Ronald E. Myers
1625 Westhaven Dr.
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November 30, 2001

Mr. Bill Kuykendal
U.S. EPA
Research Triangle Park, NC 27711

Dear Mr. Kuykendal:

I have read the revisions that are being proposed for the paved and unpaved roads sections of AP-42. First, there is little information presented to support any of the options being proposed. For example, for the paved road proposal, there is no information to characterize the physical mechanisms which cause the precipitation related mitigation of emissions and no subsequent evaluation was performed to compare (based upon the physical mechanisms) the two options using the results of calculations from daily information and hourly information. For the unpaved road proposal, the individual test results upon which the data presented in Figure 1 are derived is not summarized as has been done for the background report which is being supplemented and has been presented in all other AP-42 background reports. While the data presented in Figure 1 for the surface coal mine may already be summarized in the existing background report, there is no information in the memo from Greg Muleski of MRI to you on how the data were manipulated to accommodate the differences in silt content and vehicle weight between test runs to arrive at emission factors which can be used to arrive at a control efficiency which is independent of silt and average vehicle weight. In addition, for the unpaved road options, no information is presented which compares the emissions that would be predicted using the watering control effectiveness figure to the actual measured emissions from the over 100 emission tests that are presented in the existing background report supporting the emission factors you are proposing to replace. To provide some of these comparisons, I have obtained some data to use for evaluation.

<u>PAVED ROAD PROPOSAL</u>

The two options presented could be assumed to infer that precipitation completely suppresses emissions for either half of the day that rain occurs or only for the hour that rain occurs. Based upon information for 1990 contained in the *Solar and Meteorological Surface Observation Network 1961-1990* (SAMSON) CD-ROM, I calculated information to compare the two options for some selected cities. The cities range from having only 20 rain days per year to having 157 rain days per year. Information on the attached material includes the monthly number of rain days, the number of hours that rain was measured, the percent reduction for both of the options and the percent difference in the two options. As you may notice, on average rain occurs for only 20% of the day and ranges from 8% for Elko, NV to 37% for Olympia, WA. On average, using the daily calculation option results in almost three times the emission reduction of the hourly calculation. This difference ranges from 1.35 for Olympia to 6.25 for Winnemucca. For these two options to be comparable, the average emissions reduction would have to be two to three times the average percentage of the day that rain was measured.

In extracting this data, it appeared that most rain events were of short duration (measured values during only one or two consecutive hours) although there were a few periods for most cities where measured rain occurred for most if not all of the day. While no measured data is available to evaluate the two options, it is reasonable to expect that the following situations affect the ability of precipitation to mitigate emissions:

1) Light precipitation increases the availability of silt for suspension into the air as a result of the washing of material out of crevices of the road. While the road surface is wet, water droplets suspended into the air will contain these suspended solids and if not deposited, will become airborne particulate emissions.
2) Light precipitation can increase silt levels as a result of the washing action of water on the undercarriage of vehicles.
3) The timing of short duration rain events affects the reduction of silt during high traffic periods. Rain occurring late in the evening or at night is unlikely to significantly affect silt levels during high traffic periods since the undercarriage of the first vehicles to use the road will re-nourish the road surface due to the washing by the residual water on the road surfaces.
4) Any precipitation can increase silt levels as a result of enhancing the track out of material from unpaved areas such as construction sites, unpaved roads, quarries and other industrial locations.
5) Heavy precipitation will remove most silt from the road surface. This effect will last the longest when rain occurs during rush hours.
6) Paved roads are designed to minimize the amount of water retained on the surface.
7) Normally, high speed and volume roadways will dry within an hour after rain has ceased.
8) Low humidity, high temperature and high solar insolation conditions will reduce drying times of a road.

For light rains of short duration, which appeared to be the most prevalent, it is assumed that the times where silt content would be increased are balanced by the times where the amount of rain is sufficient to reduce the silt content of the road. As a result, emissions are suppressed only during the period when it is raining. Since the meteorological data is recorded in one hour blocks, it may be reasonable to assume that emissions are suppressed for the entire hour.

