Particulate Matter Trends Analysis for the Bishop Paiute Reservation 2004-2017

For additional information contact

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1. ACKNOWLEDGEMENTS

This project was funded by USEPA R9 under the CAA 103 grant program. We also acknowledge R9 Quality Assurance Office for reviews and approvals of Quality Assurance Project Plans for air quality monitoring.

In 2014, a study titled Weather History on the Bishop Paiute Reservation 1925-2011 was completed by Toni Richards, PhD., former Air Quality Specialist with the Bishop Paiute Tribe. This comprehensive study, including weather data from the Tribe's meteorological station and surrounding area stations, is one of the authoritative data analyses of weather and climate in the Owens Valley. The long-term trends analysis of air quality data was to be a complementary installment in analysis of the Tribe's data, and though ultimately this study covers different timelines with some overlap, it owes basic formatting and some methodology to this prior study.

Scott Weaver, former data analytical staff for Great Basin Unified Air Pollution Control District, is acknowledged for review and comments on this study.

The Bishop Tribe's IT system admins are acknowledged for their support in the maintenance of hardware and software systems used in the analysis.

Acknowledgements are also made to staff at ITEP (Institute of Tribal Environmental Professionals) for instruction in data analysis methods and tools, and data quality assurance and validation principles, and for their role as a partner in enabling data collection through the TREX (Tribal Environmental Exchange) system. The TREX DAS, T&B Systems' hosted Vista DAS, and ITEP's TAMS Center data tools were the primary specialty software used in the study.

Acknowledgements are also made to staff at Minnesota Pollution Control Agency for instruction and resources for R. Some basic analyses were drafted in R Studio with the ggplot and openair funtions; however they are not included in this study draft for additional time to completion. The Daily AQI analysis in the report was designed to be similar to the ggplot calendar plot in RStudio. Analyses in the Air Now Tech DART (Data Analysis & Reporting Tool) were attempted, but were not included in the study due to the difference in availability of monitor data in DART and from the TREX DAS (details in sections below).

2. BACKGROUND

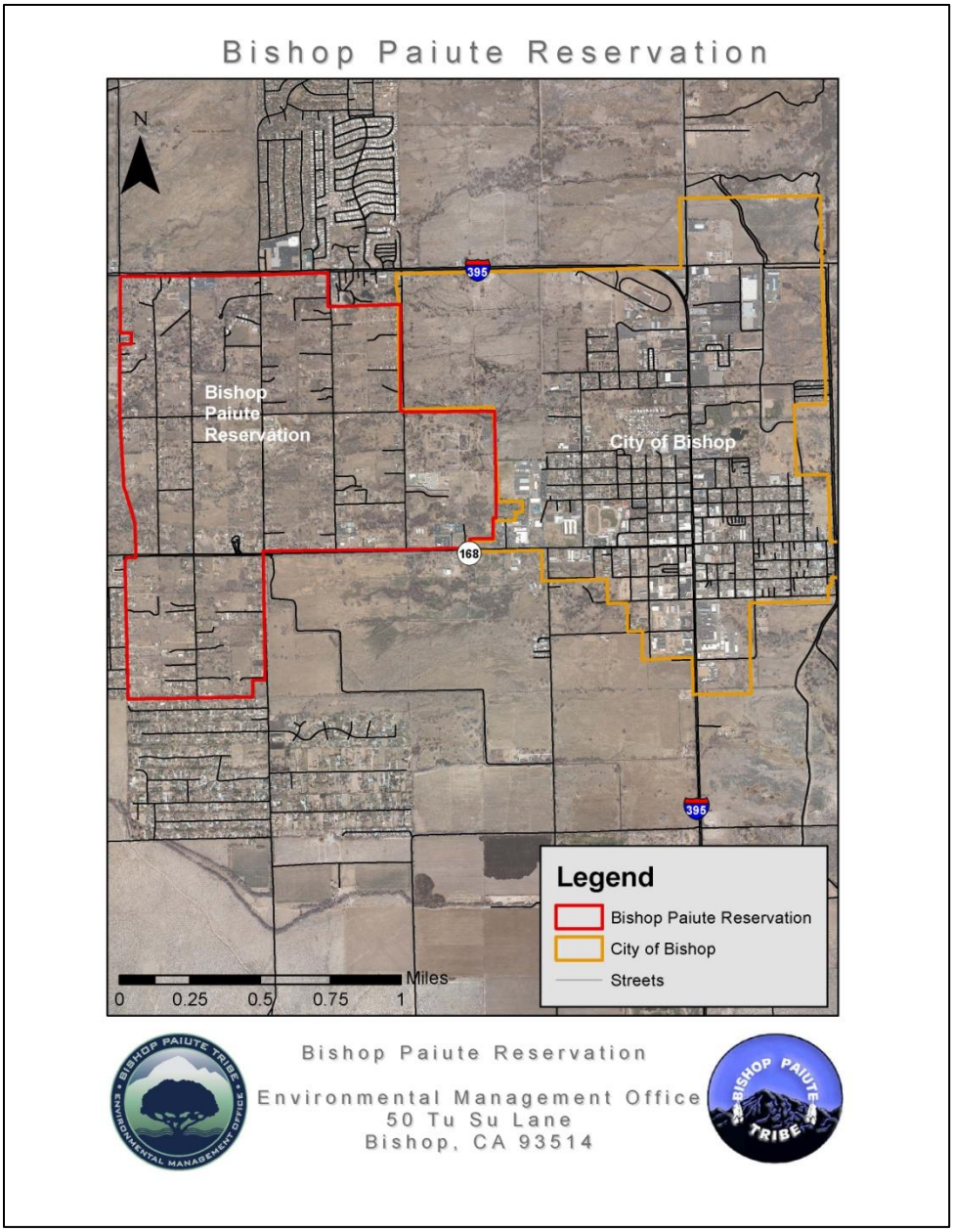
The Bishop Paiute Reservation is located in the Owens Valley, also known as Payahuunadü, in eastern California. The area is sometimes also known as "the deepest valley" as it is flanked by two 14,000-foot ranges – the Sierra Nevada to the west and the White Mountains to the east, and is the western commencement of the Northern Basin and Range physiographic province, which extends eastward into Nevada and western Utah. The region includes some of the most spectacular mountain scenery in the United States. The mountain ranges are comprised of National Forest, BLM, and in some areas, National Park lands that include substantial wilderness areas. From time immemorial, the Paiute People (or Nu Mu descendants) have been shepherds of the Valley, from crest to crest. Map 1 depicts the Owens Valley.

MAP 1. OWENS VALLEY SATELLITE VIEW

The Reservation itself comprises 875 contiguous acres and is flanked by the City of Bishop to the east. It is surrounded by private lands and by lands owned by the Los Angeles Department of Water and Power.

The Bishop Tribe is the 5th largest tribe in California with approximately 2060 members, with ~75% of members living on the reservation. Nearly all of the land on the Reservation is assigned to individual families, with a limited number of acres set aside for public and commercial facilities. Despite substantial population growth since the creation of the Reservation in 1939, many of the assigned lands are in agriculture (pasture or alfalfa, primarily) or are open lands. Map 2 shows the Reservation.

MAP 2. BISHOP PAIUTE RESERVATION



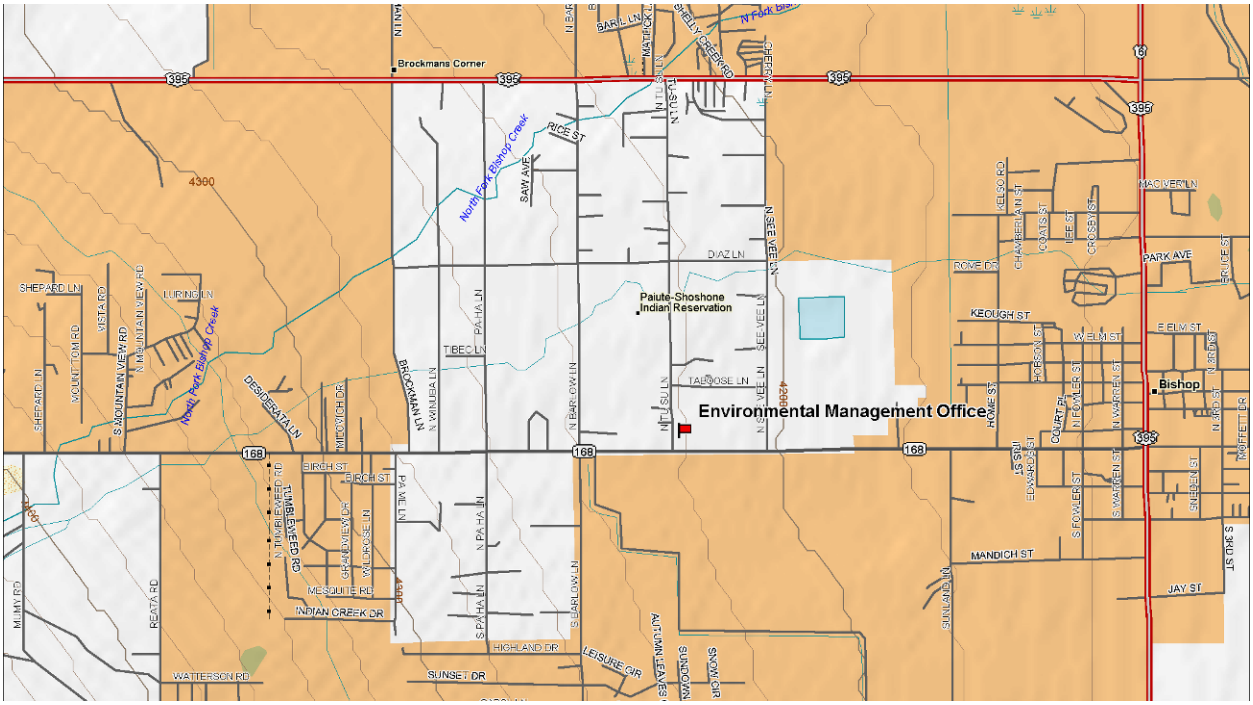
3. METHODOLOGY

Monitoring Station Location and Observation Period

The particulate matter (PM) air monitoring equipment is located on the roof of the Environmental Management Office-A (EMO-A) building at 50 Tu Su Lane, on the Bishop Paiute Reservation (N37°22', W118°25' at an elevation of 4,226 ft.). Map 3 shows the location of EMO-A on the Bishop Paiute Reservation. Photographs 1 and 2 show the equipment and location. Access is via external stairs to the roof. The meteorological tower/station is at the same location, adjacent to the building.

The Bishop Tribe operates equipment to measure the following: PM10 (less than 10 micron diameter) and PM2.5 (less than 10 micron diameter), ground-level ozone, wind speed, wind gust, wind direction, temperature, relative humidity, barometric pressure, solar radiation, and precipitation; and to calculate standard deviation of horizontal wind direction, resultant wind direction, and dewpoint temperature. This study will focus on trends in PM data since the incipience of monitoring for PM. The first full year of valid data used in this analysis is 2004, and the most recent complete year of data used in this analysis is 2017. Data completion is affected by factors such as power failures, invalid QA/QC check results, and equipment installation, maintenance, service, or malfunction. We consider daily, quarterly, and annual information to be incomplete if fewer than 75% of data are reported. Completeness for each presentation of data will be discussed in each section of the report.

MAP 3. BISHOP PAIUTE RESERVATION



PHOTOGRAPHS 1-2. PM10 AIR MONITORING EQUIPMENT PLATFORM AND WEATHER STATION

Particulate Matter Monitoring Equipment

Monitoring methodology, systematic QA/QC practices, and data collection and management practices are described extensively in the Bishop Tribe's Air Quality and Meteorology Quality Assurance Project Plans, available via the library tab at http://www.bishoptribeemo.com/index_air.htm

PM10 monitoring is conducted using a Tapered Element Oscillating Microbalance (TEOM) 1405 v 1.71 automated (or continuous) monitor. The PM10 monitor measures the mass of particulate 10 microns and smaller in aerodynamic diameter that accumulates on a filter and volumetric flow of air through the instrument. It uses these measurements to calculate the concentration of PM10 in ug/m^3 of air volume. The 1405 TEOM was manufactured by Thermo Environmental Instruments, Inc. (Thermo, formerly, Rupprecht and Pataschnick, R&P).

PM2.5 monitoring is conducted using a model 1400a TEOM/FDMS (Filter Dynamics Measurement System) 8500 monitor, manufactured by R&P. This system operates on the same TEOM principles but also incorporates a modular conditioning unit and reports in ug/m^3, Total Atmospheric PM2.5.

Both systems are designated as Federal Equivalent Method (FEM) for PM10 and PM2.5 (24-h average concentration) by the EPA under Designation No. EQPM-1090-079). These automated instruments do not require the use of a laboratory or the analysis of a filter. Both are housed in outdoor enclosures supplied by R&P (now Thermo) and manufactured by EKTO.

Data Collection

The primary method of data collection uses a Sutron 9210 XLite data logger. These are analog data. A secondary method uses an 7Ethernet connection to the instrument. These are digital data. The data from the Sutron data logger are the official data and *solely* are the subject of this study. Prior to

September 2014, the logger in service was a Zeno logger. The channel settings and wiring of the Zeno were adapted to the XLite upon install and so the data reflect the same measurements of the same parameters. All data collection is automated. Data is validated upon entry to the Sutron software database, and then in/validated again manually by the site operator, with changes saved in the database. Though this process generates null value codes for invalid data, all invalidated data in this report is treated as missing or lost data.

It should be noted, when viewing the graphs below, that beginning in late 2015, measurements of 1-hr concentrations of PM10 were capped at 900 ug/m3. This was chosen at the time of a monitor model upgrade, for which a better of 2 options for resolution was chosen for the scale of the monitor's DAS, for the purpose of better determining concentrations in comparison to state and tribal standards.

Data Analysis Methods

As mentioned, the base data used in this study is this analog data collected by the Sutron 9210 XLite logger- formerly a zeno logger prior to 2014. This data can be accessed either: 1. Online at the public TREX website; 2. Via AQS, EPA Air Data Mart, and Air Now Tech *all with some limitations* and 2. via the Sutron credentialed database extractor tool, which outputs to .txt or .csv files with validated values and non-numeric values (null value codes). Inclusion of the null value codes in the extracted files (which by default replace the numeric values) is needed to reflect the body of valid data as determined by the air monitoring site operator, and by automated validation rules in the software, which typically limit valid results to a pre-set range, or require a minimum count of polled results to average for each 1-hr average. In each section of this study, it is stated which source of data is used for the graphical displays. 24-hr average concentration values were chosen as the default average interval for the study, with other statistics used as needed for specific analyses, and described further in the study.

4. PARTICULATE MATTER DATA

This section presents an overview of PM10 and PM2.5 concentrations as recorded at the Bishop Paiute Station, with monitors operated and data collected as described in Section 3. Though data collection incipience was 2003 for PM10 and 2004 for PM2.5, 2003 has been omitted due to insufficient data capture across the entire year; otherwise, all years of recorded and archived data is presented.

Multiple methods of displaying the archive of data are included, and were selected based on availability of data and software, and applicability. Criteria for applicability include replicability, comprehensive presentation of the program's history of monitoring, and ease of interpretation for a wide audience. The goal is to provide a visualized compendium of data and trends in data at the station. Each section will describe the method used in creating graphical displays of data.

Annual Mean and Maximum Concentrations

Mean concentrations are derived from downloaded Annual Summary Data from EPA's Pre-Generated Files at the Air Data website. Data is available through AQS records starting 2005. All data graphed are in ug/m^3. *https://aqs.epa.gov/aqsweb/airdata/download_files.html#Annual*

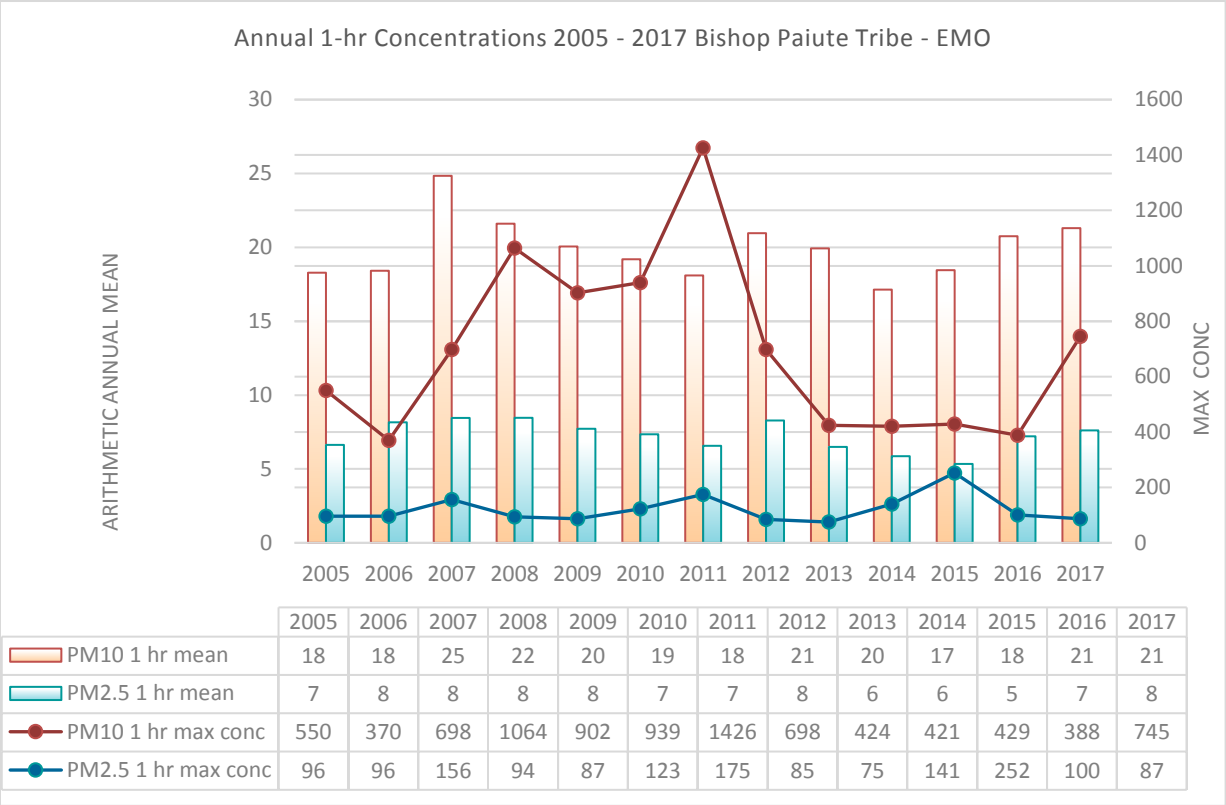
Figure 1-2 graphs are separated into 1-hour and 24-hour averaging periods, for comparison of PM categories across the same averaging periods, as 1-hour concentrations reach much higher values than 24-hour average concentrations. Values represent the arithmetic mean per PM category per year, in ug/m3. The graphs and tables below display a single mean series per particle size per averaging period, though the EPA data mart (AQS) data differentiates between PM10 Loc (local units) and PM10 Std (standard units) (all data are in ug/m^3). Roughly 16 months of PM10 data in Loc units exist as follows: 2016 values are based on PM10 Loc; 1-hr values available in the EPA data mart files are used for Figure 1; 24-hr values from TREX are inserted into the graph for Figure 2. Values for 2015 and 2017 use the highest 1-hr max (both are in the Std data rows), and average of the 2 means for Std & Loc. All other years are in PM10 Std. Conversions are assumed to be unnecessary for the purpose of visualizing the annual statistics in this section.

Figure 3 is amended to add 2018 values to the PM2.5 1-hr max series thus far, to highlight summer concentrations, which are not expected to be exceeded on the reservation in the final quarter of the calendar year. The 1-hr mean values are retained for demonstration that the highest maxes do not coincide with the highest means. Though a visual trend may be apparent, it should be noted that the 1-hr max concentration in 2011 occurred in February (as opposed to during wildfire season like the other years), during a dust storm with North winds to 44 mph as measured on the reservation.

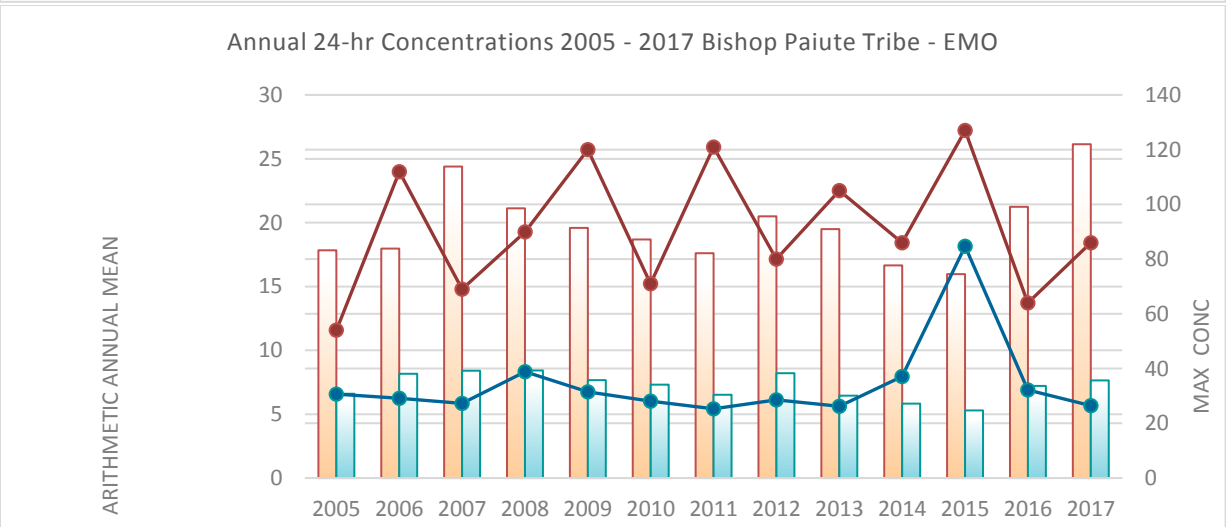
Figure 1 demonstrates that 1-hr max concentrations in PM10 declined from 2011 – 2016; however, this statistic rose again in 2017. The substantially higher 2011 value is due to the above-mentioned dust storm. As noted above in Section 3, no recordings of 1-hr concentrations over 900 ug/m^3 for PM10 are possible since October 2015; however, 2018 is the only year in which this cap was reached and the monitor "flatlined", and so the actual 1-hr max is unknown for 2018.

Figure 4 is a boxplot of the 24-hr statistics to further demonstrate the contrast between mean and max concentrations, and highlight the variability in PM10 max concentrations. Each series' mean and outliers are highlighted, and the plots are based on quartiles. The variability in 1-hr max concentrations for PM10 renders the boxplots for the 1-hr series incomparable on the same scale and so are not graphed. The PM2.5 24-hr max concentration value of 85 ug/m^3, that is calculated and displayed as an outlier in the boxplots, occurred in August 2015, due to the Rough Fire, which significantly impacted air quality and visibility in the Owens Valley.

