Arizona Department of Environmental Quality (ADEQ)
Technical Criteria Document
for
Determination of Natural Exceptional Events For Particulate Matter Equal to or Less Than Ten Microns in Aerodynamic Diameter (PM_{10})

May 31, 2000

The purpose of this guidance is to provide a tool for Arizona air quality agencies to use in the event of a PM_{10} exceedance or violation which is believed to have been caused by dust suspended by high winds. Implicitly the Technical Criteria Document addresses the 24-hour form of the PM_{10} standard; however exceedances of the annual PM_{10} standard could also be evaluated by these procedures in situations where high wind 24-hour PM_{10} events are shown to cause the annual standard to be exceeded. This document lays out the steps and decision-making process which, if followed through to completion would result in a request to ADEQ to agree that the PM_{10} exceedance event is a natural exceptional event under the ADEQ policy. If ADEQ concurs, the request would be forwarded to the EPA as a natural exceptional event. Current EPA policy which was published in a May 30, 1996 memorandum entitled "Areas Affected by PM_{10} Natural Events", requires this notification to occur within 180 days of the exceedance. Timely notification of a qualified natural exceptional event would result in flagging of the PM_{10} exceedance values in the EPA AIRS database, and the commencement of a process to develop a Natural Events Action Plan (NEAP) by the Arizona agencies working with stakeholders in order to minimize the effects of any future natural exceptional events, per the ADEQ and EPA policies. The NEAP must be in place within 18 months of the exceedance.

In the case of an exceedance that did not cause a violation of a PM_{10} standard, the technical process described in steps 1-3 below could also be followed in order to determine whether the event qualifies as a natural exceptional event. This would provide valuable information for planning purposes and for deciding whether to proceed with data flagging and NEAP development or simply to change sampling frequency. On the other hand, if the exceedance caused a PM_{10} violation it would be necessary to complete steps 1-3, and to file notification to EPA and to implement a NEAP in order to avoid an EPA action on the attainment status of the area in question. Documentation showing compliance with the requirements of Steps 1-3 is required, and completeness in meeting these documentation requirements will be judged by ADEQ.

Step 1) Have the measured PM values been properly qualified and validated?

In this step, information about the measurements, the monitoring site(s), the area around the site(s), the sampler(s), quality control, and quality assurance must be documented. A description of each site location, the operational history and data summary for all PM_{10} monitoring conducted at that site, including the exceedance and/or violation values, and a description of emissions sources and their activity levels in the area must be provided. For reporting the PM_{10}

data, including the exceedance and/or violation values, the requirements of 40 Code of Federal Regulations (CFR), Part 50.6 and 40 CFR, Part 50, Appendix K must be referenced and followed. For the site(s) of interest, this descriptive information should address the information and requirements described in 40 CFR, Part 58.26, including relevant appendices.

Documentation must be provided to show that the instrument(s) and/or sampler(s) measuring a PM_{10} exceedance or violation is an EPA Reference or Equivalent Method, per the requirements of 40 CFR, Part 50, Appendix J, and Part 58.11, referencing Appendix C. For each site location, compliance with monitoring siting objectives, probe siting and installation, and operating schedule requirements must be described following 40 CFR, Parts 58.12 and 58.13, and 40 CFR, Part 58, Appendices D and E. Compliance with quality control and quality assurance requirements of 40 CFR, Part 58.10 and 40 CFR, Part 58, Appendix A for each PM_{10} sampler of interest must also be documented, specifically addressing the history of calibrations, routine checks and maintenance, and whether the monitor received and passed a post exceedance flow rate performance audit.

Step 2) Does the event meet the "exceptional" tests?

In this step a demonstration must be made that the weather conditions during the PM_{10} exceedance meet the "exceptional" criteria for the geographic area where the exceedance occurred. The criteria for the tests for qualification of an exceptional event were developed by Climatological experts at the University of Arizona Department of Geography. The researchers studied the geological, geographic, and Climatological conditions related to PM_{10} measurements caused by high winds throughout the state. The results of their work is summarized below and described in full detail in the report titled Climatological Analysis for PM_{10} Natural Exceptional Events in Arizona, May 2000, which is available at ADEQ.

Prior research has shown that high wind speeds especially when coupled with drought conditions and low soil moisture have caused dust storms in the southwest United States. A portable wind tunnel was used by ADEQ contractors in 1989 to estimate wind erosion at various wind speeds over different soils in Arizona; Nickling, W.G. and Gillies, J.A. 1989, Emission of Fine Grained Particulates from Desert Soils. Their investigations found disturbed desert soils became suspended at about 7.0 meters per second (15.7 miles per hour). Subsequent hour-by-hour measurements of PM_{10} and wind by ADEQ at various locations have substantiated this finding. This information was given to the natural exceptional events researchers for incorporation in the qualification criteria.

The natural exceptional events research team performed statistical tests using historical Arizona PM_{10} measurements and available weather data. Consideration of the strength of statistical relationships and the availability of data to users of this guideline led to the decision that wind speed and precipitation were the key factors influencing blowing dust (PM_{10}). Consistent with EPA policy, wind speed was selected as the principle factor in identification of an exceptional event while short-term and long-term precipitation were assigned secondary weights.

Having established the relationship between climate conditions and windblown PM_{10}, the next

step is to answer the question of what constitutes an "exceptional" event. ADEQ advised the researchers that an incident rate of approximately 99.9th percentile or 1 event in a 3-year return period should be used for the meteorological condition or combination of conditions to qualify a meteorological event as "exceptional".

In general, it was found that a prerequisite for a PM_{10} event to be declared exceptional is that at least 3 hours of wind be greater than 7.0 meters per second (15.7 miles per hour) which is the approximate threshold for suspension of fine soil into the air. If this condition is met then the event is reviewed by two sequential decision paths. On the first decision path the event can be deemed "exceptional" if the 24-hour average wind speed during the PM_{10} measurement exceeds the once in 3 year statistic. However, if wind speed during the event was less than the 99.9th percentile speed but equal to or higher than the 97th percentile value then the second decision path is followed which includes precipitation tests. These steps are outlined in Figure 1.

The following is a description of the data requirements and criteria for testing a potential PM_{10} exceedance as a natural exceptional event. It is important to note that the numbered criteria are to be addressed sequentially.

Weather Data Requirements

The process for selection of the weather data source(s) to evaluate a candidate natural exceptional PM_{10} event are described below and outlined in Figure 2. The critical consideration for selection of weather stations among eligible sources of data is their ability to represent the conditions that occurred at the location of the PM_{10} monitor during the exceedance.

