to measured concentrations at the monitor from these three source types, PMF and an air dispersion model were used to develop what is termed "effective emissions."

Aermod Modeling

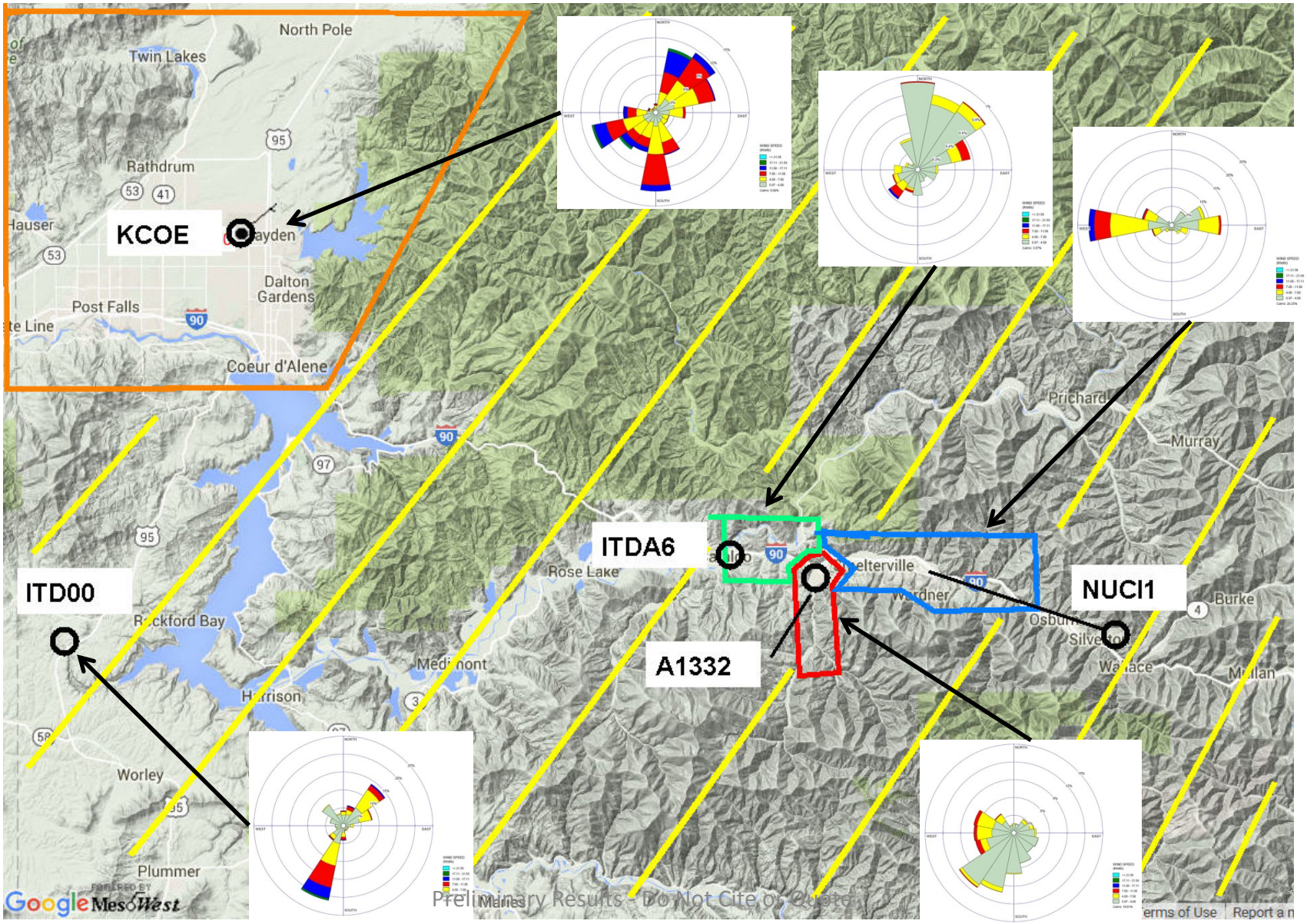
The Roll-Forward Box

The Main East-West Valley

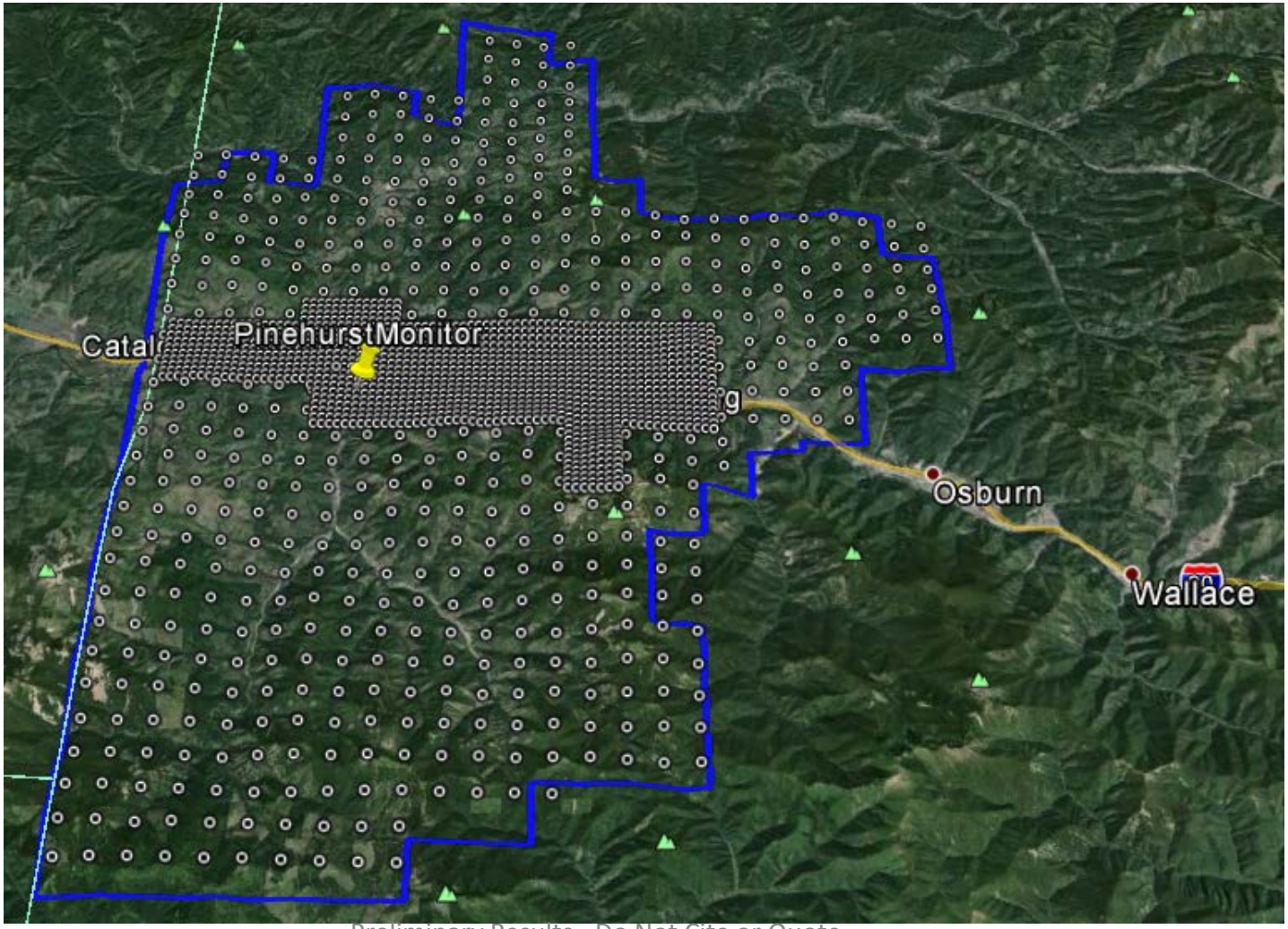




Met Station Applicability Map



AERMOD Receptors (250 m and 1km grids)



Modeling Approach

- Adapted the latest AERMOD to Linux system
- Fully utilized our Linux cluster capacity (running 92 AERMOD runs at the same time)
- Configured the emission sources as detailed as possible
- Used “unit emission” rates in the model
- Applied scaling factor to convert air concentration from unit emissions basis to actual emissions
- Conducted more than 30,000 AERMOD runs

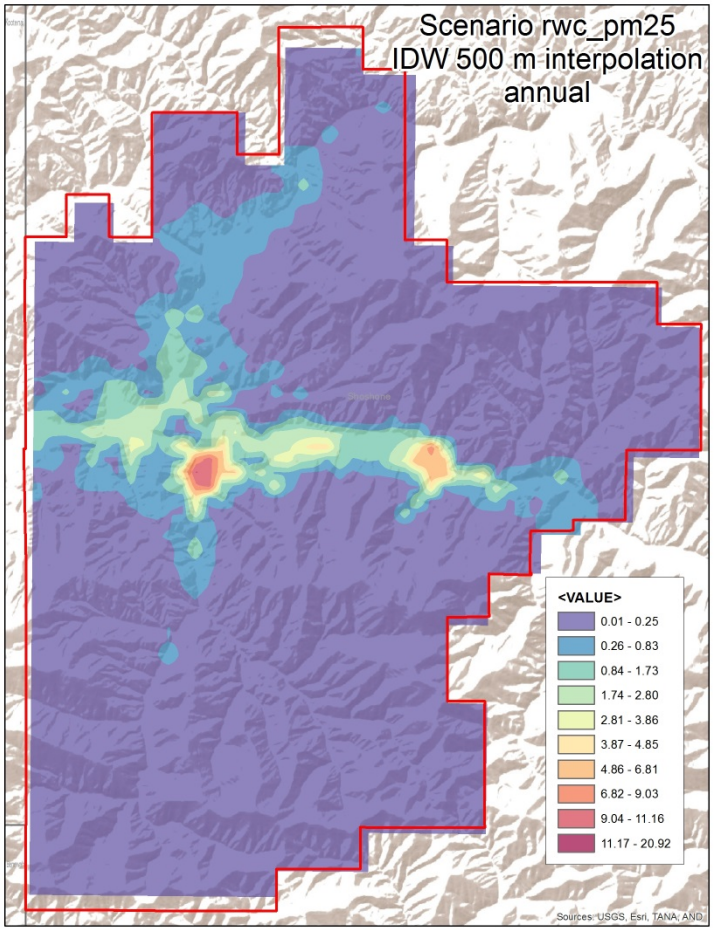
Source Categories Modeled

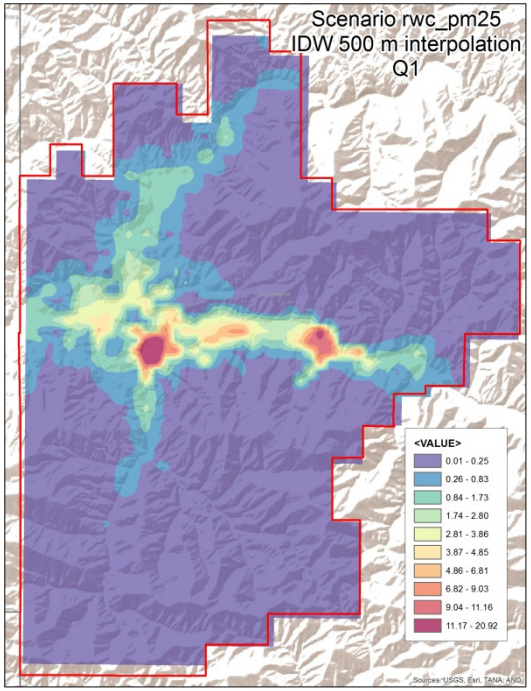
- Point Sources
  - Include large sources outside of Non-Attainment Area
  - 7 Small point sources inside NAA all < 3 tpy $PM_{2.5}$

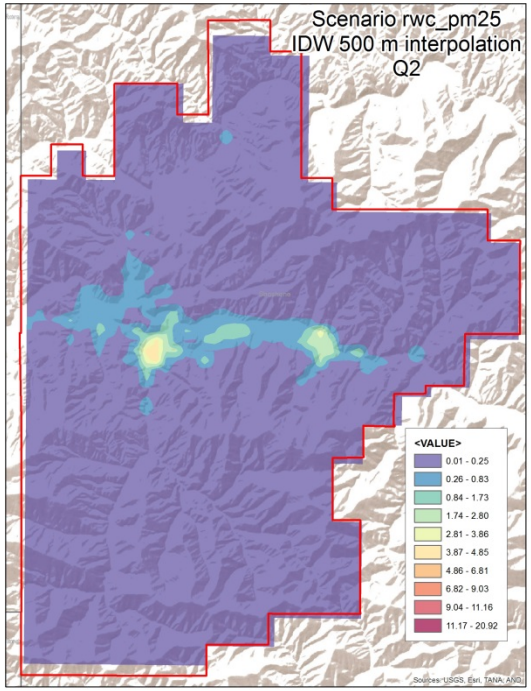
- Residential Wood Combustion
- Residential Open Burning
- On-road Vehicles
  - Emissions emitted by running vehicle on the road
  - Emissions emitted by parked vehicle (off-network)
  - Paved road dust
- Prescribed Fires
  - Include prescribe fires outside of Non Attainment Area

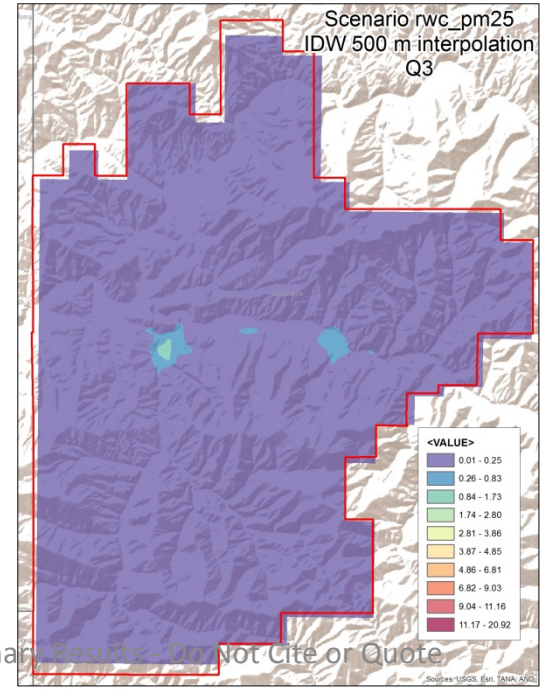
Note:
For sources outside of NAA, only large point sources and prescribe fires were modeled

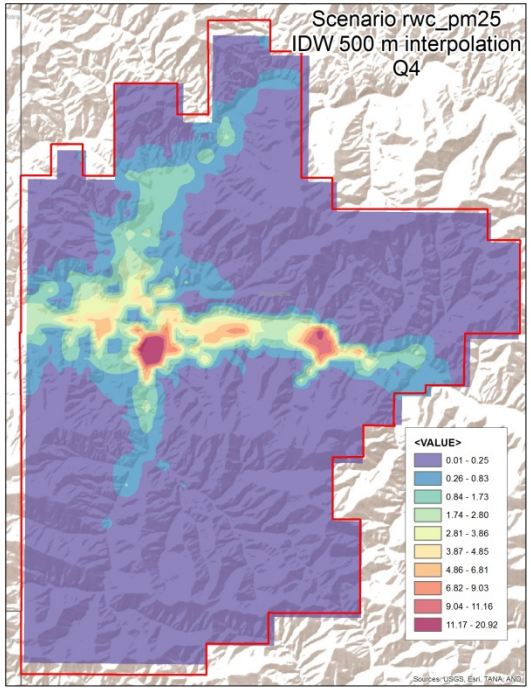
Scenario: rwc_pm25
IDW 500 m interpolation