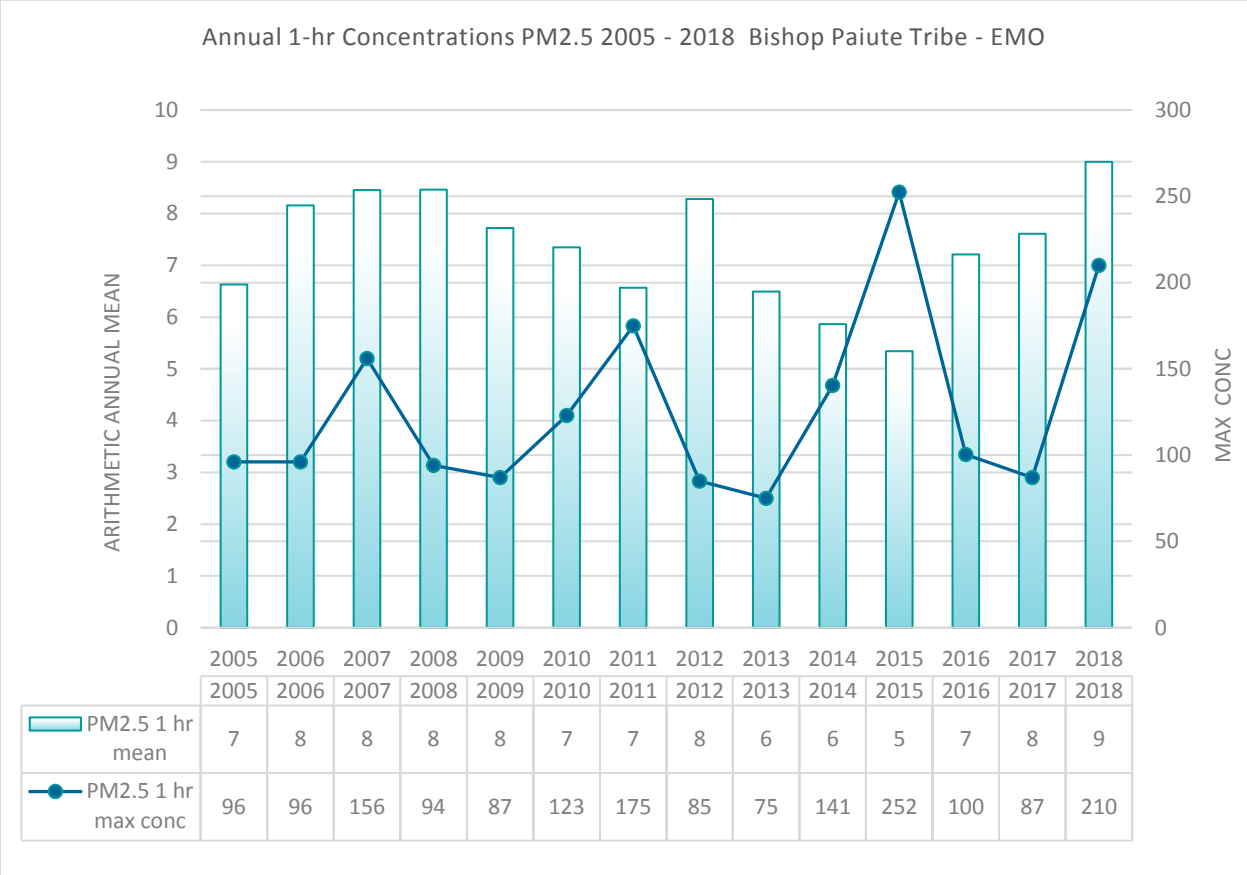
FIGURES 1-4. PM ANNUAL SUMMARY MAX/MEAN BISHOP PAIUTE RESERVATION 2005-2017



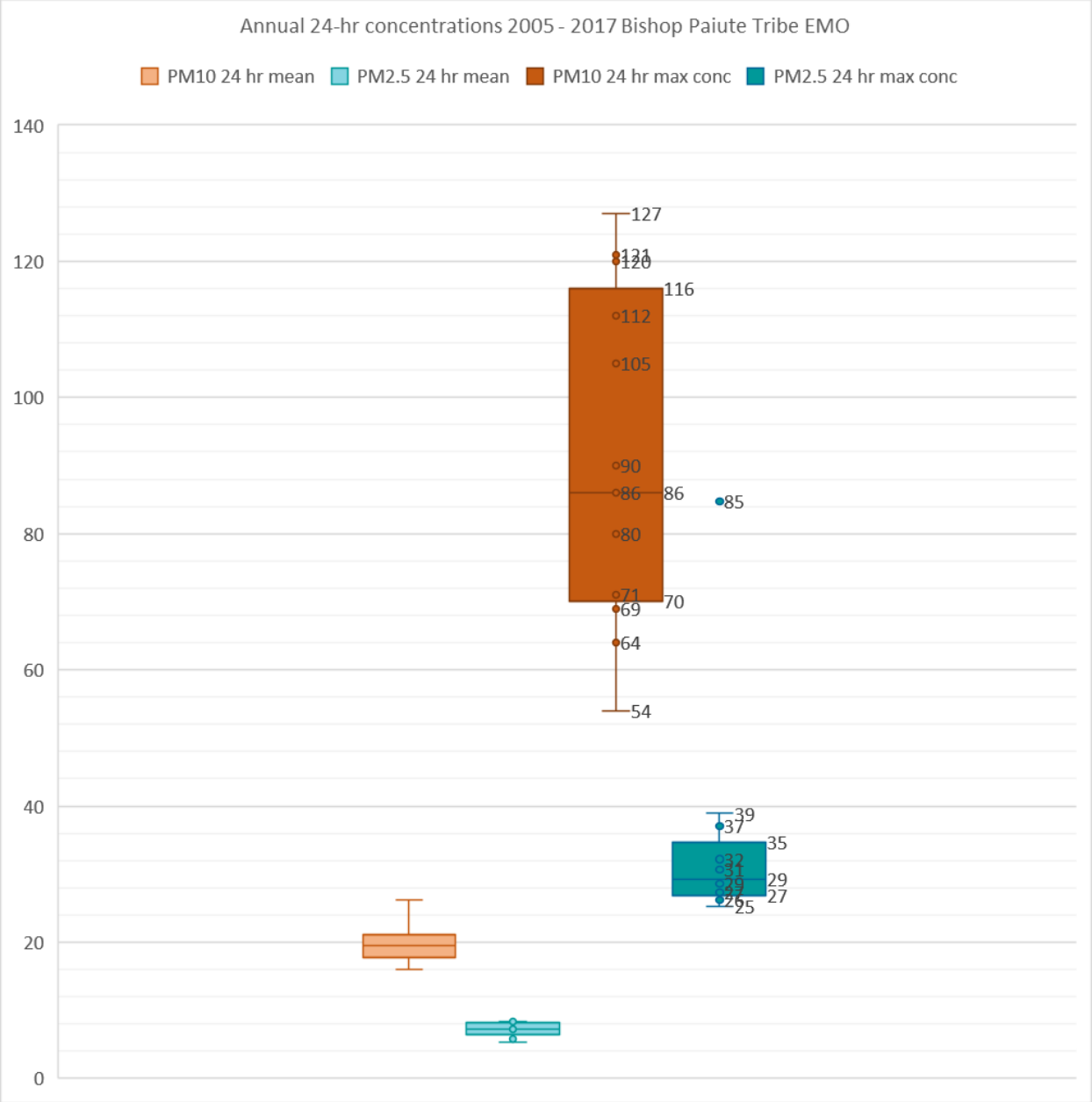
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
PM10 1 hr mean	18	18	25	22	20	19	18	21	20	17	18	21	21
PM2.5 1 hr mean	7	8	8	8	8	7	7	8	6	6	5	7	8
PM10 1 hr max conc	550	370	698	1064	902	939	1426	698	424	421	429	388	745
PM2.5 1 hr max conc	96	96	156	94	87	123	175	85	75	141	252	100	87



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
PM10 24 hr mean	18	18	24	21	20	19	18	20	19	17	16	21	26
PM2.5 24 hr mean	7	8	8	8	8	7	7	8	6	6	5	7	8
PM10 24 hr max conc	54	112	69	90	120	71	121	80	105	86	127	64	86
PM2.5 24 hr max conc	31	29	27	39	32	28	25	29	26	37	85	32	26



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PM2.5 1 hr mean	7	8	8	8	8	7	7	8	6	6	5	7	8	9
PM2.5 1 hr max conc	96	96	156	94	87	123	175	85	75	141	252	100	87	210



Annual Summary Graphs

Annual graphs are constructed using monthly statistics. The statistics are constructed from the analog-converted data as derived from the data logger. Graphs reflect the data as recorded in the TREX DAS and processed in MS Excel. Values have been rounded. For ease of viewing, single-axis graphs are presented to reflect both 24-hr and 1-hr values, and are scaled individually per parameter per year. As noted, the threshold data completion for the purpose of deriving the maximum and average 24-hourly and 1-hourly statistics is 75%. As the annual graphs were created originally for internal informational purposes, statistics for all and any data recorded during the month were displayed. Graphs have been edited to exclude monthly statistics with data capture <75%, *with the exception* of months where only “chunks” of

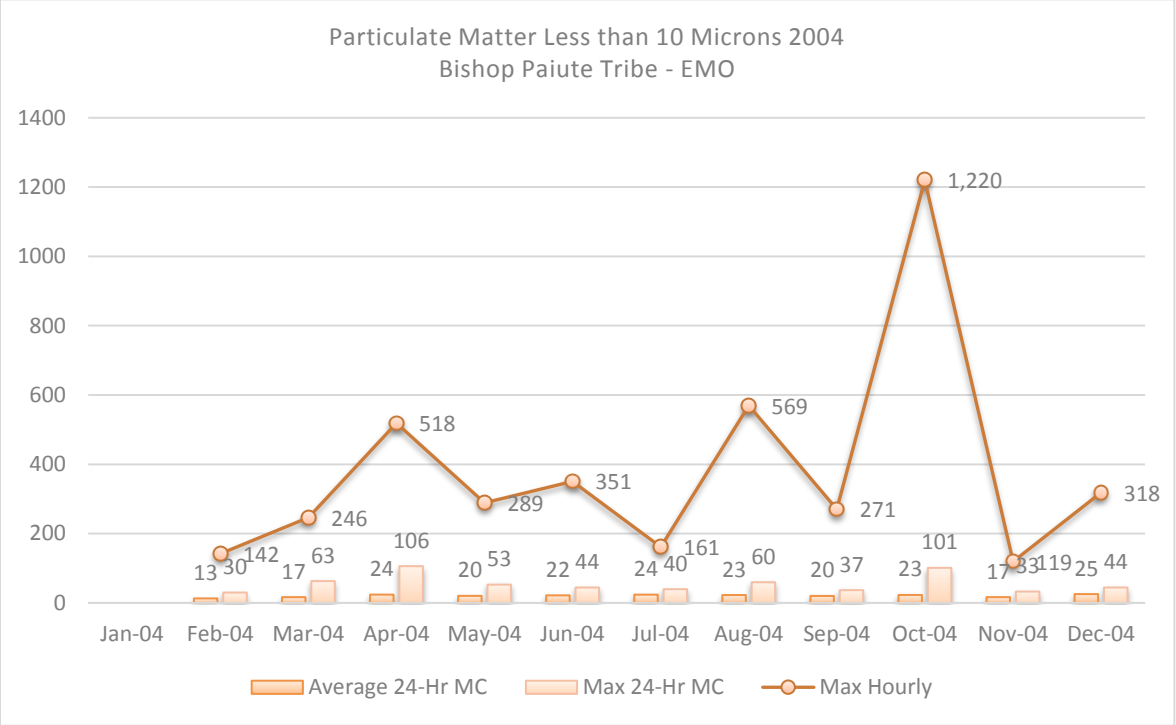
consecutive modes of capture i.e. “on” or “off” exist- and therefore “off” capture was not scattered across hours and days- and these exceptions are noted in Table 1 below. A minimum threshold of 25% capture was chosen to apply to these inclusions. For example, if the 1st 20 days of a month were captured, and the remaining were not, statistics for this month would be included in the graphs, as the statistics apply to wholly captured days despite the truncation of the capture. There are a substantial number of such months in the record, typically due to a period of monitor downtime or invalidation of data. Note that as a result of applying this rule of consecutive “chunks”, some months with total capture >75% but <75% of days captured were omitted; however, for the purpose of deriving 24-hr average values, days with interrupted capture are not as valuable as the intact days. Note also these data are only omitted for the purpose of display of 24-hr values in the graphs *in this section*, and may be reflected elsewhere for analysis.

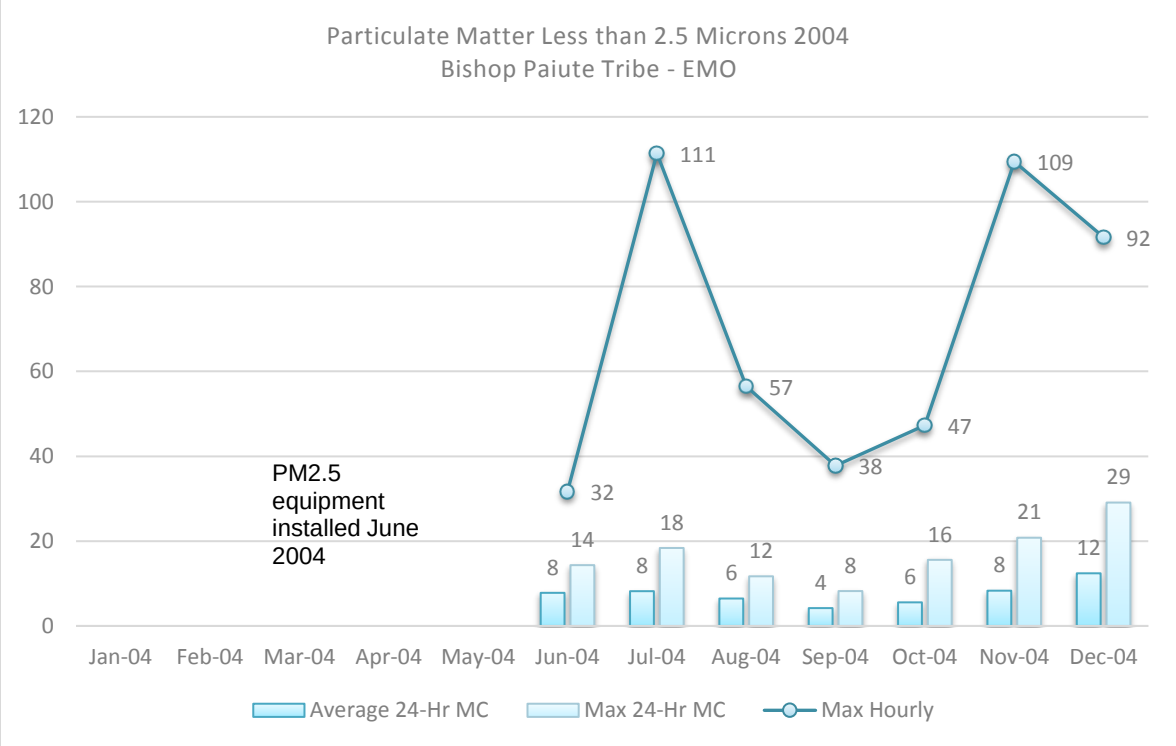
For PM2.5, 1-hr values of 0 are interpreted to be 0 or negatives validated as ambient zero, rather than missing data, and contribute to the overall capture rate.

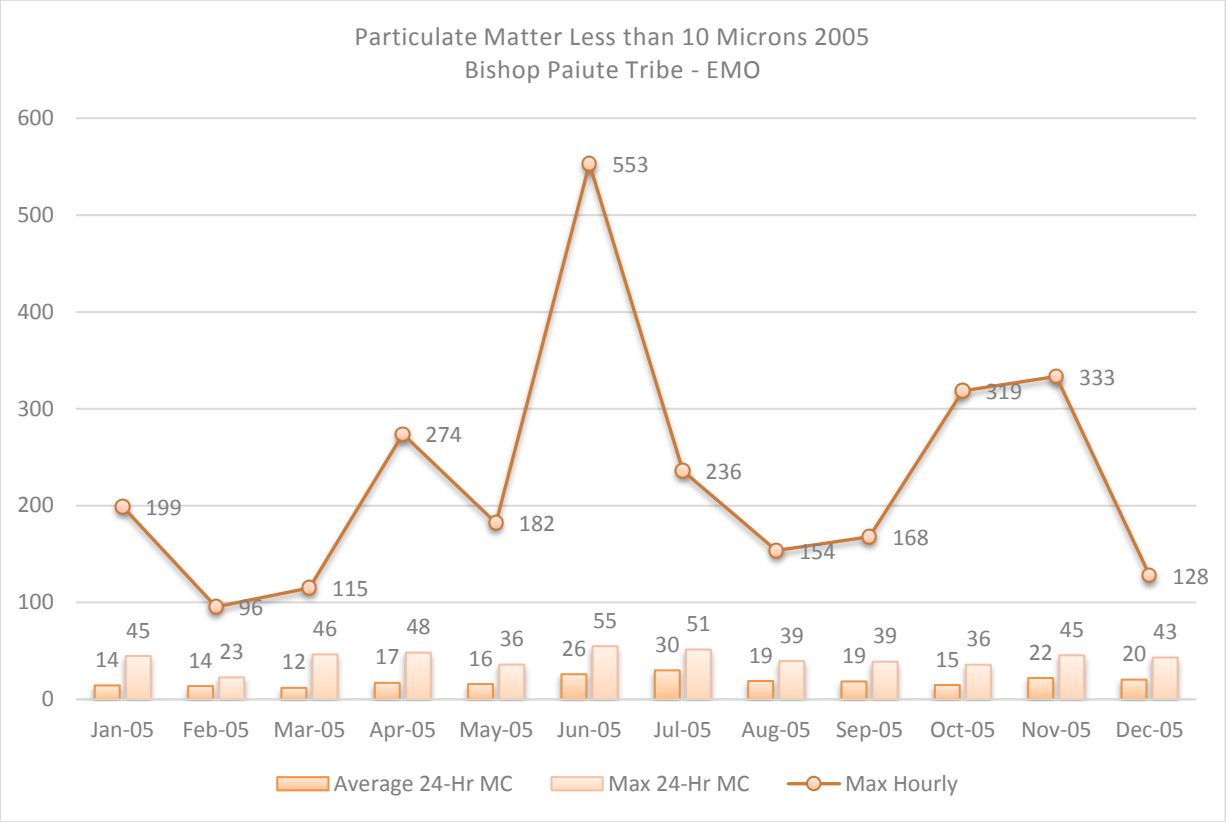
TABLE 1. CAPTURE-EXCEPTIONAL MONTHLY DATA INCLUDED IN GRAPHS

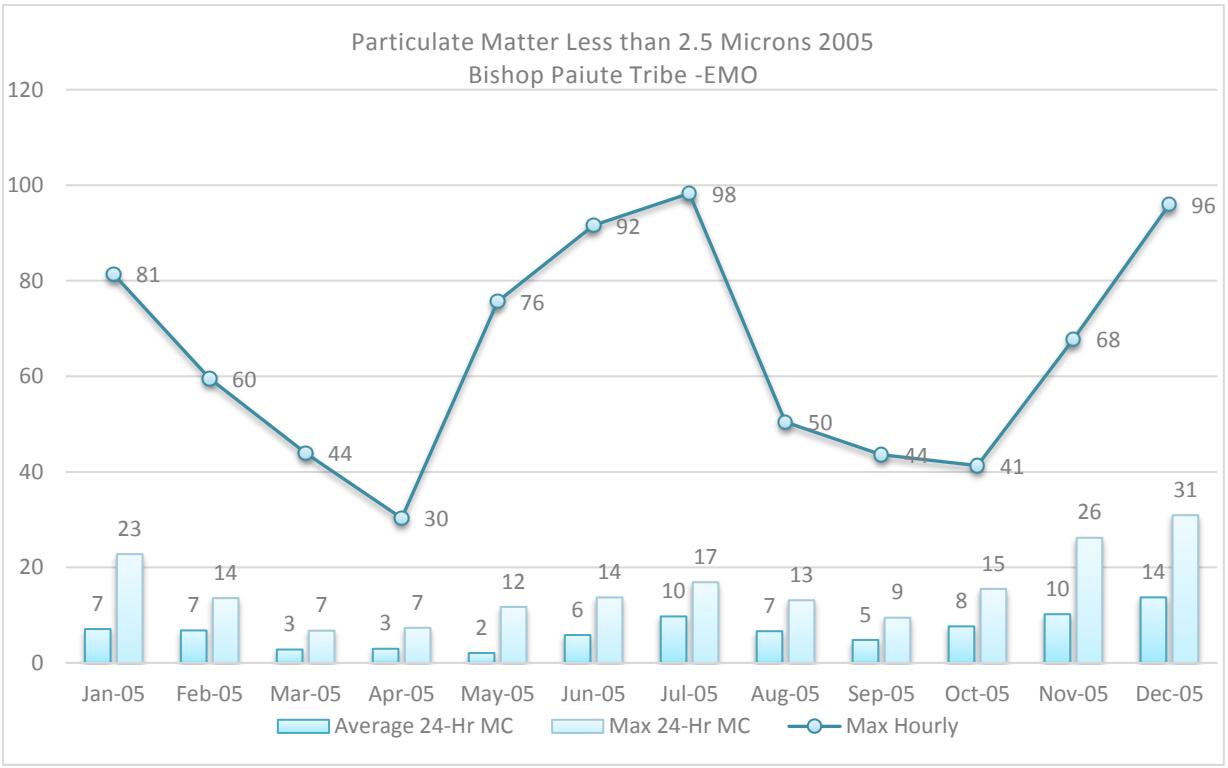
Month	Year	PM category	% Capture (as per TREX)
Aug	2006	2.5	75.3
Nov	2006	10	50.6
May	2007	2.5	42.9
Jun	2007	2.5	35.8
Oct	2007	2.5	64.8
Mar	2008	10	58.2
Mar	2008	2.5	59.5
Apr	2008	10	54.7
Sep	2009	10	51.1
Jan	2010	10	20.6
Sep	2010	10	27.9
Dec	2010	10	75.7
Nov	2012	10	72.8
Jun	2013	2.5	40.7
Apr	2014	10	78.6
Jul	2014	2.5	61.7
Aug	2014	2.5	36.8
Sep	2015	10	72.3
Oct	2016	2.5	56.0
Jul	2017	2.5	69.8
Aug	2017	10	53.5