The station locations for wind speed and precipitation used to establish the event criteria (standard stations) are shown on maps in Figures 3 and 4, respectively. Tables 1 and 2 contain the latitude/longitude of each station along with critical Climatological statistics. Alternative data sources are recommended provided that the alternative site(s) better represents the physical environment at the PM_{10} monitoring site, considering elevation, topography, and proximity. Alternative sites must have documented quality control/assurance and maintenance program and records to assure comparable quality to the standard stations. If the alternative station has a reliable and complete record of 10 years or more, that data must be used to compute long-term statistics for the criteria tests. The choice of an alternative site and decisions on the use of the data must be coordinated with ADEQ before completing the criteria tests below.

Sequential Criteria Tests

Criterion #1: Were there 3 or more hours during the PM_{10} exceedance with hourly averaged wind speeds equal to or greater than 7.0 meters per second (15.7 miles per hour)?

If criterion #1 is met, proceed to criterion #2, if not, the event does not qualify as an "exceptional" event.

Figure 1. Sequential Criteria Tests for PM_{10} Natural Exceptional Events

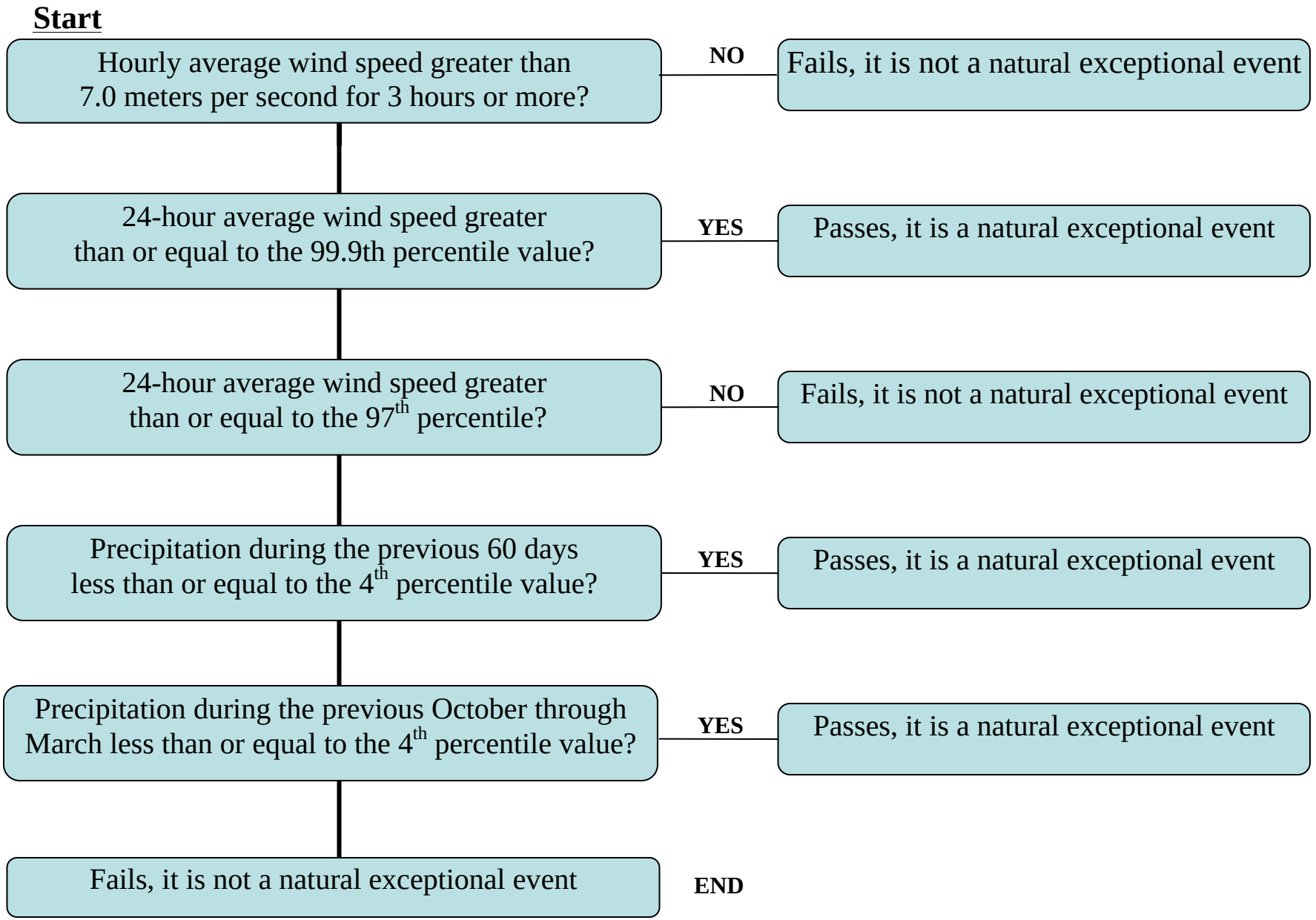


Figure 2. Weather Data Requirements for PM_{10} Natural Exceptional Events

First, for wind speed and precipitation, determine and document which weather station is most representative of the site where the PM_{10} exceedance value was measured. Depending on whether a "standard" station listed in Tables 1 and 2, or an "alternative" station is selected, go to the "standard" station option, below, or the "alternative" station options,

	Day of Exceedance Value	Lookup Value
"Standard" Station Wind Speed and Precipitation Data Values	**X**	**X**
There are 3 option for use of an "Alternate" Station in lieu of a "Standard" Station		
1) Alternate Wind Speed and Precipitation Station, demonstrated to be more representative of PM_{10} exceedance site, have more than a 10-year period of record, and quality-assured.	**X**	**X**
or		
2) Alternate Wind Speed and Precipitation Station, demonstrated to be more representative of PM_{10} exceedance site, have more than a 10-year period of record, and quality-assured.	**X**	**Use standard station default values**
or		
3) Alternate Wind Speed and Precipitation Station, demonstrated to be more representative of PM_{10} exceedance site, have more than a 10-year period of record, and quality-assured.	**X**	**Use interpolated grid values available from ADEQ**

