Air Monitoring Needs and Recommendations for New Mexico-Chihuahua Rural Task Force Region Columbus-Palomas, Deming, Ascension

Background:

Air quality has been the principal environmental issue in the New Mexico-Chihuahua Rural Task Force (RTF) region since the task force was created in 2005. Establishing an air quality monitoring network was the primary objective identified by communities in initial strategic planning sessions (see attached RTF strategic plan for Air Quality goal).

A PM10 and PM2.5 special study was conducted in 2005-2006 by New Mexico State University using SCERP funding and in collaboration with the Rural Task Force. This study showed extremely high concentrations of PM10 in Palomas and PM2.5 at the Columbus-Palomas Port of Entry.

In 2009, the Rural Task Force forwarded these results to the Air Policy Forum (APF) and requested technical assistance to establish a permanent air quality monitoring network in the sister cities and to design a community notification system for high PM events (see attached letter).

While continuing to pursue permanent air quality monitoring for Columbus-Palomas, the RTF continued its efforts to promote particulate matter and dust control measures that contribute to high ambient concentrations of PM10 and PM2.5 in the sister cities. Projects included the following:

- **Completed a GIS inventory of paved and unpaved roads in Columbus and Palomas** in 2008 to determine contribution of unpaved roads to windblown dust emissions; completed traffic counts in Palomas; created maps of paved/unpaved roads. Since that time, high traffic road between Port of Entry and Palomas Primary School has been paved. The GIS inventory for Columbus helped the Village prioritize road-paving projects.
- **Organized Dust Control Methods Workshop** in 2008 to provide information to local officials and operators on measures for road paving, windblown dust from CAFO's and cleared land. Palomas Cattle Facility installed wall and laid down rock in parking lot to keep down dust.
- **Scrap Tire Workshop, Clean-up and Disposal** to prevent scrap tire burning carried out in 2005 – 2007. Burning of scrap tires contributes to PM air quality concerns in Palomas.

In 2012, the Border 2012 Program also funded a PM Saturation Study for Columbus-Palomas in order to better understand the contributions of various emission sources to ambient PM concentrations in the sister cities. Conducted by New Mexico state climatologist Dr. Dave DuBois as part of the Binational Air Quality Assessment and in collaboration with the NM-Chih Rural Task Force, the study found that dust was highly dependent on location and can vary considerably over small distances of one kilometer in the Columbus-Palomas area. (See attached PM Saturation Study for Columbus-Palomas.)

In response to RTF requests for technical assistance from the Air Policy Forum on ambient air quality monitoring in Columbus-Palomas, the APF co-leaders and participants decided at the San Antonio National Coordinators Meeting in May 2011 that an air monitoring needs assessment was required not only for Columbus-Palomas and other border rural areas, but for border urban areas as well. The contractor was asked by the APF to co-lead with SEMARNAT's Gerardo Tarin Torres a working group on ambient monitoring in rural and urban areas. Under this contract, the contractor worked collaboratively with SEMARNAT and border state air monitoring staff to develop the border-wide air monitoring needs assessment and provided a summary and recommendations to the APF.

Air monitoring recommendations for the RTF region were developed with the NM state climatologist Dave DuBois. Follow-up activities include implementation of meteorological monitoring in Columbus and Palomas, outreach to Columbus and Palomas stakeholders on the results of the PM saturation study, and facilitation of community engagement in future air quality monitoring efforts in Columbus, Palomas and Ascension.

Borderwide Air Monitoring Needs Assessment

The Border 2012 Air Policy Forum established an air monitoring working group at its May 2011 meeting in San Antonio, TX. The purpose of the working group is to identify and evaluate the air monitoring needs for both rural and urban areas throughout the US-Mexico border region in the following areas:

- Need for additional monitoring equipment and/or network expansion in border communities;
- Technical assistance in operating, maintaining and auditing monitoring systems;
- Sharing and dissemination of information through monitoring networks and tools like AIRNow.

The group was charged with reporting to the Air Policy Forum its findings and recommendations for improving border air quality monitoring efforts. Representatives from local, state and federal governments volunteered to serve on the working group. Allyson Siwik, U.S. Co-Leader of the Border 2012 New Mexico-Chihuahua Rural Task Force, and Gerardo Tarin of SEMARNAT-Cd. Juarez agreed to coordinate the working group.

A meeting of the group brought together representatives of federal, state and local governments, and academia to evaluate needs and develop recommendations for improving air monitoring in border communities.

Needs Assessment

Adequacy of Existing Networks in New Mexico-Chihuahua Rural Task Force Region

- Deming, NM has a permanent CAMS site with PM10, O3, and NOx monitoring, as well as one PM10 NCAMS.
- No permanent meteorological or air quality monitoring exists in Palomas or Ascension.
- There is one meteorological station located in Columbus at Martha's B&B. This station will be moved to Pancho Villa State Park once the electrical system can be worked out to accommodate the met equipment.

- Some level of monitoring is needed in Columbus, Palomas and Ascension, such as improved meteorological monitoring for high wind events and low cost air quality monitoring equipment.
- Biological samples such as the fungi aspergillus and Coccidioides immitis that causes Valley Fever should be collected given prospect of increased ambient concentrations of PM given long-term drought brought about by climate change combined with overgrazed rangeland.
- Need to determine the best way to administer monitoring in RTF region given the lack of capacity and regulatory authority at the local level.

Community Notification in the New Mexico-Chihuahua Rural Task Force Region

- Rural areas lack the ability to provide notification to communities about air quality and how to reduce exposure.
- Although Deming has an air quality monitoring station, it is not integrated into AIRNow and thus real-time air quality data is not available.
- Need air quality modeling to provide air quality forecasts for border communities, including the NM-Chihuahua Rural Task Force region.

Financing

- Sufficient funding was identified as the largest obstacle to improved air quality monitoring in border communities.

Recommendations

- Establish air and/or meteorological monitoring in Rural Task Force Region as appropriate

    - It is recommended that the border states take the responsibility for monitoring in rural areas given established legal authority for public health protection and greater capacity to manage the effort.
    - Because of the high cost of establishing monitoring stations and the fact that both US and Mexican air quality regulations do not require permanent monitoring networks in low population areas, establish meteorological stations in these areas and determine threshold wind velocities that cause regional and local occurrences of high PM to aid in community notification. In Mexico, make available on the internet Agro Clima sensors in rural areas such as Ascension to help with community notification.

- Improve community notification of high air pollutant concentrations in the Rural Task Force region

    - Build strong partnership with the National Weather Service. Provide information to NWS to alert communities to high air pollution events and to

disseminate actions to be taken to minimize personal exposure. NWS needs raw data that is compatible with their systems.
- Conduct community education in rural areas about how to reduce exposure to high PM concentrations.
- Integrate Deming monitoring networks in AIRNow
- Determine how to provide PM alerts to rural communities, such as Columbus-Palomas-Ascension.
- Assist the NM Department of Health with calibration of the DREAM model by assisting with field observations and measurements. This remote sensing technology could be a useful tool in measuring and forecasting dust concentrations in rural areas of the border.
- Support surveillance projects in rural areas to gain better understanding of health effects from high PM concentrations. Research is needed to determine most effective ways to reach rural communities with advisories to reduce pollutant exposure.
- Track sources of dust for mitigation. In some cases it is the same sources or properties causing dust problems. These sources need to be addressed.

Status of Implementation of Recommendations

Through collaborative efforts between the Binational Air Quality Assessment led by New Mexico state climatologist Dr. Dave DuBois and the New Mexico-Chihuahua Rural Task Force, progress continues to be made in implementing the recommendations outlined above. The following actions have been taken since completion of the needs assessment.

- <u>Identification of meteorological monitoring site in Palomas</u> – The Rural Task Force facilitated identification of the Palomas Library as the site for a meteorological monitoring station. Dr. DuBois will purchase laptop and met equipment and set up the station. Border Partners and local teachers and students will assist with the operation of the station.
- <u>Outreach to Columbus-Palomas stakeholders on PM Saturation Study, PM health effects and how to reduce exposure</u> – Community meetings were held in Columbus and Palomas in November 2013 to report out the results of the April 2013 study and discuss PM health effects and ways to reduce exposure. Approximately 30 people were in attendance. A powerpoint in Spanish was presented by Dr. DuBois and simultaneous interpretation in Spanish was provided. Fact sheets and brochures on PM air quality and health effects were distributed. Promotoras and teachers from Palomas participated and many were interested in participating in future meteorological and air quality monitoring.

Action Plan for Air Quality Monitoring in Columbus-Palomas

Action	Schedule	Responsible Organization	Notes
Identify and establish sites for meteorological and air quality monitoring in Columbus-Palomas	Columbus – completed Palomas – Q2 2014	Dr. Dave DuBois, Binational Air Quality Assessment	Columbus – Martha's B&B to be moved to Pancho Villa State Park Palomas – Palomas Library
Identify, evaluate and purchase air quality monitoring equipment	Columbus-? Palomas ?	Dr. Dave DuBois Binational Air Quality Assessment	
Develop local capacity for operation of met and air monitoring equipment	Columbus ? Palomas ?	Dr. Dave DuBois, Rural Task Force	Local volunteers identified; training materials to be developed & translated; training conducted.

Air Quality Monitoring Training Needs in Columbus-Palomas

Action	Responsible Organization	Notes
Collect or develop Standard Operating Procedures/Manuals for air monitoring equipment	Dr. Dave DuBois, Binational Air Quality Assessment	
Translate SOP's and/or manuals	Dr. Dave DuBois Binational Air Quality Assessment	
Conduct training sessions for operation of monitoring equipment	Dr. Dave DuBois, Rural Task Force	

Border 2012 Air Policy Forum Air Monitoring Needs Assessment

Geographic Area	Pollutants of concern/met data	Network Description	Adequacy of existing network	Operability of Network	Current, planned or future capability for integrating with AIRNOW or other community notification	Identified Needs	Recommendations
Columbus, NM – Palomas, Chih.	PM 10 PM2.5	No permanent network Special Studies 1) SCERP –1 in 3 day monitoring done for ~1 year – 2006; no meteorological data 2) OBH/Border 2012 PM10 Saturation Study 1in2 day monitoring for 1 month; meteorological data collected – April 2012	No existing network	NA	Would like ability to provide community notification for days with high concentrations of particulates	-Long-term tracking of PM10 and PM2.5 levels in response to implementation of PM control measures - Community notification of high PM concentrations	-Establish air and/or meteorological monitoring in rural areas as appropriate. -Improve community notification of high air pollutant concentrations in both rural and urban areas
Deming, Luna Co, NM	PM10, O3, NOx	Permanent CAMS site with PM10, O3, and NOx monitoring. One PM10 NCAMS	Adequate	Permanently operated by trained technicians.	Not integrated into AIRNOW.		Integrate this network into AIRNow
El Paso, TX	Ozone, PM10, PM2.5, CO, NO, NO2, NOx Met	Permanent network of 6 CAMS. All equipped with CO, NOx, O3, & Met. Special purpose sites for H2S. Several PM10 NCAMS also.	Adequate, Needs expansion .	Permanently operated by trained technicians.	Currently integrated into AIRNOW.	System needs to be expanded into NW, NE, & SE of the county.	Expand existing air monitoring networks
Cd. Juarez, Chih.	Ozone, PM10, PM2.5, CO Met	Permanent network of 3 CAMS. All equipped with CO, O3, & Met. 12 PM10 NCAMS also operated (1 collocated), 6 PM2.5 e-bam	Adequate, Needs expansion and financing	Permanently operated by trained technicians.	Currently integrated into AIRNOW.	System needs to be expanded into W, SE, & SW part of the municipio. Funding for O&M of network Training needs	- Expand existing air monitoring networks - Ensure operability of monitoring networks

Doña Ana County, NM	Ozone, PM10, PM2.5, CO Met	Permanent network of 6 PM10 and O3 CAMS and 3 NOx CAMS. Two PM10 and PM2.5 NCAMS. All sites equipped with Met except one.	Adequate, Needs expansion .	Permanently operated by trained technicians.	Currently integrated into AIRNOW.	PM2.5 chemical speciation and continuous monitoring using a FRM or FEM instrument.	Expand capabilities of existing monitoring stations where needed
Ojinaga, Chihuahua	3 PM10 NCAMS, no Met	Permanent network of 3 PM10, operated by City of Ojinaga with support (technical assistance) of CIMAV	Adequate. Needs financing	Permanently operated by trained technicians.	Not integrated into AirNow	No plans for expansion, but supplies are needed.	-Ensure operability of monitoring networks - Improve community notification of high air pollutant concentrations in both rural and urban areas
Brewster County, TX	Ozone, PM2.5, Met	Permanent network of 1 CAMS located at K-Bar in Big Bend NP equipped with L3, PM2.5, & Met.	Adequate	Permanently operated by trained technicians.	Currently integrated into AIRNOW.	No plans for expansion.	None identified.
Del Rio, TX	Met	Operated by the NWS	Adequate	Permanently operated by trained technicians from the NWS.	Currently integrated into AIRNOW.	No plans for expansion.	None identified.
Eagle Pass, TX	PM2.5 & Met	Primarily assesses fine particulates from nearby lignite power plants.	Adequate	Operated by Eagle Pass ISD		No plans for expansion.	None identified.
Laredo, TX	CO, VOC (canister), PM10 (NCAMS)		Adequate	Operated by City of Laredo Health Dept.		No plans for expansion.	None identified.
Hidalgo County, TX	CAMS: Ozone, Met, PM10, PM2.5, NCAMS: VOC, SVOC,	Permanent network of 2 CAMS. One located in Mission, TX & one located in Mercedes, TX	Adequate	Permanently operated by trained technicians	Currently integrated into AIRNOW.	No plans for expansion.	None identified.

Cameron County, TX	CAMS: Ozone, Met, PM10, PM2.5, NCAMS: VOC, SVOC,	Permanent network of 2 CAMS. One located in Brownsville, TX & one Isla Blanca, TX	Adequate	Permanently operated by trained technicians	Currently integrated into AIRNOW.	No plans for expansion.	None identified.
Imperial County, CA	SLAMS: Ozone, PM10, PM2.5, NO2, CO, Met	Network consists of 5 Air Stations fully equipped with met instruments. All stations monitor for PM_{10}. Four (4) stations monitor Ozone – Two (2) stations monitor $PM_{2.5}$, CO, and NO_2. One station monitors Toxics, SO_2, H_2S, TSP, CR^{6+}, and solar radiation	Adequate	Operated by trained technicians	Not integrated into AIRNOW however the Air District maintains a real-time alert web page.	No plans for expansion – relocation of the Calexico Site is under review.	None identified.
San Diego County, CA	Ozone, PM10, PM2.5, CO, NOx, NOy, SO2, Pb, Toxic Compounds, Met Data	Permanent network of 10 monitors throughout densely populated areas of County (including Otay Mesa and Chula Vista in southern border region). Includes one National Core station (in El Cajon) integrating advanced measurement systems.	Adequate	Permanently operated by SDAPCD's trained technicians.	Currently integrated into AIRNOW.	Planned installation of one near-road NO2 monitor (possibly to include PM2.5 and CO).	None identified.
Nuevo Laredo, Tams	PM10	4 PM10 hi-vol (2 andersen, 2 wedding).		Operated by the city (supplies and change of filters provided by the City). Calibration is performed by the State quarterly.			None identified.
Reynosa, Tams	PM10	4 PM10 hi-vol (3 andersen 1 wedding)		-			None identified.
Matamoros, Tams	PM10	4 PM10 hi-vol (2 andersen 2 wedding)		-			None identified.
San Luis Río Colorado, Son	PM10	1 PM10 hi-vol (andersen)		-			Recommendation of changes to be addressed in network assessment

Nogales, Son	PM10, PST, O3, CO, NOx, SO2	2 PM10 (1 hi-vol andersen) 1 PST 1 CAMS (PEF 2011)equipped with CO, NOx, O3, SO2 &Met?		Operated by Tec de Nogales, owned by the State, (thru PEF 2011)			Recommendation of changes to be addressed in network assessment
Agua Prieta, Son	PM10, PST, O3, CO, NOx, SO2	1 PST, 1 CAMSequipped with CO, NOx, O3, SO2		Operated by Tec de Agua Prieta, owned by the State, (thru PEF 2011)			Recommendation of changes to be addressed in network assessment
Yuma County, AZ	PM10 Continuous, PM10 Filter, Ozone MET	Permanent network of Continuous PM10, Filter-base PM10 (1 in 6), ozone, and MET at Yuma Supersite	Adequate but under review	Permanently operated by trained technicians	Ozone and PM10 currently integrated into AIRNOW. Plan to upgrade PM2.5 monitor to continuous monitors in 2012/2013. (Border & PM2.5 grant funds) Daily ensemble forecast prepared for Yuma. Available by email, text, or on website http://www.azdeq.gov/environ/air/ozone/yumef.pdf This info provided for local school flag program.	Network assessment planned for 2012-2013 to assess	Recommendation of changes to be addressed in network assessment
Santa Cruz County (Nogales US), AZ	PM10 Continuous, PM10 Filter, PM2.5 Continuous (non-FEM), PM2.5 Filter, MET	Permanent network of Continuous PM10 &PM2.5, Filter-base PM10 and PM2.5 (1 in 6), ozone, and MET at Nogales Post Office	Adequate but under review	Permanently operated by trained technicians	PM10 currently integrated into AIRNOW. Plan to upgrade to FEM PM2.5 continuous monitor in 2012/2013. (Border & PM2.5 grant funds) Nogales PM Risk Forecast prepared from Oct-March. Available by email, text or on website. http://www.azdeq.gov/environ/air/ozone/nogales.pdf	Network assessment planned for 2012-2013 to assess	Recommendation of changes to be addressed in network assessment
Cochise County (Douglas US), AZ	PM10 Continuous, PM10 Filter, PM2.5 Filter, IMPROVE	Permanent network of Filter-base PM10 & PM2.5 (1 in 6), at Douglas Red Cross, Douglas, AZ	Adequate but under review, continuous PM10 planned in 2012	Permanently operated by trained technicians	Not currently integrated into AIRNOW. Plan to upgrade PM10 and PM2.5 monitors to continuous monitors in 2012/2013. (Border & PM2.5 grant funds) Preparing a review of Douglas IMPROVE data to other border IMPROVE sites in AZ, Ajo and Chiricahua, in 2012/2013.	Network assessment planned for 2012-2013 to assess	Recommendation of changes to be addressed in network assessment
Pima County, AZ	IMPROVE	Permanent IMPROVE sampler at Organ Pipe National Monument	Adequate but under review	Permanently operated by IMPROVE trained	Not currently integrated into AIRNOW. Data available on VIEWS http://views.cira.colostate.edu/web/	Network assessment planned for	Recommendation of changes to be addressed in network assessment

				technicians		2012-2013 to assess	
Baja California	Particles at Mexicali and O_3 and CO at Tijuana	Mexicali 4 automatic stations (O_3, CO, NOx, one with SO_2 $BAMPM_{10}$ & $PM_{2.5}$ and Manual PM_{10}) + 2 manual(PM_{10}) Tijuana-Tecate and Rosarito 5 automatic stations (O_3, CO, NOx, 2 SO_2, $BAMPM_{10}$ & $PM_{2.5}$ & Manual PM_{10}) + 2 manual (1 PST & 1 PM_{10}) Ensenada 1 automatic station(O_3, CO, NOx, $BAMPM_{2.5}$ & Manual PM_{10})	Adequate, but under review. Currently incorporating QA system.	Permanently operated by technicians trained by SDAPCD e INE	Integrated with SINAICA http://sinaica.ine.gob.mx/ and AIRNOW http://www.spabc.gob.mx/?id=25	Technician training recently incorporated. Equipment renovacion at Tijuana stations. Improve mobile station with monitors for H2S, BAMPM1, Betex for VOC.	Recommendation of changes to be addressed in network assessment

U.S.-Mexico Border 2020 Program
AIR POLICY FORUM AIR MONITORING WORKING GROUP

Final Report to the Air Policy Forum on Border Air Quality Monitoring Needs
April 2014

Purpose of Report

The Border 2012 Air Policy Forum established an air monitoring working group at its May 2011 meeting in San Antonio, TX. The purpose of the working group is to identify and evaluate the air monitoring needs for both rural and urban areas throughout the US-Mexico border region in the following areas:

- Need for additional monitoring equipment and/or network expansion in border communities;
- Technical assistance in operating, maintaining and auditing monitoring systems;
- Sharing and dissemination of information through monitoring networks and tools like AIRNow.

The group was charged with reporting to the Air Policy Forum its findings and recommendations for improving border air quality monitoring efforts at the August 2012 National Coordinators Meeting. Representatives from local, state and federal governments volunteered to serve on the working group. Allyson Siwik, U.S. Co-Leader of the Border 2012 New Mexico-Chihuahua Rural Task Force, and Gerardo Tarin of SEMARNAT-Cd. Juarez agreed to coordinate the working group ("Coordinators").

A meeting of the group was held July 6, 2012 in El Paso, TX and brought together representatives of federal, state and local governments, and academia to evaluate needs and develop recommendations for improving air monitoring in border communities.

Background

A number of factors indicate that a comprehensive evaluation of border monitoring networks is warranted at this time. Because the coverage of existing monitoring networks has not kept pace with the expanding footprint of many urban areas in the border region, cities such as El Paso, Juarez, Mexicali and Tijuana may need to establish additional monitoring stations in growth areas so that the networks are more fully representative of population exposure. Given logistical and financial issues, binational air quality monitoring in Arizona-Sonora has been suspended since 2011. There is currently a binational effort to review monitoring goals and objectives, network design, evaluate data and make recommendations for improvement of the binational network. Finally, special studies over the past several years demonstrate that many rural areas, such as Columbus, NM and Palomas and Ascensión, Chihuahua and Presidio, TX and Ojinaga, Chihuahua experience high concentrations of particulate matter from wind-blown dust, yet air quality monitoring capability is lacking. Although regulatory structures in both the US and Mexico do not require a permanent air quality network in rural communities with low population, there is a need to notify communities of high pollutant concentrations and provide information on how to reduce exposures. As the Border 2012 Program comes to a close and the new Border 2020 Program is initiated, specific air monitoring needs from this effort can be identified and incorporated into the action plans of the Regional Workgroups and Air Policy Forum.

Border Air Quality Monitoring Needs Assessment

A course scale air quality monitoring needs assessment for border communities was conducted by the Air Monitoring Working Group Coordinators. State and local air monitoring network contacts were surveyed to collect information such as network description including pollutants of concern and measurement of meteorological data, the adequacy of the existing network, the operability of the network, current, planned or future capability for integrating with AIRNow or other community notification system, and identified air monitoring-related needs. This information was compiled into a table to facilitate review and analysis by the Working Group. (Please see attached Monitoring Needs Assessment table.)

On July 6, 2012, the Coordinators held a Working Group meeting of local, state and federal government representatives and academia with responsibility or research interests in border air quality monitoring. (Please see the attached agenda and registration list of participants.) The group reviewed the existing networks for urban and rural communities throughout the border region. California-Baja California was not represented at the meeting; however information for the two states is incorporated into the Monitoring Needs Assessment table. Presentations were given on new and emerging monitoring technologies, training services provided by Centro Nacional de Investigación y Capacidad Ambiental (CENICA), NM Department of Health's environmental health tracking system and development of the DREAM model, and financing mechanisms for air monitoring needs in Mexico. The Working Group discussed ideas to meet some of the identified needs and recommendations were compiled.

Findings

The major findings from this effort are outlined below and represent a synthesis of the themes discussed at the July 6 meeting. Please see the minutes from the Air Monitoring Working Group meeting for more detailed discussion.

Adequacy of Existing Networks in Urban Areas

- Expansion of air monitoring networks to new population growth areas in El Paso and Cd. Juarez is needed (Ft. Bliss, Lower Valley, Vinton/Anthony in TX and to west, southeast and southwest of Juarez) to better represent population exposure.
- Expansion of monitoring capabilities in New Mexico is needed, such as PM2.5 chemical speciation, continuous monitoring at PAMS sites.

- Monitoring networks are being evaluated for Arizona-Sonora and California-Baja California. Results are not yet available.
- Special purpose monitors at Ports of Entry (POE) could be used for measuring exposures of POE employees and people idling at POE's.
- Funding of new monitoring sites is a significant obstacle given state and federal budgets.

<u>Adequacy of Existing Networks in Rural Areas</u>

- Some level of monitoring is needed in rural areas with severe PM air quality issues, such as improved meteorological monitoring for high wind events and low cost monitoring equipment.
- Biological samples such as the fungi aspergillus and Coccidioides immitis that causes Valley Fever should be collected given prospect of increased ambient concentrations of PM given long-term drought brought about by climate change combined with overgrazed rangeland.
- Need to determine the best way to administer monitoring in rural areas given the lack of capacity and regulatory authority at the local level.

<u>Operability of Networks</u>

- An annual budget for operation and maintenance of air monitoring networks in Mexico is needed as there are no resources for equipment maintenance, filters and other supplies, laboratory analysis, personnel expenses, etc.
- Identified training needs include hands-on training in both Spanish and English, funding for travel of technicians to training programs, workshops on QA/QC of data and data analysis.
- Auditing for quality assurance of monitoring data is needed for networks in Mexico.

