Desert Research Institute

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NNSS Soils Monitoring: Plutonium Valley (CAU 366) FY2013 and FY2014

prepared by

Julianne J. Miller, George Nikolich, Steve Mizell,
Greg McCurdy, and Scott Campbell

submitted to

Nevada Field Office
National Nuclear Security Administration
U.S. Department of Energy
Las Vegas, Nevada

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EXECUTIVE SUMMARY

The Desert Research Institute (DRI) is conducting a field assessment of the potential for contaminated soil transport from the Plutonium Valley Contamination Area (CA) as a result of wind transport and storm runoff in support of Nevada Nuclear Security Administration (NNSA) efforts to complete regulatory closure of the contamination areas. The DRI work is intended to confirm the likely mechanism(s) of transport and determine the meteorological conditions that might cause movement of contaminated soils. Emphasis is given to collecting sediment transported by channelized storm runoff at the Plutonium Valley investigation sites. These data will inform closure plans that are being developed, which will facilitate appropriate closure design and postclosure monitoring.

Desert Research Institute installed two meteorological monitoring stations south (station number 1) and north (station number 2) of the Plutonium Valley CA and a runoff sediment sampling station within the CA in 2011. Temperature, wind speed, wind direction, relative humidity, precipitation, solar radiation, barometric pressure, soil temperature, and airborne particulate concentration are collected at both meteorological stations. The maximum, minimum, and average or total (as appropriate) for each of these parameters is recorded for each 10-minute interval. The sediment sampling station includes an automatically activated ISCO sampling pump with collection bottles for suspended sediment, which is activated when sufficient flow is present in the channel, and passive traps for bed-load material that is transported down the channel during runoff events. This report presents data collected from these stations during FY2013 and FY2014.

The warmest month was July and the coldest months were December and January. Solar radiation reflects the same seasonal trend with the most sunlight in July and the least in December and January. Monthly mean wind speeds were highest in the spring (April and May). Winds were generally from the south and southeast throughout the year. Monthly average relative humidity ranged from the low teens to greater than 60 percent. During rain storms, the relative humidity approached 100 percent. Monthly total precipitation ranged from zero to approximately 1.7 inches. The months with the highest precipitation totals were October 2012 and August 2014. Total precipitation each year was approximately six inches. However, the northern station received less than the southern station.

The ISCO sampler is turned on to collect samples when sufficient water depth is detected in the channel. A pressure transducer is used to determine the water depth present and a photoacoustic sensor is used to determine the distance from the sensor to the dry channel bed or water surface. Because of instrument failure, both the pressure transducer and photoacoustic sensor were replaced on July 15, 2014. On that same date, a wetness plate was added to the instrument array to report the presence of water as a result of changes to electrical resistivity on the plate. Multiple sensors are used because each is subject to erroneous output: the transducer may dry out and fail or be slow to respond, the photoacoustic sensor may respond to windblown objects, and the wetness plate may respond to humid conditions or soil moisture condensation. To minimize the potential for false reports of water in the channel, the ISCO sampler was programed to turn on only if all three sensors reported the presence of sufficient water in six successive observations made 10 seconds apart.

The ISCO turned on only once during FY2013 and FY2014 (on April 16, 2014). However, when personnel came to retrieve the samples on July 15, 2014, no water had been collected. Only the pressure transducer and photoacoustic sensor were installed prior to that time and both may have been putting out erroneous signals.

Two bed-load samples were collected in March 2014. Overall, the sample with the greater portion of small particles had the higher radionuclide concentrations. The smaller particle size fraction in each sample exhibits higher concentrations of Am-241 and Pu-238. But the concentration of Pu-239/240 was higher for the smaller size fraction in one sample and for the larger size fraction in the other sample.

Light breezes of 0 to 5 mph occurred most frequently (approximately 60 percent of the time at both the northern and southern monitoring stations). The frequency of occurrence diminished approximately exponentially as the wind speed increased such that winds in the 20 to 30 mph range occurred less than one percent of the time. Additionally, winds in excess of 15 mph were almost exclusively from the southerly direction. This situation is most likely explained by the topography of the valley because the mountains that define the east and west sides of the valley draw together toward the north and protect the northern monitoring station from northerly winds.

Generally, the concentrations of $PM_{2.5}$ and PM_{10} material in the air increased approximately exponentially as wind speed increased. Significant increases in wind-blown dust concentrations were observed when wind speeds exceed 15 mph. The elevated dust concentrations were almost exclusively associated with winds from the south.

The ratio of PM_{10} to $PM_{2.5}$ is a qualitative indicator of the type of aerosol material that is being measured. The PM_{10} to $PM_{2.5}$ ratio remains below 6 for wind speeds below about 15 mph and that the ratio increases to about 10 as the wind speed increases from 15 mph to 30 mph. This increase in the ratio is an indicator of some suspension and transport of locally derived dust and soil. The ratio increases close to areas of course particles because PM_{10} has, on average, bigger particles and therefore a shorter lifetime in the atmosphere than $PM_{2.5}$. However, this ratio cannot be used quantitatively as it is subject to change with changing soil conditions.

Review of the data collected during FY2013 and FY2014 and presented here led to the following principal observations and conclusions:

1) The ISCO sampler was turned on only one time to collect water samples for suspended sediment analysis. When personnel arrived to retrieve the sample, no water had been collected in the bottles.
2) The pressure transducer and photoacoustic sensor were replaced and a wetness plate was added to the array of instruments installed to detect water in the ephemeral channel and cause the ISCO to turn on for sample collection. The ISCO did not turn on after the instruments were replaced.
3) The ratio of PM_{10} to $PM_{2.5}$ dust concentrations observed at the Plutonium Valley monitoring stations indicate suspension and transport of some locally derived dust and soil.

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LIST OF ACRONYMS

Am-241	Americium-241
CA	Contamination Area
CAS	Corrective Action Site
CAU	Corrective Action Unit
DOE	Department of Energy
DRI	Desert Research Institute
EPA	Environmental Protection Agency
GOES	Geostationary Operational Environmental Satellite
NFO	Nevada Field Office
NNSS	Nevada National Security Site
$PM_{2.5}$	Particulate matter with aerodynamic diameter less than 2.5 micrometer
PM_{10}	Particulate matter with aerodynamic diameter less than 10 micrometer
WRCC	Western Regional Climate Center

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INTRODUCTION

The U.S. Department of Energy (DOE) National Nuclear Security Administration (NNSA), Nevada Field Office (NFO), Environmental Restoration Soils Activity has authorized the Desert Research Institute (DRI) to conduct field assessments of potential transport of radionuclide-contaminated soil from Corrective Action Unit (CAU) 366, Area 11 Plutonium Valley Dispersion Sites Contamination Area (CA) during precipitation runoff events, as well as to monitor for wind suspension of fine soil particles.

Aerial surveys in selected portions of the Nevada National Security Site (NNSS) suggest that radionuclide-contaminated soils may be migrating along ephemeral channels in Areas 3, 8, 11, 18, and 25 (Colton, 1999). In Area 11, several low-level airborne surveys of the Plutonium Valley Dispersion Sites (CAU 366) show plumes of americium 241 (Am-241) that extend along ephemeral channels (Colton, 1999). These plumes are shown in Figure 1, where marker 5 indicates a plume that extends below Corrective Action Site (CAS) 11-23-04 (marker 4) and marker 6 indicates a plume that extends below CAS 11-23-03 (marker 3).

Plutonium Valley, located in Area 11 of the NNSS, was selected for the study because of the aerial survey evidence that suggests downstream transport of radionuclide-contaminated soil. The aerial survey (Figure 1) shows a well-defined finger of elevated radioactivity (marker 5) that extends to the southwest from the southernmost detonation site (marker 4). This finger of contamination overlies a drainage channel mapped on the topographic base map that is used to present the survey data, which suggests that surface runoff is a likely cause of the down-channel extension of the contaminated area. Additionally, installing monitoring instruments at sites that are strongly suspected of conveying soil from areas of surface contamination offer the most efficient means of confirming that surface runoff may transport radioactive contamination during ambient precipitation/runoff events.

Closure plans that are being developed for the CAUs on the NNSS may include postclosure monitoring for the possible release of radioactive contaminants. Determining the potential transport of radionuclide-contaminated soils under ambient meteorological conditions will facilitate an appropriate closure design and postclosure monitoring program.

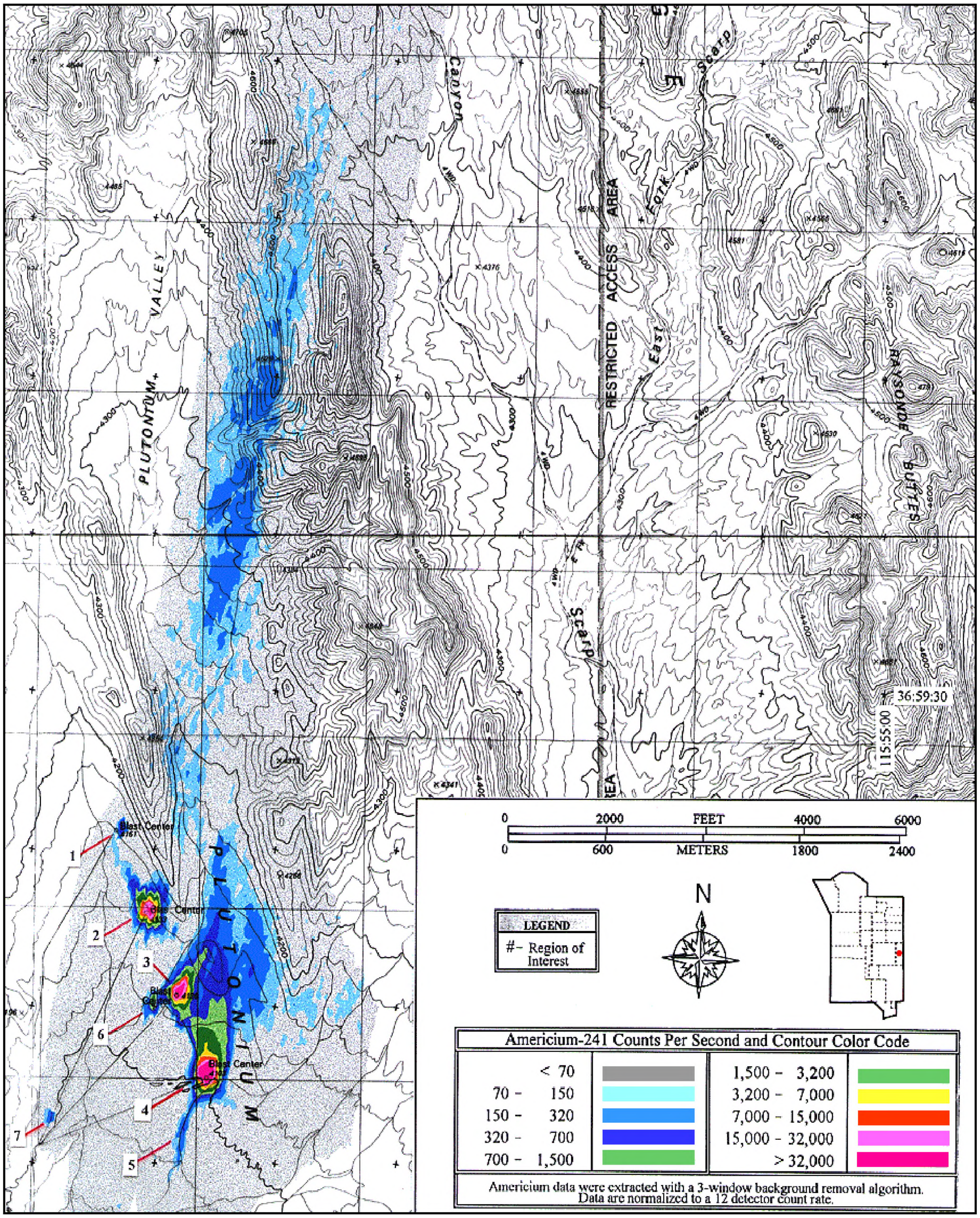


Figure 1. Americium-241 detections in Plutonium Valley suggest migration of radionuclide-contaminated soils along channels that convey runoff away from the Corrective Action Sites. Markers 1 through 4 identify the four Project 56 ground zero sites, items 5 and 6 identify plumes in channels draining the ground zero areas, and item 7 designates an isolated low-activity spot (after Colton [1999], Figure 5).

BACKGROUND

Plutonium Valley is located east of Yucca Flat Dry Lake in Area 11 of the NNSS in southeastern Nye County, Nevada. Project 56, which consisted of a series of four nuclear device safety tests, was conducted in the valley in 1955 and 1956. The safety tests were performed at test beds 11a through 11d (Figure 1, markers 1 through 4), which are aligned north to south in the valley. These test beds have been designated CASs 11-23-01, 11-23-02, 11-23-03, and 11-23-04, respectively, within CAU 366. Additionally, two contaminated waste disposal sites, CAS 11-08-01 and 11-08-02, are also included within CAU 366. The test conducted at test bed 11d (Figure 1, marker 4) (CAS 11-23-04), the southernmost test bed, resulted in extensive alpha contamination on the ground surface (B. Bailey, written communication; October 12, 2010) surrounding ground zero. Aerial surveys (Colton, 1999) detected high concentrations of Am-241 around the three southern test beds (Figure 1, markers 2 through 4) and a significant plume of Am-241 distributed in a north-northeast direction from the southernmost two test locations (Figure 1, markers 3 and 4). The Am-241 plume extending to the north-northeast from the test beds along the west face of the hills that define the east boundary of Plutonium Valley is reported at relatively low radioactivity levels. This plume is believed to have resulted from air dispersal during the test events. It is disconnected from and uphill of the test beds and is not considered a priority issue with respect to potential transport of contaminants by runoff. These surveys also showed Am-241 concentrations above background in a channel that conveys runoff toward the south from the southernmost test bed, CAS 11-23-04 (Figure 1, marker 5). This channel turns westward and, when runoff is sufficient, carries water out of the valley toward Yucca Flat Dry Lake. Because this channel conveys runoff that has traversed the southernmost test bed that is reported to have significant surficial contamination, there is potential for the runoff to transport significant levels of contamination along with sediment eroded from the test bed.

RESEARCH APPROACH

The presence of radionuclide-contaminated soils in a channel that traverses the southernmost CAS in the Plutonium Valley CA suggests radionuclide-contaminated soil has been transported during runoff events that have occurred in the past. Various studies (Colton, 1999; Shinn *et al.*, 1993) also indicate surface water has transported radionuclide-contaminated soils in the past, which suggests additional surface movement of contaminated soils is possible in the future.

Desert Research Institute proposed to perform a field-scale assessment of meteorological and hydrologic conditions that would potentially lead to the transport of radionuclide-contaminated soil from the Plutonium Valley CA. The research plan included measuring local meteorological parameters and collecting suspended and bed-load sediment transported during runoff events. The precipitation and runoff data will be used to establish threshold conditions that would likely lead to the transport of soil particles, including radionuclide-contaminated soils. Such thresholds will aid in establishing the conditions that would require monitoring drainage channel transport pathways to be implemented under a future closure plan.

Two meteorological stations, instrumented to measure temperature, relative humidity, wind speed, wind direction, soil volumetric water content, soil temperature, solar radiation, barometric pressure, precipitation, and particulate matter suspended in air, were installed in uncontaminated areas north and south of the Plutonium Valley CA on August 24 and 25, 2011. Figure 2 shows the locations of the instrument stations relative to the ground zero sites in Plutonium Valley and Figure 3 shows photographs of the two meteorological stations. Location coordinates for the two meteorological stations are provided in Table 1. The meteorological stations were installed to determine the variation in climatic conditions and predominate seasonal wind directions. In these installations, soil water content values are inferred from time domain reflectometry (TDR) observations; however, because the TDR instruments were not calibrated to the specific soil conditions at each station, the moisture content values are relative rather than absolute. The southern meteorological station (station #1) includes Geostationary Operational Environmental Satellite (GOES) data transmission equipment that is used to transmit hourly summaries of accumulated meteorological data to the Western Regional Climate Center (WRCC) at the DRI offices in Reno once each day. At the WRCC, the data are uploaded to a restricted access internet webpage that is available to the project personnel.

An ISCO sampler was installed within the Plutonium Valley CA (Figures 2 and 4) to collect suspended sediment samples during a significant runoff event. Additionally, two bed-load traps were installed near the ISCO sampler to collect samples of bed-load sediment during runoff events. The coordinates of the ISCO sampler are given in Table 1. This location is approximately 0.4 miles (0.64 km) downstream of the southernmost test ground zero (CAS 11-08-04) and approximately 0.6 miles (0.96 km) upstream of the detention basin at the southwest corner of the CA. The ISCO installation includes a photoacoustic distance sensor to detect the presence of water in the channel and report the distance to the dry channel bed or water surface and a pressure transducer to estimate the water depth in the channel. These sensors indicate the presence and depth of water in the channel and turn on the ISCO sampler when sufficient water is present. A datalogger transmits output from the water level sensors and ISCO sampler activity to the datalogger at station #1 via a radio link.

Table 1. Universal Transverse Mercator (Zone 11 S) coordinates for equipment installed for the Plutonium Valley runoff transport study.

Instrumentation	Easting	Northing
Northern Meteorological Station (#2)	592375	4093665
Southern Meteorological Station (#1)	592739	4090724
ISCO Sampler	592751	4091555

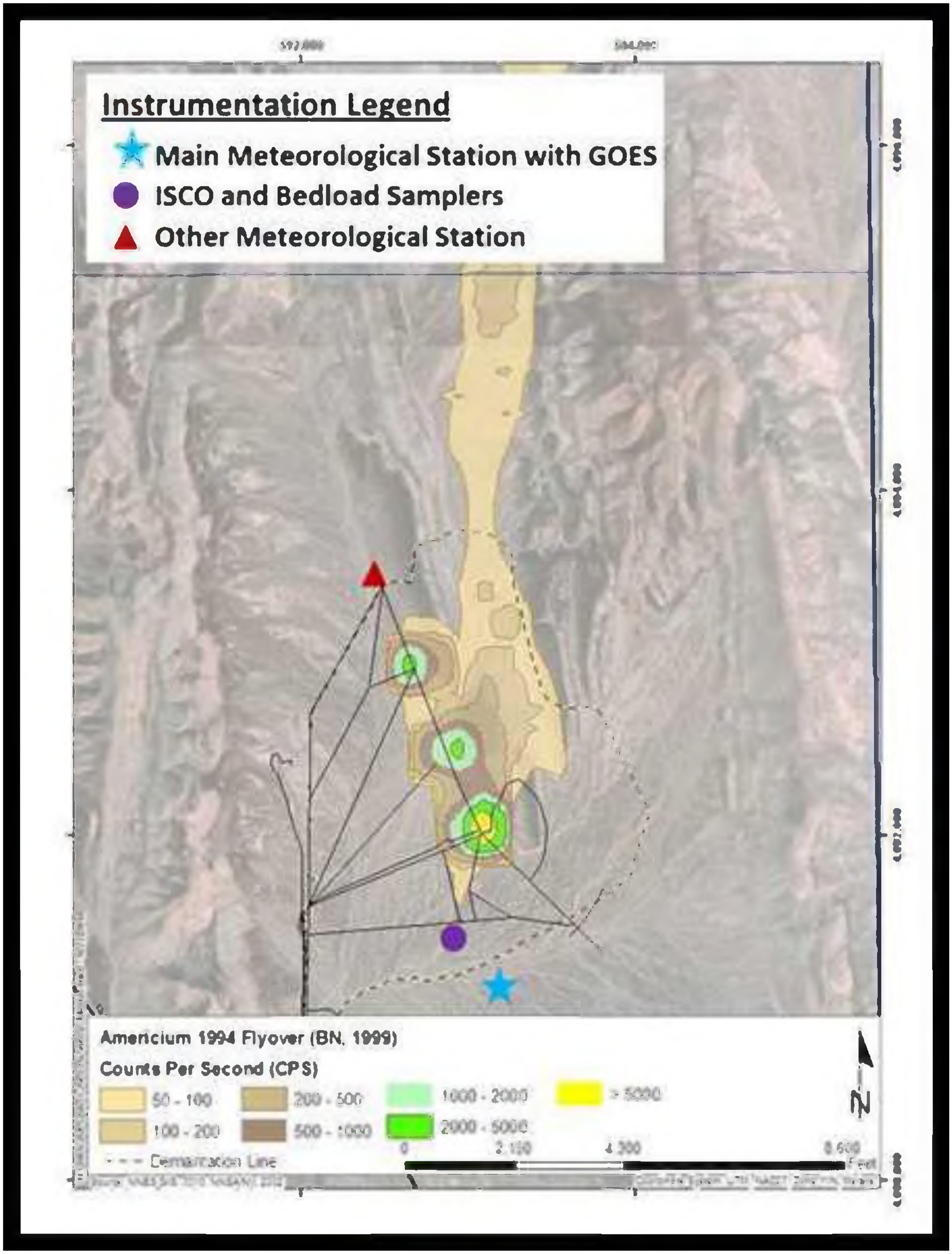


Figure 2. Approximate locations of the meteorological stations #1 (blue star) and #2 (red triangle) and ISCO installation in Plutonium Valley, Nevada.

Figure 3. The meteorological stations in Plutonium Valley were installed to measure precipitation, wind, and other meteorological parameters downwind of the Contamination Area during the dominant south wind in summer (left: station #2, northern station) and dominant north wind in winter (right: station #1, southern station).

Figure 4. The ISCO sampler (inside the orange job box) is triggered when the pressure transducer (yellow cable in the stilling well) detects runoff. The photoacoustic depth sensor (on the left, hanging from the pole) measures flow depth. Detection of runoff and flow depth data are relayed by radio signal to the southern meteorological station, and then by GOES satellite to the Western Regional Climate Center.

FISCAL YEAR 2013 AND 2014 OBSERVATIONS

Measurements of air temperature, relative humidity, wind speed and direction, soil volumetric water content, soil temperature, solar radiation, barometric pressure, and precipitation are collected every three seconds. In addition to these typical meteorological measurements, the Plutonium Valley stations are also equipped with a Met One Particulate Profiler Model 212-1. Once each minute, the Met One instrument measures particulates suspended in air using light-scattering technology. It is capable of detecting and counting suspended particulates in the range of 0.5 to 10 micrometers (μm) in diameter. The meteorological and particulate data are averaged or totaled, as appropriate, and recorded on the datalogger every 10 minutes. Then, an hourly average is calculated. Because GOES transmission time and data bandwidth are limited, only the hourly average data are transmitted by the GOES system to the WRCC. The GOES transmissions occur at precise time intervals every day and are synchronized using the GPS receiver derived time. The 10-minute data are retained on the datalogger and are manually downloaded during quarterly site visits.

Meteorological Observations

Ten-minute observations collected from the Plutonium Valley southern station (station #1) for the period October 1, 2012, through September 30, 2014, are summarized by month and year in Tables 2A and B, and for the Plutonium Valley northern station (station #2) in Tables 3A and B. Daily average values of the meteorological and environmental parameters observed at both stations are shown in time series plots presented in Appendices A through D.

During the reporting period (October 1, 2012, through September 30, 2014), the monthly summaries of meteorological data indicate that:

1) The average monthly temperature was warmest in July and coldest in December and January.
2) Soil temperature followed a pattern that was similar to the monthly temperature.
3) Monthly average relative humidity was highest in November/December and lowest in June.
4) The monthly precipitation totals exceeded one inch in October 2012 (1.72 in), July 2013 (1.33 in), and August 2014 (1.86 in) at station #1; and October 2012 (1.62 in) and July 2013 (1.00 in) at station #2.
5) The average wind speed was highest in April and May and tended to be the calmest in October through February.

Table 2A. Monthly and annual summary of meteorological observations at Plutonium Valley monitoring station #1 (south) for FY2013 (October 1, 2012, through September 30, 2013).

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	ANNUAL	VALUE
Wind Speed Avg (mph)	4.48	4.48	4.46	5.56	5.76	5.37	6.63	6.63	6.12	5.57	5.51	5.62	**AVG**	5.51
Wind Speed Max (mph)	24.77	31.14	22.50	22.06	22.13	23.12	25.43	22.26	23.81	26.18	23.40	24.41	**MAX**	31.14
Wind Speed Gust (mph)	37.70	48.74	35.07	33.17	33.76	36.24	37.70	35.73	44.13	39.31	35.00	41.43	**MAX**	48.74
Air Temperature Avg (deg F)	58.14	47.08	36.94	35.14	39.28	51.35	57.87	65.25	78.60	82.41	77.40	69.58	**AVG**	58.25
Air Temperature Min (deg F)	28.62	12.70	11.86	5.00	16.21	24.29	21.28	33.26	43.51	54.28	47.46	31.81	**MIN**	5.00
Air Temperature Max (deg F)	92.73	78.08	64.83	66.40	65.50	79.70	89.35	92.30	107.89	108.18	98.49	95.04	**MAX**	108.18
Relative Humidity Avg (%)	40.26	49.92	64.86	47.66	42.83	37.52	23.98	25.14	13.49	31.14	28.74	38.12	**AVG**	36.97
Relative Humidity Min (%)	7.01	10.74	18.66	8.62	7.84	2.12	3.67	1.52	0.31	2.52	1.87	3.77	**MIN**	0.31
Relative Humidity Max (%)	99.30	98.70	99.30	99.70	98.60	100.00	84.30	94.10	58.84	96.30	95.90	98.20	**MAX**	100.00
Total Precipitation (inch)	1.72	0.27	0.66	0.37	0.10	0.64	0.04	0.32	0.00	1.33	0.23	0.39	**TOTAL**	6.07
Soil Temperature Avg (deg F)	60.25	48.15	38.77	35.13	40.90	54.12	64.60	72.72	86.74	88.94	84.15	75.01	**AVG**	62.46
Soil Temperature Min (deg F)	36.66	29.60	24.09	17.97	28.45	32.47	37.29	46.18	57.81	61.95	62.15	45.22	**MIN**	17.97
Soil Temperature Max (deg F)	97.12	78.60	66.65	59.68	64.58	82.74	103.93	109.13	123.03	124.56	112.44	106.99	**MAX**	124.56
Soil Vol. Water Content Avg[1]	0.24	0.21	0.20	0.18	0.20	0.21	0.17	0.16	0.12	0.14	0.20	0.20	**AVG**	0.19

1 Soil Volumetric Water Content values are relative indicating changes through time.

Table 2A. Monthly and annual summary of meteorological observations at Plutonium Valley monitoring station #1 (south) for FY2013 (October 1, 2012, through September 30, 2013) (continued).

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	ANNUAL	VALUE
Soil Vol. Water Content Min[1]	0.19	0.19	0.17	0.13	0.18	0.19	0.15	0.14	0.11	0.10	0.15	0.16	**MIN**	0.10
Soil Vol. Water Content Max[1]	0.36	0.23	0.24	0.23	0.22	0.24	0.20	0.19	0.15	0.25	0.25	0.23	**MAX**	0.36
Solar Radiation Avg (ly)	11.07	7.65	4.77	6.99	10.85	14.27	17.24	17.26	19.14	14.59	15.49	13.29	**AVG**	12.72
Solar Radiation Max (ly)	77.59	61.55	42.41	58.53	75.34	82.41	96.38	92.07	101.12	86.38	86.64	89.74	**MAX**	101.12
Barometric P. Avg (in Hg)	25.86	25.93	25.84	25.97	25.89	25.85	25.77	25.79	25.76	25.83	25.85	25.79	**AVG**	25.84
Barometric P. Min (in Hg)	25.60	25.46	25.46	25.53	25.37	25.54	25.27	25.47	25.55	25.61	25.71	25.42	**MIN**	25.27
Barometric P. Max (in Hg)	26.14	26.18	26.15	26.26	26.21	26.25	26.09	26.26	25.98	25.99	25.99	26.01	**MAX**	26.26
PM_{10} Avg ($\mu g/m^3$)[2]	9.96	5.02	3.19	2.07	2.66	6.26	12.82	12.55	14.57	12.24	9.93	11.88	**AVG**	8.60
PM_{10} Max ($\mu g/m^3$)	154.43	71.18	35.05	72.91	66.17	72.25	275.19	117.92	212.28	283.53	146.17	170.86	**MAX**	283.53
$PM_{2.5}$ Avg ($\mu g/m^3$)[2]	2.52	1.69	0.99	0.56	0.85	2.60	4.61	3.79	3.37	3.52	2.35	3.06	**AVG**	2.49
$PM_{2.5}$ Max ($\mu g/m^3$)	38.70	11.91	8.81	23.37	9.95	19.56	75.98	41.32	42.42	84.62	25.37	60.49	**MAX**	84.62

1 Soil Volumetric Water Content values are relative indicating changes through time.

2 Reported PM_{10} and $PM_{2.5}$ values are estimated using optical particle sizing equipment rather than measurement devices specified in dust concentration regulations.

Table 2B. Monthly and annual summary of meteorological observations at Plutonium Valley monitoring station #1 (south) for FY2014 (October 1, 2013, through September 30, 2014).

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	ANNUAL	VALUE
Wind Speed Avg (mph)	4.92	4.10	4.49	4.46	4.41	6.37	6.84	7.38	6.35	5.80	5.17	5.04	**AVG**	5.44
Wind Speed Max (mph)	24.64	25.50	23.19	19.12	25.07	24.65	27.49	29.82	21.70	29.43	21.12	22.31	**MAX**	29.82
Wind Speed Gust (mph)	45.01	39.02	36.09	28.72	39.68	38.58	42.45	44.13	39.09	47.93	32.51	37.04	**MAX**	47.93
Air Temperature Avg (deg F)	53.06	44.99	35.88	42.47	42.82	49.71	57.27	66.76	77.08	82.54	75.33	72.28	**AVG**	58.35
Air Temperature Min (deg F)	23.89	23.59	4.44	18.16	14.16	24.22	26.32	35.82	42.79	54.12	50.58	38.80	**MIN**	4.44
Air Temperature Max (deg F)	81.28	75.69	65.57	69.44	72.39	74.01	82.63	94.42	102.70	105.40	99.48	95.65	**MAX**	105.40
Relative Humidity Avg (%)	36.82	49.72	47.79	33.73	42.67	36.90	25.53	21.15	12.82	28.80	36.09	32.50	**AVG**	33.71
Relative Humidity Min (%)	5.14	9.66	7.00	4.83	6.11	3.75	4.73	2.07	1.42	3.71	4.50	6.93	**MIN**	1.42
Relative Humidity Max (%)	97.00	94.70	89.40	97.80	96.70	98.10	89.40	97.70	41.83	86.60	99.60	84.60	**MAX**	99.60
Total Precipitation (inch)	0.60	0.85	0.09	0.11	0.78	0.18	0.11	0.43	0.00	0.66	1.86	0.06	**TOTAL**	5.73
Soil Temperature Avg (deg F)	56.57	46.65	35.79	41.27	44.44	53.11	63.30	72.98	84.98	88.84	80.86	79.07	**AVG**	62.32
Soil Temperature Min (deg F)	34.65	32.53	17.94	28.71	27.01	34.44	37.28	44.78	57.25	66.51	59.92	52.52	**MIN**	17.94
Soil Temperature Max (deg F)	88.45	73.71	58.80	62.01	70.43	83.14	94.17	108.60	120.70	121.00	109.90	108.2 0	**MAX**	121.00
Soil Vol. Water Content Avg[1]	0.19	0.19	0.18	0.19	0.19	0.21	0.19	0.19	0.14	0.16	0.24	0.18	**AVG**	0.19

1 Soil Volumetric Water Content values are relative indicating changes through time.

Table 2B. Monthly and annual summary of meteorological observations at Plutonium Valley monitoring station #1 (south) for FY2014 (October 1, 2013, through September 30, 2014) (continued).