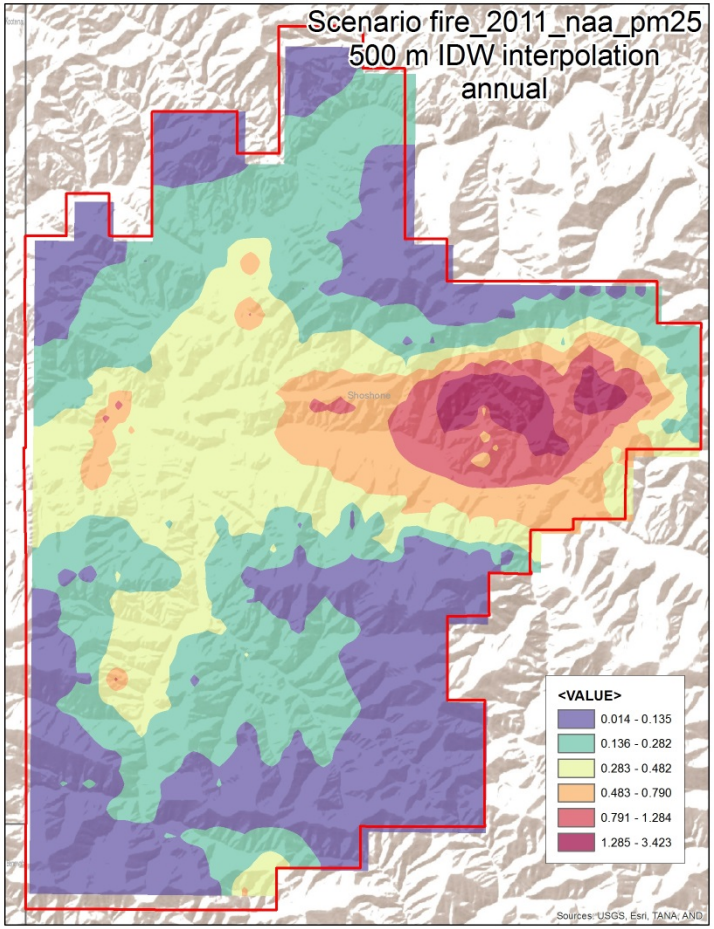


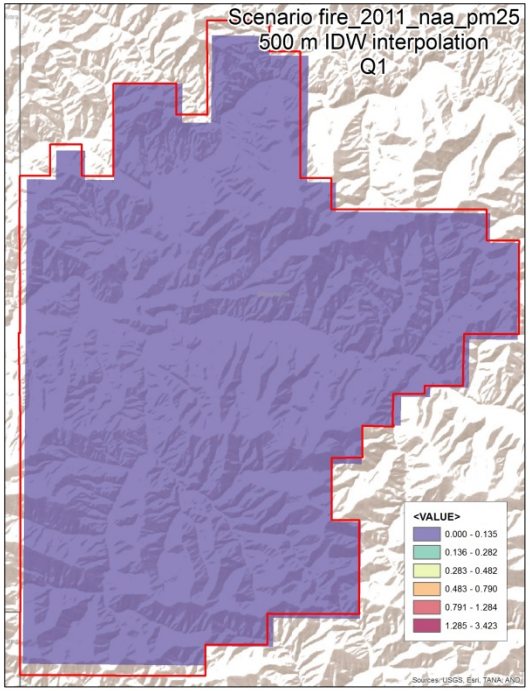


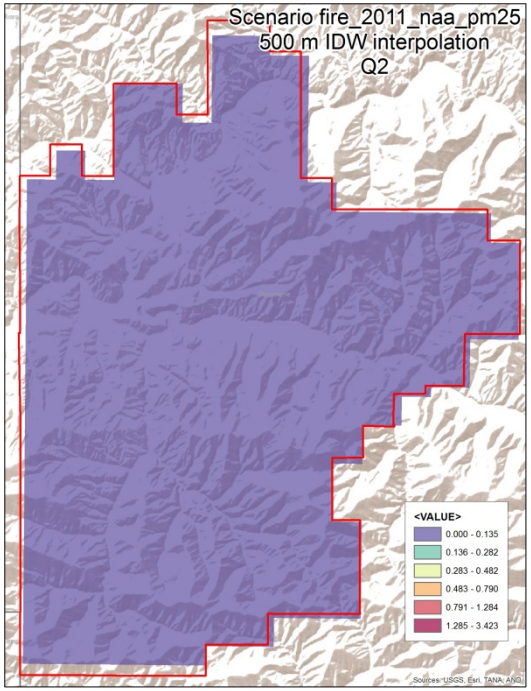


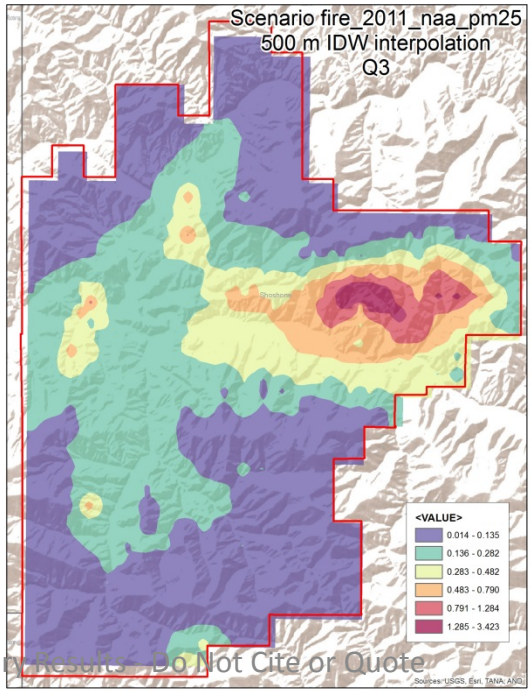


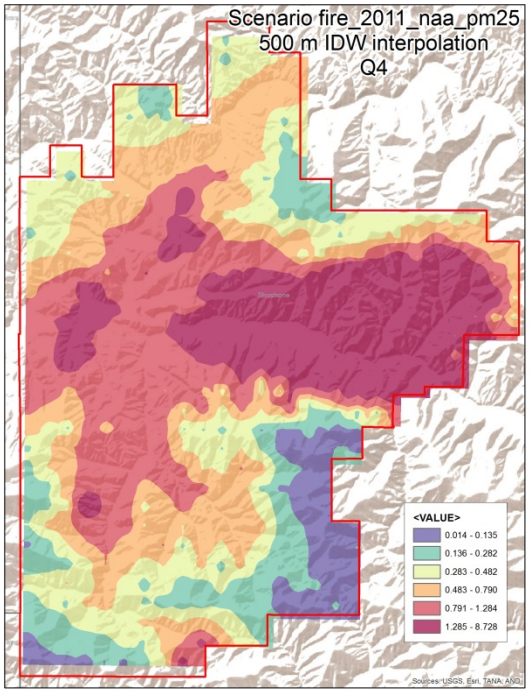
Scenario: fire_2011_naa_pm25 IDW 500 m interpolation



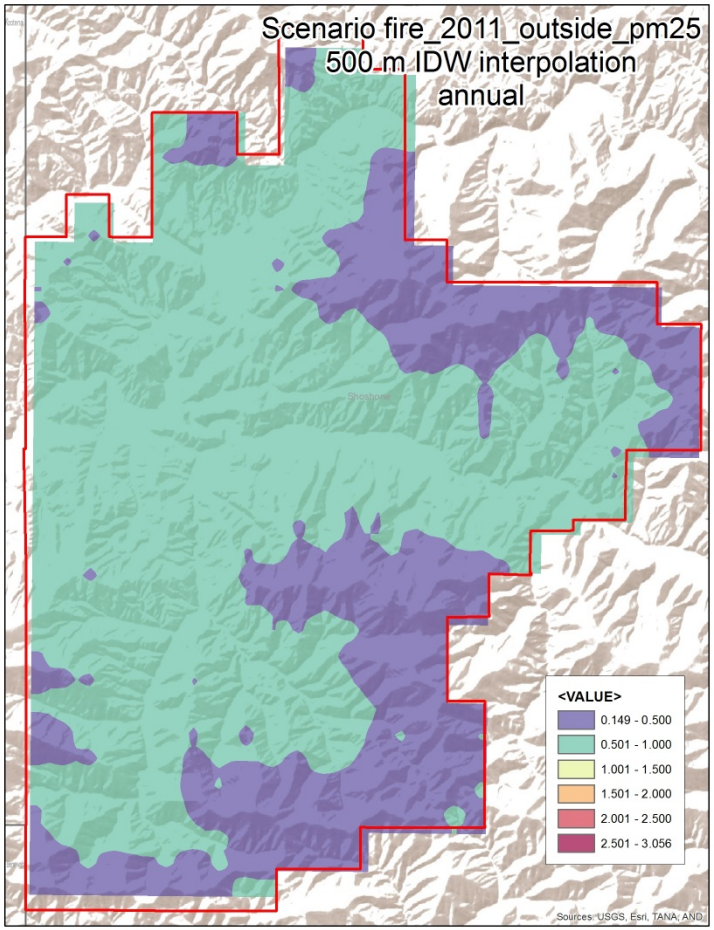


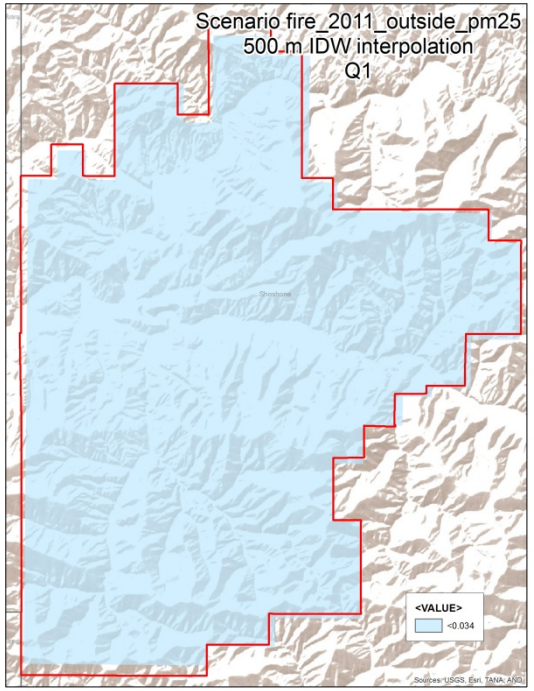


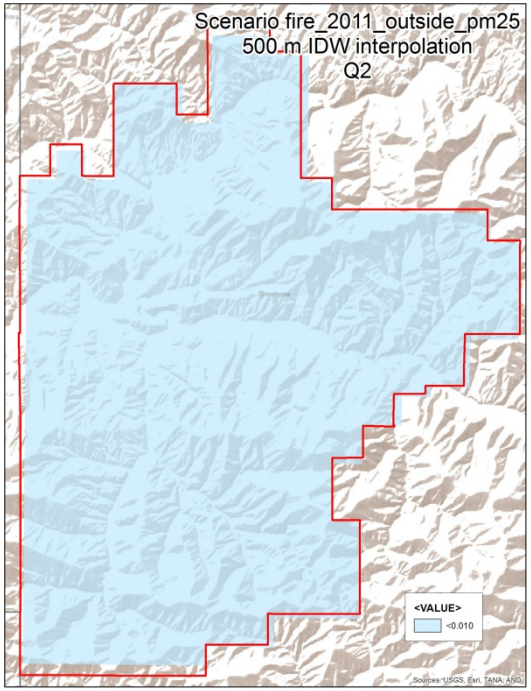


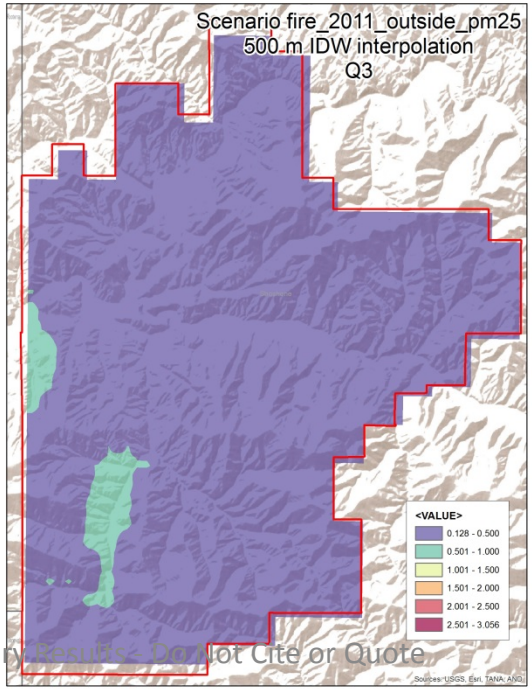


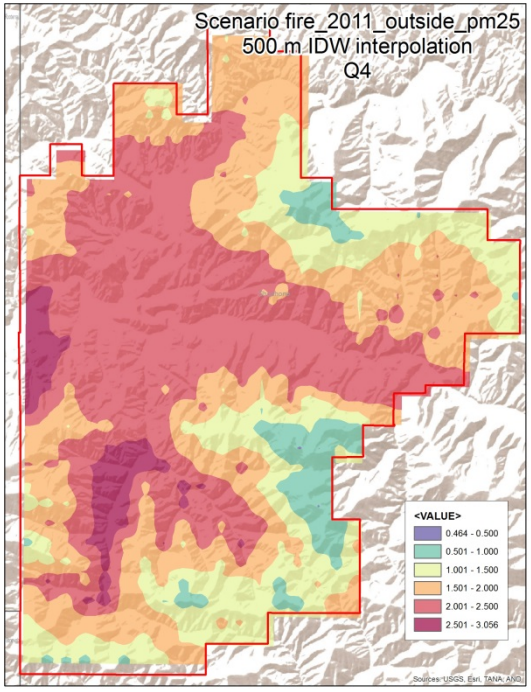
Scenario: fire_2011_outside_pm25 IDW 500 m interpolation