<u>Community Notification</u>

- Rural areas lack the ability to provide notification to communities about air quality and how to reduce exposure.
- Most of the urban monitoring networks are integrated into AIRNow or a similar real-time alert web page.
- There is no notification of forecast for high PM concentrations in Paso del Norte.
- Need air quality modeling to provide air quality forecasts for border communities.

<u>Financing</u>

- Sufficient funding was identified as the largest obstacle to improved air quality monitoring in border communities.

Recommendations

- Expand existing air monitoring networks in urban areas
    - Review existing monitoring locations using modeling to relocate monitors to locations with predictions for high concentrations of ozone.
    - Relocate monitoring sites that are no longer providing useful data.
    - Share cost of establishing new monitoring stations with other agencies. For example, the National Weather Service is interested in Transmountain Road in El Paso for a weather station.
    - Expand capabilities of existing monitoring stations where needed e.g., PM speciation in Doña Ana County

- Establish air and/or meteorological monitoring in rural areas as appropriate
    - It is recommended that the border states take the responsibility for monitoring in rural areas given established legal authority for public health protection and greater capacity to manage the effort.
    - Because of the high cost of establishing monitoring stations and the fact that both US and Mexican air quality regulations do not require permanent monitoring networks in low population areas, establish meteorological stations in these areas and determine threshold wind velocities that cause regional and local occurrences of high PM to aid in community notification. In Mexico, make available on the internet Agro Clima sensors in rural areas such as Ascension to help with community notification.
    - Track sources of dust for mitigation. In some cases it is the same sources or properties causing dust problems. These sources need to be addressed.

- Ensure operability of monitoring networks
    - In Mexico, include all O&M costs in the budget for air monitoring networks to ensure the operability of monitoring equipment and the network as a whole.
    - Build into monitoring budgets funding for training of technical personnel in Mexico.
    - Provide binational training in local areas using mobile units operated by NMSU, UTEP, NMED and others agencies and organizations.
    - Develop a webinar or videotape for QA/QC data analysis training workshop in English and Spanish. This would preclude need for funding to organize workshops and to provide travel to training locations.

- Improve community notification of high air pollutant concentrations in both rural and urban areas
    - Build strong partnership with the National Weather Service. Provide information to NWS to alert communities to high air pollution events and to disseminate actions to be taken to minimize personal exposure. NWS needs raw data that is compatible with their systems.

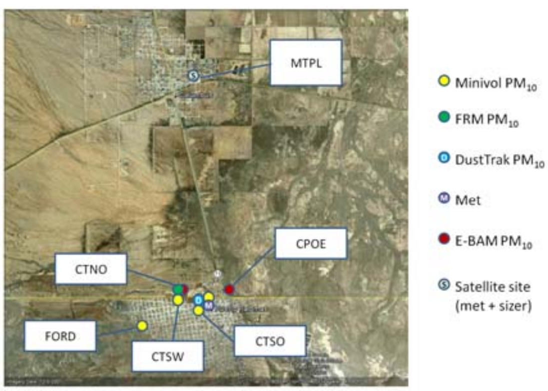
- Conduct community education in rural areas about how to reduce exposure to high PM concentrations.
- Integrate rural monitoring networks in AIRNow if not connected e.g., Deming, NM
- Determine how to provide PM alerts to rural communities, such as Columbus-Palomas-Ascension.
- Assist the NM Department of Health with calibration of the DREAM model by assisting with field observations and measurements. This remote sensing technology could be a useful tool in measuring and forecasting dust concentrations in rural areas of the border.
- Support surveillance projects in rural areas to gain better understanding of health effects from high PM concentrations. Research is needed to determine most effective ways to reach rural communities with advisories to reduce pollutant exposure.

- <u>Secure financing for improved border air quality monitoring</u>
  - Facilitate development of air monitoring proposals to the Mexican Presupuesto de Egresos de la Federación (PEF) for funding.
  - Present recommendations from this working group at Border Governors Sustainable Development Work Table to solicit support for funding of border air quality monitoring networks.
  - Facilitate collaborative funding of monitoring sites among US federal and state agencies, such as EPA, NWS, DHS, DOT and border states.
  - Create collaborative efforts between state agencies and universities to develop monitoring proposals for funding by NADB.

Overview of the Spring 2012 Columbus and Palomas Dust Study

Exposure to high levels of dust is not only a nuisance but presents a hazard both to your respiratory system and to travelling. Breathing in dust can trigger asthma attacks and make allergies worse. Following up on a study completed in 2006 we desired to measure dust in northern Palomas and in NM near the port of entry during the spring dust season.

The purpose of the air quality study was to provide information on the sources and levels of dust in and around the northern border of Palomas and surrounding the cattle holding facilities. It was conducted from March 28 to April 30, 2012. The dust we investigated were those that can be inhaled deep into the lung and smaller than 10 microns or nearly 1/7 the width of human hair. These particles are called PM10 and are regulated by the US Environmental Protection Agency. The objectives of this study were to collect a sufficient number of dust samples from the air to understand typical levels found in the Columbus/Palomas area and during dust storms and to estimate the how dust varied across the towns of Palomas and around the cattle facility over time.



During the study daily PM10 levels were higher than the United States Environmental Protection Agency's health standard on three days in Palomas and twice in Columbus. The two violations of the health standard in Columbus were during dust storms caused by high winds.

These dust storms not only affected the town of Columbus but most of southern New Mexico. The dust was blown across most of New Mexico and even seen crossing the southern Great Plains as the dust plumes were carried by strong winds.

The highest exposures to PM10 were from regional dust storms that caused wind blown dust from locations surrounding the town and outlying areas. Overall the highest daily dust concentrations were measured at just south of the cattle facility. PM10 concentrations at that site over the study period averaged 52 percent of the US EPA standard. The second highest average PM10 concentrations were measured immediately west of the cattle facility. There the average daily PM10 was 49 percent of the standard. We found that dust was highly dependent on location and can vary considerably over small distances of one kilometer.

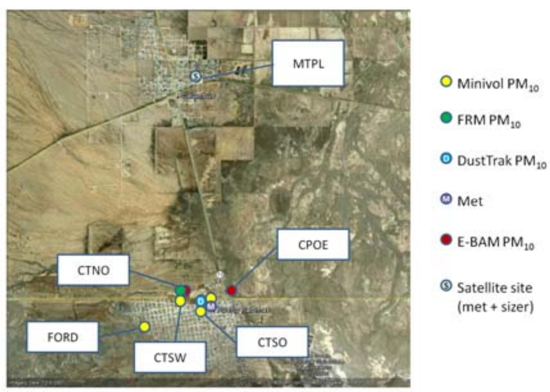
Project Partners:

DRI Desert Research Institute · United States Environmental Protection Agency · Border 2020 Frontera 2020 · New Mexico Environment Department · New Mexico Department of Health · NM State · SEMARNAT Secretaría de Medio Ambiente y Recursos Naturales

Resumen del Estudio de Polvos en Columbus y Palomas durante la Primavera del 2012

La exposición a altos niveles de polvo no sólo es una molestia sino representa un riesgo para el sistema respiratorio y para viajar. La inhalación de polvo puede provocar ataques de asma y empeorar las alergias. Continuando con un estudio realizado en 2006, se midió el polvo al norte de Palomas y en NM cerca del Puerto de Entrada, durante la temporada de polvo de primavera.

El propósito del estudio de calidad del aire fue contar con información sobre las fuentes y los niveles de polvo en los alrededores de la frontera norte de Palomas y en los alrededores de los corrales de ganado. El estudio se realizó del 28 de marzo al 30 de abril del 2012. El polvo que se investigó fue aquel que puede ser inhalado profundamente en el pulmón y que es menor a 10 micrones o casi 1/7 el ancho de un cabello humano. Estas partículas son llamadas PM10 y están reguladas por la Agencia de Protección Ambiental (US EPA). Los objetivos de este estudio fueron recoger un número suficiente de muestras de polvo del aire para entender los niveles típicos que se encuentran en el área de Columbus/Palomas durante las tormentas de polvo y para estimar cómo es que varió entre ambas localidades y alrededor de los corrales de ganado con el tiempo.



Durante el estudio, los niveles diarios de PM10 fueron superiores a la norma de salud de USEPA en tres días en Palomas y dos veces en Columbus. Las dos violaciones de la norma en Columbus fueron durante las tormentas de polvo causadas por fuertes vientos.

Las tormentas de polvo no sólo afectaron la ciudad de Columbus, sino la mayor parte del sur de Nuevo México. El polvo se presentó en la mayor parte de Nuevo México e incluso cruzó por el sur de las Grandes Llanuras, al ser llevado por los fuertes vientos.

Las mayores exposiciones a PM10 fueron por las tormentas de polvo regionales, que causaron los polvos llevados por el viento desde localidades que rodean la ciudad y los alrededores. En general, las más altas concentraciones diarias de polvo fueron registradas al sur de los corrales de ganado. Las concentraciones de PM10 en ese sitio durante el período del estudio promediaron un 52 por ciento de la norma de la EPA. El segundo promedio más alto de PM10 se midió inmediatamente al oeste de las instalaciones de ganado. Allí, el promedio diario de PM10 fue el 49 por ciento de la norma. Encontramos que el polvo fue altamente dependiente de la ubicación y puede variar considerablemente en pequeñas distancias de un kilómetro.

Socios del Proyecto:

DRI Desert Research Institute · United States Environmental Protection Agency · Border 2020 Frontera 2020 · New Mexico Environment Department · New Mexico Department of Health · NM State · SEMARNAT Secretaría de Medio Ambiente y Recursos Naturales

Columbus/Palomas Aerosol Saturation Study:

Final Report

Dave DuBois, Ph.D.
Principal Investigator
NM State Climatologist
New Mexico State University

Additional Contributors:
Dr. Juan Pedro Margez
Rebecca Armenta
Elizabeth Smith
Max Bleiweiss

June 25, 2012

ACKNOWLEDGEMENTS

This project was a joint effort between New Mexico State University and Border Partners. Funding for this project was provided by the US EPA Border 2012.

Additional funding was provided through the New Mexico of Health, Office of Border Health under a MOA 13828 with the New Mexico Department of Health, Office of Border Health. Mr. Paul Dulin provided overall project management.

Much appreciation goes to Allyson Siwik for connecting us with Border Partners and Erin Ward for including us in the on-going US Border 2012 project.

We would like to acknowledge assistance in the field sampling from Peter Edmonds, Marison Guillen, and Grace Jones, with Border Partners.

Contents

1. Introduction

1.1. Background

This plan describes an aerosol saturation study to be conducted in and around the town of Palomas, Mexico. This study is partly in response to complaints, perceived health issues, and unanswered questions about the relative contributions of the various fugitive dust sources in Palomas.

The study region includes the border communities of Columbus and Palomas in southern New Mexico as shown in Figure 1-1. East to west, it covers an expanse of 4 kilometers and north to south it covers approximately 7 kilometers. This area is characterized by a small population, highly variable PM concentrations, and a very limited record of compliance measurements for PM_{10}.

Figure 1.1-1. Palomas study region. Image courtesy of Google Earth.

1.2. Study Objectives

The Palomas PM_{10} study described in this program plan is needed to provide information on the sources and levels of PM_{10} in and around the northern border and the cattle holding facilities. The objectives of this study are:

- To acquire a database of particulates and environmental conditions with specified precision, accuracy, and validity which is suitable to determine contributions of elevated PM_{10} concentrations
- To estimate the spatial and temporal distributions of PM_{10} concentrations, especially near fugitive dust sources.
- To estimate fugitive dust contributions based on existing PM_{10} emissions information

2. Ambient Measurements

2.1. Aerosol and Meteorological Monitoring Network

The focus of the ambient aerosol and meteorological measurement network was on collecting data to help understand the impacts of fugitive dust sources such as the cattle facility and unpaved roads in and around Palomas. To do this we installed and operated a small network of aerosol samplers surrounding the cattle facility over a period of a month. Sample collection began on March 28, 2012 and end on April 29, 2012. Figures 2.1-2 and 2.1-2 show the sampling days and network operations during the study.

Figure 2.1-1. March 2012 sampling calendar

◄ Mar 2012 ~ April 2012 ~ May 2012 ►

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 Sample Day	2 change filters	3 Sample Day Peter collects all samples NMSU collects filters Juan Pedro sample day	4 change filters	5 Sample Day	6 change filters	7 Sample Day
8 change filters	9 Sample Day	10 change filters Peter collects all samples NMSU collects filters	11 Sample Day	12 change filters	13 Sample Day	14 change filters
15 Sample Day	16 change filters Peter collects all samples NMSU collects filters	17 Sample Day Juan Pedro sample day	18 change filters	19 Sample Day	20 change filters	21 Sample Day
22 change filters	23 Sample Day	24 change filters Peter collects all samples NMSU collects filters Juan Pedro sample day	25 Sample Day	26 change filters	27 Sample Day	28 change filters
29 Sample Day	30 end of sampling Peter collects all samples NMSU collects filters take samplers down	Notes:				

Figure 2.1-2. April 2012 sampling calendar

The measurements were collected using a combination of 24-hour integrated filter samples and continuous sampling. One of the samplers collected PM_{10} with an EPA Federal Reference Method while the remaining were non-reference methods. The filter samplers were analyzed for total mass concentration to be compared to the 24-hour National Ambient Air Quality Standard. The increased time resolution provided by the continuous or real-time measurements enabled examination of brief spikes in pollutant concentrations from the various fugitive dust sources in Palomas and Columbus.

The Palomas monitoring network was designed to provide samplers on all sides of the cattle facility. A sampler located on the west side of Palomas was used as an upwind station when the winds are blowing from the west to southwest directions. Wind transport directions will be logged at one station downwind of the cattle facility. Two monitoring stations were installed on the US side of the border in Columbus to address particulates north of Palomas. Another station in the town of Columbus also operated during part of the study. Figure 2.1-3 shows the Palomas monitoring site map centered around the cattle facility.

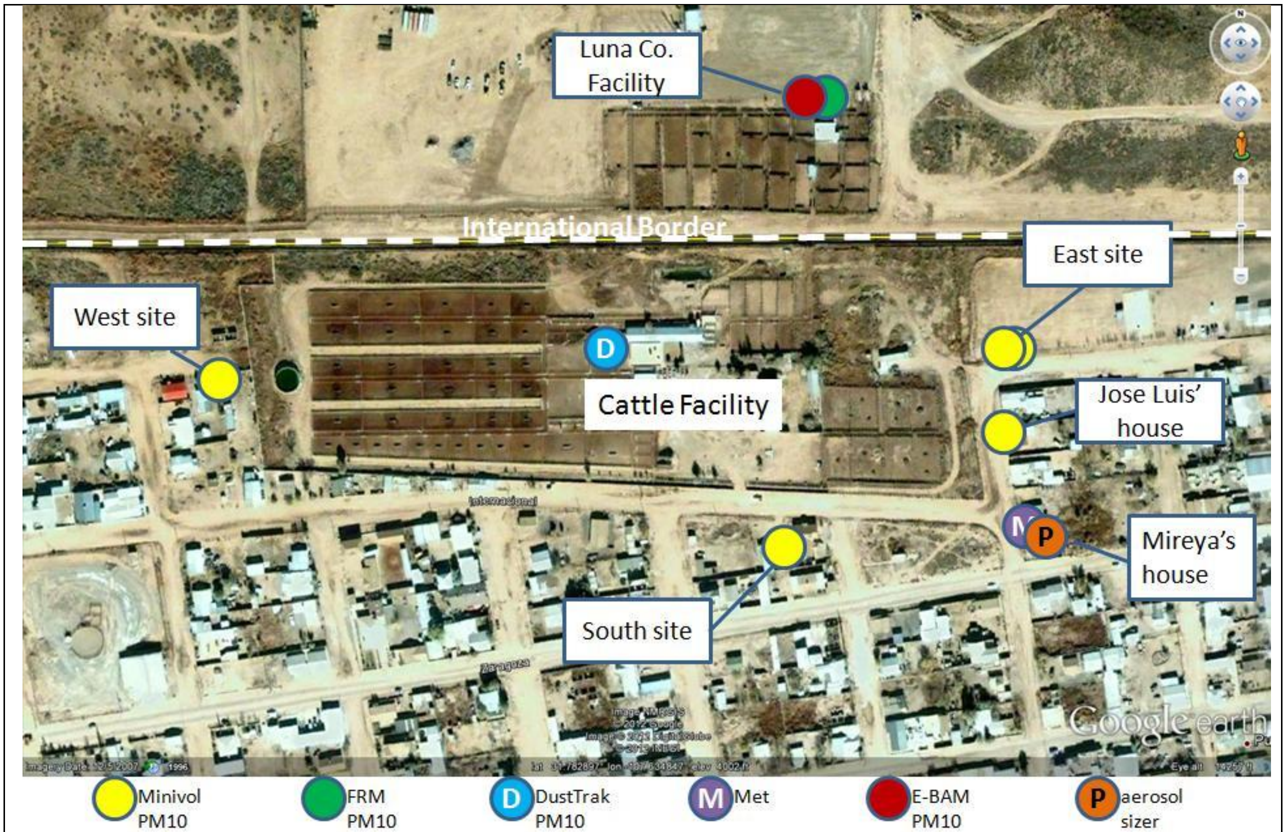


Figure 2.1-3. Palomas study area with aerosol monitoring network.

At the home of Mireya Perez at the corner of Zaragosas and Juventino Rosas Streets, we operated a Davis VantagePro weather station and a MetOne particle sizer model 212. This site (CTSE) was located approximately 70-meters south-southeast of the PRIN station, 120-meters south-southeast of CTNE, and 170-meters east of the CTSO station. The VantagePro console was located indoors and was connected through the wireless connection to the sensors. The MetOne particle sizer was connected to a laptop indoors through a cable from the sampler. In order to make this cable connection we ran this through an existing hole in the wall. Weather station sensors was attached to a television antenna approximately 1-meter above the roof and provided some mitigation of roof wind flow interference from the building. Overall height of the weather station sensors was 3-meters above the ground. The particle sizer was fastened to the

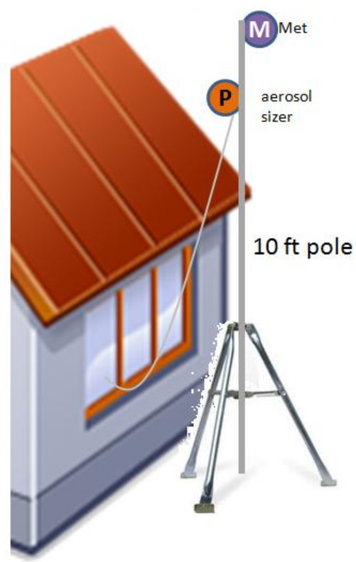


Figure 2.1-4. Weather station configuration in Palomas

top of a 3-meter pole attached and stabilized by a metal tripod. The height of 3-meters allowed the sampler to be above the roof of the house and avoid the house blocking winds from the west. Roads in three of the directions away from the sampling site are paved. The portion of Juventino Rosas Street south of the station is unpaved. Based on limited observations during the station set-up and take-down, Zaragosa Street is more heavily travelled. Figure 2.1-4 shows a schematic of the instrumentation at this location.

Two MiniVol PM_{10} samplers were installed on a power pole near the northeast corner of the cattle facility in Palomas (CTNE). Samplers were placed 3-meters above the ground. This location on Juventino Rosas Street as it bends toward the elementary school. The purpose of this site was to collect collocated filter samples that will be chemically speciated by the Desert Research Institute, Environmental Analysis Facility laboratory for elemental species, ions, and carbon fraction. Operating the study on an every other day schedule for one month provides 15 samples that will be chemically speciated. More detail on the chemical analysis is provided in section 2.2.1.4.

A Minivol PM_{10} sampler was installed south of the cattle facility (CTSO) in Palomas on a television antenna pole at a height of 3-meters above the ground. This purpose of this site was to gauge particle concentrations from the town, unpaved roads, and the cattle facility near the southern boundary. An unpaved road borders the southern wall of the cattle facility north of the sampler and will contribute to the total dust loading on the samples. Based on our limited observations during the installation traffic on this road is very light, with an estimated vehicle count of less than ten per hour. The road is approximately 15 meters north of the sampler.

On the western border of the cattle facility in Palomas, a Minivol sampler was installed to measure PM_{10} upwind of the cattle facility assuming westerly winds. The location (CTSW) was at the eastern end of Aeropuerto Road. The sampler was mounted on a power pole at a height of 3-meters above the ground. Similar to the southern site, this location is influenced by unpaved roads along with the cattle facility. Other local particulate emissions could include sporadic residential burning.

A Minivol PM_{10} sampler was installed in the western edge of Palomas at the Ford Elementary School (FORD). The Minivol was attached to a flag pole adjacent to a basketball court on the west side of the school. The sampler was at a height of 4-meters above the ground. This is 1.2 kilometers west-southwest of the cattle facility and located at the corner of Zaragosa and Alvillar Streets. At this point Zaragosa is paved but becomes unpaved west of the school. For southwest winds, this could be used as an upwind monitoring site. Based on a recent set of photos, the surrounding roads are a mix of paved and unpaved roads. Immediately surrounding the school were dirt playgrounds.

On the northern border of the cattle facility an E-BAM will be operated at the Luna County cattle holding area. This site will be used to measure the influence of the Palomas cattle facility on points north in the US. The E-BAM instrument has built-on wind speed and wind direction sensors that will be useful in estimating transport of fugitive dust near the ground.

An E-BAM instrument will be operated near the Columbus Port of Entry to gauge particulates on the far northeast side of the Palomas cattle area. Particulates at this location were influenced by primarily paved road emissions and idling emissions as well as vehicle traffic at the border crossing. We located the station at least 20 meters east of the Port of Entry parking lots to minimize the contamination from idling vehicles. Directly east of the monitoring site were disturbed open desert near the international border. An unpaved road ran southeast of the Port of Entry along the US/Mexico border fence. This road is only used by US Border Patrol vehicles patrolling the fence area.

The Palomas monitoring network was augmented with the NM Department of Health satellite station in Columbus and two MetOne E-BAM PM_{10} monitors on loan from the New Mexico Environment Department Air Quality Bureau. A MetOne particle sizer was operated at the NM Department of Health satellite monitoring station as part of its normal operation. This site is located in the backyard of Martha's Bed and Breakfast, on the southeast side of Columbus. A meteorological station is located at this site collecting wind data at 3-meters, temperature and RH at 1.5-meters, along with precipitation, and solar radiation.

The table below summarizes the study monitoring network and instrumentation at each monitoring site

Site ID	**Network**	**Location**	**Instruments**
PRIN	Palomas	In front of house of Principal Jose Luis east of cattle facility in Palomas	Minivol PM_{10} with Teflon filter
CTSE	Palomas	Mireya Perez's house southeast of the cattle facility; instruments were mounted on the east end of the roof at 3 meters above the ground	MetOne Profiler 212 particle sizer Davis VantagePro2 weather station
CTNE	Palomas	Northeast corner of cattle facility in Palomas	Minivol PM_{10} with Teflon filter (DRI) Minivol PM_{10} with quartz filter (DRI)

Site ID	Network	Location	Instruments
CTSW	Palomas	West of cattle facility in Palomas	Minivol PM_{10} with Teflon filter
CTSO	Palomas	South of cattle facility in Palomas	Minivol PM_{10} with Teflon filter
FORD	Palomas	Ford School in western portion of Palomas	Minivol PM_{10} with Teflon filter
CTNO	Columbus	North of cattle facility in Luna County, NM lot	BGI PQ100 PM_{10} with Teflon filter Hourly E-BAM PM_{10}
CPOE	Columbus	US Port of Entry, in east parking lot behind office complex	Hourly E-BAM PM_{10}
MTPL	Columbus	NM DOH satellite site at Martha's Place Bed & Breakfast	3-meter meteorological station MetOne model 212 profiler particle sizer

The following map (Figure 2.1-5) shows the location of the monitoring site with their corresponding site identifications. The site CTD1 and CTD3 were used by Dr. Margez for collecting data with the TSI DustTrack instruments during windy days. Unfortunately, he was not able to conduct sampling on the two days with highest wind due to scheduling conflicts.