Figure 3. Standard Climatological Station Map for Wind Speed

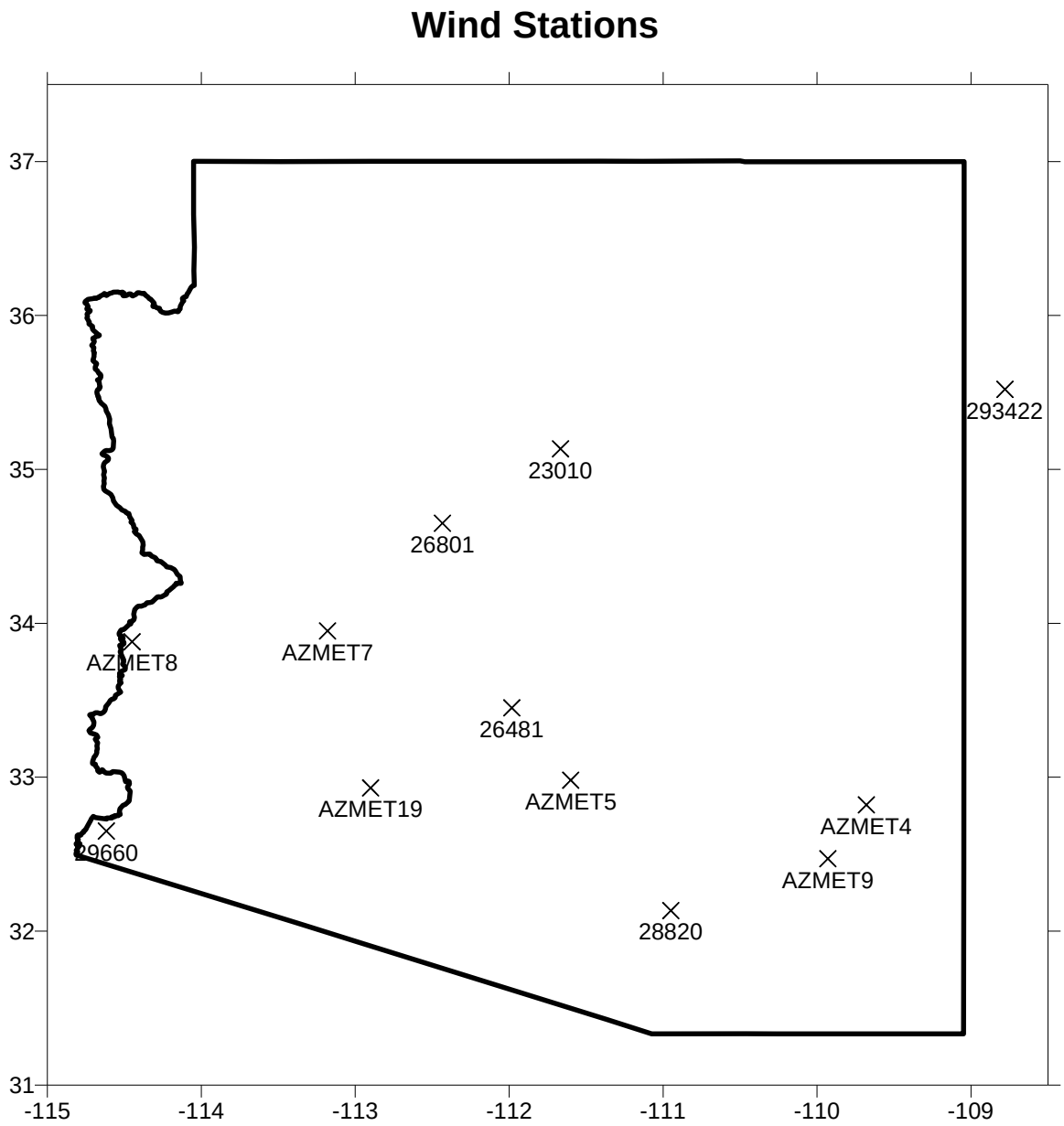


Table 1. Standard Climatological Stations Used for Average Daily Wind Speed Return Periods and Lookup Values

LOCATION	ID	LAT	LON	LEV (m)	97% (m/s)	99.9% (m/s)
FLAGSTAFF PULLIAM ARPT	23010	35.13	111.67	2135	5.6	8.2
PHOENIX SKY HARBOR INTL AP	26481	33.45	111.98	337	4.6	6.3
PRESCOTT LOVE FIELD	26801	34.65	112.43	1530	5.9	8.0
TUCSON INTERNATIONAL AP	28820	32.13	110.95	777	6.1	8.8
YUMA MCAS	29660	32.65	114.62	63	6.0	8.3
GALLUP, NEW MEXICO	293422	35.52	108.78	1971	6.4	9.9
SAFFORD	AZMET4	32.82	109.68	901	5.5	8.3
COOLIDGE	AZMET5	32.98	111.60	422	4.8	7.9
AGUILA	AZMET7	33.95	113.18	655	5.2	7.8
PARKER	AZMET8	33.88	114.45	94	6.8	9.5
BONITA	AZMET9	32.47	109.93	1346	5.3	8.8
PALOMA	AZMET19	32.93	112.90	219	4.6	7.1