Rains which are somewhat more intense or longer duration can remove imbedded silt from the road surface. These type events have a 18% probability (10 x 3/24 x 7 = .18, for commute periods of 3 hours) of removing the majority of the silt from the traffic system. If it is assumed that silt levels increase linearly and it takes forty three hours for silt levels to return to the normal levels during this type of event, and that the rain was of average duration (.2 x 24 = 4.8 hr), this would be equivalent to a 55% suppression of emissions for two days ((0 x 4.8 + 0.5 x 43 x 1)/48 = 0.45). For the remaining 82% of the time, emissions would be suppressed for only the 4.8 hours when it was raining (and also during lower traffic flow) for an average of 20% suppression of emissions. On average, the resulting emissions would be reduced 26% (.55 x .18 + .82 x .2 = .26) or the equivalent of 1.32 times the amount if emissions were assumed to be zero only during the 5 hours of recorded rain.

For long duration rains (say of one or 2 days duration), silt levels would require 36 hours to return to normal levels as above. As a result, emissions would be suppressed for two days plus the duration for silt levels to return to normal. For a one day rain, emissions over a three day period (one day of rain plus two days to recover) would be reduces by 66% or 2 times the amount if emissions were assumed to be zero only during the 24 hours of recorded rain. Emissions over a four day period (two days of rain plus two days to recover) would be reduced by 75% or 1.5 times the amount if emission were assumed to be zero only during the 48 hours of recorded rain.

As can be seen, for the two options to be comparable, all of the rains would have to last all day and silt levels would require more than two days to return to normal levels. For the more typical climate, a mixture of these type events is likely. Based upon my observations, I would think that the first type event would occur more than half the time, while the third type event would only occur less than 10% of the time. For illustration, it is assumed that the first type event occurs 60% of the time, the second type event occurs 30% of the time and the third type event occurs 10% of the time. Based upon these assumptions, the number of hours of rain would need to be multiplied by 1.2 to estimate the residual mitigation of rain
(1 x 0.6 + 1.3 x 0.3 + 2 x 0.1 = 1.19)

It is recognized that calculating the mitigating effect of precipitation using the number of days with measurable precipitation may be simpler than obtaining and calculating the mitigation using hourly data. As a result, to provide users with a method to calculate mitigation from daily precipitation data, it is suggested that rather than using the following equation:

$$E_{ext} = k\ (sL/2)^{0.65}\ (W/3\ )^{1.5}\ (1\text{-}P/4N)$$

It is also recommended that the use of hourly data be optional using the following equation:

$$E_{ext} = k\ (sL/2)^{0.65}\ (W/3\ )^{1.5}\ (1\text{-}1.2P/N)$$

UN-PAVED ROAD PROPOSAL

While I can understand the desire to have separate emission factors for urban and industrial roads even though the basic parameters are nearly the same, it is contrary to good scientific principals to use a limited data set to isolate a parameter and to ignore a larger data set that includes parameters that address many if not all the variables which affect the overall effect. Although some AP-42 readers may incorrectly and unsuccessfully attempt to isolate the effect of watering to increase surface moisture content, this can be corrected using an explanation in the text of the section to highlight the inter-relatedness of the effects caused by watering and proper maintenance of an industrial unpaved road surface. While, a revised industrial unpaved road equation may only have an exponent of about 0.4 to estimate the effects of moisture content on emissions, the exponent is an accurate reflection based upon all of the available data.

Within the context of using the bi-linear control performance model from EPA-450/3-88-08, there is no limitation on the maximum baseline moisture content that is applicable when using this model. It has is recommended that the range of baseline moisture contents be presented for AP-42 readers to understand the potential limitations of this model. It is also recommended that the individual baseline and controlled data that are represented by the approximately 38 points in the figure be presented in the revised memo (or supplement to the background report) so that users may access this information should they want to better understand the available data. In presenting this data, information on the silt content, average weight, vehicle speed and number of tires be included in the data summaries. It is also suggested that data from the existing background data (other than the coal mine data) be added to the existing figure so that a more comprehensive characterization of the quality of the models performance can be discerned. The entire data set used for the previous version of the unpaved road equation was evaluated to identify groups of data where the vehicle weight and the silt content were nearly the same. Nineteen groups of data were identified and the moisture ratio and control efficiency were calculated. Attached is the complete ordered data set with the nineteen data sets identified. On the last page of this attachment is a figure that presents the predicted control efficiency and the actual control efficiency for these nineteen pairs of data. Within these nineteen data, there were five which had negative control efficiencies due to the higher moisture level condition having higher emissions than the condition to which it was compared. It is suggested that additional pairs of data be identified within this data set and the basis of the model be re-evaluated and revised to agree with the data.