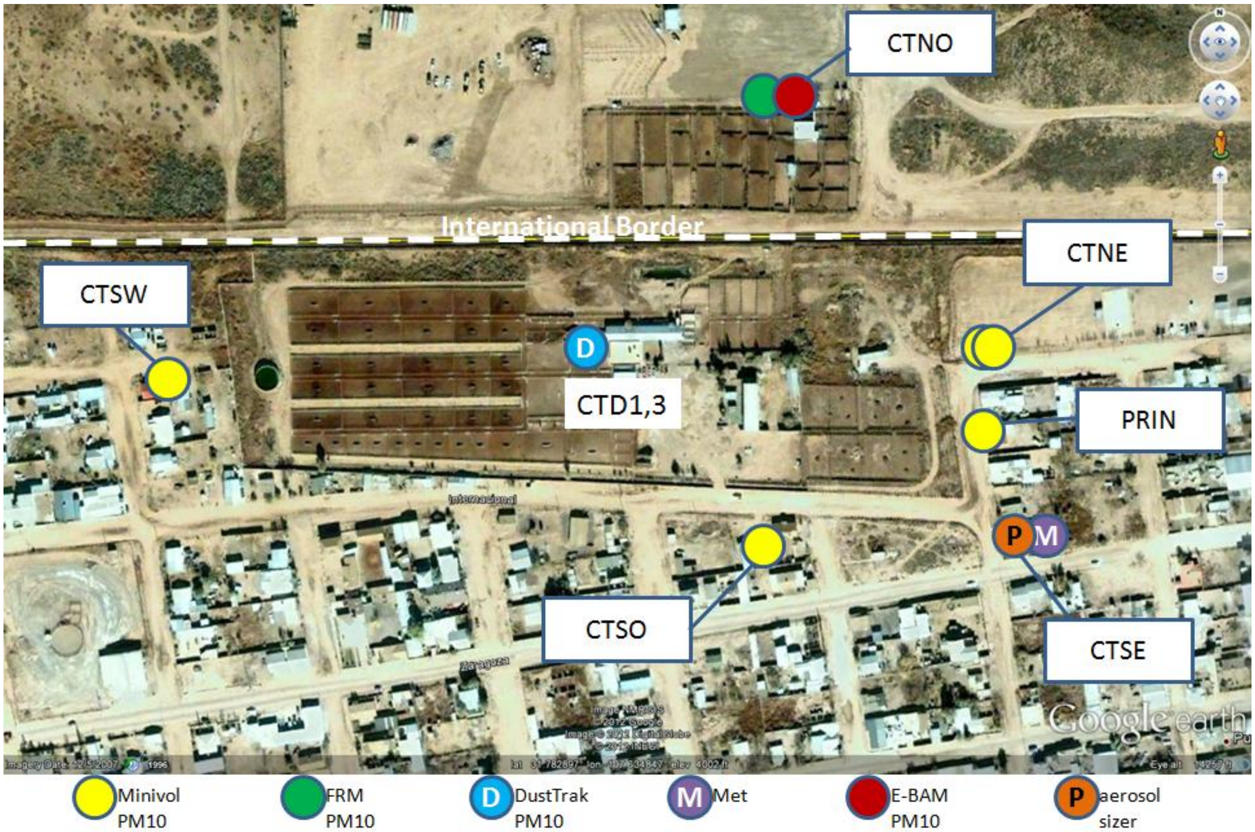


Figure 2.1-5. Monitoring network surrounding the cattle facility with site IDs

Figure 2.1-6 shows the general location of the all of monitoring stations including those in Columbus.

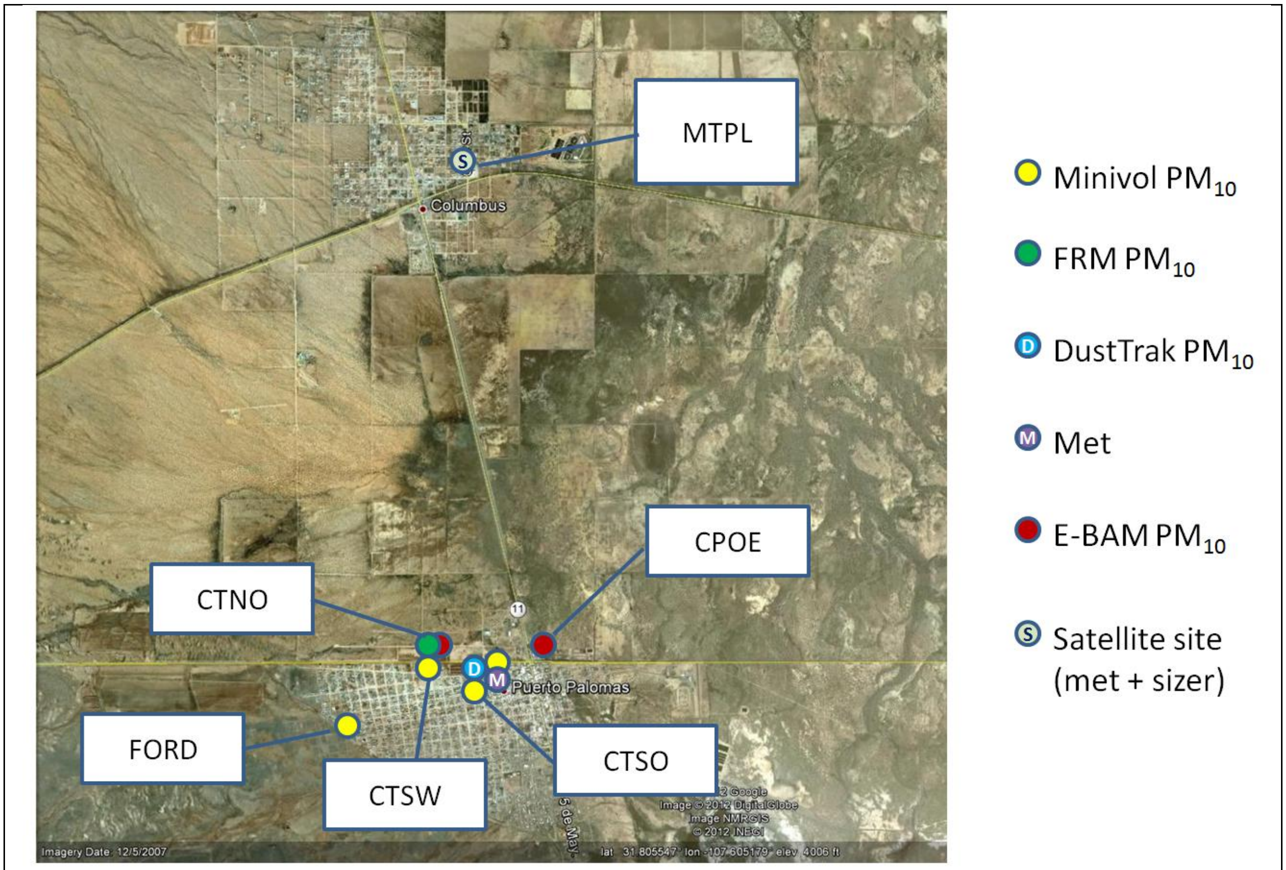


Figure 2.1-6. Regional monitoring network

2.2. Ambient Aerosol Instrumentation

2.2.1. Filter based Measurements

2.2.1.1. Minivol PM_{10} Sampler

Integrated filter samples were collected for 24-hour integrated PM_{10} mass concentrations using battery powered Airmetrics MiniVol TAS samplers. Four of the units were on loan from the Desert Research Institute and two were from the NM DOH study. These samplers consisted of a pump, timer, tubing and fittings, removable filter holder, flow meter, impactor inlet, and battery pack. We operated the samplers at a constant 5.0 liters per minute (lpm) flow rate during the 24-hour sample. Samples were collected at a height of 3-meters above the ground by attaching to various poles and antennas in Palomas. We used 47 mm diameter Teflon (PTFE) filters that allowed us flexibility in using both gravimetric and light transmission analysis. The PM_{10} samples were collected on filters in numbered filter cassettes, labeled PALXXX. Two removable battery packs accompanied each sampler so that one was charging while the other is being used in sampling. Every time a filter was changed, the discharged batter was replaced with a freshly charged battery.

2.2.1.2. BGI PM_{10} Sampler

A BGI PQ100 sampler was used in this study to collect PM_{10} using an EPA Federal Reference Method. The PQ100 used a PM_{10} size selective inlet followed by a 47 mm Teflon (PTFE) filter, at a constant flow rate of 16.7 lpm. The PM_{10} inlet is designed for a 50% collection efficiency for particles of aerodynamic diameter of 10 µm or less at a flow rate of 16.7 lpm. The sampler was equipped to operate from a solar panel charged 12 VDC battery which provides power for a 24-hour sampling period. The PM_{10} samples were collected on filters in numbered filter cassettes, labeled PALXXX. The sampler's air inlet was operated at a height of 1.5-meters above the ground similar to the height of the MetOne E-BAM inlet.

2.2.1.3. Filter Media and Chemical Analysis

All of the Palomas monitoring stations used Teflon (PTFE) filter substrates since they are durable and can be used to determine the mass concentration, black carbon fraction through light transmission, and potentially elemental composition through XRF or PIXE. These However these filters cannot be analyzed for carbon using the Thermal Optical Reflectance method because of its presence in the filter material, though they have very low blank levels for ions and elements. The primary use of the Teflon filters was in the determination of 24-hour mass concentration using a gravimetric analysis. The filters were weighed at the NMSU Department of Chemistry. A portion of the filters were reweighed at the College of Agriculture Consumer and Environmental Sciences (ACES) soils laboratory for quality checks. Weighing was performed on a Mettler M5 microbalance with +/- 1 µg precision. The balance has a capacity 20 grams, a range of 20 mg on the optical scale and an accuracy of ±0.002 mg. A Cahn-33 microbalance was used to verify the filter tare weights at the Department of Chemistry.

Although not reported in this document, we will also be using a method to evaluate the filter's opacity using a Magee Scientific OT21 dual wavelength (370 nm and 880nm) optical transmissometer thus providing an estimate of the black carbon content. We use this method since carbon cannot be measured directly on the Teflon membrane filters due to presence of carbon in the filter media. This method is also provides a cost savings over the traditional TOR/quartz combination method.

Chemical analysis of the filters collected at the CTNE site, northeast corner of the cattle facility, will be done at the Desert Research Institute's Environmental Analysis Facility. Results of this analysis are also not reported in this document. The Teflon filters will be analyzed using x-ray fluorescence to determine the elemental composition. X-ray fluorescence (XRF) analysis is performed on Teflon membrane filters for Al, Si, P, S, Cl, K, Ca , Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Br, Rb, Sr, Y, Zr, Mo, Pd, Ag, Cd, In, Sn, Sb, Ba, La, Au, Hg, Tl, Pb, and U with an energy dispersive x-ray fluorescence (EDXRF) analyzer. XRF analyses are performed on a Panalytical Epsilon 5 energy dispersive XRF spectrometer (Almelo, Netherlands). The quartz filters collected alongside the Teflon samples will be analyzed using the Thermal Optical Reflectance (TOR) method for organic and elemental carbon. This method is based on the principle that different types of carbon-containing particles are converted to gases under different temperature and oxidation conditions (Chow et al., 1993). The different carbon fractions from TOR are useful for comparison with other methods which are specific to a single definition for organic and elemental carbon.

2.2.2. Continuous Aerosol Measurements

2.2.2.1. Continuous PM_{10} with Beta-Attenuation Monitors

The MetOne E-BAM PM_{10} monitor was used at two locations in the US to collect hourly average PM_{10} mass concentration readings to be compared to the 24-hour integrated samples in Palomas. This time resolution provided information on the variation of PM_{10} over the course of the day and peak concentrations during high wind periods. Procedures were followed according to the manufacturer's guidance and calibration was accomplished manually by means of a Mylar film that represents a specific particulate concentration against which to set the monitor. The monitor maintained an error log with date, time, and type of error. Three BAM instruments were on loan from the New Mexico Environment Department Air Quality Bureau from February 24. 2012 to May 22, 2012. Two were used in the study in Columbus and the third was not used due to a malfunctioning pump.

2.2.2.2. Continuous Particle Size Monitor

An Optical Particle Counter was used to measure the real time aerosol size distribution at one location southeast of the cattle facility. A MetOne model 212 Optical Particle Counter measured particle sizes from 0.5 to 10 microns in eight size ranges, taking a sample every 60 seconds. This data will be used to interpret the 24-hour integrated filter samples by indicating the size of the particles and temporal behavior. For example if the majority of particles are large, in the upper size ranges of the instrument, this probably indicates that the area is influenced by dust or other source.

2.2.2.3. Continuous Light Scattering Monitor

A continuous sampling 16ephelometer will be used to measure the PM_{10} mass concentration at the site. The TSI DustTrak II Model 8530 is a laser photometer that provides aerosol mass readings and calibrated using Arizona Road Dust at the factory. This instrument is important since it measures mass concentrations in micrograms per cubic meter, and is can be correlated with US EPA health standards for particulate matter. The sampler will be operated on a 2-minute sampling interval to track localized events within the cattle facility. The samplers will be used to measure vertical gradient of PM_{10} by operating them at the same location but a different heights.

1.1. Meteorological Measurement Instrumentation

1.1.1. Columbus

The Columbus weather station is part of the NM Department of Health's "Assessment of Land-based Sources of Air Quality Contaminants in the Binational Border Region of Southwestern New Mexico, Northwestern Chihuahua and West Texas" project. This monitoring station is located at Martha's Bed and Breakfast at the corner of Lima and Main Street. In the past a NWS Cooperative station was hosted at this location but was discontinued in 2011. The period of record at this location started in August of 1909 and continued till May 2011. The cooperative site identification number is 292024. This site is approximately 380 meters (0.23 miles) northwest of the Pancho Villa State Park. The predominant landuse in the surrounding block is commercial with a few residences located more than a block away. The adjacent streets are paved with some appear to be "chip sealed" but unpaved roads are numerous in the area.

Instrumentation at this site included wind speed and direction at 3 meters, solar radiation, rain rate, and temperature and humidity at 1.5 meters. This site also collects particle size counts from 0.5 to 10.0 microns in 8 size bins. A Campbell Scientific CR1000 data logger acquires data in 5-minute and hourly averages. During summer months this site is capable of collecting ozone using a 2B Technology ozone monitor.

1.1.2. Palomas

A Davis VantagePro2 meteorological station was used to collect meteorological variables including temperature, humidity, wind speed and wind direction at a location near the southeast corner of the cattle facility in Palomas. The base station provides a wireless connection between the datalogger and the sensor package and was located at the home of Mireya Perez at the corner of Zaragosas and Juventino Rosas Streets. The sensor package was located on a television mast approximately 3 meters above the ground and 1 meter above the height of the roof of the house. To collect data, the data logger was connected to a laptop using a USB cable and the Davis WeatherLink software. The software package will be installed on the laptop PC and be used to store the data in a tabular format. Data was logged in 5-minute intervals during the study.

The following table below describes each sampler type and pollutants collected and sampling interval.

Instrument (# available)	**Target Pollutant(s)**	**Sampling Interval**
MiniVol samplers (6)	4 sites with 24-hour PM_{10} mass on 47mm Teflon filter media – to be analyzed for gravimetric mass and elemental carbon 1 site with 24-hour PM_{10} mass on 47mm Teflon and quartz filter media – Gravimetric mass, elements, elemental and organic carbon. On a subset of filters organic speciation using thermal desorption method (TD-GCMS) will be investigated.	Every other day
BGI PQ100 Federal Reference Method sampler (1)	1 site with 24-hour PM_{10} mass on 47mm Teflon filter media to be analyzed for gravimetric mass and elemental carbon	Every other day
Nephelometer (2)	Two continuous PM_{10} DustTrack II instruments operated to give concentration every 60 seconds.	1-minute
Optical Particle Counter (1)	Continuous aerosol size distribution using MetOne profiler 212 with 8-bin sizes from 0.5 to 10 µm. This will be operated to give size distribution every 5-minutes.	5-minutes
MetOne E-BAM (2)	Hourly PM_{10}, with temperature, relative humidity, and wind speed and direction	1-hour
Meteorological station (1)	The met station will provide continuous temperature, relative humidity, wind speed, wind direction. Averaging time will be set at 5-minutes.	5-minutes

2. Database and Data Validation

The purpose of the data evaluation is to summarize the accuracy and precision of the measurements, to identify and investigate extreme and inconsistent values, and to perform data comparisons and investigate discrepancies in the data. Data to be used in this study will acquired from ongoing measurement efforts and those specific to this study. An evaluation is critical since experience has shown that even the best designed field studies contain errors that need to be found, quantified, and flagged. The evaluation will involve plotting and examining pollutant time series data to identify spikes and outliers for investigation. While some of the spike will be from neighborhood-scale source activities there may be some from activities in close range of the monitor. The evaluation will also consider comparisons between measurements of the same or similar variable at the same or nearby site using different measurement devices and procedures. We will use scatter plots, linear regression, and correlation analysis to do these comparisons.

2.1. QA and Data Validation

Standard operating procedures (SOPs) are to systematize the actions needed to properly operate a measurement or analytical technique. These SOPs have been drafted for each of the instruments to be used in the study. The SOPs included a summary of the measurement method, principles of operation, its expected precision and accuracy, the assumptions made in the instrument. The SOPs also included a list of materials, equipment, and supplies necessary for the operation of the instrument.

A detailed central database (CD) was developed in MS Excel. Data from the study along with supplemental emissions activity and meteorological data were uploaded and archived at the CD. Data analysis was carried out using a combination of tools including statistical analysis and geospatial analysis.

3. Temporal and Spatial Variations in PM_{10}

This section presents the descriptive statistics and time series of PM_{10} mass concentrations, particle size measurements, and meteorological conditions collected in the Palomas, Mexico and Columbus, NM areas.

3.1. PM_{10} Mass Concentrations

Table 3-1 summarizes daily PM_{10} along with the mean and median concentrations for all sites during this study. The first four stations are in Palomas, and the bottom three are located in

Columbus. This table shows high PM_{10} occurs on both sides of the border and can be observed at the same magnitude.

Table 3.1-1 Maximum, Mean, and percentiles of hourly PM_{10} measured at each site. Concentrations are rounded to the nearest $\mu g/m^3$ to allow for easier comparison between sites

Site Code	Number of samples	Max PM_{10}	Mean PM_{10}	Median PM_{10}	5^{th} percentile	25^{th} percentile	75^{th} percentile	95^{th} percentile
FORD	15	531	72	29	5	18	56	262
CTSW	16	199	74	69	20	33	95	169
CTSO	16	169	78	75	23	44	98	148
PRIN	15	121	58	40	19	35	82	117
CTNO (filter)	6	305	149	127	54	75	205	283
CTNO (BAM)	51	515	52	35	18	27	52	98
CPOE (BAM)	39	451	45	29	15	22	42	71

Figure 3.1-1 shows box plots of 24-hr PM_{10} mass concentration measured at four monitoring sites in Palomas and three monitoring sites in Columbus, NM. The boxes represent the 25%, 50% (median) and 75% percentiles, and whiskers show the 5% and 95% percentiles. The "x" show the 1^{st} and 99^{th} percentile while the "-" denote the maximum and minimum values.

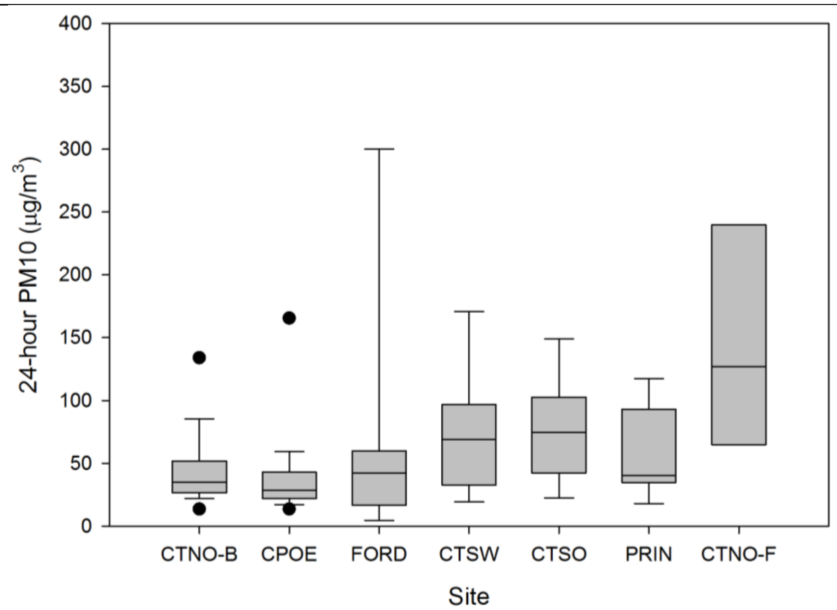


Figure 3.1-1. 24-hour PM_{10} mass concentrations.

In Figure 3.1-1, CTNO-B refers to the Beta Attenuation Monitor sampling method at the monitoring station and CTNO-F refers to the filter based sampling methodology. Both of the CTNO samplers were situated next to each other.

With respect to the 24-hr PM_{10} National Ambient Air Quality Standard of 150 µg/m^3, PM_{10} levels exceeded the standard at all sites except for PRIN. A total of four exceedances were observed at the New Mexico stations using BAM PM_{10} monitors. Both stations recorded exceedances on April 14, 2012 and April 26, 2012 due to high winds.

The site CTSW, west of the cattle facility, recorded two exceedances, with one on April 15 (159 µg/m^3) and another on April 21, 2012 (199 µg/m^3). The CTSO site south of the cattle facility recorded only one exceedance on April 21, 2012 (169 µg/m^3). The FORD station, located on the far western part of Palomas, exceeded the standard once on April 5, 2012 with a 24-hour PM_{10} concentration of 531 µg/m^3. On that day, this station recorded the highest PM_{10} throughout the network. In fact one site, CTSW, recoded its lowest value on that day. Exceedances were recorded on April 1 (163 µg/m^3), April 11 (218 µg/m^3), and April 23 (305 µg/m^3). It was interesting to see that none of the Palomas samplers recorded high PM_{10} on those days.

Figure 3.1-2 shows all valid MiniVol PM_{10} concentrations during the study. The graph clearly shows PM_{10} concentrations high in the latter part of the study from April 14th to the 23rd. We have found that there is no clear correlation between maximum wind speeds and maximum daily PM_{10} (R^2=0.002). However there is a correlation between daily averaged PM_{10} over the network and daily averaged wind speed (R^2=0.69) for winds over 5 mph (2.2 m/s).

Highest PM_{10} across all sites occurred on April 21, 2012 with a mean PM_{10} concentration of 199 µg/m^3. Two of the Palomas stations recorded PM_{10} concentrations in excess of the US EPA 24-hour National Ambient Air Quality Standard. 24-hour concentrations varied from 199 µg/m^3 at CTSW to 65 µg/m^3 at the FORD site. Winds were not a large factor as the daily mean wind speed was 0.8 m/s with a highest 5-minute maximum wind speed of 6.7 m/s occurring at 5 pm. The daily averaged PM_{10} at the Luna County cattle yard measured 97 µg/m^3 based on the BAM sampler.

On April 15, the CTSW station recorded the third exceedance of the US EPA 24-hour National Ambient Air Quality Standard. The PM_{10} concentration at CTSW was 159 µg/m^3 similar to the 146 µg/m^3 measured at the FORD site. Average PM_{10} across all Palomas sites was 85 µg/m^3 on this day. Winds may have played a role in these PM_{10} concentrations since the maximum 5-minute wind speed was 12.1 m/s at 1:20 pm while the daily average wind speed was 4 m/s.