Figure 4. Standard Climatological Station Map for Precipitation

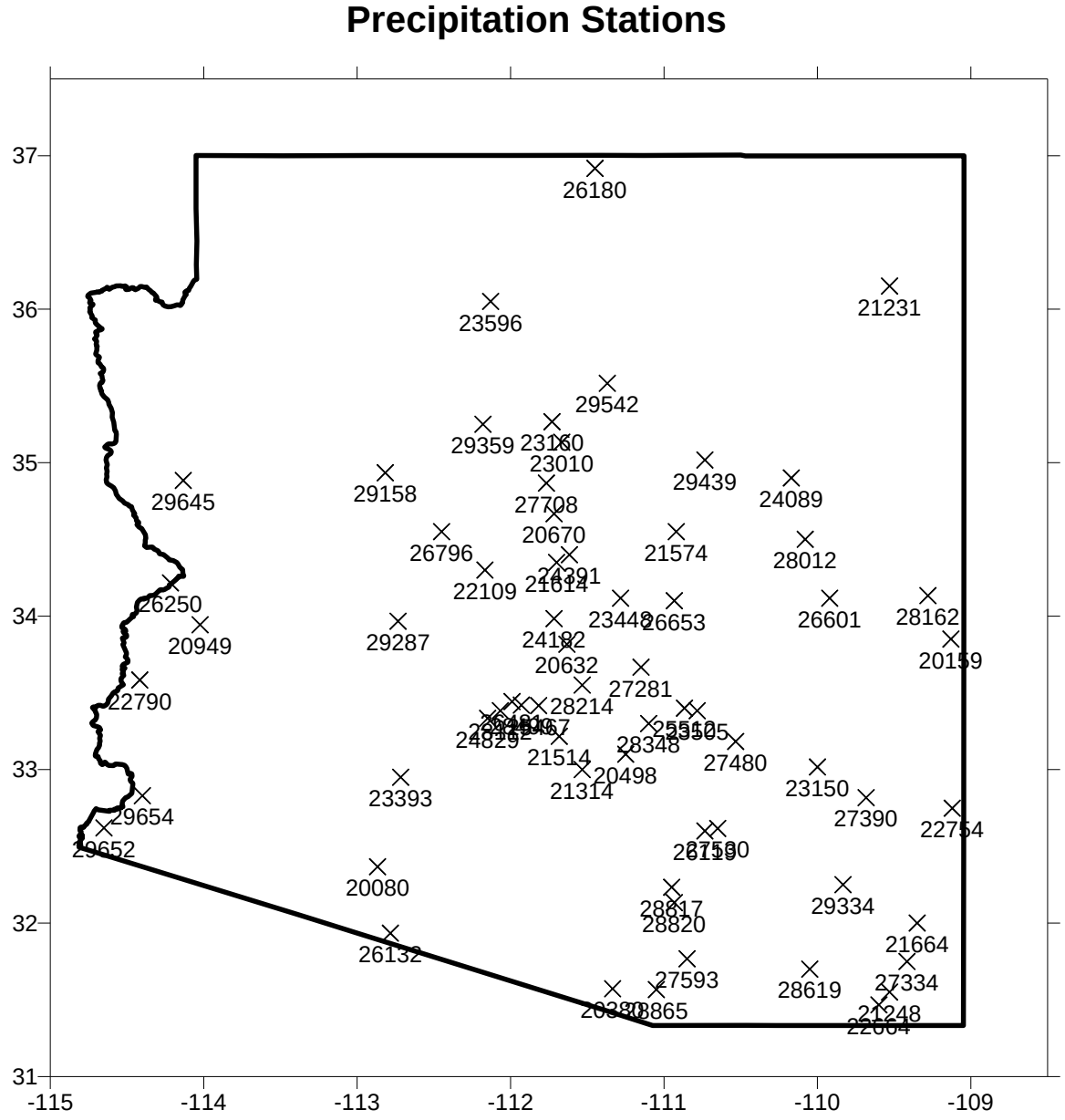


Table 2. Standard Climatological Stations Used for Precipitation Return Periods and Lookup Values

LOCATION	ID	LAT	LON	LEV(m)	60 DAY (mm)	WINTER (mm)
AJO	20080	32.37	112.87	537	0	19
ALPINE	20159	33.85	109.13	2454	12	94
ARIVACA	20380	31.57	111.34	1103	1	68
ASHURST HAYDEN DAM	20498	33.10	111.25	499	0	57
BARTLETT DAM	20632	33.82	111.63	503	0	81
BEAVER CREEK RANGER STATION	20670	34.67	111.72	1164	6	115
BOUSE	20949	33.94	114.02	282	0	10
CANELO	21231	36.15	109.53	1522	3	37
CANYON DE CHELLY	21248	31.55	109.53	94	3	57
CASA GRANDE NATIONAL MONUMENT	21314	33.00	111.53	433	0	51
CHANDLER HEIGHTS	21514	33.22	111.68	442	0	62
CHEVELON RANGER STATION	21574	34.55	110.92	2135	9	101
CHILDS	21614	34.35	111.70	808	5	93
CHIRICAHUA NATIONAL MONUMENT	21664	32.00	109.35	1615	3	85
CORDES	22109	34.30	112.17	1149	2	67
DOUGLAS BISBEE AIRPORT	22664	31.47	109.60	1249	1	35
DUNCAN	22754	32.75	109.12	1116	2	55
EHRENBERG	22790	33.58	114.42	143	0	7
FLAGSTAFF AIRPORT	23010	35.13	111.67	2135	11	134
FORT THOMAS	23150	33.02	110.00	853	2	50
FORT VALLEY	23160	35.27	111.73	2239	12	124
GILA BEND	23393	32.95	112.72	226	0	17
GISELA	23448	34.12	111.28	884	4	103
GLOBE	23505	33.38	110.78	1080	4	117
GRAND CANYON NATL PARK	23596	36.05	112.13	2101	6	91
HOLBROOK	24089	34.90	110.17	1545	0	34
HORSESHOE DAM	24182	33.98	111.72	616	0	86
IRVING	24391	34.40	111.62	1159	5	127
LAVEEN	24829	33.33	112.15	340	0	26
MESA	25467	33.42	111.82	376	0	39
MIAMI	25512	33.40	110.87	1085	2	126
ORACLE	26119	32.60	110.73	1385	7	158
ORGAN PIPE CACTUS NATL MONUMENT	26132	31.93	112.78	511	0	42
PAGE	26180	36.92	111.45	1302	3	28
PARKER	26250	34.22	114.22	125	0	12
PHOENIX SKY HARBOR	26481	33.44	111.99	337	0	35
PINETOP FISH HATCHERY	26601	34.12	109.92	2195	14	161
PLEASANT VALLEY RANGER STATION	26653	34.10	110.93	1540	6	136
PRESCOTT	26796	34.55	112.45	1650	6	85
ROOSEVELT	27281	33.67	111.15	672	1	71
RUCKER CANYON	27334	31.75	109.42	1637	4	57
SAFFORD AGRICULTURE CENTER	27390	32.82	109.68	900	2	45
SAN CARLOS RESERVOIR	27480	33.18	110.53	772	1	104
SAN MANUEL	27530	32.62	110.65	1086	2	75
SANTA RITA EXPERIMENT RANGE	27593	31.77	110.85	1311	4	109
SEDONA RANGER STATION	27708	34.87	111.77	1286	5	116
SNOWFLAKE	28012	34.50	110.08	1720	6	50
SOUTH PHOENIX	28112	33.38	112.07	354	0	33
SPRINGERVILLE	28162	34.13	109.28	2145	3	41
STEWART MOUNTAIN	28214	33.55	111.53	433	1	75
SUPERIOR	28348	33.30	111.10	915	2	137
TEMPE	28499	33.42	111.93	357	0	42
TOMBSTONE	28619	31.70	110.05	1405	2	55
TUCSON UNIVERSITY OF ARIZONA	28817	32.23	110.95	738	1	44
TUCSON INTERNATIONAL AIRPORT	28820	32.13	110.93	786	2	51
TUMACACORI NATIONAL MONUMENT	28865	31.57	111.05	996	1	83
WALNUT CREEK	29158	34.93	112.82	1551	4	79
WICKENBURG	29287	33.97	112.73	631	0	54
WILLCOX	29334	32.25	109.83	1281	3	41
WILLIAMS	29359	35.25	112.18	2057	11	105
WINSLOW MUNICIPAL AIRPORT	29439	35.02	110.73	1489	3	39
WUPATKI NATIONAL MONUMENT	29542	35.52	111.37	1496	1	28
YUCCA	29645	34.88	114.13	594	0	33
YUMA CITRUS STATION	29652	32.62	114.65	58	0	7
YUMA PROVING GROUND	29654	32.83	114.40	99	0	5