I hope these comments are helpful. Should you require any clarification in my comments or the attachments I am providing, please contact me at (919) 851-1564.

Sincerely,

Ronald E. Myers

Estimate of Paved Road Emissions Reduction due to rain events

		January	February	March	April	May	June	July	August	September	October	November	December	Annual
Olympia, WA	Rain Days	25	20	16	14	14	13	4	7	1	20	26	23	157
	Estimated Reduction per EIP	40%	36%	26%	23%	23%	22%	6%	11%	2%	32%	43%	37%	22%
	Rain Hours	230	214	133	110	59	74	14	30	2	137	226	166	1395
	Estimated Reduction	31%	32%	18%	15%	8%	10%	2%	4%	0.3%	18%	31%	22%	16%
	Percent Difference from EIP	23%	11%	31%	35%	65%	53%	71%	64%	83%	43%	28%	40%	26%
Harrisburg, PA	Rain Days	12	13	10	16	16	7	10	11	12	7	8	14	128
	Estimated Reduction per EIP	19%	23%	16%	27%	26%	12%	16%	18%	20%	11%	13%	23%	18%
	Rain Hours	82	66	59	64	91	16	50	98	43	60	36	109	774
	Estimated Reduction	11%	10%	8%	9%	12%	2%	7%	13%	6%	8%	5%	15%	9%
	Percent Difference from EIP	43%	58%	51%	67%	53%	81%	58%	26%	70%	29%	63%	35%	50%
Albany, NY	Rain Days	16	12	9	12	15	12	8	11	10	7	9	12	124
	Estimated Reduction per EIP	26%	21%	15%	20%	24%	20%	13%	18%	17%	11%	15%	19%	17%
	Rain Hours	93	94	63	77	112	27	31	88	29	46	46	78	784
	Estimated Reduction	13%	14%	8%	11%	15%	4%	4%	12%	4%	6%	6%	10%	9%
	Percent Difference from EIP	52%	35%	42%	47%	38%	81%	68%	33%	76%	45%	57%	46%	47%
Raleigh, NC	Rain Days	10	10	9	12	15	5	8	12	4	9	6	15	115
	Estimated Reduction per EIP	16%	18%	15%	20%	24%	8%	13%	19%	7%	15%	10%	24%	16%
	Rain Hours	68	43	61	30	65	10	18	35	9	46	25	74	484
	Estimated Reduction	9%	6%	8%	4%	9%	1%	2%	5%	1%	6%	3%	10%	6%
	Percent Difference from EIP	43%	64%	44%	79%	64%	83%	81%	76%	81%	57%	65%	59%	65%
Springfield, IL	Rain Days	9	11	12	10	14	14	7	8	6	8	7	13	112
	Estimated Reduction per EIP	15%	20%	19%	17%	23%	23%	11%	13%	10%	13%	12%	21%	15%
	Rain Hours	35	79	51	43	76	46	30	32	31	62	46	101	632
	Estimated Reduction	5%	12%	7%	6%	10%	6%	4%	4%	4%	8%	6%	14%	7%
	Percent Difference from EIP	68%	40%	65%	64%	55%	73%	64%	67%	57%	35%	45%	35%	53%
Spokane, WA	Rain Days	18	11	7	10	17	8	5	4	0	11	11	10	101
	Estimated Reduction per EIP	29%	20%	11%	17%	27%	13%	8%	6%	0%	18%	18%	16%	14%
	Rain Hours	94	48	29	53	79	40	29	16	0	75	38	63	564
	Estimated Reduction	13%	7%	4%	7%	11%	6%	4%	2%	0%	10%	5%	8%	6%
	Percent Difference from EIP	56%	64%	65%	56%	61%	58%	52%	67%	ERR	43%	71%	48%	53%
Oklahoma City, OK	Rain Days	3	9	14	14	10	4	7	8	9	5	5	9	92
	Estimated Reduction per EIP	5%	16%	23%	23%	16%	7%	11%	13%	15%	8%	8%	15%	13%
	Rain Hours	26	69	79	62	48	12	22	21	33	19	33	40	464
	Estimated Reduction	3%	10%	11%	9%	6%	2%	3%	3%	5%	3%	5%	5%	5%
	Percent Difference from EIP	28%	36%	53%	63%	60%	75%	74%	78%	69%	68%	45%	63%	58%