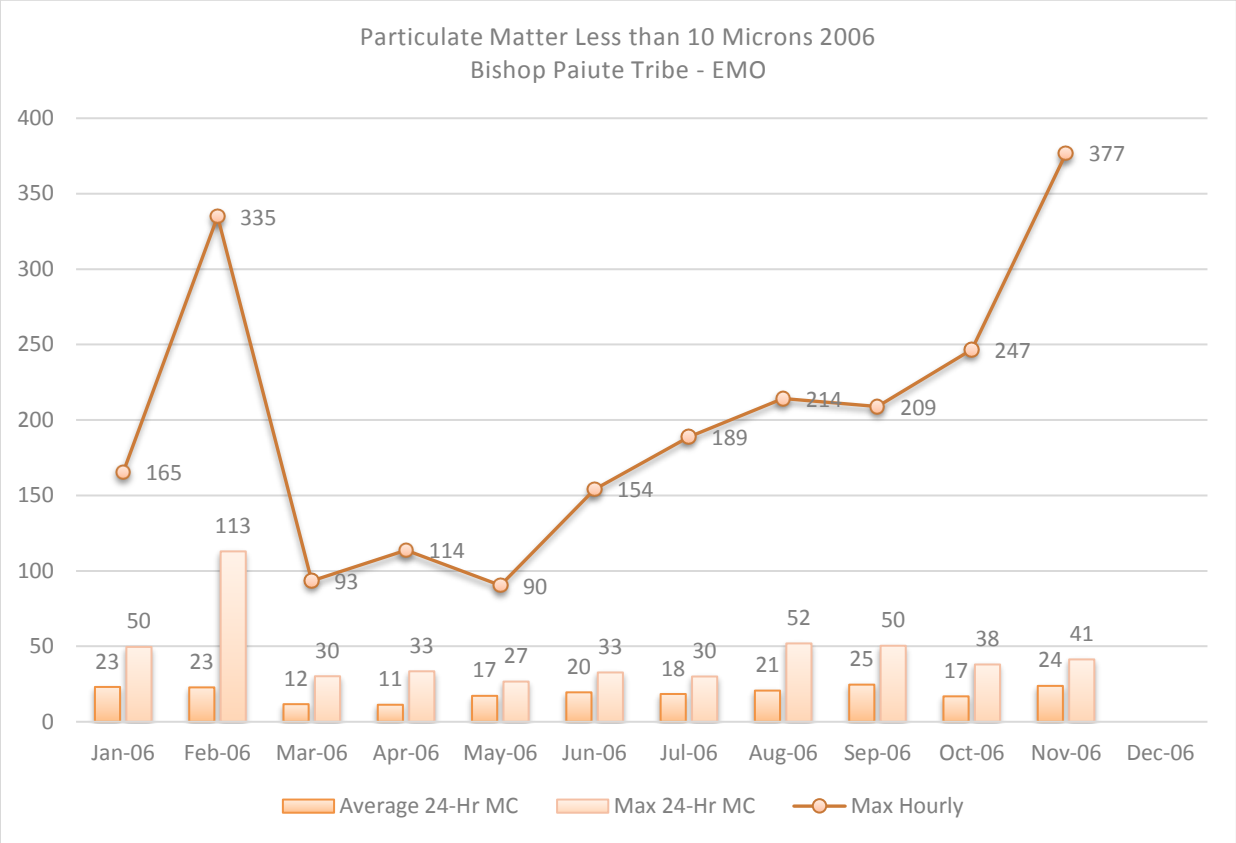
FIGURES 5-32. PM ANNUAL SUMMARIES BISHOP PAIUTE RESERVATION 2004-2017

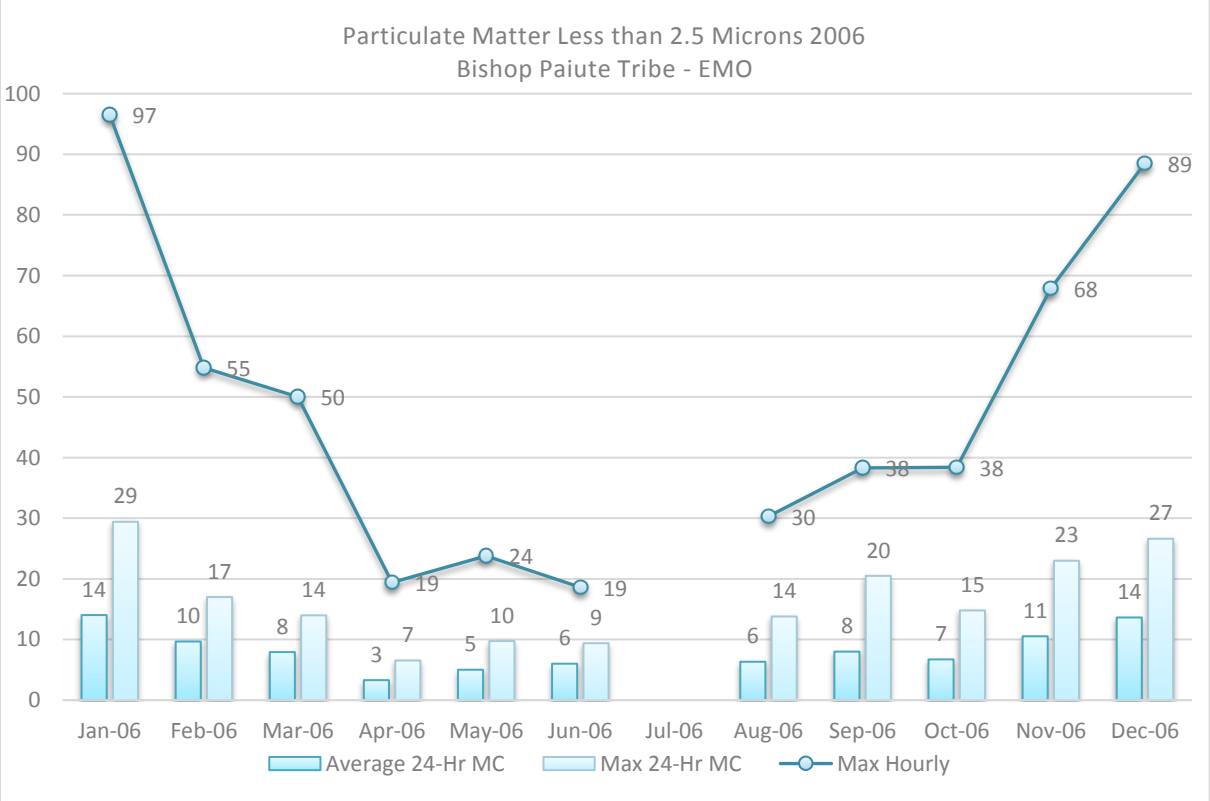


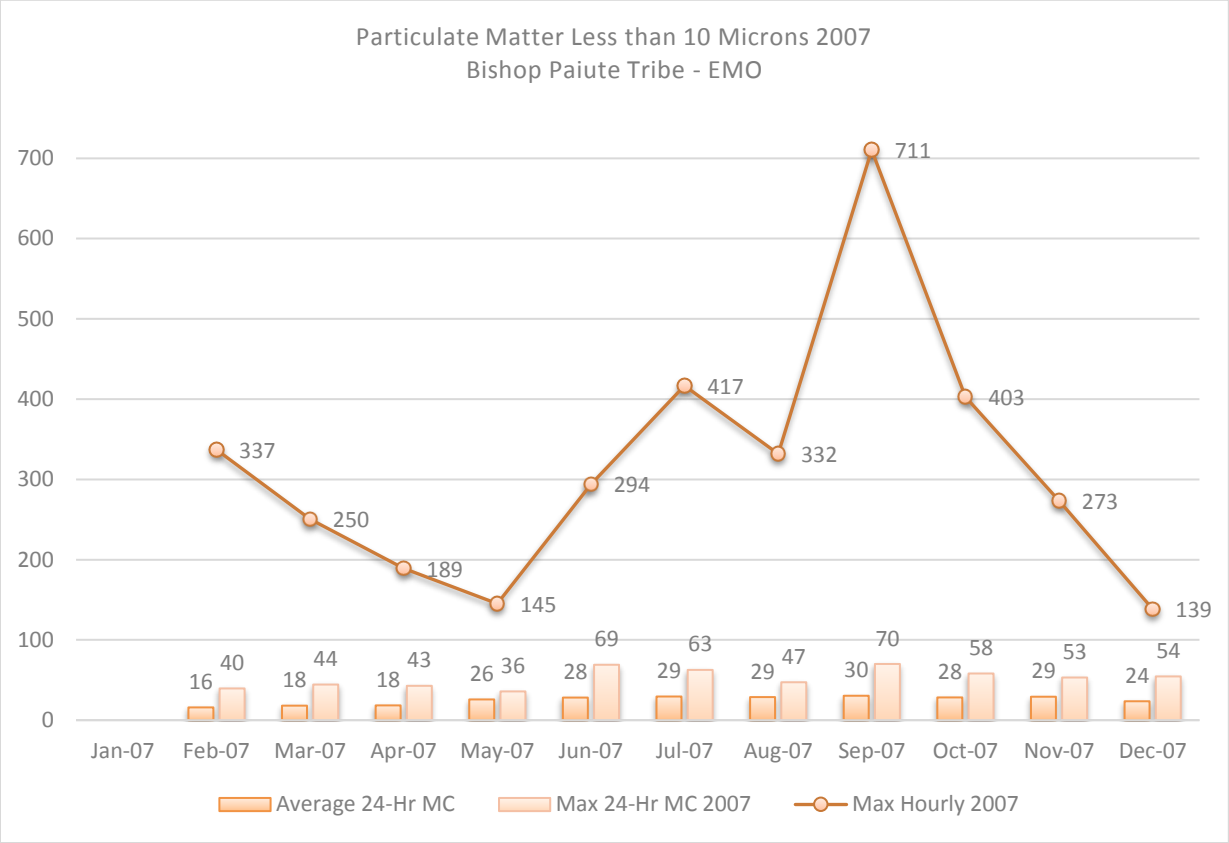


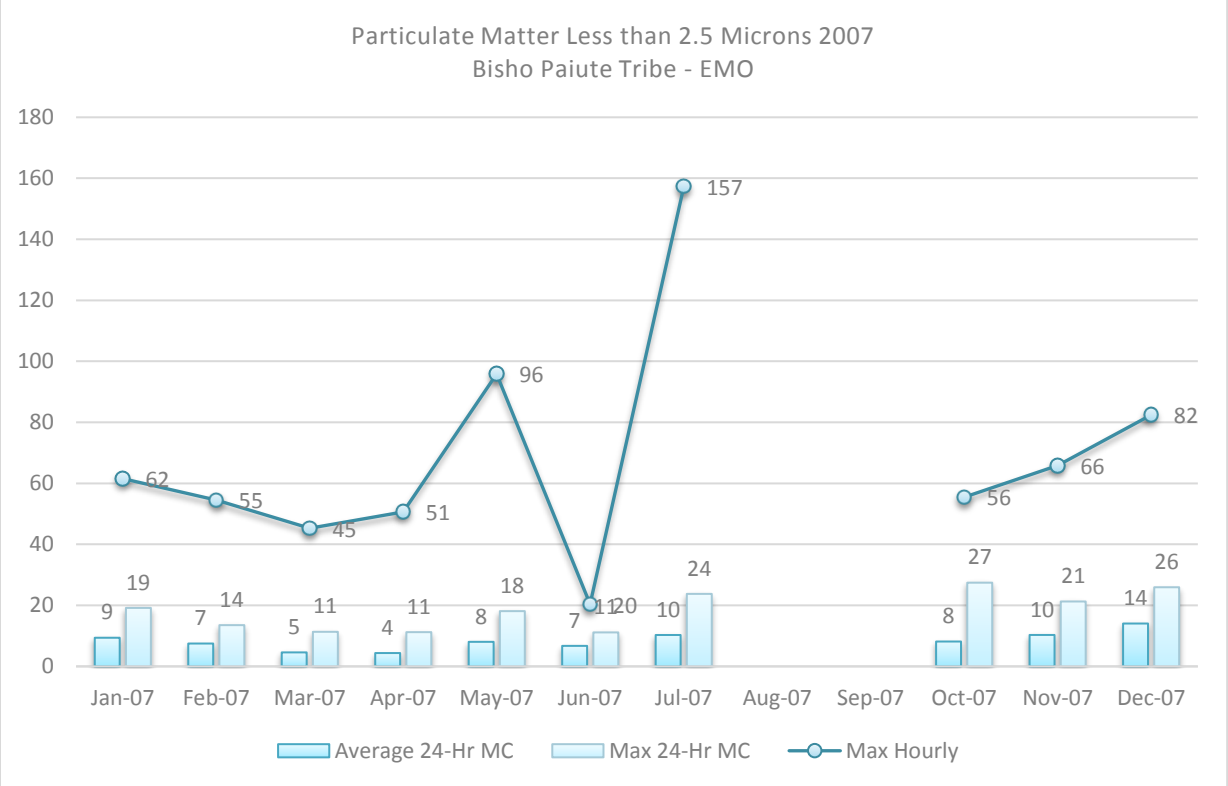

Particulate Matter Less than 10 Microns 2005
Bishop Paiute Tribe - EMO
600
500
400
300
200
100
0
199
96
115
274
182
553
236
154
168
319
333
128
45
14
23
14
46
12
48
17
36
16
55
26
51
30
39
19
39
19
36
15
45
22
43
20
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05
Average 24-Hr MC
Max 24-Hr MC
Max Hourly

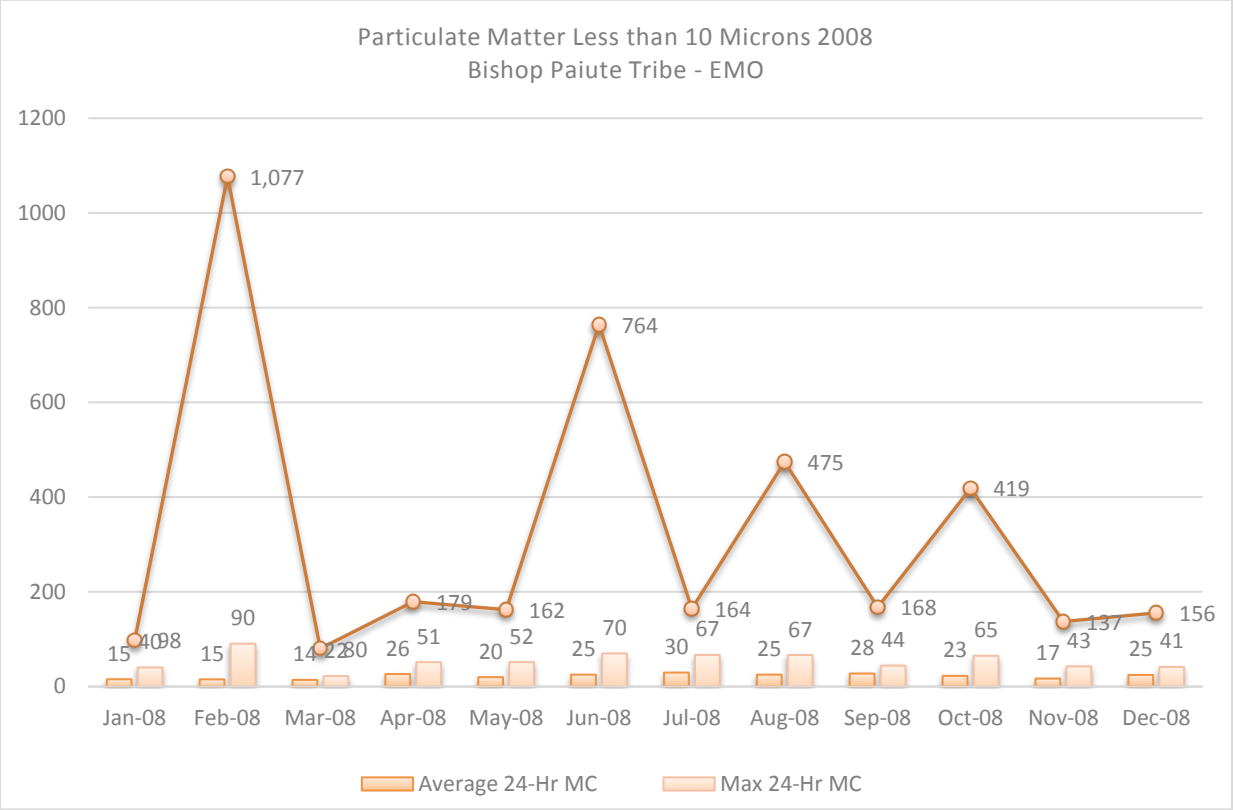

Particulate Matter Less than 2.5 Microns 2005
Bishop Paiute Tribe -EMO
120
100
80
60
40
20
0
81
60
44
30
76
92
98
50
44
41
68
96
23
7
14
7
7
3
7
3
12
2
14
6
17
10
13
7
9
5
15
8
26
10
31
14
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05
Average 24-Hr MC
Max 24-Hr MC
Max Hourly

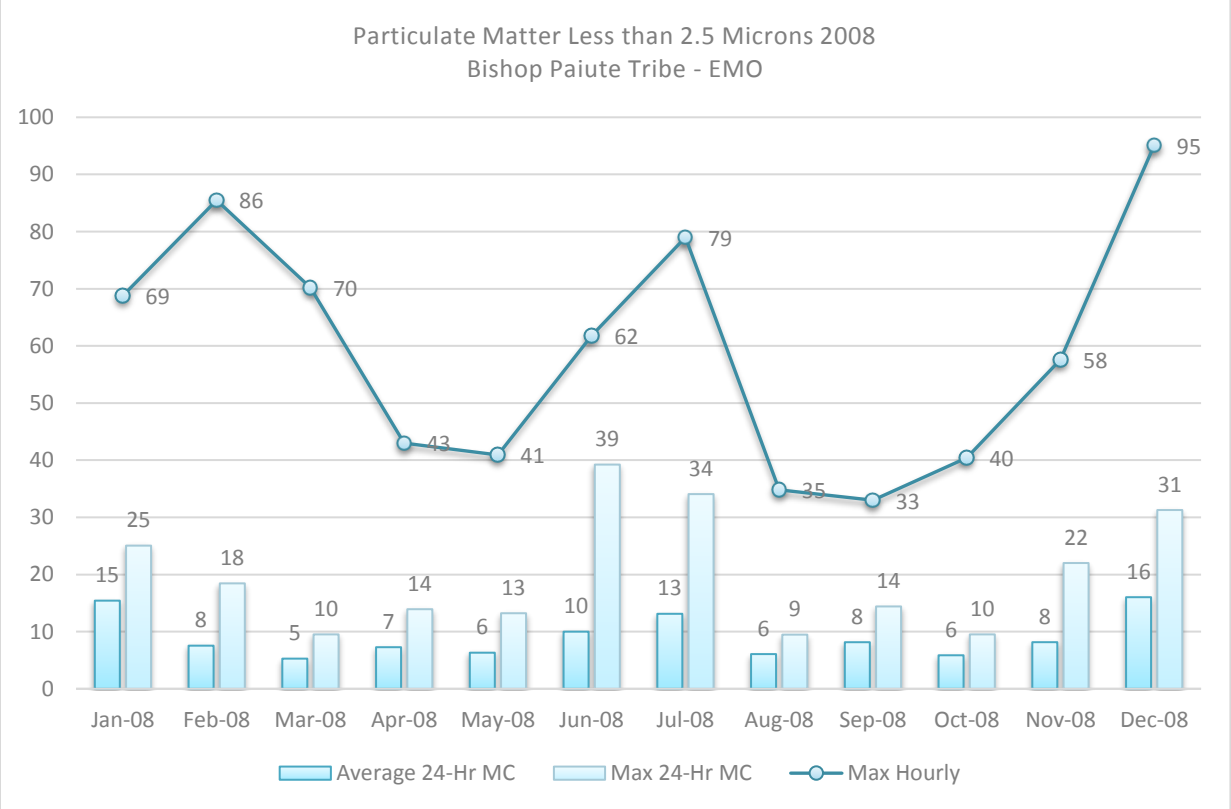

Particulate Matter Less than 10 Microns 2006
Bishop Paiute Tribe - EMO
400
350
300
250
200
150
100
50
0
165
335
93
114
90
154
189
214
209
247
377
23
50
23
113
12
30
11
33
17
27
20
33
18
30
21
52
25
50
17
38
24
41
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Average 24-Hr MC
Max 24-Hr MC
Max Hourly

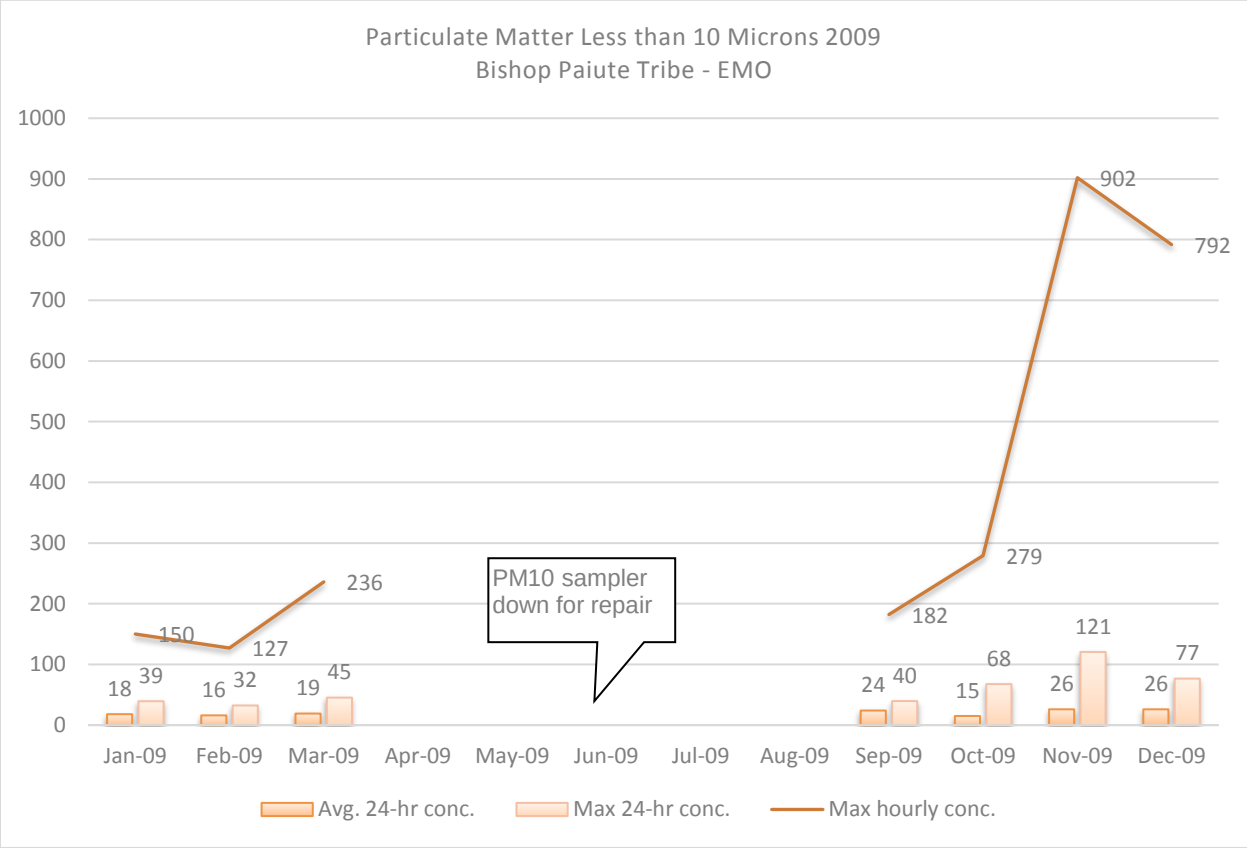

Particulate Matter Less than 2.5 Microns 2006
Bishop Paiute Tribe - EMO
100
90
80
70
60
50
40
30
20
10
0
97
55
50
19
24
19
30
38
38
68
89
14
29
10
17
8
14
3
7
5
10
6
9
6
14
8
20
7
15
11
23
14
27
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Average 24-Hr MC
Max 24-Hr MC
Max Hourly

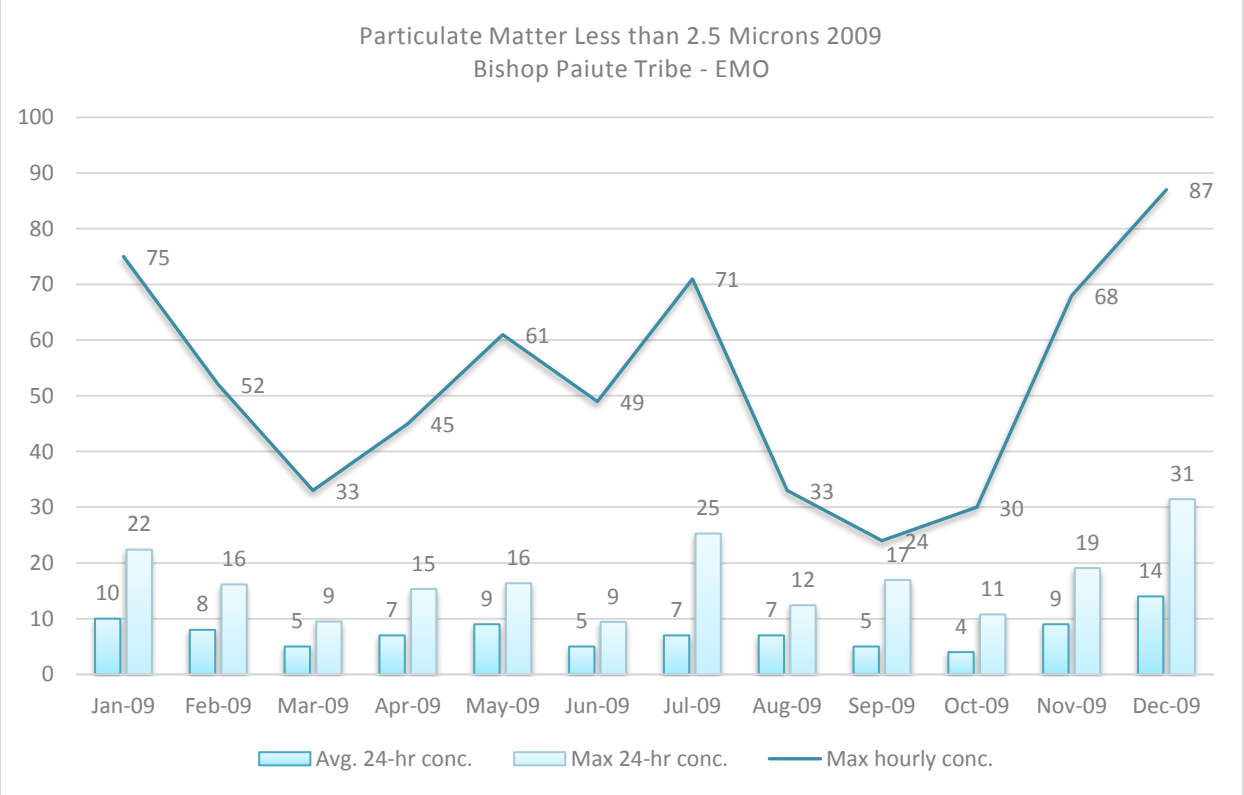

Particulate Matter Less than 10 Microns 2007
Bishop Paiute Tribe - EMO
700
600
500
400
300
200
100
0
337
250
189
145
294
417
332
711
403
273
139
16
40
18
44
18
43
26
36
28
69
29
63
29
47
30
70
28
58
29
53
24
54
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
Average 24-Hr MC
Max 24-Hr MC 2007
Max Hourly 2007