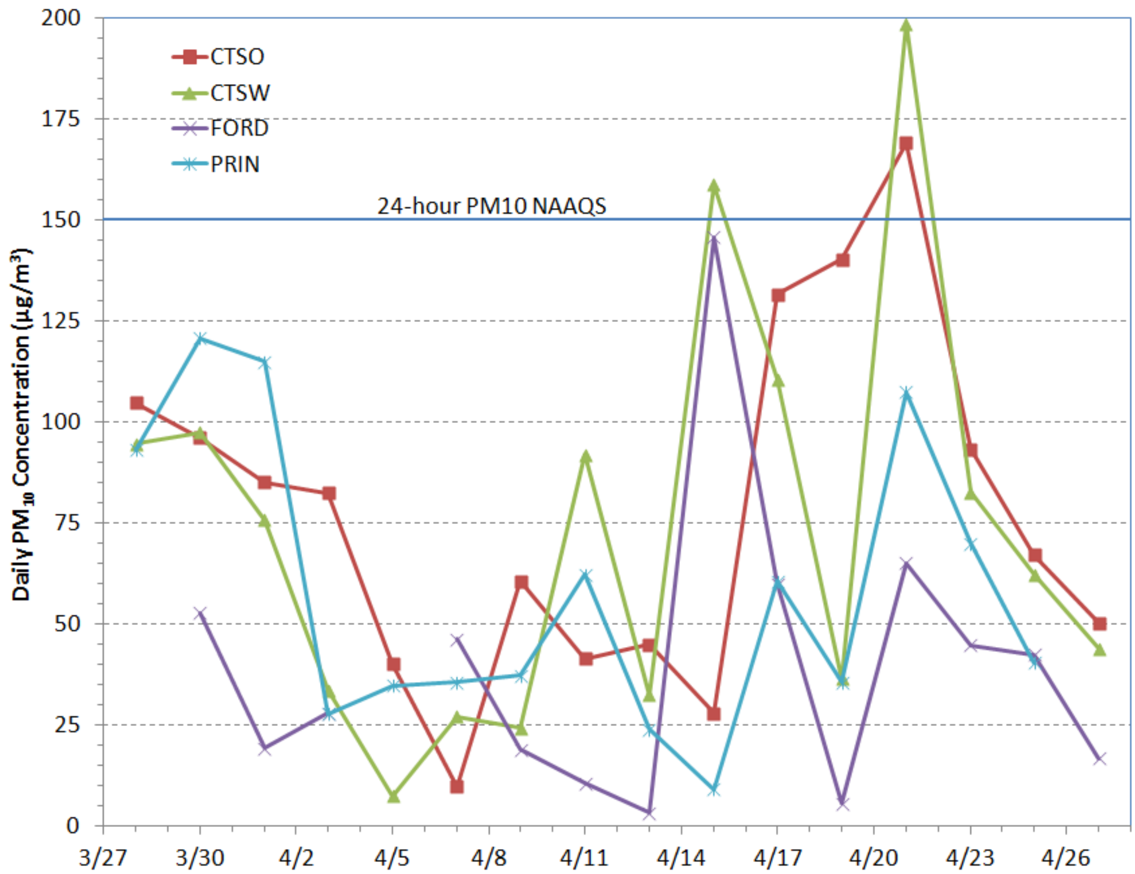


Figure 3.1-2. All valid MiniVol 24-hour PM_{10} sample concentrations during the study

Figure 3.1-2 shows a comparison of 24-hour PM_{10} measured by the MetOne Beta Attenuation Monitor and the BGI PQ100 PM_{10} filter sampler with units of µg/m^3. As the plot shows, there was a significant bias between the two measurement methods, as compared to the 1:1 line drawn on the plot. As a guide, a good comparison would show points scattered along the 1:1 line. This is an unexpected result given their close proximity and other studies have shown good agreement with the two types of sampling techniques (Watson et al., 2011). We anticipate that the two instruments measure the same or very similar aerosols and provide approximately the same concentrations. Possible causes of this problem can include sampler malfunction, improper sample handling in the field, and

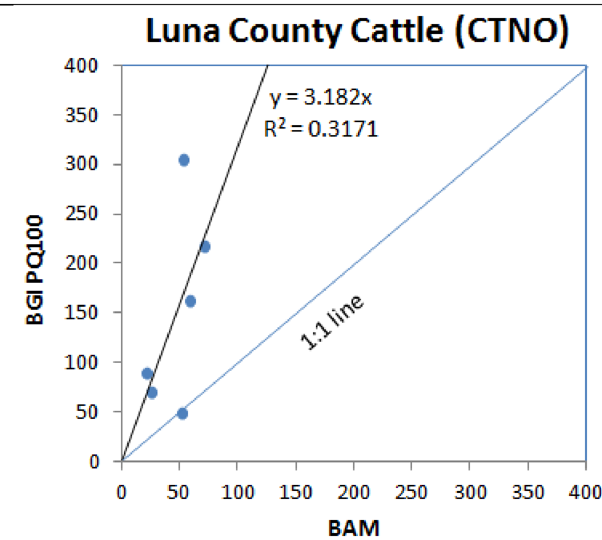


Figure 3.1-3. BAM compared to filter sampler. Concentrations are in µg/m^3.

potentially errors in the laboratory analysis. Due to the short turn-around in the sampling study, we did not include a systematic check with the two instruments or a comparison with other instruments to eliminate sources of error.

3.2. Meteorological Conditions

The study occurred during the months of late March and April which are typically highly variable in temperatures and wind with little precipitation. Figure 3.2-1 shows the temperatures during study as measured at the CTNE station by the Davis VantagePro weather station. The top line shows the air temperature in degrees Celsius at approximately 3-meters above the ground. The bottom trace is the dew point temperature.

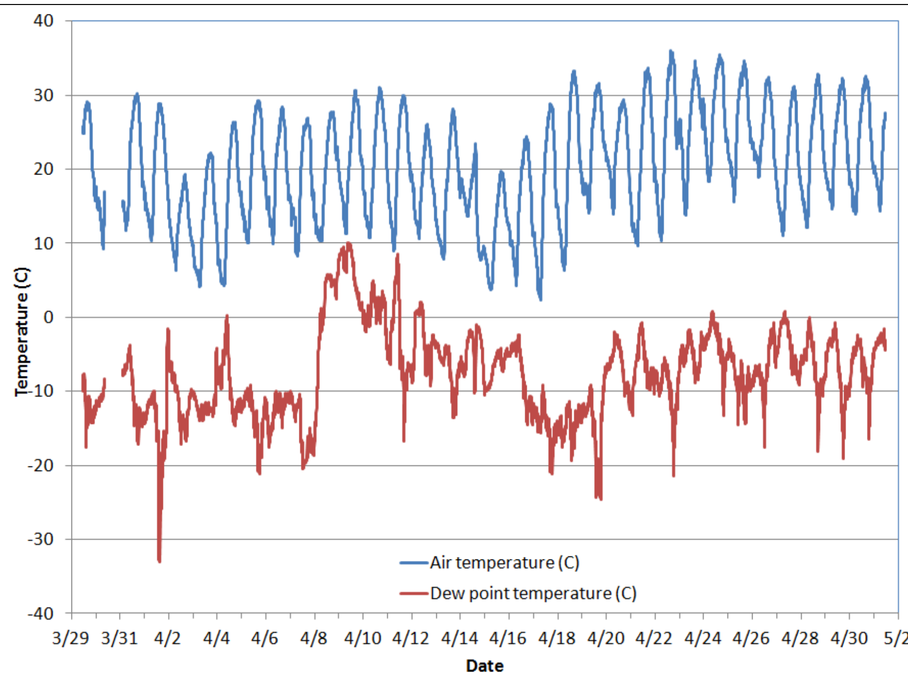


Figure 3.2-1. Air temperatures and dew point temperatures through the study measured at the CTSE site

Based on our observations and those at nearby climate stations, it did not rain during the study although relative humidity was high from April 9 to 10 as a storm passed over the area. This is shown in Figure 3.2-1 when the difference between the air temperature and dew point temperatures are at their smallest. The majority of the winds were from the westerly directions as show in Figure 3.2-2.

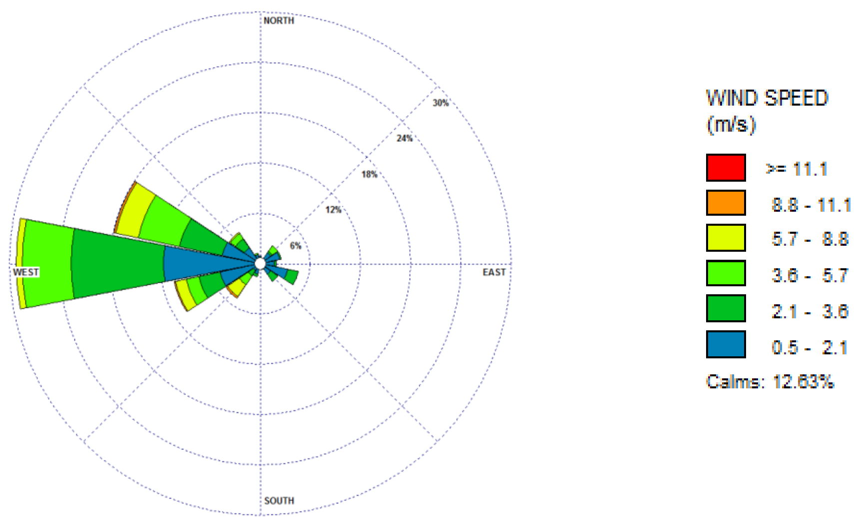


Figure 3.2-2. Wind rose showing wind direction statistics during the study at the CTSE site

The highest winds were from the west-northwest, west-southwest, and southwest directions. Figure 3.2-3 shows the 5-minute averaged wind speeds and wind gusts during the study. The wind observations were collected at a height of approximately 3-meters above the ground from a Davis Vantage Pro station. Winds shows showed the typical afternoon peaks and low winds during the morning hours.

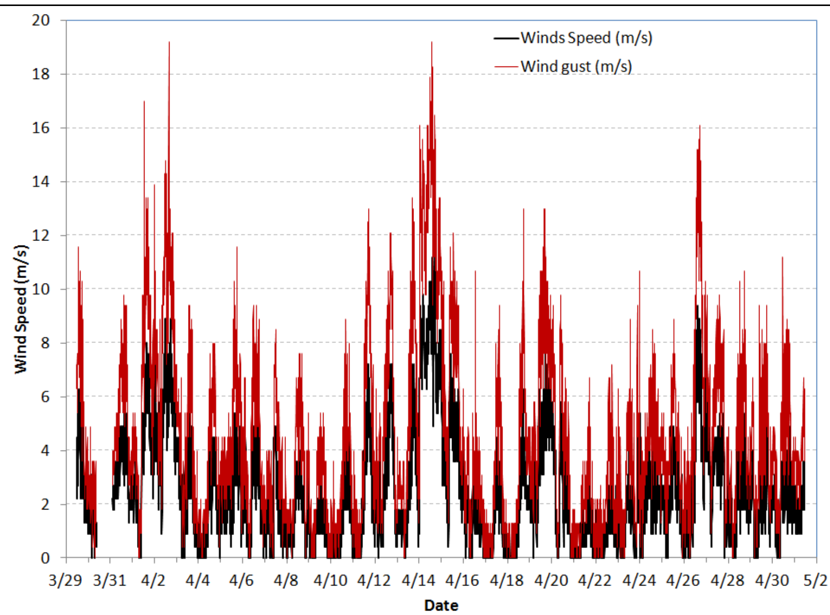


Figure 3.2-3. Wind and wind gusts over the duration of the study at the CTSE site

The highest winds were from the west-northwest, west-southwest, and southwest directions. Figure 3.2-3 shows the 5-minute averaged wind speeds and wind gusts during the study. The

wind observations were collected at a height of approximately 3-meters above the ground from a Davis Vantage Pro station. Winds shows showed the typical afternoon peaks and low winds during the morning hours.

The month of April was both warmer than the long term average and much drier than normal as shown in Figure 3.2-4. In fact this climate division experienced the record driest for any April.

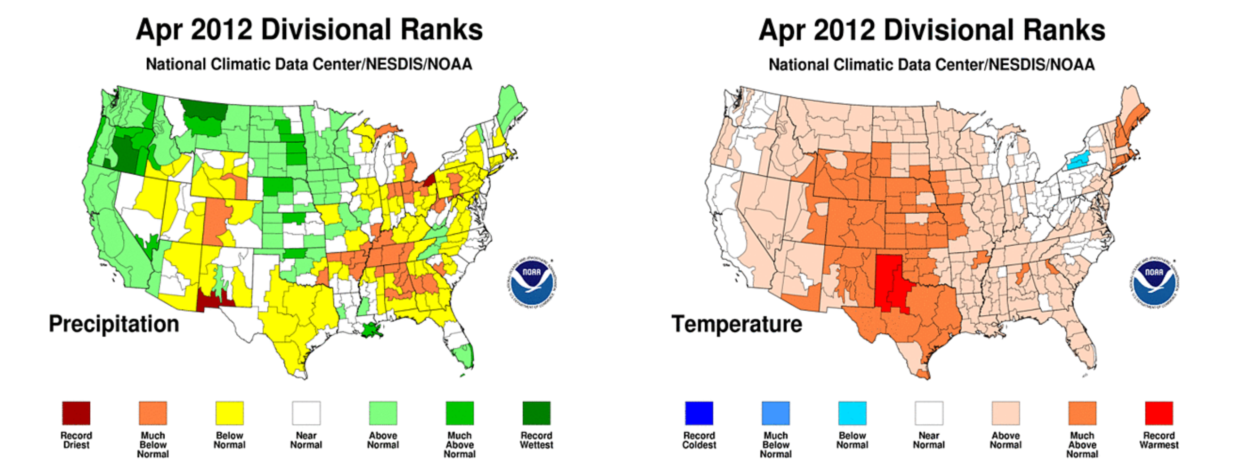


Figure 3.2-4. Climate division precipitation (left) and temperature (right) rankings for April 2012.

3.3. High Wind Events

An examination of the high wind events are important since they quantitatively indicate when wind erosion occurs and qualitatively show locations where local dust source impacts are important. The highest PM concentrations are observed at measurement locations closest to the disturbed land, but the deep mixing layers and turbulent updrafts can keep dust particles suspended for transport over long distances. Concentration distributions shift toward the small particle including the $PM_{2.5}$ size fraction with distance from the source as larger particles deposit owing to gravitational settling.

There were three distinct high wind events during the sampling study as shown in Figure 3.2-2. The first event occurred on April 2, 2012 but did not produce significant wind erosion. Peak wind measured at the Davis weather station was 43 mph at 3:45 pm. The last it rained in the region was two weeks prior on March 20. The second and most intense in terms of wind speed and PM_{10} concentration occurred on April 14, 2012. The third event occurred on April 26, 2012 and ranked second in terms of peak PM_{10} concentration. Unfortunately both high wind episodes did not coincide with the MiniVol filter sample days but they were captured with the hourly BAM instruments in Columbus.

Figure 3.2-2 shows the time series of hourly PM_{10} at both Columbus, New Mexico locations. These two were 735 meters (0.46 mile) apart surrounded in the immediate area by different landuse. The Luna County Cattle monitor was surrounded by cattle pens and a large unpaved lot whereas the Port of Entry station was surrounded partly by a paved lot on the west and open desert to the east. As the plot shows there were two noticeable peaks in aerosol concentrations during the study with both attributed to wind erosion from high winds. The first high wind event occurred on April 14, 2012 with peak hourly PM_{10} of 1920 $\mu g/m^3$ at the Luna cattle facility. On that day there were seven hours where the PM_{10} concentrations were at or near 1000 $\mu g/m^3$.

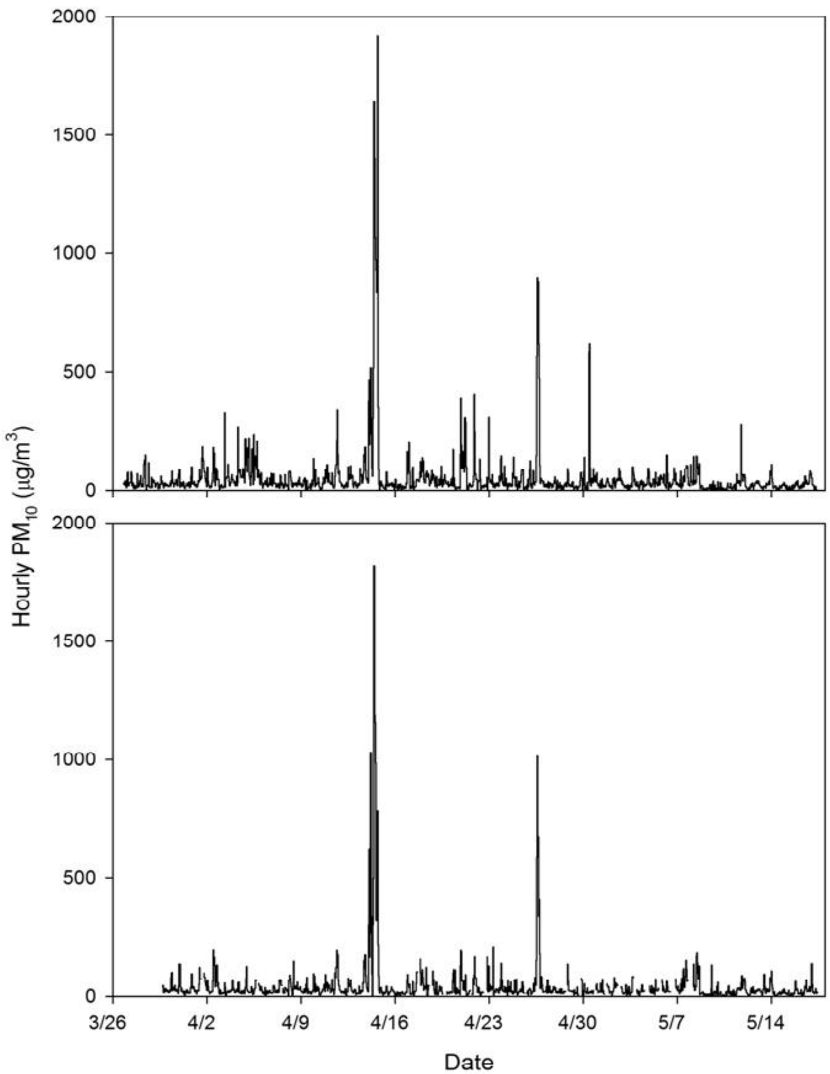


Figure 3.3-1. Hourly PM_{10} measured at the Luna County cattle facility (top) compared with Columbus Port of Entry (bottom) using Beta Attenuation Monitors.

It should be noted that the peak concentration the two strongest dust days were similar at both sites. This indicates that during the worst dust events, the dust plume concentrations are similar over this scale. In general there was more variability in daily peak concentrations at the Luna County Cattle facility compared to the Port of Entry and was to be expected give the numerous fugitive dust sources surrounding each monitor.

3.3.1. April 14 High Wind Event

This event was triggered by a cold front moving eastward across the state and was responsible for the highest winds and highest PM_{10} concentrations. This storm system brought snow showers to the higher elevations in the Gila Mountains but dry winds to the lower desert of Southwest New Mexico. Winds started early and were observed over 6 m/s (13.4 mph) over most of the day in Columbus. Peak winds on the April 14 as measured by the BAM instrument were 9.9 m/s (22.1 mph) at 5 pm MDT and 43 mph in Palomas at 1:45 pm. Figure 3.2.1-1 shows a forecast of surface winds at 1 pm as the cold front moves over the region, extending across Luna County from the SW to NE corners. Winds were from the northwest behind the front and from the west-southwest ahead of the front. On the right of Figure 3.2.1-1 is a visible band image from the GOES satellite at 4:02 pm. This image shows an extensive dust plume originating from northern Chihuahua and clearly flowing into the panhandle of Oklahoma.

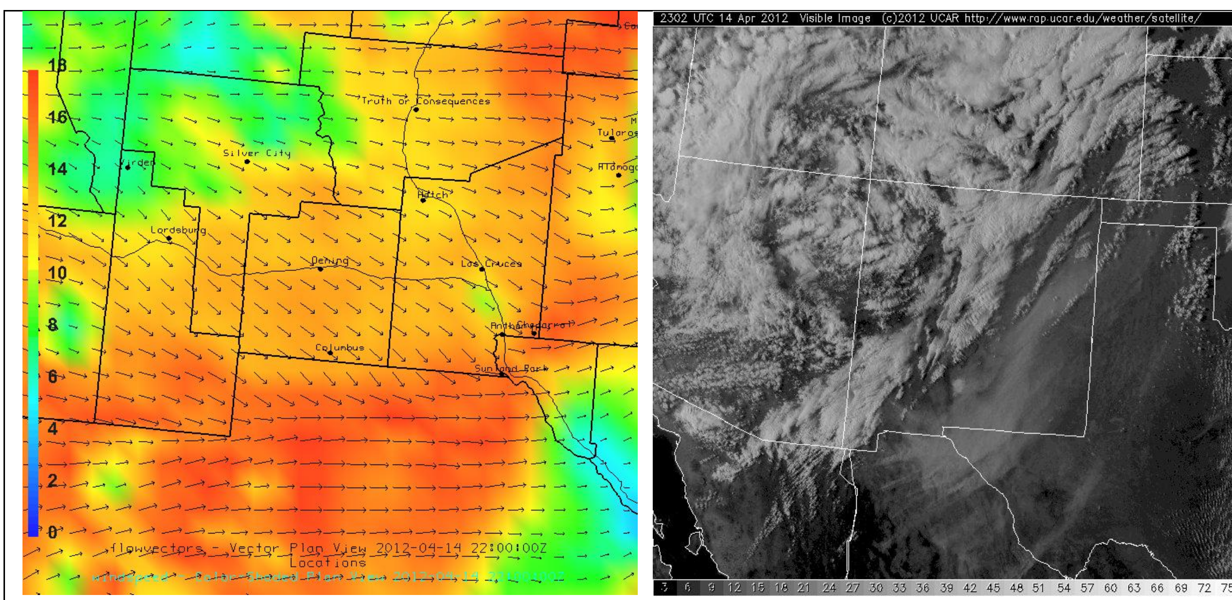


Figure 3.3.1-1. Predicted surface winds from the RUC model at 22 UTC (3 pm MDT) on left and GOES visible image at 23:02 UTC (4:02 pm MDT).

Processing the longwave infrared bands of the NOAA AVHRR satellite during this storm revealed that Palomas was on the western edge of the dust plume. Figure 3.3.1-2 shows the outline of the plume in relation to the study area.

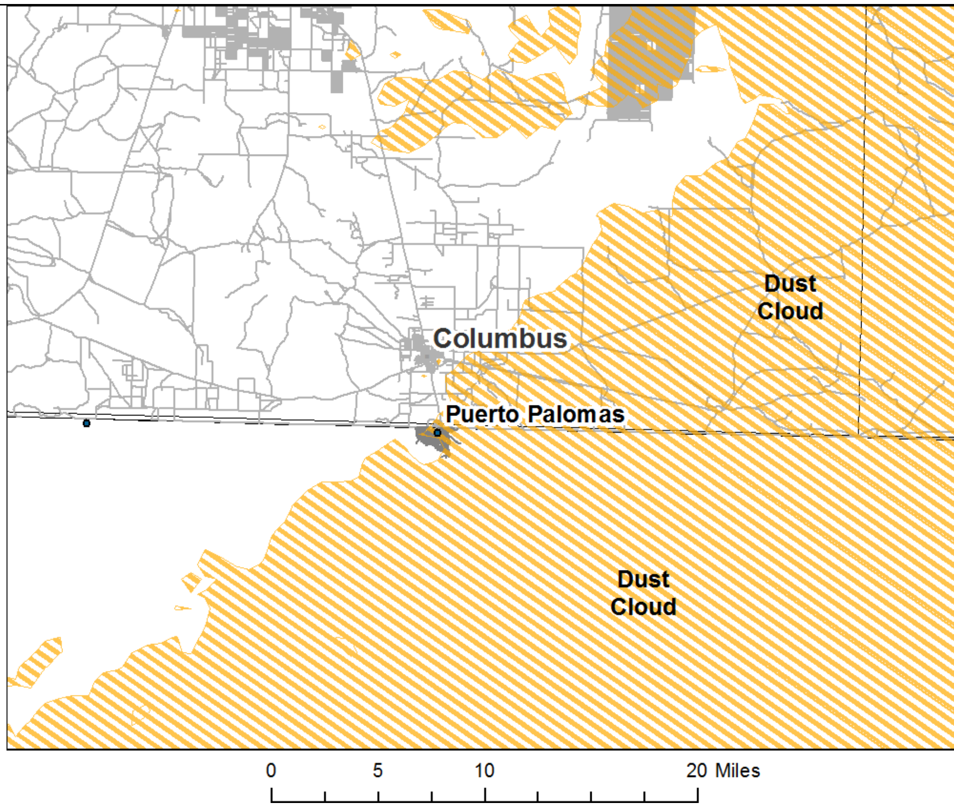


Figure 3.3.1-2. Dust plume outline over the Palomas and Columbus region on April 14, 2012

The MiniVol PM_{10} network did not collect data on this day due to the every other day sampling schedule. Both BAMs recorded similar concentrations throughout this dust event as Figure 3.2.1-2 shows. The concentrations measured at the Port of Entry sampler however dropped at 3 pm whereas they continued to be high (>900 µg/m^3) for several more hours. In fact the peak PM_{10} occurred at 5 pm at the Luna County cattle facility site.

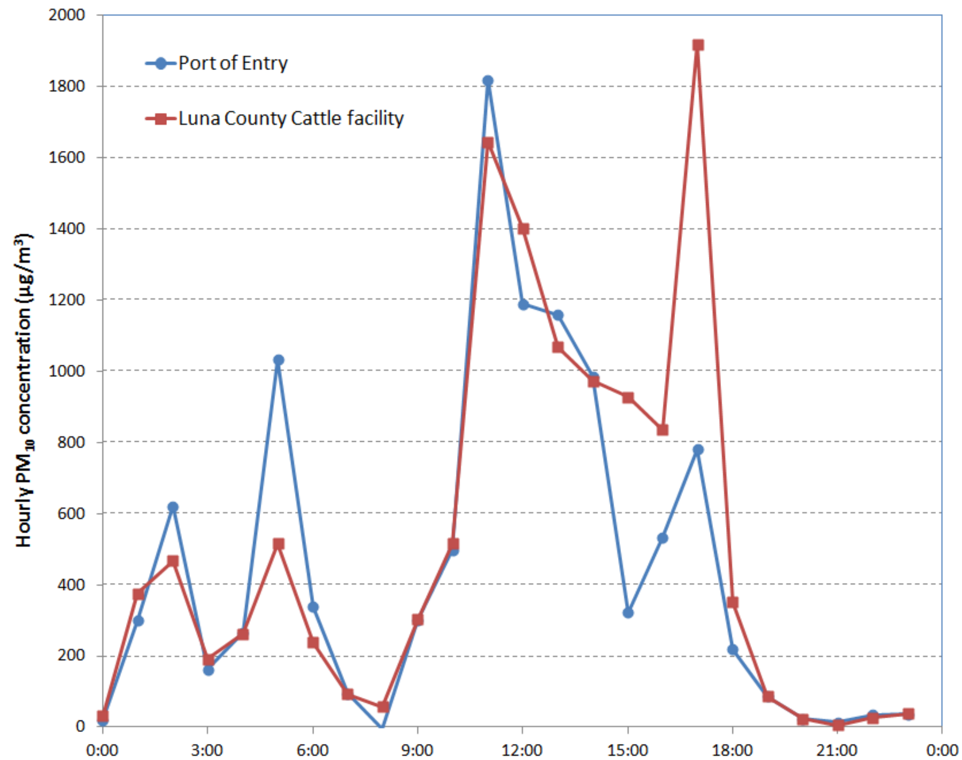


Figure 3.3.1-3. Hourly PM_{10} during the April 14, 2012 dust event based on the MetOne BAM. Time on x-axis is local in MDT.