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	ANNUAL	VALUE
Soil Vol. Water Content Min[1]	0.15	0.16	0.13	0.18	0.17	0.19	0.17	0.16	0.12	0.12	0.17	0.14	**MIN**	0.12
Soil Vol. Water Content Max1	0.22	0.26	0.22	0.20	0.23	0.24	0.22	0.23	0.18	0.19	0.36	0.22	**MAX**	0.36
Solar Radiation Avg (ly)	15.68	9.77	9.82	11.77	13.68	17.40	22.75	22.15	21.15	20.01	20.40	20.16	**AVG**	17.06
Solar Radiation Max (ly)	73.54	61.58	61.93	60.55	73.63	88.76	92.72	90.74	74.23	96.59	88.51	81.28	**MAX**	96.59
Barometric P. Avg (in Hg)	25.85	25.91	25.96	25.98	25.83	25.86	25.80	25.79	25.72	25.87	25.85	25.80	**AVG**	25.85
Barometric P. Min (in Hg)	25.30	25.51	25.33	25.50	25.40	25.44	25.37	25.42	25.52	25.69	25.64	25.58	**MIN**	25.30
Barometric P. Max (in Hg)	26.21	26.18	26.26	26.33	26.05	26.20	26.19	26.17	25.90	26.04	26.03	25.96	**MAX**	26.33
PM_{10} Avg ($\mu g/m^3$)[2]	3.61	2.01	0.93	1.29	2.15	3.09	5.58	7.17	11.10	7.36	5.95	5.97	**AVG**	4.68
PM_{10} Max ($\mu g/m^3$)	60.31	19.71	32.71	82.27	79.37	88.79	213.71	169.20	59.46	350.54	104.38	94.85	**MAX**	350.54
$PM_{2.5}$ Avg ($\mu g/m^3$)[2]	0.72	0.58	0.17	0.26	0.52	0.75	1.16	1.48	1.64	1.10	0.88	0.93	**AVG**	0.85
$PM_{2.5}$ Max ($\mu g/m^3$)	11.12	3.07	4.48	13.27	9.38	20.09	21.01	29.43	6.47	19.46	4.66	8.16	**MAX**	29.43

1 Soil Volumetric Water Content values are relative indicating changes through time.

2 Reported PM_{10} and $PM_{2.5}$ values are estimated using optical particle sizing equipment rather than measurement devices specified in dust concentration regulations.

Table 3A. Monthly and annual summary of meteorological observations at Plutonium Valley monitoring station #2 (north) for FY2013 (October 1, 2012, through September 30, 2013).

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	ANNUAL	VALUE
Wind Speed Avg (mph)	4.65	4.61	4.50	5.91	6.11	5.54	6.79	6.58	5.99	5.53	5.51	5.69	**AVG**	5.62
Wind Speed Max (mph)	24.34	24.46	21.99	22.21	22.45	23.38	23.34	22.03	22.11	22.78	23.34	27.62	**MAX**	27.62
Wind Speed Gust (mph)	37.12	36.75	34.56	31.86	34.49	36.09	35.58	33.61	35.15	42.09	38.14	51.88	**MAX**	51.88
Air Temperature Avg (deg F)	58.40	47.86	37.27	35.36	39.55	51.27	57.77	65.01	78.09	82.10	76.97	69.51	**AVG**	58.26
Air Temperature Min (deg F)	29.51	11.88	13.19	4.28	14.54	25.07	20.66	35.80	44.72	54.57	48.88	32.21	**MIN**	4.28
Air Temperature Max (deg F)	92.07	77.86	64.78	65.98	64.54	79.12	88.99	91.72	106.74	107.19	98.31	94.10	**MAX**	107.19
Relative Humidity Avg (%)	37.38	46.85	62.89	46.09	40.82	35.75	22.93	23.99	13.29	30.07	27.33	37.15	**AVG**	35.38
Relative Humidity Min (%)	6.31	10.13	17.79	8.27	7.14	1.92	3.69	1.34	0.00	2.46	1.90	3.69	**MIN**	0.00
Relative Humidity Max (%)	98.20	98.40	98.60	99.20	98.70	99.80	85.00	92.50	58.46	94.00	92.00	95.60	**MAX**	99.80
Total Precipitation (inch)	1.62	0.26	0.54	0.35	0.20	0.54	0.05	0.20	0.00	1.00	0.22	0.55	**TOTAL**	5.53
Soil Temperature Avg (deg F)	61.52	49.24	39.78	35.83	41.57	54.08	64.72	74.25	87.00	90.10	85.07	75.48	**AVG**	63.22
Soil Temperature Min (deg F)	41.56	33.63	29.95	24.58	32.77	36.73	45.45	52.20	65.05	65.10	67.69	50.95	**MIN**	24.58
Soil Temperature Max (deg F)	93.04	72.70	58.75	54.10	56.28	73.90	93.31	101.41	112.80	115.86	106.03	103.48	**MAX**	115.86
Soil Vol. Water Content Avg[1]	0.12	0.11	0.10	0.09	0.09	0.09	0.05	0.05	0.04	0.06	0.05	0.08	**AVG**	0.08

1 Soil Volumetric Water Content values are relative indicating changes through time.

Table 3A. Monthly and annual summary of meteorological observations at Plutonium Valley monitoring station #2 (north) for FY2013 (October 1, 2012, through September 30, 2013) (continued).

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	ANNUAL	VALUE
Soil Vol. Water Content Min[1]	0.07	0.09	0.06	0.05	0.08	0.06	0.04	0.04	0.04	0.04	0.04	0.06	**MIN**	0.04
Soil Vol. Water Content Max[1]	0.27	0.14	0.18	0.16	0.12	0.16	0.07	0.06	0.05	0.12	0.09	0.13	**MAX**	0.27
Solar Radiation Avg (ly)	11.95	9.00	6.44	8.28	11.19	13.43	17.68	19.37	21.07	18.33	17.61	13.68	**AVG**	14.00
Solar Radiation Max (ly)	73.62	65.78	64.22	61.29	73.97	89.05	101.90	100.78	102.24	104.31	97.16	86.90	**MAX**	104.31
Barometric P. Avg (in Hg)	26.54	26.61	26.51	26.65	26.56	26.52	26.44	26.46	26.43	26.50	26.53	26.47	**AVG**	26.52
Barometric P. Min (in Hg)	26.26	26.14	26.11	26.18	26.01	26.19	25.91	26.11	26.20	26.27	26.38	26.06	**MIN**	25.91
Barometric P. Max (in Hg)	26.84	26.88	26.84	26.97	26.91	26.96	26.78	26.96	26.67	26.69	26.68	26.70	**MAX**	26.97
PM_{10} Avg ($\mu g/m^3$)[2]	9.87	4.73	3.03	1.84	2.40	6.23	12.77	15.25	16.28	13.35	10.61	10.85	**AVG**	8.93
PM_{10} Max ($\mu g/m^3$)	169.37	45.56	39.88	72.05	96.05	129.43	298.94	109.39	134.43	346.67	235.47	184.16	**MAX**	346.67
$PM_{2.5}$ Avg ($\mu g/m^3$)[2]	2.41	1.57	0.93	0.51	0.77	2.51	4.48	6.72	3.45	3.54	2.35	2.79	**AVG**	2.67
$PM_{2.5}$ Max ($\mu g/m^3$)	37.53	11.71	9.37	19.62	14.96	28.06	70.12	45.13	25.87	70.35	32.45	69.40	**MAX**	70.35

1 Soil Volumetric Water Content values are relative indicating changes through time.

2 Reported PM_{10} and $PM_{2.5}$ values are estimated using optical particle sizing equipment rather than measurement devices specified in dust concentration regulations.

Table 3B. Monthly and annual summary of meteorological observations at Plutonium Valley monitoring station #2 (north) for FY2014 (October 1, 2013, through September 30, 2014).

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	ANNUAL	VALUE
Wind Speed Avg (mph)	5.07	4.54	4.95	4.98	4.69	6.51	6.77	7.14	6.24	5.70	5.36	5.09	**AVG**	5.59
Wind Speed Max (mph)	23.37	23.20	22.60	21.41	25.27	28.34	27.83	26.86	20.48	27.21	17.31	22.67	**MAX**	28.34
Wind Speed Gust (mph)	36.83	37.56	33.03	39.82	40.04	42.74	43.99	41.14	32.59	49.61	31.78	33.61	**MAX**	49.61
Air Temperature Avg (deg F)	53.52	46.06	36.61	43.29	43.28	49.93	57.05	66.31	76.52	82.47	75.39	72.04	**AVG**	58.54
Air Temperature Min (deg F)	24.77	23.95	6.33	18.14	13.17	24.63	27.91	34.91	44.63	54.43	51.75	38.95	**MIN**	6.33
Air Temperature Max (deg F)	81.23	76.05	65.89	67.69	71.89	73.72	82.06	94.37	102.40	104.20	95.59	95.32	**MAX**	104.20
Relative Humidity Avg (%)	35.18	46.47	43.90	30.91	40.04	34.60	24.58	20.89	12.66	27.53	31.13	32.13	**AVG**	31.67
Relative Humidity Min (%)	5.33	8.36	6.14	4.08	6.22	3.20	4.10	2.10	1.34	3.57	4.23	6.66	**MIN**	1.34
Relative Humidity Max (%)	96.10	93.60	88.30	96.90	96.30	97.10	89.10	97.10	39.23	83.10	88.10	85.50	**MAX**	97.10
Total Precipitation (inch)	0.61	0.66	0.12	0.09	0.70	0.16	0.06	0.46	0.00	0.64	0.28	0.06	**TOTAL**	3.84
Soil Temperature Avg (deg F)	57.72	47.71	37.00	42.09	45.06	53.91	63.85	73.77	85.76	89.87	81.72	78.95	**AVG**	63.12
Soil Temperature Min (deg F)	39.21	35.25	22.36	32.07	29.71	36.70	41.28	46.98	62.67	70.54	65.77	57.60	**MIN**	22.36
Soil Temperature Max (deg F)	82.09	66.51	53.17	54.79	63.21	74.70	85.33	101.10	113.60	113.80	100.90	99.00	**MAX**	113.80
Soil Vol. Water Content Avg[1]	0.08	0.08	0.08	0.07	0.07	0.09	0.07	0.07	0.05	0.06	0.10	0.06	**AVG**	0.07

1 Soil Volumetric Water Content values are relative indicating changes through time.

Table 3B. Monthly and annual summary of meteorological observations at Plutonium Valley monitoring station #2 (north) for FY2014 (October 1, 2013, through September 30, 2014) (continued).

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	ANNUAL	VALUE
Soil Vol. Water Content Min[1]	0.05	0.06	0.05	0.06	0.06	0.07	0.06	0.05	0.04	0.04	0.07	0.05	**MIN**	0.04
Soil Vol. Water Content Max[1]	0.16	0.16	0.10	0.08	0.18	0.17	0.09	0.16	0.06	0.09	0.13	0.08	**MAX**	0.18
Solar Radiation Avg (ly)	16.43	11.71	10.61	11.40	13.95	18.16	23.16	26.96	29.36	25.48	24.13	19.95	**AVG**	19.28
Solar Radiation Max (ly)	81.37	70.44	61.93	67.35	68.81	104.70	91.09	98.65	94.44	101.00	99.69	86.79	**MAX**	104.70
Barometric P. Avg (in Hg)	26.53	26.59	26.64	26.67	26.51	26.53	26.47	26.45	26.39	26.55	26.52	26.48	**AVG**	26.53
Barometric P. Min (in Hg)	25.95	26.16	25.98	26.15	26.04	26.09	26.01	26.06	26.17	26.35	26.31	26.24	**MIN**	25.95
Barometric P. Max (in Hg)	26.92	26.88	26.97	27.05	26.74	26.90	26.89	26.87	26.58	26.74	26.74	26.65	**MAX**	27.05
PM_{10} Avg ($\mu g/m^3$)[2]	3.41	2.06	0.97	1.31	2.04	2.96	4.76	6.16	9.16	6.58	4.80	4.49	**AVG**	4.06
PM_{10} Max ($\mu g/m^3$)	79.92	188.02	101.19	93.87	49.53	116.57	90.07	212.62	123.71	578.14	27.46	60.44	**MAX**	578.14
$PM_{2.5}$ Avg ($\mu g/m^3$)[2]	0.64	0.52	0.15	0.24	0.47	0.66	1.05	1.43	1.56	1.06	0.72	0.72	**AVG**	0.77
$PM_{2.5}$ Max ($\mu g/m_3$)	11.27	11.36	4.01	12.75	5.39	17.97	18.32	31.35	6.64	12.50	5.28	6.44	**MAX**	31.35

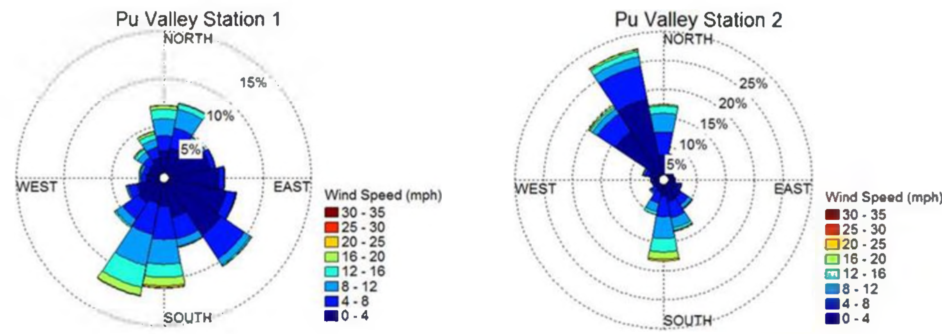
1 Soil Volumetric Water Content values are relative indicating changes through time.

2 Reported PM_{10} and $PM_{2.5}$ values are estimated using optical particle sizing equipment rather than measurement devices specified in dust concentration regulations.

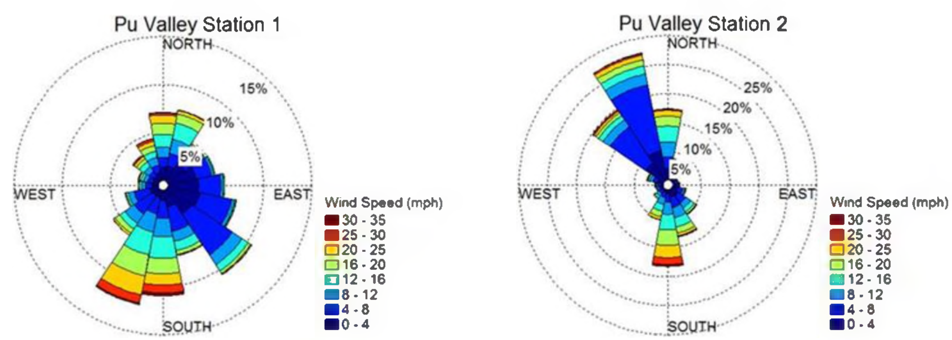
Temperature, relative humidity, and barometric pressure at the two stations track very similarly because of the relatively close proximity of the stations. Summer rainfall amounts exhibit the greatest difference because summer precipitation is associated with thunderstorms that have limited aerial extent and may produce measureable rainfall at one station but no rainfall at the other. Additionally, soil moisture content at the monitoring stations may differ because of the spatial distribution of rainfall and differences in the soil composition, surface slope, and local drainage patterns.

All wind conditions observed at the Plutonium Valley monitoring stations are summarized in the wind roses shown in Figures 5A and 5B for FY2013 and FY2014, respectively. The wind roses are based on the 10-minute average wind speed and direction, which are calculated from 3-second observations. The annual wind roses for each of the stations are quite similar. At station #1, southerly and northerly winds are most common. Winds from the south-southwest occur approximately 25 percent of the time during both years. East/west winds are the least common and occur only approximately five percent of the time. At station #2, northwest winds are dominant but southerly winds also occur with significant frequency. Wind roses for the two monitoring stations indicate that the south-southwest winds dominant at station #1 are secondary at station #2, and the northwesterly winds dominant at station #2 are secondary at station #1. The wind directions at the Plutonium Valley stations appear to be controlled by the local topography. The valley is approximately 8 miles long and ranges from less than 0.1 mile wide at the extreme north and south ends to approximately 2.5 miles across at the opening to Yucca Flat on the west. Station #1 is located near the west end of a line that marks the widest part of the valley, whereas station #2 is located toward the north end of the valley where the width is less than 0.8 miles. The long narrow valley fosters predominantly north-south oriented winds and precludes most of the east-west oriented winds. East-west winds are more common at station #1 than at station #2 because the valley is significantly wider at station #1 than at station #2. When considering only the winds in excess of 15 mph (Figures 6A and 6B), southerly winds are dominant at both stations #1 and #2.

The Plutonium Valley monitoring stations generally exhibit similar meteorological conditions, although station #2 is approximately 2.78 km (1.73 mi) north of and 25 m (82 ft) higher than station #1. However, both stations are sufficiently separated to illustrate the meteorological variability likely to be observed in southwestern desert climates. For example, the typical 10-minute wind direction at station #1 is from the south-southwest or east, but from the north-northwest at station #2, maximum and minimum soil temperatures are slightly more extreme at station #1. Additionally, the amount of precipitation received at station #1 was only 0.1 inch greater than at station #2, even though October 2013 produced the highest precipitation record at both stations (Tables 2 and 3).



Station #1 (South) 10-Minute Average Wind Speed	Station #2 (North) 10-Minute Average Wind Speed



Station #1 (South) 10-Minute Average Maximum Wind Speed Based on 3-Second Wind Gust Readings	Station #2 (North) 10-Minute Average Maximum Wind Speed Based on 3-Second Wind Gust Readings

Figure 5A. Wind roses representing 10-minute average (top) and 10-minute average maximum (bottom) wind speed and direction for all wind conditions observed at Plutonium Valley monitoring stations #1 (south) and #2 (north) during FY2013; 10-minute averages are calculated from 3-second observations.

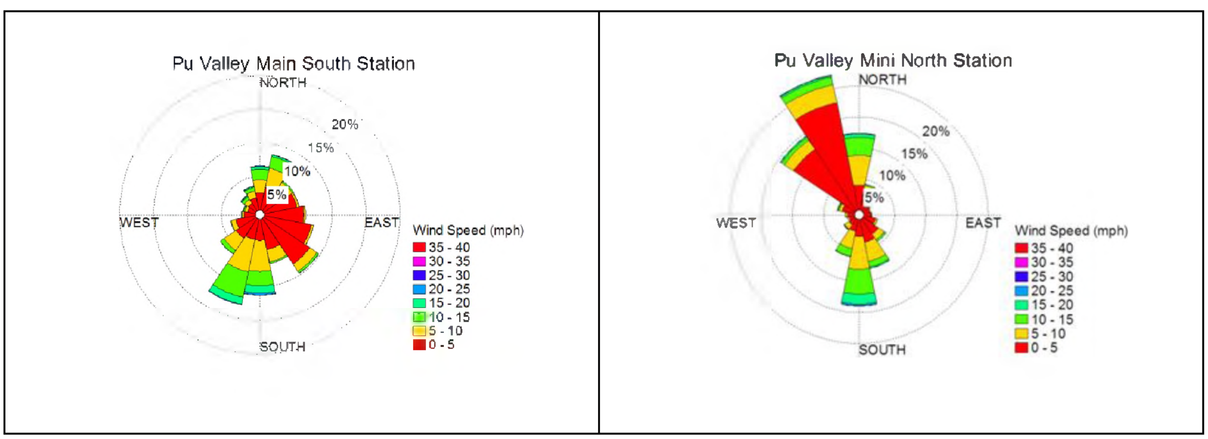
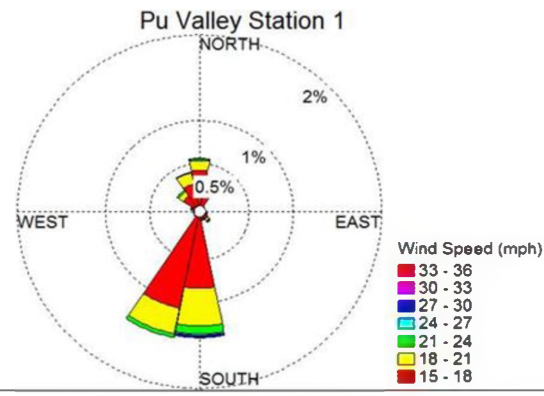
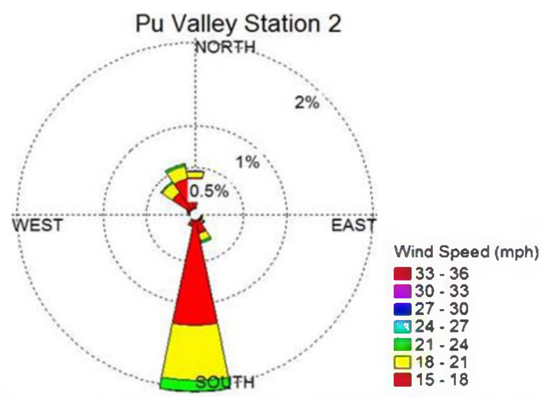


Figure 5B. Wind roses representing 10-minute average wind speed and direction for all wind conditions observed at stations #1 (left: southern station) and #2 (right: northern station) in Plutonium Valley during FY2014; 10-minute average wind speeds are calculated from 3-second observations.



Pu Valley #1 (South) Station Average 10-Minute Wind Speed > 15 mph



Pu Valley #2 (North) Station Average 10-Minute Wind Speed > 15 mph

Figure 6A. Wind roses representing wind speeds in excess of 15 mph observed at the Plutonium Valley meteorological stations in FY2013.

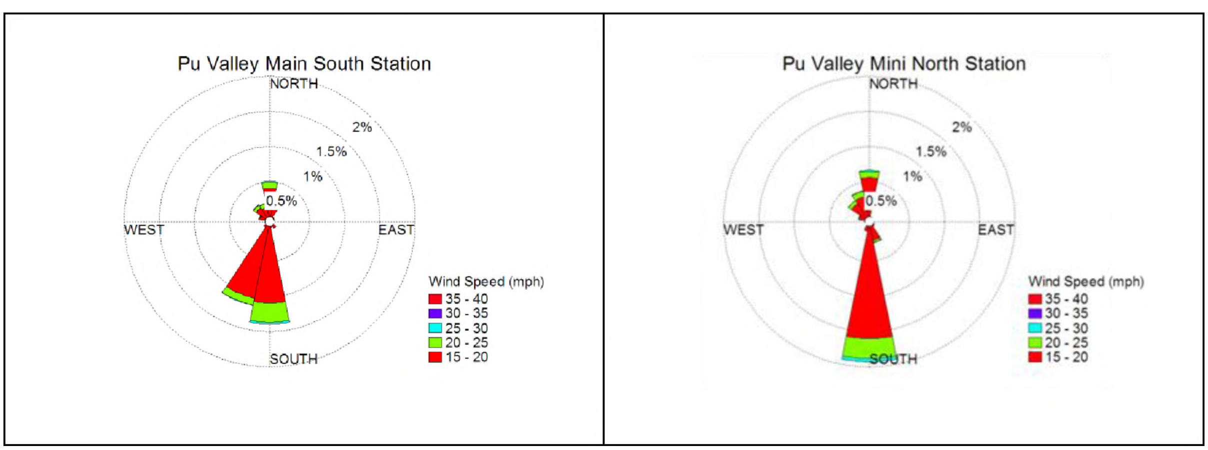


Figure 6B. Wind roses representing wind speeds in excess of 15 mph observed at the Plutonium Valley meteorological stations in FY2014.

Channel Runoff Observations

The top graphs in Figures 7A and 7B display the water depth reported by the pressure transducer for FY2013 and FY2014, respectively. Variability of the depth indicated by the pressure transducer in early FY2013 (October 1, 2012, through January 3, 2013) is believed to be because of the failure to include a temperature correction in the programming function that calculates water depth from the pressure observation. The temperature correction was added to the water depth calculation on January 3, 2013. Reported water depth values became very erratic on July 22, 2013, indicating the failure of the transducer. The reason for sensor failure is unknown. The pressure transducer was replaced on July 15, 2014.

Although it is not possible to determine the actual depth of water (because there was no temperature correction applied in the calculation), the pressure transducer indicates water in the channel in association with a precipitation event on December 13, 2012. This precipitation event, preceded by 0.02 inches of rainfall between 0300 hours and 0600 hours earlier in the day, lasted approximately 3 hours (1200 hours to 1500 hours) and produced a total of approximately 1.5 inches of rainfall. The maximum 10-minute rainfall, 0.05 inches, occurred at about 1400 hours which is when the pressure transducer showed its initial response. There was no indication of water in the channel between January 3, 2013, and July 22, 2013. After replacing the pressure transducer on July 15, 2014, water was reported in the channel on two occasions: the early afternoon of August 3, 2014, and again just before noon on August 4, 2014. Both of these events are associated with measured precipitation and the reported water depth in the channel was 2 inches to 2.5 inches for both. On August 3, water in the channel was reported approximately 30 minutes after the precipitation event peaked at 0.22 inches. On August 4, rainfall began at approximately 0200 hours and continued sporadically throughout the morning. Water was reported in the channel at approximately 1000 hours, about 30 minutes after the maximum 10-minute precipitation, 0.12 inches, occurred. However, another shower at approximately 1300 hours did not result in water in the channel.

The bottom graphs in Figures 7A and 7B display the distance from the photoacoustic sensor to the reflecting surface. The initial sensor was installed approximately 4.4 feet above the dry channel bed. The replacement sensor—installed on July 15, 2014—was approximately 1.74 meters (5.71 feet) above the dry channel bed. (Note that in these graphs the units of distance to the reflecting surface are incorrectly labeled as inches. They should be labeled as feet for values dated before July 15, 2014, and as meters after that date.)

There were three occasions during FY2013 when the photoacoustic sensor indicated a reflecting surface above the dry channel bed. On July 21, 2013, the reflecting surface was 9.6 inches above the dry channel bed (3.6 feet below the photoacoustic sensor). This elevated reflecting surface was recorded approximately 12 hours after 0.09 inches of precipitation was recorded at the south (#1) monitoring station. The July 21 elevated reflecting surface lasted approximately two hours. The reflecting surface rose approximately 4.8 inches above the dry channel bed (4.0 feet below the sensor) on September 5 and 9, 2013. Each of these events occurred approximately 14 hours after precipitation events of 0.09 inches and 0.12 inches were recorded at the south (#1) monitoring station.

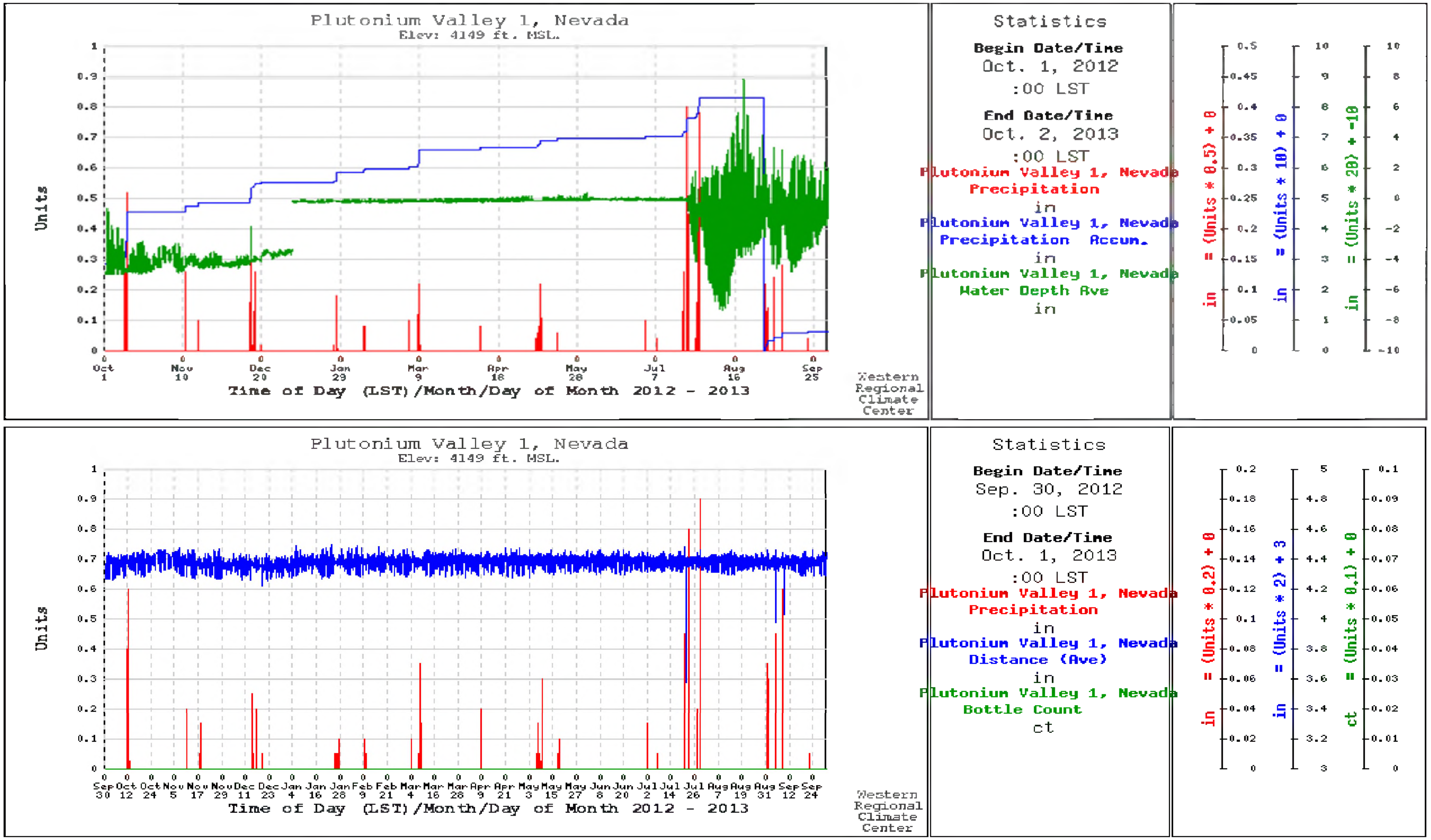


Figure 7A. Depth of water (top) above the pressure transducer and average distance of the reflection surface (bottom) under the photoacoustic sensor and bottle count. No bottle count indicates that the ISCO sample system was not activated during FY2013. The units of distance to the reflecting surface are incorrectly shown as inches; they should be feet for values dated before July 15, 2014, and as meters after that date.