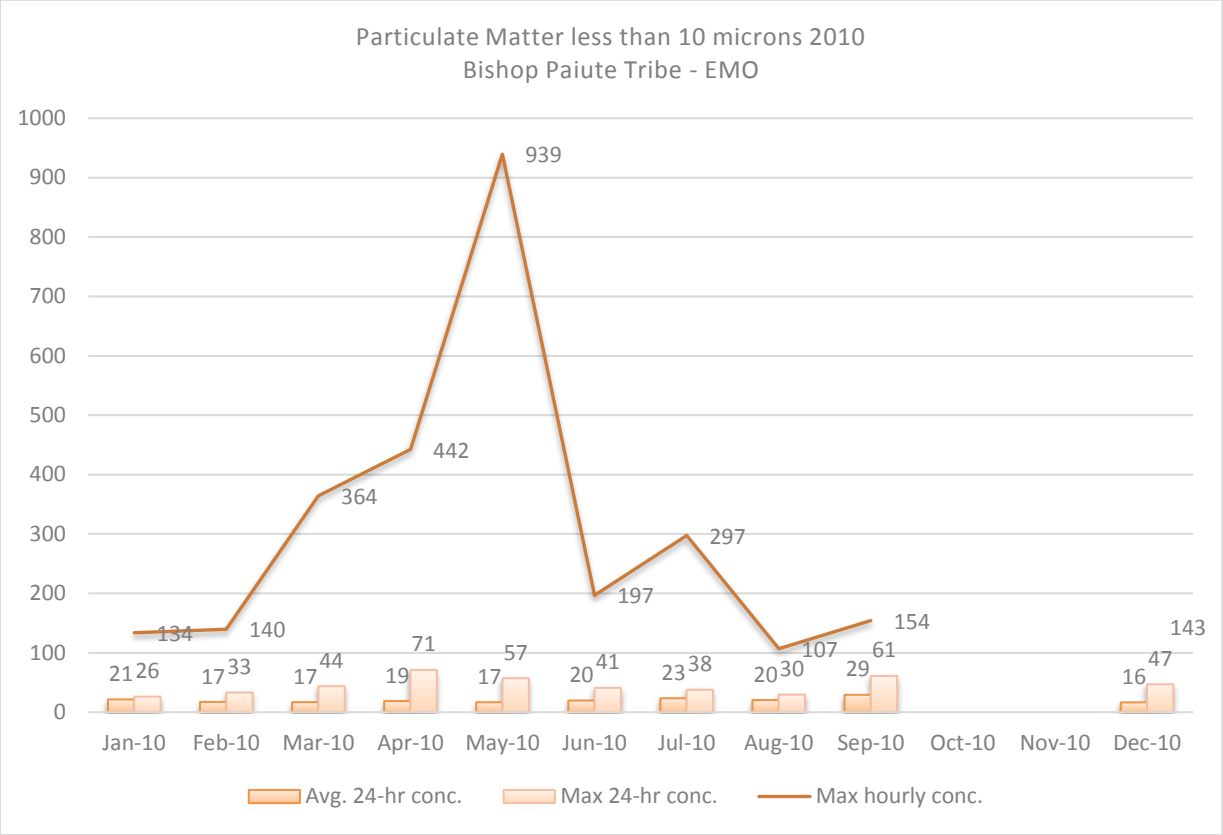

Particulate Matter Less than 2.5 Microns 2007
Bisho Paiute Tribe - EMO
180
160
140
120
100
80
60
40
20
0
62
55
45
51
96
157
56
66
82
9
19
7
14
5
11
4
11
8
18
7
11
20
10
24
8
27
10
21
14
26
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
Average 24-Hr MC
Max 24-Hr MC
Max Hourly

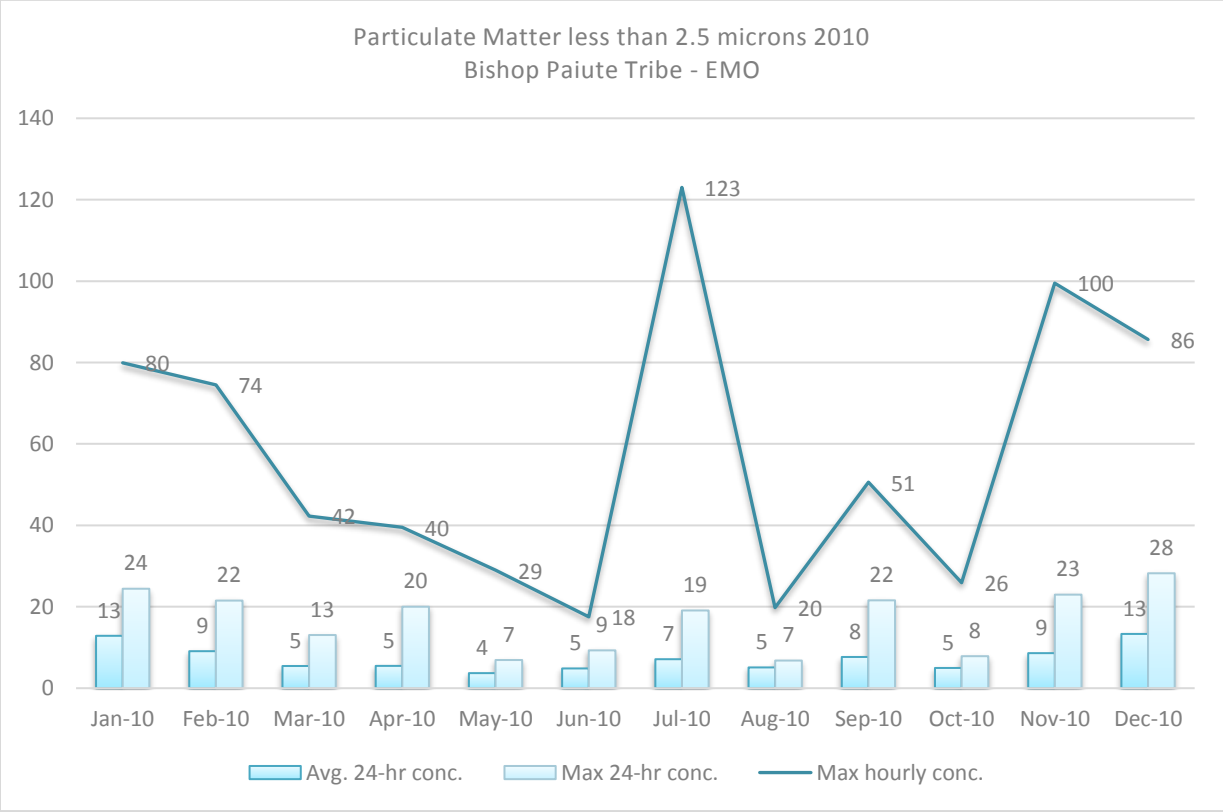

Particulate Matter Less than 10 Microns 2008
Bishop Paiute Tribe - EMO
1200
1000
800
600
400
200
0
1,077
764
475
419
179
162
164
168
156
137
90
98
80
70
67
67
65
51
52
44
43
41
40
30
25
26
20
25
28
23
17
25
15
15
14
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Jun-08
Jul-08
Aug-08
Sep-08
Oct-08
Nov-08
Dec-08
Average 24-Hr MC
Max 24-Hr MC

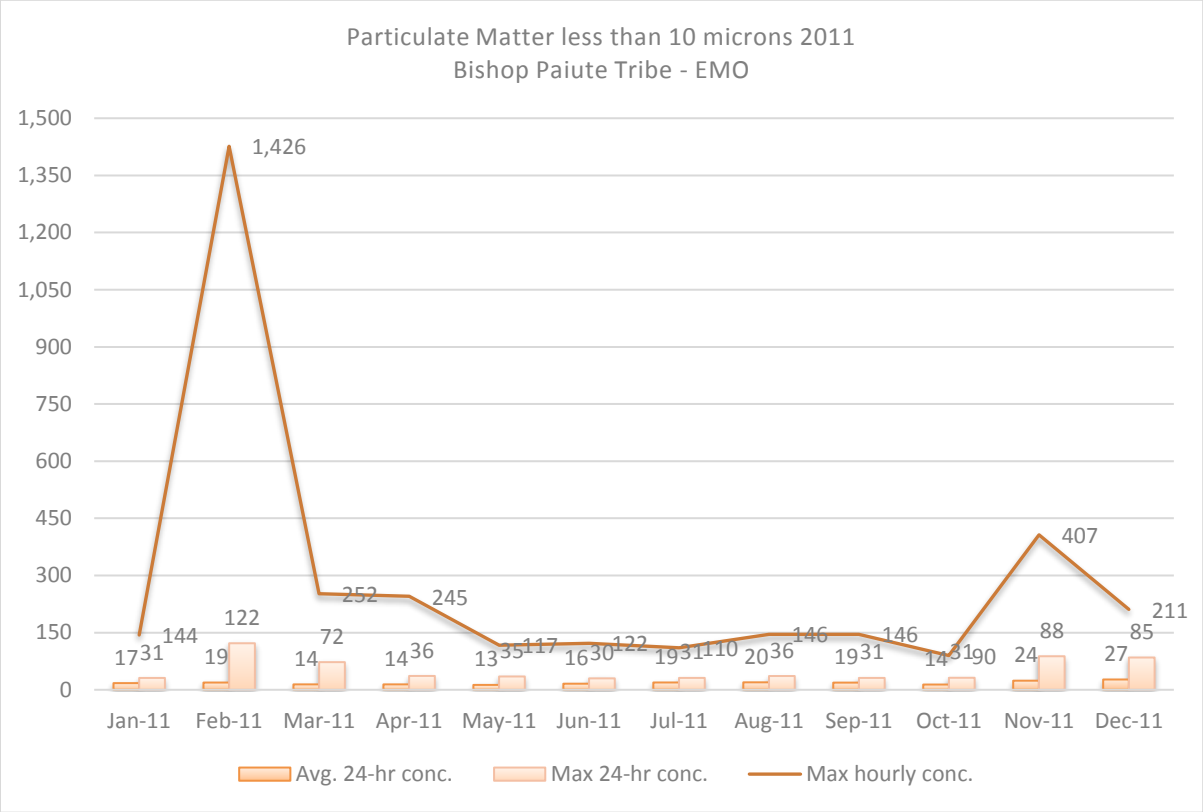

Particulate Matter Less than 2.5 Microns 2008
Bishop Paiute Tribe - EMO
100
90
80
70
60
50
40
30
20
10
0
95
86
79
70
69
62
58
43
41
40
39
35
34
33
31
25
22
18
16
15
14
14
13
13
10
10
10
9
8
8
8
7
6
6
5
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Jun-08
Jul-08
Aug-08
Sep-08
Oct-08
Nov-08
Dec-08
Average 24-Hr MC
Max 24-Hr MC
Max Hourly

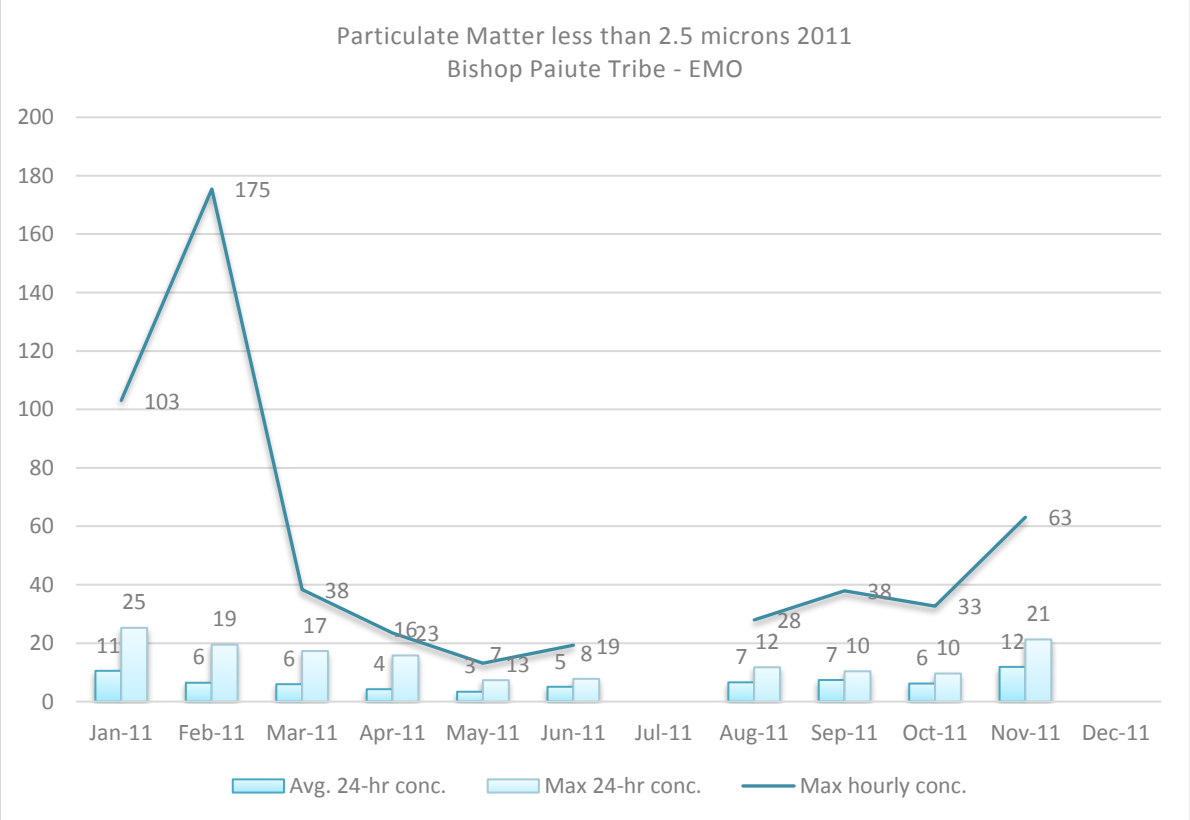

Particulate Matter Less than 10 Microns 2009
Bishop Paiute Tribe - EMO
1000
900
800
700
600
500
400
300
200
100
0
Jan-09
Feb-09
Mar-09
Apr-09
May-09
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
18
39
16
32
19
45
24
40
15
68
26
121
26
77
150
127
236
182
279
902
792
PM10 sampler down for repair
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

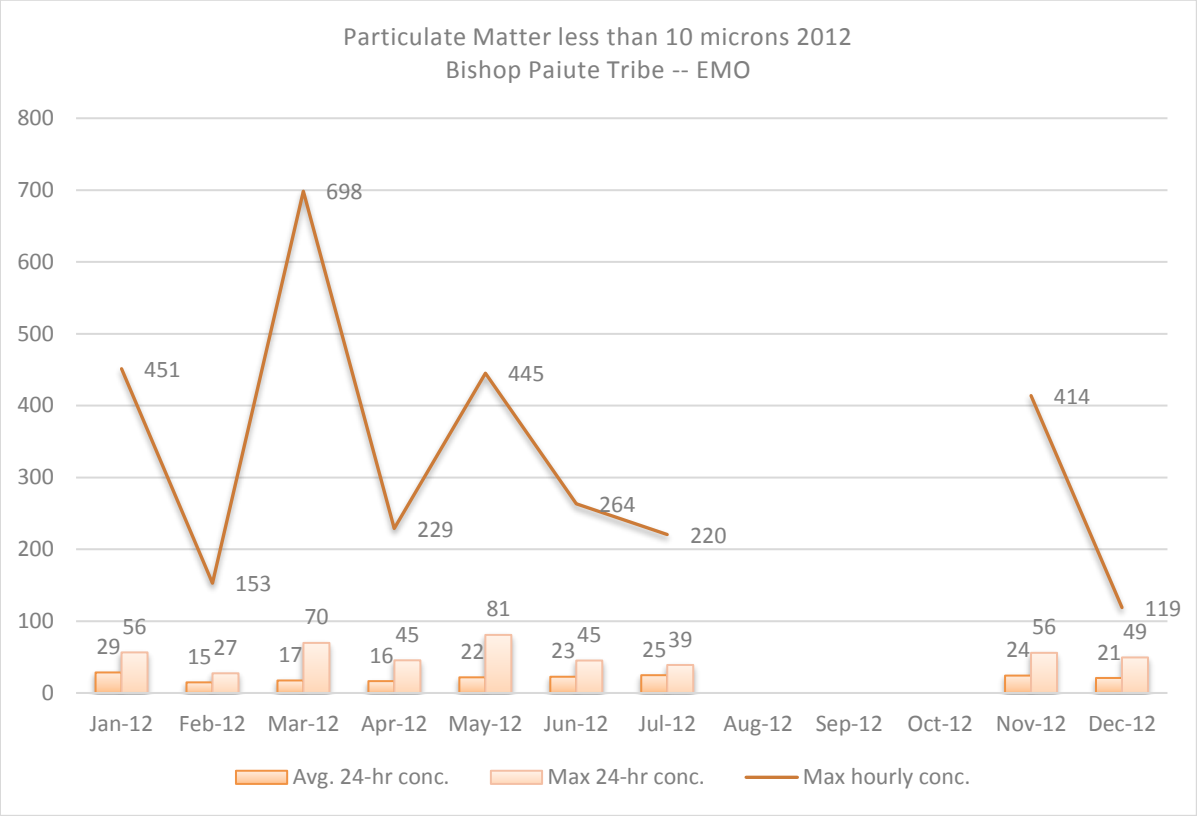

Particulate Matter Less than 2.5 Microns 2009
Bishop Paiute Tribe - EMO
100
90
80
70
60
50
40
30
20
10
0
Jan-09
Feb-09
Mar-09
Apr-09
May-09
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
10
22
8
16
5
9
7
15
9
16
5
9
7
25
7
12
5
17
4
11
9
19
14
31
75
52
33
45
61
49
71
33
24
30
68
87
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

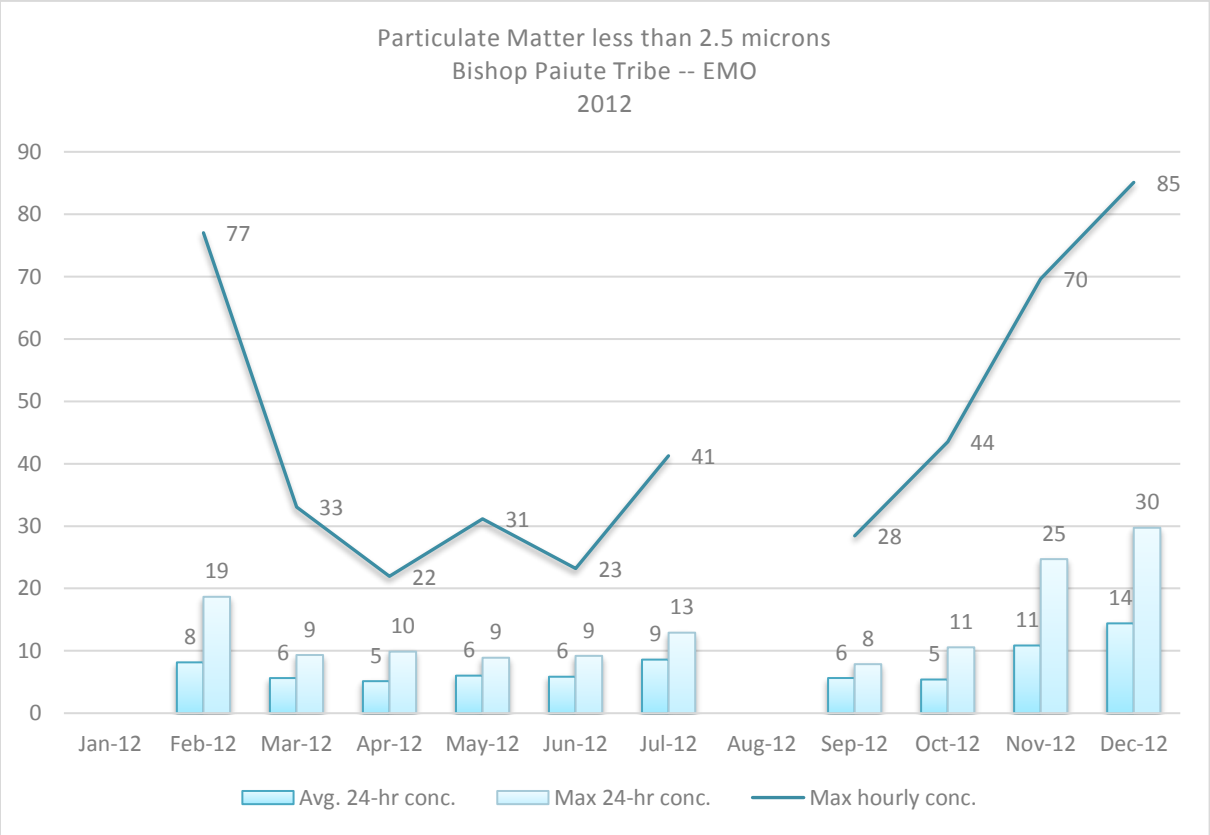

Particulate Matter less than 10 microns 2010
Bishop Paiute Tribe - EMO
1000
900
800
700
600
500
400
300
200
100
0
939
442
364
297
197
154
143
140
134
71
57
61
47
44
41
38
33
30
26
21
17
19
20
23
29
16
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10
Dec-10
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

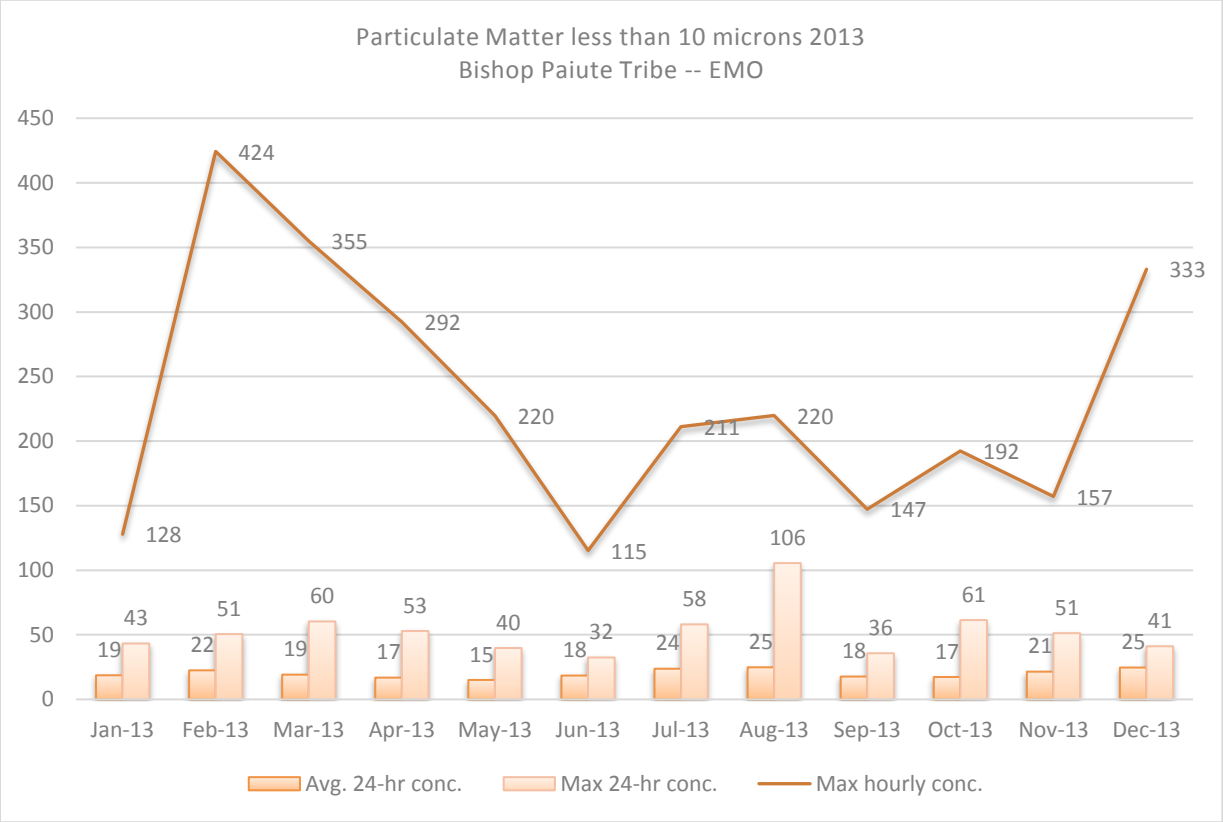

Particulate Matter less than 2.5 microns 2010
Bishop Paiute Tribe - EMO
140
120
100
80
60
40
20
0
123
100
86
80
74
51
42
40
29
28
26
24
22
23
22
20
19
18
13
13
9
5
5
4
5
7
8
5
9
13
7
5
8
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10
Dec-10
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