Overall the 24-hour averaged PM_{10} concentration at the Luna County cattle facility was higher at 515 µg/m^3 compared to the Port of Entry value of 451 µg/m^3.

3.3.2. April 26 High Wind Event

A quickly moving upper level low and cold front brought in high winds to the border area in the afternoon. The day started off with fairly calm winds in the 2 to 3 m/s range. The forecast for the area predicted winds speeds of 30 to 40 mph with isolated gusts of 50+ mph on east slopes. The National Weather Service also forecasted blowing dust to reduced visibilities to less than a mile in dust prone areas. Peak winds on the April 14 as measured by the BAM instrument were 9.9 m/s (22.1 mph) at 5 pm MDT and 36 mph at 4:50 pm in Palomas. Hourly averaged winds were observed between 6 m/s (13.4 mph) and 7 m/s (15.7 mph) from 3 to 7 pm afternoon in Columbus at the NM DOH satellite station.

Figure 3.2.2-1 shows map of the forecasted winds and wind directions from the North American Model (NAM) model for 5 pm on that day. The model predicted the typical southwest wind during from these storms. Strongest winds of the region appear to be over the Columbus/Palomas area based on the model. On the right side of Figure 3.2.2-1 shows a visible

GOES satellite image from 5:45 pm and the resulting dust plumes (light gray swaths) from the high winds. Earlier in the day clouds obscured the dust although dust was observed at the ground. Unfortunately clouds obscured on both passes of the MODIS imager on this day.

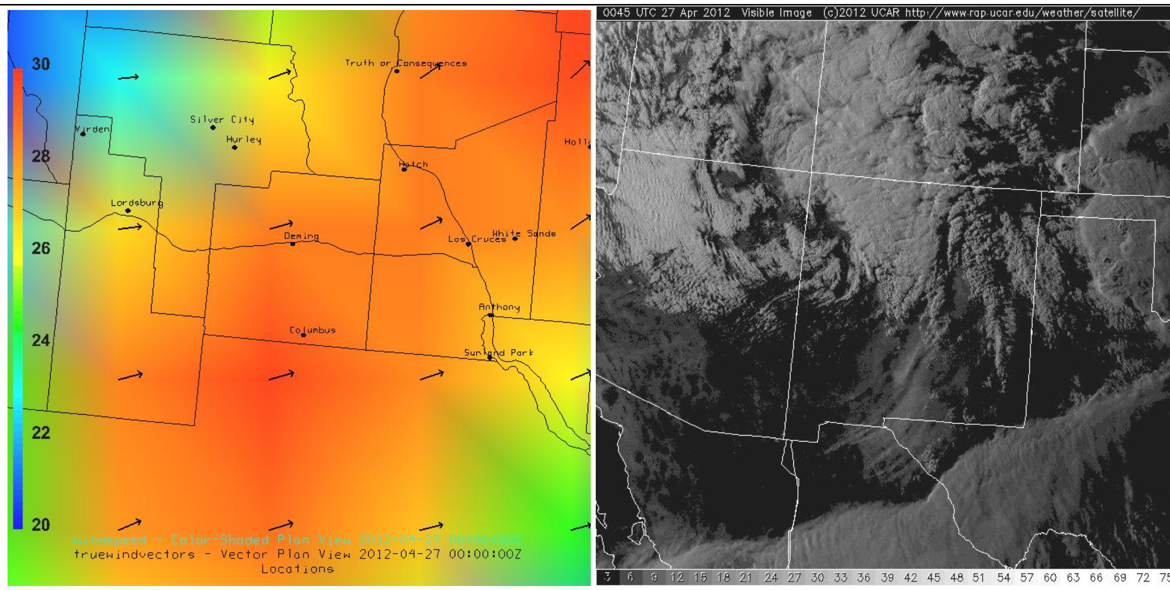


Figure 3.3.2-1. Predicted surface winds from the NAM model at 00:00 UTC (5 pm MDT) on left and GOES visible image at 00:45 UTC (5:45 pm MDT).

Similar to the first major dust episode on April 14, the MiniVol PM_{10} network did not collect data on this day due to the every other day sampling schedule. Figure 3.2.2-1 shows a time series graph of hourly PM_{10} from the two E-BAMS in Columbus. Note how the two stations recorded similar concentrations with peak PM_{10} on the same hour. This potentially shows that the impacts of the nearby dust sources are equally important at both locations and one is not much more impacted more than the other. Since winds were from the southwest during this episode sources likely responsible include those in the town of Palomas as well as those upwind in the disturbed range lands of Chihuahua.

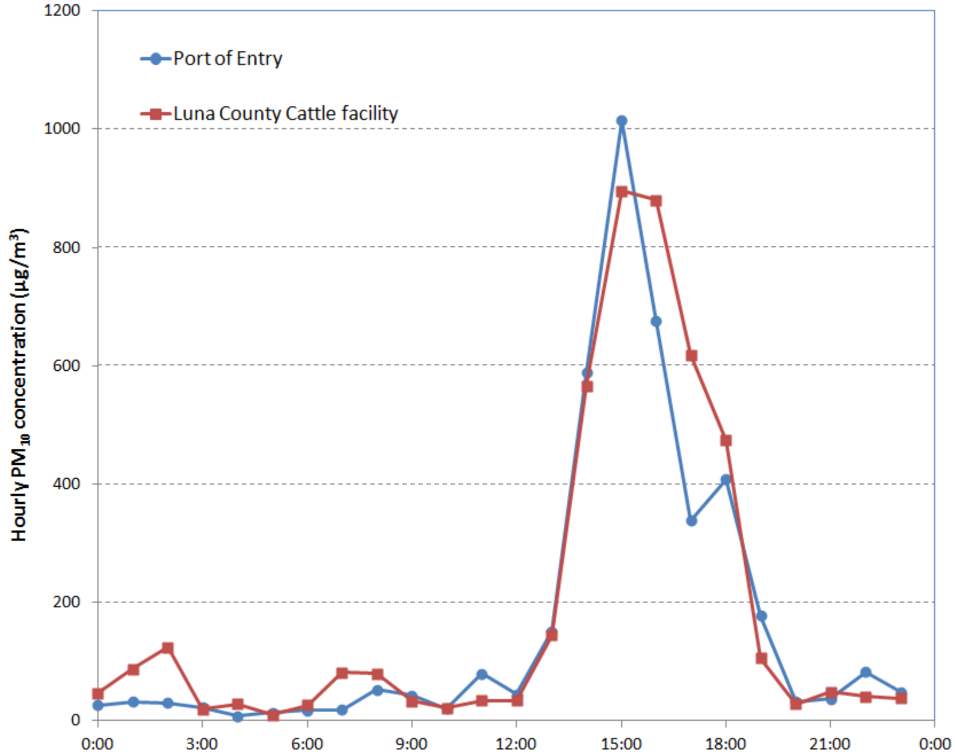


Figure 3.3.2-2. Hourly averaged PM_{10} concentrations during the April 26, 2012 high wind dust episode as measured by the MetOne E-BAMs. Time on x-axis is local MDT.

Processing the longwave infrared sounder bands 6 and 8 of the NOAA GOES satellite during this storm revealed that Palomas was on the edge of the dust plume on 23 UTC (5 pm), but likely outside after 00 UTC (6 pm) and 01 UTC (7 pm local). Figure 3.3.2-3 shows the outline of the large scale plumes in relation to the study area. The late afternoon satellite passes used in our analysis did not coincide with the highest concentrations measured at the study sites but nevertheless were within the end of the dust episode. Earlier in the day clouds obscured the ground and prohibited a good view of the dust near the peak at around 3 pm MDT.

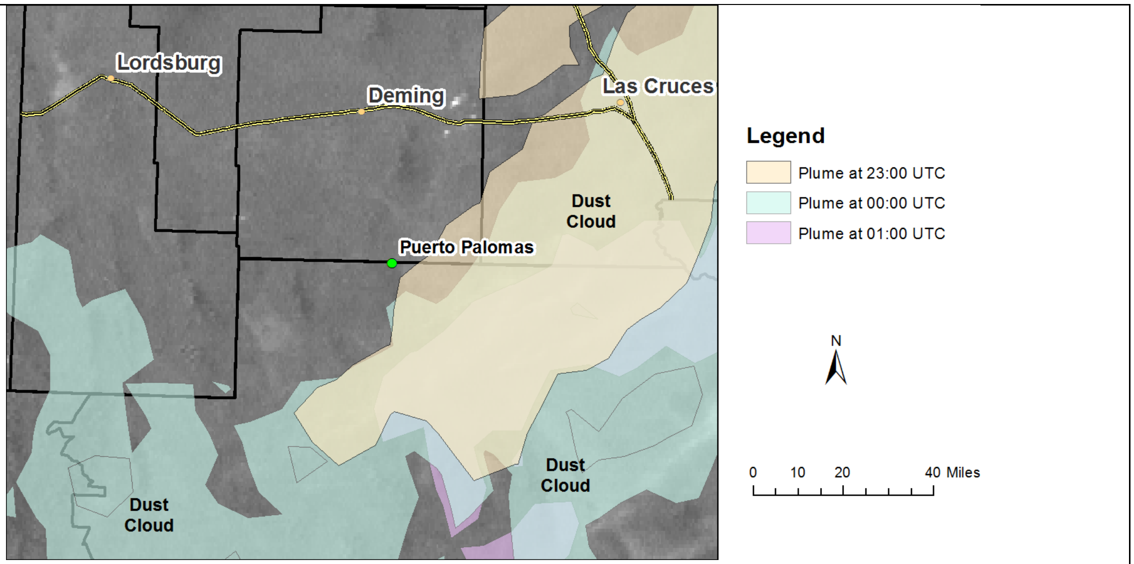


Figure 3.3.2-3. Dust plume outlines from April 26, 2012 based on long wave sounder infrared channel satellite imagery at 23, 00, and 01 UTC

3.4. Diurnal Patterns

The variation of hourly PM_{10} concentrations can reveal characteristics of the source types and meteorological patterns at a monitoring station. Figure 3.3-1 compares the Port of Entry with the Luna County cattle yard hourly PM_{10} data over the whole study. Highest concentrations typically occur in the late afternoon peaking at 4 pm at the Port of Entry while the peak is not a obvious at the cattle yard station although the highest concentrations do occur by 5 pm. In general higher median PM_{10} concentrations also occur during the early morning and late night. Meteorology likely drives this phenomena since winds are typically lower during those times and prevents pollutant dilution and causes pollutants to remain in the local where they were emitted. For example, a car driving on an unpaved road causes dust generation close to the road and with no wind to disperse it, it will remain in the general area for some time. An interesting feature of both sites is a minimum concentration point in the morning approximately between 8 and 10 am for the 5th through 20th percentile values. The role of meteorology could also play in the role of this since intense mixing of the lower boundary layer starts to intensity as the ground heats up and creates an unstable layer.

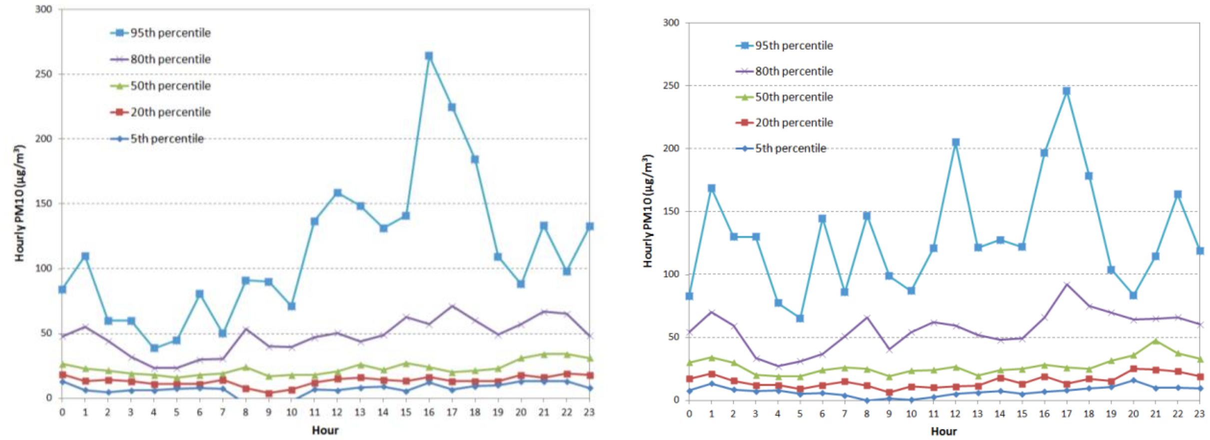


Figure 3.4-1. Daily variations in PM_{10} at the Columbus Port of Entry station (left) and Luna County cattle yard (right) by percentile. Each curve represents the specific percentile of that hour of day over the entire study.

An examination of the particle size instrument data provided a view of both the diurnal patterns of particles in Palomas as well as influences from type of emission sources. Figure 3.4-2 shows the $PM_{2.5}/PM_{10}$ ratio from April 13 to 16th.

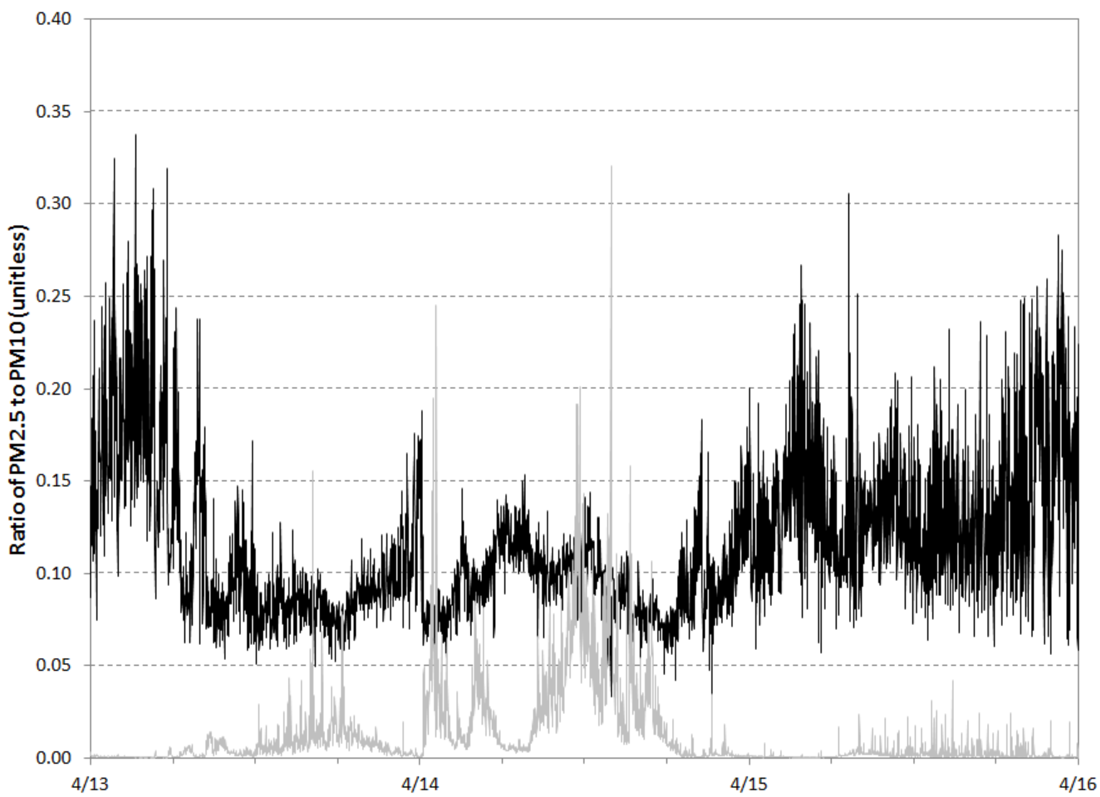


Figure 3.4-2. $PM_{2.5}$ to PM_{10} ratio during the April 14, 2012 dust storm. Black trace shows the ratio while the gray line is the PM_{10} data shown on a unitless scale.

Normally during dust storms the ratio is in the 0.10 to 0.12 range based on examination of data from the NMED data. Small ratios indicate particles concentrations are weighted more toward the larger particles and larger rations indicate particles weighted toward smaller particles. Dust storms are dominated by the larger particle sizes since the physical mechanism that produces the dust are typically more than 2 to 3 µm in diameter and most likely larger than 10 µm. When the ratio is high in the 0.4 to 0.8 range, it shows that the particles are dominated by small sizes less than 10 µm and likely less than 1 µm in diameter. Sources for this size of particle include combustion of fuels such as biomass burning or internal combustion engines. Although less likely in this area of the country, they can also be formed in the atmosphere from photochemical and/or thermal reactions.

A day that was influenced by smaller particles occurred on March 30, 2012 after a cold front cooled the area down 20°F compared to the previous day. The ratios greater than 0.3 between 3:00 to 6:00 am show an enhancement of smaller particles that could be from vehicle exhaust, cooking or residential heating. A temperature inversion probably and low winds likely provided the ideal conditions for pollutant such to be observed as these since the low temperature that morning was 49°F. As the sun rose, mixing of the atmosphere dispersed these pollutants and as a result the particle mix was again dominated by larger dust particles. This is evident by the low ratio after 6 am.

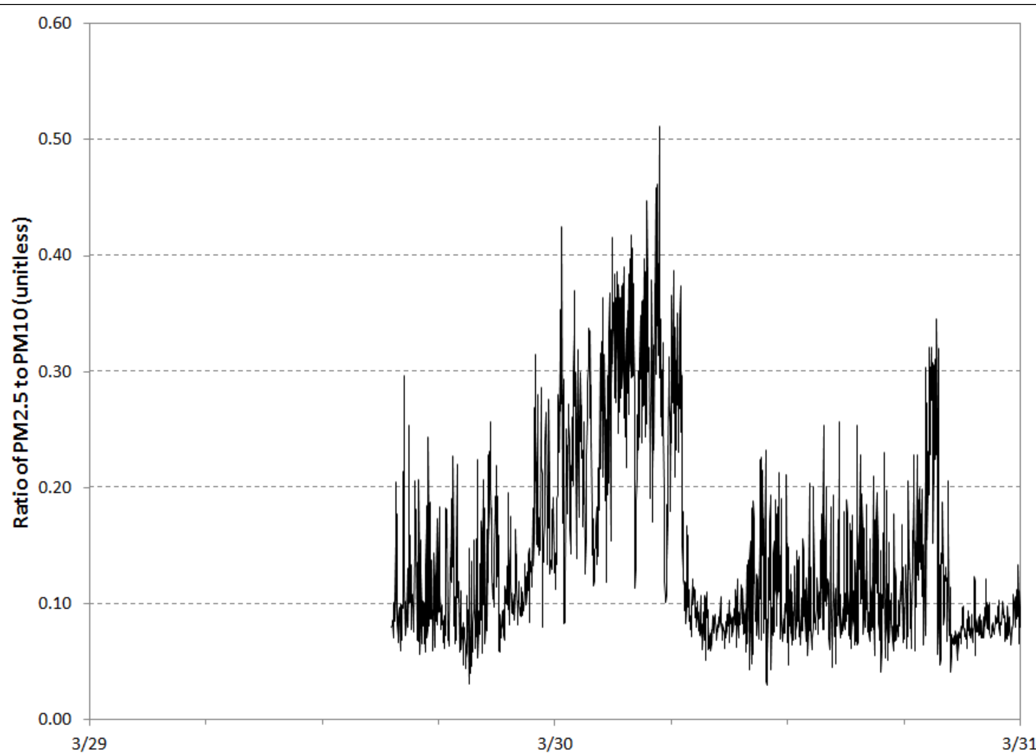


Figure 3.4-3. The morning of March 30 influenced by smaller particles

4. Source Characterization

This study began with the goal of providing quantitative fugitive dust emissions in the town of Palomas to include the cattle facility and unpaved roads. However, just as the project started we received word that the cattle facility will no longer be accepting cattle due to an international policy change. The project was well underway and we decided to proceed with the monitoring effort and change the emphasis to provide measurements of exposure to PM_{10} around the cattle facility with the hope of capturing both low wind and high wind erosion events that continually plague this area due to lack of dust control measures. As a result we will not estimate emissions from the cattle facility from normal activity due to livestock.

4.1. Unpaved road emissions

Unpaved road emissions can be the largest source of fugitive dust in small communities such as this. While wind erosion may the largest overall averaged over the year, unpaved road dust emissions occur throughout the year and on a regular, daily basis. This source type is most significant in locations where people use unpaved roads for commuting back and forth from home to work. Consequently peak unpaved road dust occurs twice a day during the morning and in the evening when people drive home from work.

Since we did not design the study to specifically collect data to estimate PM_{10} emissions of unpaved roads, we estimated emissions using EPA emission factors and best available activity information. This source type includes all Palomas roads that were gravel or dirt as of 2008. Figure 4.1-1 shows the locations of all unpaved roads in the county based on a previous project by Dr. Alfredo Granados (Granados-Olivas et al., 2008). According to this data there were 38.6 miles of unpaved roads and 3.92 miles of paved roads in 2008.

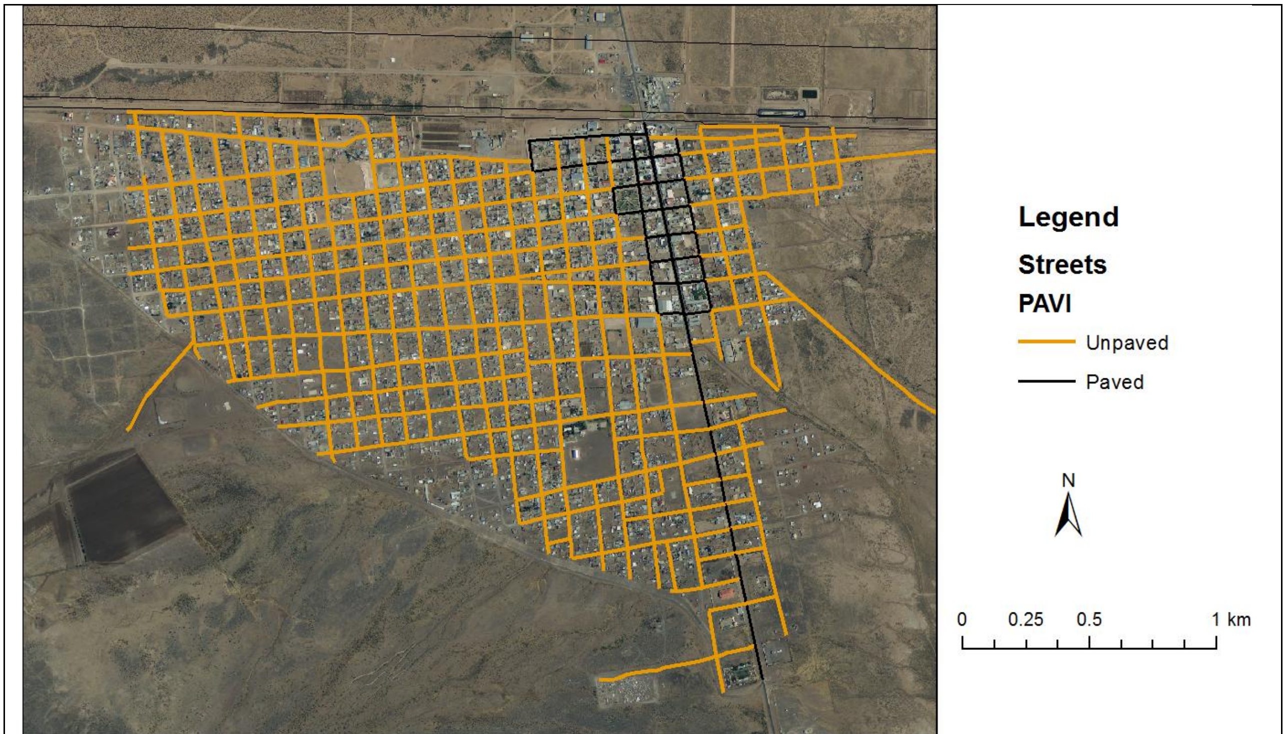


Figure 4.1-1. Unpaved road GIS from Dr. Alfredo Granados

According to AP-42 for unpaved public roads, the emission factor for PM_{10} in pounds of PM_{10} per vehicle miles traveled (VMT) is

$$\text{Emission Factor} = \left(\frac{k(s/12)^a (S/30)^d}{(M/0.5)^c} - C \right) \left(\frac{365 - \text{P}}{365} \right)$$

where s is the surface material silt content in percent, S is the mean vehicle speed in miles per hour, M is the surface material moisture content in percent, P is the number of days in a year with at least 0.254 cm (0.01 inch) of precipitation and C is the emission factor for 1980's vehicle fleet exhaust, brake and tire wear.