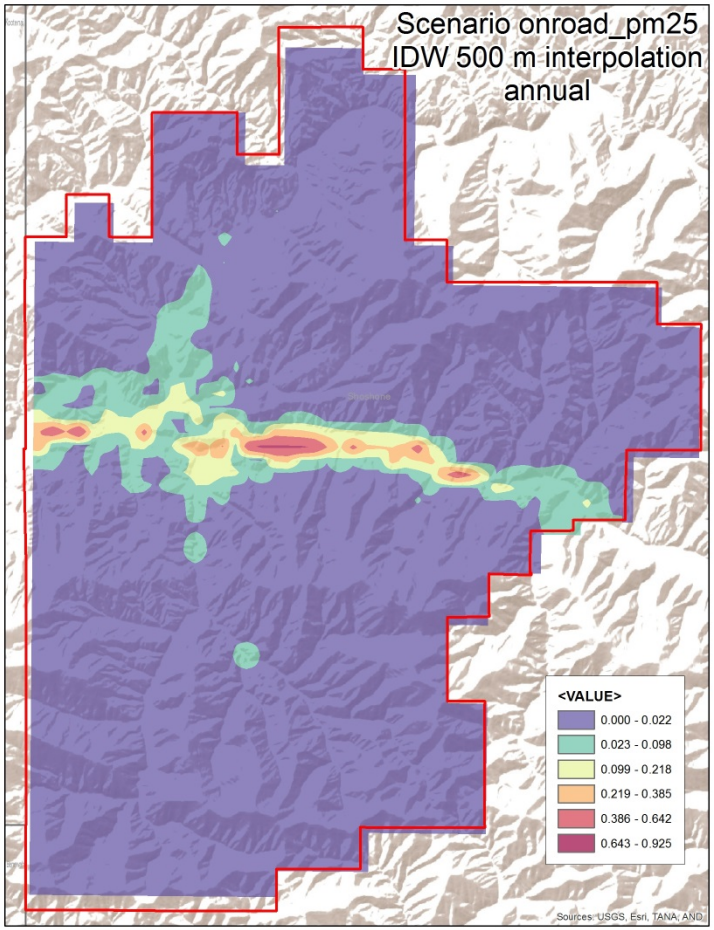


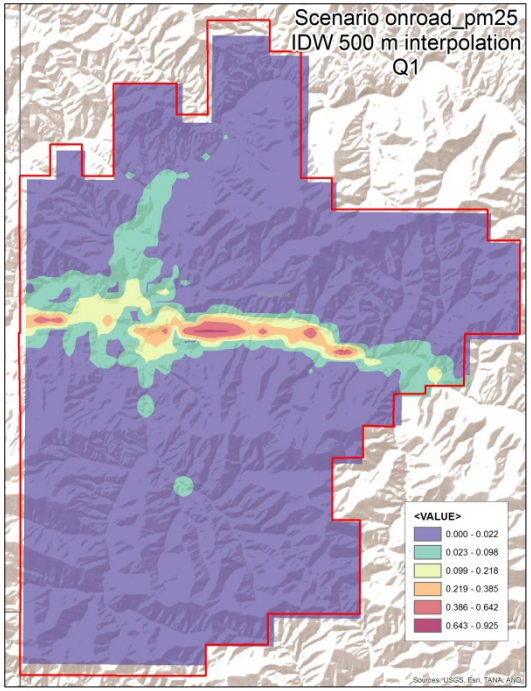


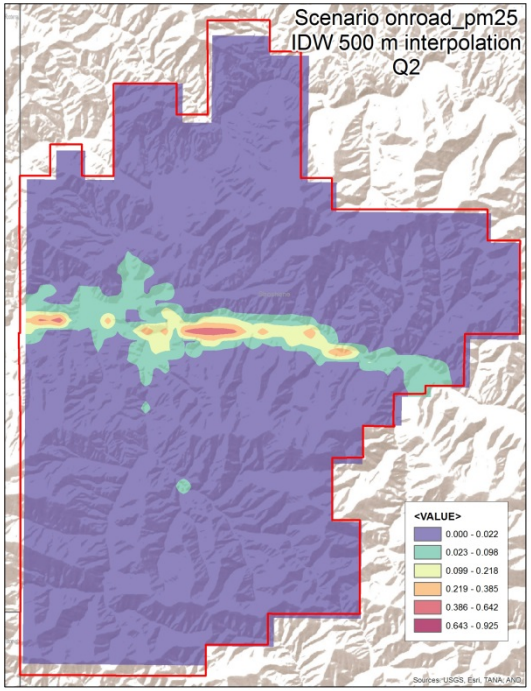


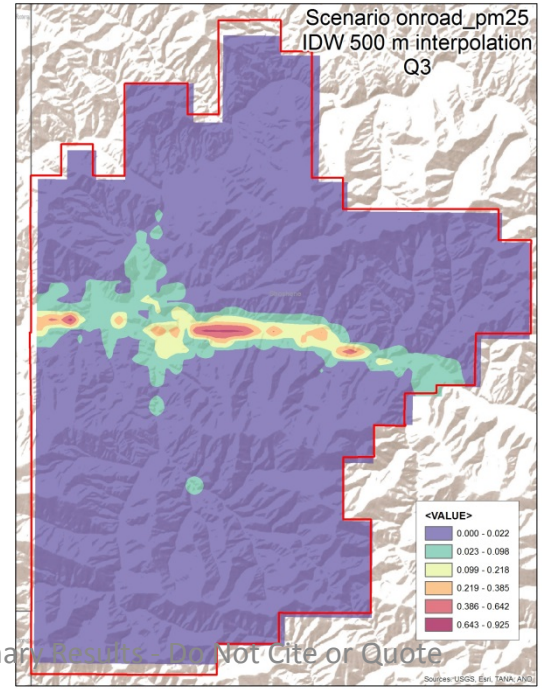


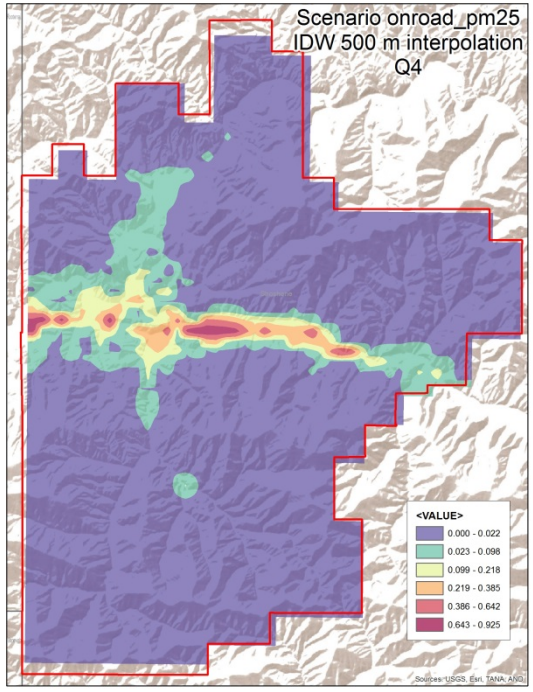
Scenario: onroad_pm25
IDW 500 m interpolation



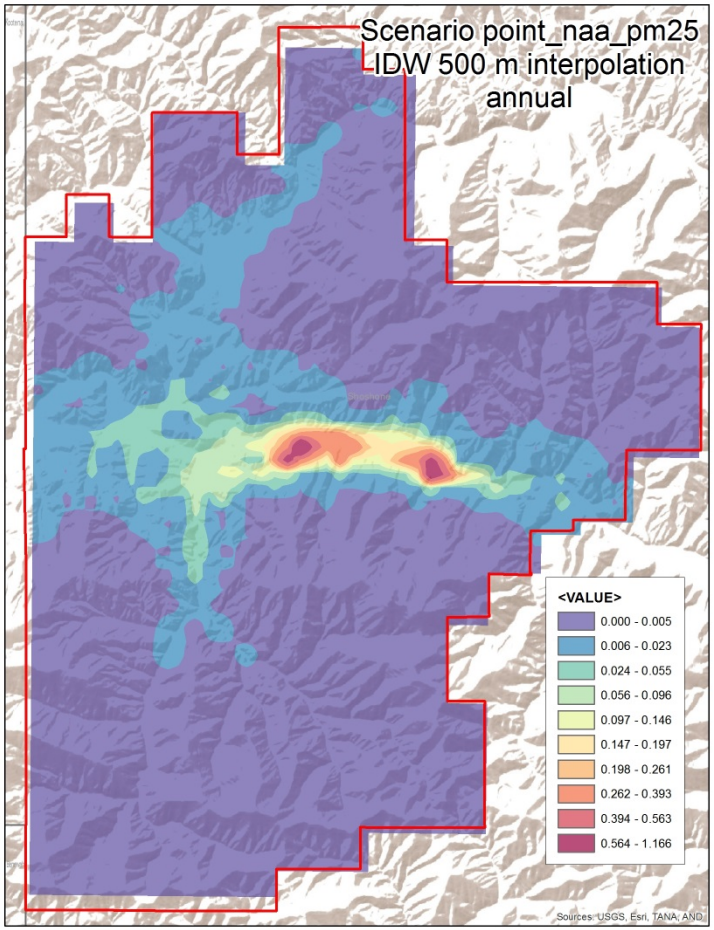


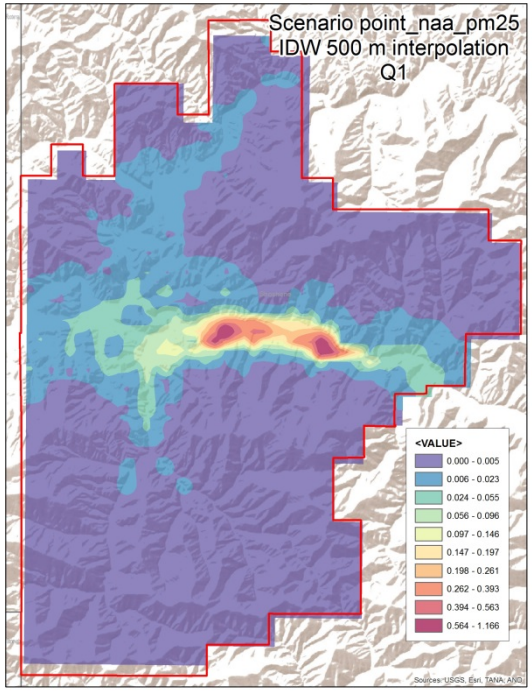


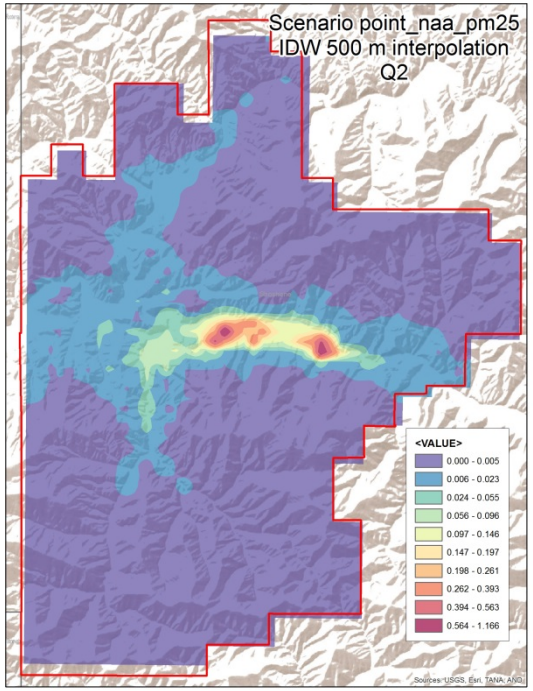


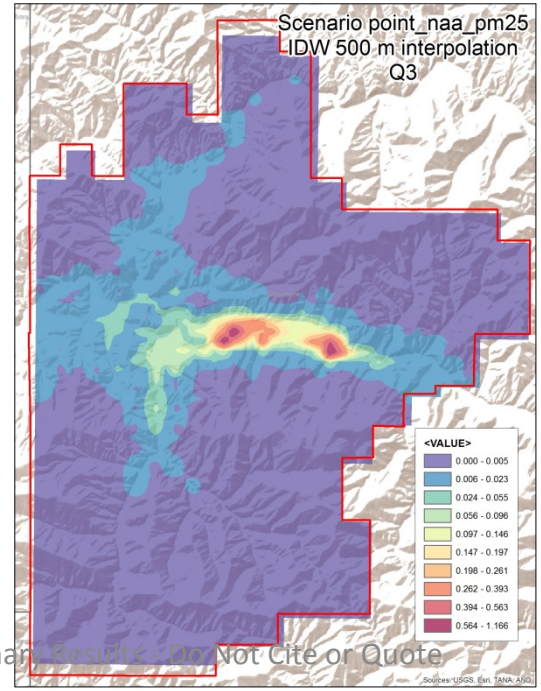


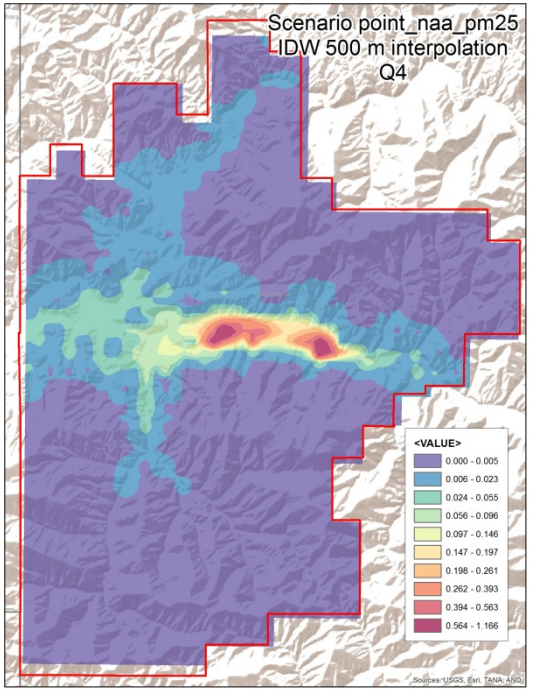
Scenario: point_naa_pm25 IDW 500 m interpolation