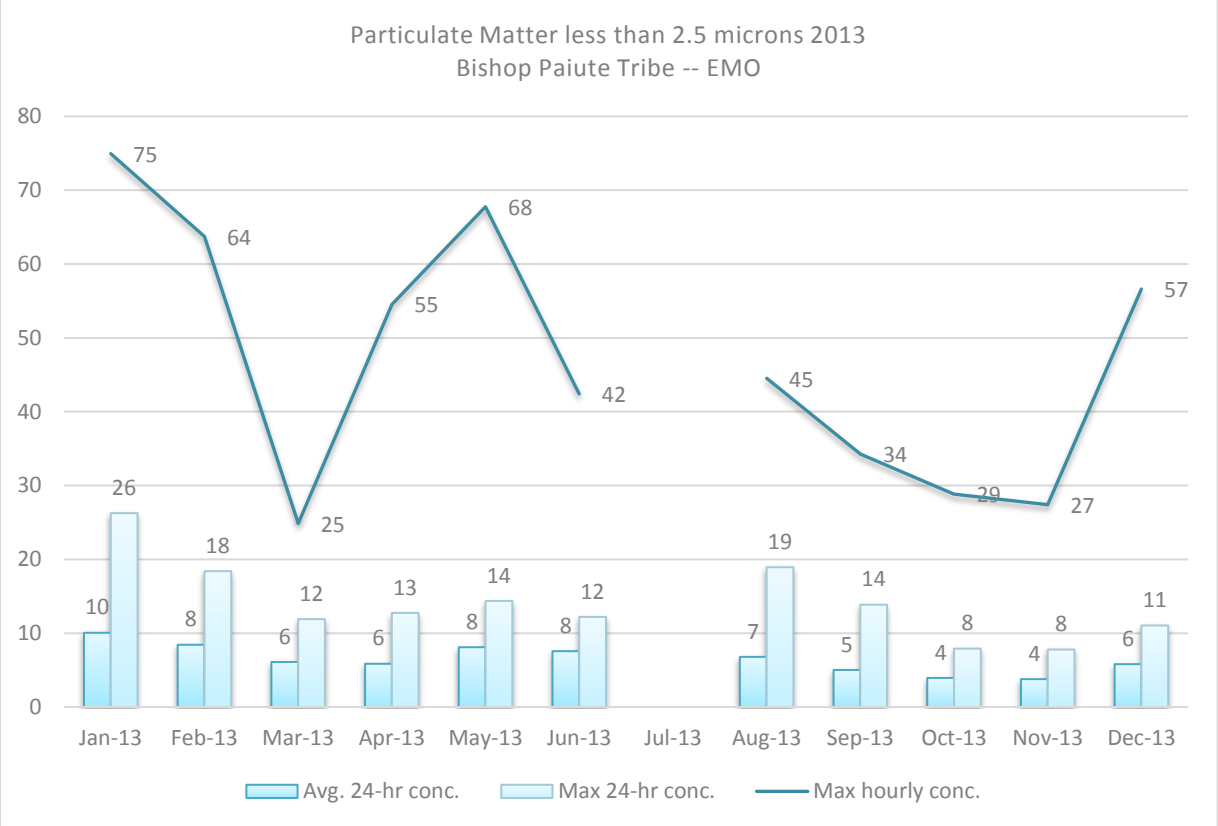

Particulate Matter less than 10 microns 2011
Bishop Paiute Tribe - EMO
1,500
1,350
1,200
1,050
900
750
600
450
300
150
0
1,426
407
252
245
211
144
122
72
36
117
122
110
146
146
90
88
85
17
31
19
14
14
13
35
16
30
19
31
20
36
19
31
14
31
24
27
Jan-11
Feb-11
Mar-11
Apr-11
May-11
Jun-11
Jul-11
Aug-11
Sep-11
Oct-11
Nov-11
Dec-11
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

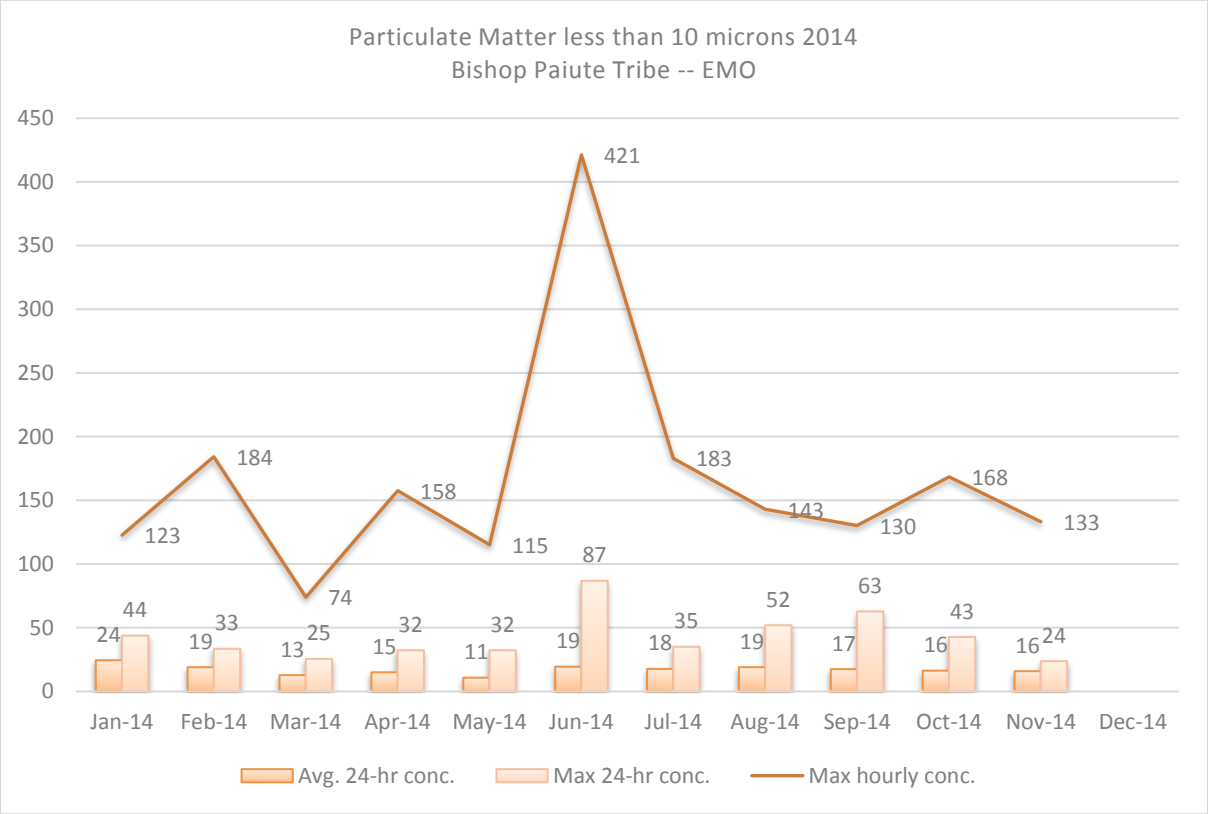

Particulate Matter less than 2.5 microns 2011
Bishop Paiute Tribe - EMO
200
180
160
140
120
100
80
60
40
20
0
175
103
63
38
38
33
28
25
19
17
16
23
21
19
13
12
12
11
6
6
4
3
7
5
8
7
10
6
10
Jan-11
Feb-11
Mar-11
Apr-11
May-11
Jun-11
Jul-11
Aug-11
Sep-11
Oct-11
Nov-11
Dec-11
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

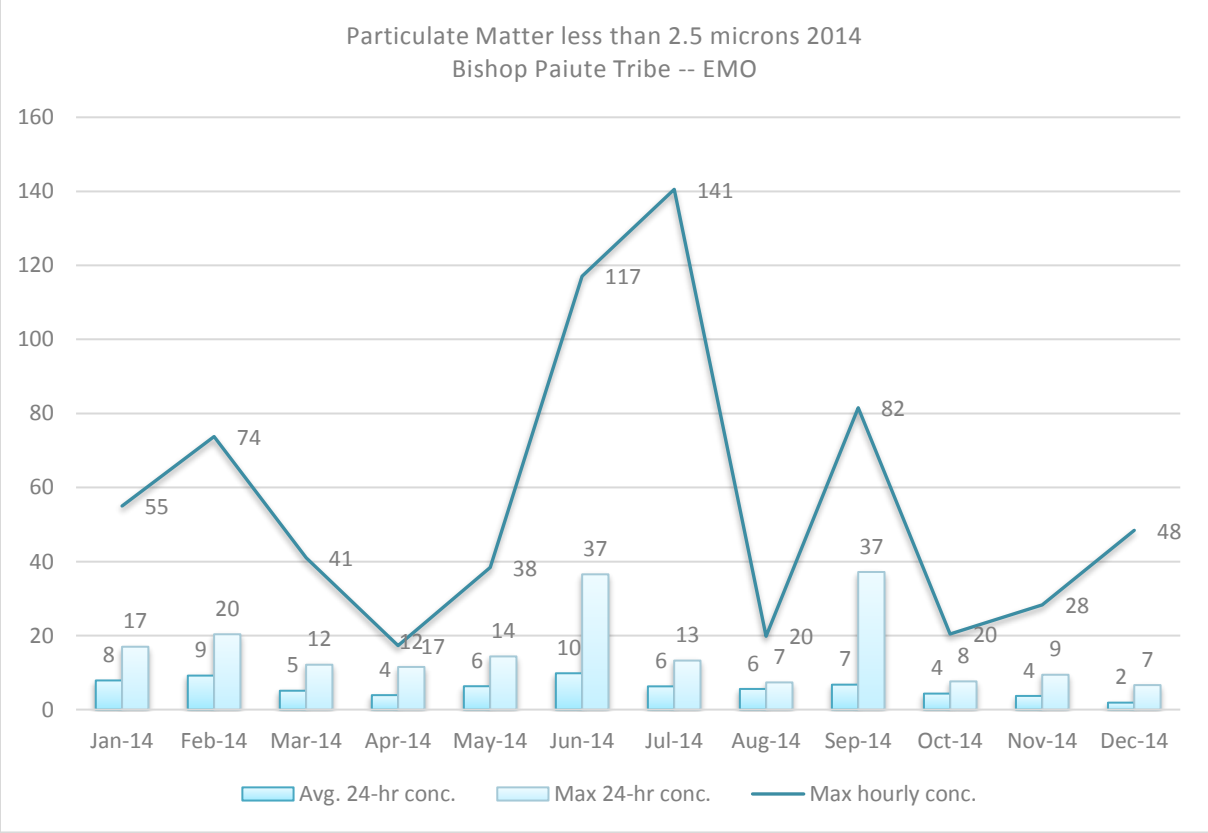

Particulate Matter less than 10 microns 2012
Bishop Paiute Tribe -- EMO
800
700
600
500
400
300
200
100
0
451
153
698
229
445
264
220
414
119
29
56
15
27
17
70
16
45
22
81
23
45
25
39
24
56
21
49
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

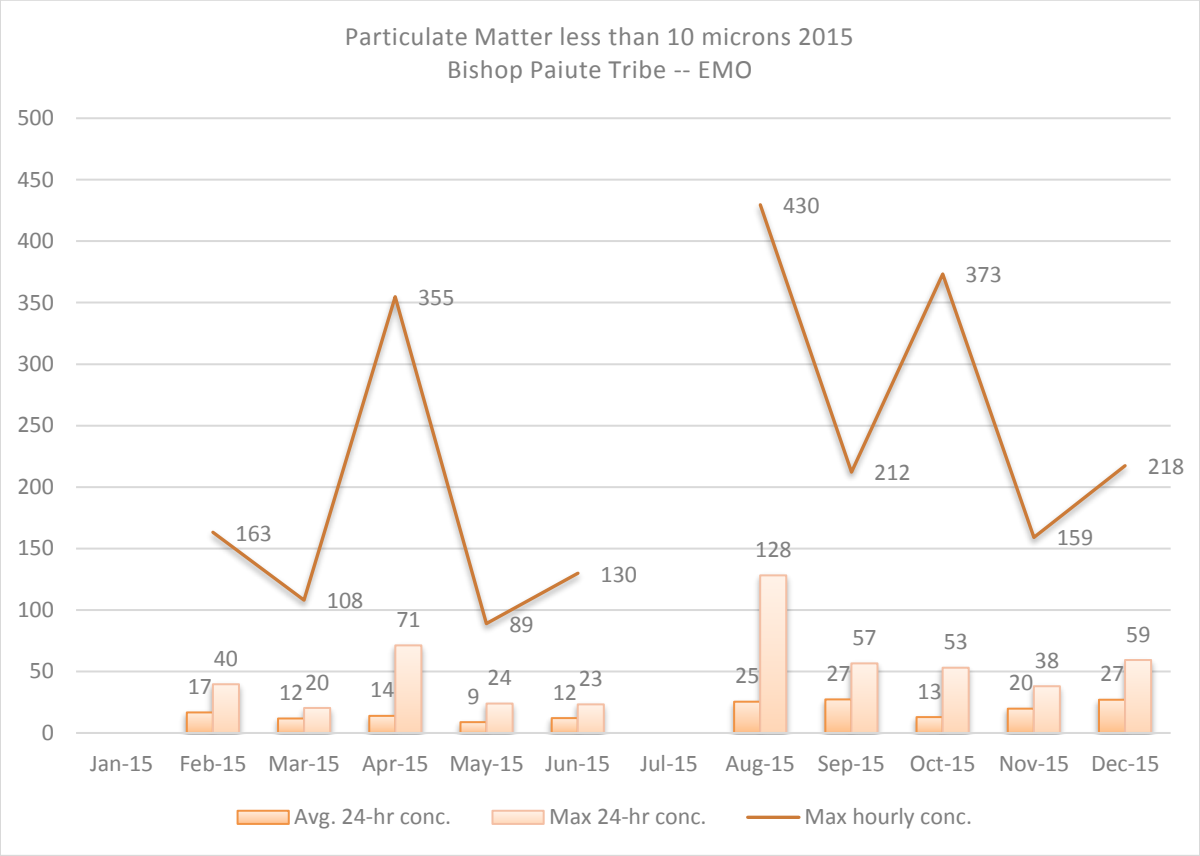

Particulate Matter less than 2.5 microns
Bishop Paiute Tribe -- EMO
2012
90
80
70
60
50
40
30
20
10
0
77
33
22
31
23
41
28
44
70
85
8
19
6
9
5
10
6
9
6
9
9
13
6
8
5
11
11
25
14
30
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

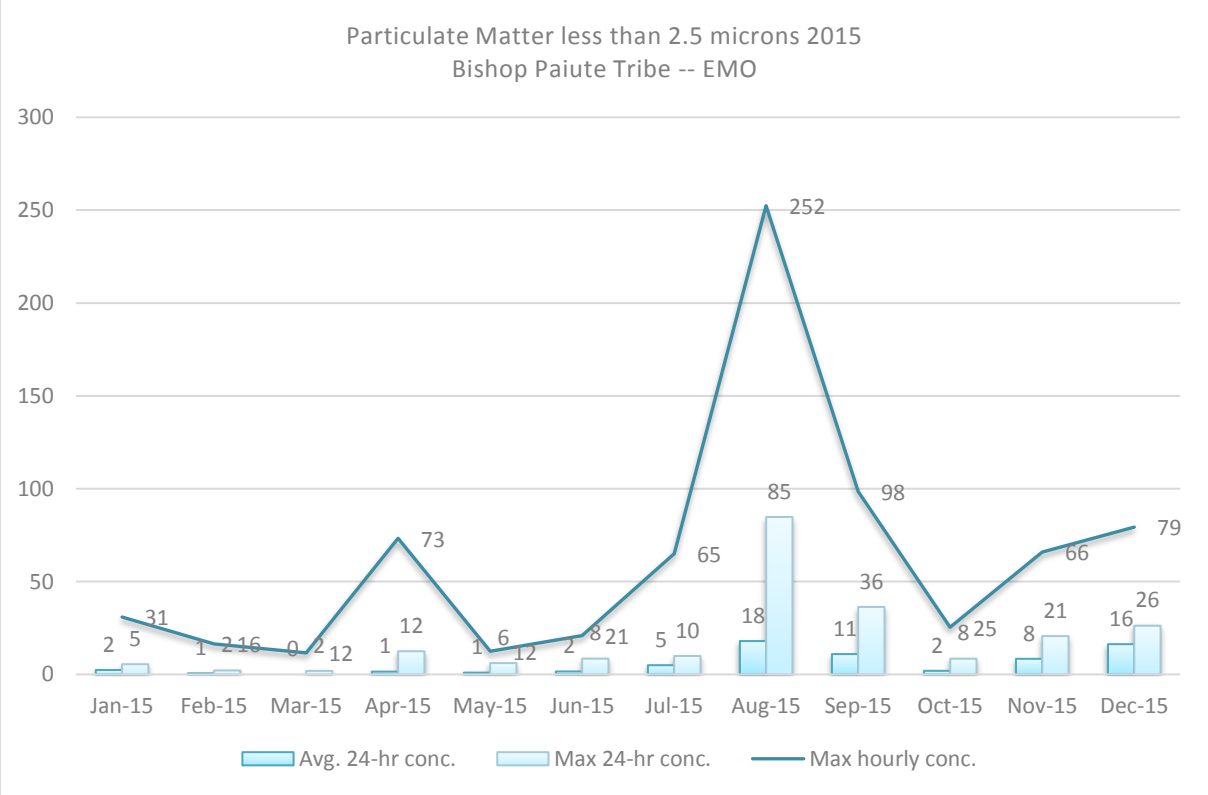

Particulate Matter less than 10 microns 2013
Bishop Paiute Tribe -- EMO
450
400
350
300
250
200
150
100
50
0
424
355
292
220
115
211
220
147
192
157
333
128
43
51
60
53
40
32
58
106
36
61
51
41
19
22
19
17
15
18
24
25
18
17
21
25
Jan-13
Feb-13
Mar-13
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

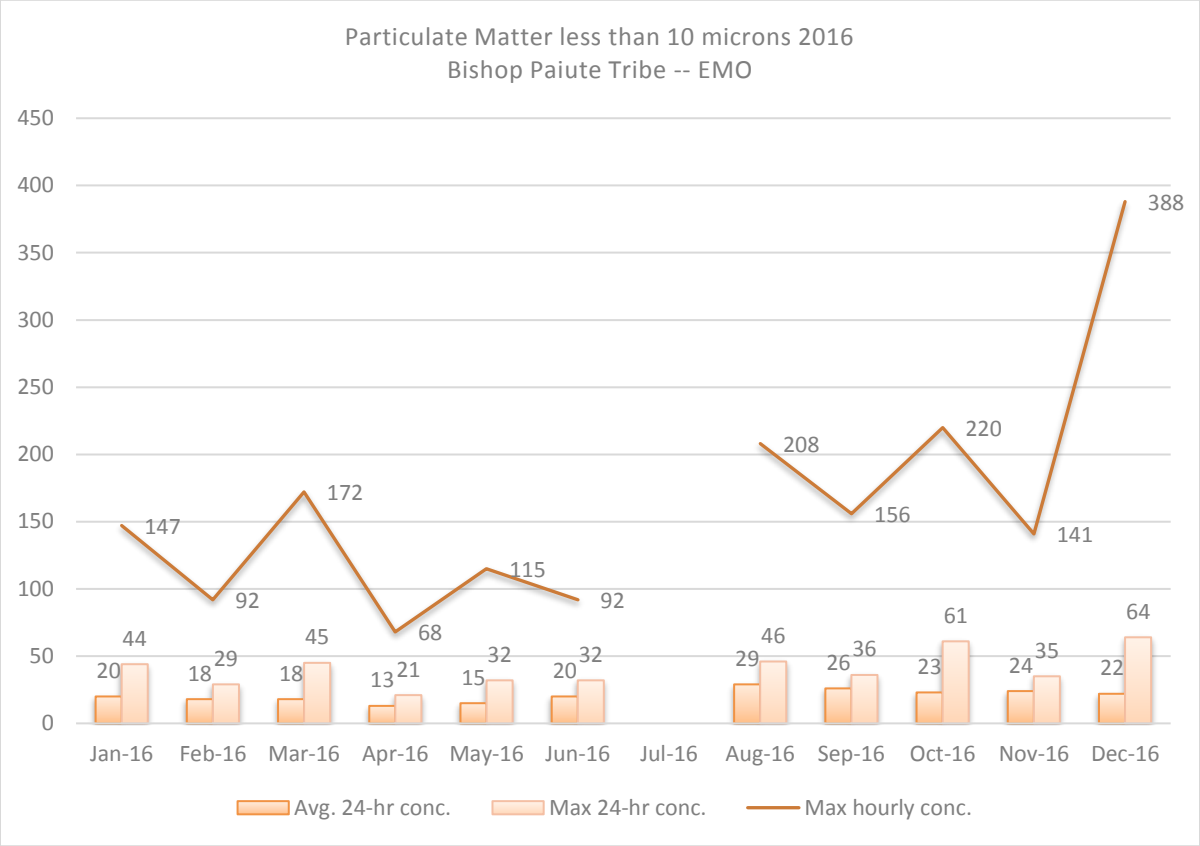

Particulate Matter less than 2.5 microns 2013
Bishop Paiute Tribe -- EMO
80
70
60
50
40
30
20
10
0
75
64
25
55
68
42
45
34
29
27
57
26
18
12
13
14
12
19
14
8
8
11
10
8
6
6
8
8
7
5
4
4
6
Jan-13
Feb-13
Mar-13
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

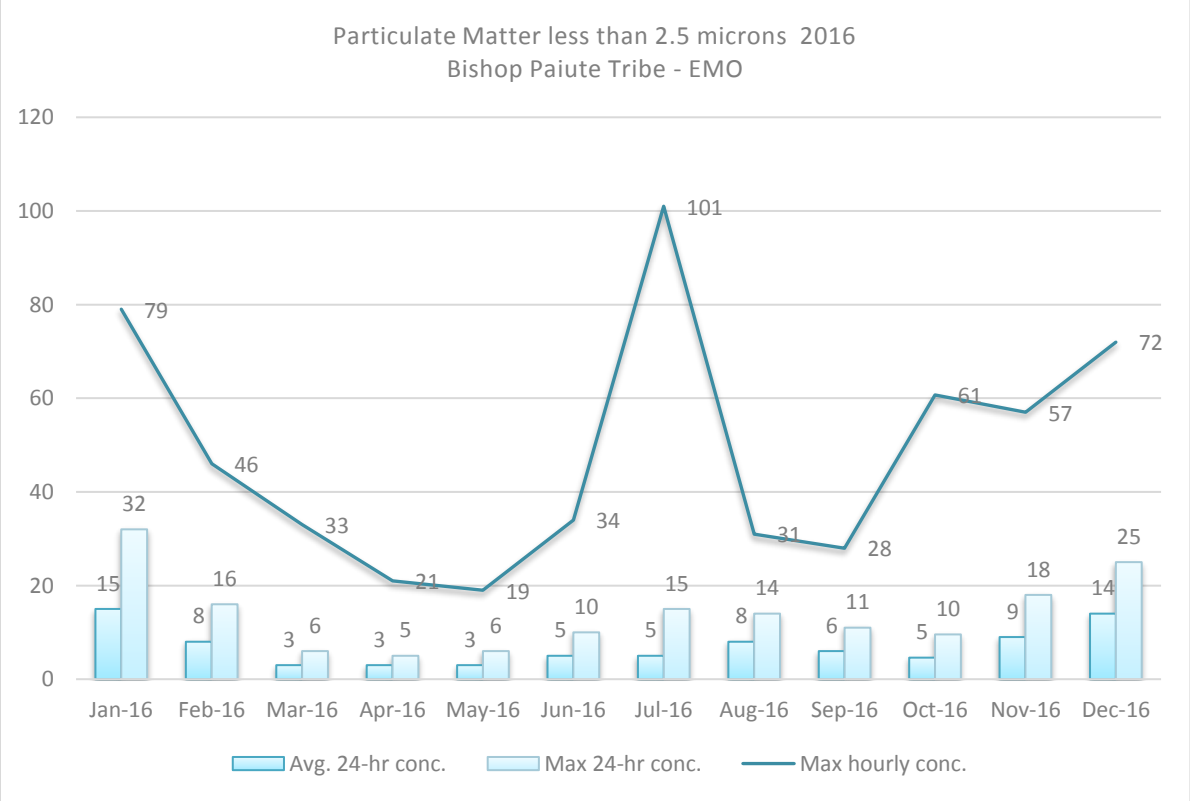

Particulate Matter less than 10 microns 2014
Bishop Paiute Tribe -- EMO
450
400
350
300
250
200
150
100
50
0
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
123
184
74
158
115
421
183
143
130
168
133
24
44
19
33
13
25
15
32
11
32
19
87
18
35
19
52
17
63
16
43
16
24
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