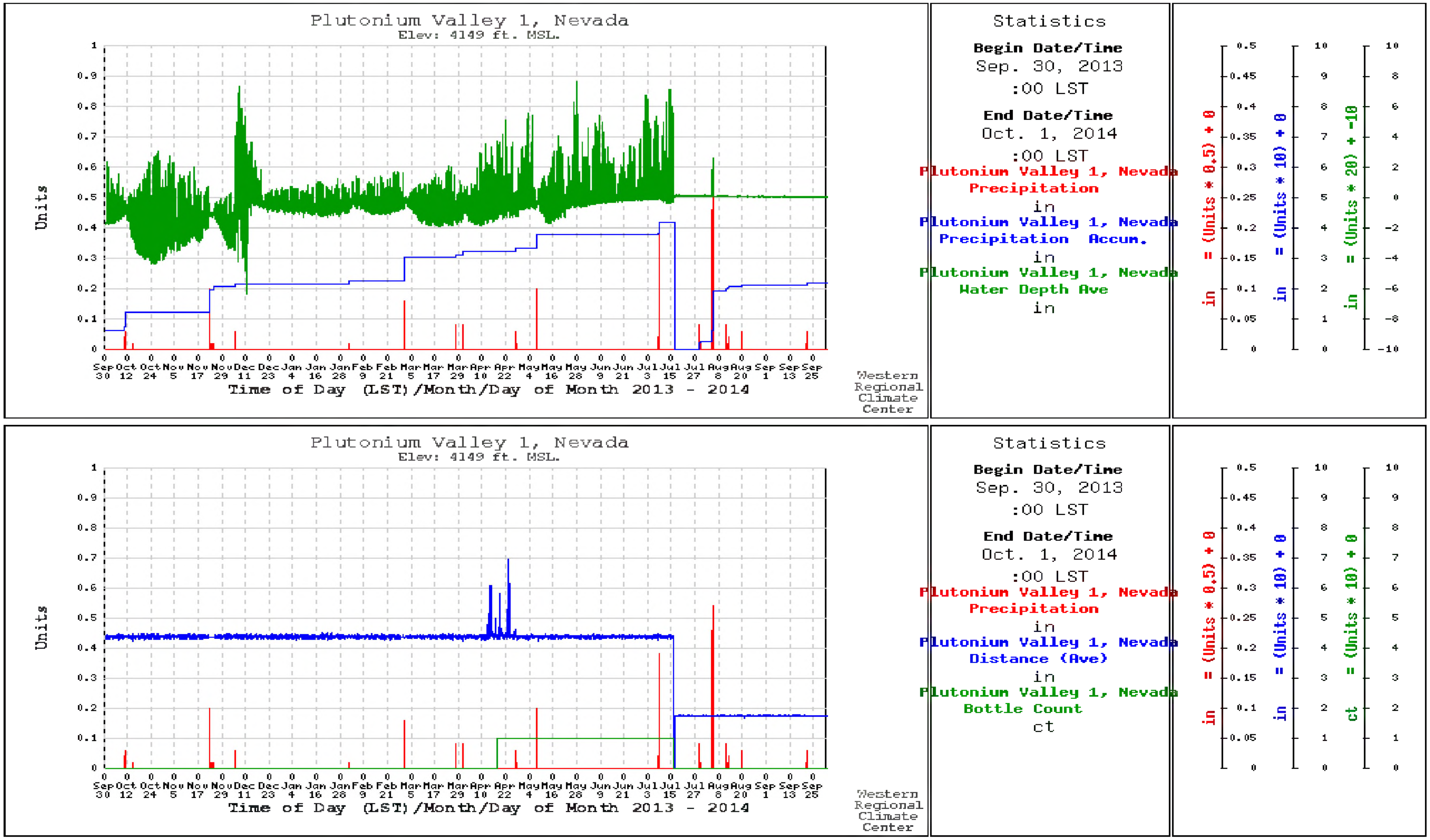


Figure 7B. Depth of water (top) above the pressure transducer, average distance of reflection surface (bottom) under the photoacoustic sensor, and bottle count. Bottle count change at 1500 April 16, 2016, indicates the ISCO sample system was triggered during FY2014. The units of distance to the reflecting surface are incorrectly shown as inches; they should be feet for values dated before July 15, 2014, and as meters after that date.

There were no occasions during FY2014 when the photoacoustic sensor indicated an elevated reflecting surface. However, between April 11 and 24, 2014, there were a number of times when the photoacoustic sensor indicated that the reflecting surface was farther from the sensor than the dry channel bed. Because this is physically impossible, these values are probably indicative of sensor failure.

Several of the precipitation events observed during FY2013 and FY2014 seemed to produce water in the drainage channel as suggested primarily by the pressure transducer. However, there was no incident when the water depth was sufficient to turn on the ISCO sampler.

Ephemeral Transport Sample Collection

Bed-load samples were collected on March 12, 2014, and new bed-load sample nets were installed. As bed-load samples had not been collected since installation of the sample nets in 2011, the samples represent an integration of all bed-load transport through the channel between 2011 and 2014.

The samples were submitted for grain size and radionuclide analysis. After the particle size analysis the samples were combined into three size fractions: < 63 µm, 63 µm to 250, and > 250 µm. Material from the two smaller size fractions was analyzed to determine Am-241, plutonium-238 (Pu-238), and plutonium 239-240 (Pu-239, -240) concentrations. Material larger than 250 µm was not analyzed for radionuclide content. The results of these analyses are shown in Table 4. Sample PV33612 was collected approximately two meters upstream of sample PV33613. Both samples were collected in a net trap installed on the thalweg of the channel.

Table 4. Particle size distribution and radionuclide concentrations for channel bed-load samples collected at the ISCO sampler station in Plutonium Valley on March 12, 2014.

Sample	**Particle Size Distribution**			**< 63 µm**			**63 µm to 250 µm**		
	< 63 µm	**63 µm to 250 µm**	**>250 µm**	**Am-241**	**Pu-238**	**Pu-239/240**	**Am-241**	**Pu-238**	**Pu-239/240**
	%	**%**	**%**	**pCi/g**	**pCi/g**	**pCi/g**	**pCi/g**	**pCi/g**	**pCi/g**
PV36612	7.08	18.92	74	32.8	3.4	1.82	3.85	0.19	16.4
PV36613	33.49	43.41	23.1	63.7	7.27	436	16.5	1.01	61

The particle size distributions of the two samples were significantly different. In sample PV33612, the > 250 µm size fraction was the largest at 74 percent of the sample. However, in sample PV33613, the 63 µm to 250 µm size fraction was the largest (43 percent) and the two smaller size fractions combined represented approximately 74 percent of the sample. The upstream sample net may have collected most of the larger bed-load material, which resulted in the downstream bag having a smaller proportion of the > 250 µm material.

To determine if radionuclides are more likely associated with the smaller or larger particle sizes the radionuclide concentrations observed for the <63 µm size fraction and the 63 µm to 250 µm size fraction were compared. The Am-241 and Pu-238 concentrations were consistently higher for the <63 µm size fraction than for the 63 µm to 250 µm size fraction in both samples. However, the Pu-239/240 concentration was higher for the 63 µm to 250 µm size fraction in the upstream sample (PV33612) and was higher for the < 63 µm size fraction in the downstream sample (PV33613). Even with this variation, it appears that the higher radionuclide concentrations are associated with the smaller particle size fraction.

The nonparametric Wilcoxon signed-ranks test (Helsel and Hirsch, 1992) was used to assess, statistically, the likelihood that the < 63 µm and 63 µm to 250 µm size fractions will have different radionuclide concentrations. The radionuclide data was arranged in matched pairs representing the grain-size fractions for this test. The null hypothesis for this test is that the two size fractions have radionuclide concentrations from the same population, that is, they will have similar, statistically indistinguishable, concentrations. The test results indicate that the probability the two size fractions come from the same population of radionuclide concentration was very low, 0.078 percent. This low probability is strong evidence the two size fractions represent different populations of radionuclide concentration. Thus, substantiating the initial conclusion that higher radionuclide concentrations are associated with the smaller particle size fraction.

The ISCO automated sampler is turned on when water is determined to be present in the channel at a specified depth. Water presence is determined by a pressure transducer that is calibrated to report water depth above the transducer and a photoacoustic sensor that is calibrated to report distance from the sensor to the channel bed or water surface. A wetness plate that indicates the presence of water was added to the detection system on July 15, 2014. It was in place for only 10 weeks at the end of FY2014. Each of these sensors must indicate the presence of water in the channel at a specific depth in six consecutive observations collected at 10-second intervals in order to turn on the ISCO. This process is described in additional detail in Appendix F.

During FY2013 and FY2014, the ISCO sampler turned on only once on April 16, 2014. Figure 7B shows that there were no precipitation events on this date. When personnel arrived on-site to retrieve the sample and reset the ISCO command program on July 15, 2014, none of the collection bottles contained water. It appears that erroneous output from the pressure transducer and the photoacoustic depth sensor, triggered the ISCO sampler (Appendix F). To prevent erroneous triggering of the ISCO sampler, the wetness plate was added as a third check. There were no other occasions when the pressure transducer and photoacoustic sensor, or the pressure transducer, photoacoustic sensor, and wetness plate, reported values of water in the channel that would turn on the ISCO sampler. Therefore, no water samples were collected and no suspended sediment analyses were performed during FY2013 and FY2014.

Soil Water Content

Time domain reflectometry (TDR) values were reviewed to assess the soil response to precipitation. The TDR instruments were not calibrated for the site specific soil conditions. Therefore, they do not measure the absolute soil moisture content. The TDR observations will indicate the relative differences in soil moisture over time at each station individually. Changes in soil volumetric water content during FY2013 and FY2014 are shown in Figures 8A and 8B, respectively. At station #1, soil moisture content ranged from a minimum of approximately 10 percent to approximately 35 percent. At station #2, the minimum soil moisture content each year was approximately 4 percent and the maximum was approximately 26 and 16 percent in FY2013 and FY2014, respectively. These observations

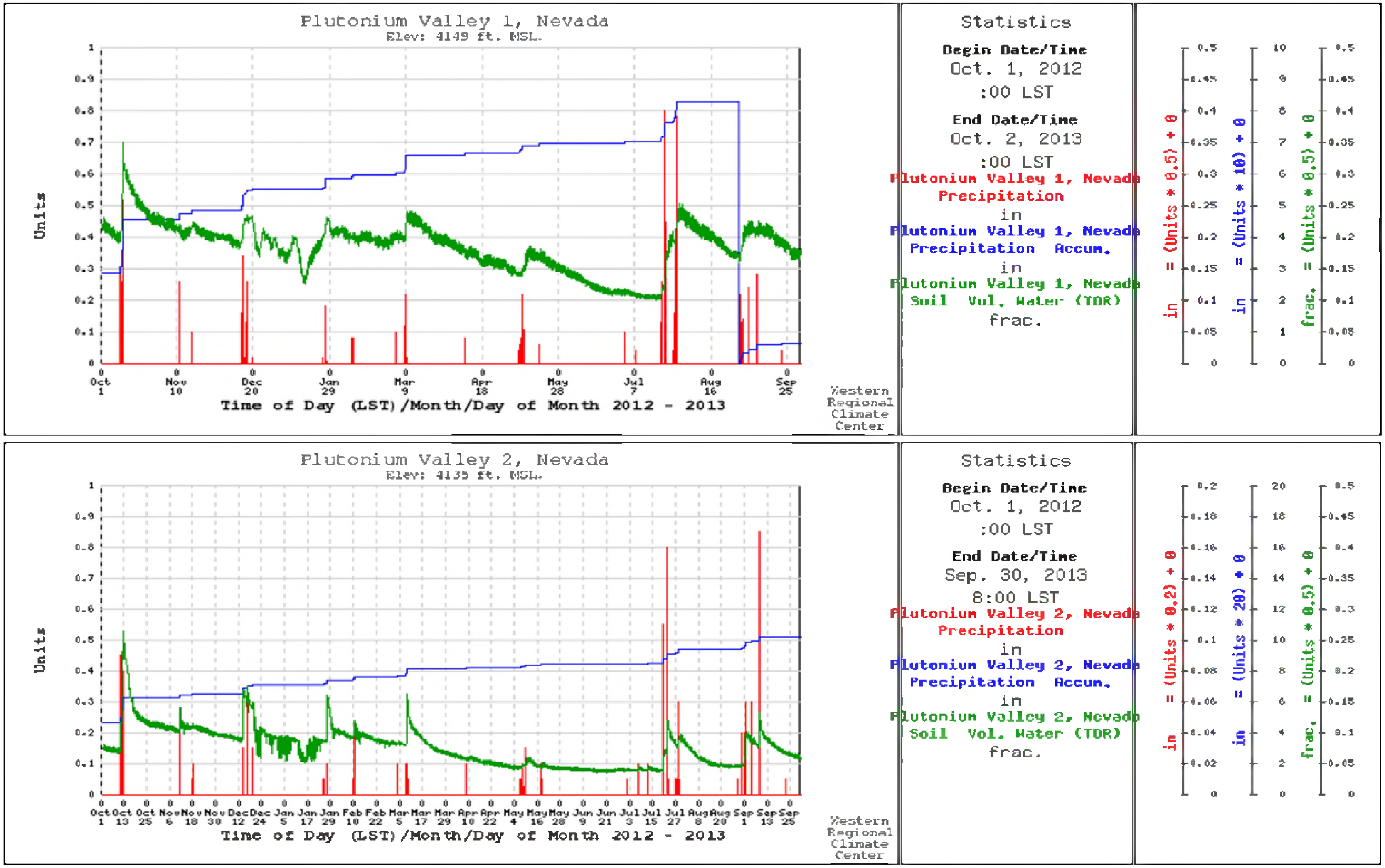


Figure 8A. Soil moisture (volumetric water content) observations show changes that reflect precipitation events at Plutonium Valley stations #1 (top) and #2 (bottom) for FY2013.

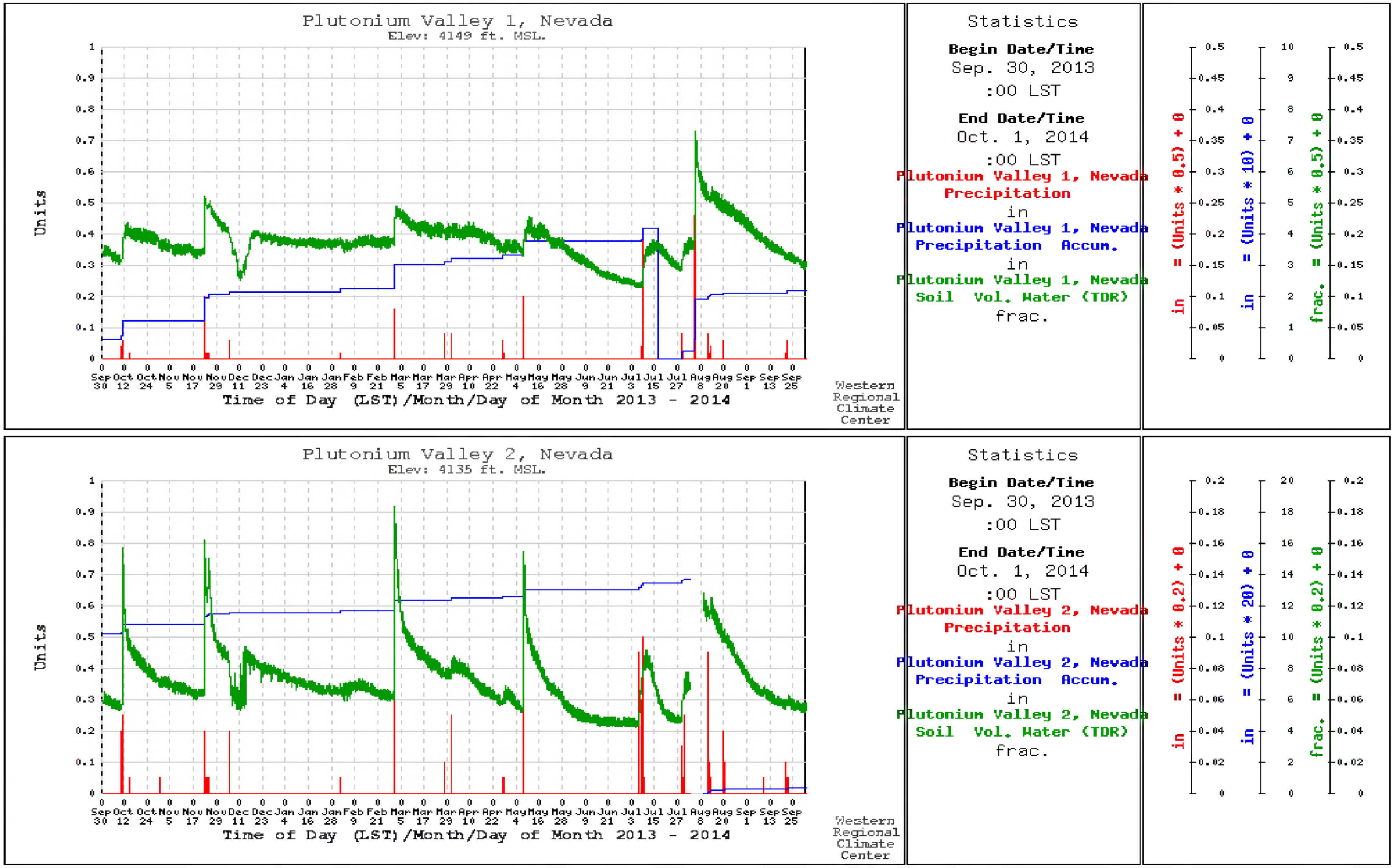


Figure 8B. Soil moisture (volumetric water content) observations show changes that reflect precipitation events at Plutonium Valley stations #1 (top) and #2 (bottom) for FY2014.

indicate the differences in local soil conditions at each station. The minimum moisture content occurs at both stations in the late summer, July and August, whereas the maximum moisture content may occur in the late summer or early fall in response to a thunderstorm occurrence. In general, soil moisture increases noticeably only if the daily total precipitation exceeds approximately 0.04 inches and the soil moisture response appears to be proportional to the magnitude of precipitation. Precipitation amounts of less than 0.04 inches do not produce a notable change in the measured moisture content.

Aeolian Transport Observations

Because plutonium tends to bind to smaller-sized soil particles (Shinn *et al.*, 1993), it is important to assess the prospects of significant aeolian (wind-borne) transport of sediments from the CA. Wind speeds need to exceed a certain threshold below which very little aeolian transport occurs. This threshold depends on variables such as soil crust strength, extent of soil disturbance, soil moisture, and vegetation cover.

Generally, winds above 15 mph are required for wind erosion to produce elevated PM_{10} (particulate matter with an aerodynamic radius of less than 10 μm) concentration in the air. The concentration of PM_{10} is an indicator of small-sized particles that are suspended in air and can be easily inhaled in the human respiratory system. Met One Particle Profilers (Model 212) are located at both meteorological stations to monitor airborne particle sizes. The counts for particles in eight size ranges between 0.5 to 10 μm are reported every minute and are subsequently averaged and recorded every 10 minutes. The particle counts are converted to a PM_{10} mass concentration in $\mu g/m^3$ (micrograms per cubic meter). This conversion results in an estimate of PM_{10} that is useful for understanding dust concentrations in the context of other PM_{10} measurements in other locations, but this estimate is not considered accurate enough for regulatory purposes (i.e., for use by EPA to regulate air quality levels).

Wind speeds and associated dust concentrations observed at the Plutonium Valley monitoring stations are summarized by 5 mph wind-speed classes in Tables 5A and 5B for FY2013 and FY2014, respectively. Light winds (0 to 5 mph) are the most common. They occurred 57 percent of the time at the south station and 55 percent of the time at the north station during FY2013 and 59 percent of the time at the south station and 57 percent of the time at the north station in FY2014. Wind speeds in excess of 15 mph occurred less than 5 percent of the time (less than approximately 430 hours) and wind speeds in excess of 20 mph occurred less than 1 percent of the time (less than approximately 80 hours) at either station during either year. Figure 9 shows the frequency of occurrence for each wind-speed class, which is similar at both stations.

The PM_{10} concentrations generally increase as wind speed increases but remain fairly low at wind speeds below approximately 15-20 mph. Winds are below 20 mph 99 percent of the time. During FY2013, the PM_{10} concentrations associated with the highest wind-speed class were approximately 40 $\mu g/m^3$ at both stations (Table 5A). During FY2014, the maximum PM_{10} concentration observed at station #2 was 46 $\mu g/m^3$ (Table 5B), which was slightly higher than observed in FY2013. The PM_{10} at station #1 was 82.9 $\mu g/m^3$, which was almost twice the concentration observed in FY2013. However, high wind and corresponding high PM_{10} events are relatively rare and generally last for only short periods of time as is evident from the data in Table 5A and 5B.

Table 5A. The average $PM_{2.5}$ and PM_{10} concentrations by wind-speed class at both meteorological stations in Plutonium Valley during FY2103.

Wind Speed Class (mph)	Duration (hours)	FY13 Pu Valley South Wind Distribution Frequency (%)	FY13 Cumulative Frequency (%)	Average Wind Speed (mph)	FY13 Pu Valley South PM_{10} (µg/m^3)	FY13 Pu Valley South $PM_{2.5}$ (µg/m^3)	FY13 Pu Valley South Ratio PM_{10} (µg/m^3) to $PM_{2.5}$ (µg/m^3)
Station #1 (south)							
5	4683.67	56.714%	56.714%	2.71	7.63	2.27	3.36
10	2157.00	26.119%	82.834%	7.21	8.67	2.62	3.31
15	1030.50	12.478%	95.312%	11.82	10.44	2.93	3.56
20	344.83	4.176%	99.487%	16.56	17.81	4.27	4.17
25	38.67	0.468%	99.956%	20.20	28.21	5.79	4.87
30	3.67	0.044%	100.000%	26.49	41.17	5.65	7.29
Station #2 (north)							
5	4632.83	55.504%	55.504%	2.77	8.06	2.46	3.28
10	2350.00	28.154%	83.658%	7.22	8.95	2.79	3.21
15	1017.33	12.188%	95.847%	12.00	10.63	3.13	3.39
20	304.83	3.652%	99.499%	16.97	18.50	4.52	4.09
25	41.67	0.499%	99.998%	21.15	37.83	7.55	5.01
30	0.17	0.002%	100.000%	27.62	23.85	6.76	3.53

Table 5B. The average $PM_{2.5}$ and PM_{10} concentrations by wind-speed class at both meteorological stations in Plutonium Valley during FY2014.

Wind Speed Class (mph)	Duration (hours)	FY14 Pu Valley South Wind Distribution Frequency (%)	Cumulative Frequency (%)	Average Wind Speed (mph)	FY14 Pu Valley South PM_{10} (µg/m^3)	FY14 Pu Valley South $PM_{2.5}$ (µg/m^3)	FY14 Pu Valley South Ratio PM_{10} (µg/m^3) to $PM_{2.5}$ (µg/m^3)
Station #1 (south)							
5	5129.17	59.340%	59.340%	2.56	3.69	0.72	5.16
10	2139.83	24.756%	84.096%	7.28	4.93	0.88	5.62
15	1033.33	11.955%	96.051%	12.07	6.51	1.13	5.77
20	283.00	3.274%	99.325%	16.86	10.68	1.71	6.24
25	53.33	0.617%	99.942%	21.65	19.73	2.50	7.88
30	5.00	0.058%	100.000%	26.35	82.91	8.06	10.29
Station #2 (north)							
5	4869.00	57.460%	57.460%	2.72	3.45	0.68	5.06
10	2300.50	27.149%	84.609%	7.27	3.81	0.73	5.21
15	993.17	11.721%	96.330%	12.05	5.29	1.01	5.25
20	259.00	3.057%	99.386%	16.87	8.91	1.43	6.23
25	46.17	0.545%	99.931%	21.64	20.16	2.71	7.44
30	5.83	0.069%	100.000%	26.28	46.07	4.83	9.54

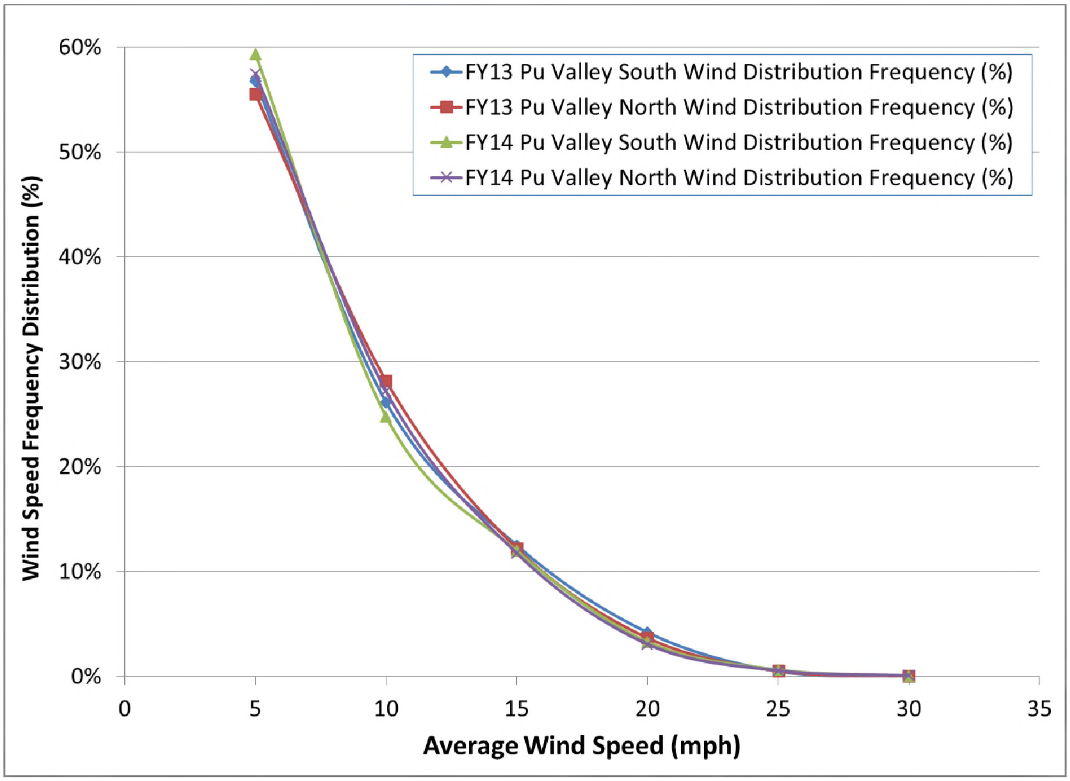


Figure 9. Wind-speed frequency by wind-speed class for the Plutonium Valley stations #1 (blue and green lines) and #2 (red and purple lines) during FY2013 and FY2014.

Figure 10 shows PM_{10} concentration increase nonlinearly in response to increases in wind speed. The two monitoring stations show similar trends and values for average PM_{10} concentrations. The dust values are slightly higher at both stations for FY2013 than for FY2014 for wind-speed classes below 25 mph. One interpretation of this is that regional conditions during FY2014 were less favorable for dust emissions than in FY2013. This could be a result of soil crusting, soil moisture, or vegetation differences between the two years.

The PM_{10} concentrations at the #1 and #2 monitoring stations are nearly identical during each year, and the PM_{10} concentrations at the highest wind-speed class are inconsistent with the dust conditions for the lower wind-speed classes. In both FY2013 and FY2014, station #2 recorded higher concentrations of PM_{10} with wind speeds above 20 mph than station #1. In FY2014, this difference was substantial. It is important to note that there are comparatively few data points at the higher wind speeds so that the PM_{10} averages are more prone to large variability. Moreover, since the distribution of wind speeds is slightly different between stations #1 and #2, the comparison of PM_{10} concentrations is not for the same periods of time for the two stations. For these reasons, relatively large differences between the two stations are more likely to appear at higher wind speeds.

The PM_{10} "roses" for both Plutonium Valley monitoring stations are shown in Figures 11A and 11B for FY2013 and FY2014, respectively. This type of figure is similar to a wind rose except that the PM_{10} rose illustrates the frequency of PM_{10} concentration instead of wind speed for specific wind directions. Higher PM_{10} concentrations occur with greater frequency in association with the north and south wind directions. The orientation of

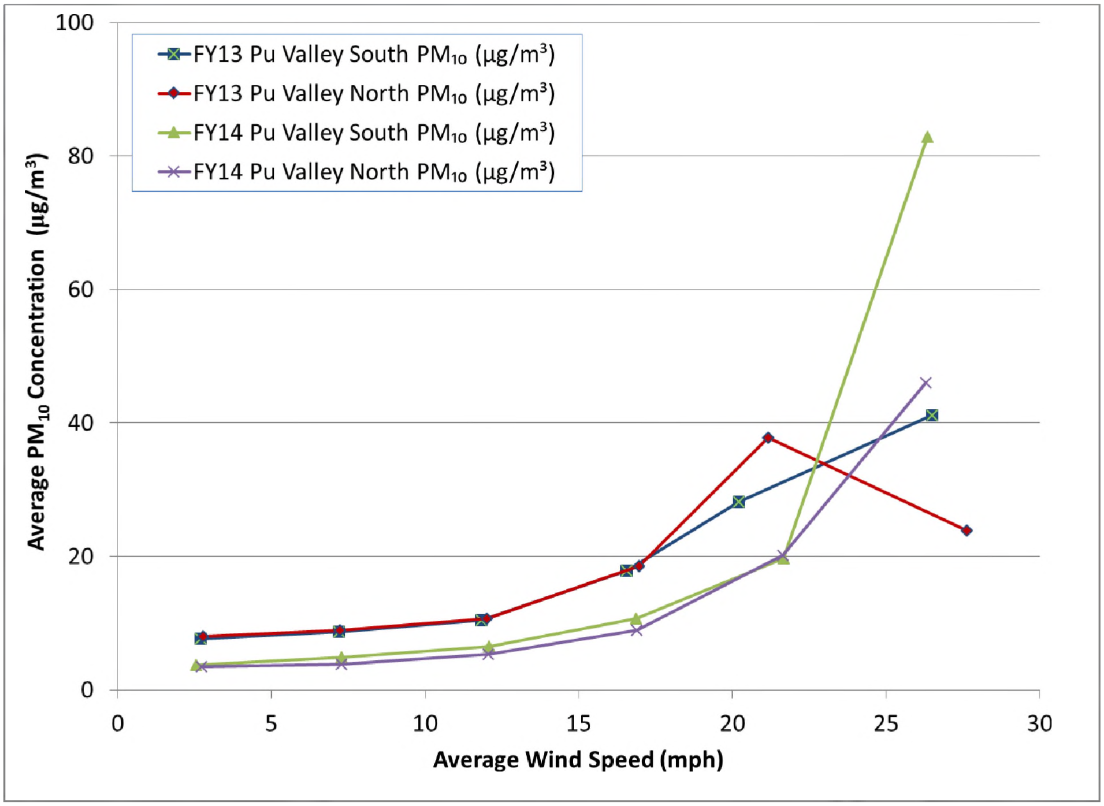
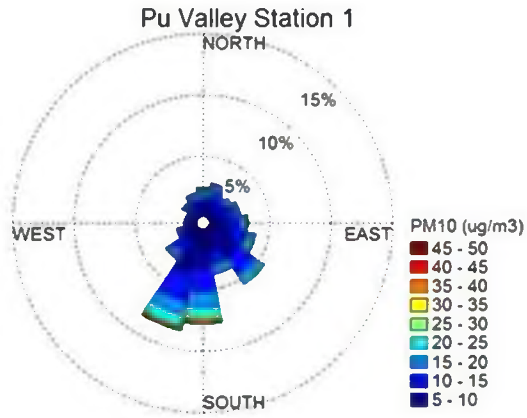
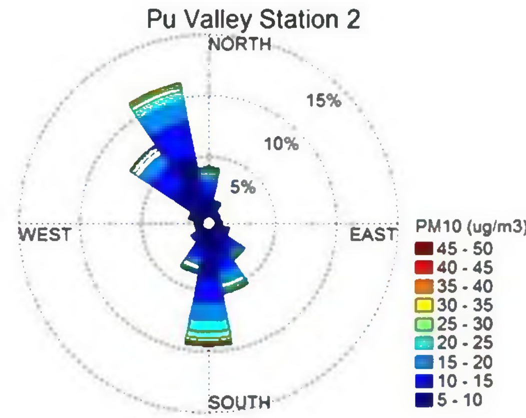


Figure 10. Plotting PM_{10} concentration against the average wind speed for each wind-speed class reveals that the PM_{10} concentrations increase approximately exponentially with increasing wind speed.