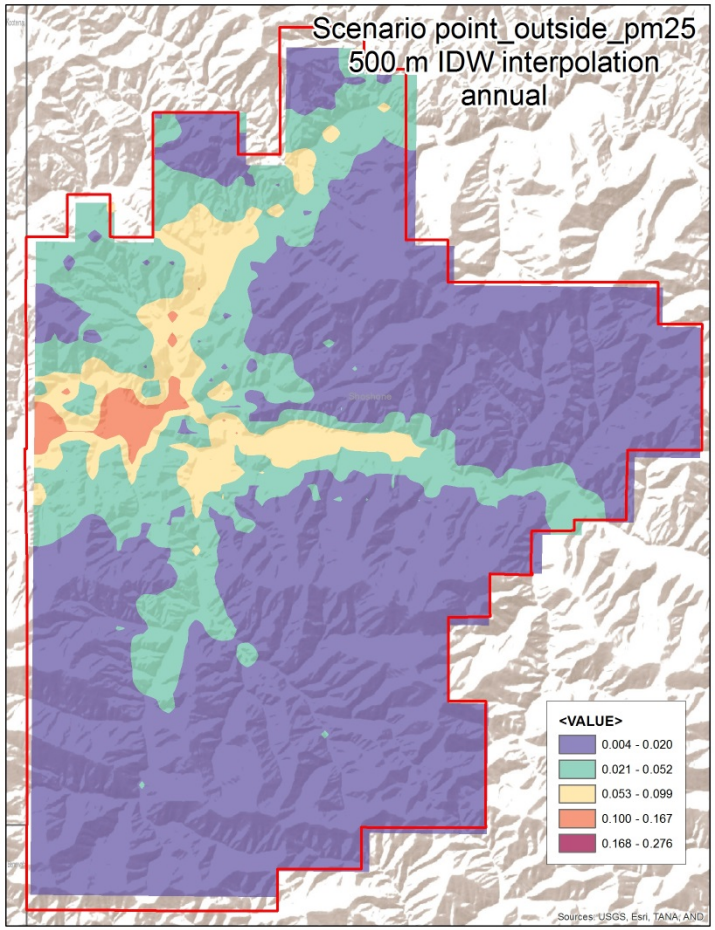


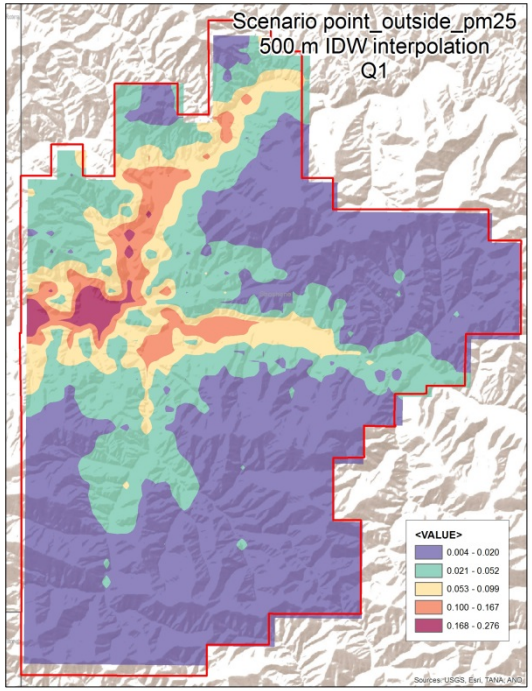


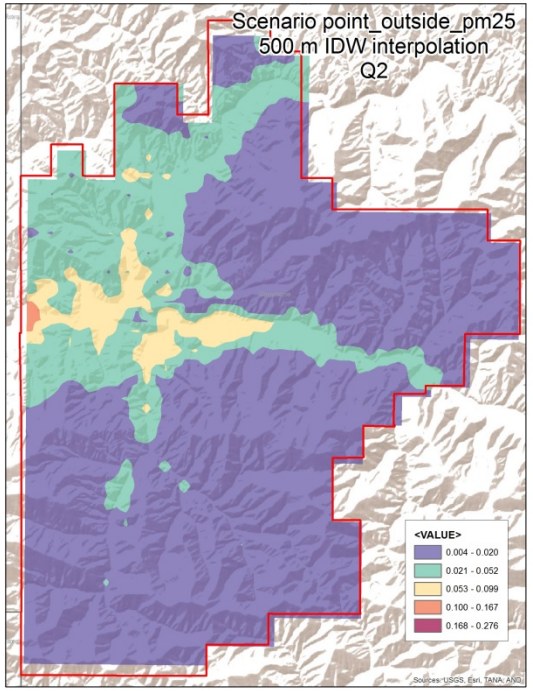


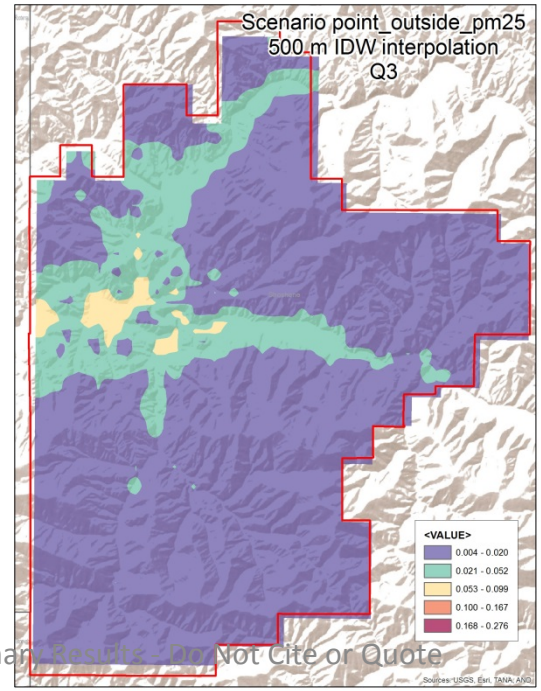


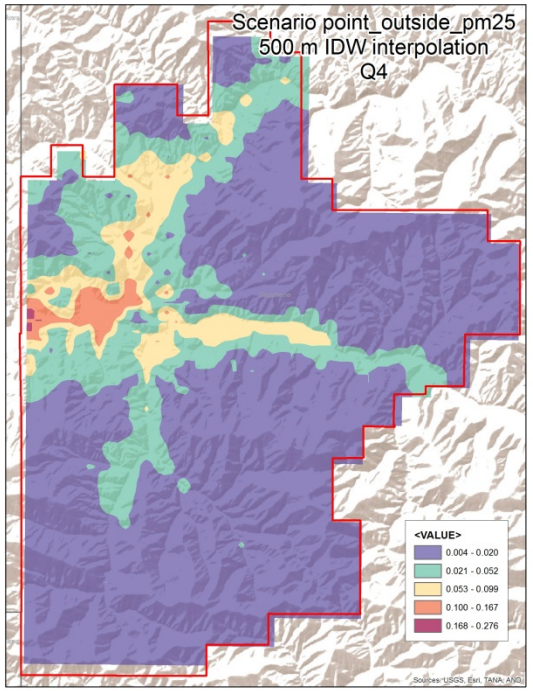
Scenario: point_outside_pm25 IDW 500 m interpolation



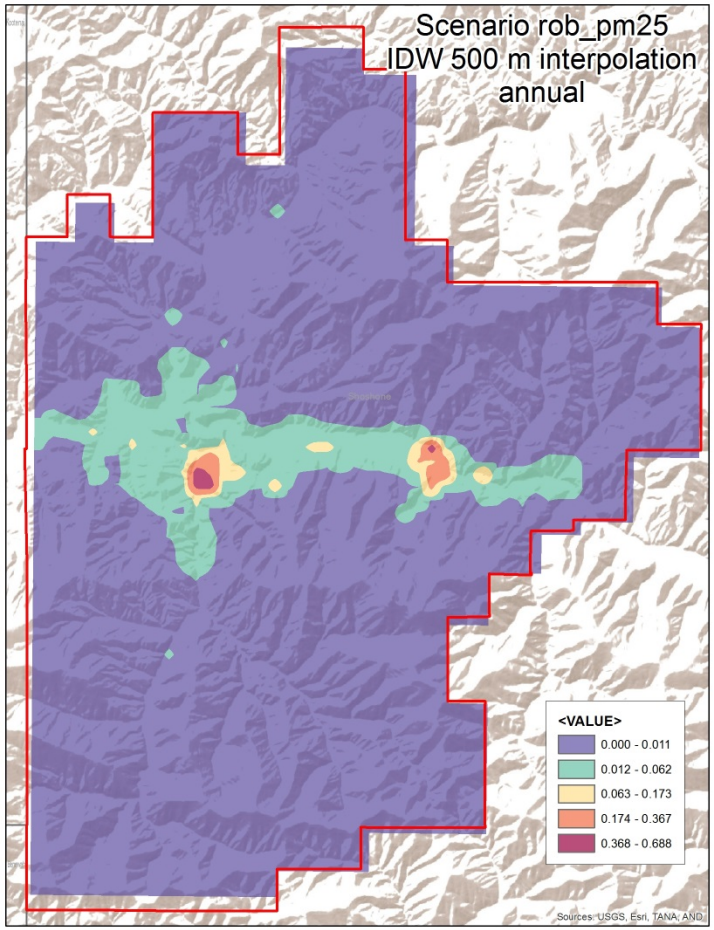


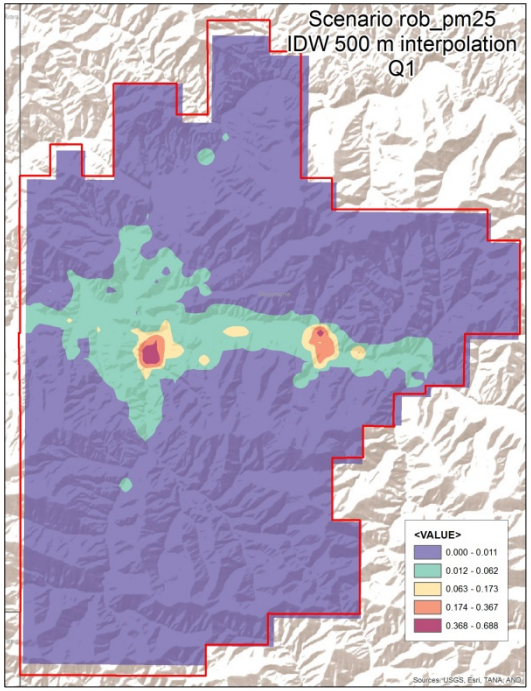


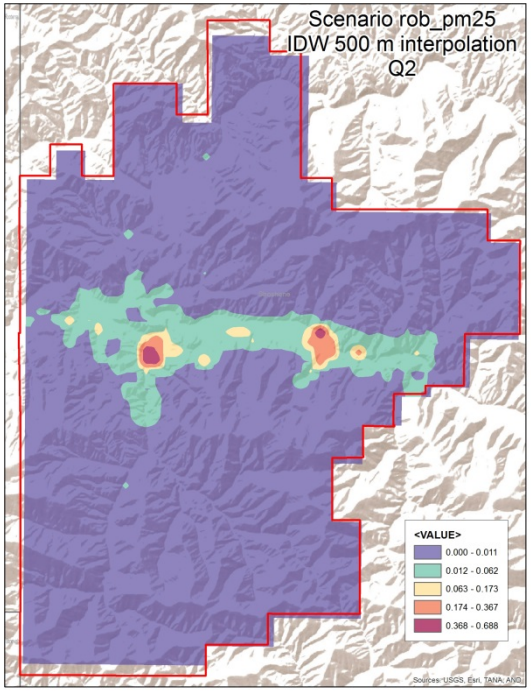


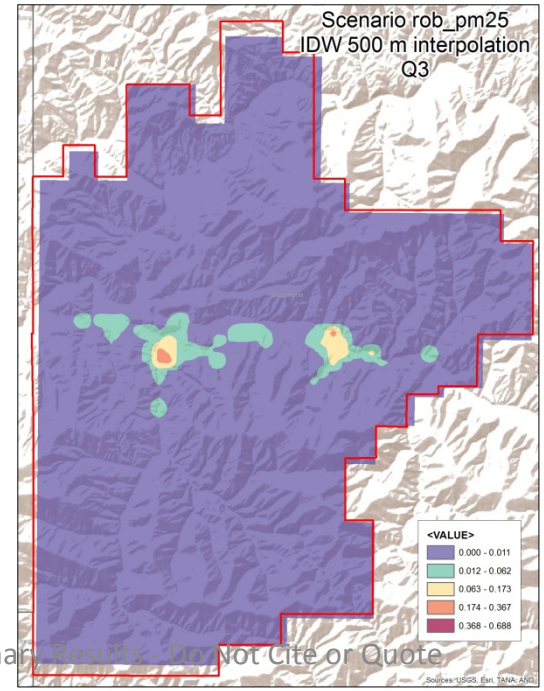


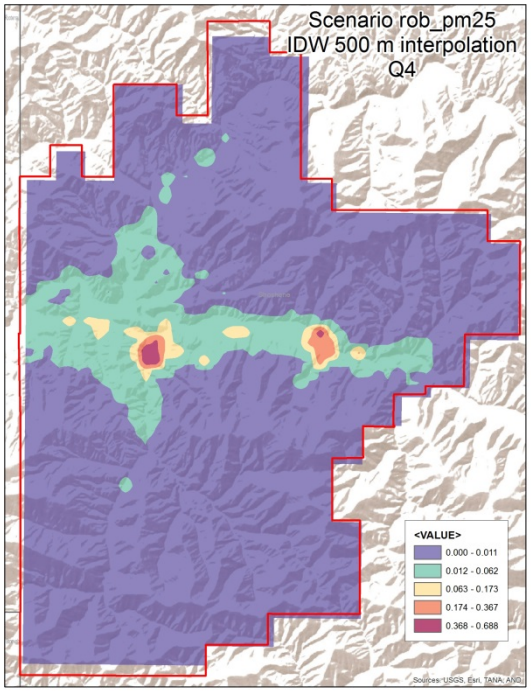
Scenario: rob_pm25
IDW 500 m interpolation











Scenario: 2013_pm25
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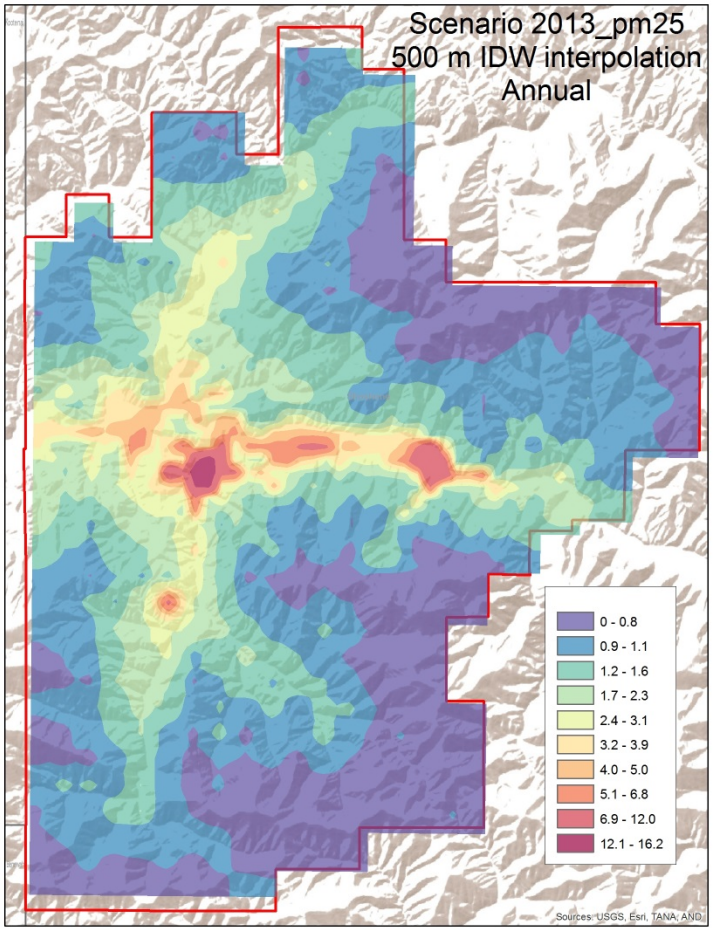
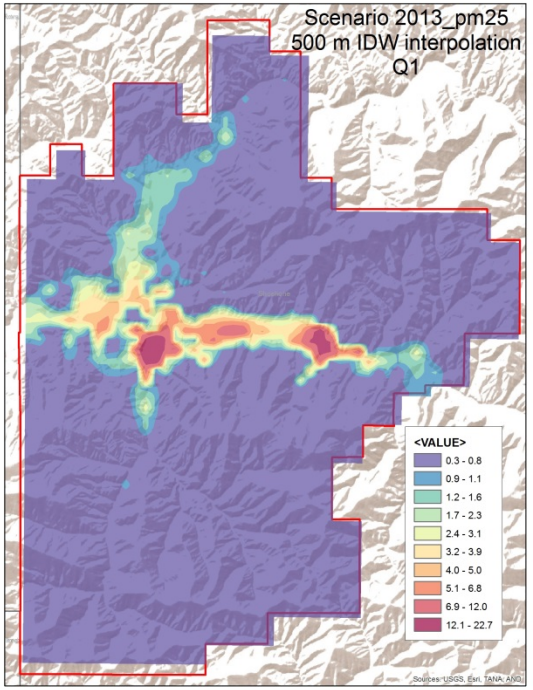
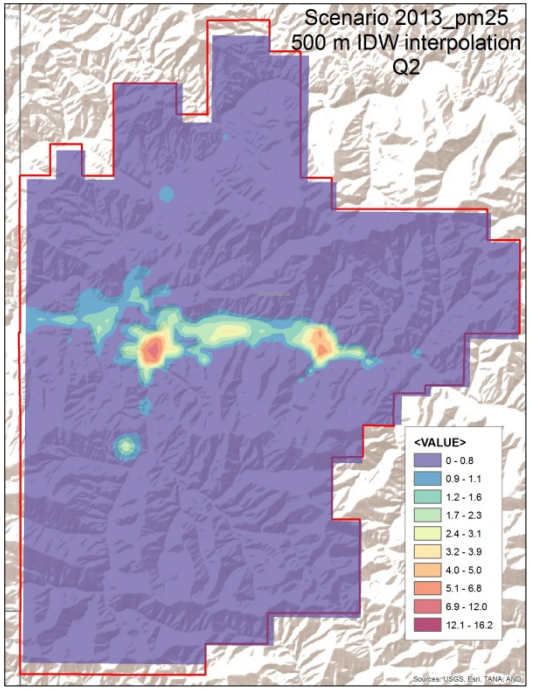
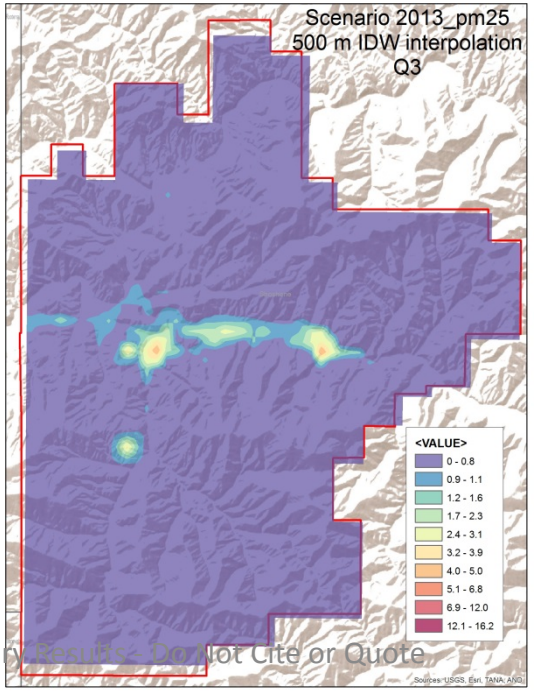
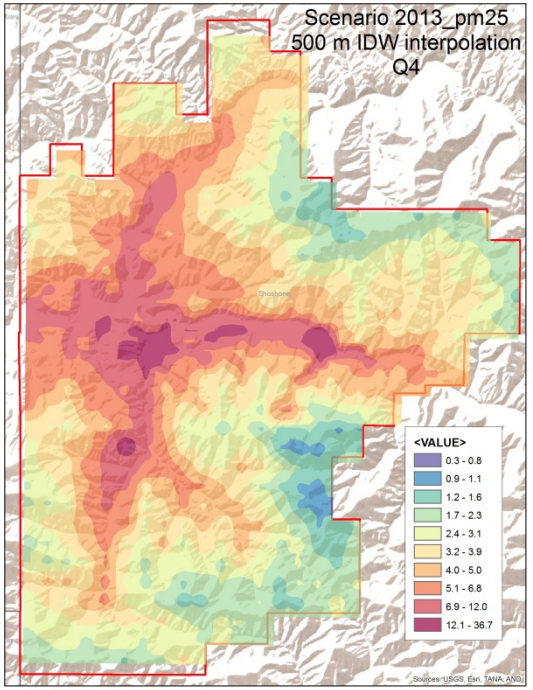