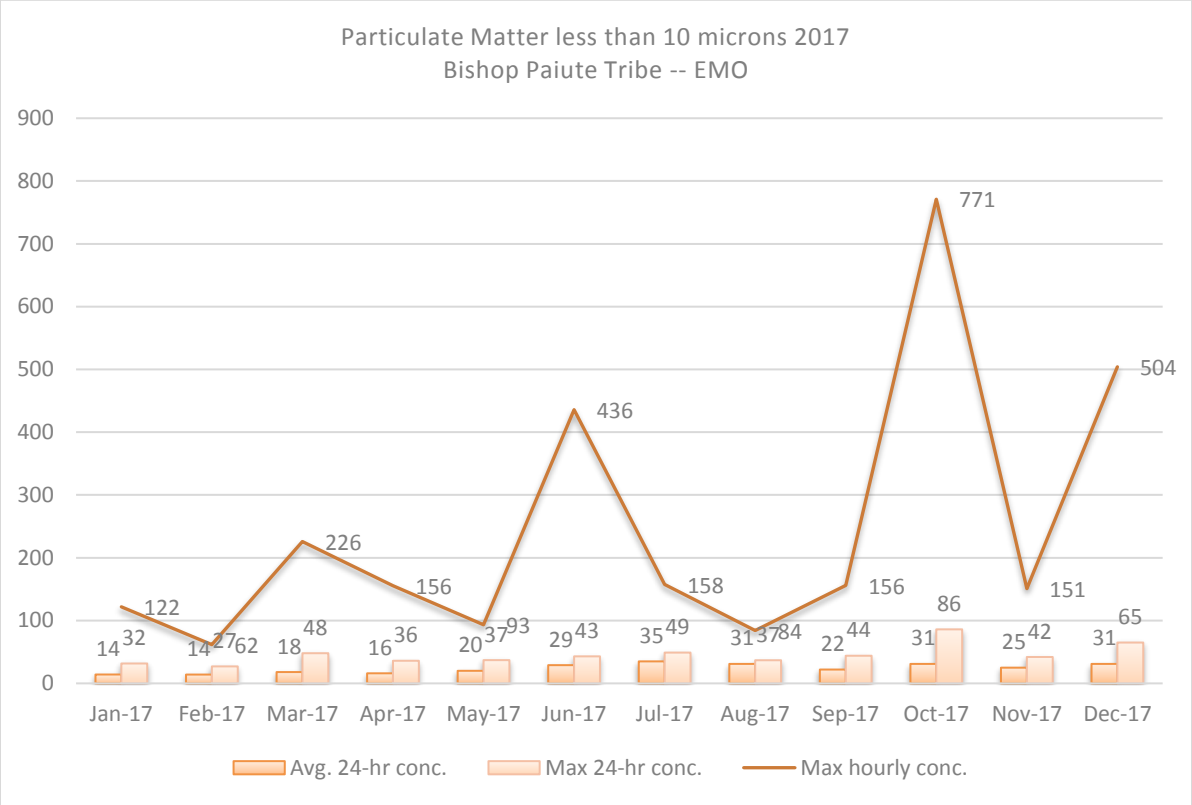

Particulate Matter less than 2.5 microns 2014
Bishop Paiute Tribe -- EMO
160
140
120
100
80
60
40
20
0
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
55
74
41
12
38
117
141
20
82
20
28
48
8
17
9
20
5
12
4
12
6
14
10
37
6
13
6
7
7
37
4
8
4
9
2
7
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

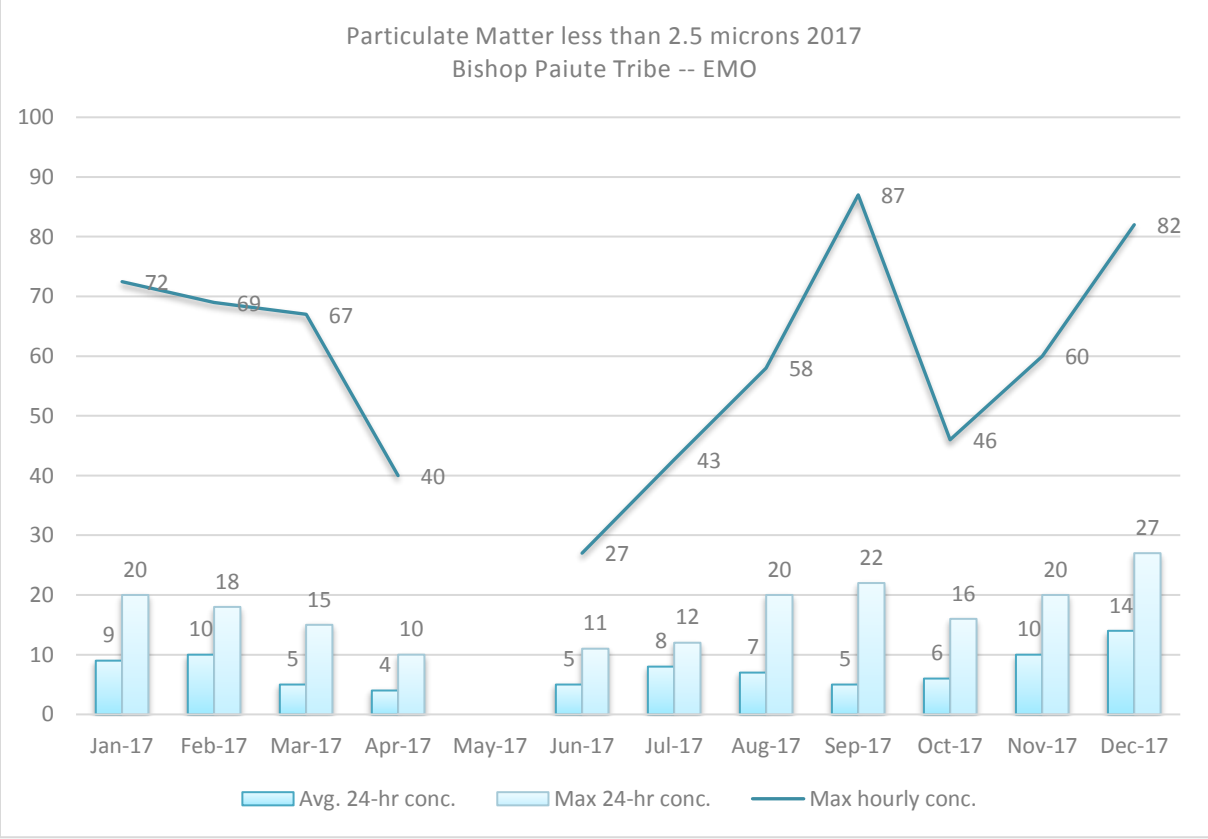

Particulate Matter less than 10 microns 2015
Bishop Paiute Tribe -- EMO
500
450
400
350
300
250
200
150
100
50
0
Jan-15
Feb-15
Mar-15
Apr-15
May-15
Jun-15
Jul-15
Aug-15
Sep-15
Oct-15
Nov-15
Dec-15
163
108
355
89
130
430
212
373
159
218
17
40
12
20
14
71
9
24
12
23
25
128
27
57
13
53
20
38
27
59
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.


Particulate Matter less than 2.5 microns 2015
Bishop Paiute Tribe -- EMO
300
250
200
150
100
50
0
Jan-15
Feb-15
Mar-15
Apr-15
May-15
Jun-15
Jul-15
Aug-15
Sep-15
Oct-15
Nov-15
Dec-15
31
16
12
73
12
21
65
252
98
25
66
79
2
5
1
2
0
2
1
12
1
6
2
8
5
10
18
85
11
36
2
8
8
21
16
26
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.


Particulate Matter less than 10 microns 2016
Bishop Paiute Tribe -- EMO
450
400
350
300
250
200
150
100
50
0
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.


Particulate Matter less than 2.5 microns 2016
Bishop Paiute Tribe - EMO
120
100
80
60
40
20
0
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

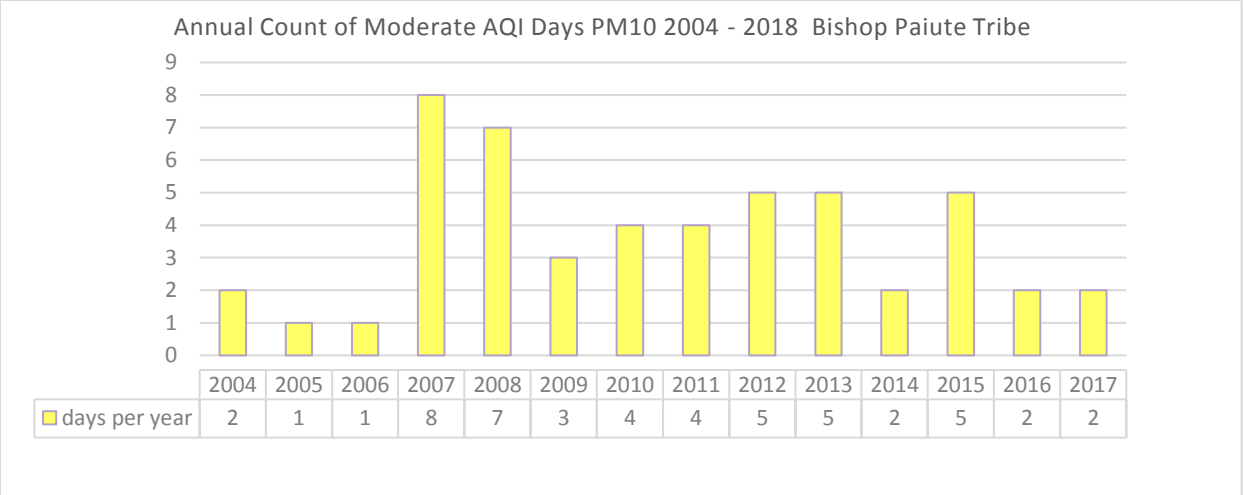

Particulate Matter less than 10 microns 2017
Bishop Paiute Tribe -- EMO
900
800
700
600
500
400
300
200
100
0
Jan-17 Feb-17 Mar-17 Apr-17 May-17 Jun-17 Jul-17 Aug-17 Sep-17 Oct-17 Nov-17 Dec-17
14 32 14 27 18 48 16 36 20 37 29 43 35 49 31 37 22 44 31 25 42 31
122 62 226 156 93 436 158 84 156 771 151 504
86 65
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

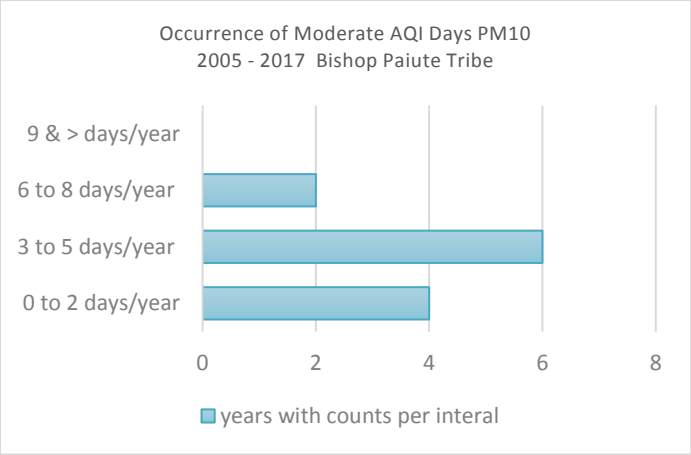

Particulate Matter less than 2.5 microns 2017
Bishop Paiute Tribe -- EMO
100
90
80
70
60
50
40
30
20
10
0
Jan-17 Feb-17 Mar-17 Apr-17 May-17 Jun-17 Jul-17 Aug-17 Sep-17 Oct-17 Nov-17 Dec-17
9 20 10 18 5 15 4 10 5 11 8 12 7 20 5 22 6 16 10 20 14 27
72 69 67 40 27 43 58 87 46 60 82
Avg. 24-hr conc.
Max 24-hr conc.
Max hourly conc.

Annual & 5-Year Daily AQI

Annual graphs of daily Air Quality Index (AQI) values are presented for PM10. AQI values are generated by TREX, with the exception of some PM10 Loc values 2015-2017, for which the AQI was generated with the EPA AQI calculator. AQI values for PM2.5 are unavailable in TREX. AQI daily summary data is available via TREX starting 2004. AQI values are in the "Good" or "Moderate" ranges, except 2018 data, with the introduction of "unhealthy" range value PM10 data, is partially included in this section. Figure 33 presents the years of data collection in terms of the number of days per year for which the 24-hr average exceeded the "Good" AQI range and were in the "Moderate" range, and Figure 34, the distribution across intervals.

FIGURES 33-34. PM10 ANNUAL AQI COMPARISONS BISHOP PAIUTE RESERVATION 2004-2017



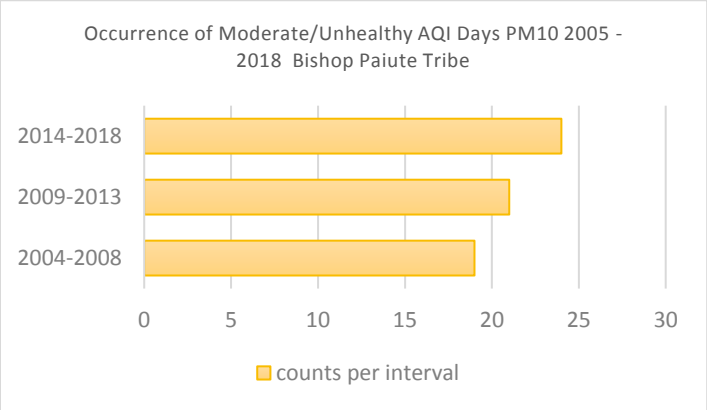


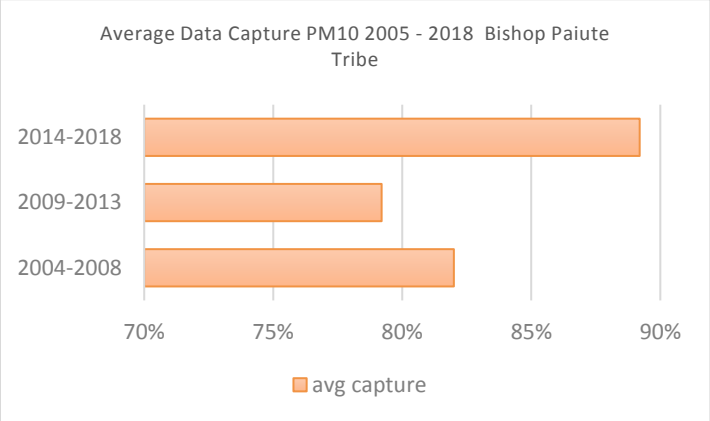
Data from 2018 thus far were appended into Figure 35 below, which demonstrates the incidence of "Moderate", or "Unhealthy"- as introduced into the data in 2018, days per 5-year interval since 2004. This appending with 2018 data was singularly applied to the Figures in this subsection, as it is the only instance which changes readily in terms of any trend with the addition of 2018 data, in that the 5-year intervals show an increase over time in incidence of days with AQI >51 ("moderate"), compounded by

the introduction of AQI values >100 ("unhealthy") in 2018. This may be due to improvement in data capture over time, rather than a reflection of ambient conditions changing over time.

All numbers in Figures 37 – 50 are AQI values and are NOT in ug/m^3

FIGURES 35-36. PM10 AQI 5-YEAR INTERVAL COMPARISONS BISHOP PAIUTE RESERVATION 2004-2018





FIGURES 37-50. PM10 ANNUAL DAILY AQI VALUES BISHOP PAIUTE RESERVATION 2004-2017

Date	Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04	Jul-04	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04
1	NA	NA	NA	NA	NA	14	23	17	19	20	15	14
2	NA	NA	NA	NA	NA	20	14	18	33	16	22	14
3	NA	NA	NA	NA	NA	16	18	17	34	17	19	NA
4	NA	NA	NA	NA	NA	17	32	27	12	27	25	30
5	NA	NA	NA	NA	NA	14	26	22	9	20	18	29
6	NA	NA	NA	NA	NA	11	23	16	9	19	17	27
7	NA	NA	NA	NA	NA	23	25	14	15	19	8	28
8	NA	NA	NA	NA	NA	32	24	14	23	35	3	36
9	NA	NA	NA	NA	NA	8	23	20	20	15	12	36
10	NA	NA	NA	NA	NA	14	16	20	22	12	16	27
11	NA	NA	NA	NA	NA	15	13	22	23	16	12	31
12	NA	NA	NA	NA	NA	12	21	53	19	16	7	22
13	NA	NA	NA	NA	NA	17	35	23	17	19	12	29
14	NA	NA	NA	NA	NA	27	35	18	22	24	12	40
15	NA	NA	NA	NA	NA	15	32	17	25	19	20	18
16	NA	NA	NA	NA	NA	17	36	17	20	39	23	23
17	NA	NA	NA	NA	NA	26	23	15	23	46	13	25
18	NA	NA	NA	NA	NA	24	14	24	32	18	21	23
19	NA	NA	NA	NA	NA	17	13	23	9	69	12	27
20	NA	NA	NA	NA	NA	18	13	22	9	8	16	40
21	NA	NA	NA	NA	NA	16	14	16	11	6	8	13
22	NA	NA	NA	NA	NA	36	18	15	13	16	21	8
23	NA	NA	NA	NA	NA	23	15	18	12	20	13	9
24	NA	NA	NA	NA	NA	18	15	14	11	13	27	17
25	NA	NA	NA	NA	NA	41	15	15	11	18	15	23
26	NA	NA	NA	NA	NA	20	19	41	9	18	4	28
27	NA	NA	NA	NA	18	15	22	18	15	9	11	41
28	NA	NA	NA	NA	14	22	22	11	23	11	3	3
29	NA	NA	NA	NA	7	20	32	14	24	13	21	16
30	NA		NA	NA	10	23	19	27	22	18	30	2
31	NA		NA		10		20	28		7		14

Date	Jan-05	Feb-05	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05
1	13	10	9	14	7	15	25	26	27	10	22	18
2	10	7	10	11	12	36	21	23	27	10	25	4
3	9	14	11	12	13	11	20	18	23	8	15	4
4	13	16	10	6	22	14	29	36	25	8	16	13
5	33	18	9	13	16	24	29	26	14	11	17	22
6	18	18	8	17	3	33	29	14	20	13	15	25
7	7	21	9	44	5	12	30	17	28	15	24	15
8	NA	19	9	9	10	16	32	18	36	13	13	25
9	8	19	9	5	11	11	20	27	17	17	17	13
10	11	18	12	13	5	10	15	20	16	10	15	12
11	3	16	20	24	4	14	26	18	11	15	11	19
12	15	10	9	20	8	18	30	19	15	21	15	16
13	41	13	43	26	21	20	47	16	14	16	14	20
14	25	18	24	12	19	38	38	16	17	33	8	27
15	20	21	13	14	17	29	32	9	22	31	10	24
16	14	13	17	15	11	50	22	8	22	11	20	33
17	11	11	19	18	11	14	23	10	13	14	19	26
18	15	9	24	18	13	13	37	16	14	9	19	19
19	13	3	6	9	16	19	42	13	30	11	16	19
20	16	7	2	13	33	35	34	11	13	13	17	40
21	12	NA	8	14	17	24	31	9	10	14	36	21
22	14	9	4	26	11	40	31	16	10	10	32	20
23	11	10	6	13	15	33	26	13	12	8	36	15
24	15	9	4	8	15	26	21	17	12	16	21	17
25	10	8	5	15	18	51	16	16	11	6	26	12
26	8	15	4	18	22	14	23	20	10	13	20	6
27	10	5	8	27	18	24	30	13	NA	10	7	27
28	13	11	4	10	22	16	34	14	NA	7	23	13
29	5		6	7	17	26	21	15	12	7	42	22
30	3		5	10	9	26	16	21	8	14	25	23
31	7		6		20		20	18		20		5

Date	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06
1	13	14	5	8	18	21	15	12	28	11	38	NA
2	18	16	11	9	24	17	15	15	16	11	33	NA
3	18	24	5	5	23	12	17	16	17	23	21	NA
4	23	11	2	4	19	11	27	20	16	33	16	NA
5	26	7	10	1	19	10	21	16	17	35	20	NA
6	40	22	9	5	16	23	20	13	38	13	20	NA
7	27	13	6	19	17	25	18	23	23	7	22	NA
8	22	18	4	7	21	16	19	20	29	14	20	NA
9	27	16	14	10	15	17	12	20	21	14	11	NA
10	27	24	11	8	23	16	12	14	17	8	19	NA
11	41	15	5	11	22	19	22	15	22	12	35	NA
12	46	15	4	9	18	30	18	16	22	11	14	NA
13	27	23	8	13	14	19	18	19	20	10	17	NA
14	10	36	14	7	20	11	18	26	46	7	9	NA
15	5	13	16	5	22	11	15	18	40	10	31	NA
16	7	20	19	7	21	9	17	25	23	8	NA	NA
17	25	31	12	4	13	11	26	19	13	6	NA	NA
18	13	22	9	11	14	15	19	22	18	11	NA	NA
19	8	12	9	9	20	12	21	14	41	15	NA	NA
20	15	12	21	13	11	20	12	14	28	8	NA	NA
21	14	9	9	31	6	21	9	23	17	12	NA	NA
22	7	9	11	17	5	22	17	18	28	12	NA	NA
23	11	19	16	8	7	19	11	18	11	15	NA	NA
24	16	18	14	10	8	17	10	15	7	14	NA	NA
25	23	11	8	14	7	20	13	16	15	27	NA	NA
26	23	39	5	12	22	27	15	15	22	20	NA	NA
27	18	79	28	15	10	29	21	14	16	13	NA	NA
28	37	2	18	7	6	13	22	21	25	18	NA	NA
29	26		6	8	9	16	15	18	23	18	NA	NA
30	20		7	13	12	21	12	21	15	33	NA	NA
31	19		7		22		9	48		26		NA