Criterion #2: Was the 24-hour average wind speed on the day of the PM_{10} event equal to or greater than the 99.9th percentile level (one occurrence in 3 years) wind speed for the geographic area?

This is answered by comparing the actual 24-hour wind speed measured at the most representative standard station from Figure 3 and Table 1 during the event, with the 99.9th percentile value for that station in Table 1. If an alternative station is used, the 24-hour average wind speed during the event from that station is compared to the long term 99.9th percentile value calculated for that station, when available. If the data record for the alternative station is insufficient for long-term statistics, i.e. less than 10 years, the 24-hour average wind speed measured at the alternative station during the event is compared to the 99.9th percentile value on Figure 5 for the geographic location of the alternative station.

If the wind speed during the event was equal to or greater than the 99.9th percentile value, it qualifies as an exceptional event. If the wind speed during the event was less than the 99.9th percentile value, proceed to criterion #3.

Criterion #3: Was the 24-hour average wind speed on the day of the PM_{10} event equal to or greater than the 97th percentile level (10 occurrences per year) for the geographic area?

This is answered by comparing the actual 24-hour wind speed measured at the most representative standard station from Figure 3 and Table 1, during the event, with the 97th percentile value taken from that same wind station in Table 1. If an alternative station is used, the 24-hour wind speed average during the event is compared to the long term 97th percentile value for that station, when available. If the data record for the alternative station is insufficient for long-term statistics, i.e. less than a 10 year record, then the 24-hour wind speed average measured at the alternative station during the event is compared to the 97th percentile value on Figure 6 for the geographic location of the alternative station. If greater detail than provided on Figure 6 is needed, ADEQ can furnish gridded values for the area in question.

If the wind speed during the event was equal to or greater than the 97th percentile value, proceed to criterion #4. If the wind speed was less than the 97th percentile value, the event does not qualify as an "exceptional" event.

Criterion #4: Have there been dry conditions during the 60 days prior to the PM_{10} exceedance such that the 60-day cumulative precipitation is lower than the 4th percentile value from long-term statistics?

This is answered by comparing the cumulative precipitation measured during the 60 days prior to the PM_{10} event at the most representative standard precipitation station in Figure 4 and Table 2 with the long-term 4th percentile value for that station in Table 2. If an alternative station is being used, the 60-day cumulative precipitation amount measured at that station during the PM_{10} event are compared to the long-term 4th percentile 60-day precipitation value calculated for that station. If the data record for the alternative station is insufficient for long-term statistics, i.e. less than a 10-year record, then the precipitation measured at the alternative station for the 60 days