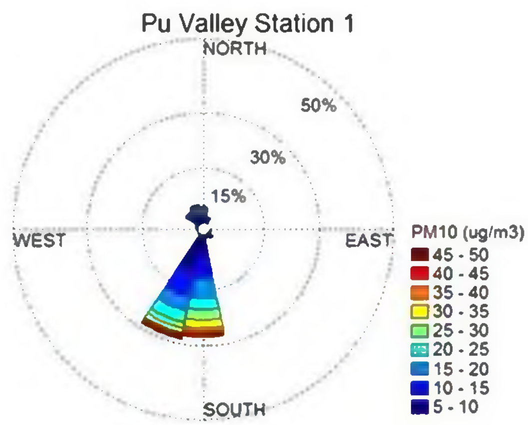
the PM_{10} concentration frequency is similar to the orientation of wind speeds (Figures 5A, 5B, 6A, and 6B). Both the higher wind speeds and higher PM_{10} concentrations are associated with the southerly wind direction. Although they occur less frequently, there are substantial dust concentrations associated with the infrequent, lower-speed easterly winds. At both meteorological monitoring stations in Plutonium Valley, PM_{10} concentrations are fairly low (below 10 µg/m^3) 80 to 85 percent of the time, which indicates relatively stable surface conditions and approximates natural background levels for PM_{10} concentration.

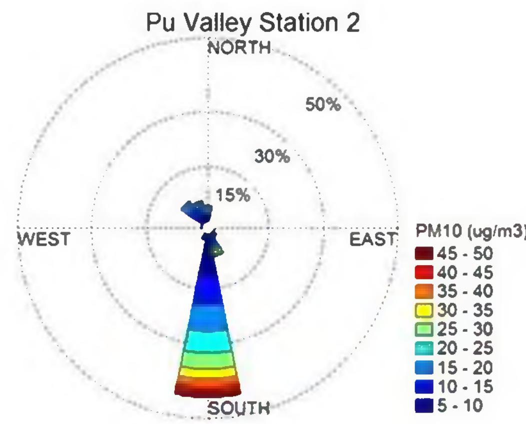
Figures 11A and 11B also illustrate the PM_{10} concentrations associated with wind speeds in excess of 15 mph. At higher wind speeds, there is a greater potential for higher PM_{10} concentrations. At both meteorological monitoring stations in Plutonium Valley, when the wind speed exceeds 15 mph, the PM_{10} concentrations are significantly greater than when wind speeds are less than 15 mph. The PM_{10} concentrations range from 25 µg/m^3 to 60 µg/m^3 when wind speeds exceed 15 mph. For reference, the Environmental Protection Agency (EPA) standard for airborne PM10 particulate is a maximum of 150 µg/m3 averaged over a 24 hour period, which is shown on the EPA's website (http://www.epa.gov/air/criteria.html). This standard is for typical urban and rural aerosols and does not account for any potential radionuclide contamination.





Met. Station #1 (South) Average 10-Minute PM_{10}	Met. Station #2 (North) Average 10-Minute PM_{10}





Met. Station #1 (South) Avg. Hourly PM_{10} for Wind Speeds > 15 mph	Met. Station #2 (North) Avg. Hourly PM_{10} for Wind Speeds > 15 mph

Figure 11A. PM_{10} rose diagrams that show the distribution of PM_{10} for all 10-minute average wind speeds (top) and for 10-minute average wind speeds greater than 15 mph (bottom) at stations #1 and #2 during FY2013.

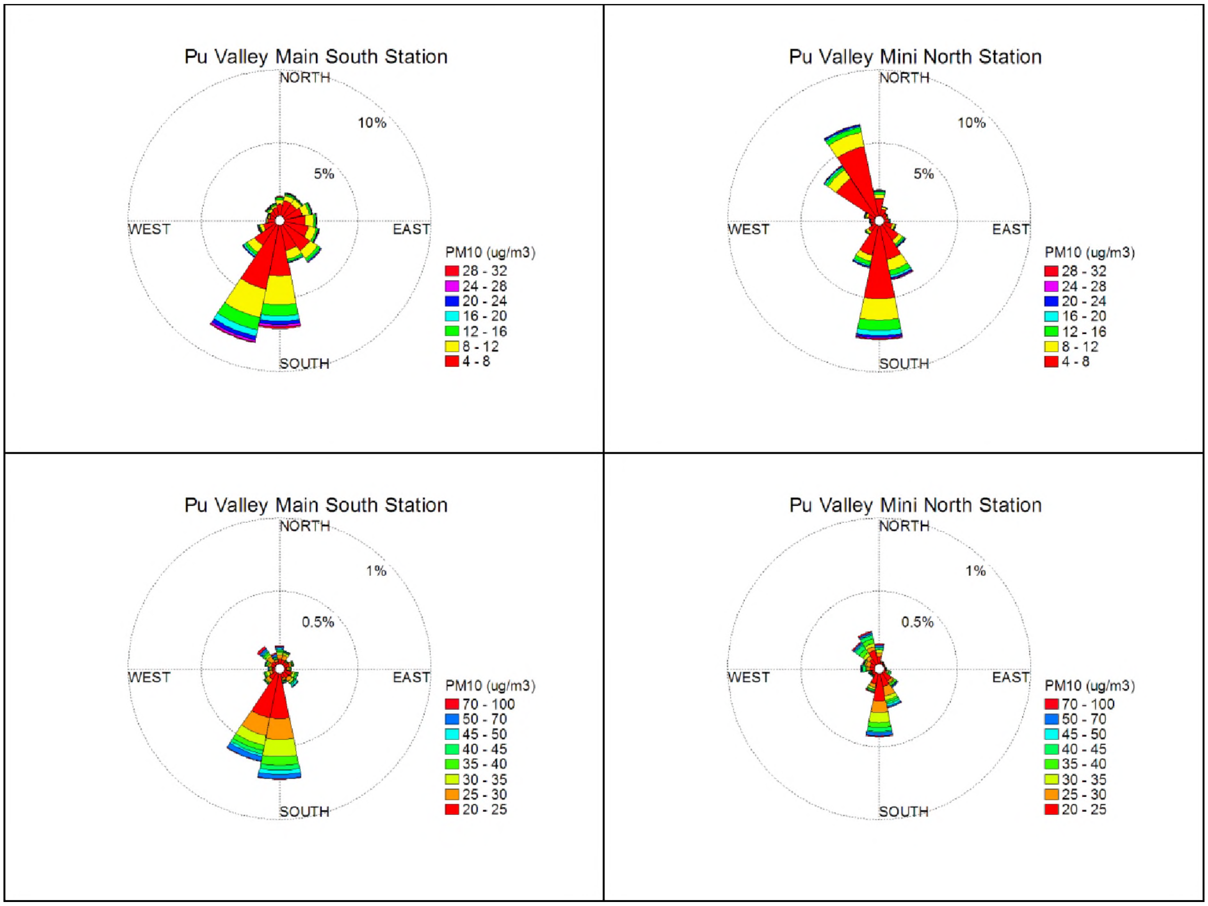


Figure 11B. PM_{10} rose diagrams that show the distribution of PM_{10} for all 10-minute average wind speeds (top) and 10-minute average wind speeds greater than 15 mph (bottom) at stations #1 and #2 during FY2014.

PM_{10} to $PM_{2.5}$ Ratio: Source Proximity for Observed Dust Conditions

The $PM_{2.5}$ fraction of the FY2014 airborne dust was analyzed in a manner similar to the PM_{10} analyses described above. The $PM_{2.5}$ dust concentration is associated with wind-speed classes in Tables 5A and 5B. Figure 12 shows the relationship between $PM_{2.5}$ concentration and average wind-speed class for FY2013 and FY2014. The $PM_{2.5}$ dust concentration also exhibits an approximately exponential relationship with wind speed similar to the PM_{10} dust (Figure 10). The $PM_{2.5}$ concentrations were higher during FY2013 than they were during FY2014 for wind speeds below 25 mph. The difference in $PM_{2.5}$ concentrations between the north and south stations during each of the two years were negligible for wind speeds below 20 mph. At wind speeds above 20 mph, the north station recorded elevated $PM_{2.5}$ concentrations relative to the south station in FY2013, whereas in FY2014, the south stations recorded the higher dust concentrations at these wind speeds.

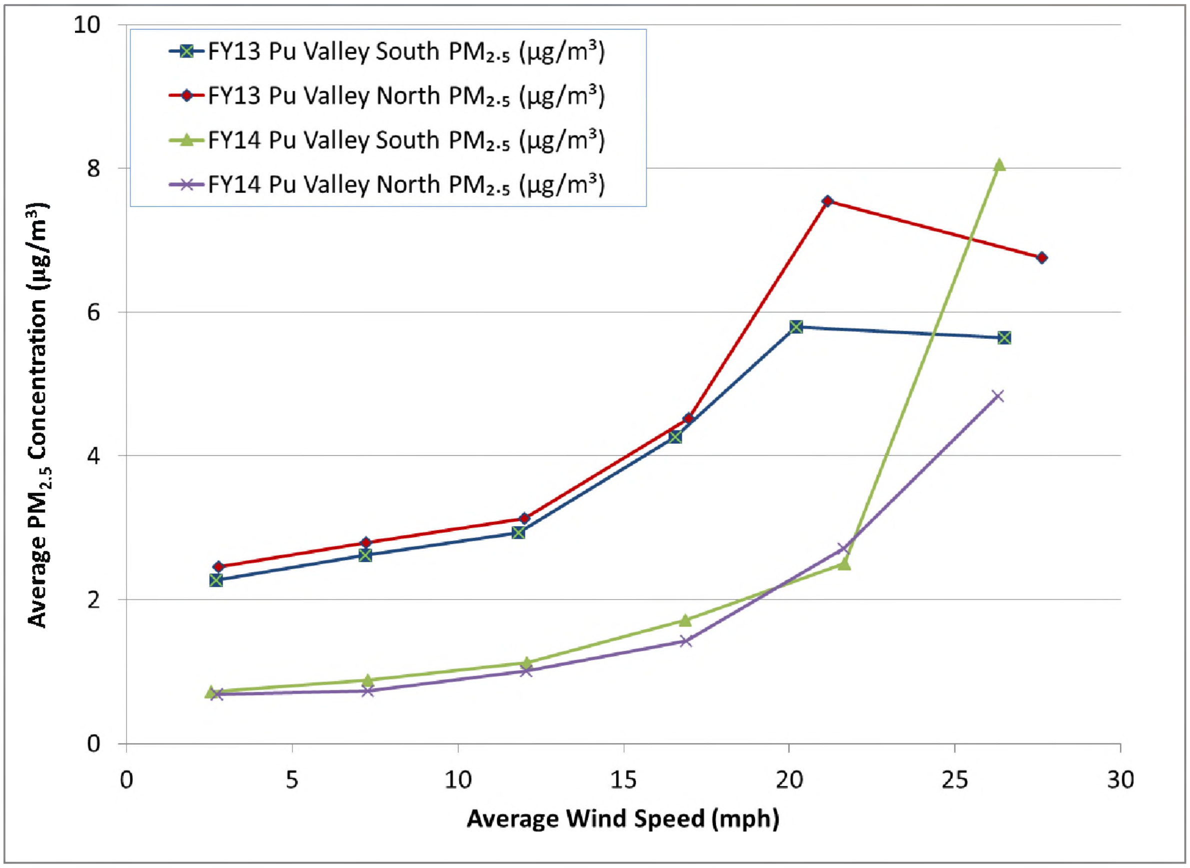


Figure 12. The $PM_{2.5}$ concentrations versus average wind-speed class for Plutonium Valley station #1 (blue and green lines) and station #2 (red and purple lines) during FY2013 and FY2014. This shows that the $PM_{2.5}$ concentration increases approximately exponentially as does the PM_{10} version, except that the $PM_{2.5}$ axis covers a range of values an order of magnitude smaller.

The ratio between PM_{10} and $PM_{2.5}$ is a qualitative indicator of the type of aerosol material that is being measured. By definition, PM_{10} includes larger suspended dust particles than $PM_{2.5}$. Figure 13 shows that the PM_{10} to $PM_{2.5}$ ratio remains below 6 for wind speeds below about 15 mph and that the ratio increases to about 10 as the wind speed increases from 15 mph to 30 mph. This increase in the ratio is an indicator of some suspension and transport of locally derived dust and soil. The ratio increases close to areas of course particles because PM_{10} has on average bigger particles and therefore a shorter lifetime in the atmosphere than $PM_{2.5}$. However, this ratio cannot be used quantitatively as it is subject to change with soil conditions (e.g., compare ratios between years in Figure 13).

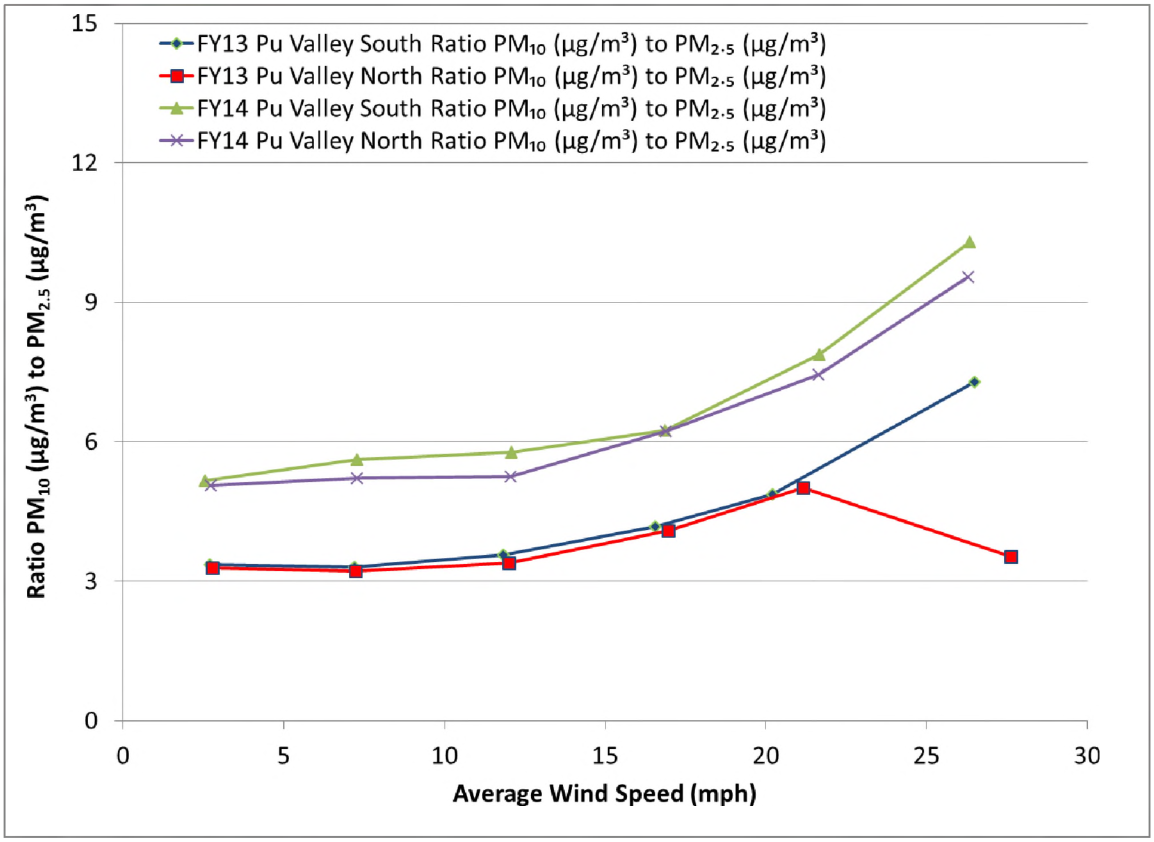


Figure 13. The PM_{10} to $PM_{2.5}$ ratios versus average wind-speed class for Plutonium Valley station #1 (blue and green lines) and station #2 (red and purple lines) for FY2013 and FY2014

Major Dust Events of FY2014

Eleven major dust events, indicated by significant increases in PM_{10} concentrations, were identified in FY2014. Figures 14 and 15 show examples that illustrate the common relationships between dust concentration and wind speed. All 11 events are presented in Appendix E. As discussed above with respect to average wind and dust conditions, these individual events indicate that elevated dust concentrations are associated with increasing or high wind conditions. In general:

1) Wind speed at the two Plutonium Valley monitoring stations were similar; this might be expected because of the proximity of the stations.
2) The wind events lasted between 16 and 36 hours.
3) Maximum PM_{10} dust concentrations usually occurred in conjunction with the strongest winds during these events.
4) There is strong similarity in the dust concentration at both monitoring stations. Only three of the 11 events show differences between the stations with station #1 exhibiting greater dust concentrations during the February 19, 2014 and April 22, 2014 events and station #2 showing greater dust concentrations during the December 3, 2013 event.

5) Background dust concentrations are less than 5 μg/m^3 at wind speeds below 3 mph.

6) Dust concentrations began to increase as soon as the wind increases, but high dust concentrations are associated with winds greater than approximately 15 mph.

7) The highest dust concentrations are generally associated with the onset and early periods of the high wind speeds.

The similar dust concentrations observed at the monitoring stations #1 and #2 suggest dust transported over significant distances made up the majority of dust in these major events. The long transport time allows the concentration to mix uniformly through the atmosphere and produce similar concentrations at both stations. A decline in dust concentration before the winds diminish suggests the available mobile dust fraction is easily exhausted during any individual wind event and additional dust generation is dependent on stronger winds or other phenomena that break up aggregated dust particles.

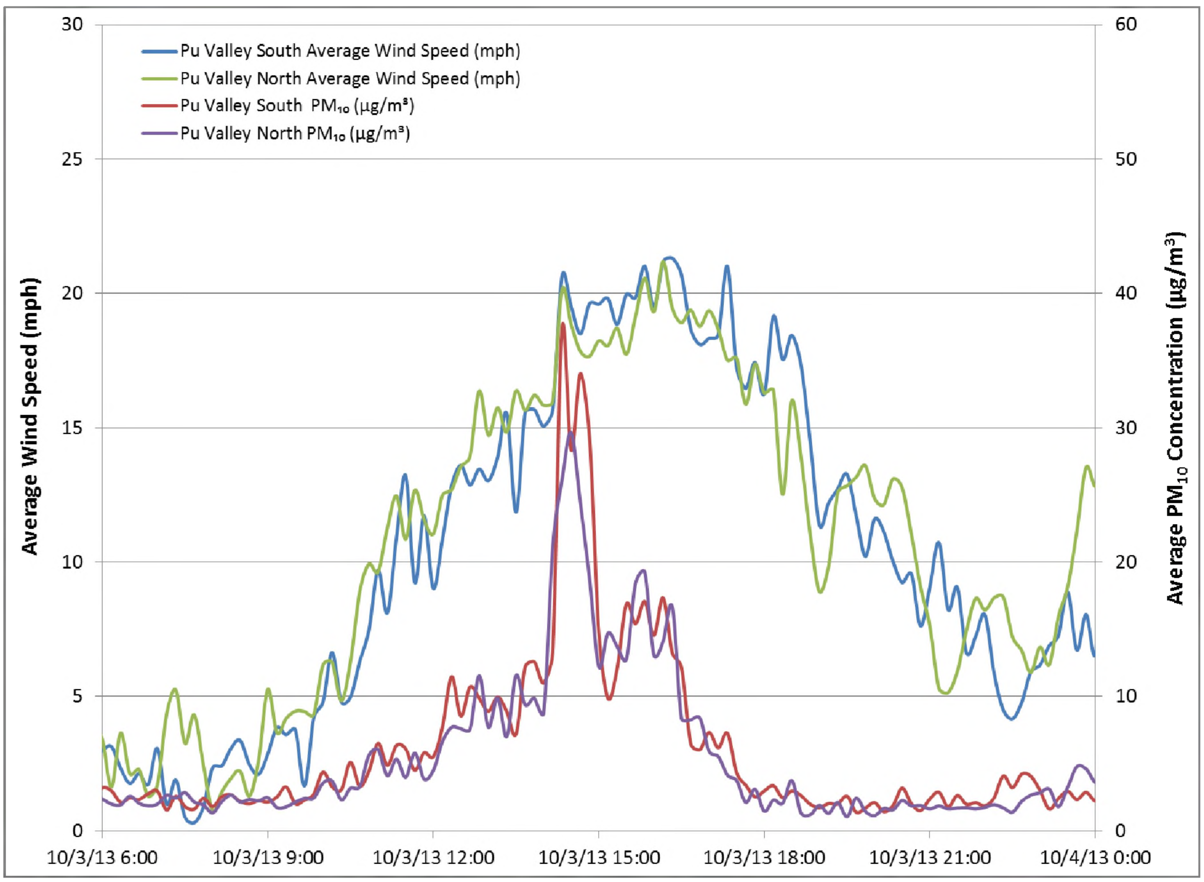


Figure 14. The wind event of October 13, 2013, maintained winds above 5 mph for approximately 13 hours; winds above 15 mph lasted approximately 5 hours, but dust concentrations exceeded 10 μg/m^3 for only 2 to 3 hours.

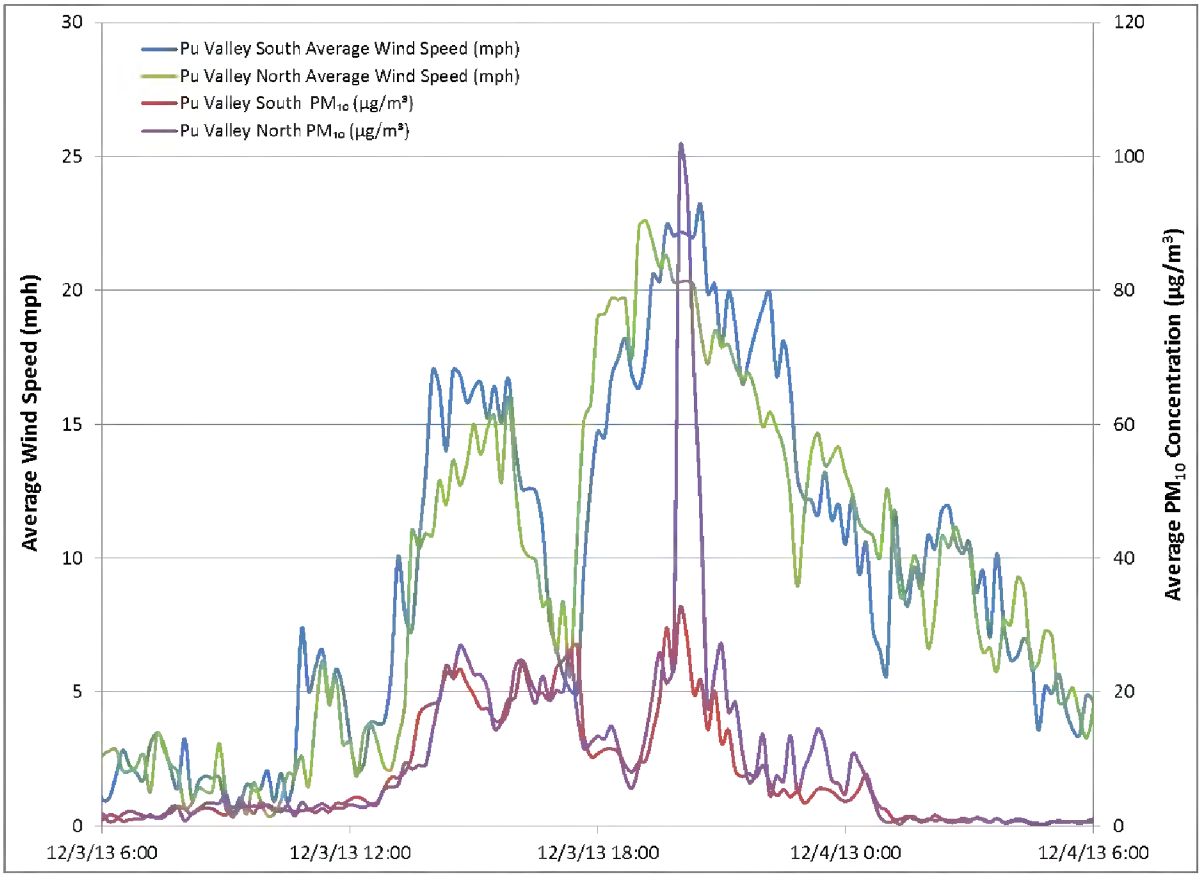


Figure 15. Wind events on December 3 and 4, 2013 maintained winds above 5 mph for approximately 18 hours and consisted of two separate periods of winds above 15 mph that totaled approximately 10 hours. Winds above 20 mph only lasted for approximately 2 hours. The dust was elevated during the time the winds exceeded 15 mph, but the peak dust concentrations occurred only when the winds exceeded 22 mph for one hour at station #2. This event represents the greatest difference between dust concentrations at the two stations.

CONCLUSIONS

Wind speed and precipitation are the meteorological parameters most related to the migration of contaminated soil particles. During the second year of observations, a period of consistently high wind speeds was observed in the spring and the largest precipitation events were recorded in October. Differences between the wind speed, wind direction, and precipitation observations at meteorological stations #1 (south) and #2 (north) reflect the notable spatial variability of meteorological conditions observed in southwestern desert climates.

Although increases in PM_{10} concentration are observed at wind speeds of approximately 10 mph, there is a sharp increase in PM_{10} concentrations as the wind speed exceeds 15 mph. This is reflected in the slope of the lines for both stations in Figure 10. Records indicate that the relationship between airborne dust and wind speed is similar at both the northern and southern meteorological stations. Most dust transport appears to occur during short periods of time when wind speed is strong. Additionally, the dust concentrations diminished before the wind speeds dropped off. This suggests that the surface soils are generally stable and that winds of any specific speed can transport limited amounts of dust. The maximum observed PM_{10} daily average concentrations were in the range of 50 to 60 $\mu g/m^3$ (in some cases higher), which is well below the 24-hour average PM_{10} standard of 150 $\mu g/m^3$ set forth by the EPA for urban areas and rural communities.

Numerous precipitation events are indicated in the data record for FY2013 and FY2014. The two largest produced maximum 10-minute precipitation totals of approximately 0.4 inches. Most events produced less than 0.2 inches in 10 minutes. The pressure transducer indicated the presence of water in the channel on three occasions. There may have been other occasions of water in the channel, but the pressure transducer was not operating throughout the data collection period. When detected, the depth of water in the channel at the pressure transducer was never sufficient to cause the ISCO sampler to turn on. Therefore, no samples of channel runoff were collected and no suspended sediment analyses were performed during this reporting period.

Two bed-load samples, collected in March 2014, represented an integration of all bed-load transport since samplers were installed in 2011. Overall, the sample with the greater portion of small particles had the higher radionuclide concentrations. The smaller particle size fraction exhibits higher concentrations of Am-241 and Pu-238 in both samples. But the concentration of Pu-239/240 was higher for the smaller size fraction in one sample and for the larger size fraction in the other sample.

FUTURE WORK

Data transmitted from the Plutonium Valley site instrumentation will be reviewed monthly by project personnel to identify precipitation events that exceed the specified rainfall threshold (~0.2 in [0.5 cm]) assumed to result in potential runoff and assess proper operation of the instrumentation and remote communication equipment. Field inspections will be scheduled to service instrumentation only if necessary.

In response to a runoff event that triggers the ISCO sampler, project personnel will recover the collected water and bed-load samples. These samples will be submitted to a specified laboratory to determine particle size distribution and radionuclide concentrations. These data will help establish relationships between the sediment eroded and transported during runoff events and the significance of channel runoff as a pathway for radionuclide migration from the CAU.

Additionally, meteorological data collected leading up to and during the runoff event will be analyzed to characterize the meteorological conditions that produced the runoff. This analysis will help delineate threshold conditions that are likely to result in sediment transport and migration of radionuclide-contaminated soils. Establishing these thresholds will help identify meteorological conditions that may trigger monitoring and sampling of channel runoff migration pathways. Requirements for monitoring meteorological conditions and for sampling runoff pathways can then be appropriately incorporated in closure plans. Meteorological data, particularly wind data and soil moisture content, will continue to be compared against the air particulate data to determine PM_{10} transport in conjunction with wind events.

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Helsel, D.R., and R.M. Hirsch. 1992. Statistical Methods in Water Resources. Studies in Environmental Science volume 49, Elsevier, New York, 529pp.

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APPENDIX A: DAILY AVERAGE/TOTAL METEOROLOGICAL OBSERVATIONS AT PLUTONIUM VALLEY STATION #1 FOR FY2013

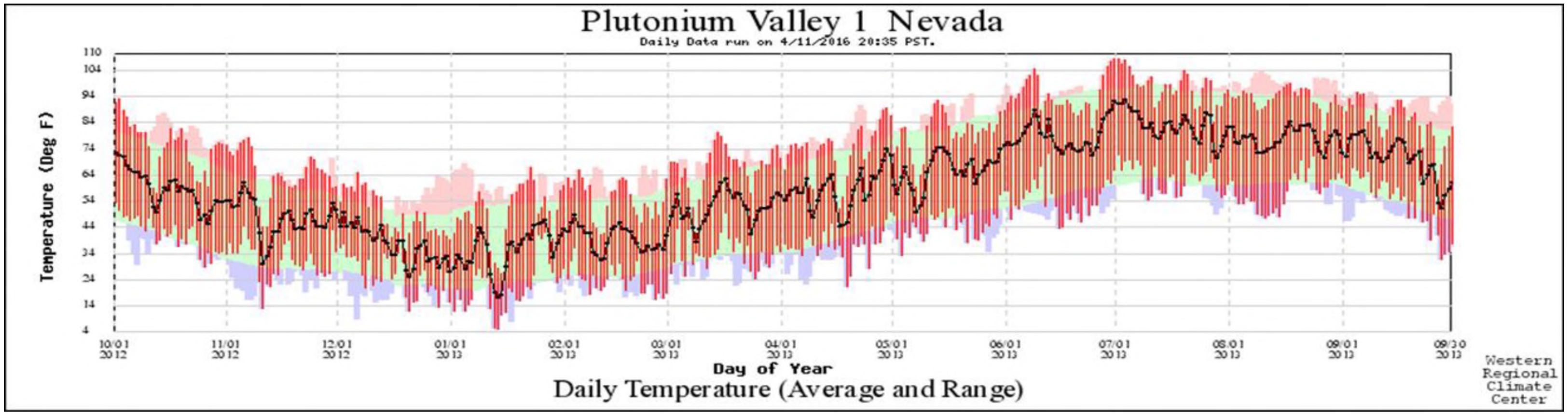

Figure A-1. Daily average, maximum, and minimum air temperature from October 1, 2012, to September 30, 2013, at Plutonium Valley station #1 (south). The underlying pastel colors represent the period-of-record (2011 to 2013) extremes (red and blue) and averages (green).