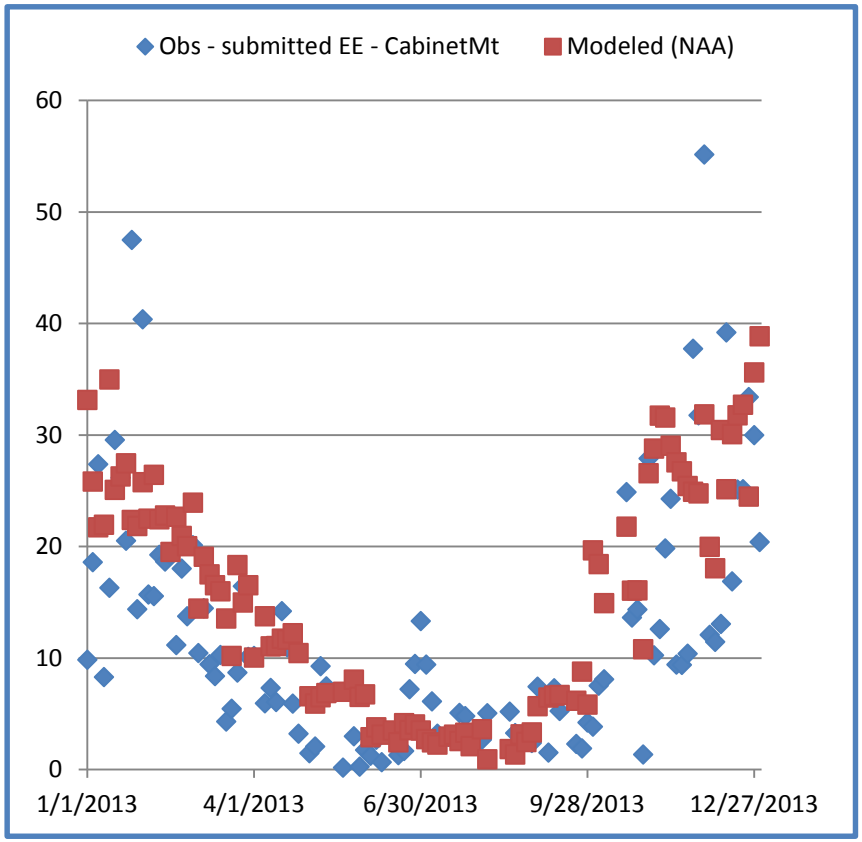




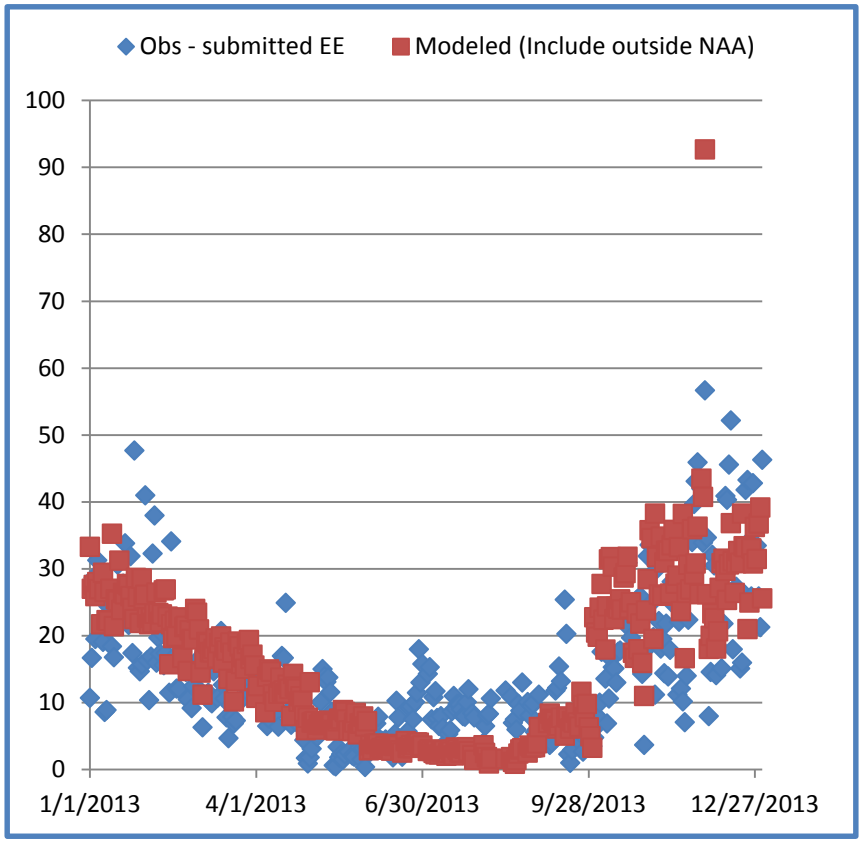


Daily Time Series

Inside NAA

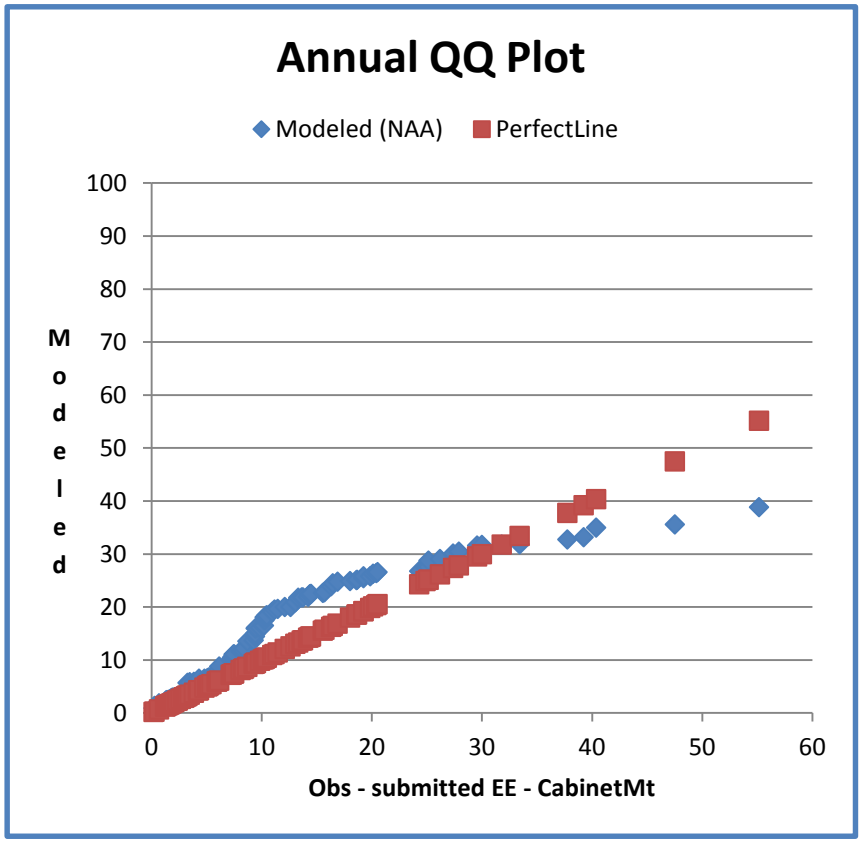


Inside and Outside NAA

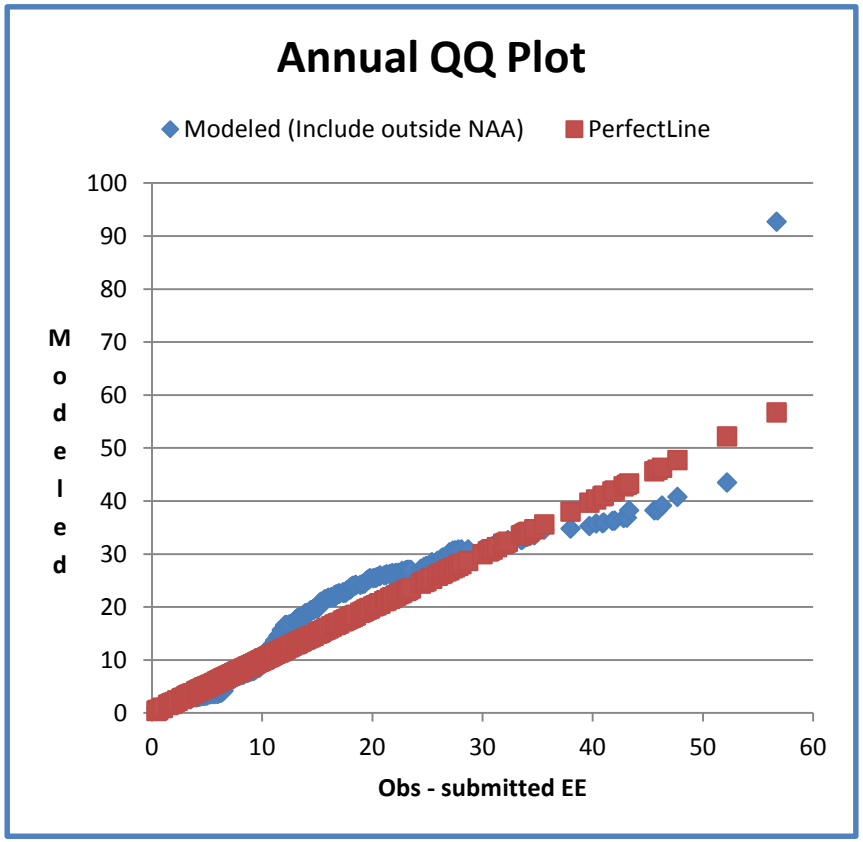


Annual QQ Plot

Inside NAA

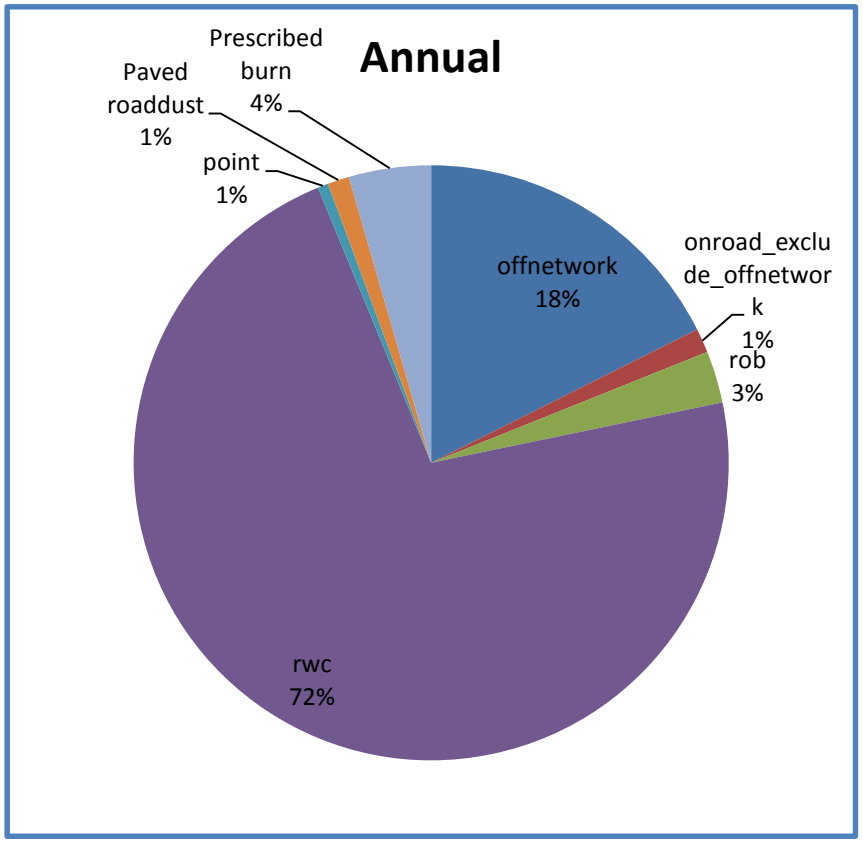


Inside and Outside NAA



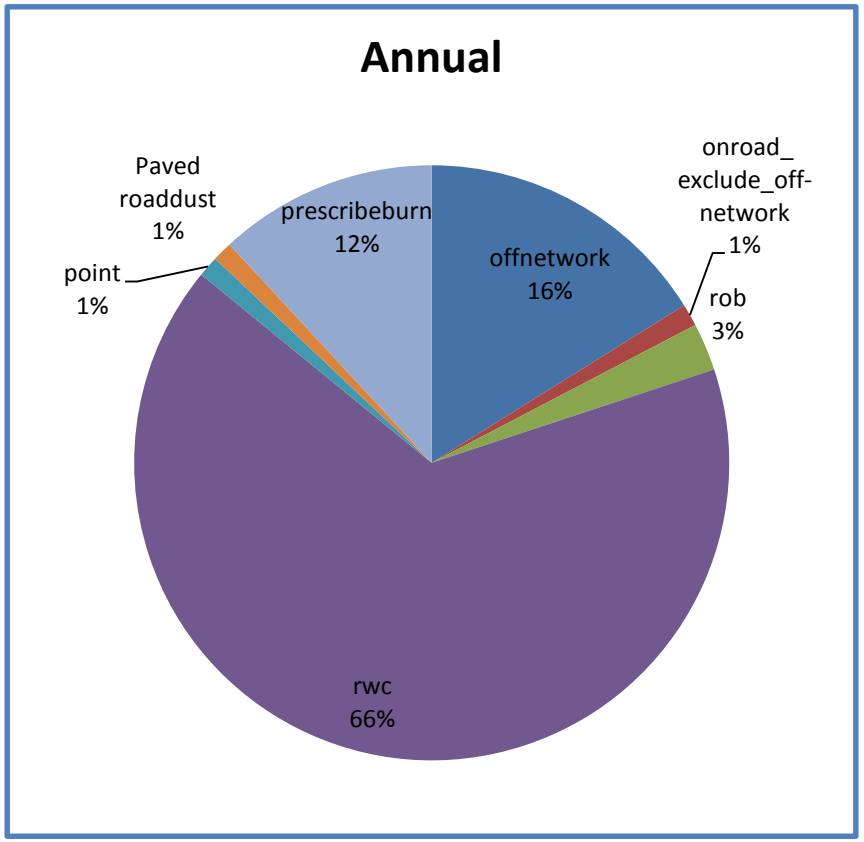
Annual Contribution Percentage By Source