A 6 percent silt content was used in the absence of local data and to be consistent with the Cd. Juarez emission inventory (IMIP, 2000). This compares with a 7 percent silt content based on measurements taken during a field study at the US Army's Ft. Bliss to measure unpaved road emissions (Kuhns et al., 2005). Percent moisture data at the 2-cm depth was retrieved from the Jornada USDA SCAN station at the Jornada Long-Term Ecological Reserve.

Daily soil moisture from the SCAN sites for 2011 was averaged over one year to arrive at a mean moisture content. A mean vehicle speed of 25 mph was used based on knowledge of local roads in Palomas. The number of days per year with at least 0.01 inches of precipitation for 1909 to 2011 was obtained from data collected at the Columbus NWS Cooperative

Observation station. Table 4.7-1 summarizes the values used in the AP-42 equation for this inventory.

Table 4.7-1 Constants used in the unpaved road emission factor

Constant	Description	Value
k	particle size specific constant	1.8 lb/VMT
s	Silt content	6%
a	Silt content exponent	1
S	Mean vehicle speed	25 mph
d	Vehicle speed exponent	0.5
M	Surface moisture content	1.5%
c	Moisture content exponent	0.2
P	# of days/year with 0.01" rain	39
C	Age correction factor	0.00047 lb/VMT

Since vehicle activity levels are difficult to estimate we intended to operate a time lapse camera system viewing one of the roads to estimate unpaved road traffic but the system was not ready for quick turn-around of this study. To estimate vehicle activity levels we used an estimate from a report by ERG, Inc. and the International Communities Research Center evaluating per capita vehicle kilometers travelled over many cities in Mexico (Wolf et al., 2003). For small cities less than 25,000 they estimate that the per capita vehicle kilometers travelled (VKT) is 1.9 per day per person. For reference they used the city of Castaños, Coahuila (pop. 19,586) for the small city vehicle activity level. For Palomas, this activity level might be lower since it is about a quarter the size of Castaños and people's driving behavior could be different. Nevertheless we used this activity level since it is the best available data. For all of Palomas, the per capita VKT is multiplied by the population to calculate the total VKT per day. This is for all road types, both paved and unpaved. To partition out the unpaved portion, we used the road inventory from Granados-Olivas et al. (2008) to calculate a ratio of length of unpaved roads to all roads of 0.91.

To consider the portion of particle emissions that become suspended in the air after some fraction has settled-out due to gravitational settling, we use a "transportable fraction" correction. For a small city such as Palomas, there is a mix of urban landuse and open land. We used a fraction of 0.75 since most of the buildings are one story and spread apart. This fraction is then multiplied to the emission factor.

Finally, we calculate an emission rate in tons of PM_{10} per year based on the following equation.

$$\text{Emission Rate} = [Activity\ level] * [Emission\ factor]$$

After calculations are done, the estimated emission rate for the city is 268 tons of PM_{10} per year. This is only for emissions caused by vehicles travelling on the roads and does not consider wind erosion or tail pipe emissions from the engine.

4.2. Wind erosion

Wind erosion is typically the largest emission source in rural arid regions on an annual basis. This source type is also most difficult to estimate because it relies on soil moisture, wind speed, wind gusts, level of disturbance, particle sizes, the reservoir of particles available for movement, soil type, and any sheltering effects that modify the wind patterns in and around the source area. A difficulty in estimating wind blown dust emissions from observational data is that the sizes and locations of the sources and their contributions to the overall dust loading is unknown. For example it is very difficult to assess contributions from several upwind dust sources with each having a similar chemical signature. However PM data collected from monitoring stations that are located both upwind and downwind of the majority of fugitive sources can be used to determine frequency and magnitude of wind blown emission events.

5. Summary

During the study, three exceedances of the 24-hour PM_{10} National Ambient Air Quality Standards were observed in Palomas and two in New Mexico. The two exceedances in New Mexico were during strong dust storms due to high winds. These episodes were not only affected the Palomas/Columbus area but most of southern New Mexico and parts of southern Great Plains as the dust plumes were transported by strong southwesterly winds.

Several conclusions can be drawn from the PM_{10} samples in this study with respect to particle measurements, emission sources, and human exposure. The highest exposures to PM_{10} were from regional dust storms that brought in both transported dust on top of wind blown dust locally generated from erodible areas.

Overall the highest 24-hour averaged PM_{10} concentrations were measured at the CTSO site, south of the cattle facility. PM_{10} concentrations at that site over the study period averaged 78 $\mu g/m^3$ with a median value of 75 $\mu g/m^3$. The second highest average PM_{10} concentrations were measured at the CTSW site, west of the cattle facility. There the average daily PM_{10} was 74 $\mu g/m^3$ and the median value was 69 $\mu g/m^3$.

An analysis of homogeneity across the study PM_{10} network showed that concentrations are highly variable on most days. There were three days when the PM_{10} concentrations varied by more than a factor of 10, and one day when the highest and lowest spanned more than 150 $\mu g/m^3$.

6. Recommendations

A micro inventory of landcover surrounding the monitoring stations will be useful in determining the potential contribution of each source to the sample collected at the monitoring site. This would be a continuation of the work of Granados-Olivas (2008) and include more road-side traffic data and a detailed survey and locations of vacant lots, storage piles, unpaved and paved streets, construction sites, and industrial operations.

Since there is no local meteorological monitoring in Palomas, it would be very useful to begin collecting data to establish a meteorological baseline to include air temperature, humidity, precipitation, wind speed, wind direction, and solar radiation. The least expensive method to collect climate data is with a volunteer observer. This is demonstrated with the 10,000+ member CoCoRaHS volunteer rain gauge network across the US. The benefits of working with CoCoRaHS is that there already exists a database structure and free mapping capability and some level of quality assurance from the data administrators both at the national level and at the regional level. The only cost is of purchasing the rain gauge for less than $40 USD. An inexpensive digital thermometer can also be used to collect temperature data. Temperature data can be archived in the CoCoRaHS database in the "comments" section of the database. However, a dedicated observer or observer team needs to be assigned. Another possibility that might be easier to get started is with a real-time observing station. A real-time data system would be useful for weather forecast verification and dust forecasting. There are a few relatively inexpensive weather stations that could be installed such as a Davis Vantage Pro that was used in this study. These types of stations have software and hardware to connect to the internet.

6.1. Control Measures

A combination of various fugitive dust control strategies can be applied to the area to reduce exposure to PM_{10} during both high and low wind conditions. There are numerous handbooks (Countess, 2006; Bolander & Yamada, 1999), articles (Cai et al., 1983), and studies (Gillies et al., 1999; Billman and Arya 1985) related to fugitive dust control techniques that can be used as a guide.

To reduce PM_{10} from unpaved roads, a list of high priority roads can be assembled based on casual observations or through a traffic counting project. There are several options for unpaved road emissions controls depending on soil type, vehicle activity, vehicle type, and ultimately budget. The most effective method is paving but it is the most costly. Chemical suppressants are widely available for use on unpaved roads and costs vary depending on the type and quality.

Reducing wind blown dust exposure from open areas, and vacant land is also difficult due to the number of sources and cost of controls. In Palomas disturbed exposed areas are numerous and vary in size from residential plots, playgrounds, to rangeland surrounding the city. Simple wind erosion mitigation options include wind break around playgrounds or soil stabilization through revegetation or the application of surface treatments. Pardyjak et al. (2006) concluded that the height of the barrier was more important than the number of rows of wind breaks. Surface application of chemical suppressants are another type of control measure and vary widely in cost per square meter and effectiveness.

6.2. Emission Inventory

The quality of an inventory depends on the inputs and assumptions used in developing the inventory. The inherent variability of fugitive dust emissions may preclude absolute emissions estimates. Nevertheless, the examination of physical processes shows that better knowledge of the locations of these emissions, the joint frequencies of activities and different meteorological conditions, and more site specific measurements of key parameters would provide more representative emissions rates than are now available.

As in most areas in the arid southwest wind erosion represents the largest PM_{10} emission source on an annual basis, it would be beneficial to refine this source as much as possible. New technologies exist that allow characterization of the wind erodibility of soils with less expense than employing large straight-line wind tunnels. This effort would apply the dust characterization technologies standardized by the research community to representative fugitive dust emitters within each source type with erodible lands. Comparisons would be made with more spatially diverse data, such as those in the soil surveys, to determine the degree to which these surveys can be used to extrapolate the measurements from a reduced number of sampling sites. These values would be incorporated into the emissions inventory to better estimate emissions from specific soil types.

Silt content is an indicator of the amount of particles less than 75 µm in the soil sample. A recent analysis of soil samples collected across California indicated that dry silt content is not a reliable surrogate for PM_{10} emission potential since a soil sample may have a large silt content, but a small PM_{10} content (Carvacho et al. 2001). Silt content for use in AP-42 is determined by sieving dried soil samples acquired from surface loading tests. Silt content is measured using a 200 mesh screen as defined by the ASTM method C-136. Soil scientists commonly speak of the term “silt” which does not refer to the same quantity as “silt content” as used in AP-42. Soil scientists use the term “silt” as particles with sizes between 2 and 50 µm. They also call sand as particles from 50 to 2000 µm and clay as the smallest particles less than 2 µm. These particle fractions are measured by a combination of wet sieving and pipetting using ASTM method 136-95a. One way to estimate the AP-42 “silt content” is to sum silt and clay.

Another way of estimating unpaved road VMT is to calculate it using a common practice of multiplying the total number of miles of unpaved roads by the average daily traffic volume (ADTV). Thus, the emissions in tons per year are calculated by multiplying the ADTV, the miles of unpaved roads, the unpaved road emission factor, the number of pounds in a ton and the number of days in a year. Since unpaved road ADTV is not measured, an estimate based on a method used by WRAP can be used. For example ADTV was based on a study conducted in Clark County, Nevada for their 2001 PM_{10} State Implementation Plan (SIP) to estimate urban unpaved road volume. In that survey, an average ADTV or 69.2 was obtained. A survey would have to be conducted for driving habits in Palomas to improve the unpaved road inventory

Based on site surveys done for this project, the total unpaved road emissions are highly uncertain due to the lack of activity levels. GIS data from the Dr. Alfredo Granados was consulted to estimate the kilometers of unpaved roads. As this is considered the best available dataset for locations, improvements can be made to update the many kilometers of unpaved roads since the first inventory.

6.3. Suggestions for Future Studies

6.3.1. Wind Erosion Susceptibility

Based on work from Granados-Olivas et al. (2008) an inventory of area source could be produced. This would include both non wind generated emissions as well as those caused by high winds. Figure 6.3.1-1 shows an example of the location of open lots in Palomas.

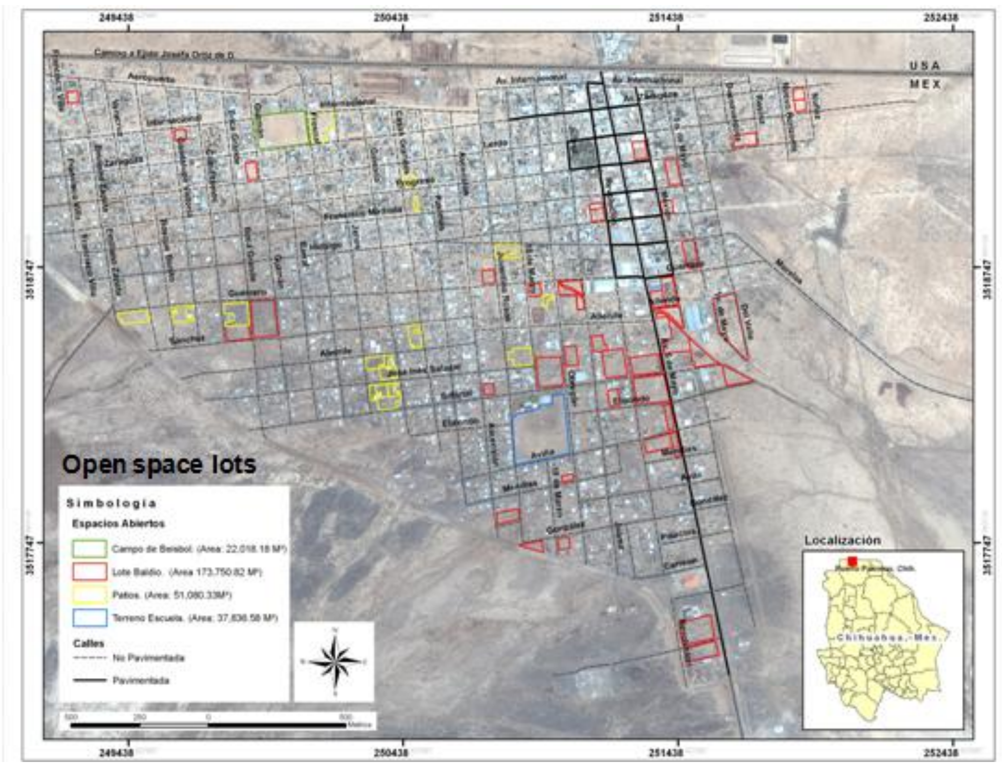
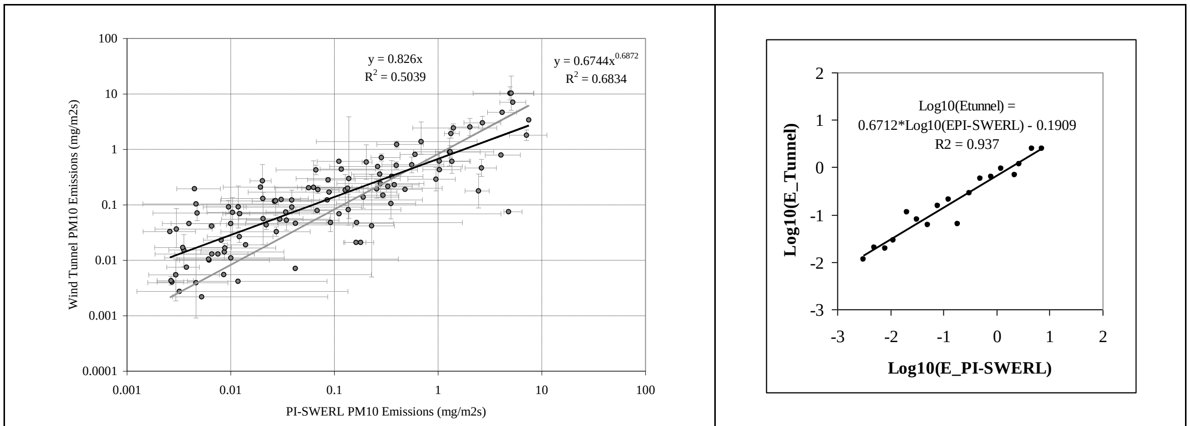


Figure 6.3.1-1. Open lots indentified by Granados-Olivas et al. (2008)

The straight-line portable wind tunnel is currently the method that is closest to a "standard" instrument for direct measurement of PM_{10} dust emission fluxes from soils. For example, The University of Guelph's suction-type straight-line field wind tunnel is approximately 1 m × 1 m × 11 m long. The long test section of the wind tunnel is required, by scaling considerations for the correct simulation of the physics of the atmospheric boundary layer and the sand saltation process. Unlike large field wind tunnels, the Portable In-Situ Wind ERosion Laboratory (PI-SWERL, Figure 6.3.1-2) provides a measure of the stability of a soil by directly generating wind shear above the surface using a rotating annular ring. The advantage of the PI-SWERL is the relative speed with which measurements can be performed, with each test requiring less than fifteen minutes including setup. Side-by-side tests between the PI-SWERL and the University of Guelph straight-line field wind tunnel were conducted at 23 different sites in Southern California (Etyemezian et al., 2006a). Applying a simple empirical correction based on surface cover to the PI-SWERL data yielded the correspondence shown in Figure 6.3.1-2a. When the data from Figure 6.3.1-2a were averaged appropriately (over 0.2 decades in the case of the figure), the resultant relationship between wind tunnel and PI-SWERL measurements was quite strong (Figure 6.3.1-2b).



a. PM_{10} emissions from all sites at all levels of shear stress	b. same as a. but data averaged over intervals of 0.2 decades

Figure 6.3.1-2. Scatter plot of wind tunnel PM_{10} emissions versus PI-SWERL measured PM_{10} emissions from 23 collocated tests. An empirical correction has been applied to the PI-SWERL data to account for differences in the boundary layer depth from University of Guelph wind tunnel.

6.3.2. Unpaved road emission refinement

Inhalable dust emissions from paved and unpaved roads are frequently estimated by measuring airborne concentrations of PM_{10} upwind and downwind of a road (Cowherd et al., 1984; Gillies et al., 1999). Combined with measurements of wind speed and direction, the differences between the downwind and upwind concentrations can be used to estimate the horizontal flux of PM_{10} dust across the plane that is parallel to the road and perpendicular to the ground. The upwind/downwind technique is not practicable for measurement of emission factors on the scale of an entire airshed because of the costs involved. A more common practice is to measure a surrogate for emission factors. In the AP-42 guidance document (USEPA, 1999), the USEPA suggests the procurement of loose debris from roads by vacuuming and subsequently analyzing the vacuumed material for silt content. Silt, in this case, is defined operationally as the portion of material that passes through a 200 mesh sieve, corresponding roughly to particles having geometric diameters less than 75 microns.

Kuhns et al. (2001) and Etyemezian et al. (2003a) have described a vehicle-based alternative to silt measurements. The TRAKER (Testing Re-entrained Aerosol Kinetic Emissions from Roads) is a cargo van that measures road dust emission potential by utilizing three inlets, two that are behind each of the front tires and one that extends through the front bumper in front of the vehicle. As the TRAKER is driven on a road, air that is laden with particles suspended behind the front tires and background air sampled ahead of the front bumper are channeled to nephelometer-style instruments (TSI, DustTrak model 5820) located inside the vehicle. The instruments record PM_{10} concentrations in one-second intervals. An onboard GPS logs the location of each one-second measurement as well as other parameters such as the speed, acceleration, and heading of the TRAKER.

The great advantage of mobile road dust sampling systems such as the TRAKER is the speed and spatial and temporal resolution with which data can be acquired. Etyemezian et al. (2003b) assembled a PM_{10} paved and unpaved road emission inventory for the Treasure Valley, Idaho using several hundred of miles of roadway measurements during winter and summer in place of the customary dozen or two silt measurements at fixed locations traditionally used for the same purpose. The TRAKER also allows for determining which roadway parameters (e.g. location, traffic volume, posted speed limit, and proximity to other dust sources such as construction sites) have a measurable effect on emission factors with a high level of precision (Etyemezian et al., 2006b). The TRAKER has been used to measure paved and unpaved road dust emissions in Las Vegas, NV (Kuhns et al., 2001, Etyemezian et al., 2005), the Treasure Valley, ID (Etyemezian et al., 2003b), El Paso, TX (Gillies et al., 2005; Kuhns et al., 2005), and Lake Tahoe, NV (Kuhns et al., 2004).

Figure 6.3.1-3. Testing Re-entrained Aerosol Kinetic Emissions from Roads (TRAKER) van

7. References

Billman, B.J.; Arya, S.P.S. (1985). Windbreak effectiveness for storage-pile fugitive-dust control: A wind tunnel study. Report Number EPA-600/S3-85/059; prepared by U.S. Environmental Protection Agency, Research Triangle Park, NC,

Bolander, P. and A. Yamada. (1999) Dust Palliative Selection and Application Guide. USDA Forest Service, Report number 9977 1207-SDTDC.

Cai, S.; Chen, F.F.; Soo, S.L. (1983). Wind penetration into a porous storage pile and use of barriers. Enivron. Sci. Technol., 17: 298-305.

Carvacho, O.F., L.L. Ashbaugh, M.S. Brown, and R.G. Flocchini. (2001). Relationship between San Joaquin Valley soil texture and PM10 emission potential using the UC Davis Dust Resuspension Test Chamber. Transactions of the ASAE 44(6): 1603-1608.

Chow, J.C., J.G. Watson, L.C. Pritchett, W.R. Pierson, C.A. Frazier, and R.G. Purcell (1993). The DRI Thermal/Optical Reflectance Carbon Analysis System: Description, evaluation, and applications in U.S. Air Quality Studies. Atmos. Envr. 28A(8): 1185-1201

Countess,R. (2006). WRAP Fugitive Dust Control Handbook. Prepared by Countess Environmental, Westlake Village, CA, September 7, 2006.

Cowherd, C. (1984). Paved Road Particulate Emissions: Source Category Report. Report No. EPA-600/7-84-077. Prepared by U.S. Environmental Protection Agency, Research Triangle Park, NC, USA.

Draxler, R.R., Hess, G.D., (1997). Description of the HYSPLIT_4 Modeling System. Report No. NOAA Technical Memorandum ERL ARL-224. National Oceanic and Atmospheric Administration, Air Resources Laboratory, Silver Spring, MD. http://www.arl.noaa.gov/data/models/hysplit4/win95/arl-224.pdf.

Etyemezian, V., H. Kuhns, and G. Nikolich (2006a). Precision and repeatability of the TRAKER vehicle-based paved road dust emission measurement. Atmos. Environ. 40: 2953-2958.

Etyemezian, V., S. Ahonen, J. Gillies, J. Goreham, I. Kavouras, G. Nikolich, D. Shafer, M. Sweeney, and M. Young (2006b). Plutonium Soil Stabilization Study at the Nevada test Site: Final Report. Prepared for Encapco Technologies LLC, Napa, CA, and the Naval Facilities Engineering Service Center, Port Hueneme, CA. March, 2006.

Gillies, J.A.; Watson, J.G.; Rogers, C.F.; DuBois, D.; Chow, J.C.; Langston, R.; and Sweet, J. (1999). Long Term Efficiencies of Dust Suppressants to Reduce PM10 Emissions from Unpaved Roads. J. Air & Waste Mgmt Assoc., 49:3-16.

Gillies, J.A., V. Etyemezian, H. Kuhns, D. Nikolich, and DA. Gillette (2005). Effect of vehicle characteristics on unpaved road dust emissions. Atmos. Environ. 39: 2341 – 2347.

Granados-Olivas, A., I.R. Alvarado, and N.C. Reyes-Villegas. (2008). Report of Palomas Inventory of Unpaved Roads and GIS Training at Local Schools. Prepared for US-Mexico Border 2012 Program, New Mexico-Chihuahua Rural Task Force, Air Quality Subcommittee

IMIP (2000). Roadway Improvement Survey for Ciudad Juárez. Prepared for the Texas Natural Resource and Conservation Commission. Prepared by Instituto Municipal de Investigación y Planeacion, Ciudad Juárez, Chihuahua, December 2000.

Kuhns, H., Etyemezian, V., Landwehr, D., MacDougall, C., Pitchford, M., Green, M. (2001). Testing Re-entrained Aerosol Kinetic Emissions from Roads (TRAKER): A New Approach to Infer Silt Loading on Roadways. Atmos. Environ. 35: 2815-2825.

Kuhns, H., J. Gillies, V. Etyemezian, D. DuBois, S. Ahonen, D. Nikolic and C. Durham (2005). Spatial Variability of Unpaved Road Dust PM10 Emission Factors near El Paso, Texas. J. Air & Waste Mgmt Assoc.55: 3-12.

Moosmuller, H., J.A. Gillies, C.F. Rogers, D.W. DuBois, J.C. Chow, J.G. Watson and R. Langston (1998). Particulate emission rates for unpaved shoulders along a paved road. . J. Air & Waste Mgmt Assoc., 49:3-16.

Mueller, P.K., G.M. Hidy, J.G. Watson, R.L. Baskett, K.K. Fung, R.C. Henry, T.F. Lavery, and K.K. Warren (1983). The Sulfate regional Experiment: Report of findings, Volumes 1, 2, and 3. Report EA-1901, Electric Power Research Institute, Palo Alto, CA

Pardyjak, E.R., P. Ramamurthy, and S. Speckart. (2006). Development of windbreaks as a dust control strategy for communities in arid climates such as the US-Mexico border region. SCERP Project number A-04-06.

Theil, H., (1950). "A rank-invariant method of linear and polynomial regression analysis" I, II and III, Nederl. Akad. Wetensch. Proc., 53, 1950.

USEPA (1999). Compilation of air pollutant emission factors - Vol. I, Stationary point and area sources. Report No. AP-42, 5th ed. Prepared by U.S. Environmental Protection Agency, Research Triangle Park, NC, USA.

Watson, J.G., J.C. Chow, L. Chen, X. Wang, T.M. Merrifield, P.M. Fine, and K. Barker. (2011). Measurement system evaluation for upwind/downwind sampling of fugitive dust emissions. Aerosol and Air Quality Research, 11:331-350, doi:10.4209/aaqr.2011.03.0028

Wolf, M., P. Fields, and S. González-Ayala (2003). Developing a National Emissions Inventory for Mexico On-Road Mobile Source Emissions Inventory. Prepared by Eastern Research Group, Inc., International Communities Research Center. Presented at the 12th International Emission Inventory Conference "Emission Inventories - Applying New Technologies," San Diego, CA

Appendix A: Daily Spatial Maps of Palomas PM_{10} from MiniVol samples

Figure A-1. March 28, 2012

Figure A-2. March 30, 2012. Predominant winds from west.