Date	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07
1	NA	9	15	13	NA	32	14	28	14	38	29	26
2	NA	21	7	21	NA	21	18	28	11	33	36	36
3	NA	20	9	17	NA	14	26	20	15	37	23	41
4	NA	15	9	17	NA	32	26	NA	19	51	15	51
5	NA	16	29	28	11	58	28	NA	49	42	24	39
6	NA	20	21	16	9	24	35	NA	31	6	26	25
7	NA	21	18	18	19	9	25	24	39	7	29	2
8	NA	18	21	15	20	19	25	21	27	28	28	4
9	NA	25	41	24	29	21	29	23	20	32	40	8
10	NA	16	15	16	31	19	55	31	32	22	18	9
11	NA	8	14	17	28	25	47	16	41	30	11	13
12	NA	12	13	23	22	19	26	16	26	22	12	28
13	NA	7	18	13	16	26	31	22	33	8	26	11
14	NA	9	13	39	27	23	22	29	25	10	21	22
15	NA	9	20	5	24	29	23	38	12	15	22	26
16	NA	9	28	10	22	25	31	31	9	35	34	28
17	NA	10	13	13	28	14	37	42	15	25	22	32
18	NA	10	14	5	31	30	30	25	43	21	20	17
19	NA	8	31	18	24	54	26	42	54	20	30	24
20	NA	14	20	13	28	29	25	26	48	20	26	13
21	NA	21	6	9	19	26	14	44	32	15	27	5
22	NA	36	11	6	27	30	16	27	7	38	21	19
23	NA	10	9	7	17	24	38	24	7	20	14	16
24	NA	13	9	13	17	13	27	28	10	28	23	22
25	42	23	15	23	26	22	22	26	30	21	30	12
26	43	14	27	16	24	31	23	30	41	37	37	14
27	44	3	12	20	33	27	27	34	58	52	32	4
28	45	5	11	22	18	NA	20	22	23	25	39	30
29	46		16	21	20	NA	21	33	29	27	40	35
30	47		11	24	30	16	24	14	25	15	49	33
31	48		13		27		24	16		21		22

Date	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
1	34	22	11	NA	12	13	26	20	24	21	9	18
2	33	14	6	NA	18	14	42	15	21	31	6	12
3	37	5	16	NA	15	17	47	11	21	20	10	20
4	21	3	11	NA	20	22	32	21	28	8	8	18
5	5	15	13	NA	20	10	18	27	29	10	20	24
6	7	24	14	NA	16	16	25	23	21	18	10	19
7	12	17	16	NA	22	8	29	23	29	20	16	28
8	14	14	13	NA	18	12	27	18	35	16	10	36
9	21	12	14	NA	30	17	24	12	38	26	4	36
10	17	12	13	NA	25	16	57	15	26	39	15	38
11	25	9	13	NA	21	14	44	16	14	7	22	30
12	11	12	14	NA	37	16	37	16	24	10	12	24
13	8	68	13	NA	14	19	29	23	24	19	13	19
14	12	8	11	NA	15	20	17	30	19	13	7	13
15	20	7	8	17	13	20	15	28	20	18	12	10
16	6	15	20	13	18	20	20	19	30	19	12	20
17	6	14	14	21	15	20	16	24	26	21	18	19
18	12	15	NA	24	12	13	16	27	25	21	20	24
19	18	15	NA	36	20	12	21	29	41	16	23	32
20	13	13	NA	22	27	17	25	19	21	21	29	32
21	18	13	NA	25	47	20	19	20	16	15	36	35
22	13	10	NA	22	15	19	20	35	22	24	26	12
23	5	5	NA	18	20	25	14	18	24	20	23	10
24	1	5	NA	13	18	46	25	14	25	22	39	7
25	2	5	NA	20	9	58	24	28	37	18	26	3
26	5	5	NA	20	4	52	17	20	29	14	9	9
27	0	8	NA	20	9	37	27	NA	24	20	8	19
28	4	7	NA	24	10	26	42	NA	18	25	4	30
29	18	11	NA	34	13	53	25	NA	27	24	4	30
30	14		NA	32	14	29	30	33	18	56	11	32
31	21		NA		15		22	57		22		33

Jan-09		Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
Date												
1	28	18	42	NA	NA	NA	NA	NA	NA	15	13	21
2	13	23	6	NA	NA	NA	NA	NA	NA	18	15	16
3	10	21	14	NA	NA	NA	NA	NA	NA	27	14	12
4	24	25	14	NA	NA	NA	NA	NA	NA	13	32	33
5	17	30	12	NA	NA	NA	NA	NA	NA	17	83	62
6	11	12	8	NA	NA	NA	NA	NA	NA	20	21	26
7	25	4	6	NA	NA	NA	NA	NA	NA	18	14	25
8	19	4	14	NA	NA	NA	NA	NA	NA	11	18	15
9	15	3	20	NA	NA	NA	NA	NA	NA	19	23	22
10	12	10	20	NA	NA	NA	NA	NA	NA	15	36	43
11	10	18	34	NA	NA	NA	NA	NA	NA	13	22	35
12	10	13	20	NA	NA	NA	NA	NA	NA	57	19	12
13	11	16	15	NA	NA	NA	NA	NA	NA	12	16	10
14	15	6	13	NA	NA	NA	NA	NA	NA	6	10	16
15	13	11	13	NA	NA	NA	NA	NA	NA	7	19	22
16	18	3	18	NA	NA	NA	NA	NA	20	7	27	21
17	15	16	25	NA	NA	NA	NA	NA	27	6	32	23
18	16	17	21	NA	NA	NA	NA	NA	33	6	15	18
19	21	14	NA	NA	NA	NA	NA	NA	21	8	23	18
20	30	16	NA	NA	NA	NA	NA	NA	18	3	47	25
21	36	18	NA	NA	NA	NA	NA	NA	22	8	18	30
22	21	13	NA	NA	NA	NA	NA	NA	19	12	35	4
23	14	9	NA	NA	NA	NA	NA	NA	18	12	17	6
24	17	22	NA	NA	NA	NA	NA	NA	20	9	25	10
25	8	10	NA	NA	NA	NA	NA	NA	20	7	23	14
26	4	20	NA	NA	NA	NA	NA	NA	14	16	16	30
27	15	21	NA	NA	NA	NA	NA	NA	16	40	19	27
28	14	17	NA	NA	NA	NA	NA	NA	34	4	10	NA
29	19		NA	NA	NA	NA	NA	NA	37	6	12	NA
30	23		NA	NA	NA	NA	NA	NA	11	9	13	NA
31	21		NA		NA		NA	NA		13		NA

Date	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10
1	NA	31	6	8	8	12	21	14	22	NA	NA	NA
2	NA	21	12	11	11	14	15	21	16	NA	NA	NA
3	NA	22	14	40	15	18	26	21	23	NA	NA	NA
4	NA	21	3	22	12	15	35	23	30	NA	NA	NA
5	NA	7	5	3	13	11	18	23	24	NA	NA	NA
6	NA	4	8	3	32	11	27	18	54	NA	NA	NA
7	NA	2	8	9	14	12	35	17	26	NA	NA	NA
8	NA	10	17	9	16	19	26	16	24	NA	NA	NA
9	NA	12	5	59	26	24	16	20	NA	NA	NA	27
10	NA	15	7	28	12	23	16	25	NA	NA	NA	19
11	NA	22	18	56	6	20	13	25	NA	NA	NA	24
12	NA	21	17	8	8	18	18	19	NA	NA	NA	11
13	NA	17	9	7	11	10	23	19	NA	NA	NA	29
14	NA	17	6	16	13	17	21	18	NA	NA	NA	24
15	NA	19	16	18	17	25	33	17	NA	NA	NA	12
16	NA	22	21	17	NA	14	29	20	NA	NA	NA	18
17	NA	26	12	16	28	17	14	18	NA	NA	NA	8
18	NA	24	31	17	9	24	15	25	NA	NA	NA	7
19	NA	22	34	29	15	15	17	21	NA	NA	NA	4
20	NA	12	17	48	11	10	26	19	NA	NA	NA	28
21	NA	8	19	1	24	17	28	18	NA	NA	NA	22
22	NA	10	21	2	11	14	22	11	NA	NA	NA	7
23	NA	20	18	5	5	26	17	19	NA	NA	NA	8
24	NA	12	30	10	11	26	22	18	NA	NA	NA	10
25	NA	12	21	14	30	23	27	25	NA	NA	NA	13
26	31	30	9	16	52	15	14	27	NA	NA	NA	9
27	11	6	15	18	20	15	17	17	NA	NA	NA	12
28	17	5	12	6	8	22	27	17	NA	NA	NA	21
29	24		40	5	6	38	NA	9	NA	NA	NA	8
30	23		26	5	10	22	NA	10	NA	NA	NA	6
31	10		5		10		14	17		NA		13

Date	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11
1	25	15	15	9	6	14	NA	14	16	10	37	66
2	17	16	15	11	15	8	NA	12	17	10	18	25
3	15	13	9	25	18	13	NA	15	15	19	39	8
4	12	11	18	12	15	19	NA	26	16	16	9	6
5	16	7	16	12	17	12	22	17	18	4	20	11
6	11	5	8	16	18	10	20	18	20	3	10	41
7	11	84	7	11	13	8	13	12	23	4	9	27
8	23	32	8	9	9	6	17	19	26	4	31	23
9	15	15	19	5	8	12	12	19	15	6	24	26
10	16	20	12	5	5	14	11	19	25	11	33	21
11	26	23	11	8	10	13	14	20	8	10	23	24
12	29	18	11	14	14	13	17	22	13	11	14	32
13	25	12	18	16	18	16	NA	12	14	11	15	35
14	16	25	10	34	10	16	NA	17	12	12	18	35
15	9	33	14	25	6	19	NA	12	15	9	14	20
16	8	14	21	5	9	28	15	19	16	9	20	17
17	8	8	39	7	10	16	15	18	15	13	22	18
18	17	11	60	11	6	15	25	18	15	11	28	23
19	26	5	11	12	6	15	17	33	18	15	10	12
20	15	8	5	15	11	13	15	31	15	17	8	16
21	18	5	6	11	11	15	20	15	18	16	16	33
22	10	15	10	6	11	21	21	17	24	11	19	19
23	13	12	4	5	13	20	18	18	18	9	22	20
24	14	13	6	10	11	16	14	21	16	19	19	19
25	7	9	4	18	27	12	17	22	15	29	18	27
26	19	3	9	10	13	9	20	22	12	14	15	37
27	23	11	6	13	15	17	27	12	17	23	21	36
28	23	19	7	22	12	23	29	11	22	22	27	37
29	19		8	33	6	NA	22	15	19	15	22	40
30	8		5	5	8	NA	12	17	29	14	67	29
31	6		7		16		12	16		18		34

Date	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
1	30	9	13	6	14	22	12	27	10	NA	17	19
2	31	10	12	6	21	12	21	25	9	NA	14	12
3	41	18	12	17	21	21	24	29	8	NA	17	20
4	27	21	15	12	16	29	26	21	12	NA	12	31
5	36	13	19	14	13	11	33	12	18	NA	24	21
6	33	12	58	11	16	10	25	18	19	NA	21	13
7	31	20	10	19	18	14	23	NA	17	NA	NA	18
8	10	14	16	22	17	20	26	NA	12	NA	NA	23
9	25	19	19	27	21	42	21	NA	11	NA	NA	12
10	30	25	18	42	25	12	22	NA	18	NA	NA	15
11	32	11	22	14	24	19	20	NA	NA	NA	NA	30
12	23	7	21	14	19	21	34	NA	NA	NA	NA	21
13	34	7	16	11	15	22	36	NA	NA	NA	NA	4
14	31	6	17	3	64	22	18	NA	NA	NA	NA	16
15	23	6	14	10	19	27	17	21	NA	NA	NA	12
16	22	8	16	11	20	20	30	22	NA	NA	12	28
17	39	18	3	9	29	18	35	27	NA	NA	6	35
18	51	18	5	10	20	19	24	21	NA	NA	11	20
19	52	14	9	8	19	20	19	24	NA	NA	29	26
20	31	17	14	11	21	22	15	18	NA	NA	31	37
21	9	11	12	10	18	41	18	17	NA	NA	37	46
22	18	11	18	15	18	23	21	NA	NA	NA	16	22
23	9	8	18	32	20	19	23	NA	NA	NA	22	11
24	13	21	26	17	20	32	16	19	NA	NA	23	8
25	17	11	9	15	40	26	17	18	NA	16	22	18
26	12	16	4	32	3	14	20	15	NA	24	28	21
27	9	12	14	16	7	17	23	12	NA	16	31	9
28	18	10	10	11	12	20	20	16	NA	15	51	13
29	23	23	16	14	13	18	14	15	NA	20	22	17
30	28		14	20	17	13	26	18	NA	23	28	7
31	15		19		20		31	18		24		14

Date	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13
1	21	35	18	2	19	10	33	76	18	18	14	19
2	12	26	15	7	16	16	30	43	23	17	14	20
3	22	14	12	8	17	30	25	27	17	54	10	34
4	25	23	11	18	18	20	27	25	12	16	8	18
5	30	31	54	14	37	18	16	30	18	13	20	30
6	16	24	20	9	23	18	10	30	16	12	23	27
7	13	40	19	22	1	20	14	29	16	21	28	12
8	15	9	10	20	4	14	13	28	33	17	28	17
9	23	5	12	9	7	19	18	17	16	13	21	23
10	5	13	10	11	12	21	15	15	13	9	20	40
11	5	7	26	9	10	18	11	16	27	13	22	30
12	5	11	16	13	11	23	14	17	21	13	47	36
13	8	13	20	8	16	13	11	15	14	10	16	19
14	6	9	20	7	26	21	8	18	16	NA	22	17
15	7	23	15	25	12	16	23	21	19	NA	26	24
16	14	21	14	6	18	14	24	18	20	NA	33	25
17	24	17	10	10	5	17	21	19	18	19	28	33
18	20	36	18	7	7	18	22	17	13	13	40	24
19	18	33	15	12	8	8	23	7	13	11	22	14
20	11	14	35	14	13	12	20	10	27	14	19	14
21	14	16	12	17	22	25	34	9	23	9	7	6
22	29	18	21	45	18	8	19	16	4	11	11	8
23	40	47	23	20	14	12	7	15	11	17	10	25
24	9	7	17	17	21	13	19	44	12	18	13	17
25	17	24	20	16	18	10	21	23	16	19	17	20
26	9	21	16	17	13	17	24	30	7	19	14	22
27	10	19	18	16	8	19	10	12	13	25	18	38
28	8	26	14	17	7	26	31	15	10	16	19	16
29	11		14	22	9	17	53	14	12	13	16	25
30	7		13	49	11	20	51	16	17	10	18	35
31	19		8		9		34	14		13		38

Date	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14
1	24	12	7	4	NA	19	28	44	12	8	1	NA
2	30	17	12	7	NA	15	18	48	18	10	NA	NA
3	30	21	15	13	NA	13	16	17	19	17	4	NA
4	26	20	13	17	NA	15	26	9	NA	11	14	NA
5	26	28	14	2	NA	15	29	20	NA	15	19	NA
6	36	31	8	10	NA	14	32	19	12	11	15	NA
7	38	28	5	9	NA	14	15	12	15	NA	19	NA
8	41	15	5	19	NA	14	16	17	9	NA	13	NA
9	19	10	14	16	NA	18	17	16	9	14	17	NA
10	13	6	18	13	NA	22	17	14	16	NA	20	NA
11	23	22	11	27	NA	21	19	16	16	NA	22	NA
12	7	24	8	15	NA	21	12	14	21	NA	32	NA
13	13	16	9	14	NA	12	11	14	18	NA	NA	NA
14	21	19	9	16	NA	10	16	17	12	NA	NA	NA
15	24	18	15	16	NA	13	20	17	21	NA	NA	NA
16	22	6	19	NA	NA	17	10	13	19	NA	NA	NA
17	20	11	24	17	NA	38	13	9	25	NA	NA	NA
18	24	21	6	14	NA	67	14	16	16	NA	NA	NA
19	26	17	10	17	NA	25	12	19	55	NA	NA	NA
20	21	16	11	18	8	19	11	21	14	NA	NA	NA
21	28	19	15	27	5	7	11	13	11	NA	NA	NA
22	23	15	12	13	8	9	16	25	12	14	NA	NA
23	26	16	14	8	9	14	12	12	14	27	NA	NA
24	21	17	12	14	12	15	9	12	18	32	NA	NA
25	16	23	NA	NA	11	11	12	21	11	8	NA	NA
26	14	30	5	NA	7	14	9	17	13	6	NA	NA
27	21	7	10	NA	7	13	16	11	3	11	NA	NA
28	30	5	13	NA	17	11	12	16	2	14	NA	NA
29	22		12	NA	13	12	15	19	4	15	NA	NA
30	8		3	NA	13	15	17	12	11	17	NA	NA
31	4		9		11		24	12		40		NA

Date	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15
1	NA	NA	4	21	18	11	31	13	19	NA	11	34
2	NA	NA	18	1	13	11	8	13	37	NA	17	38
3	NA	NA	6	9	11	12	11	18	29	13	6	33
4	NA	22	8	10	22	8	15	14	39	NA	8	26
5	NA	21	14	13	14	8	4	14	22	NA	18	29
6	NA	36	10	12	22	6	7	16	17	8	17	30
7	NA	37	12	15	15	8	13	17	51	10	22	43
8	NA	15	12	4	2	8	7	11	31	11	10	30
9	NA	6	16	6	1	22	5	12	46	8	13	39
10	NA	15	14	12	9	4	5	17	34	10	11	26
11	NA	16	14	15	11	3	6	21	27	NA	21	23
12	NA	13	13	7	11	4	7	15	30	NA	29	13
13	NA	13	5	19	16	6	7	24	52	13	19	11
14	NA	11	6	59	10	11	14	27	36	16	17	6
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18	NA	13	10	11	6	15	27	32	11	5	19	31
19	NA	11	8	13	2	15	15	35	14	7	27	20
20	NA	9	15	12	6	11	NA	25	10	8	20	26
21	NA	28	14	19	7	8	NA	37	14	8	19	35
22	NA	20	10	18	2	12	NA	31	21	11	22	25
23	NA	21	9	13	1	13	NA	42	NA	10	28	15
24	NA	10	5	3	3	15	NA	34	NA	11	21	15
25	NA	5	4	4	3	14	NA	29	NA	14	14	9
26	NA	9	5	5	8	20	NA	29	NA	15	12	19
27	NA	12	8	3	11	13	NA	32	NA	25	12	26
28	NA	7	6	10	8	14	NA	72	NA	13	22	15
29	NA		16	12	11	18	15	87	NA	11	25	19
30	NA		13	14	11	19	22	38	NA	8	35	27
31	NA		18		11		17	9		12		19

Date	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
1	21	11	21	13	11	19	44	31	21	19	10	12
2	32	17	19	12	13	21	22	25	25	20	13	9
3	41	19	21	13	13	19	17	NA	20	18	15	11
4	24	19	16	15	29	23	16	NA	18	19	16	27
5	10	16	28	15	16	22	19	21	32	19	14	15
6	NA	15	8	14	9	22	18	26	23	19	23	17
7	9	12	12	19	7	18	21	16	29	19	19	22
8	15	17	9	19	9	20	21	19	30	15	22	55
9	20	17	11	6	9	20	NA	19	33	20	20	39
10	17	26	12	6	9	24	NA	25	22	27	22	23
11	19	22	41	8	8	19	NA	23	25	21	19	9
12	29	22	13	6	15	6	NA	23	27	22	25	26
13	19	15	12	8	23	12	20	21	29	32	21	30
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18	17	12	16	14	11	13	19	28	20	17	19	17
19	21	16	14	14	29	11	19	28	33	26	29	25
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22	19	9	13	19	8	NA	NA	34	23	24	24	18
23	9	19	10	6	13	16	NA	22	11	54	30	14
24	13	21	13	8	10	NA	21	27	11	29	29	6
25	15	22	13	11	6	19	NA	29	14	23	32	13
26	15	18	16	13	7	24	27	36	17	22	29	14
27	24	11	18	11	11	29	35	24	18	23	9	19
28	21	12	21	11	14	23	28	29	22	8	15	24
29	18	19	7	12	14	NA	42	26	21	10	19	19
30	10		11	8	13	21	27	29	30	6	24	20
31	6		10		16		NA	30		11		19

Date	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17
1	11	25	19	9	13	20	41	NA	19	39	30	25
2	9	22	13	10	17	23	31	NA	23	16	38	28
3	15	17	20	16	18	31	37	NA	40	25	31	26
4	7	16	13	17	27	27	42	NA	21	24	24	12
5	7	12	10	26	29	22	NA	NA	19	27	19	16
6	19	12	19	32	34	26	31	NA	27	34	31	18
7	13	9	24	7	9	37	32	NA	21	21	25	23
8	10	13	13	6	13	39	31	NA	30	66	36	18
9	6	10	16	10	14	22	40	NA	23	NA	29	19
10	11	9	19	16	24	17	44	NA	15	NA	27	14
11	12	10	8	15	28	19	27	NA	20	34	25	19
12	16	9	8	15	20	13	31	NA	9	47	31	18
13	9	11	16	13	12	15	33	NA	12	32	36	29
14	10	12	19	8	13	20	32	NA	14	27	26	28
15	11	19	20	NA	11	25	NA	NA	18	23	31	38
16	11	15	22	NA	6	24	NA	27	21	NA	11	25
17	19	4	25	NA	11	23	32	29	26	NA	6	16
18	24	10	19	10	9	21	35	27	29	31	16	32
19	8	11	18	13	10	31	32	26	19	35	19	30
20	6	8	27	12	14	33	31	29	22	33	23	56
21	14	8	14	14	16	32	40	28	12	19	18	10
22	3	7	9	18	18	37	27	23	9	21	13	41
23	7	7	7	15	19	31	28	28	8	19	14	37
24	12	22	13	13	24	38	31	31	11	21	20	41
25	14	16	7	13	22	32	22	31	12	22	24	35
26	11	15	10	16	21	33	20	29	20	22	16	26
27	13	11	16	19	19	25	NA	33	19	27	7	36
28	11	18	10	22	17	29	24	32	19	23	16	40
29	12		15	16	19	24	26	33	29	20	19	36
30	29		44	15	26	30	NA	27	19	31	25	40
31	28		13		33		NA	28		27		39

5. METEOROLOGICAL DATA COMPARISONS

The climate of Payahuunadü/Owens Valley is high desert (rain shadow) with seasonal monsoonal influence. Due to the desert climate, daily high and low temperatures can vary (diurnally) by up to 40 and even 50 degrees F. Annual precipitation is low and is dominated by winter pac-nor-west and mid-pacific storms that track into the California interior and contain enough moisture to defy the rain shadow effect, and by summer seasonal orographic and monsoon activity that can track from the White Mountains as well as the Sierras. Due to the high desert climate, precipitation can vary widely from one year to the next and the annual total can be dependent on as little as a single storm. Precipitation in winter and Spring is pacific storm-driven; summer precipitation is dependent on monsoonal flow and generally quite low. Fall precipitation is highly variable.

Winds are the driving force behind much of the air pollution in the Owens Valley and are of primary meteorological interest. Maximum wind gusts can exceed 50mph, generally outside of the summer months. Average wind speeds are around 20mph, as concluded in the 2011 Weather History Study. Average winds do not vary substantially from year to year, and also according to the study, maximum gusts generally between 40 – 60 mph are observed each year.