Inside NAA



Compare to Urban Increment

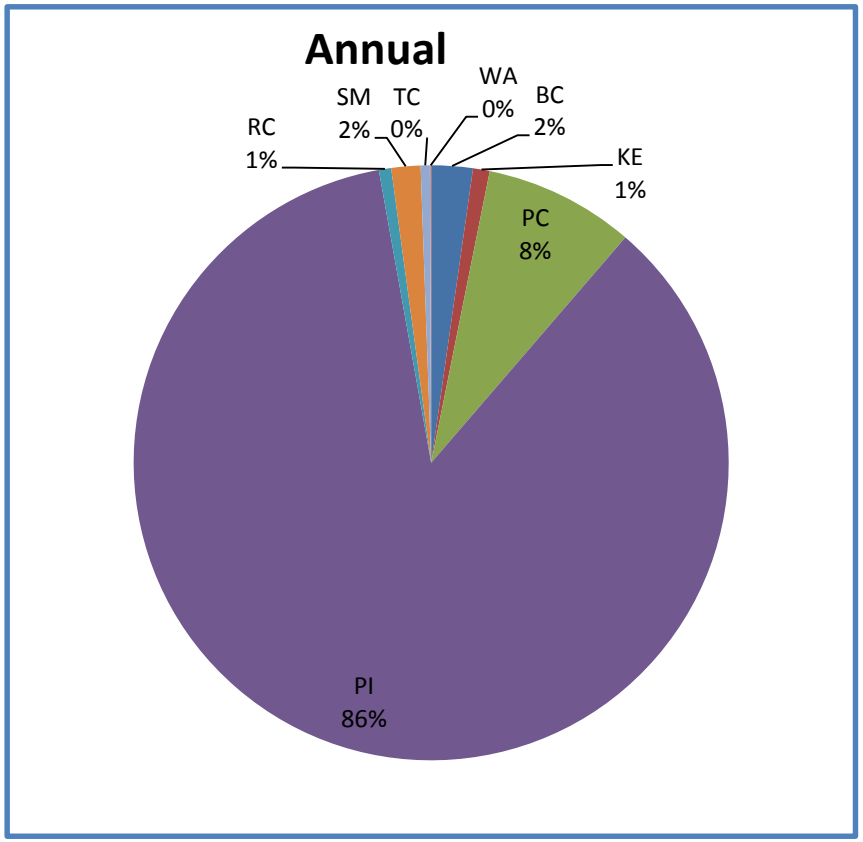
Inside and Outside NAA



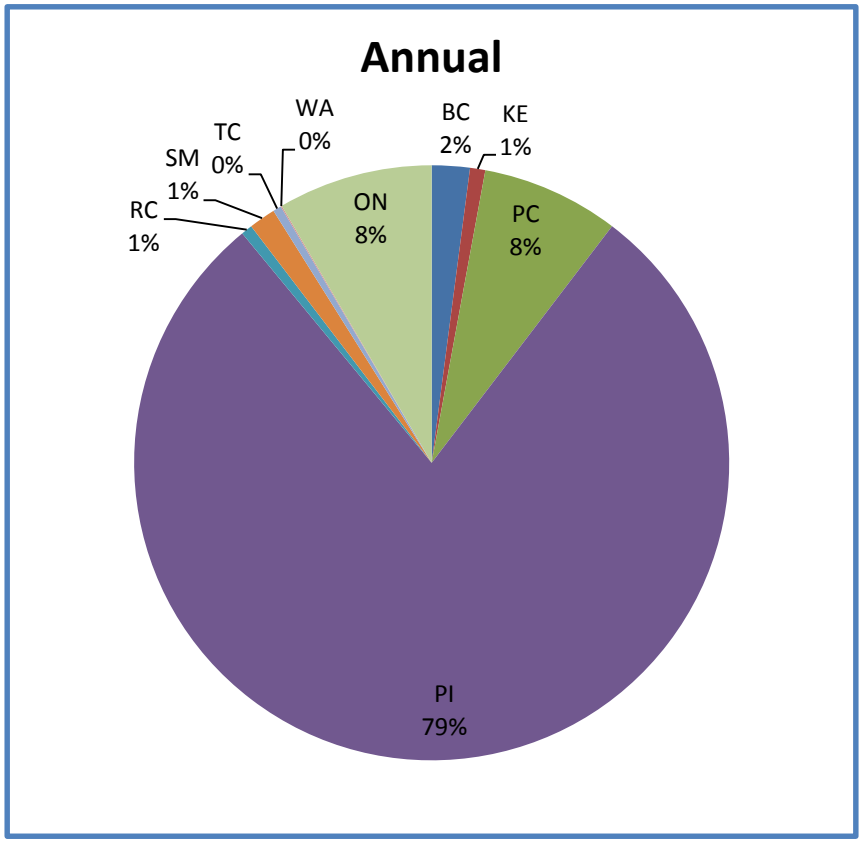
Compare to total PM2.5

Annual Contribution Percentage by Control Area

Inside NAA



Inside and Outside NAA

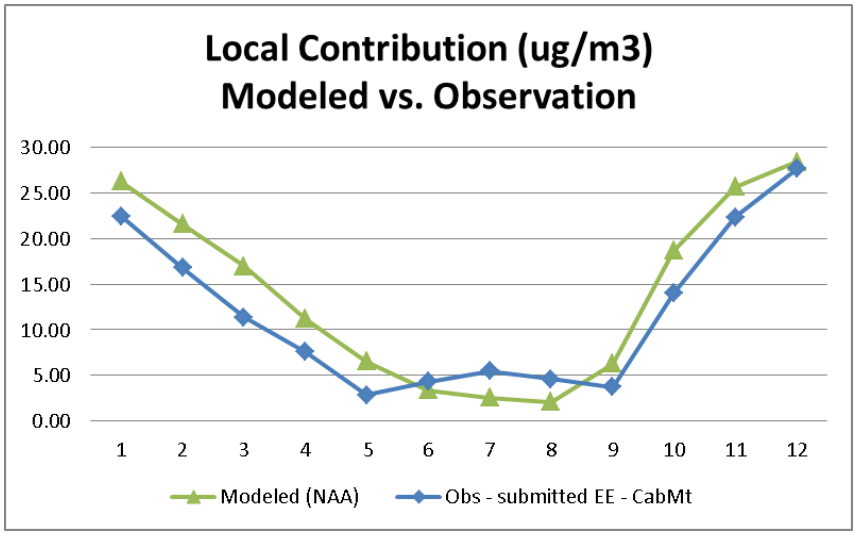


Compare to Urban Increment

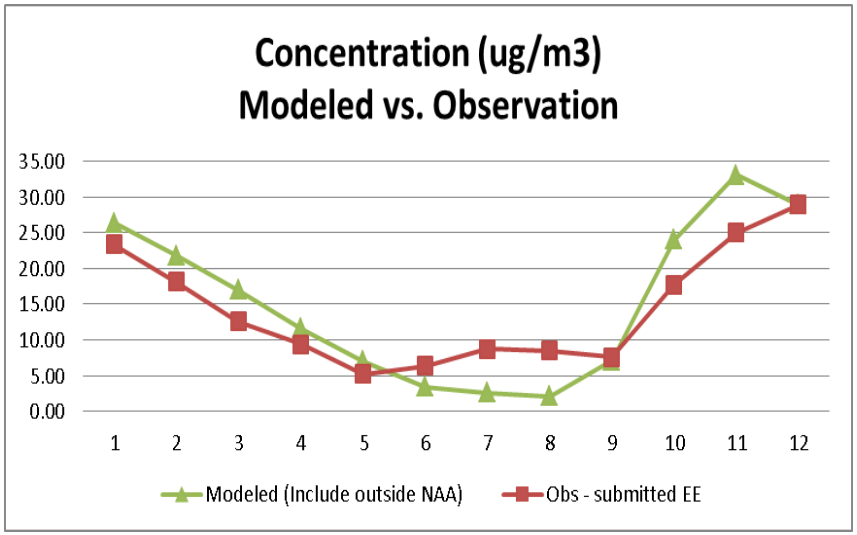
Compare to total PM2.5

Monthly Concentration

Inside NAA

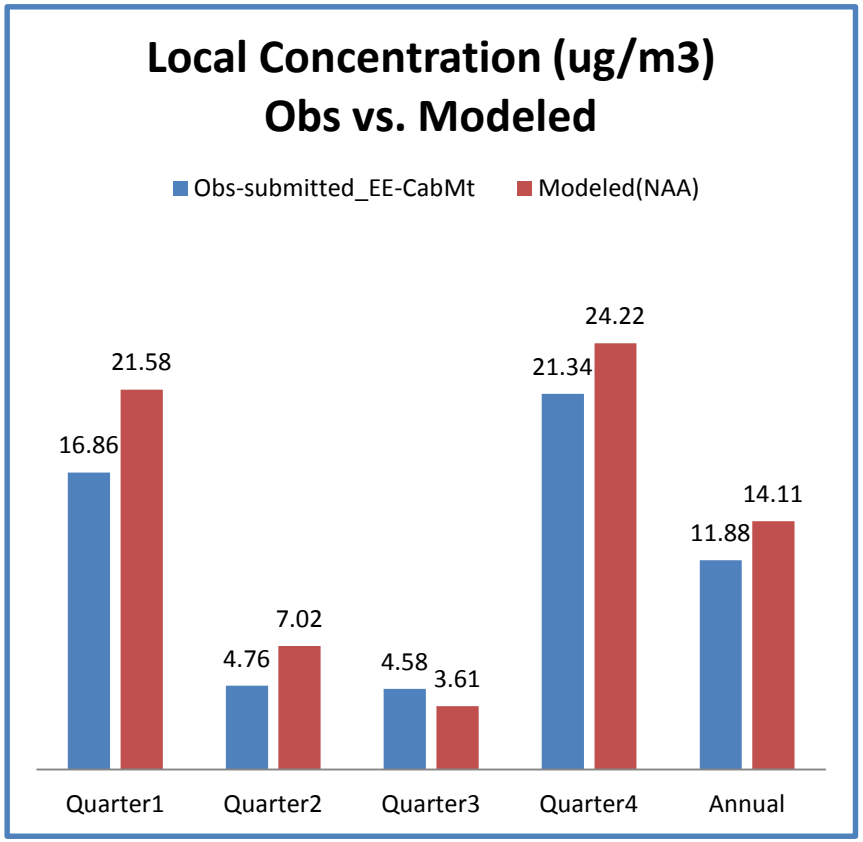


Inside and Outside NAA

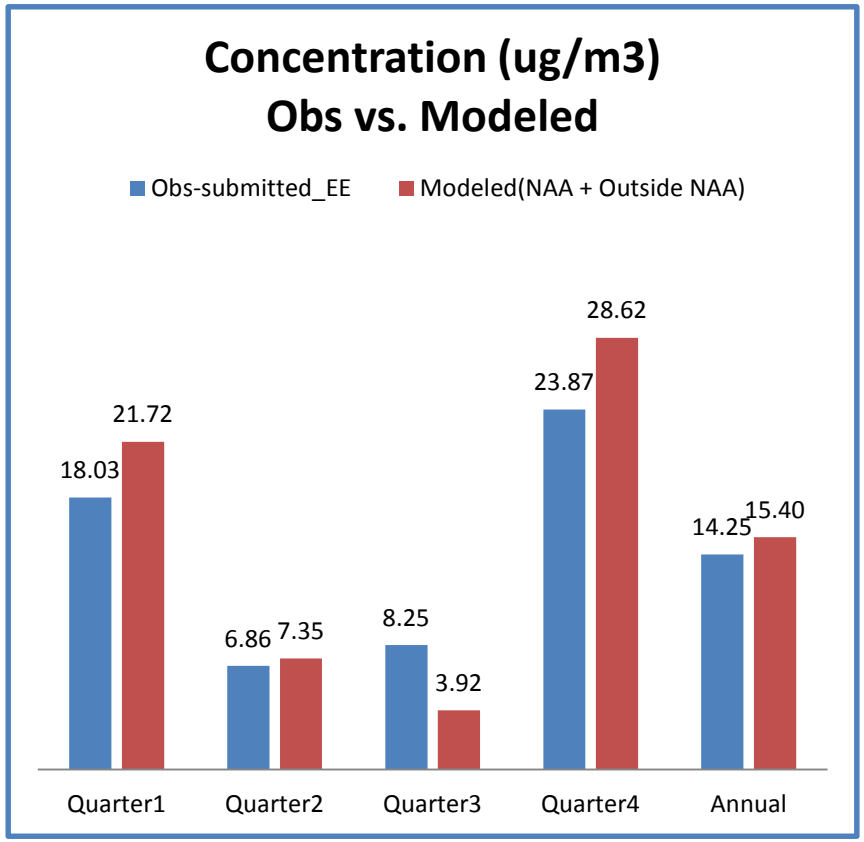


Quarterly and Annual Concentration

Inside NAA

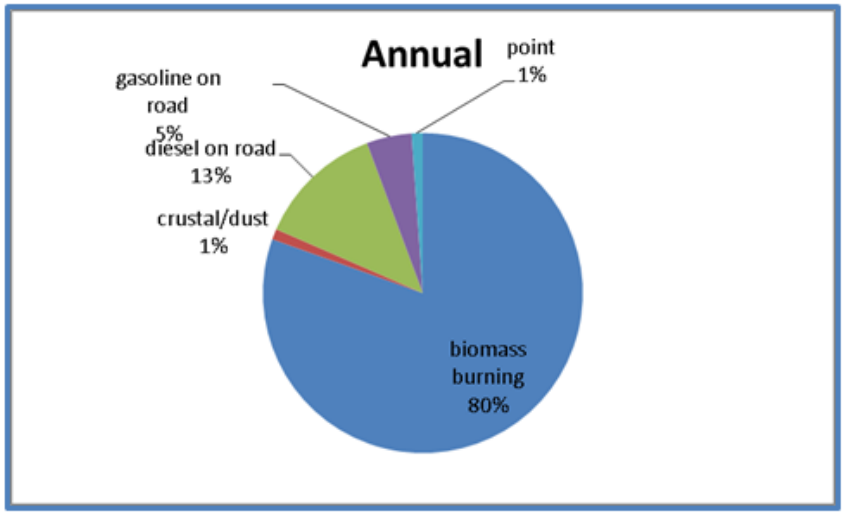


Inside and Outside NAA

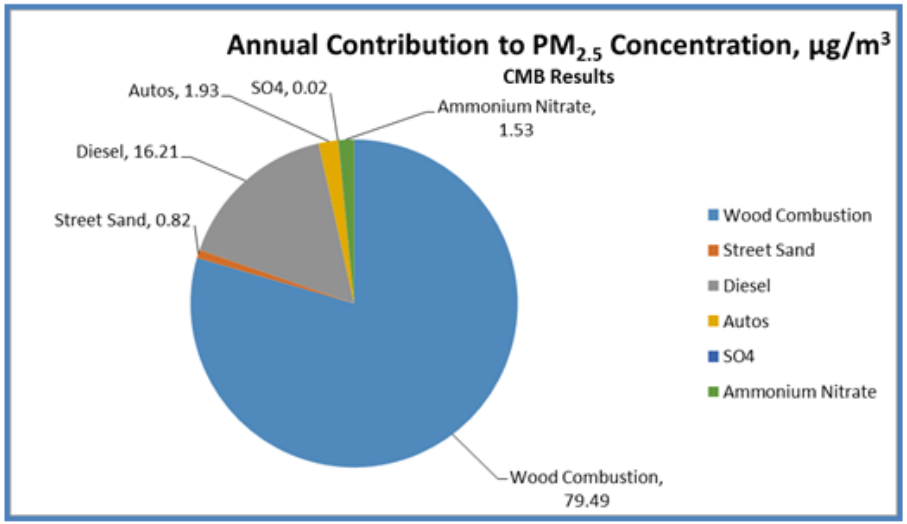


Comparison - Annual

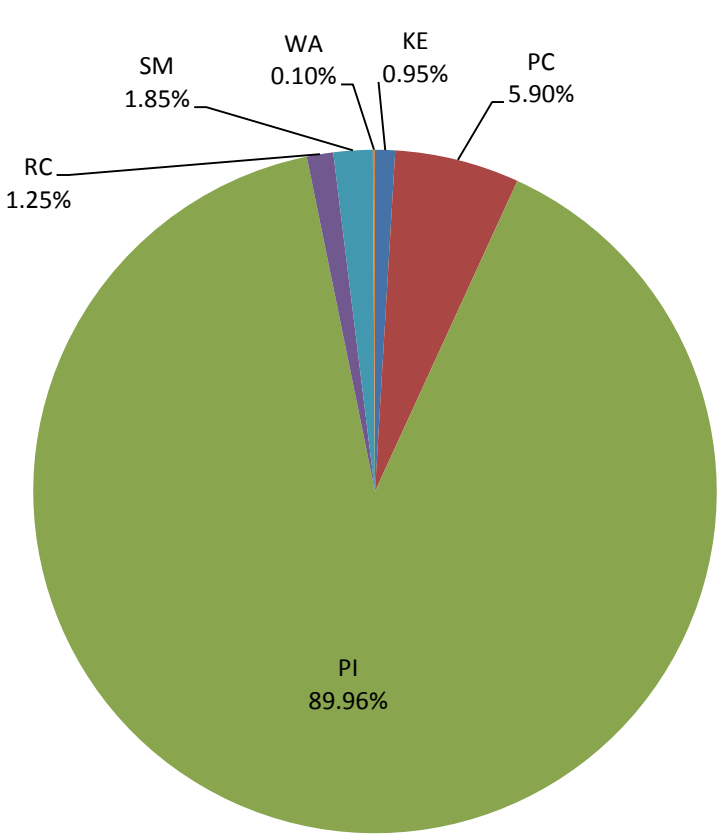
Modeled



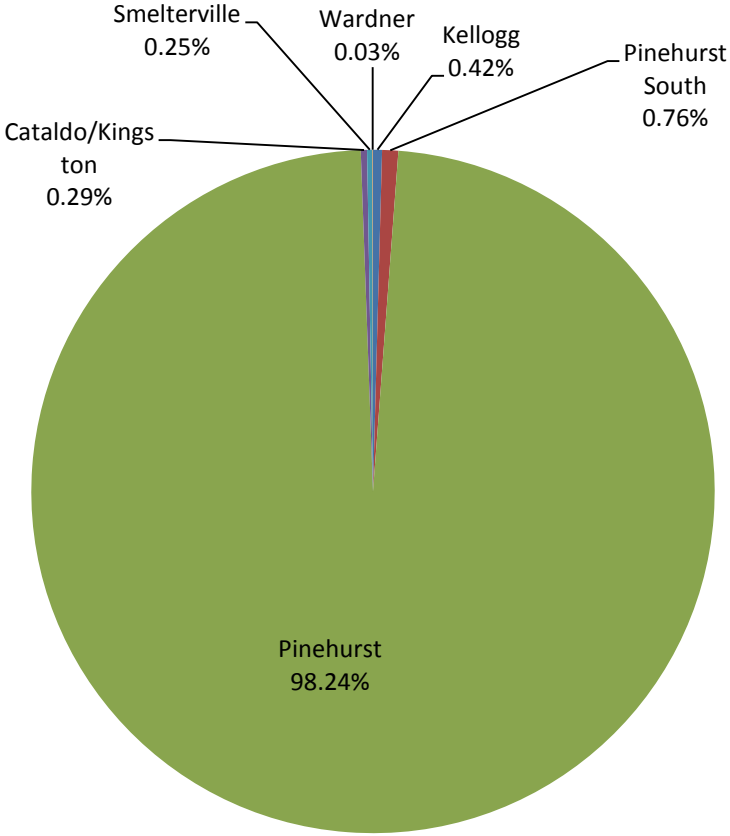
U of M CMB



Approximate AERMOD-CALPUFF comparison: RWC Impacts from Different Areas



AERMOD Contributions



Calpuff Contributions

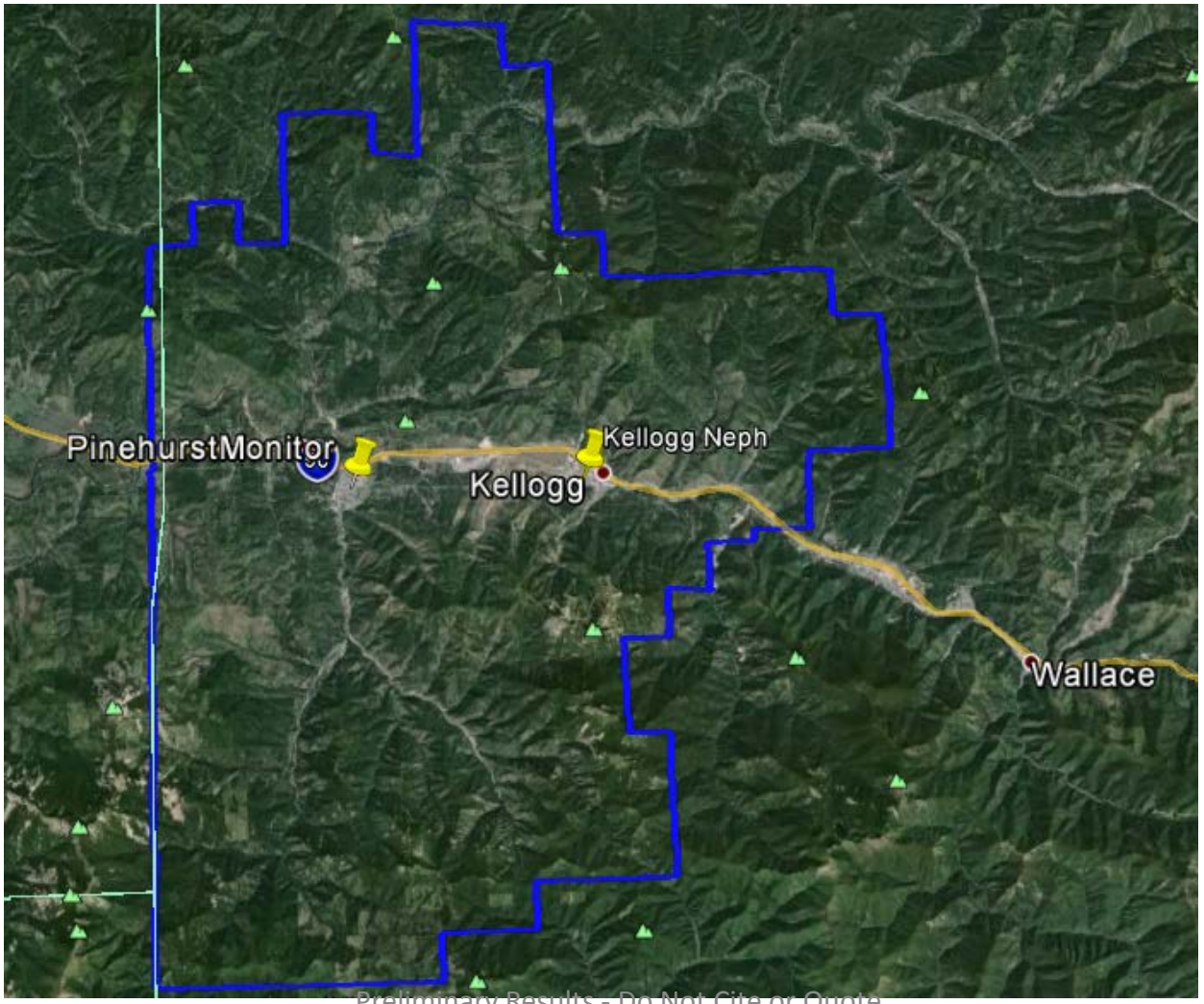
Pinehurst Monitor
vs.
Kellogg nephelometer