Figure A-3. April 1, 2012. Predominant winds from west.

Figure A-4. April 3, 2012. Predominant winds from west.

Figure A-5. April 5, 2012. Predominant winds from west.

Figure A-6. April 7, 2012. Predominant winds from northeast

Figure A-7. April 9, 2012. Predominant winds from the east-southeast

Figure A-8. April 11, 2012. Predominant winds from southwest.

Figure A-9. April 13, 2012. Predominant winds from west-southwest.

Figure A-10. April 15, 2012. Predominant winds from west-northwest.

Figure A-11. April 17, 2012. Predominant winds from northwest.

Figure A-12. April 19, 2012. Predominant winds from west.

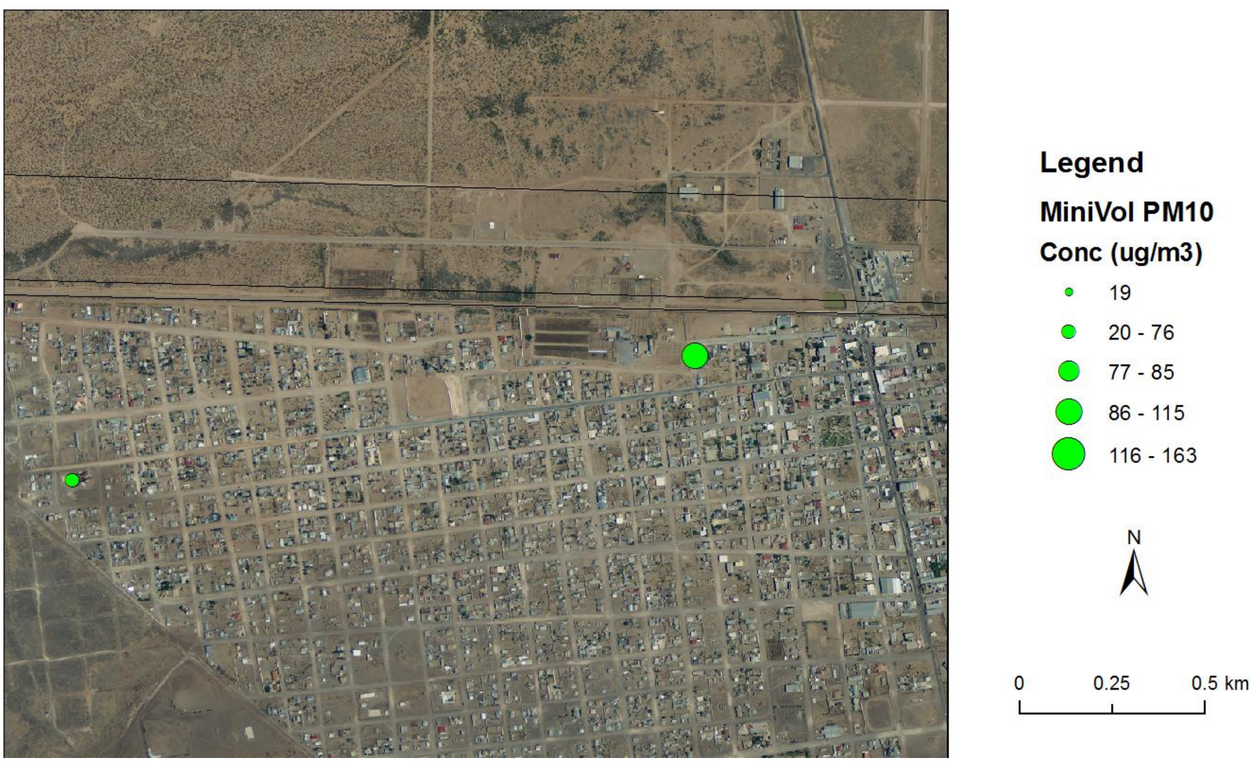


Figure A-13. April 21, 2012. Predominant winds from northwest.

Figure A-14. April 23, 2012. Predominant winds from east-southeast.

Figure A-15. April 25, 2012. Predominant winds from west.

Figure A-16. April 27, 2012. Predominant winds from west-northwest.

Figure A-17. April 29, 2012. Predominant winds from west.

PROCEDIMIENTO ESTÁNDAR DE OPERACIÓN

PARA

Muestreador Minivol para PM10 de Airmetrics

SOP # AQ004

NMSU
Oficina del Climatólogo Estatal
Departamento de Plantas y Ciencias Ambientales
Apartado Postal 30003
Las Cruces, Nuevo México 88003

1.0 DISCUSIÓN GENERAL

1.1 Propósito del Procedimiento

Este procedimiento describe el funcionamiento de los muestreadores portátiles de PM para la recolección de muestras de partículas suspendidas en sustratos de filtro que son amenos a la medición de la masa de aerosoles y varios análisis químicos. El muestreador portátil de filtros permite que el paso aire a través de un orificio de entrada para PM_{10} que selecciona el tamaño de las partículas. El muestreador es operado por una batería recargable y puede ser programado para iniciar y terminar el muestreo a horas predeterminadas.

1.2 Principio de Medición

Para este proyecto, el muestreador portátil de PM_{10} hace pasar aire ambiente a través de un filtro de membrana de Teflón a un flujo constante de 5 litros por minuto (lpm). El aseguramiento de este flujo se logra calibrando el muestreador para tomar en cuenta específicamente la temperatura ambiente y presión atmosférica promedio en el sitio, durante cada estación del año.

Los muestreadores vienen equipados para funcionar con una batería recargable. Durante el funcionamiento normal, el muestreador se conecta a un paquete cargado de baterías antes del muestreo en el campo, haciendo que el lugar en que se coloca el muestreador no dependa de la disponibilidad de corriente eléctrica. Cada muestreador viene con dos paquetes de baterías para permitir el muestreo ‘continuo’ en el campo; mientras que el muestreador está funcionando con una batería (hasta 24 horas de muestreo con una sola carga), la otra batería está siendo cargada usando un adaptador de corriente alterna (AC).

El muestreador viene equipado con un orificio de entrada que contiene una unidad de impactador con un punto de límite para partículas de 10-µm de diámetro y un sistema de control de flujo capaz de mantener un flujo constante dentro de las especificaciones de diseño del orificio de entrada. El impactador está diseñado para proveer una eficiencia de colección de 50% para partículas con un diámetro aerodinámico de 10 µm o menos a un flujo de lpm. El tubo del orificio de entrada conduce el aire a una bomba de diafragma de doble cilindro. Desde la bomba, el aire es forzado a través de un rotámetro estándar (0-10 lpm) en el que es agotado a la atmósfera dentro del albergue del muestreador. Un medidor de tiempo transcurrido es utilizado para totalizar el tiempo que el muestreador es operado dentro de las especificaciones de flujo y voltaje. El muestreador viene equipado con un circuito que apaga automáticamente el muestreador si las baterías no proveen suficiente voltaje a la bomba como para mantener el flujo del muestreador dentro de las especificaciones. Un circuito semejante es utilizado para interrumpir el muestreo si no puede mantenerse un flujo mínimo a una tasa del 10% bajo el flujo establecido. Si ocurre esta situación, se mantendrá encendida una luz indicadora de "carga baja de la batería" o "flujo bajo", hasta que se reinicie el circuito, y se deberá tomar acción para darle servicio al muestreador y/o al paquete de baterías.

Las muestras de PM_{10} son tomadas usando paquetes de filtros numerados en portafiltros de policarbonato (con una sección de extensor), marcada PALXXX (para Palomas). Cada paquete de filtros es cargado con un filtro de membrana de Teflón Whatman PTFE de 46.2 mm (VWR #70240-148), que ha sido previamente pesado, con tamaño de poros de 2 µm. La membrana de Teflón remueve las partículas para poder medir la masa de las partículas a través de un análisis gravimétrico, visibilidad a través de absorción de luz, elementos a través de fluorescencia de rayos-X o análisis ICP-MS, cloruro, nitrato y sulfato a través de cromatografía iónica, potasio y sodio a través de espectrofotometría de absorción atómica, y amoníaco a través de colorimetría automatizada.

Se graba el flujo del rotámetro del muestreador al principio de cada período de muestreo. Se calcula el volumen de la muestra en base al promedio de los flujos al inicio y al final del muestreo y la duración del muestreo. Otras características adicionales del muestreador portátil incluyen un cronómetro programable, que puede ser programado para correr hasta seis ciclos de encendido/apagado (es decir, 12 pasos de programación) en un período de 24 horas, o un ciclo de encendido/apagado de 24 horas que comienza y termina en cualquier día de la semana hasta para seis días. El muestreador puede ser suspendido de una variedad de estructuras (por ejemplo, teléfono, postes de electricidad, postes de luz) usando el sujetador colgante del muestreador.

La Figura 1-1 ilustra el muestreador portátil de PM_{10} con el sujetador colgante.

1.3 Interferencias de Medición

1.3.1 Deposición Pasiva: La deposición pasiva ocurre cuando las partículas y gases se depositan en los filtros antes y después del muestreo. Se utilizan muestras de campo en blanco para cuantificar la desviación, la cual es generalmente menos de 30 µg de masa para un filtro de 47 mm de diámetro durante un período pasivo de 24 a 48 horas de duración.

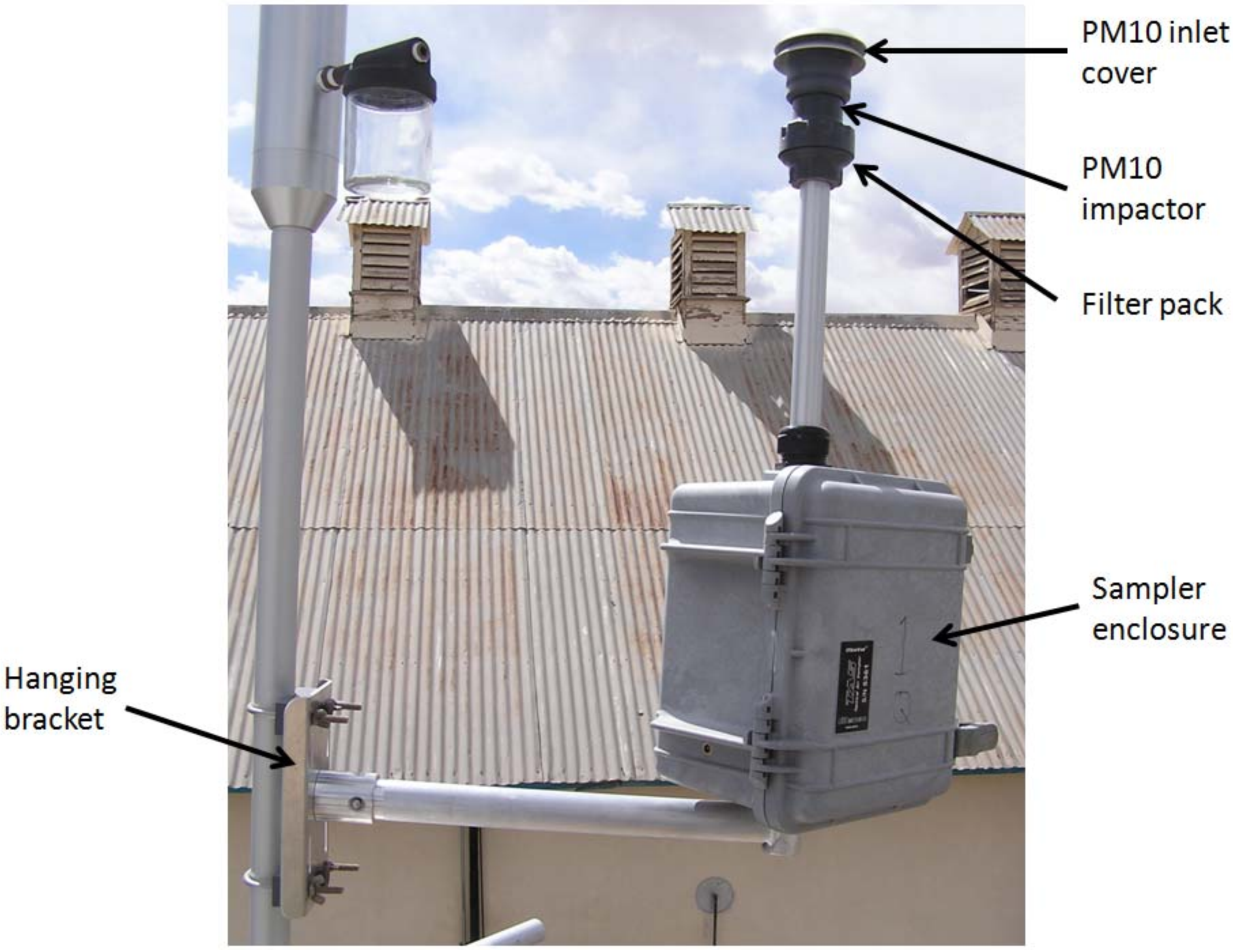
1.3.2 Rebote de Partículas en la Placa del Impactador: Las partículas mayores de 10 µm pueden volver a quedar atrapadas en el flujo de aire luego de rebotar en la placa del impactador. Esta situación se previene limpiando y engrasando la placa del impactador después de cada muestreo de 24horas.

1.3.3 Absorción Gaseosa y Volatilización de Partículas: El ácido nítrico y los gases orgánicos pueden ser absorbidos por partículas en el filtro. Al contrario, el nitrato de amonio puede disociarse y el nitrato de partículas y el amonio pueden escapar en forma de ácido nítrico y gas de amoníaco. Los filtros son descargados y refrigerados inmediatamente después del muestreo para minimizar la volatilización a largo plazo.

1.3.4 Integridad del Filtro y Contaminación: La integridad del filtro puede quedar comprometida si éste es manipulado de manera inadecuada, lo cual causa la pérdida de pedazos del filtro después de tomar el peso de pre-exposición. La contaminación del filtro resulta de la deposición en el filtro de material distinto al aerosol que está siendo muestreado (por ejemplo, huellas digitales, polvo). Los efectos de la pérdida de material de filtro son minimizados al llevar a cabo un análisis gravimétrico de los filtros de membrana de Teflón que son menos desmenuzables que los filtros de fibra de cuarzo. Las pérdidas de material de filtro y la contaminación son minimizadas colocando y removiendo los filtros en y de los portafiltros en condiciones controladas de laboratorio. Las manos con guantes y las pinzas son utilizadas en este procesamiento de filtros. Se proporcionan portafiltros adicionales en el campo para minimizar la necesidad de cargar y descargar filtros en el campo. Cada portafiltros es sellado por separado antes y después del muestreo. Se inspeccionan lotes de filtros y se mandan para ser analizados químicamente antes de su uso para asegurar que cumplen con los niveles mínimos de concentración para filtros en blanco al ser recibidos del fabricante.

1.3.5 Pérdida de Partículas Durante el Transporte: Se ha determinado que las partículas gruesas (mayores de 2.5 micras) se desprenden de los filtros que están altamente cargados, durante el transporte. EL flujo bajo (5 lpm) del muestreador portátil minimiza la sobrecarga de los filtros para el período especificado (24 horas) de duración del muestreo. Además las muestras son almacenadas bajo refrigeración y transportadas con manipulación mínima.

1.3.6 Pérdidas de transmisión: La partículas que atraviesan por un orificio de entrada de selectividad por tamaño podría resultar en pérdidas de partículas. Los cálculos muestran que las pérdidas por difusión e impacto son menores del 1% para las partículas menores de 10 micras de diámetro aerodinámico.



Hanging bracket = Abrazadera o sujetador colgante
PM10 inlet cover = Cobertura del orificio de entrada de PM10
PM10 impactor = Impactador de PM10
Filter pack = Paquete de filtros
Sampler enclosure = Albergue/recinto del muestreador

Figura 1-1. Diagrama del Muestreador de Sondeo Minivol para PM_{10} de Airmetrics.

1.4 Rangos y Valores Típicos

El rango de concentraciones medidas a través de este método es limitado por la sensibilidad de los instrumentos analíticos y la desviación estándar de los valores obtenidos por el blanco dinámico. Para concentraciones promedio de masa de 24 horas, el rango es de aproximadamente 6 a 300 $\mu g/m^3$.

1.5 Límites Inferiores Típicos Cuantificables, Precisión, y Exactitud

Para las concentraciones de masa, el límite inferior típico cuantificable es aproximadamente de 3 a 6 $\mu g/m^3$ para los flujos y duraciones de muestreos de 24 horas utilizados en este proyecto. La precisión es calculada a través de análisis de laboratorio replicados y pruebas de rendimiento para el flujo. Esta precisión es entre 6 y 9 μg/filtro, o aproximadamente entre 1 y 2 $\mu g/m^3$ para un muestreador de 24 horas que representa un volumen de muestra de 7.2 m^3. La exactitud por lo general recae dentro de la precisión de la medición.

1.6 Responsabilidades

El operador del sitio será responsable de llevar a cabo este procedimiento de operación estándar y de completar y enviar todos los documentos.

El supervisor de las operaciones de campo será responsable de programar las visitas del operador del sitio, identificar y corregir deficiencias, y coordinar la transferencia de muestras con el laboratorio.

El supervisor del laboratorio será responsable de preparar las muestras, enviarlas al campo, recibirlas del campo, revisar la documentación e integridad de las muestras, y comunicar deficiencias y medidas de remedio al supervisor de las operaciones de campo.

1.7 Definiciones

El muestreador Minivol para PM_{10} de Airmetrics constituye toda la unidad de muestreo.

Las cajas de envío son estuches de transporte aislados, que contienen portafiltros cargados, con uniones de desconexión rápida.

1.8 Procedimientos Relacionados

SOP # AQ005	Procedimiento de Análisis Gravimétrico
SOP # AQ006	Procedimiento de Montaje, Desmontaje, y Limpieza del Paquete de Filtro
SOP # AQ007	Envío, Recibo, y Cadena de Custodios de la Muestra

2.0 APARATO, INSTRUMENTACIÓN, SUMINISTROS, Y FORMULARIOS

2.1 Instrumentación

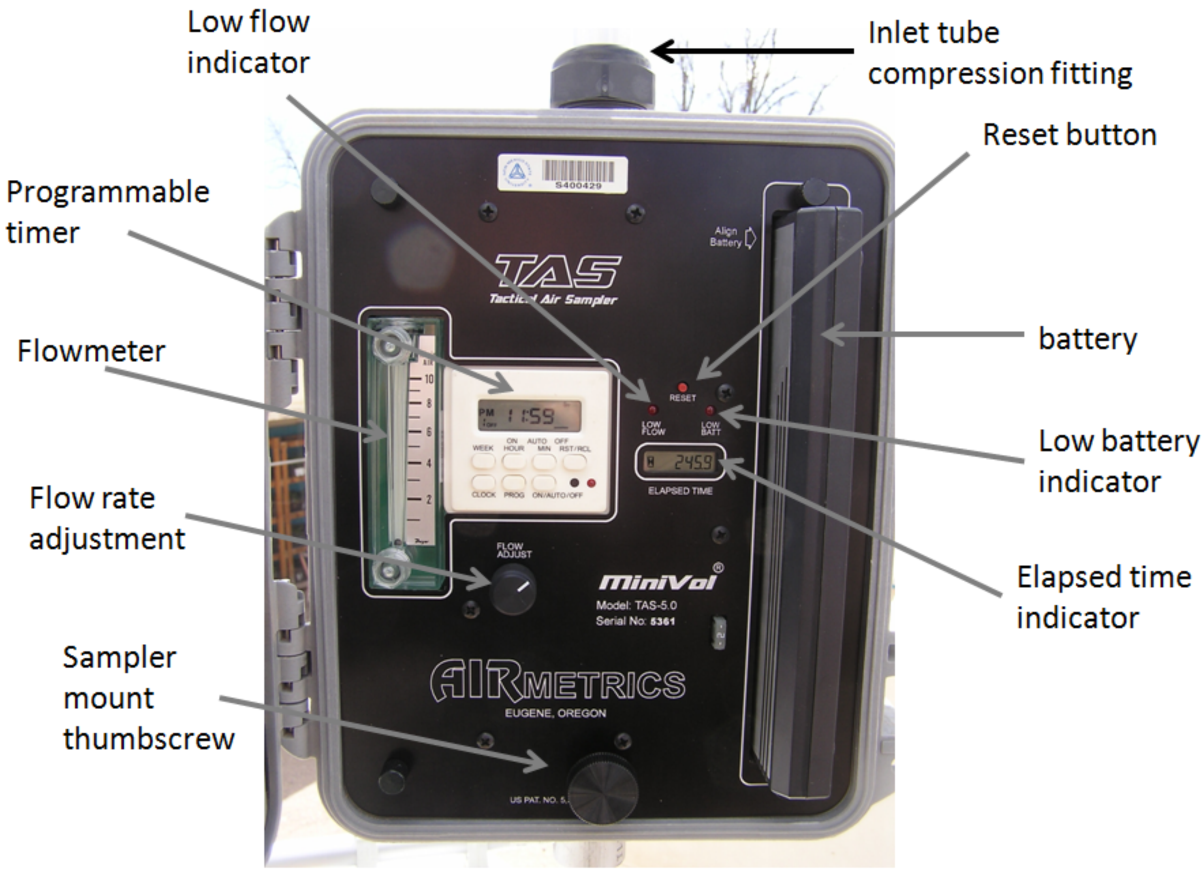
2.1.1 Muestreador Minivol con para PM10 con Filtro de Airmetrics: La versión del muestreador portátil para PM_{10} utilizado en este proyecto se muestra en el diagrama de la Figura 2-1.

2.1.2 Accesorios del Muestreador: Sujetador de montaje universal y correas de trinquete.

2.1.3 Ensambladura de los Portafiltros y del Impactador: La Figura 2-3 ilustra la ensambladura del orificio de entrada y del paquete de filtros. Los portafiltros están abiertos y pueden acomodar filtros de 47 mm de diámetro. Los empaques que hay entre las partes previenen las fugas de flujo y proveen una manera de sujetar fácilmente cada etapa.

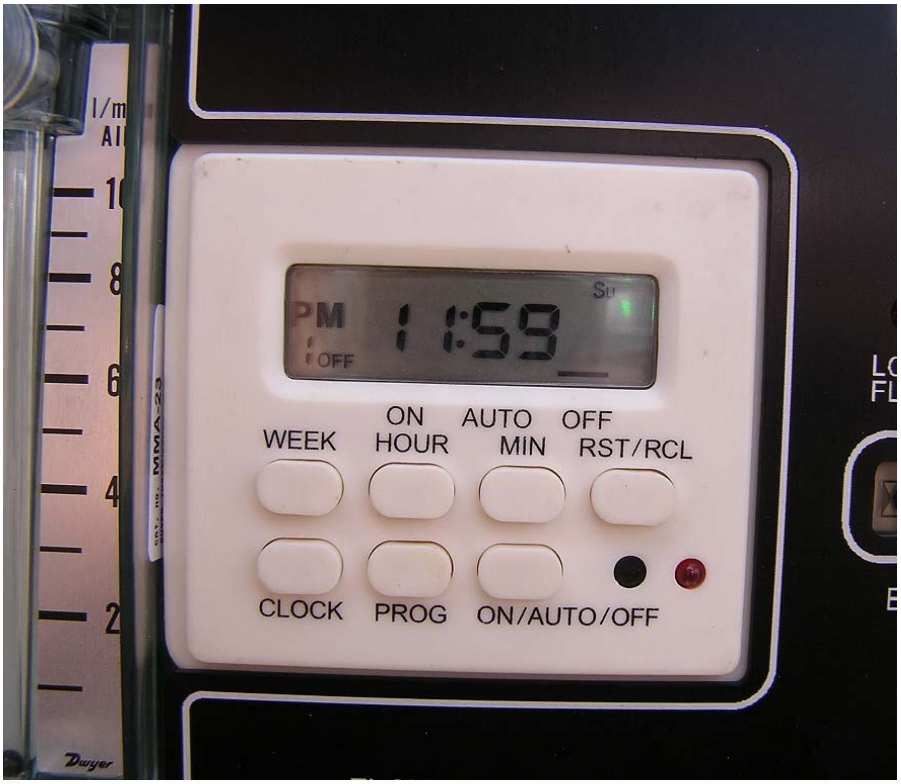
Se colocan etiquetas de identificación adhesivas en los portafiltros al cargar los filtros. Los primeros tres dígitos designan la identificación del sitio (por ejemplo, PAL para el Estudio de Palomas), los siguientes tres dígitos especifican la identificación numérica que es específica a cada paquete de filtros.

Cada estuche contiene hasta dos ensambladuras de filtros/orificios de entrada, cargador para baterías, dos baterías, abrazadera, correa, y manual. Una etiqueta con el código de sitio de tres dígitos será pegada a la parte superior y a los lados del estuche. Cada paquete de filtros y la hoja de datos de campo que lo acompaña está sellado en una bolsa ziplock separada, conteniendo el nombre del sitio de muestreo y la fecha en la hoja de datos de campo, y teniendo apuntada esta información en la bolsa ziplock.