Figure 5. 99.9th Percentile Average Daily Wind Speed Map

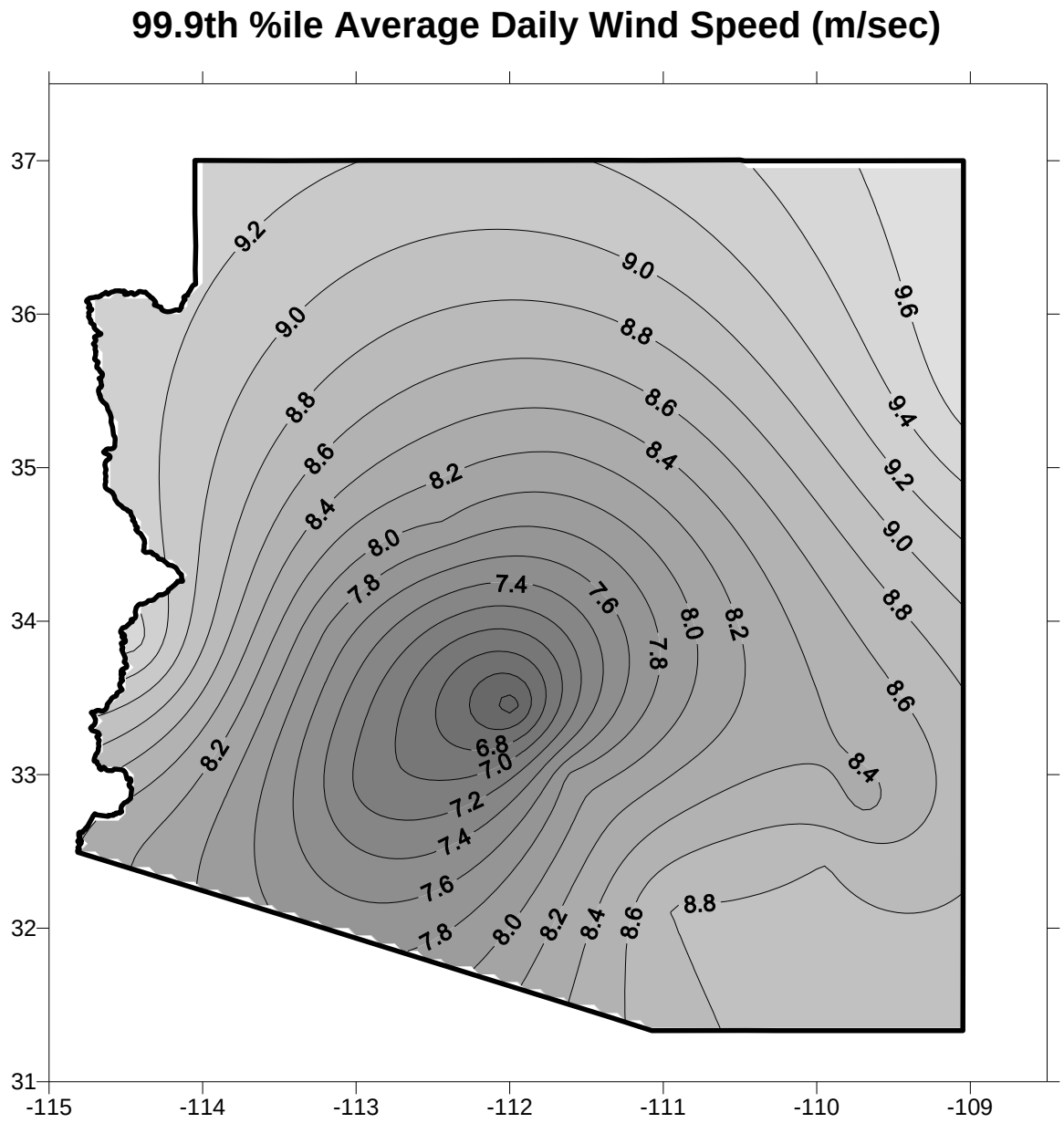
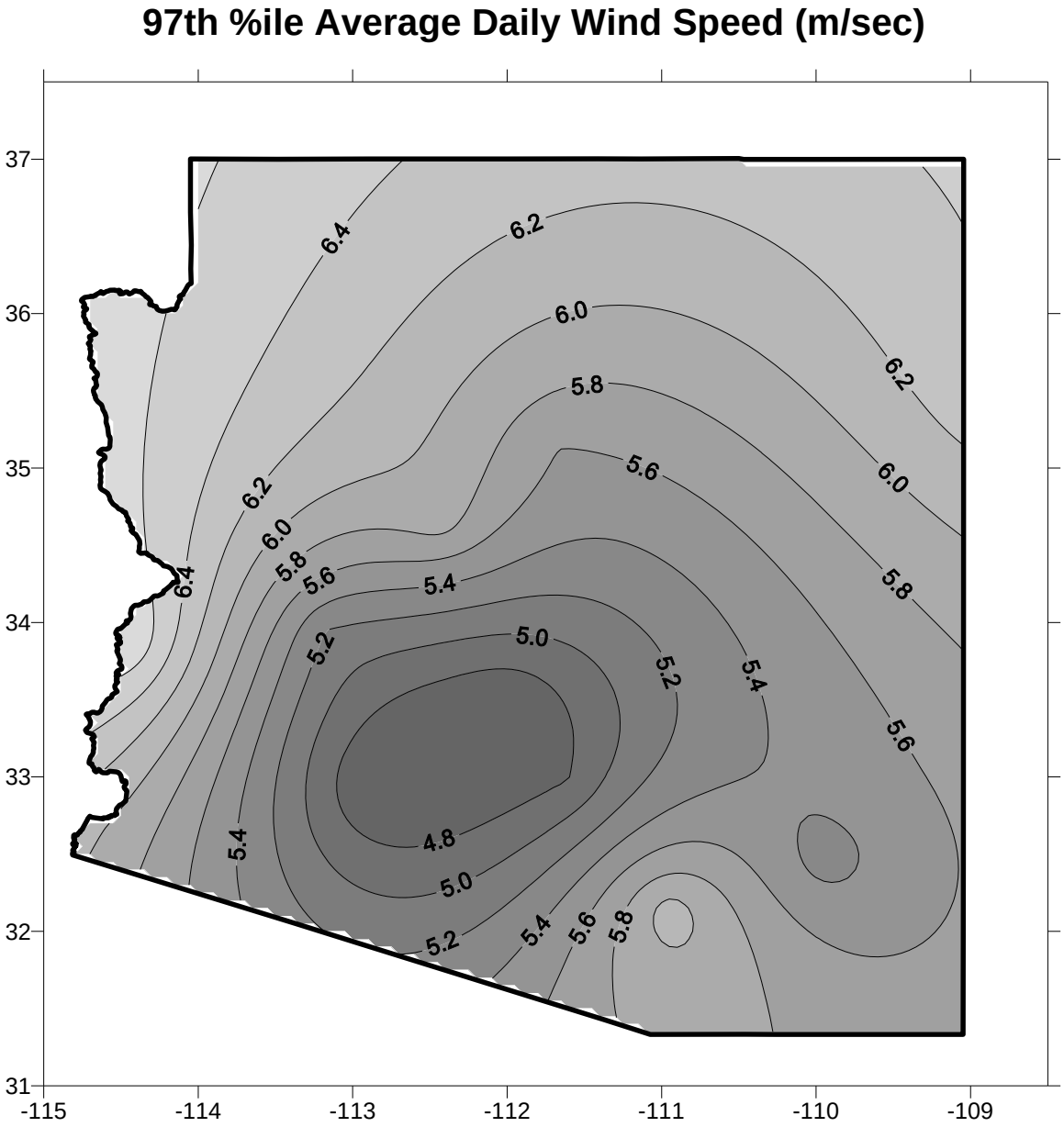


Figure 6. 97th Percentile Average Daily Wind Speed Map



prior to the exceedance is compared to the 60-day average long-term 4th percentile value on Figure 7 for the geographic area of the alternative station. If greater detail than provided on Figure 7 is needed, ADEQ can furnish gridded values for the area in question.

If this criterion is met, the PM_{10} event qualifies as an exceptional event. If this criterion is not met, proceed to Criterion #5.

Criterion #5: Have there been dry conditions during the previous winter (October-March) such that the cumulative precipitation is lower than the 4th percentile value from long-term statistics?

This is answered by comparing the cumulative precipitation for the October-March period prior to the PM_{10} event at the most representative standard precipitation station in Figure 4 and Table 2 with the long-term 4th percentile value for October-March precipitation at that station from Table 2. Note that if the PM_{10} exceedance occurred in the October-March time frame that the preceding October-March precipitation data are used. If an alternative station is being used, the cumulative precipitation amount measured at that station during the October-March period prior to the PM_{10} event is compared to the 4th percentile long-term value calculated for that station. If the data record for the alternative station is insufficient for long-term statistics, i.e. less than a 10-year record, then the precipitation measured at the alternative station for the October-March period prior to the PM_{10} event is compared to the long-term October-March 4th percentile values on Figure 8 for the geographic location of the alternative station. If greater detail than provided on Figure 8 is needed, ADEQ can furnish gridded values for the area in question.

If this criterion is met, the PM_{10} event qualifies as an "exceptional" event. If this criterion is not met, the event does not qualify as an "exceptional" event.

Step 3) *What were the sources of the emissions causing the exceedance, i.e., were the exceedances caused by dust suspended by high winds*?