Unmonitored Area Analysis

Pinehurst PM2.5 SIP

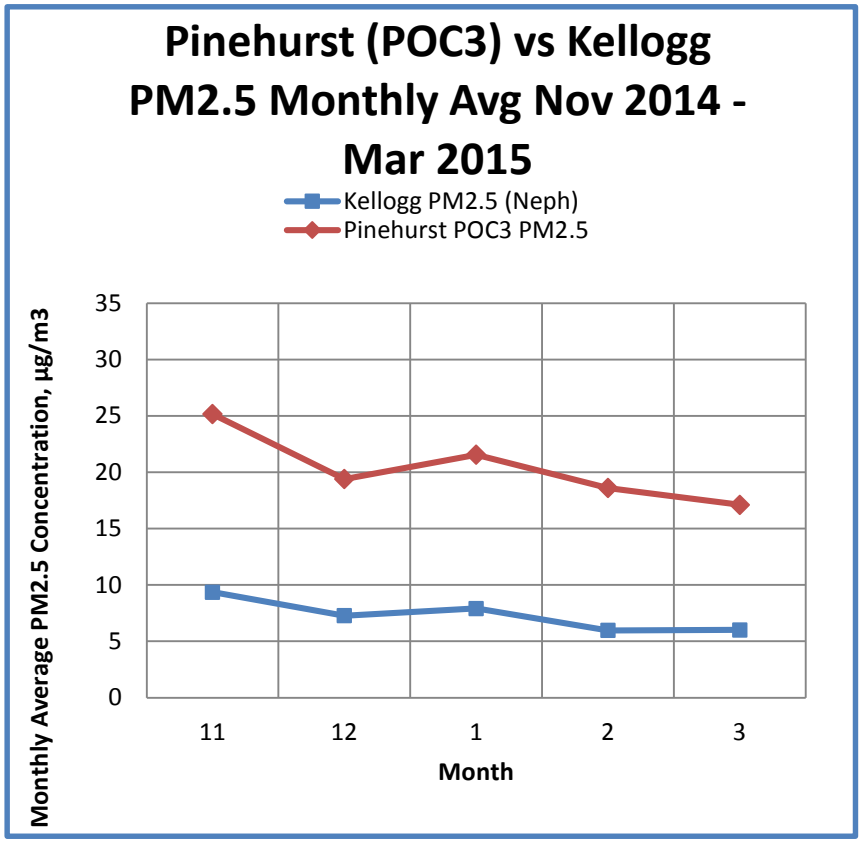
April 2016

Monitor Locations

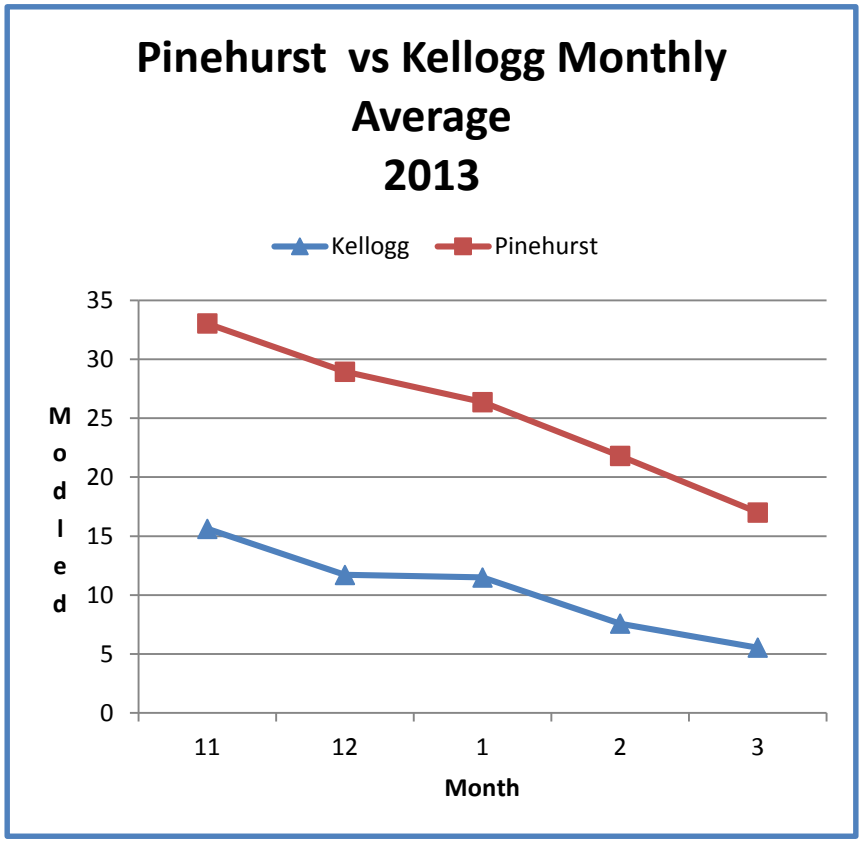


Monthly Concentration Time Series

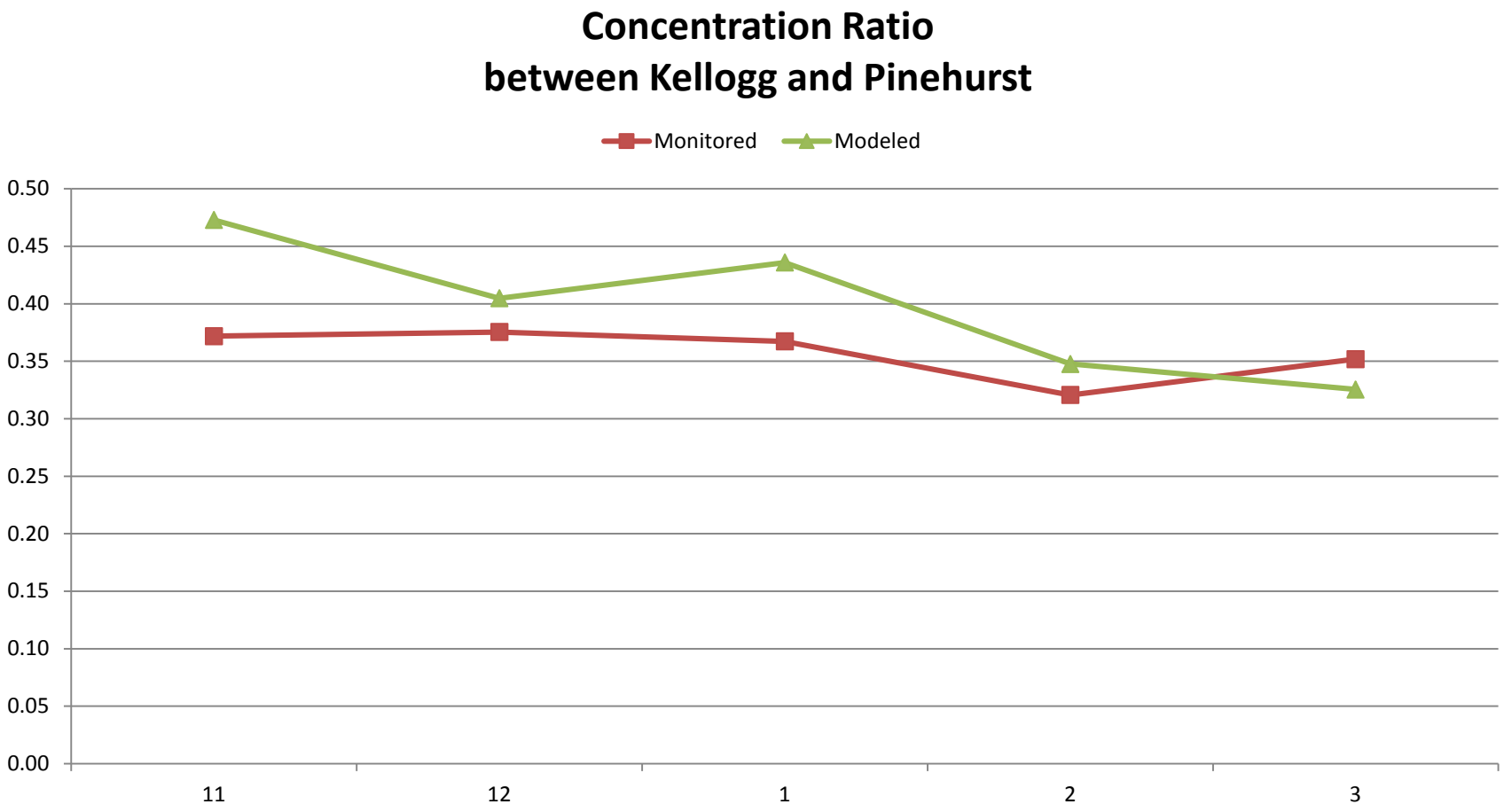
Monitored

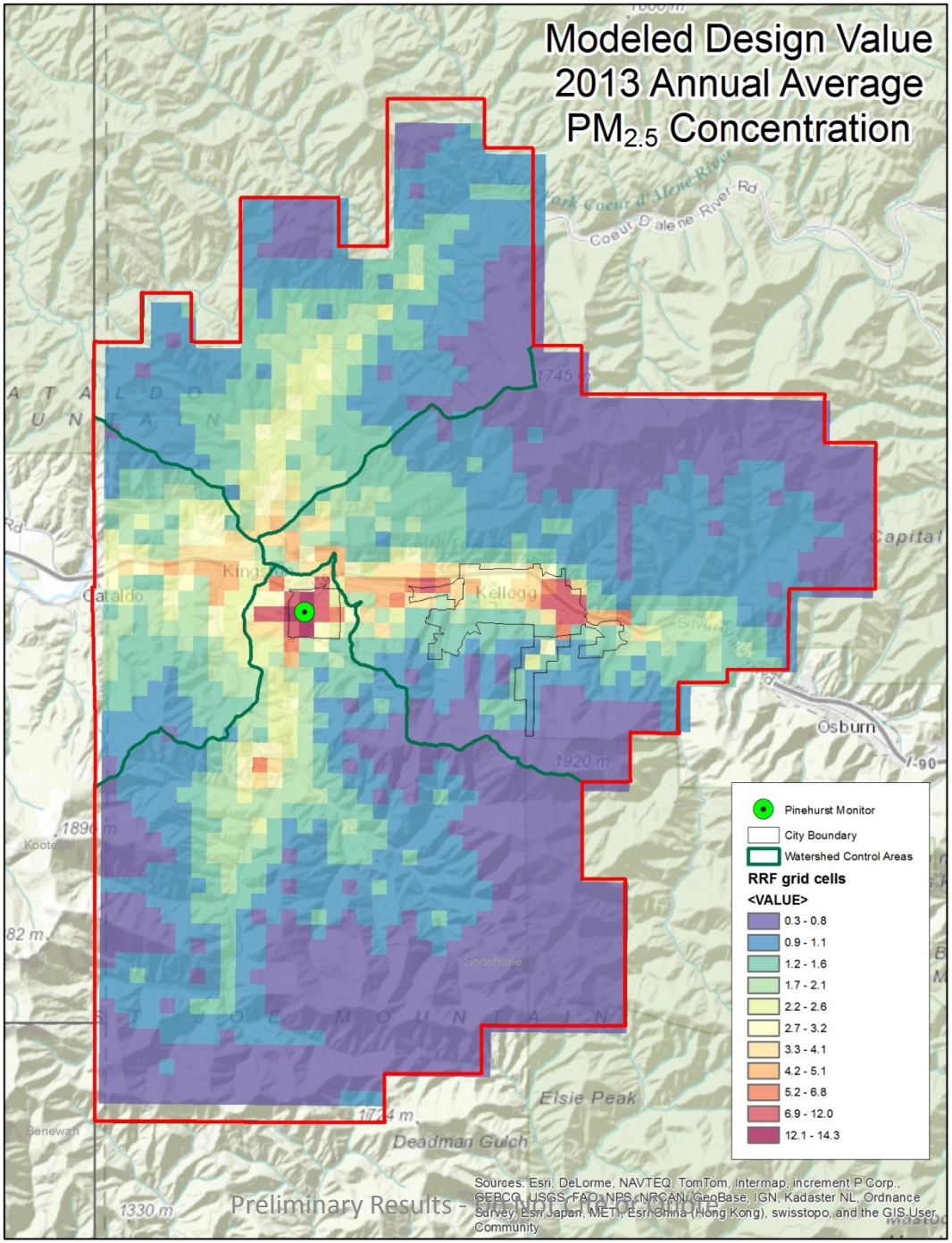


Modeled



Monthly Concentration Ratio Kellogg / Pinehurst





Preliminary Results - Subject to Change

Conclusions

- Model is biased high, but is suitable for use in a relative sense in the roll-forward model.
- Model concentration map can be used for un-monitored area analysis.
- By using multiple met regions, results are similar to CALPUFF results from a previous exercise.

- Thanks to Oregon DEQ for the over all approach

Questions/Discussion?

Supplemental Information

Residential Wood Combustion

- Generated emission based on survey data
- Developed detailed temporal profiles based on survey data and heating degree days
- Configured as a point source for each house location
- Allocated emissions based on Shoshone County house/Apt/trailers/duplex database

Residential Open Burning (ROB)

- Includes yard waste and burn barrels
- Developed detail temporal profiles based on survey data
- Configured as volume source for each house location
- Allocated emissions based on house database

Onroad Emissions Except off-network

- Ran MOVES for year 2013 to generate hourly emissions for each month and each weekday
- Configured each road link as a line source
- Allocated emissions to each road link
  - Used VMT as surrogate for restricted road
  - Used lane-length as surrogate for unrestricted road

Onroad Off-network Emissions

- Ran MOVES for year 2013 to generate hourly emissions for each month and each weekday
- Configured each location as a volume source
- Used Shoshone County database as surrogate to allocate emissions to residences, schools, business etc.
  - Trip starts at house and business/school locations

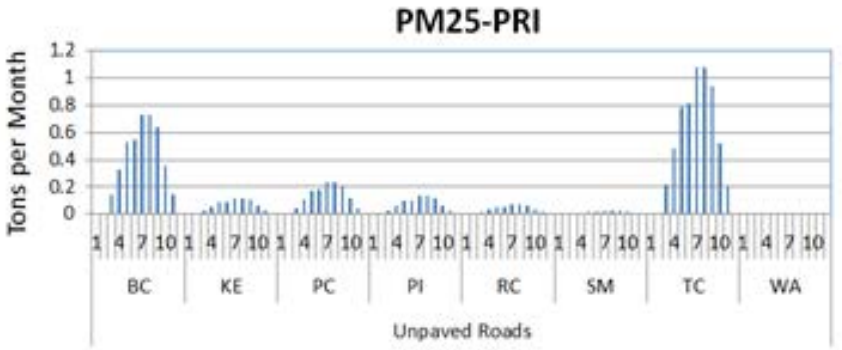
Paved Road Dust Emission

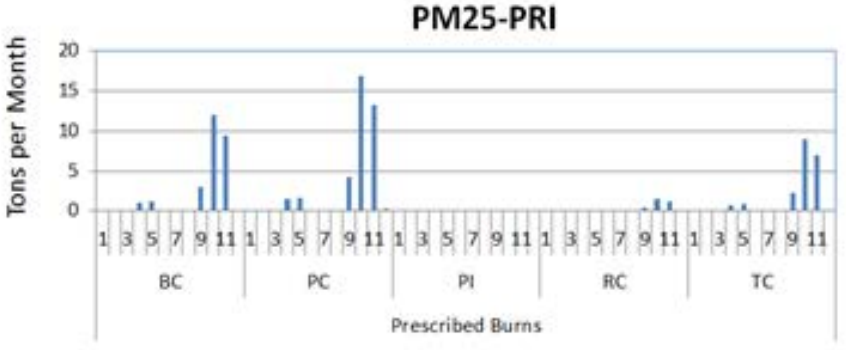
- Used AP-42 method to generate hourly emissions for each month and each weekday
- Configured each road link as line source
- Allocated emissions to each road link
  - Used VMT as surrogate for restricted roads
  - Used lane-length as surrogate for unrestricted roads

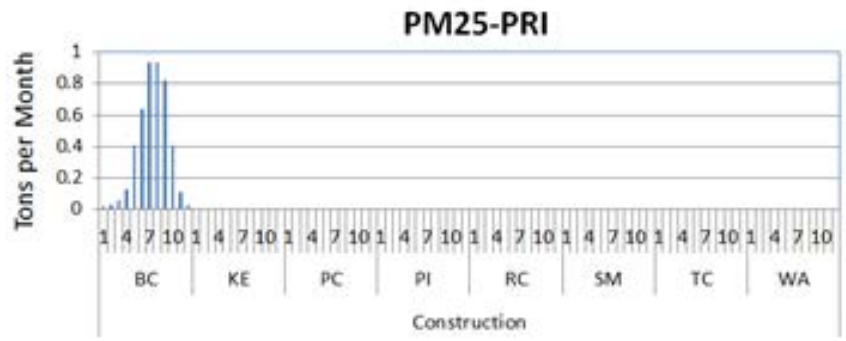
Prescribed Fire Emissions

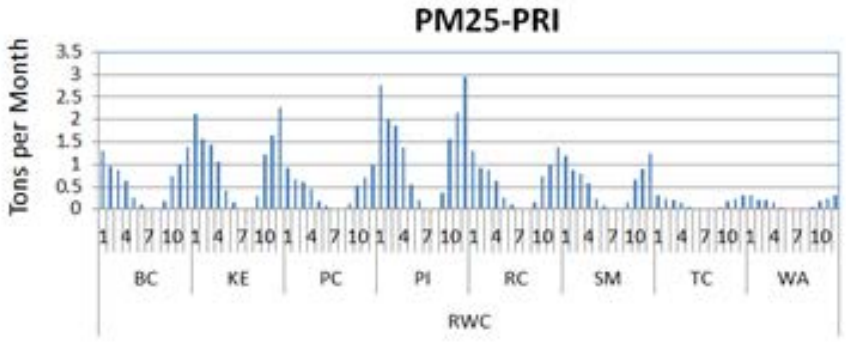
- Compiled prescribed fire from different databases