Annual PM10 & Wind Direction Distribution

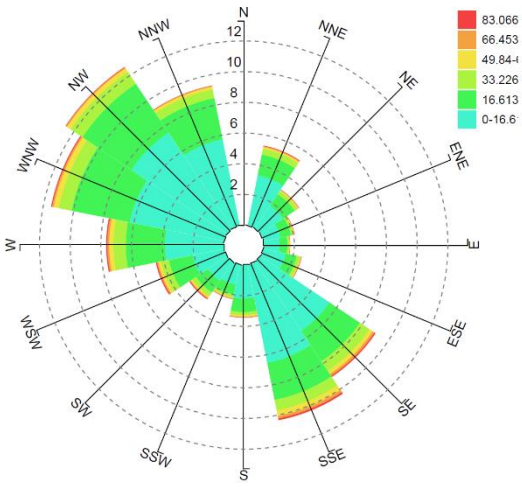
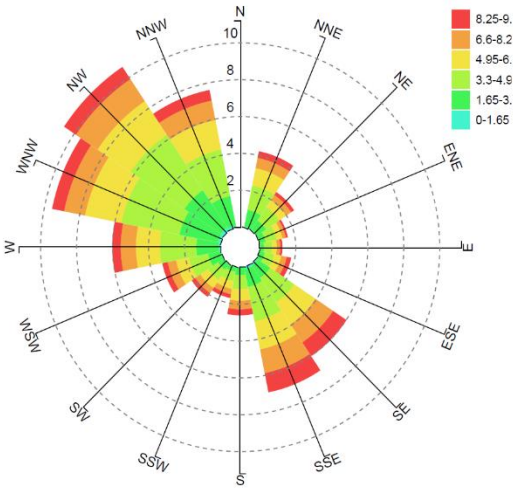
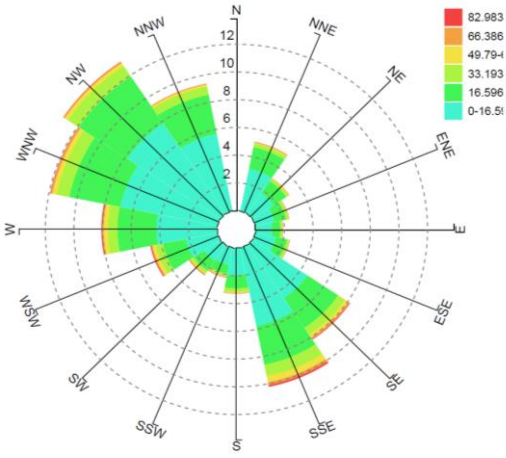
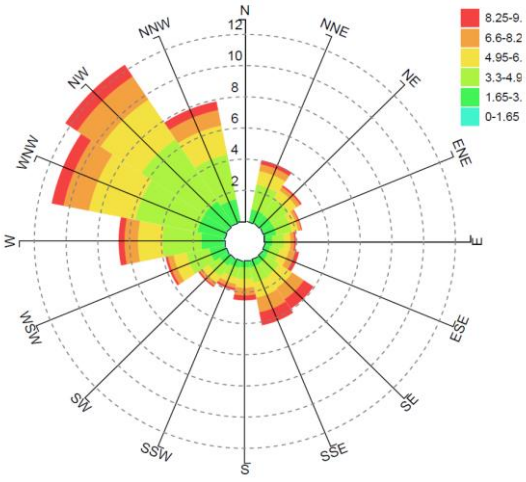
Analyses using 5-minute data for PM10 concentrations, resultant wind direction, and maximum wind gust were used to create wind roses in this section. 5-minute data was chosen for the roses, to create the basis (working files) for other possible short-term analysis of wind events. All years through 2015 are sourced with TREX extracted data; 2016 and 2017 data are sourced from the Tribe's DAS with Vista Data Vision software, hosted by T&B Systems. All years were run in the wind rose utility regardless of data capture. Missing data in the TREX extracted files are codes with null values; missing data in the VDV files are blanks. Wind data in TREX and in Vista are in mph.

Wind roses were created using the Windrose Creation Utility at the TAMS (Tribal Air Monitoring Support) data tools webpage. http://datatools.tamscenter.com/windrose/ This tool was chosen for its ability to import any data from any year, and ability to not only display the "magnitude" of a pollutant across the distribution of corresponding wind directions, but also to display another selected parameter; for this study, the maximum wind gust was chosen. Both PM10 concentrations (recorded in ug/m3) and max wind gusts (recorded in mph) are divided into 6 percentile rankings, and displayed with no units. Why some years' data exceeds the upper percentile in the utility is being investigated; likewise the omission of data from direct north. Each rose is displayed with a key showing the low thresholds for the (consistent) percentiles/categories. We assume that the utility ignores and treats as missing all non-numeric values, and does not exclude corresponding valid data with the same timestamp.

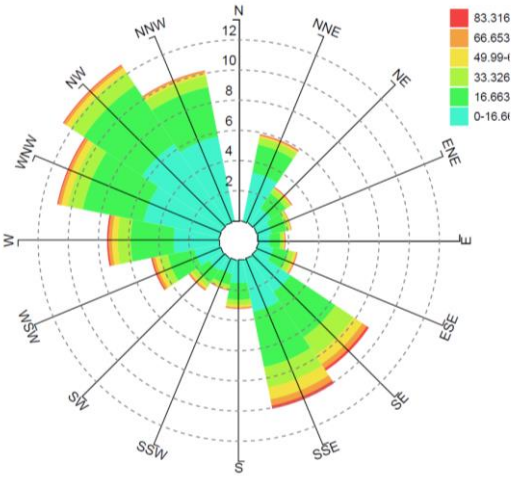
The charts for each year can be compared for simple visual differences or correlation between PM10 concentrations and the maximum wind gust speed during the hour. For example, for a given year, the PM10 wind rose may show that the highest concentrations were concurrent with W, NW, and N winds,

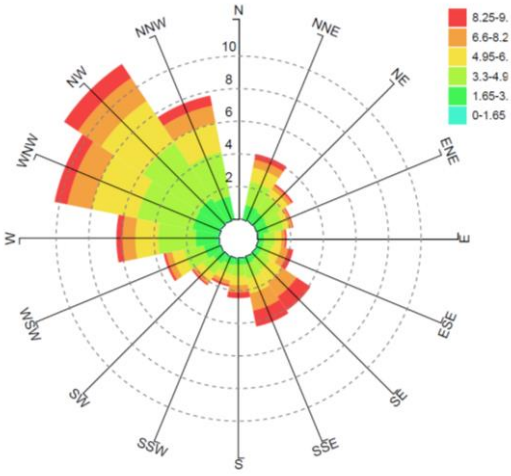
though the max gust rose may show that roughly equal incidents of hourly maximum gust speeds were concurrent with the predominant SE direction as well as the directions related to the highest PM concentrations. Though no change in wind direction over the years is evident or expected, it remains to be statistically determined whether the occurrence of the highest PM10 concentrations (for which 1-hr values would be used) are correlated increasingly in later years with the directions of the NW quadrant, as opposed to the SE quadrant. Variation in direction of high concentrations may evidence variation in the source of the concentrations.

FIGURES 51-76. PM10 & MAX GUST WIND ROSES BISHOP PAIUTE RESERVATION 2005-2017

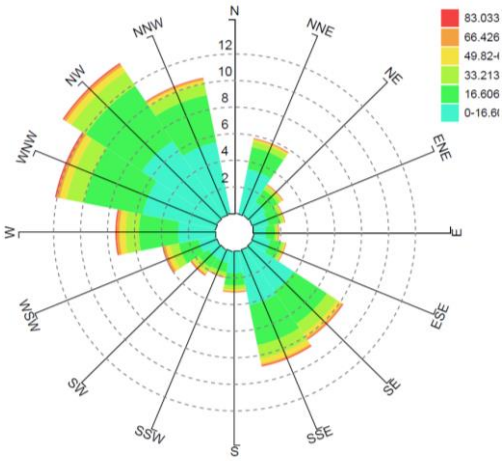
YEAR	PM10	MAX GUST
2005		
2006		

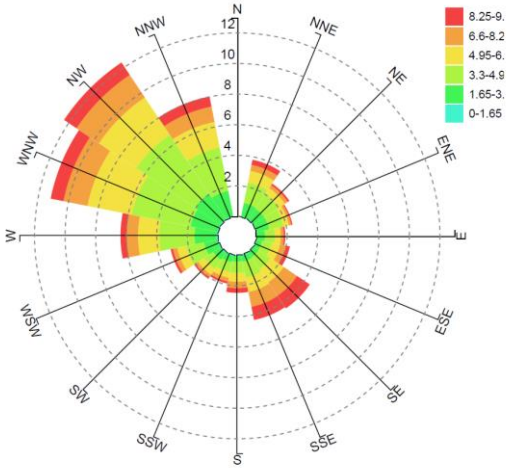
2007



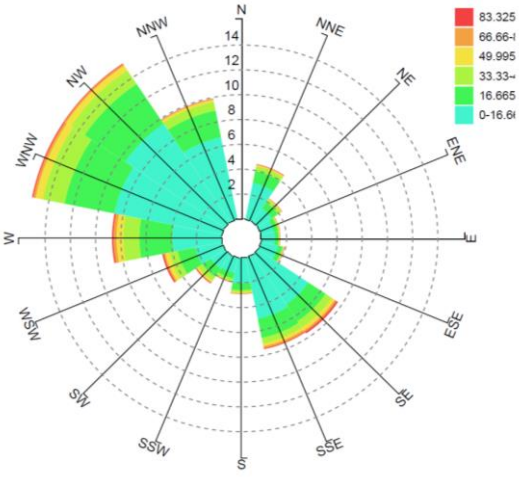


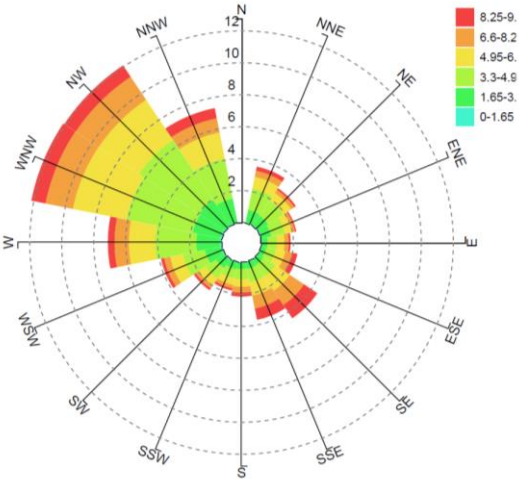
2008



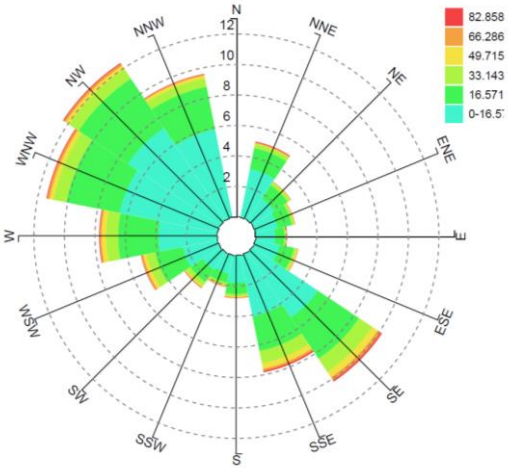


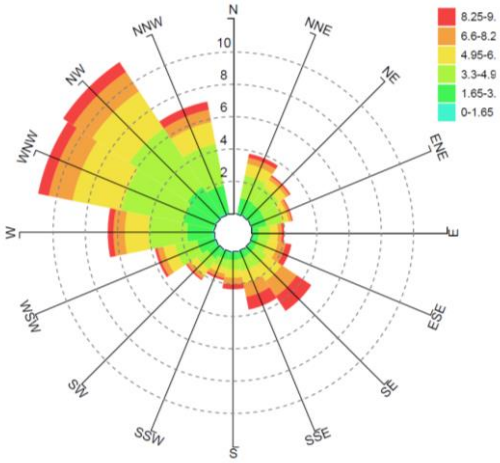
2009



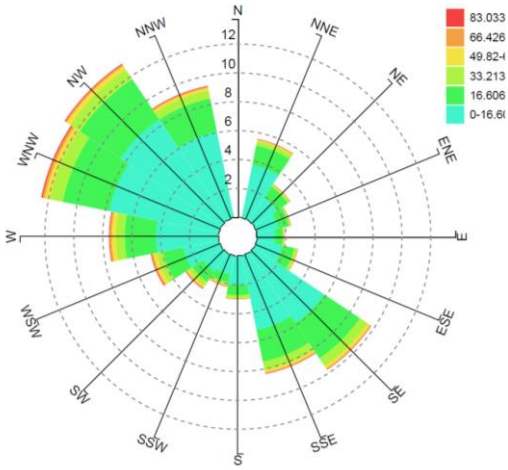


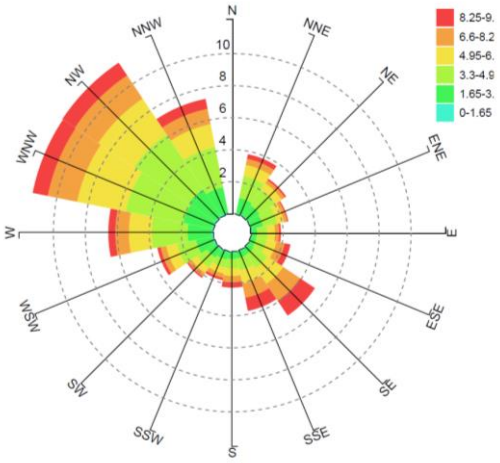
2010



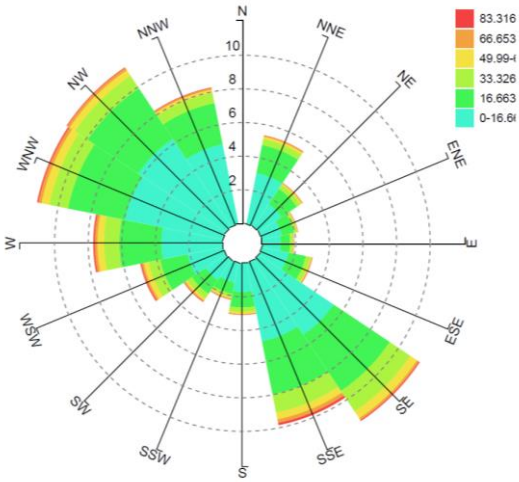


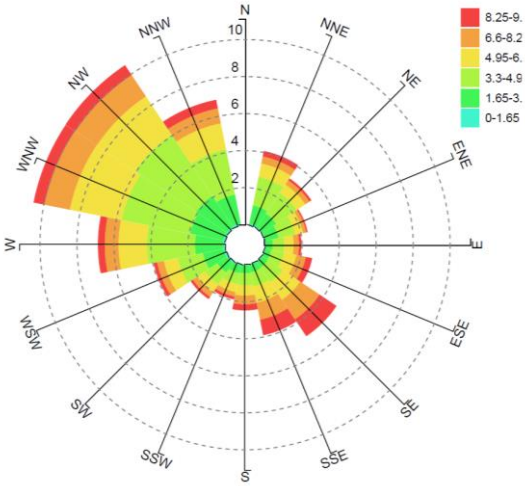
2011



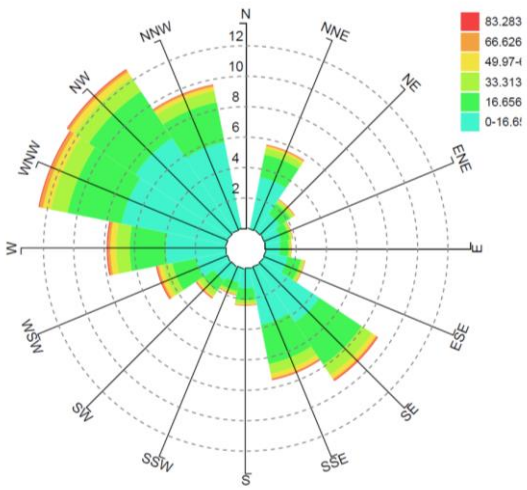


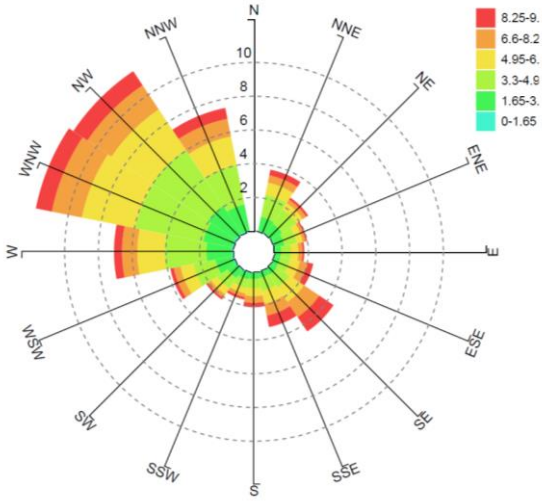
2012



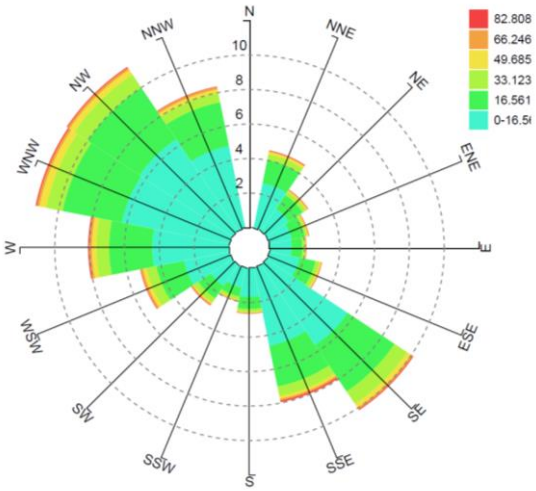


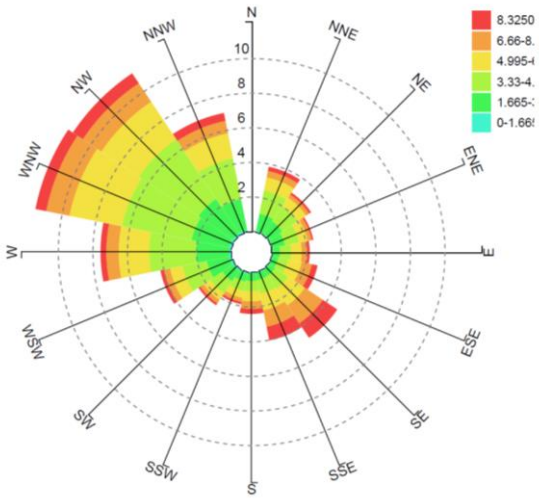
2013



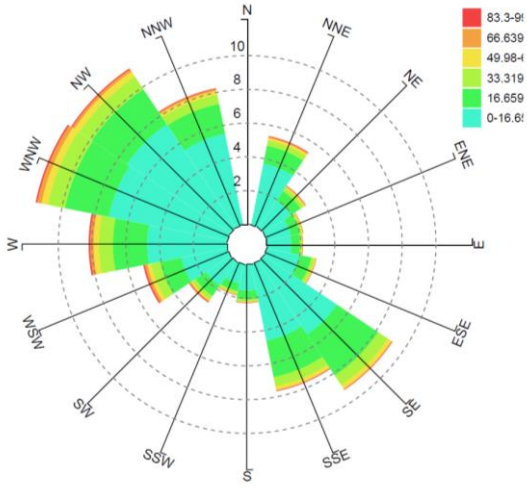


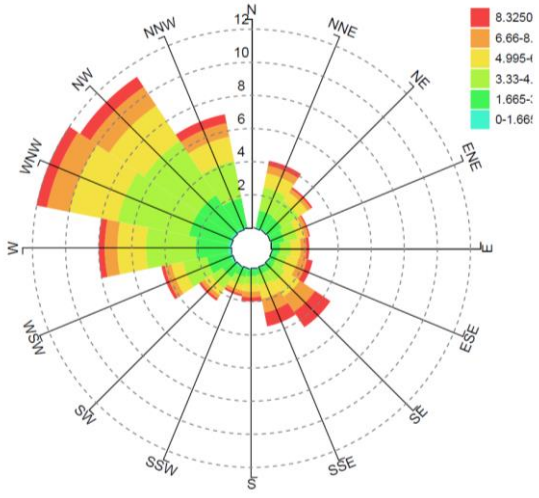
2014



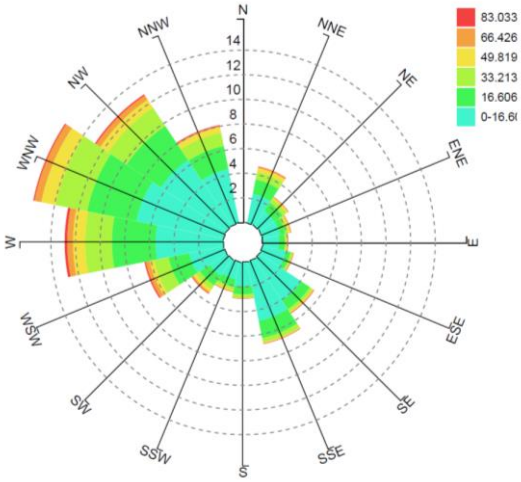


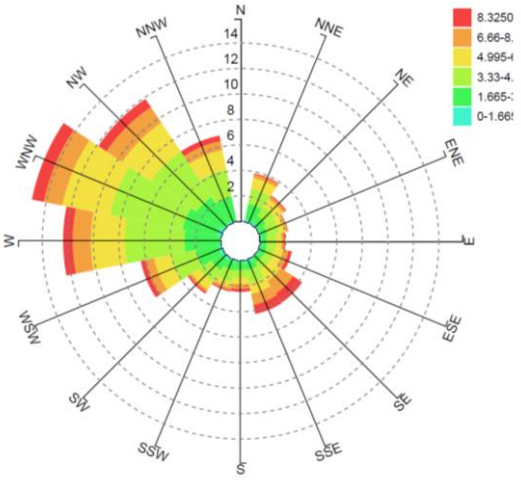
2015



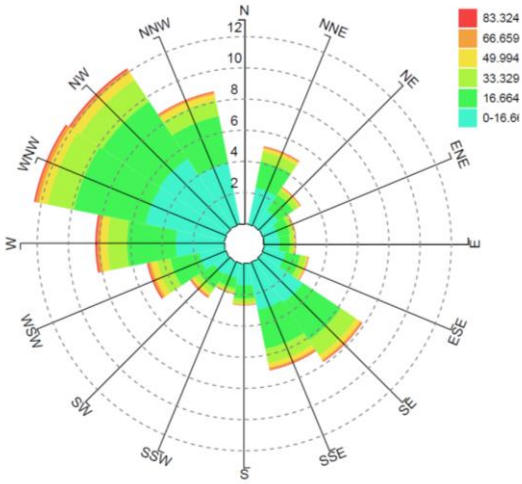


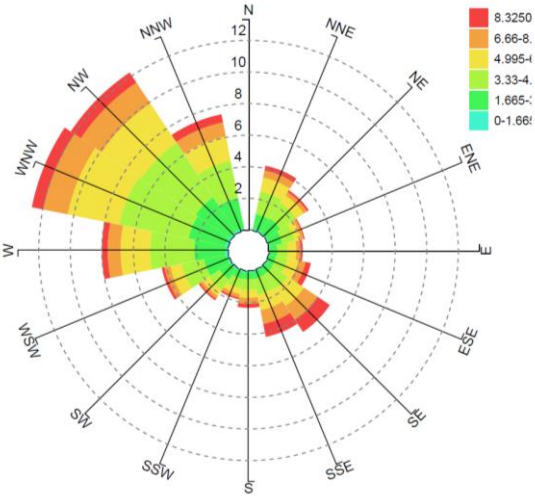
2016





2017





Due to an unknown- but evidently changeable- criteria in the statistical sorting of the data ranges by the utility into percentiles, the roses for PM2.5 don't display a consistent pattern for each year, and thus they are excluded from this report. Roses may not be the best visual for annual PM2.5, as the large volume of low-concentration data tended to visually overwhelm the relatively small amount of high-concentration data. This may be better examined in the future in terms of months, times of day, and concurrence with PM10, in addition to direction. Sources of PM2.5 on the reservation include residential wood smoke in the winter months, and transported wildfire smoke in the summer months. While the wood smoke related concentrations are fairly stable each year, the wildfire related concentrations vary across the years. Resultant wind speed (recorded in mph) is used instead of max wind gust for comparison with PM2.5, as valley inversion patterns and transport into the Owens Valley are major factors in PM2.5 high concentrations locally, as opposed to the wind events that drive PM10 high concentrations.

6. SUMMARY AND CONCLUSIONS

In an attempt to gain a better understanding of historical particulate pollution patterns for the Bishop Paiute Reservation, we examined data from the Tribe's air quality monitoring station. This yielded nearly 15 years of data from either 2004 or 2005, with 2017 being the last full calendar year included in the analysis (and some 2018 data selectively included). The goal was to present as much data as possible in logical, simple, and relevant graphical displays of PM series that could be examined for any long term patterns and trends. A number of constraints were encountered with the data sets or were inherent in the analysis, and were explained where relevant in the report. Conclusions on the patterns and trends are generally stated in the section of the report relevant to the data used for the analysis. Preliminary observations from this report that may lead to further statistical investigations can be summarized as:

1. The introduction of daily AQI values >moderate, i.e. unhealthy in 2018, for PM10.
2. Inventorying daily AQI for PM2.5 for comparison with no. 1 above.
3. Potential (though not consistent) increases over time of PM2.5 1-hr max concentrations.
4. Reconciliation of annual statistics with past annual data capture rates and coverages.
5. Potential variation over time of PM10 concentrations to correlate increasingly with NW wind direction quadrant.
6. Inclusion of existing analyses performed by the Air Program for periodic high-PM10 events, i.e. wind and dust storms, and for high PM2.5 events, i.e. wildfire episodes.
7. Examination of elevated PM2.5 values during dust events v. wood stove burning.