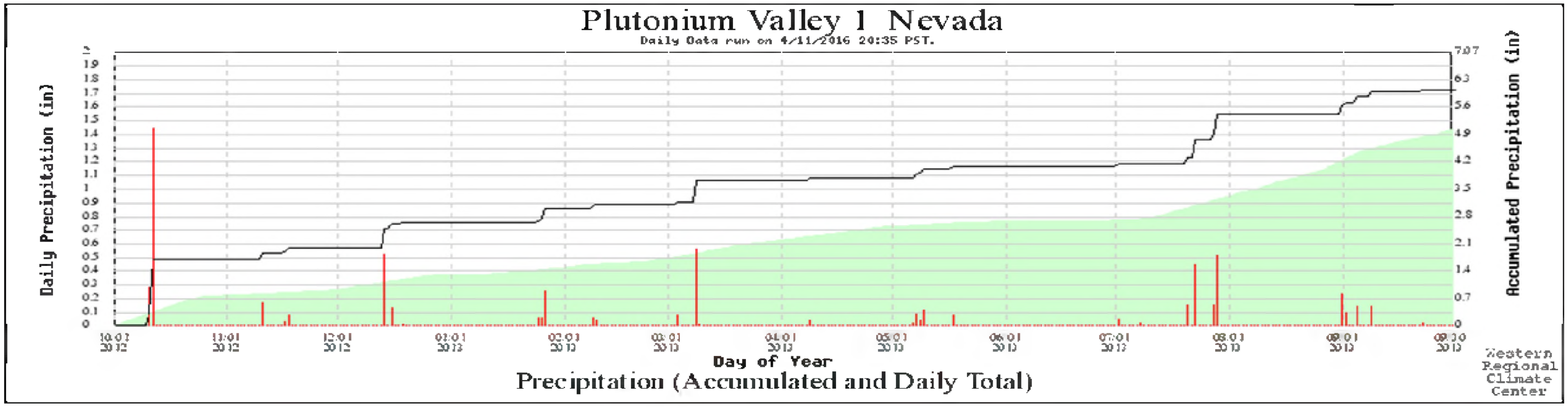

Figure A-2. Daily total (red bars) and accumulated (black line) precipitation data collected at the Plutonium Valley station #1 (south) from October 1, 2012, to September 30, 2013. The underlying light green shaded area represents the station period-of-record (2011 to 2013) average precipitation accumulation.

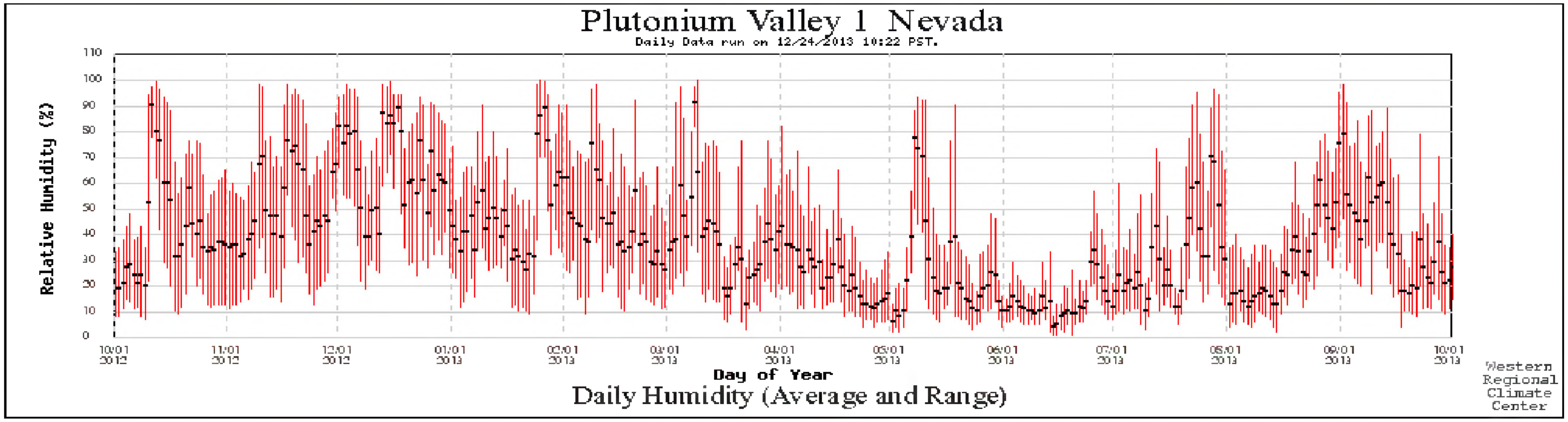

Figure A-3. Daily relative humidity average (black marks) and maximum and minimum (red bars) recorded at Plutonium Valley station #1 (south) from October 1, 2012, to September 30, 2013.

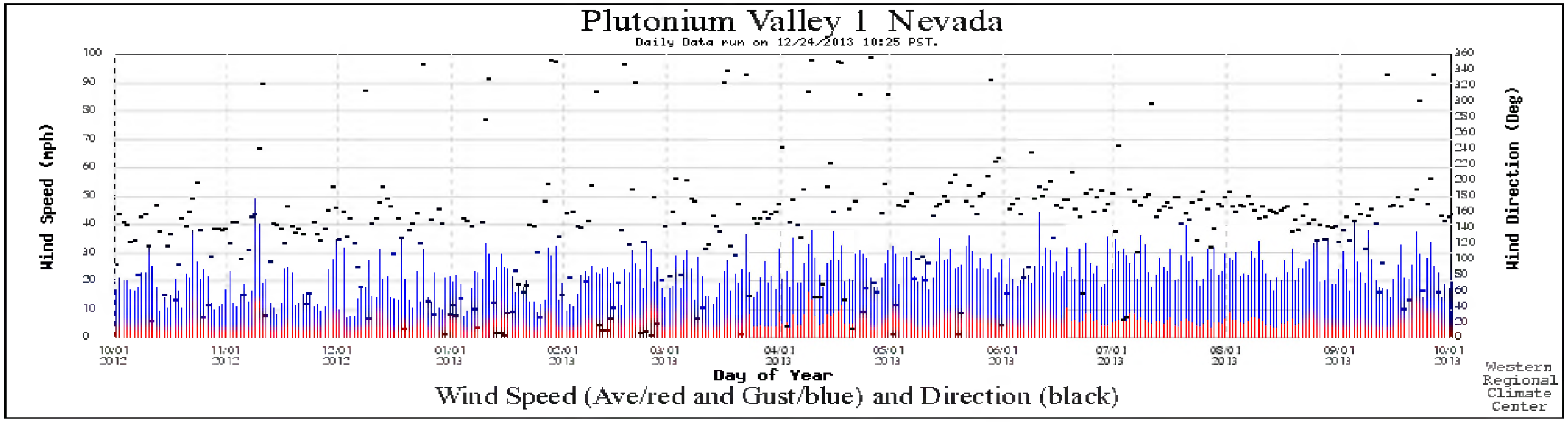

Figure A-4. Wind speed (red: daily average; blue: daily peak gust) and wind direction (black marks) recorded at Plutonium Valley station #1 (south) from October 1, 2012, to September 30, 2013.

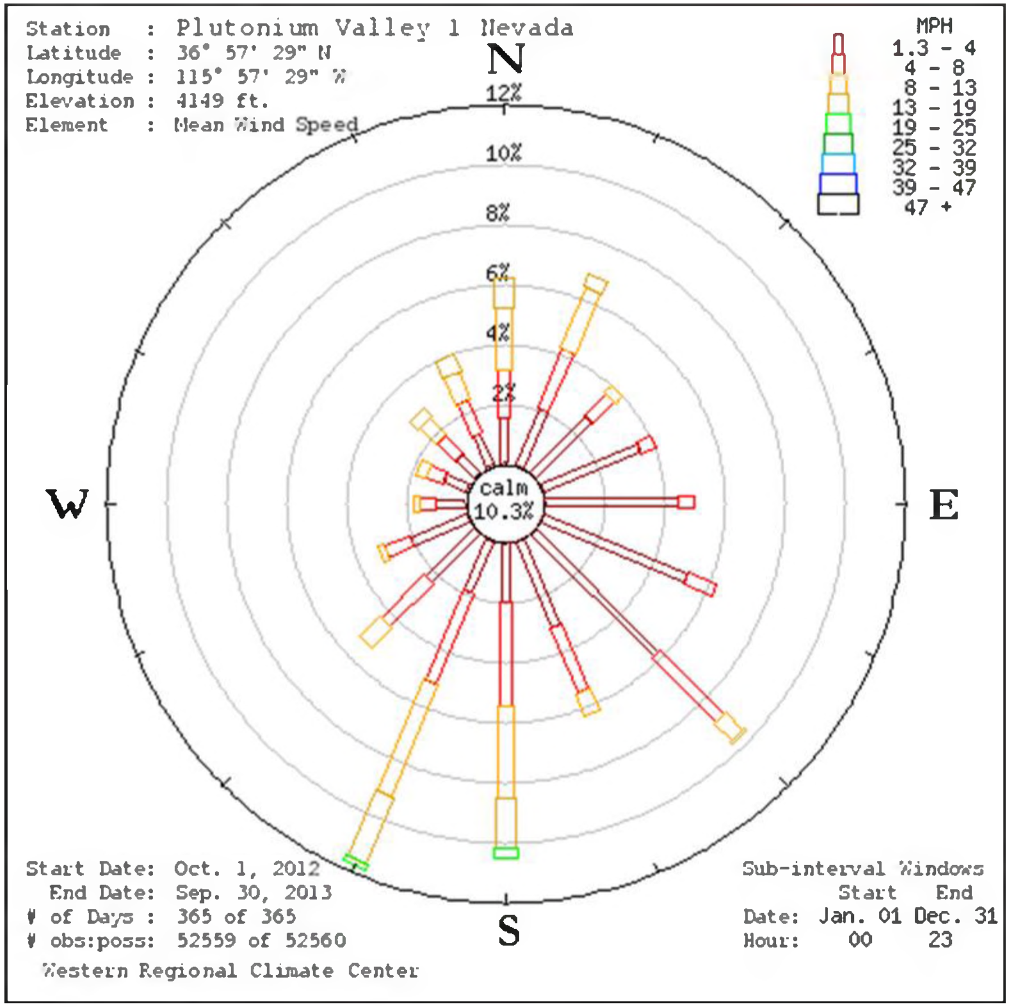

Figure A-5. Wind rose for the period of October 1, 2012, to September 30, 2013, at Plutonium Valley station #1 (south).

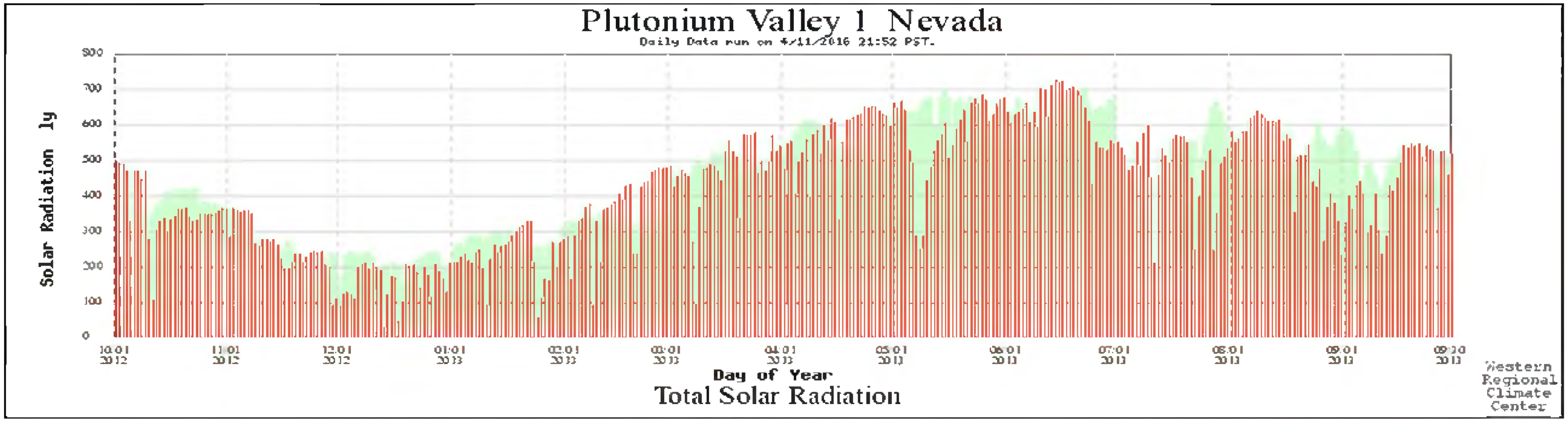

Figure A-6. Daily solar radiation recorded at the Plutonium Valley station #1 (south) from October 1, 2012, to September 30, 2013. The underlying light green shaded area represents the period-of-record (2011 to 2013) maximum daily solar radiation.

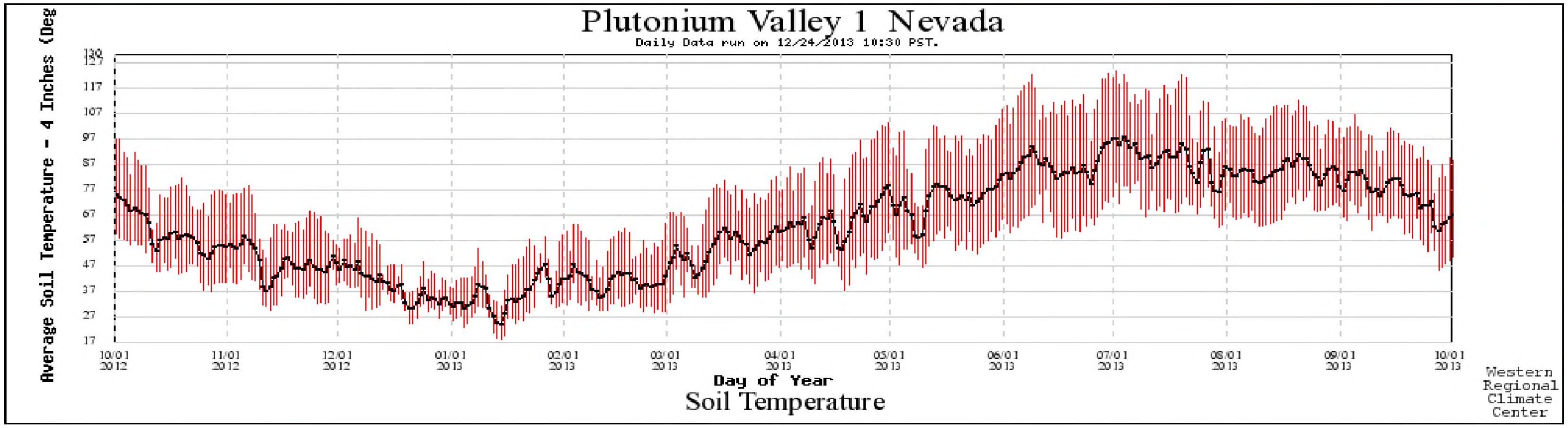

Figure A-7. Daily soil temperature average (black line) and maximum and minimum (red bars) recorded at the Plutonium Valley station #1 (south) from October 1, 2012, to September 30, 2013.

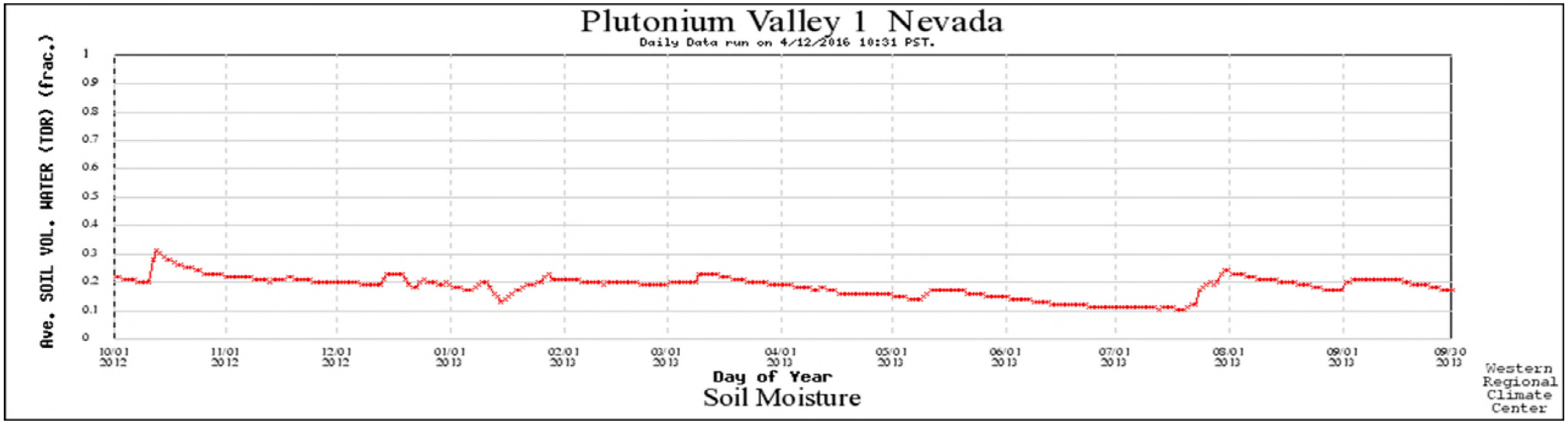

Figure A-8. Daily average soil moisture recorded at the Plutonium Valley station #1 (south) from October 1, 2012, to September 30, 2013.

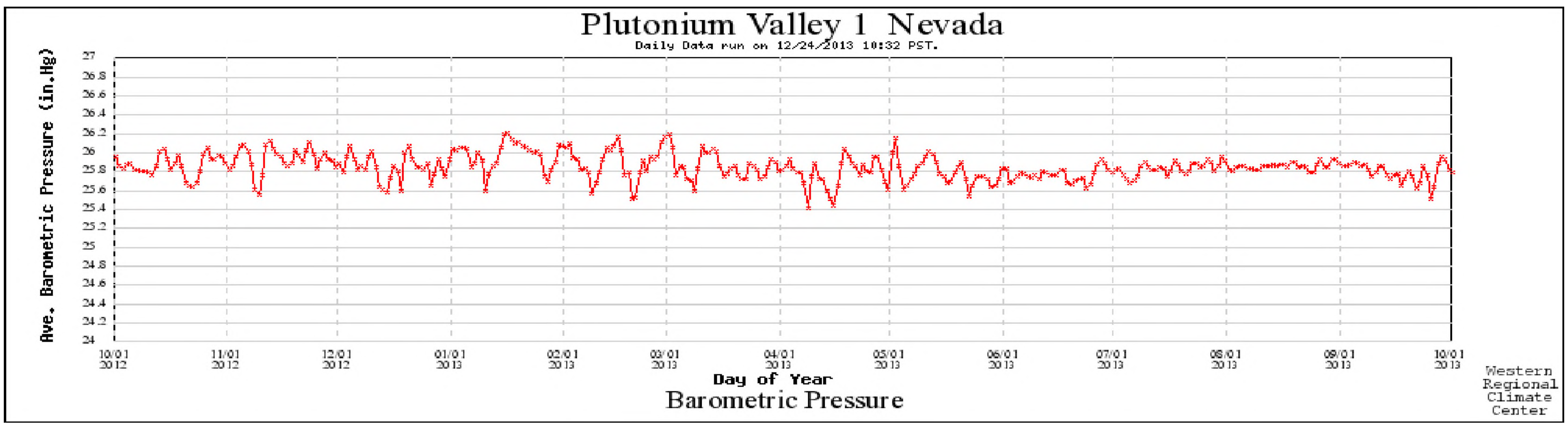

Figure A-9. Daily average barometric pressure recorded at the Plutonium Valley station #1 (south) from October 1, 2012, to September 30, 2013.

APPENDIX B: DAILY AVERAGE/TOTAL METEOROLOGICAL OBSERVATIONS AT PLUTONIUM VALLEY STATION #2 FOR FY2013

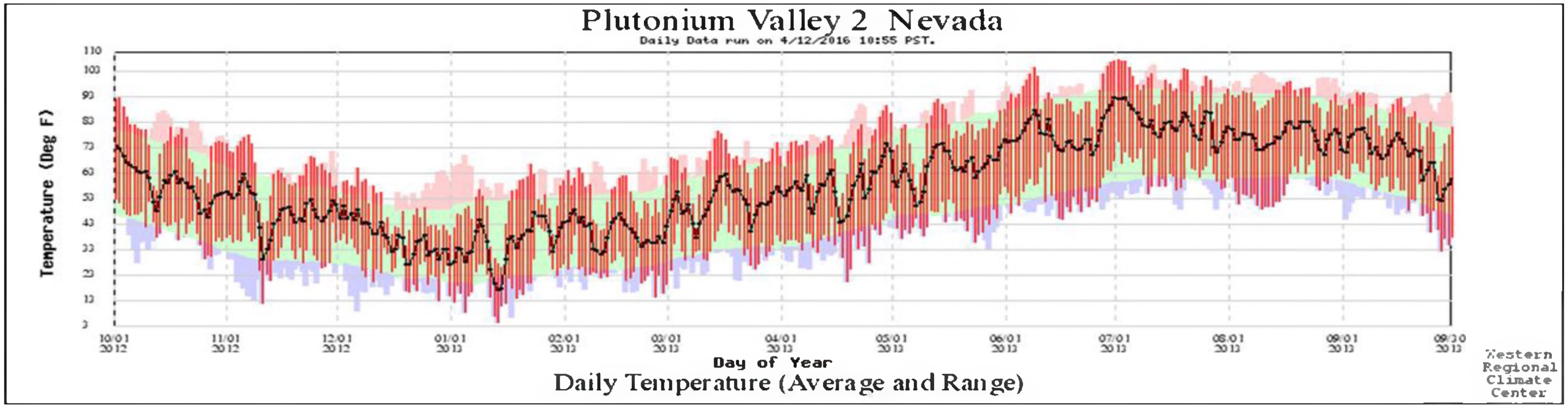

Figure B-1. Daily average (black marks), maximum (upper end of red bar), and minimum (lower end of red bar) air temperature at Plutonium Valley station #2 (north) from October 1, 2012, to September 30, 2013. The underlying pastel colors represent the period-of-record (2011 to 2013) extremes (light red and light blue) and averages (light green).

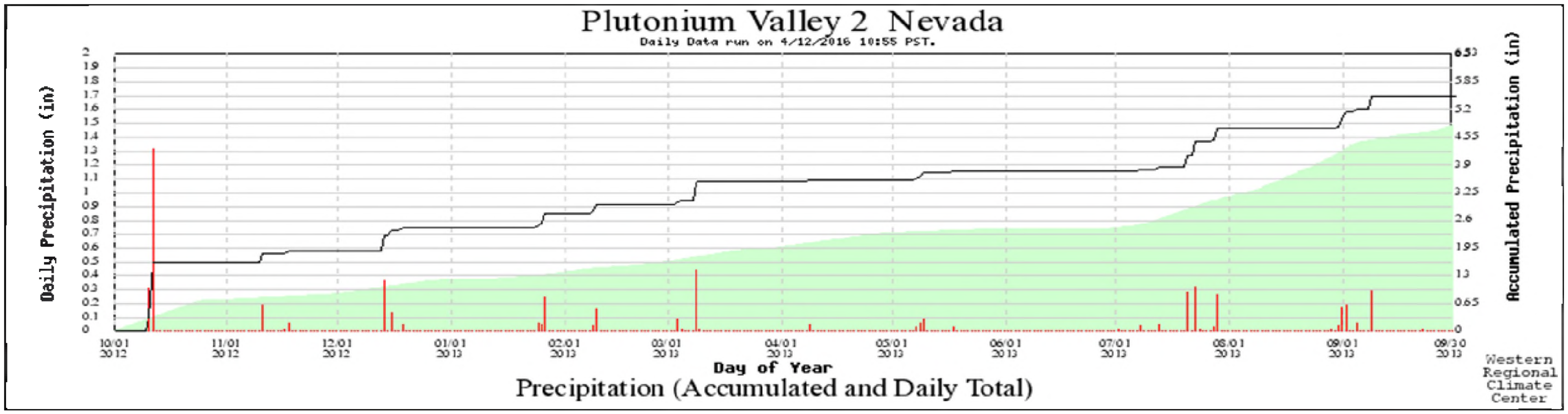

Figure B-2. Daily total (red bars) and accumulated (black line) precipitation data collected at the Plutonium Valley station #2 (north) from October 1, 2012, to September 30, 2013. The underlying light green shaded area represents the station period-of-record (2011 to 2013) average precipitation accumulation.

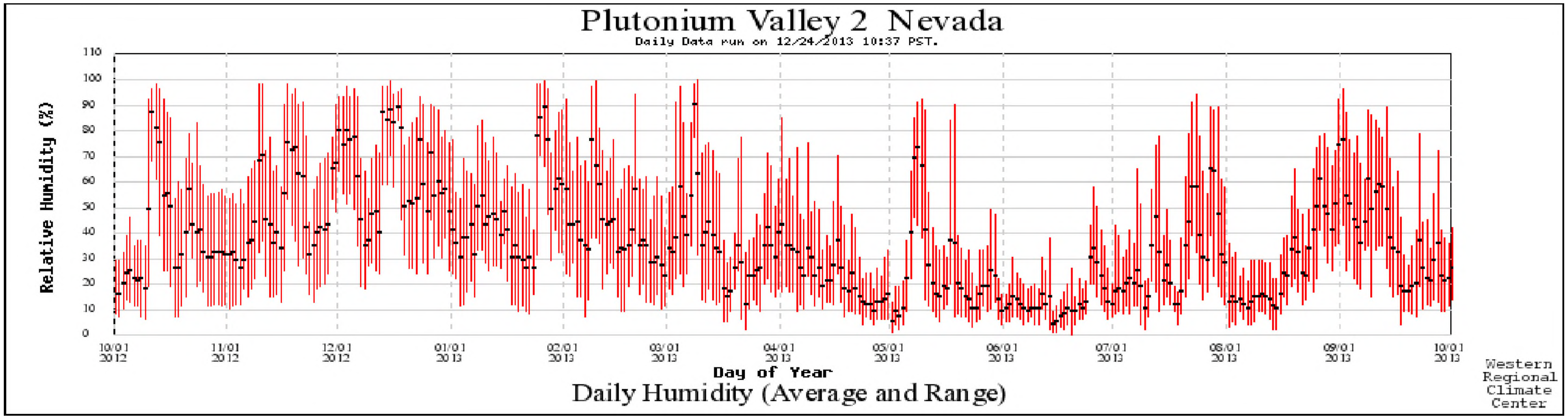

Figure B-3. Daily relative humidity average (black marks) and maximum and minimum (red bars) recorded at Plutonium Valley station #2 (north) from October 1, 2012, to September 30, 2013.

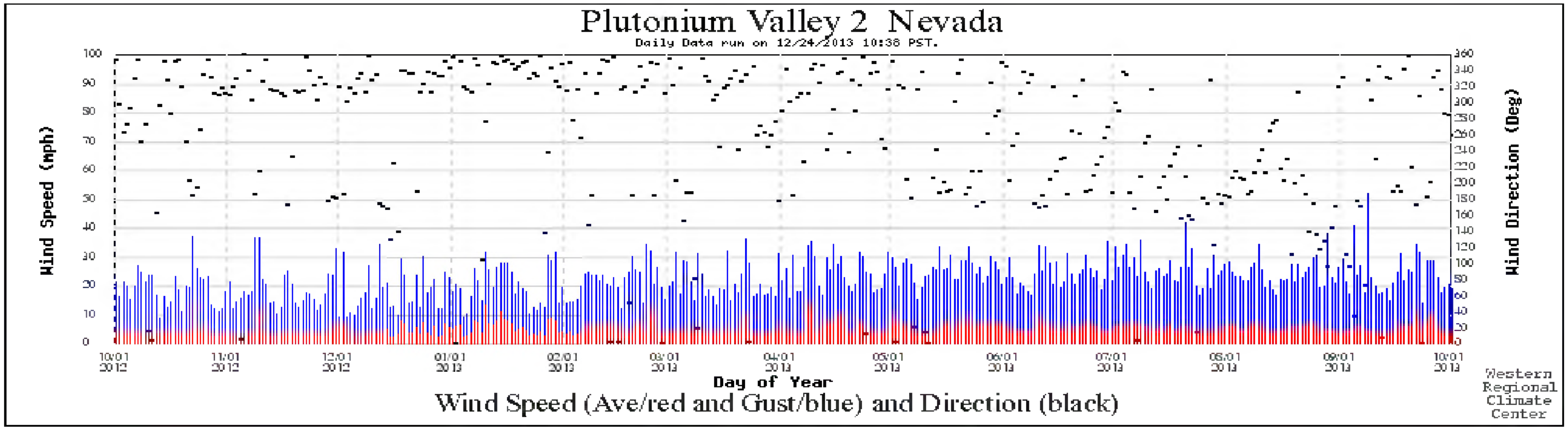

Figure B-4. Wind speed (red: daily average; blue: daily peak gust) and wind direction (black marks) recorded at Plutonium Valley station #2 (north) from October 1, 2012, to September 30, 2013.