- Developed monthly temporal profile
- Source configuration
  - WRAP ENVIRON 2012 report
  - Separated fires into class 1 and class 2 fires
  - Modeled each fire as two volume sources, one at ground and the other one aloft
- Modeled EPA's 2011 NEI Rx emissions and detailed burn databases in 2013
  - Mt/Id Airshed Group, IDL permitted burns, FPA sites

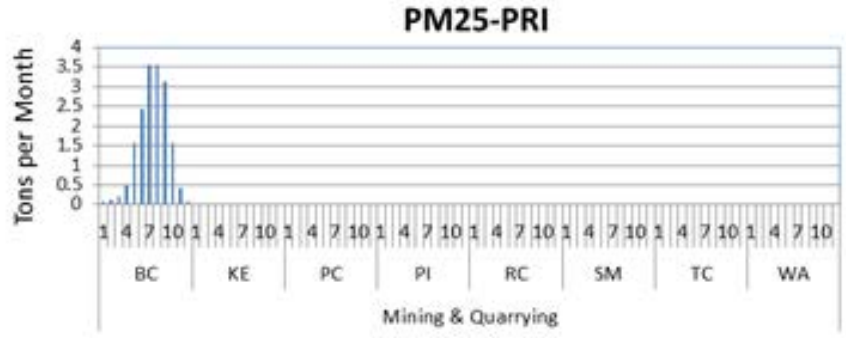
Monthly EI Profile Patterns PM2.5 a

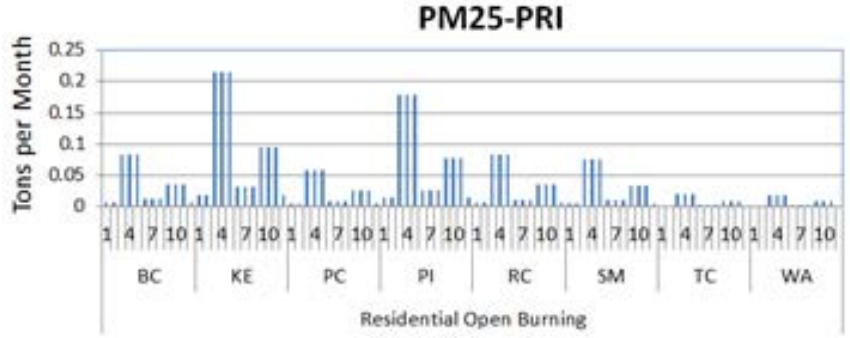












Annual Contribution at Monitor Location ($\mu g/m^3$)

	Annual		Annual Total
	NAA	**Outside**	
Off-network	2.484		**2.484**
Onroad_exclude_off-network	0.186		**0.186**
ROB	0.398		**0.398**
RWC	10.162		**10.162**
Point	0.081	0.093	**0.174**
Paved road dust	0.166		**0.166**
Prescribed burn	0.630	1.202	**1.832**
Grand Total	**14.107**	**1.295**	**15.401**

Quarterly Contribution at Monitor Location ($\mu g/m^3$)

	Quarter1		Quarter1 Total
	NAA	Outside	
offnetwork	2.809		**2.809**
onroad_exclude_offnetwork	0.210		**0.210**
rob	0.471		**0.471**
rwc	17.748		**17.748**
point	0.091	0.138	**0.229**
pavedroaddust	0.255		**0.255**
prescribeburn	0.000	0.000	**0.000**
Grand Total	**21.584**	**0.138**	**21.722**

	Quarter2		Quarter2 Total
	NAA	Outside	
offnetwork	1.955		**1.955**
onroad_exclude_offnetwork	0.115		**0.115**
rob	0.441		**0.441**
rwc	4.296		**4.296**
point	0.069	0.085	**0.154**
pavedroaddust	0.044		**0.044**
prescribeburn	0.101	0.245	**0.346**
Grand Total	**7.021**	**0.330**	**7.350**

	Quarter3		Quarter3 Total
	NAA	Outside	
offnetwork	2.030		**2.030**
onroad_exclude_offnetwork	0.156		**0.156**
rob	0.177		**0.177**
rwc	0.929		**0.929**
point	0.074	0.056	**0.130**
pavedroaddust	0.072		**0.072**
prescribeburn	0.168	0.255	**0.422**
Grand Total	**3.605**	**0.311**	**3.916**

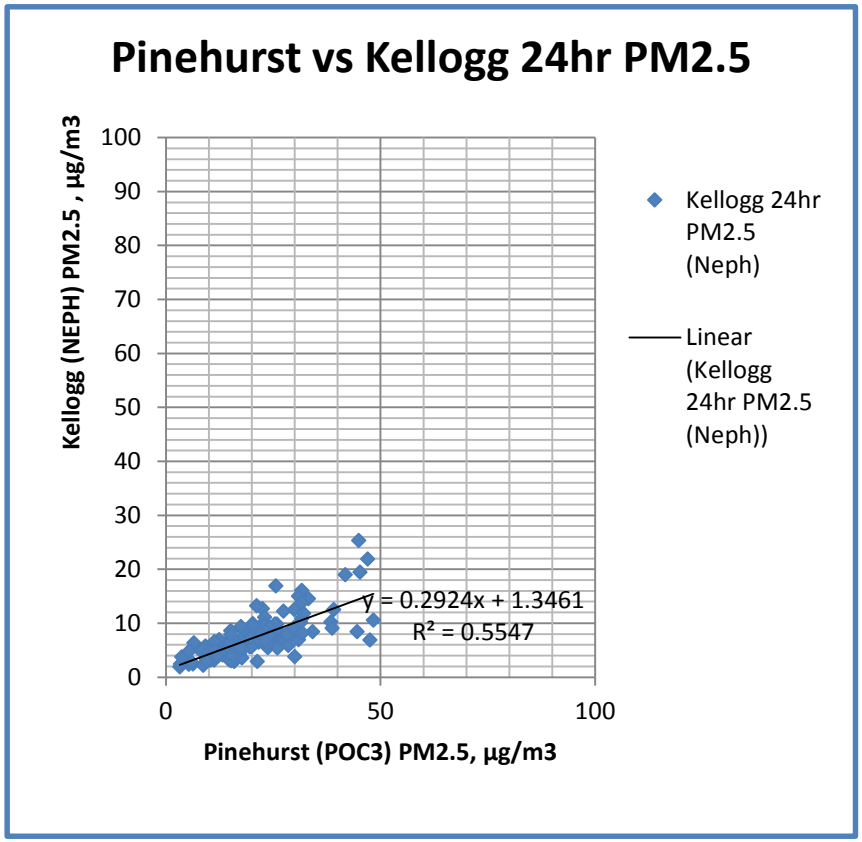
	Quarter4		Quarter4 Total
	NAA	Outside	
offnetwork	3.141		**3.141**
onroad_exclude_offnetwork	0.263		**0.263**
rob	0.505		**0.505**
rwc	17.676		**17.676**
point	0.091	0.092	**0.183**
pavedroaddust	0.291		**0.291**
prescribeburn	2.250	4.308	**6.558**
Grand Total	**24.217**	**4.400**	**28.617**

Monitor and Model Data

- Data Range
  - 11/7/2014 – 3/24/2015
- Monitor Data Type
  - Pinehurst : FRM
  - Kellogg : Nephelometer
  - Nephelometer data from Kellogg has been adjusted to be FRM-like
- Model Data
  - Contribution from all sources we modeled including sources from outside of NAA

24hr Concentration Scatter Plot
Pinehurst vs Kellogg

Monitored



Modeled