Initially this step entails the development of a modeling plan for inclusion in the notification to EPA of the occurrence of the natural exceptional event within 180 days of the PM_{10} violation or exceedance. This plan should provide a preliminary discussion of conditions during the exceedance, particularly the suspected source categories of windblown PM_{10} on the day of the exceedance. The modeling plan should describe in as much detail as possible the approximate dimensions of the modeling domain, emission inventory construction methods, sources of meteorological data, and the types of models to be used.

The actual modeling analysis must be coordinated with ADEQ during the development and execution stages and be included in the NEAP public review process. The final modeling analysis is to be submitted with the NEAP within 18 months of the exceedance.

A logical starting point for evaluating the sources contributing to the PM exceedance would be a mapping of all PM sources significantly influencing the monitor(s) in question on the day of the event. The size of the inventory area will depend on the types of sources and their proximity to the monitor(s). A monitor with large areas of recently disturbed light, desert soils in the

Figure 7. 4th Percentile Previous 60 Days' Cumulative Precipitation Map

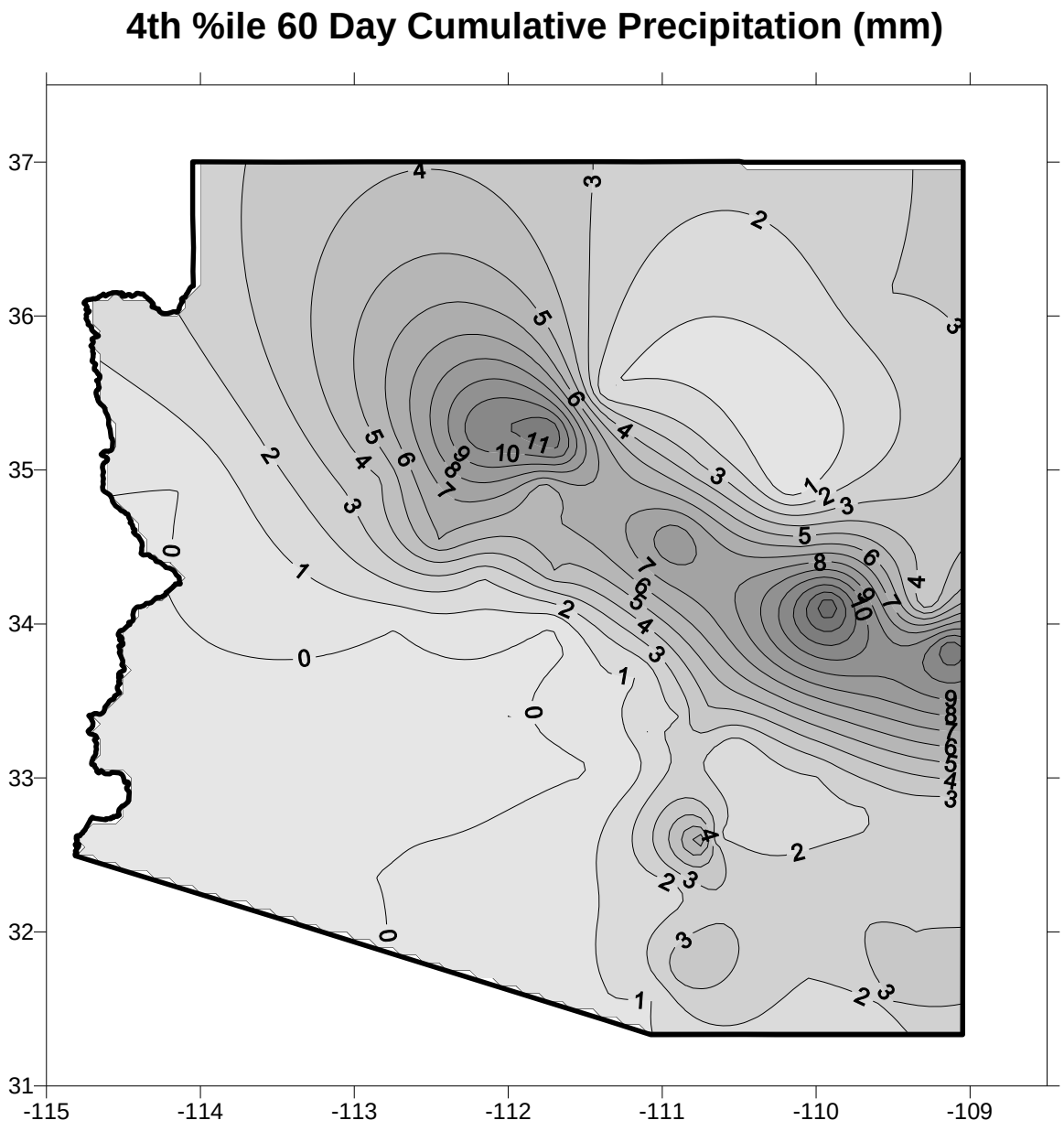
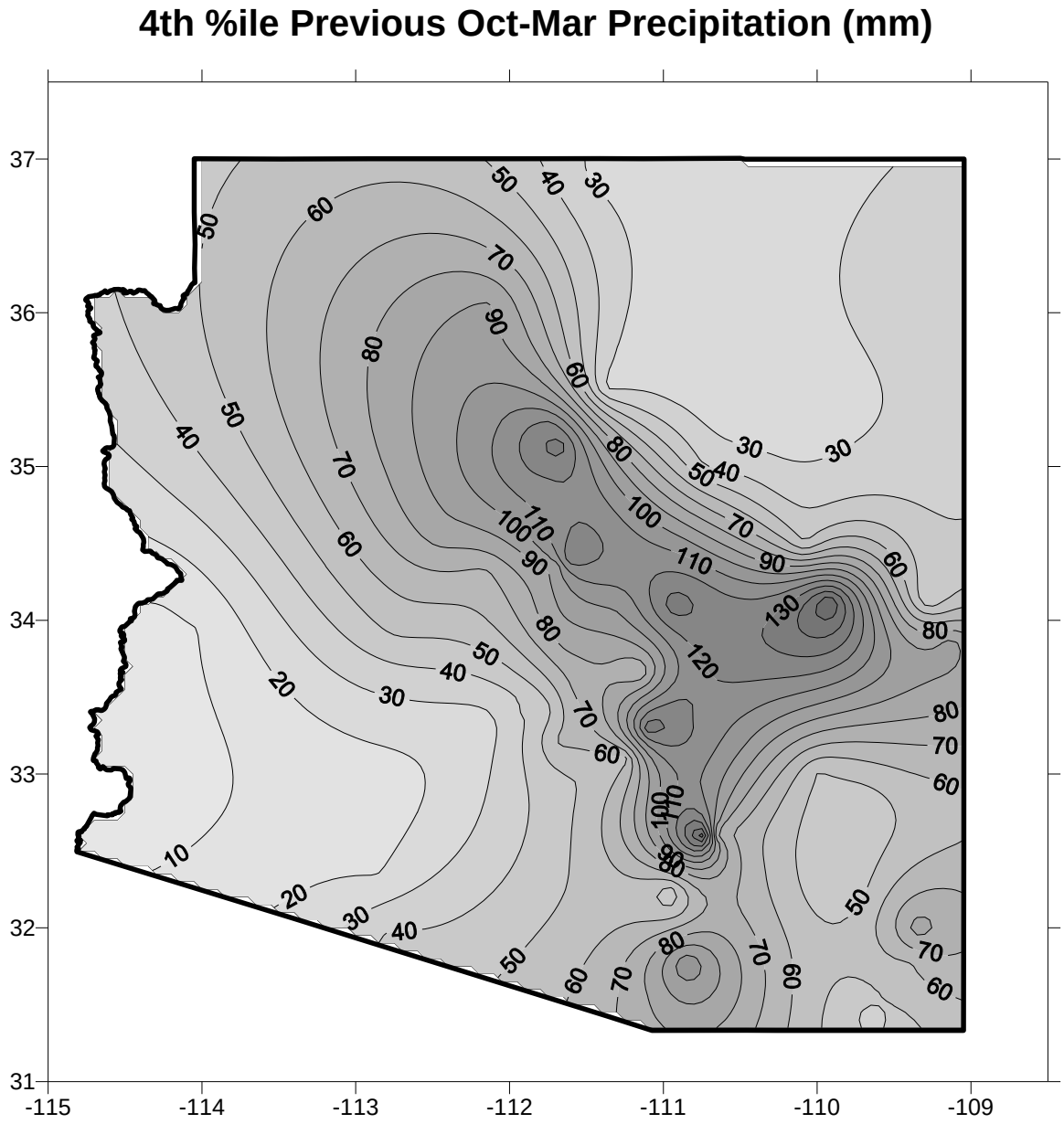