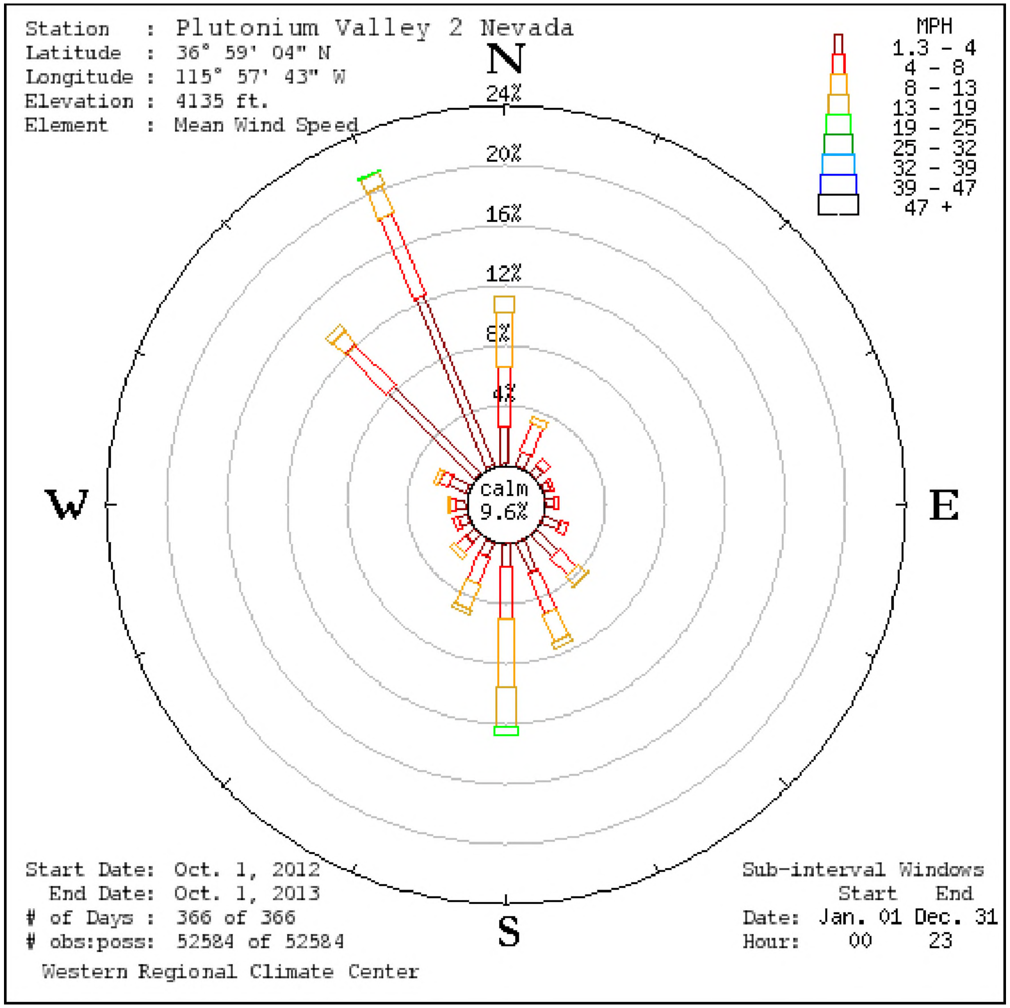

Figure B-5. Wind rose for the period of October 1, 2012, to September 30, 2013, at Plutonium Valley station #2 (north).

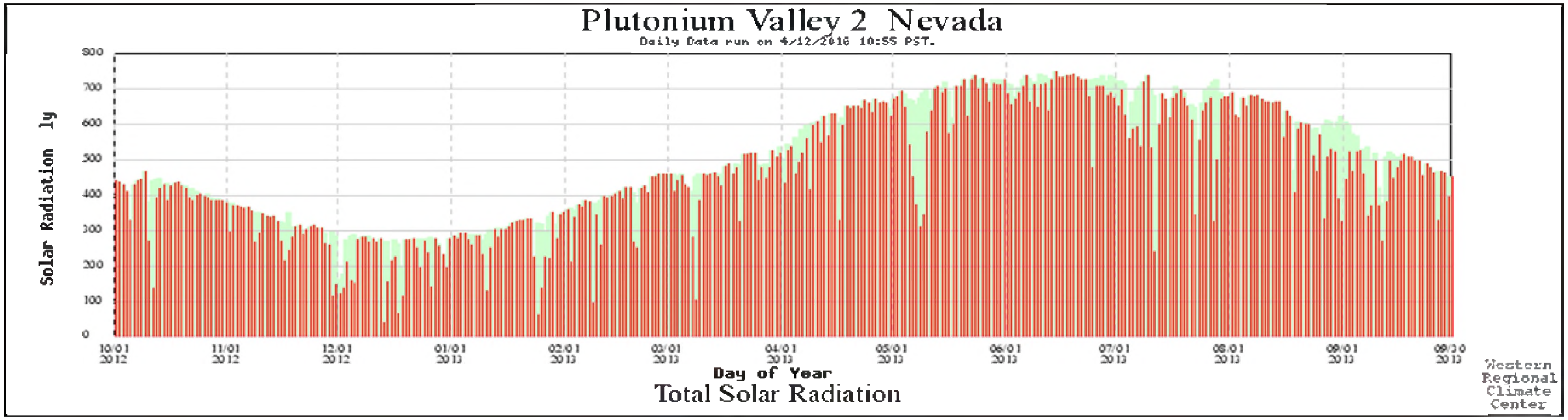

Figure B-6. Daily solar radiation recorded at the Plutonium Valley station #2 (north) from October 1, 2012, to September 30, 2013. The underlying light green shaded area represents the period-of-record (2011 to 2013) maximum daily solar radiation.

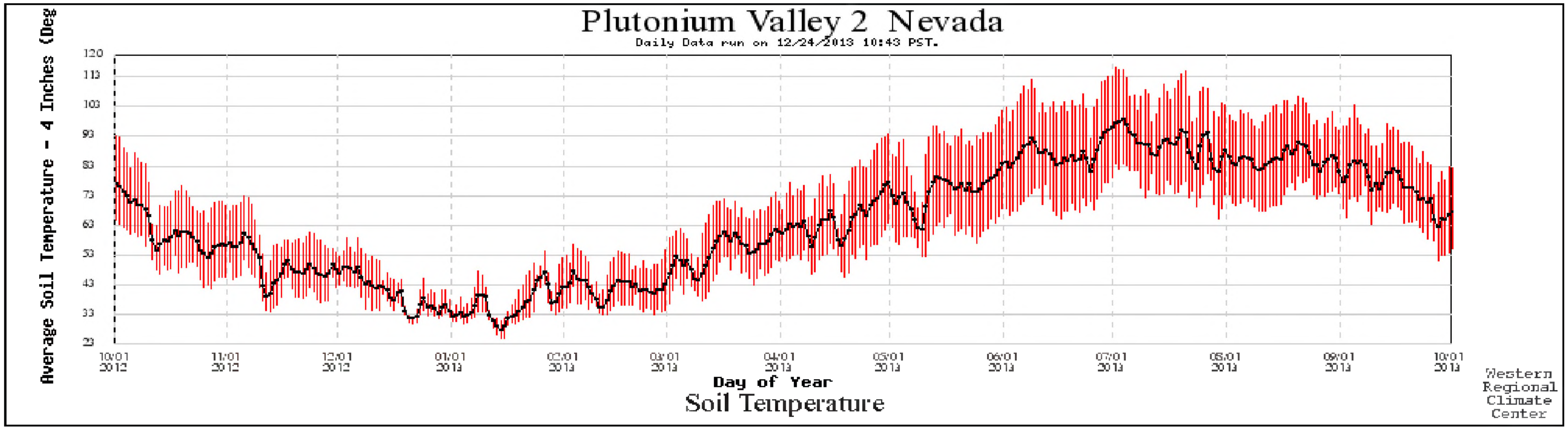

Figure B-7. Daily soil temperature average (black line) and maximum and minimum (red bars) recorded at the Plutonium Valley station #2 (north) from October 1, 2012, to September 30, 2013.

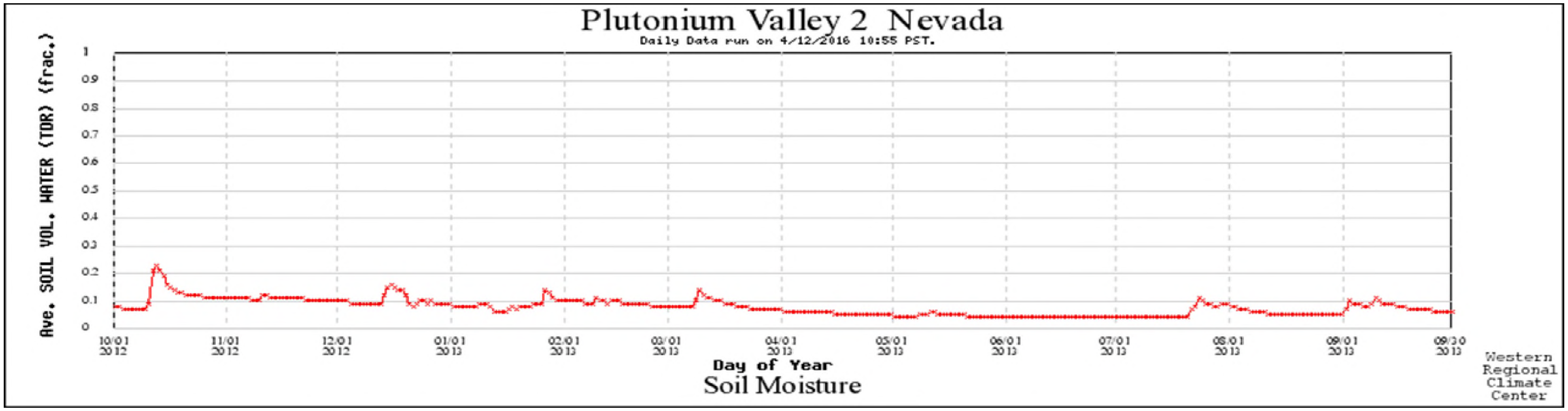

Figure B-8. Daily average soil moisture recorded at the Plutonium Valley station #2 (north) from October 1, 2012, to September 30, 2013.

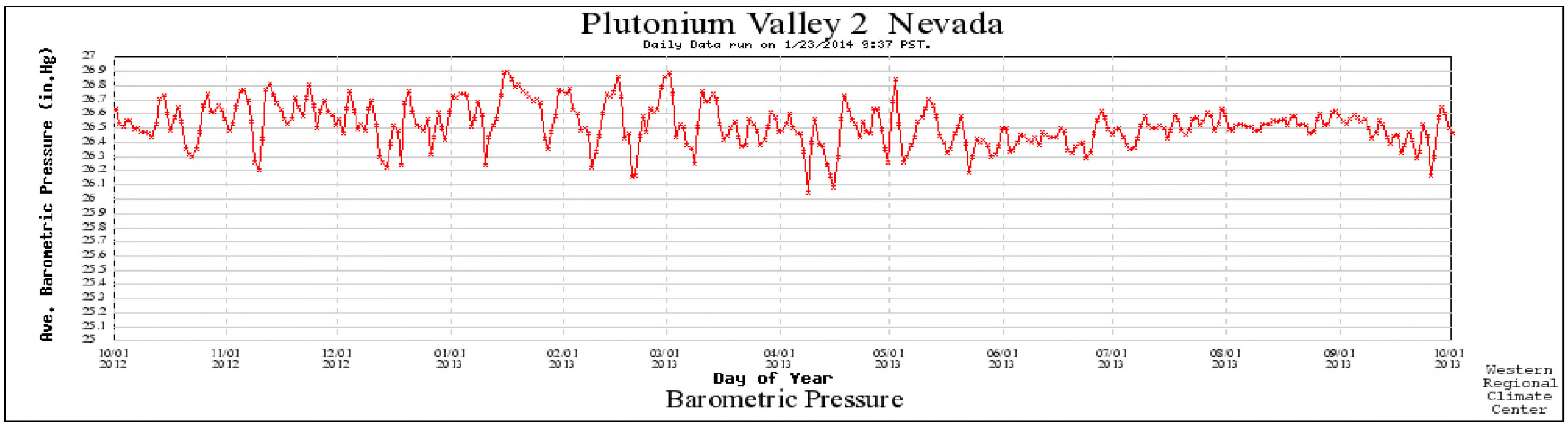

Figure B-9. Daily average barometric pressure recorded at the Plutonium Valley station #2 (north) from October 1, 2012, to September 30, 2013.

APPENDIX C: DAILY AVERAGE/TOTAL METEOROLOGICAL OBSERVATIONS AT PLUTONIUM VALLEY STATION #1 FOR FY2014

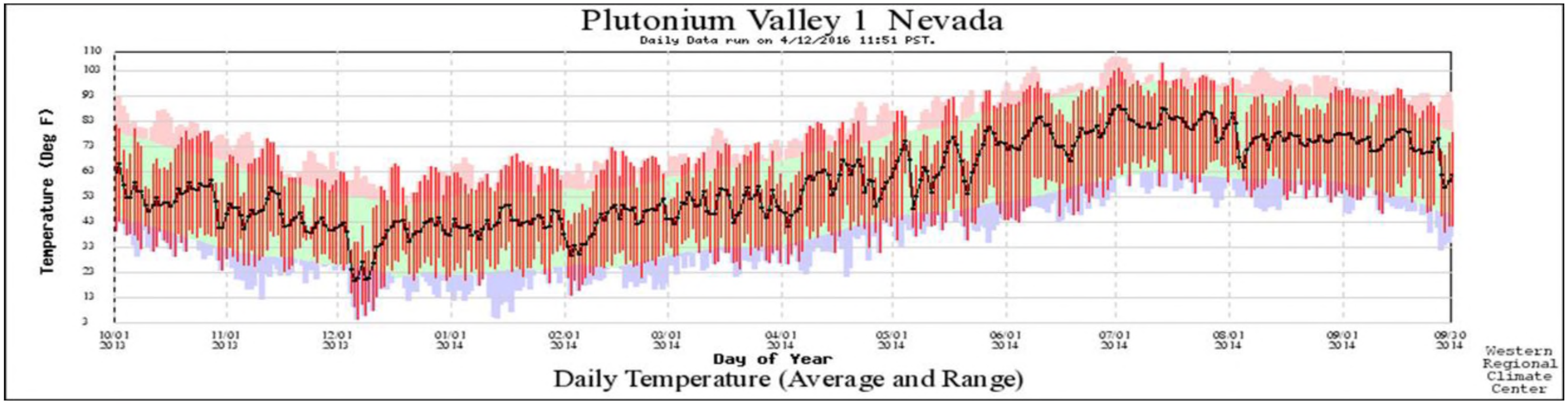

Figure C-1. Daily average (black line) and maximum and minimum (ends of the red bars) air temperature at Plutonium Valley station #1 (south) from October 1, 2013, to September 30, 2014. The underlying pastel colors represent the period-of-record (2011 to 2014) extremes (red and blue) and averages (green).

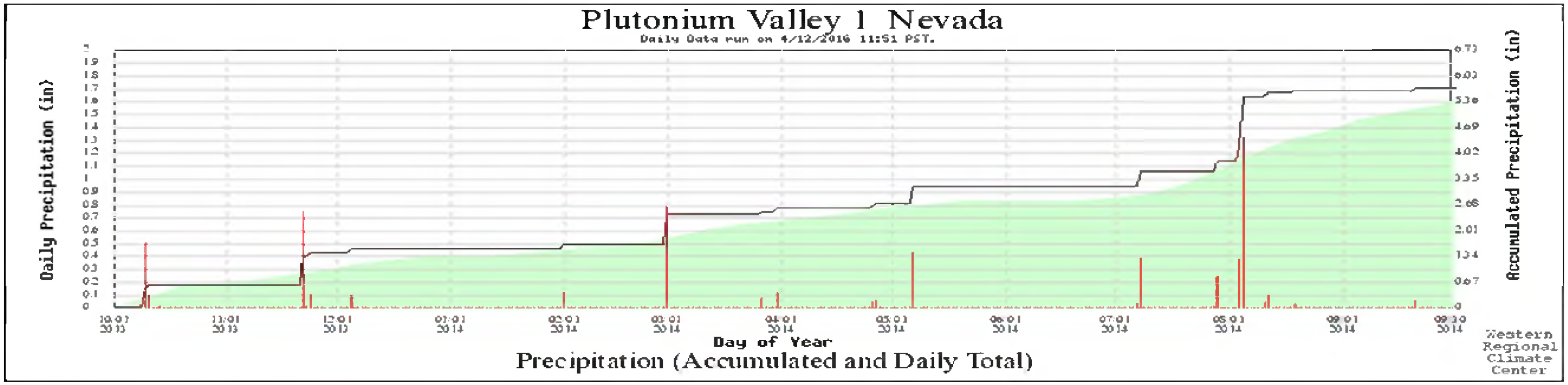

Figure C-2. Daily total (red bars) and accumulated (black line) precipitation data collected at the Plutonium Valley station #1 (south) from October 1, 2013, to September 30, 2014. The underlying light green shaded area represents the station period-of-record (2011 to 2014) average precipitation accumulation.

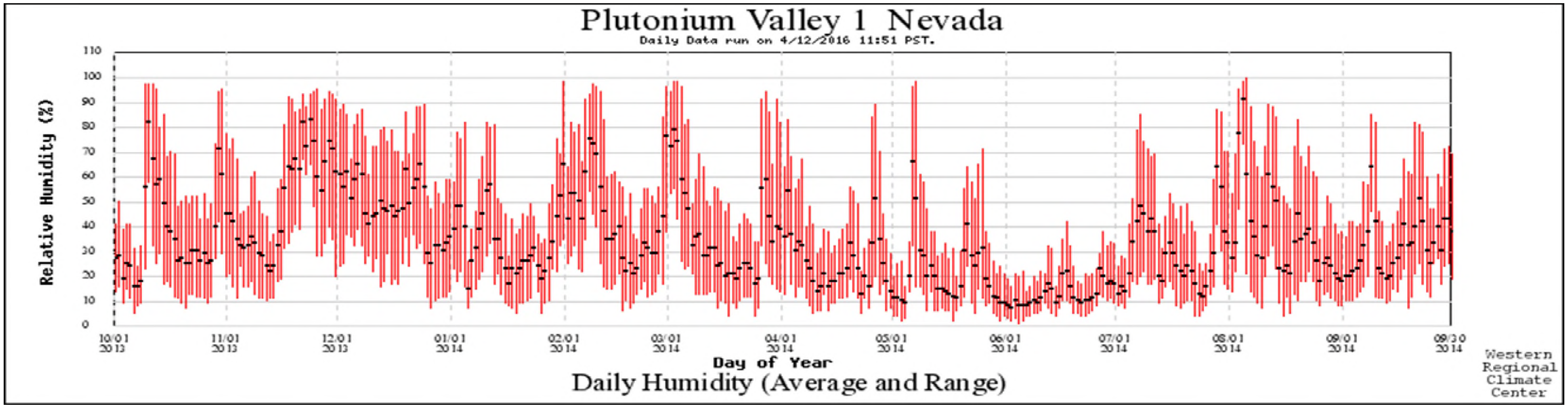

Figure C-3. Daily relative humidity average (black marks) and maximum and minimum (red bars) recorded at Plutonium Valley station #1 (south) from October 1, 2013, to September 30, 2014.

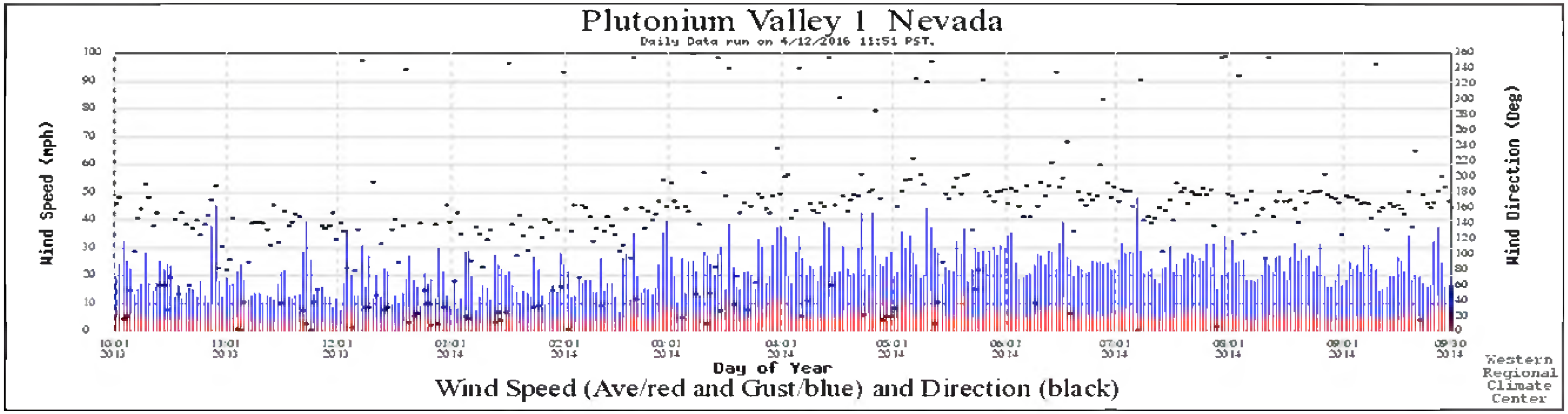

Figure C-4. Wind speed (red: daily average; blue: daily peak gust) and wind direction (black marks) recorded at Plutonium Valley station #1 (south) from October 1, 2013, to September 30, 2014.

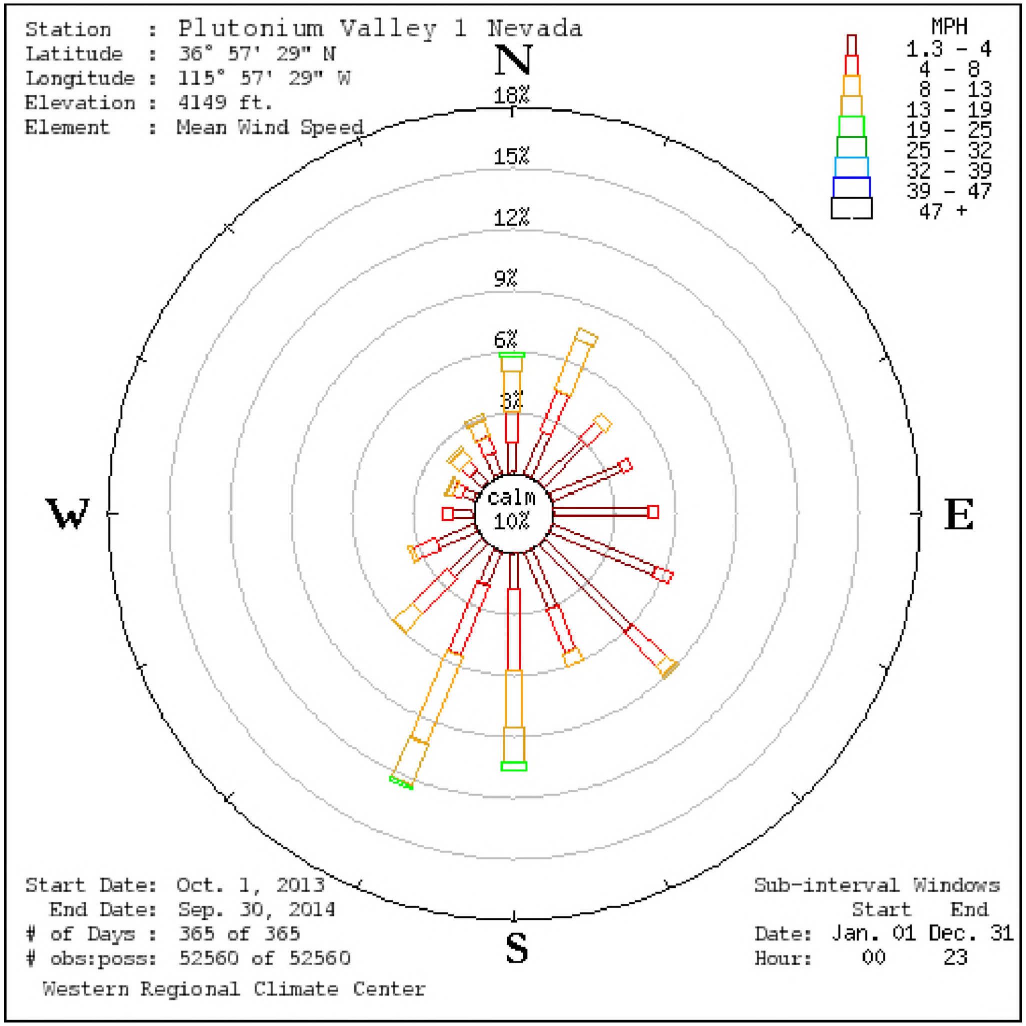

Figure C-5. Wind rose for the period of October 1, 2013, to September 30, 2014, at Plutonium Valley station #1 (south).

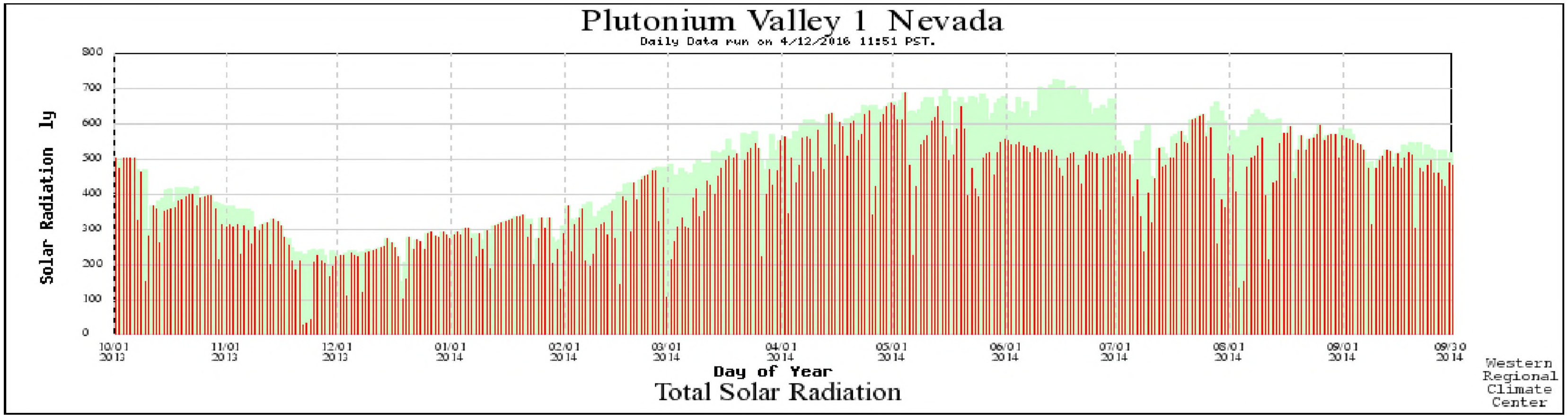

Figure C-6. Daily solar radiation (red bars) recorded at the Plutonium Valley station #1 (south) from October 1, 2013, to September 30, 2014. The underlying light green shaded area represents the period-of-record (2011 to 2014) maximum daily solar radiation.

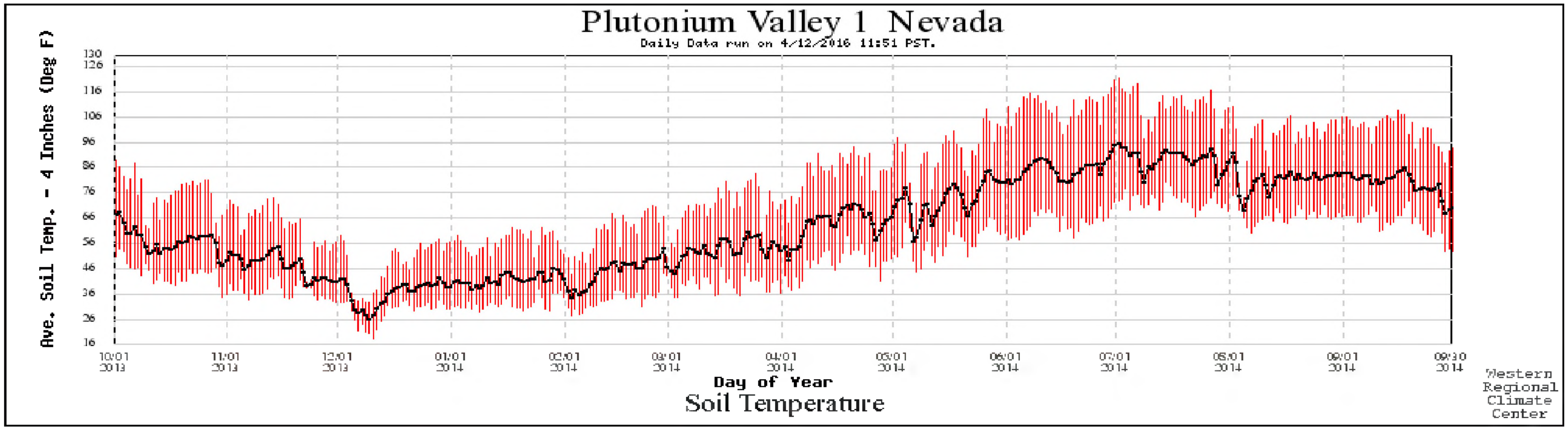

Figure C-7. Daily soil temperature average (black line) and maximum and minimum (red bars) recorded at the Plutonium Valley station #1 (south) from October 1, 2013, to September 30, 2014.

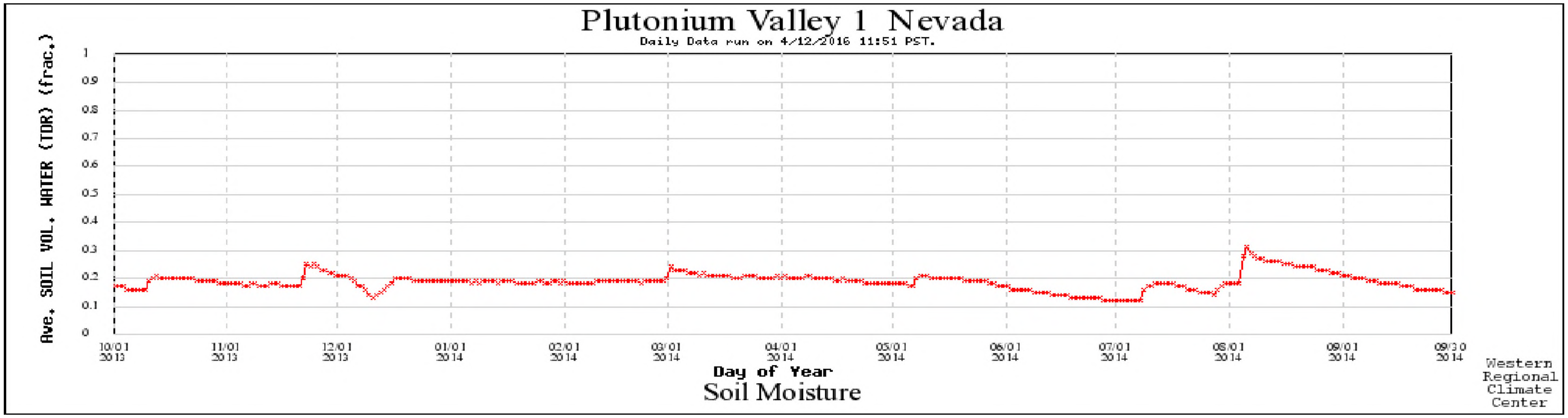

Figure C-8. Daily average soil moisture recorded at the Plutonium Valley station #1 (south) from October 1, 2013, to September 30, 2014.