Estimate of Paved Road Emissions Reduction due to rain events

		January	February	March	April	May	June	July	August	September	October	November	December	Annual
Houston, TX	Rain Days	14	11	10	9	5	4	10	1	10	4	7	9	87
	Estimated Reduction per EIP	23%	20%	16%	15%	8%	7%	16%	2%	17%	6%	12%	15%	12%
	Rain Hours	103	48	43	31	15	8	26	1	26	20	28	35	384
	Estimated Reduction	14%	7%	6%	4%	2%	1%	3%	0%	4%	3%	4%	5%	4%
	Percent Difference from EIP	39%	64%	64%	71%	75%	83%	78%	92%	78%	58%	67%	68%	63%
Birmingham, AL	Rain Days	12	13	11	9	8	5	0	0	0	7	3	11	76
	Estimated Reduction per EIP	19%	23%	18%	15%	13%	8%	0%	0%	0%	11%	5%	18%	10%
	Rain Hours	109	66	83	29	34	15	0	0	0	17	18	33	404
	Estimated Reduction	15%	10%	11%	4%	5%	2%	0%	0%	0%	2%	3%	4%	5%
	Percent Difference from EIP	24%	58%	37%	73%	65%	75%	ERR	ERR	ERR	80%	50%	75%	56%
Winnemucca, NV	Rain Days	12	13	11	9	8	5	0	0	0	7	3	11	76
	Estimated Reduction per EIP	19%	23%	18%	15%	13%	8%	0%	0%	0%	11%	5%	18%	10%
	Rain Hours	16	25	21	34	45	5	0	19	6	5	7	26	209
	Estimated Reduction	2.2%	3.7%	2.8%	4.7%	6.0%	0.7%	0.0%	2.6%	0.8%	0.7%	1.0%	3.5%	2.4%
	Percent Difference from EIP	89%	84%	84%	69%	53%	92%	ERR	ERR	ERR	94%	81%	80%	77%
Elko, NV	Rain Days	3	2	5	8	6	3	2	3	1	1	4	0	34
	Estimated Reduction per EIP	5%	4%	8%	13%	10%	5%	3%	5%	2%	2%	7%	0%	5%
	Rain Hours	8	2	9	16	9	7	2	6	1	1	9	0	70
	Estimated Reduction	1.1%	0.3%	1.2%	2.2%	1.2%	1.0%	0.3%	0.8%	0.1%	0.1%	1.3%	0.0%	0.8%
	Percent Difference from EIP	78%	92%	85%	83%	88%	81%	92%	83%	92%	92%	81%	ERR	83%
Las Vegas, NV	Rain Days	5	4	0	1	0	2	4	0	3	1	2	0	20
	Estimated Reduction per EIP	8%	7%	0%	2%	0%	3%	6%	0%	5%	2%	3%	0%	3%
	Rain Hours	25	14	0	2	0	8	10	0	7	3	3	0	72
	Estimated Reduction	3.4%	2.1%	0.0%	0.3%	0.0%	1.1%	1.3%	0.0%	1.0%	0.4%	0.4%	0.0%	0.8%
	Percent Difference from EIP	58%	71%	ERR	83%	ERR	67%	79%	ERR	81%	75%	88%	ERR	70%

Annual Avg using Daily Data
Ave 12.8%
Std 5.3%
Min 2.7%
Max 21.5%

Annual Avg using Hourly Data
Ave 5.9%
Std 4.1%
Min 0.8%
Max 15.9%

Differences between Hourly and Daily Data
Ave 58.4%
Std 15.0%
Min 25.9%
Max 82.8%