Figure 8. 4th Percentile Previous October - March Cumulative Precipitation Map



immediate vicinity would likely be swamped by local emissions which would dictate a relatively small inventory area. Historically high wind PM_{10} exceedances have all been attributable to disturbed land in the immediate vicinity of the monitor. Regional or background PM_{10} levels are typically elevated and the windblown component may need to be considered; that may significantly increase the complexity of this technical analysis and the NEAP planning process.

The emissions inventory will be needed for the present modeling evaluation, and also later in the process if a NEAP is developed, to apply Best Available Control Measures (BACM), as currently defined by EPA for the appropriate sources.

An atmospheric dispersion model approved by EPA in their Guideline on Air Quality Models or alternative modeling tool approved by ADEQ must be used to assess the episode using the inventory and representative meteorology, Absolute agreement between modeled PM_{10} and the actual measurements are less important than the relative contributions of the sources because the purpose of the modeling is to show that the exceedance was caused by windblown PM_{10} In other words, that the exceedance would not have occurred without the windblown PM_{10}.

The dispersion modeling results should be evaluated and compared with information gained by analysis of the PM filters for chemical composition, particle size distribution, and physical characteristics to interpret the contributions of the different PM sources and for comparison and reconciliation with the dispersion modeling results.

Step 4) *If the PM_{10} event qualifies as a natural exceptional event, what are the required contents for notification to ADEQ and EPA?*

EPA requires the notification that a PM_{10} exceedance is a natural exceptional event within 180 days of the violation or exceedance measurement, along with a plan to develop a NEAP for later submittal within 18 months of the exceedance date. This notification must include the following components from steps 1-3 above.

From Step 1: Provide complete documentation that the PM_{10} sampler(s) was collecting valid samples on the day of the exceedance. Provide similar documentation that sample handling, laboratory work, quality control and quality assurance, and calculations were properly conducted.

From Step 2: Provide complete documentation of all data, assumptions and calculations made to qualify the PM_{10} exceedance as an exceptional event.

From Step 3: Provide a modeling plan describing in as much detail as possible the tools and methods that will be used to determine the relative contributions of windblown PM_{10} sources during the PM_{10} exceedance for subsequent use in the final NEAP. A preliminary assessment of the contributing windblown PM_{10} sources should also be included.

In addition, the notification to EPA through ADEQ must include a process and time line to develop a NEAP for public notification of potential PM_{10} exceedances caused by natural exceptional events, and a plan to adopt Best Available Control Measures (BACM) on the

man made portions of the source(s) of windblown dust to be identified in the modeling to be performed pursuant to the plan from Step 3. The requirements for NEAP content and review are to follow current EPA and ADEQ policies or other guidance. All of the documentation described here in Step 4 must be submitted to the ADEQ Director under a cover letter requesting that ADEQ analyze and process the request, make recommendations, and forward the request to EPA.

References

United States Environmental Protection Agency (USEPA). May 30, 1996. Areas Affected by PM_{10} Natural Events, USEPA policy memorandum.

Arizona Department of Environmental Quality. Apri128, 1999. Air Qua1ity Exceptional and Natura1 Events Policy, Level One, Number 0159.000.

USEPA 40 Code of Federal Regulations (CFR), Part 50.6

USEPA 40 CFR, Part 50, Appendix J.

USEPA 40 CFR, Part 50, Appendix K.

USEPA 40 CFR, Part 58.10.

USEPA 40 CFR, Part 58.11

USEPA 40 CFR, Part 58.12.

USEPA 40 CFR, Part 58.13

USEPA 40 CFR, Part 58.26.

USEPA 40 CFR, Part 58, Appendix A.

USEPA 40 CFR Part 58, Appendix C.

USEPA 40 CFR, Part 58, Appendix D.

USEPA 40 CFR, Part 58, Appendix E.

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Comrie, A. and Garfin-Woll, G. May 2000. Climatological Analysis for PM_{10} Natural Exceptional Events in Arizona. Prepared for ADEQ under contract.

Hubb1e, M. 2000. Wind Speed Effects on PM_{10}: Douglas, Arizona. ADEQ Air Assessment Section internal memorandum # 131.

USEPA 40 CFR, Part 51, Appendix W. Guideline on Air Quality Models.