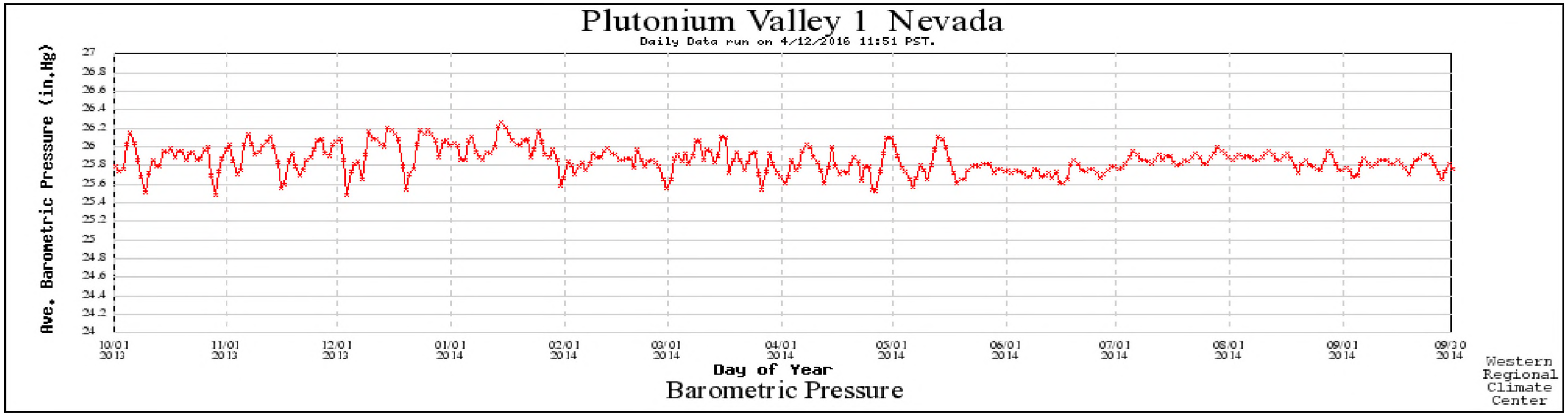

Figure C-9. Daily average barometric pressure recorded at the Plutonium Valley station #1 (south) from October 1, 2013, to September 30, 2014.

APPENDIX D: DAILY AVERAGE/TOTAL METEOROLOGICAL OBSERVATIONS AT PLUTONIUM VALLEY STATION #2 FOR FY2014

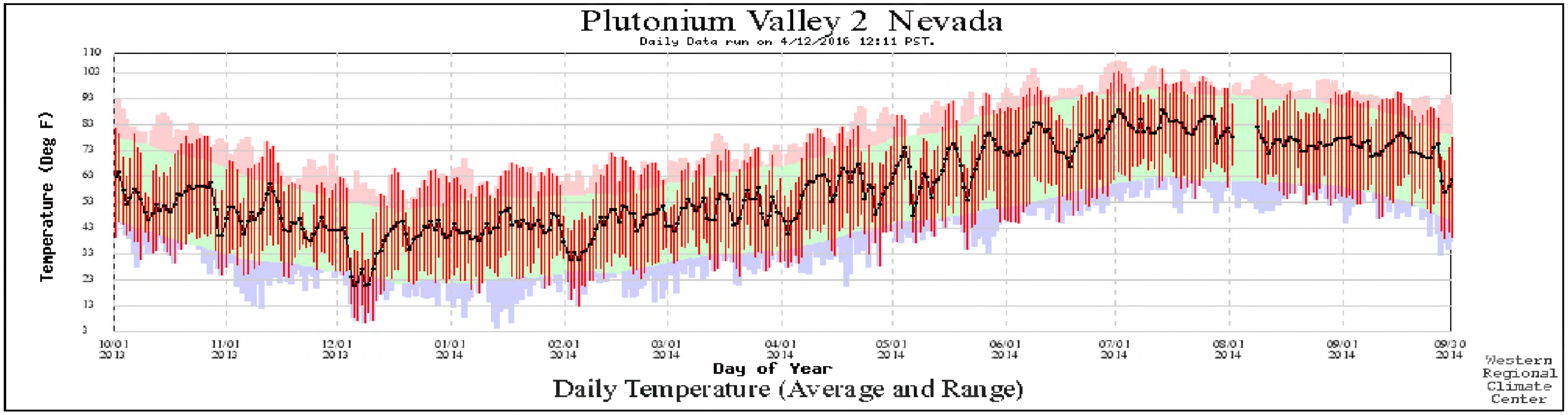

Figure D-1. Daily average (black line) and maximum and minimum (ends of the red bars) air temperature at Plutonium Valley station #2 (north) from October 1, 2013, to September 30, 2014. Underlying pastel colors represent the period-of-record (2011 to 2014) extremes (red and blue) and averages (green).

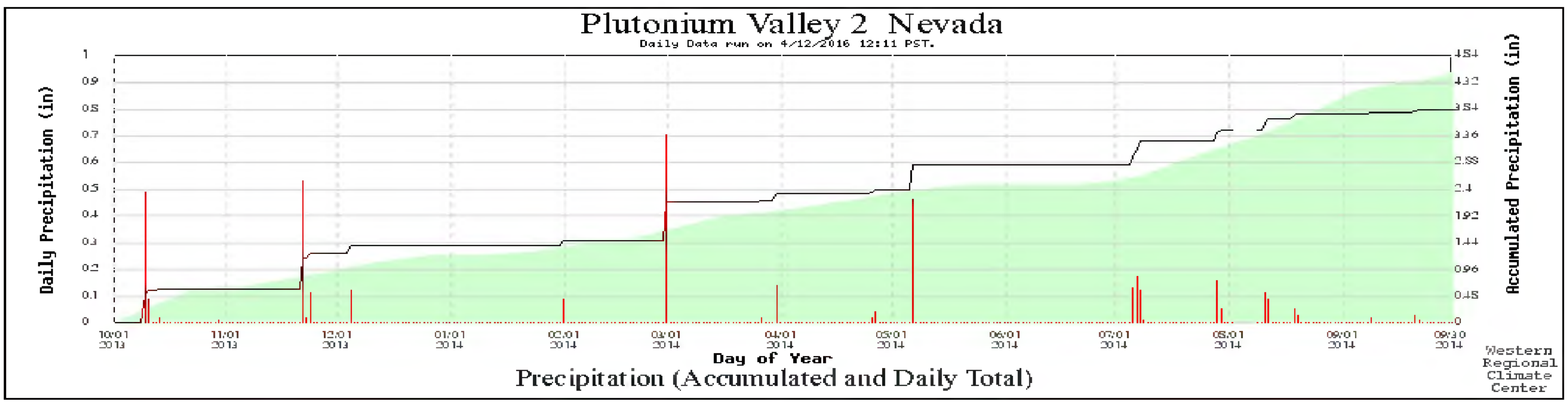

Figure D-2. Daily total (red bars) and accumulated (black line) precipitation data collected at the Plutonium Valley station #2 (north) from October 1, 2013, to September 30, 2014. The underlying light green shaded area represents the station period-of-record (2011 to 2014) average precipitation accumulation.

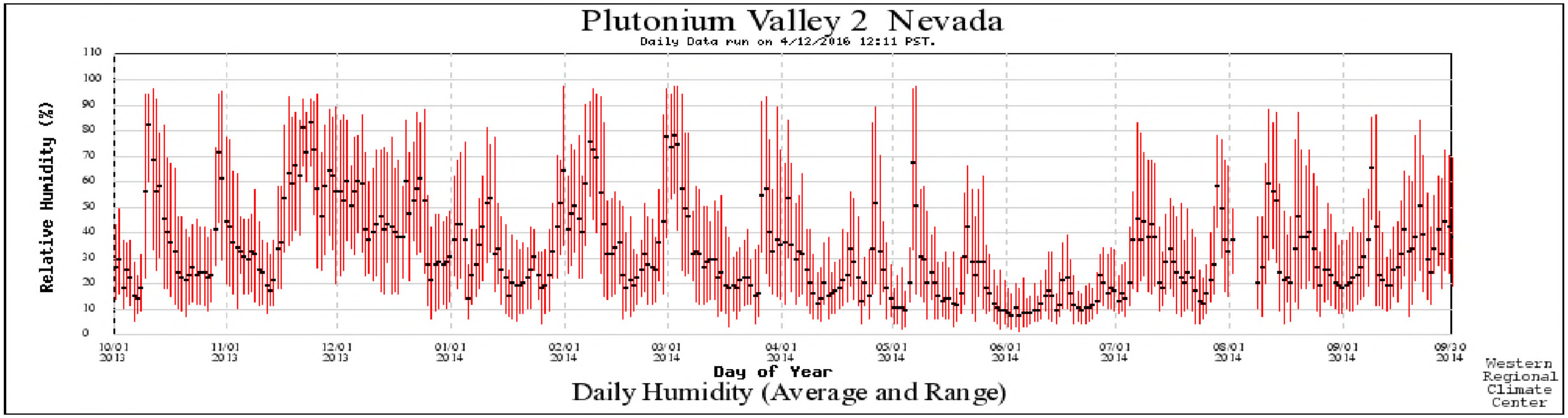

Figure D-3. Daily relative humidity average (black marks) and maximum and minimum (red bars) recorded at Plutonium Valley station #2 (north) from October 1, 2013, to September 30, 2014.

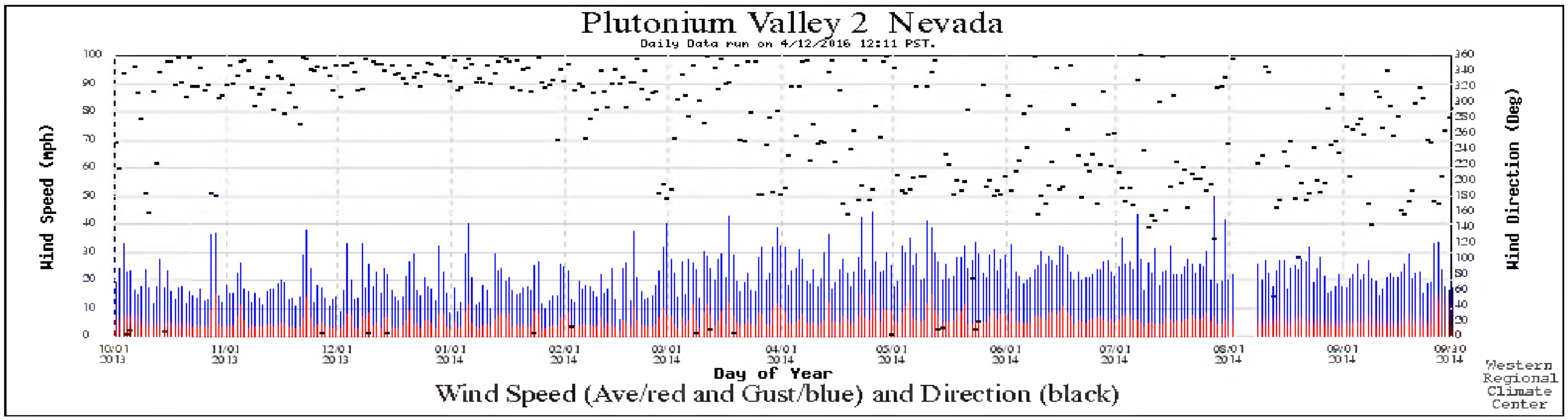

Figure D-4. Wind speed (red: daily average; blue: daily peak gust) and wind direction (black marks) recorded at Plutonium Valley station #2 (north) from October 1, 2013, to September 30, 2014.

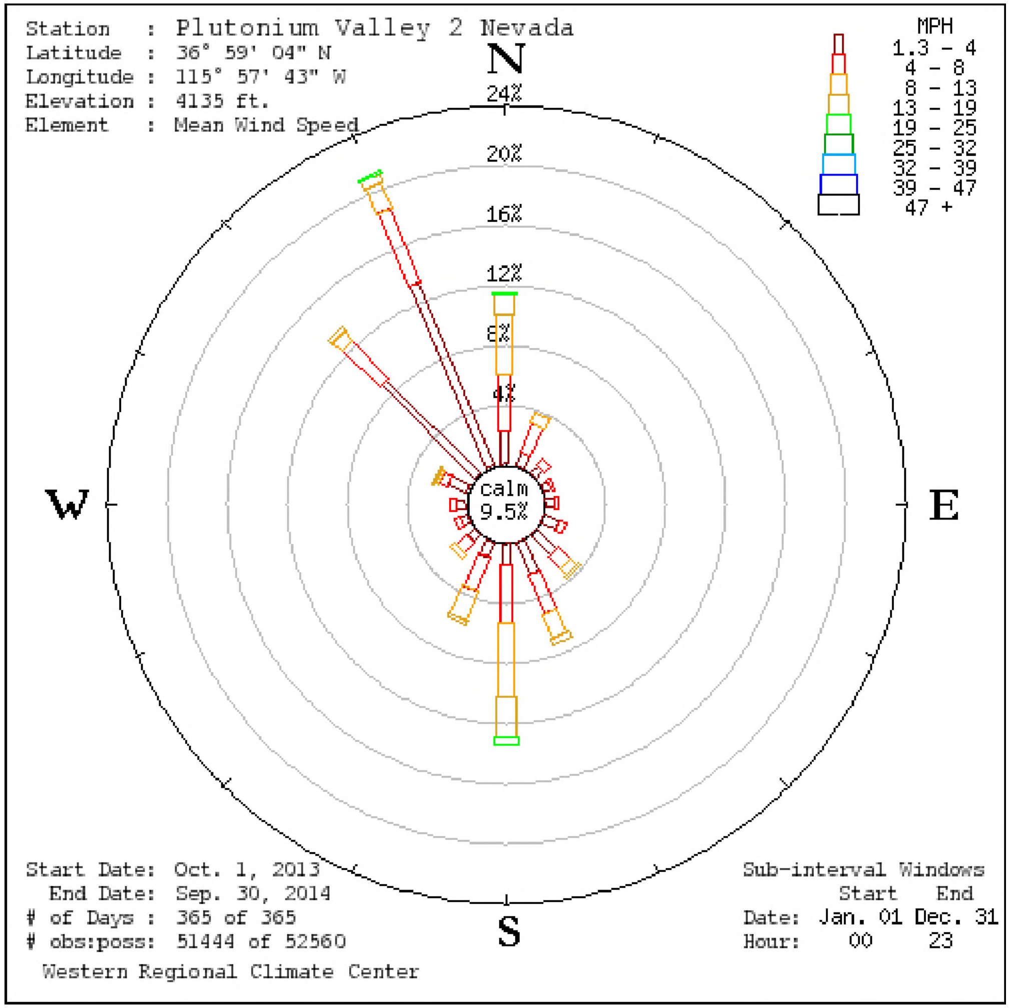

Figure D-5. Wind rose for the period of October 1, 2013, to September 30, 2014, at Plutonium Valley station #2 (north).

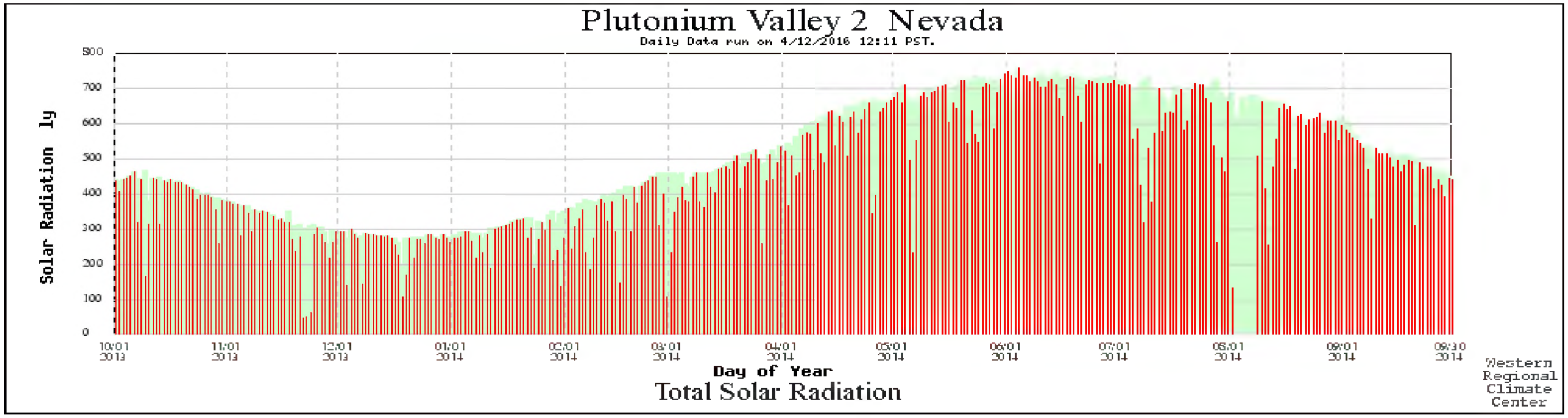

Figure D-6. Daily solar radiation recorded at the Plutonium Valley station #2 (north) from October 1, 2013, to September 30, 2014. The underlying light green shaded area represents the period-of-record (2011 to 2014) maximum daily solar radiation.

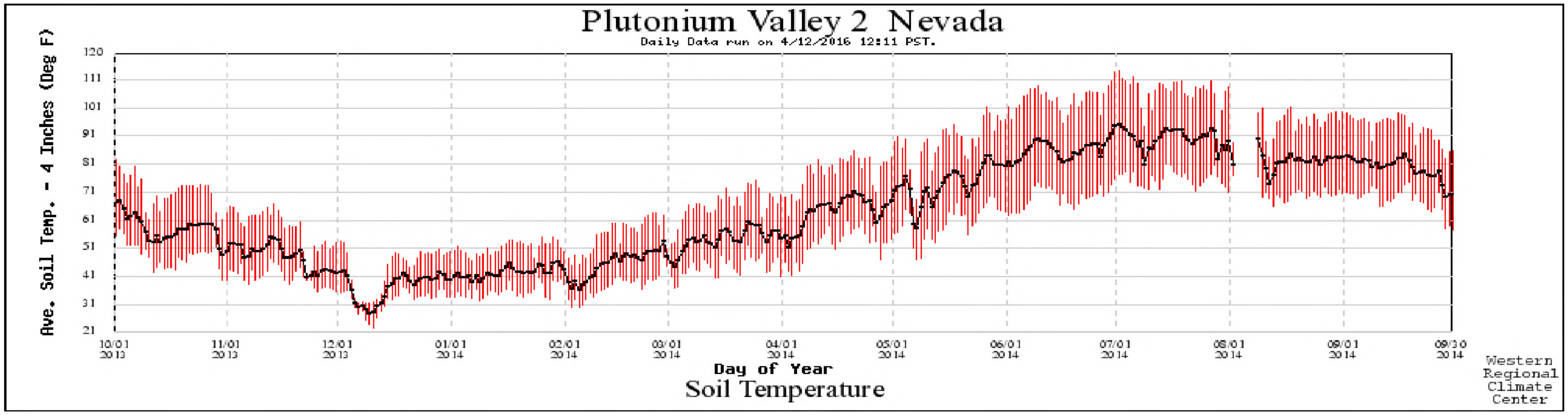

Figure D-7. Daily soil temperature average (black line) and maximum and minimum (red bars) recorded at the Plutonium Valley station #2 (north) from October 1, 2013, to September 30, 2014.

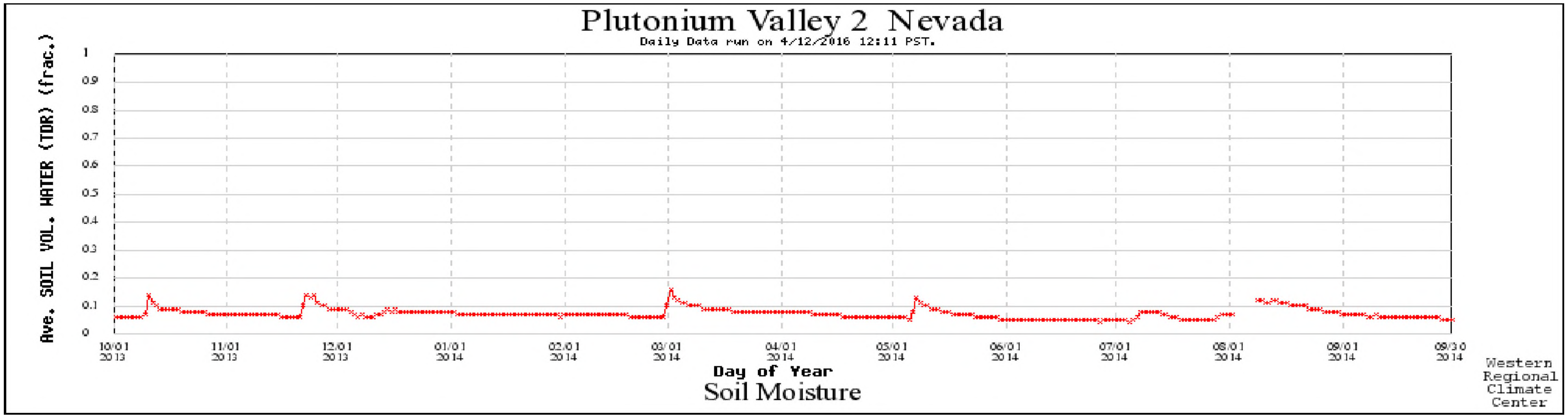

Figure D-8. Daily average soil moisture recorded at the Plutonium Valley station #2 (north) from October 1, 2013, to September 30, 2014.

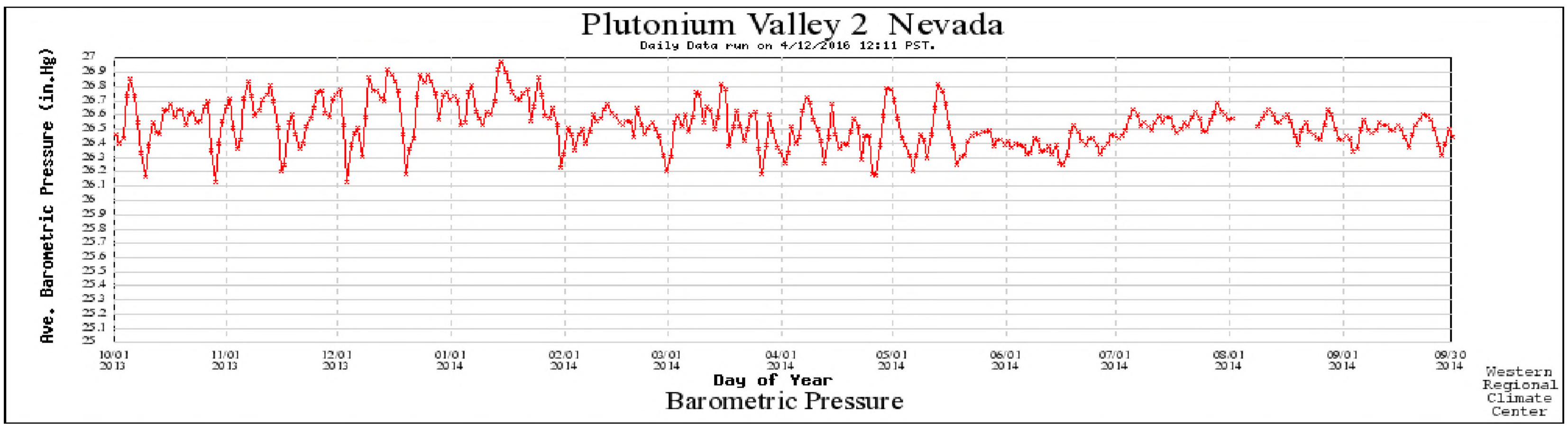

Figure D-9. Daily average barometric pressure recorded at the Plutonium Valley station #2 (north) from October 1, 2013, to September 30, 2014.

APPENDIX E: MAJOR WIND AND DUST EPISODES DURING FY2014

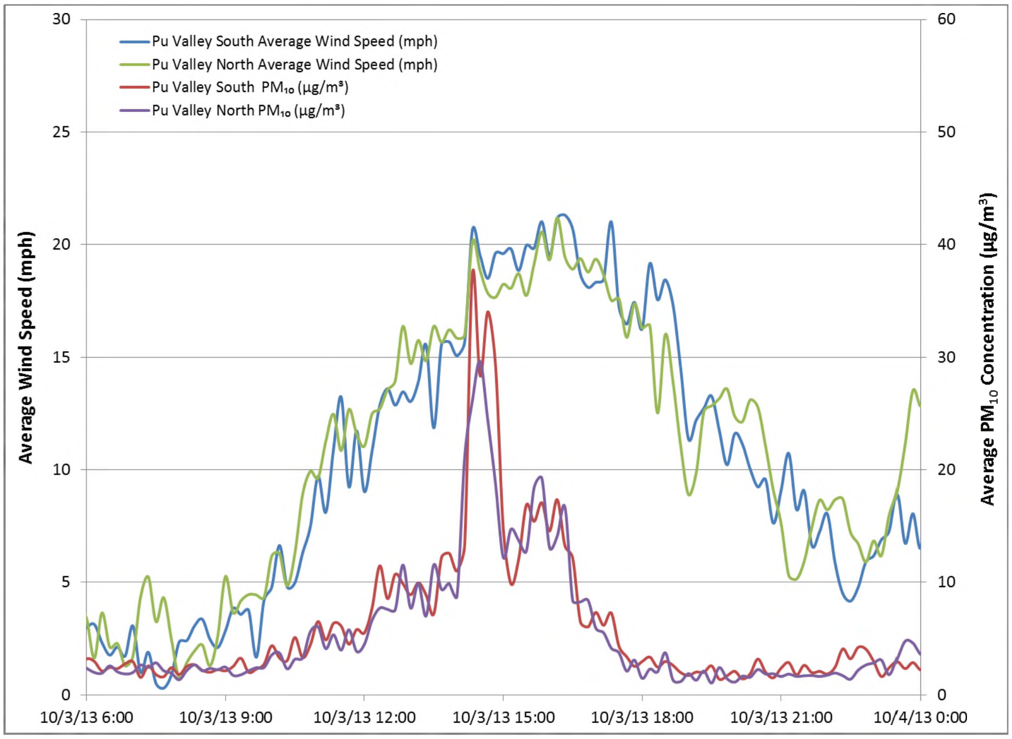

Figure E-1. October 13, 2013, dust transport episode Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

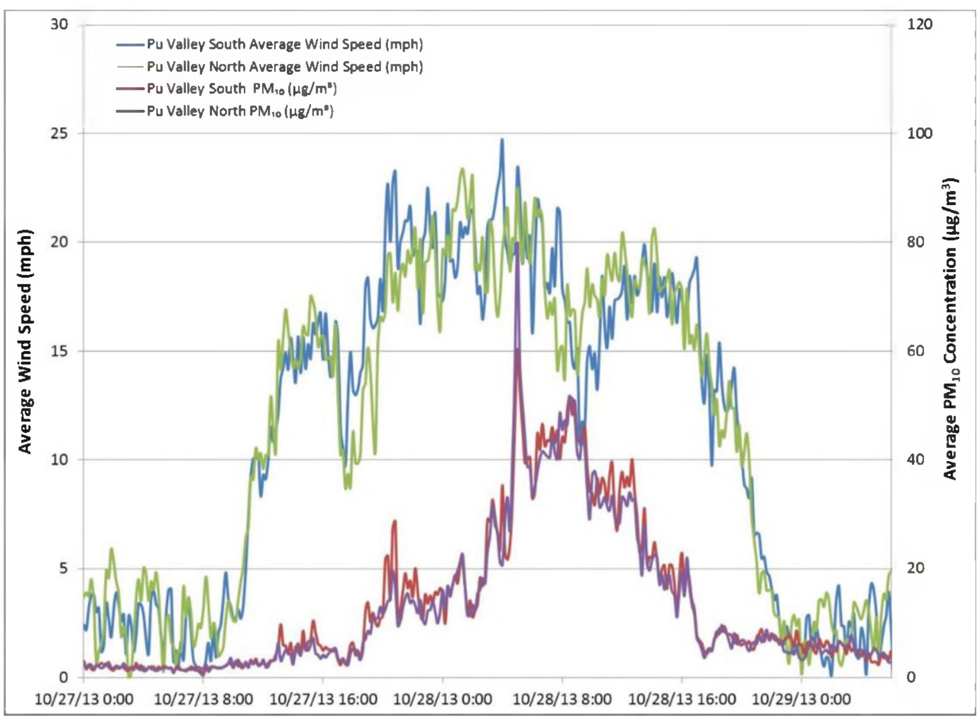

Figure E-2. October 28, 2013, dust transport episode Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

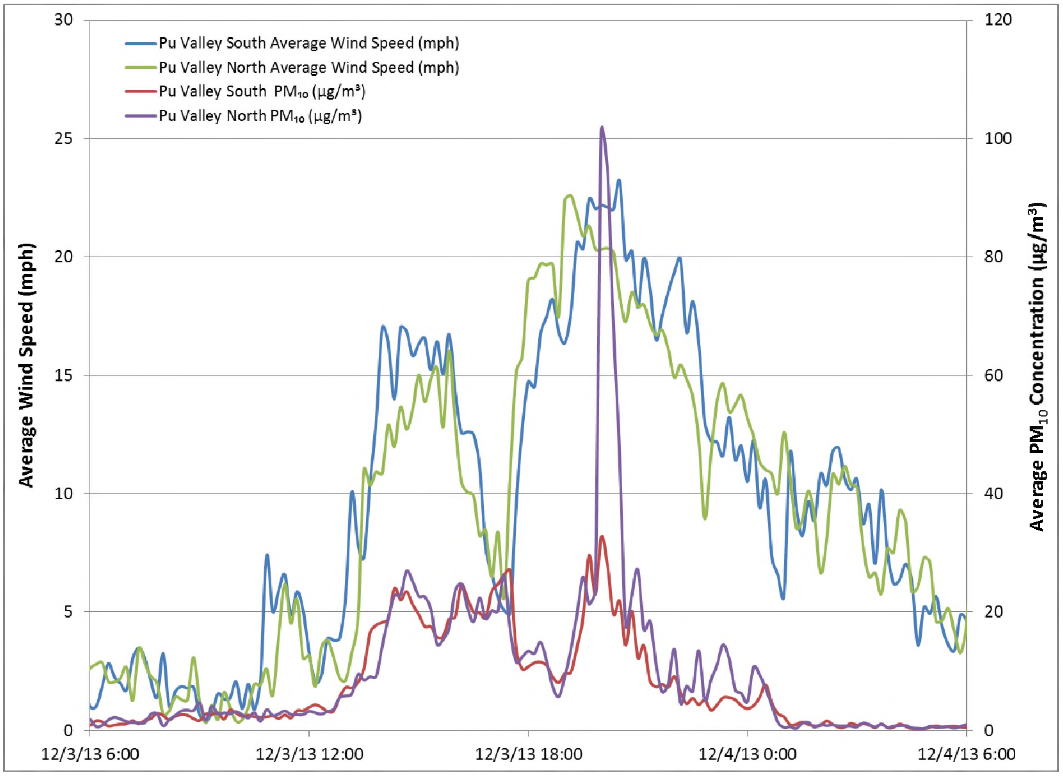

Figure E-3. December 3, 2013, dust transport episode Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

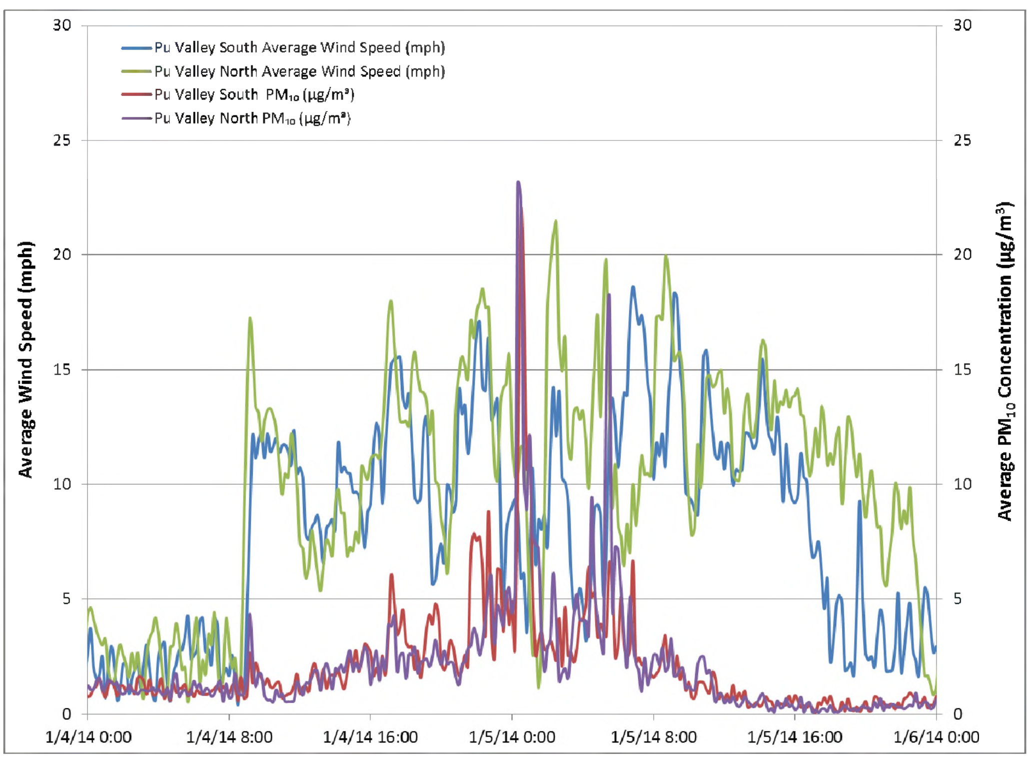

Figure E-4. January 5, 2014, dust transport episode Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

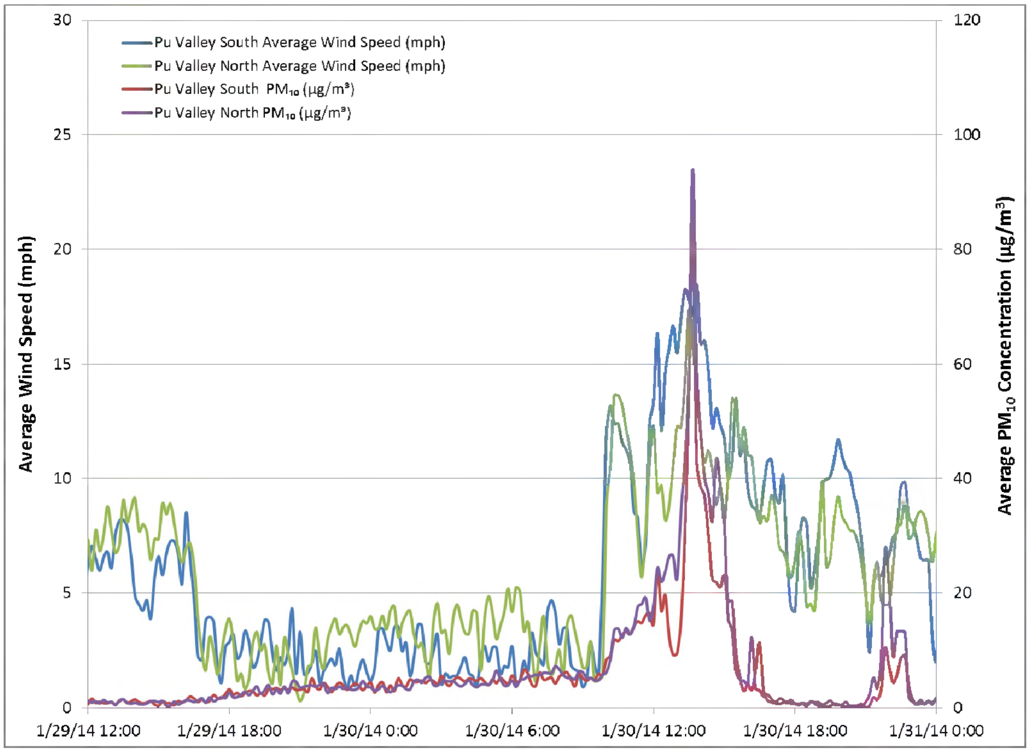

Figure E-5. January 30, 2014, dust transport episode Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

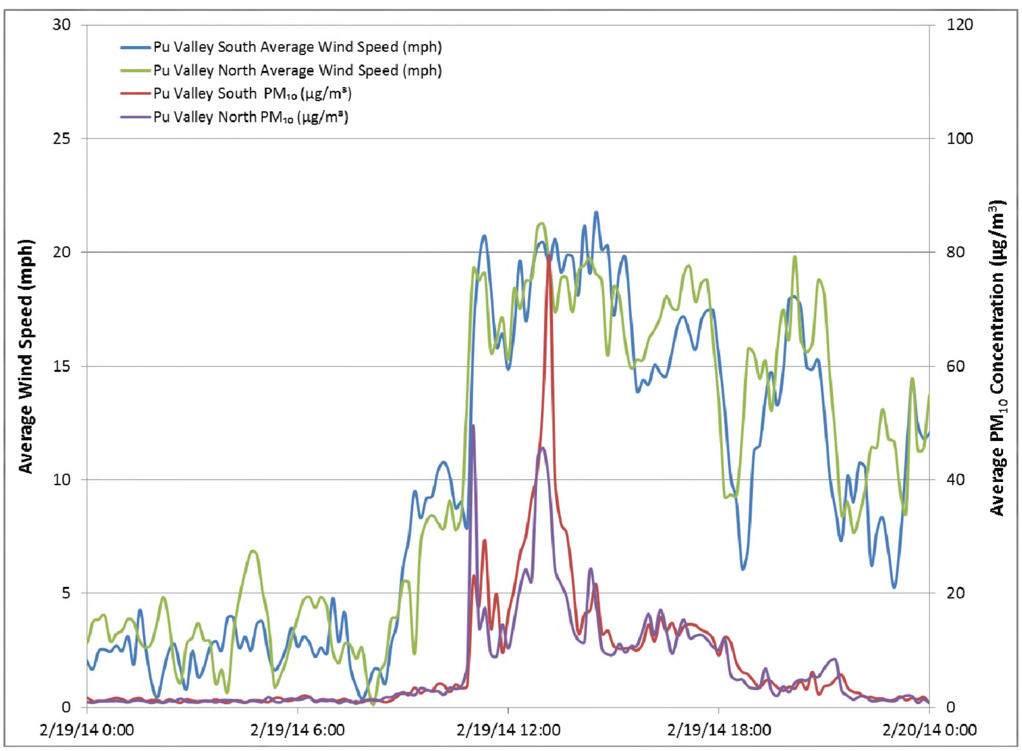

Figure E-6. February 19, 2014, dust transport episode Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

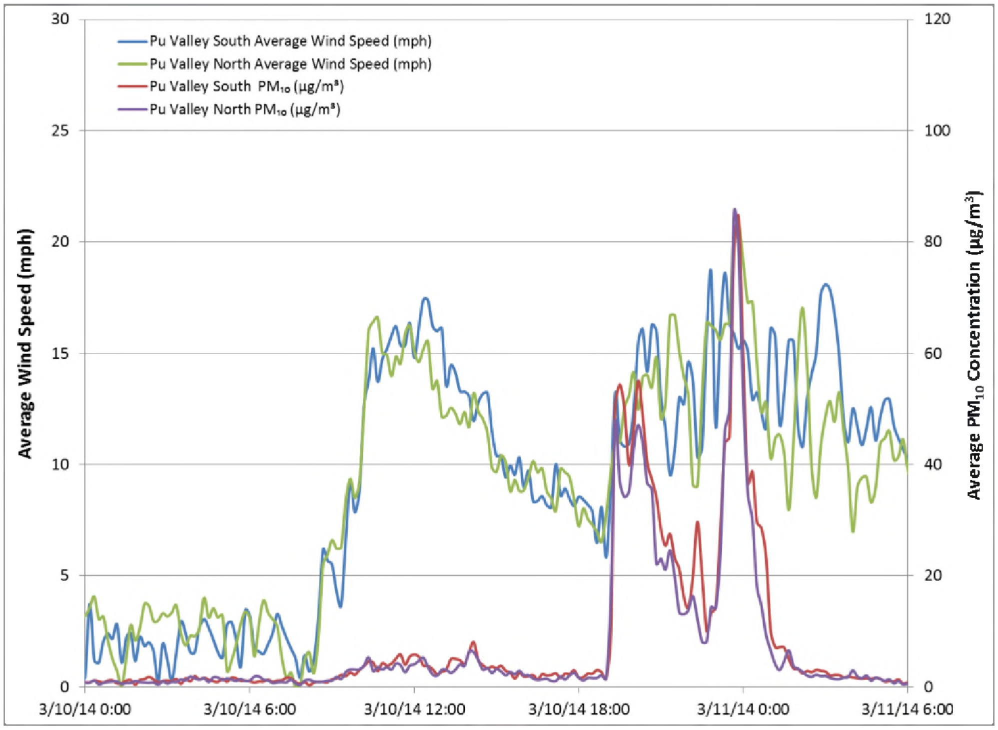

Figure E-7. March 10, 2014, dust transport episode Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

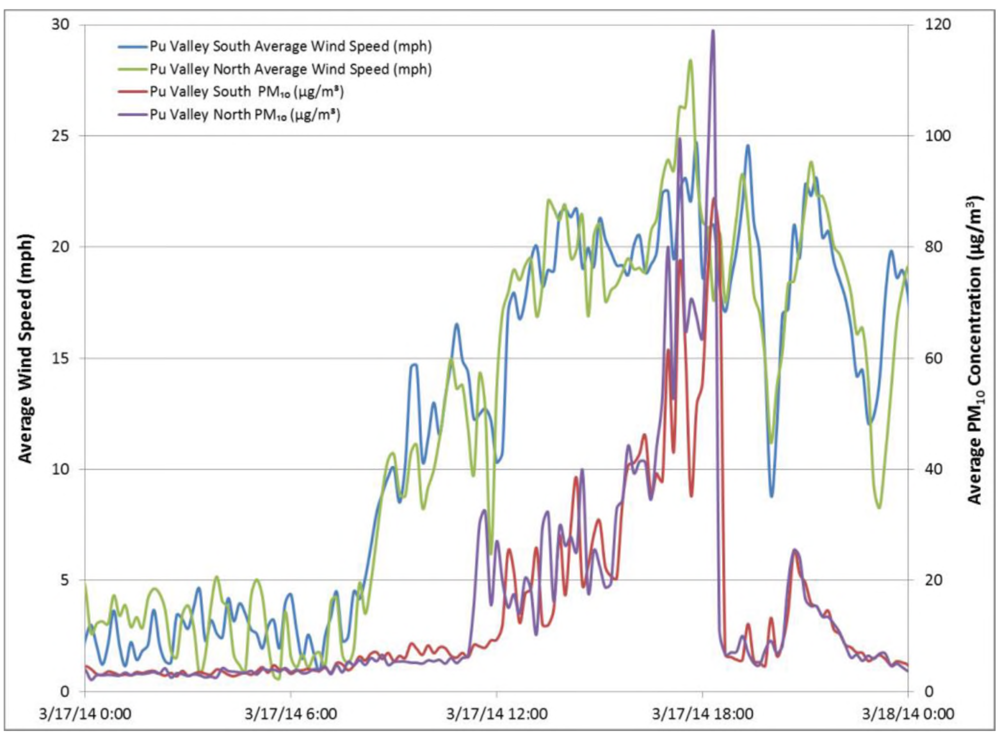

Figure E-8. March 1, 2014, dust transport episode at Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

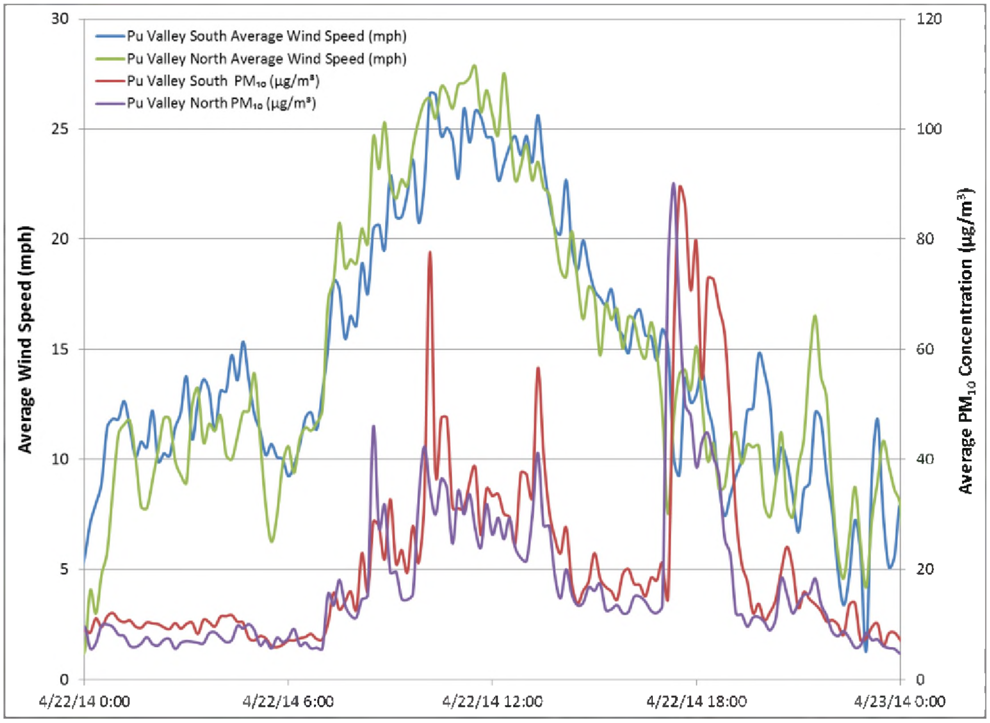

Figure E-9. April 22, 2014, dust transport episode at Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

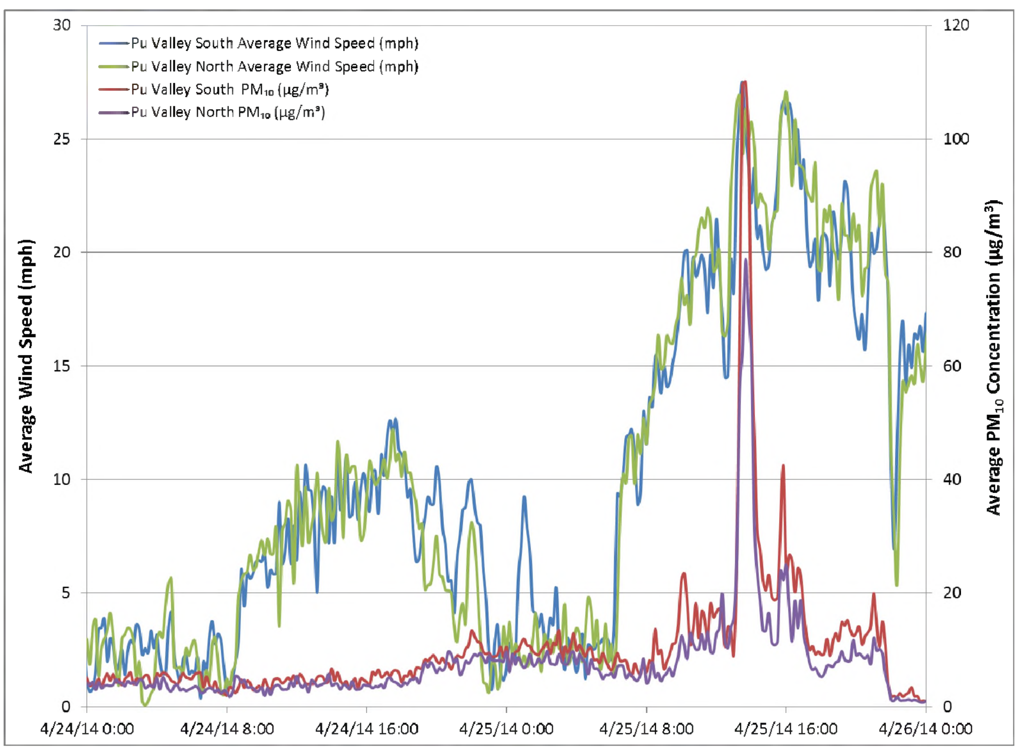

Figure E-10. April 25, 2014, dust transport episode at Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

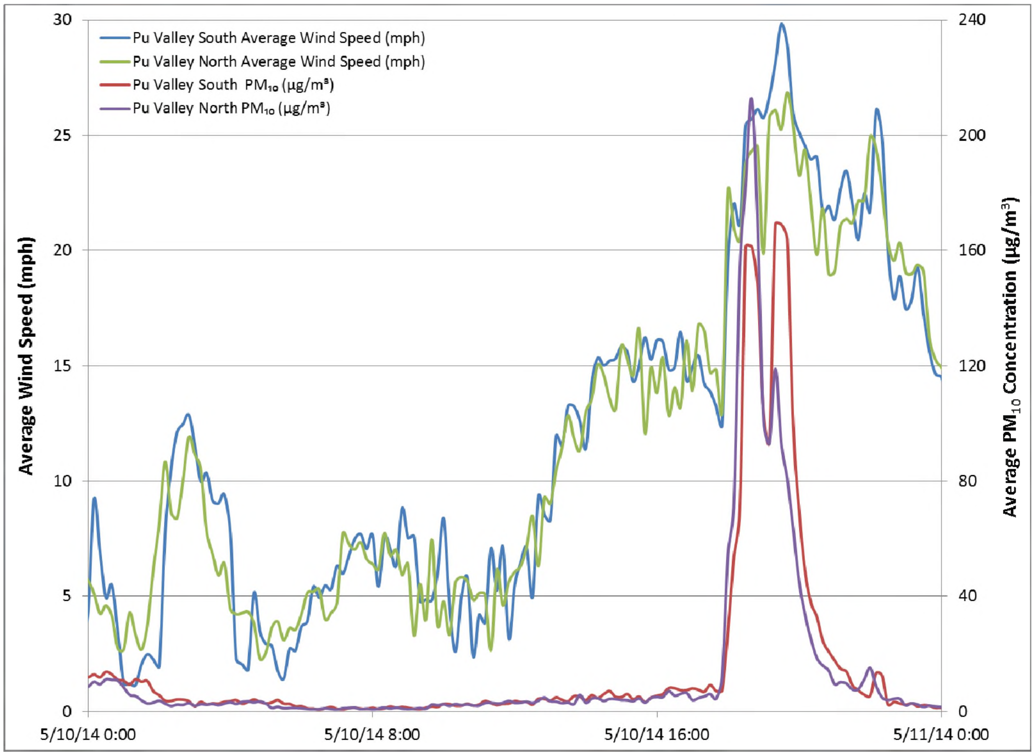

Figure E-11. May 10, 2014, dust transport episode at Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

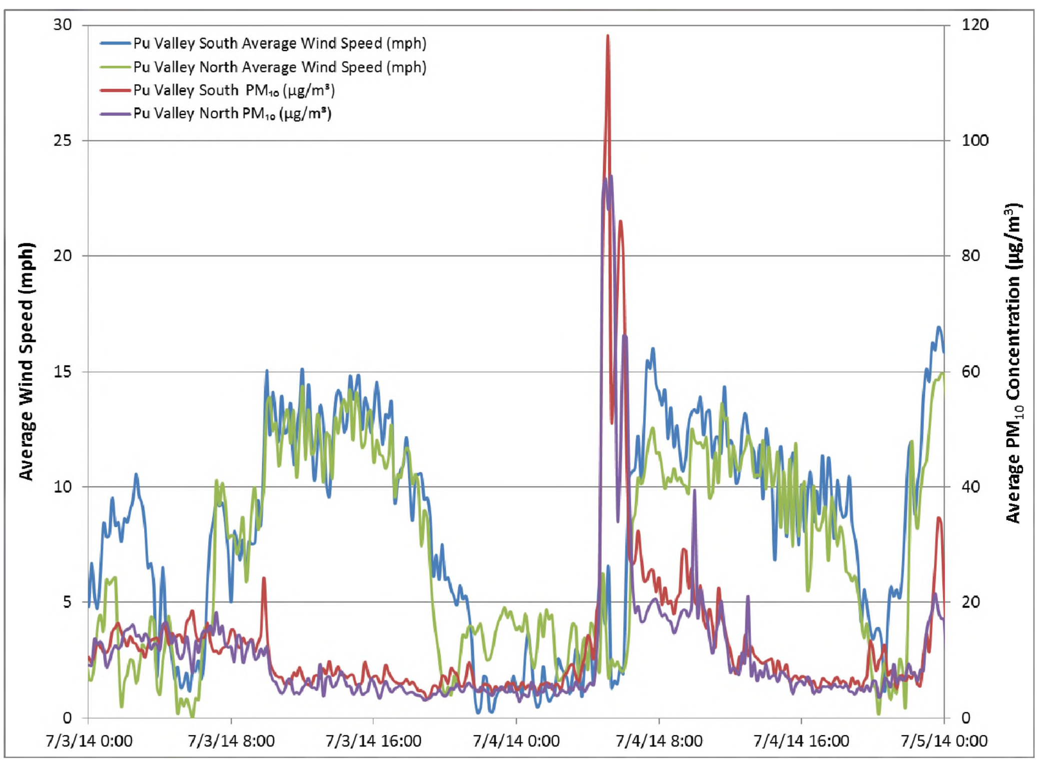

Figure E-12. July 4, 2014, wind and dust transport episode at Plutonium Valley stations #1 (blue line, red line) and #2 (green line, purple line).

APPENDIX F: ISCO SAMPLER OPERATION FY2013 AND FY2014

The ISCO automated sampler is turned on when water is determined to be present in the channel at a sufficient, specified depth. Water presence is determined by a pressure transducer that is calibrated to report the water depth above the transducer and a photoacoustic sensor that is calibrated to report the distance from the sensor to the channel bed or water surface. A wetness plate that indicates the presence of water was added to the detection system on July 15, 2014. It was in place for only 10 weeks at the end of FY2014. Because all three water observation systems are subject to error, the ISCO sample pump is turned on only when all three sensors indicate that sufficient water is present for each of six consecutive observations, which are collected at 10 second intervals.

The pressure transducer is programed to report the depth of water above the sensor based on the pressure of water above the transducer. The pressure value is corrected for water temperature using the temperature of the pressure transducer sensor. The pressure transducer is set between cement paving blocks placed in the channel to give the photoacoustic sensor a clean, level reflecting surface. The pressure transducer is approximately two inches below the top of the paving blocks. Because a two-inch water depth is required to ensure that the ISCO intake is completely submerged, the transducer output instructs the ISCO to collect a sample only if the water depth above the transducer is greater than four inches. The pressure transducer is subject to output errors because it tends to dry out when the channel is dry and humidity is low and requires some time to rewet and give accurate values of pressure and water depth.

The photoacoustic sensor produces a sound wave and measures the time between emission and return of the wave from a reflecting surface. The observed time is interpreted to give the distance from the sensor to the reflecting surface. Distance from the sensor to the dry channel reflecting surface at the Plutonium Valley installation was 4.5 feet when installed in 2011 and 1.74 meters (5.6 feet) after the sensor was replaced in 2014. The photoacoustic sensor authorizes the ISCO to turn on if the distance to the reflecting surface is less than 1.6 meters, which is approximately equivalent to a water depth of 5.5 inches. The photoacoustic sensor will also respond to other objects, such as tumbleweeds, and is therefore subject to errors in determining the presence of water in the channel.

The wetness plate is set on edge and embedded into the surficial channel-bed sediments. When dry, the wetness plate has a resistance of 150 ohms. Resistance of the wetness plate decreases as moisture on the plate increases. It is programmed to report the presence of water when resistance of the plate is < 100 ohms. The moisture increase may result from the presence of water in the channel, condensation from high humidity, or high water content in the channel bed sediments.

Activation of the ISCO sampler is indicated by a change in the bottle count report. The count goes from zero to one when the ISCO is turned on. Graphs of precipitation, water depth, and distance to the reflecting surface for the day before and after the bottle count increase are plotted in Figure F-1. Although no precipitation was reported on April 16, 2014, the bottle count incremented to one on that day. Both the average and maximum water depth values indicated by the pressure transducer exhibit a diurnal cycle that has a minimum at approximately 0600 hours, which indicated no water above the transducer, and a maximum at approximately 1600 hours, which indicated approximately four inches of water. Four inches of water above the transducer would be sufficient to instruct the ISCO to collect a sample. From approximately 1315 hours to approximately 1600 hours, the photoacoustic sensor indicated an average distance to the reflecting surface of approximately 4.5 feet, but the minimum and maximum observed distances during that period were approximately 4 feet and 9 feet, respectively. The minimum distance at four feet would be equivalent to approximately six inches of water in the channel and would have been sufficient to instruct the ISCO to collect a sample. At the time, the ISCO was instructed to turn on if either the pressure transducer or the photoacoustic sensor indicated sufficient water in the channel during any one observation. Because both the measurements of the water depth and the distance to the water surface instructed the ISCO to collect a sample, the ISCO turned on and the bottle count jumped to one. However, on July 15, 2014, when personnel arrived on-site to retrieve the sample and reset the ISCO command program, none of the collection bottles contained water. This was a failed collection effort that potentially resulted from erroneous indications of the presence of water in the channel from both sensors. The wetness plate was installed on July 15, 2014, to reduce the chances of an erroneous instruction to turn on the ISCO and increase the likelihood that a sample would be collected if the ISCO was turned on. At the same time, the program instruction to turn on the ISCO was modified to require five consecutive observations that exceed the "turn on" criteria for each sensor.

Because the ISCO reset must be performed manually, the ISCO could not run a second time between April 16, 2014, and July 15, 2014. Because the water sensors did not instruct the ISCO to collect a sample on any other occasion during FY2013 and FY2014, no water samples were collected and no suspended sediment analyses were performed during these two years of operation.

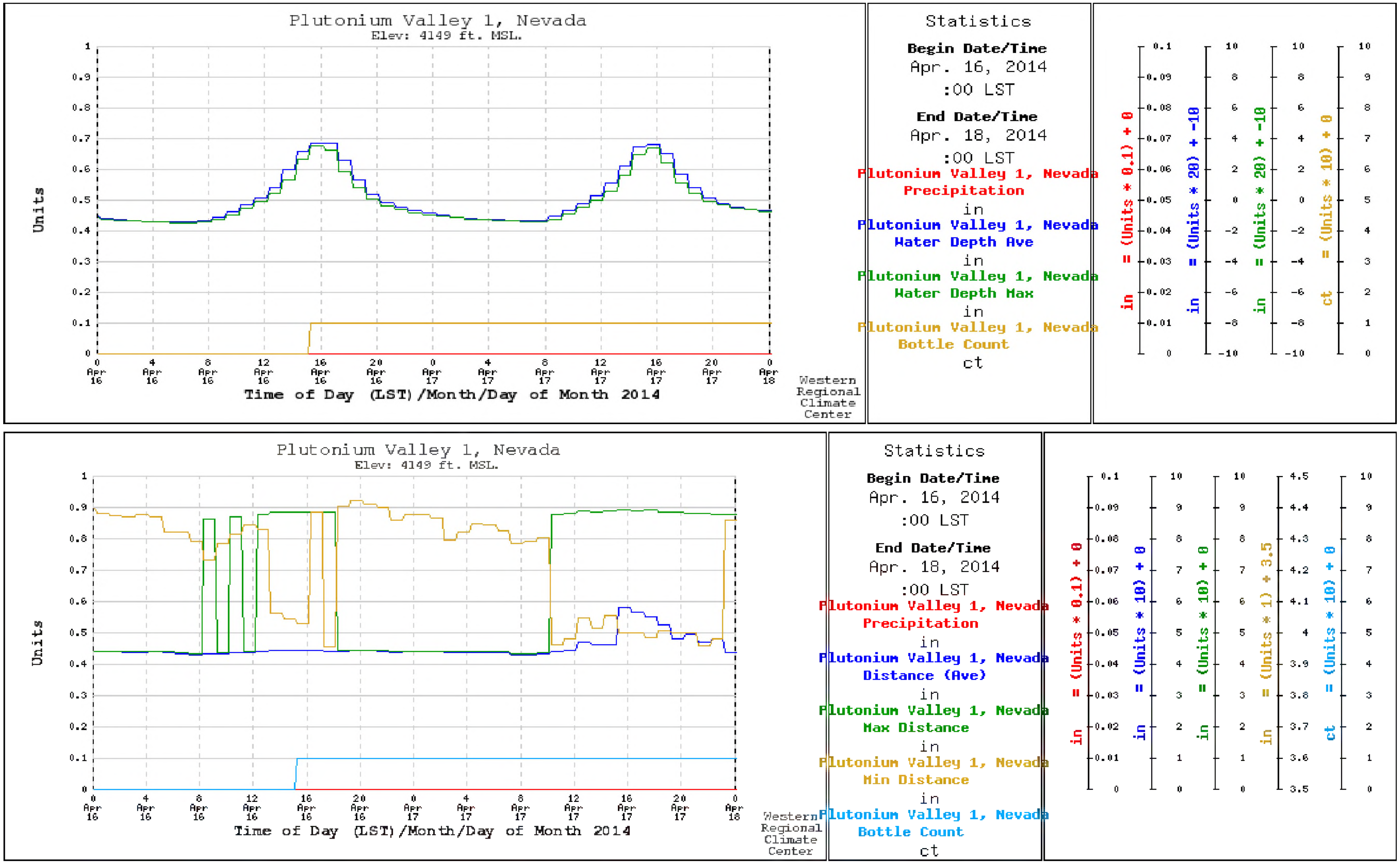

Figure F-1. The pressure transducer indicated a high value approximately 5 inches above the minimum (top) and the photoacoustic sensor (bottom) indicated a series of minimum distances of approximately 4.04 units and a series of maximum distances of approximately 9 units at the time the bottle count advanced.