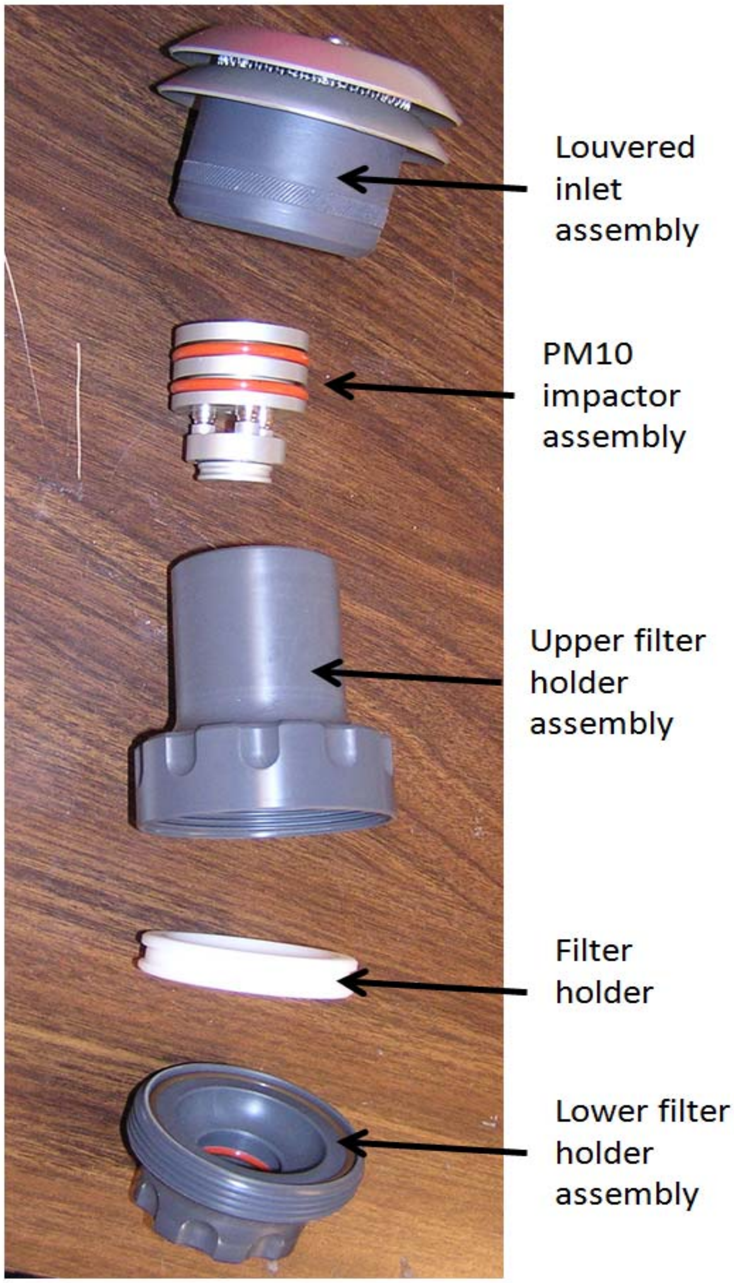
Inlet tube compression fitting = Conexión por compresión del tubo del orificio de entrada
Low flow indicator = Indicador de flujo bajo
Programmable timer = Cronómetro programable
Flowmeter = Caudalímetro/flujómetro
Flow rate adjustment = Ajuste del flujo
Sample mount thumbscrew = Tornillo de pulgar para montaje del muestreador
Reset button = Botón de reinicio
Battery = Batería
Low battery indicator = Indicador de carga baja de la batería
Elapsed time indicator = Indicador de tiempo transcurrido

Figura 2-1. Vista frontal del Muestreador Minivol de Sondeo para PM_{10} de Airmetrics.



On Auto Off = Encendido Automático Apagado
Week Hour Min RST/RCL = Semana Hora Minutos Reiniciar/Borrar
Clock Prog On/Auto/Off = Reloj Programar Encendido/Apagado/Automático

Figura 2-2. Vista Frontal de los Controles del Cronómetro del Muestreador Minivol para PM_{10} de Airmetrics.



Louvered inlet assembly = Piezas de celosía del orificio de entrada
PM10 impactor assembly = Piezas del impactador de PM10
Upper filter holder assembly = Piezas en la parte superior del portafiltros
Filter holder = Portafiltros
Lower filter holder assembly = Piezas en la parte inferior del portafiltros

Figura 2-3. Paquete del Filtro y Piezas del Orificio de Entrada para el Muestreador Minivol para PM_{10} de Airmetrics.

2.1.5 Pinzas: Las pinzas se utilizan para remover los filtros de los portafiltros y para colocarlos en sus Placas de Petri numeradas en el laboratorio.

2.1.7 Instrumento para Calibración del Rotámetro. Un calibrador para auditorías de campo deltaCal de BGI será utilizado para calibrar el rotámetro en lpm.

2.2 Suministros

2.2.1 Botella de alcohol: para limpiar la placa impactadora del orificio de entrada y para preparar una solución de grasa para la placa del impactador.

2.2.2 Tubo de grasa para vacío.

2.2.6 Pipetas desechables Pasteur: para engrasar los impactadores.

2.2.7 Placas de Petri de 47 mm: Los filtros se colocan en estas placas para determinar la masa antes de cargar y los filtros expuestos son transferidos del portafiltros con etiquetado de identificación idéntico a la Placa de Petri, después del muestreo.

2.2.8 Toallitas Kim: para eliminar el exceso de grasa de las superficies no impactantes.

2.2.9 Botella de aire comprimido: para limpiar varios artículos en el muestreador que son difíciles de alcanzar.

2.2.10 Etiquetas de identificación en blanco: Si la etiqueta original de identificación es dañada o no puede pegarse, se copiará el número de identificación en una etiqueta en blanco, usando un bolígrafo, y ésta se colocará en el paquete de filtro o en la Placa de Petri.

2.2.11 Guantes desechables: Deberán usarse guantes siempre que los filtros sean cargados o descargados de los portafiltros. Los guantes deberá ser desechados después de ponerse en contacto con cualquier contaminante y luego de cada sesión de carga y descarga de filtros.

2.3 Hojas de Datos

La Figura 2-4 ilustra un ejemplo de una hoja de datos para el campo de la manera que es enviada en el estuche de transporte, antes de tomar la muestra. La Figura 2-5 ilustra un ejemplo de una hoja de datos para el campo después de haber sido llenada por el técnico de campo.

3.0 ESTÁNDARES DE CALIBRACIÓN

El estándar de transferencia para los flujos del muestreador portátil de PM_{10} es un deltaCal de BGI que ha sido calibrado contra un Medidor de Flujo Crítico Venturi en NIST antes del comienzo del programa de muestreo. Un rotámetro externo (independiente) calibrado, puede también ser utilizado mensualmente para pruebas de rendimiento de flujo.

4.0 OPERACIÓN DEL MUESTREADOR

4.1 Diagrama de Flujo

La Figura 4-1 resume el procedimiento cotidiano de operaciones de campo para el muestreador portátil de PM_{10}. El cambio de filtros y las pruebas de rendimiento para el flujo se llevan a cabo entre cada período de muestreo y requieren aproximadamente entre 5 y 10 minutos por muestreador. La limpieza y engrase del impactador se llevan a cabo después de cada muestreo de 24 horas.

4.2 Inicio

4.2.1 Limpie el Impactador de PM_{10}: El impactador de PM_{10} deberá ser limpiado y engrasado después de cada corrida de muestreo para minimizar el rebote de partículas y su re-arrastre. La limpieza del impactador deberá llevarse a cabo en un área bien ventilada.

4.2.1a Limpie de arriba hacia abajo la superficie de embudo del impactador con un hisopo con alcohol usando una botella comprimible, poniendo especial atención en la placa del impactador. Limpie la grasa restante con toallitas Kim (Kim Wipes) y deje que se seque la ensambladura del impactador con el aire.

4.2.1b Apriete suavemente una cantidad muy pequeña de grasa en la placa del impactador. Use una espátula para esparcir la grasa en la placa. No deje que entre grasa en la superficie del embudo. La grasa deberá cubrir la parte superior de la placa.

4.2.2 Preparación del Paquete de Baterías:

4.2.2a Carga del Paquete de Baterías: Ambas baterías del muestreador deberán ser cargadas antes de la corrida inicial. Las baterías deberán ser cargadas por un mínimo de 12 horas. Después de un muestreo de 24 horas, desconecte la batería usada del muestreador y cámbiela por una batería cargada. Conecte el enchufe de carga del adaptador AC/DC a la batería usada y conecte el adaptador a un enchufe AC. Desconecte el adaptador AC/DC del paquete de baterías después de cargarlo.

4.2.2b Chequeo de la Batería: Al oprimir el botón en la batería, aparecerá la condición de la batería. La capacidad de cada batería cargada deberá ser chequeada antes de salir al campo. Si la batería no puede ser cargada de manera adecuada, apunte el número de identificación de la batería y no use ese paquete de baterías.

Minivol Sampler Network Name:________________ Sampler ID:________________ Date shipped from NMSU:________ By:_____

Field Data Sheet Site Name (code):_______________ Technician:________________ Date shipped to NMSU:_________ By:_____

Filter ID	PM10 or PM2.5	Sampling Date (MMDDYY)	Sampling Period* HHMM to HHMM		Elapsed time on meter (HH.H)		Flow Rate (lpm)			
					Start	End	Start	End	Flag	Comments

*Time of Day: Mountain (MST, MDT)

TRADUCCIÓN DE LA HOJA DE DATOS:
Minivol Sampler = Muestreador Minivol ; Network Name = Nombre de la Red ; Sampler ID = Identificación del Muestreador ;
Date Shipped from NMSU:____By: = Fecha de Envío desde NMSU:____Por: ; Field Data Sheet = Hoja de Datos para el Campo ;
Site Name (code) = Nombre del Sitio (código) ; Technician = Técnico ;
Date Shipped to NMSU:____By: = Fecha de Envío a NMSU:____Por: ;
Filter ID = Identificación del Filtro ; PM10 or PM2.5 = PM10 o PM2.5 ;
Sampling Date (MMDDYY)= Fecha de Muestreo (Mes, Día, Año) ;
Sampling Period* (HHMM to HHMM) = Período de Muestreo* (Horas y Minutos a Horas y Minutos) ;
Elapsed Time on Meter (HH.H) = Tiempo Transcurrido en el Medidor de Tiempo (Horas y Décimos de Hora) ;
Flow Rate (lpm) = Flujo (lpm) ; Start = Inicio ; End = Final ; Flag = Señal de Alerta;
Comments = Comentarios ; *Time of Day: Mountain (MST, MDT) = *Hora del Día: Montaña (MST, MDT)

Figura 2-4. Ejemplo de una Hoja de Datos de Campo Antes del Muestreo.

NM STATE

Minivol Sampler
Field Data Sheet

Network Name: Palomas
Site Name (code): CTNE

Sampler ID: 5651
Technician: DuBois

Date shipped from NMSU: 3/21/12 By: DWD
Date shipped to NMSU: 3/23/12 By: DWD

Filter ID	PM10 or PM2.5	Sampling Date (MMDDYY)	Sampling Period* HHMM to HHMM		Elapsed time on meter (HH.H) Start	Elapsed time on meter (HH.H) End	Flow Rate (lpm) Start	Flow Rate (lpm) End	Flag	Comments
PAL052	PM10	032212	0000	2359	146.5	170.5	5.0	5.0		

*Time of Day: Mountain (MST, MDT)

Figura 2-5. Ejemplo de una Hoja de Datos de Campo Después del Muestreo.

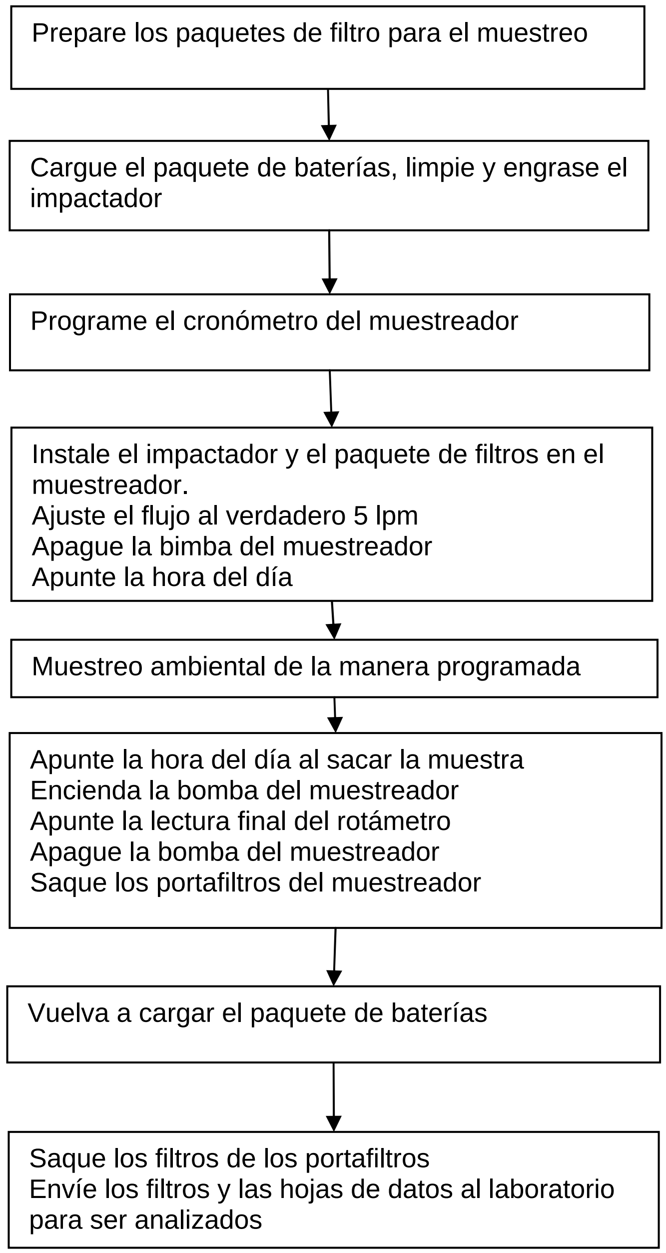


Figura 4-1. Diagrama de Flujo para Operaciones Cotidianas.

4.3 Operaciones Cotidianas

4.3.1 Una vez se haya calibrado el rotámetro del muestreador (refiérase a la Sección 5) y se haya determinado un punto de ajuste para un flujo verdadero de 5 lpm, os paquetes de baterías hayan sido cargados, el impactador haya sido limpiado, y se haya verificado que no hay fugas en el muestreador, el muestreador podrá ser utilizado para recolectar muestras.

4.3.2 El muestreador se colocará con el orificio de entrada viendo hacia arriba. Deberá ubicarse en un área sin obstrucciones, por lo menos a 30 cm de cualquier cosa que pueda obstaculizar el flujo de aire. La abrazadera universal para colgar el muestreador podrá sujetarse a un poste de electricidad. La abrazadera colgante deberá estar ubicada por lo menos 3 metros arriba del nivel del suelo.

4.3.3 Para Comenzar el Muestreo:

4.3.3aInspeccione los filtros: cada bolsa de plástico ziplock contiene hojas de datos similares a las de la Figura 2-4 además de un paquete de filtros inexpuestos, pre-marcados. El sitio de muestreo y la fecha para cada paquete de filtros se escriben en la bolsa ziplock. Al recibir un conjunto de filtros del laboratorio, quítele la tapadera a cada paquete de filtros, asegúrese de que el aro del filtro y el aro que no puede desenroscarse estén adecuadamente asegurados arriba de cada filtro (puede ser que el filtro quede desalineado o flojo durante el envío y manipulación). Asegúrese de que cada paquete de filtros en la caja de envío esté limpio (que no haya ningún material foráneo obvio en el filtro). Las hojas de datos deberán contener las identificaciones de los filtros para cada sitio y fecha de muestreo. Asegúrese de que el número de identificación del paquete de filtros sea el mismo número que aparece en la hoja de datos de campo. Si no es el mismo, cambie la hoja de datos de campo. Cambie aquellos filtros que no pasen la inspección con filtros de la caja de reemplazo y cambie el número de identificación de la manera correspondiente.

4.3.3b Coloque el muestreador en una superficie nivelada, firme.

4.3.3cPrepárese para tomar la Muestra. Abra el estuche gris de Pelican® halando los seguros en el lado. Desatornille cualquiera de las tapaderas de la agarradera (ver Figura 1-1). Asegúrese de insertar una batería recientemente cargada en el compartimiento para la batería. Asegúrese de que la batería quede bien colocada en el muestreador, empujándola ligeramente.

4.3.3d Procedimientos para Programar el Cronómetro.

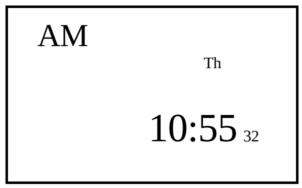
- Primero que nada, asegúrese de que la hora y el día de la semana correctos hayan sido programados en el cronómetro. Al empujar el botón del reloj (CLOCK) una vez aparecerá la hora actual y el día de la semana. Para corregir la hora o el día de la semana, oprima y mantenga oprimido el botón "CLOCK" (esquina inferior izquierda del Cronómetro Programable en la Figura 2-2) para los siguientes cuatro pasos:

  -- Oprima el botón "WEEK" (semana) hasta que aparezca el día correcto de la semana (Su = domingo; Mo = lunes; Tu = martes; We = miércoles; Th = jueves; Fr = viernes; Sa = sábado).

-- Oprima el botón "HOUR" (hora) hasta que aparezca la hora correcta del día. Por favor tome nota que hay horas antes del mediodía (a.m.) y después del mediodía (p.m.).

-- Oprima el botón "MIN" hasta que aparezca el minuto correcto de la hora.

-- Verifique la hora del reloj que aparece y deje de oprimir el botón "CLOCK". Ejemplo de la lectura del reloj para el día jueves a las 10:55 a.m.:



4.3.3e Programando la Hora de Encendido (ON) y Apagado (OFF) del Muestreador.

(1) Para empezar el primer período de muestreo (Paso 1 de programación con "1^{ON}"):

- La pantalla del cronómetro indica "1^{on}" (esquina inferior izquierda de la pantalla) y se comienza a programa el día y hora de inicio del muestreo.

- Oprima el botón "WEEK" (semana) para seleccionar el día de la semana para el muestreo. Hay 10 pasos consecutivos para este botón.

  -- Pasos 1 al 7: Muestreo en cualquier día de la semana (la pantalla muestra Mo, Tu, We, Th, o Fr cada vez que se presiona el botón "WEEK" (semana)).

  -- Paso 8: Muestreo diariamente los días hábiles con la misma hora de encendido o apagado (la pantalla muestra los cinco días hábiles: Mo Tu We Th Fr).

  -- Paso 9: Muestreo diariamente los fines de semana con la misma hora de encendido o apagado (la pantalla muestra: Sa Su)

  -- Paso 10: Muestreo cada día de la semana con la misma hora de encendido o apagado (la pantalla muestra los siete días de la semana).

  -- Si se le pasó la selección que deseaba, deberá volver al paso 1 y deberá volver a hacer los 10 pasos. Seleccione "Fr" en el paso 5 para comenzar el muestreo el día viernes.

- Oprima el botón "HOUR" (hora) para seleccionar la hora de inicio del muestreo.

  -- La hora del día incrementa una hora a la vez al presionar el botón "HOUR"; de 1 a 12 AM y luego de 1 a 12 PM.

-- Seleccione "AM 12" para iniciar el muestreo a medianoche por un período de muestreo de 24 horas.

• Oprima el botón "MIN" para seleccionar el minuto de inicio del muestreo.

-- Cada vez que se oprime el botón "MIN", los minutos aumentan uno a uno desde el minuto :01 al :59.

-- Seleccione ":00" para iniciar el muestreo a medianoche.

• La pantalla deberá mostrar:

AM
Fr
1^{ON} 12:00

Para iniciar el muestreo a medianoche (12:00 AM) del día viernes.

(2) Para detener el primer período de muestreo:

• Oprima el botón "PROG" y la pantalla mostrará "1_{OFF}". Comience a programar el final del tiempo de muestreo.

• Repita los pasos anteriores para seleccionar el día de la semana y pare el tiempo de muestreo a las 11:59 PM del día viernes.

• La pantalla deberá mostrar:

PM
Fr
1_{OFF} 11:59

Para dejar de muestrear a medianoche (11:59 PM) del mismo día (es decir, viernes).

(3) Continúe programando la siguiente fecha y hora de muestreo u oprima el botón "RST/RCL" (reiniciar/borrar) para borrar la pantalla de tal manera que muestre:

PM Mo Tu We Th Fr Sa
Su
3^{ON} -- --

Para el resto de la programación (pasos 3^{ON} a 6^{OFF}).

(4) Oprima el botón "CLOCK" para continuar con la hora actual.

(5) IMPORTANTE: Coloque el botón "ON/AUTO/OFF" en modalidad "AUTO". Una barra aparecerá en el borde inferior de la pantalla. Si no está en modalidad AUTO, el muestreador no correrá.

4.3.3f Si no ha instalado el Paquete de Baterías Cargadas en el muestreador, ahora es el momento de hacerlo. Oprima el botón "ON/AUTO/OFF" y cámbielo de modalidad "AUTO" a modalidad "ON" y la bomba se encenderá. Deje correr la bomba por un minuto para asegurarse de que la batería tenga voltaje adecuado para arrancar la bomba y para verificar que la bomba esté funcionando de manera apropiada. Oprima el botón "ON/AUTO/OFF" para apagar la bomba y poner el muestreador en modalidad "OFF".

4.3.3g Instale la Ensambladura del Impactador Limpio (ver la Figura 2-3). Empujando con el dedo pulgar desde la parte inferior, saque el impactador por la parte superior del tubo y póngalo sobre la palma de la mano que tiene libre. Inspeccione los empaques en la ensambladura del impactador para verificar su condición, cámbielos de ser necesario. Remueva todo material foráneo de la ensambladura del impactador. Vuelva a insertar cuidadosamente la ensambladura del impactador en el tubo (desde la parte superior) hasta que la parte superior del impactador esté nivelada con la parte superior del tubo.

4.3.3h Instale el filtro Inexpuesto: Los paquetes de filtros deberán se almacenados en un recinto para evitar contaminar el filtro. Sosteniendo el paquete de filtros horizontalmente, desenrosque cuidadosamente la tapadera del paquete de filtros y almacene la tapadera en una bolsa ziplock. Reemplace la tapadera del paquete de filtros con la tapadera modificada con ranuras con el albergue del impactador y el orificio de entrada con celosía. Asegúrese de que el aro anti-resbalones quede firmemente colocado sobre el filtro para prevenir fugas (asegúrese de que el número de identificación del nuevo filtro corresponda con el número de identificación que aparece en la hoja de datos para ese sitio y esa fecha). Sujete el paquete de filtros y la ensambladura del orificio de entrada al muestreador, empujándolo hacia abajo en el tubo del orificio de entrada del muestreador hasta que ya no bajen más. Apunte el número de identificación del muestreador.

4.3.3i Verifique el Flujo Inicial. Encienda la bomba manualmente, oprimiendo el botón "ON/AUTO/OFF" y poniéndolo en modalidad "ON". Cubra el tubo del orificio de entrada con la palma de la mano para inspeccionar si hay fugas. Si el rotámetro indica más de 0.2 lpm, entonces hay una fuga. Inspeccione todas las uniones del portafiltros. Se habrá determinado un punto de ajuste para 5 lpm durante la calibración de cada muestreador. Este punto de ajuste corresponderá a un flujo verdadero de 5 lpm. Ajuste la velocidad de la bomba con el botón de "Ajuste del Flujo de Muestreo" en la tarjeta del controlador (ver la Figura 2-1), hasta que la lectura del rotámetro sea el valor del punto de ajuste al 0.1 lpm más cercano, tomando la lectura al centro de la bolita. El muestreador deberá correr al menos por un minuto para calentarlo y para estabilizar el flujo. Cuando el flujo se haya estabilizado al punto de ajuste, oprima el botón "ON/AUTO/OFF" y póngalo en modalidad de apagado (es decir, "OFF") y luego en modalidad automática (es decir, "AUTO") para apagar la bomba. Apunte el flujo "Inicial" y la lectura "Inicial" del medidor de tiempo transcurrido (ubicado en la parte superior del cronómetro programable, (ver la Figura 2-1) en la hoja de datos de campo pre-asignada. (El medidor de tiempo transcurrido consiste de una pantalla de lectura de seis dígitos: los primeros cuatro dígitos representan el número en horas completas; los últimos dos dígitos representan número en 0.1 (es decir, décimos de hora.)

- Apunte la lectura "Final" del medidor de tiempo transcurrido en la hoja de datos de campo (ver la Figura 2-4) y calcule el tiempo total de muestreo (∆Tiempo en la Figura 2-4).

- Verifique que las horas totales de muestreo sean 24 horas. Si el tiempo total de muestreo excede los límites pre-especificados, verifique el procedimiento de programación e inspeccione el indicador de carga baja de la batería y flujo bajo. Infórmele al administrador de campo para recibir servicio inmediato si hay algún problema.

- Verifique que el "Cronómetro Programable" esté en modalidad "AUTO".

4.3.3j Coloque el muestreador en la abrazadera de montaje. Gire el tornillo negro de pulgar del muestreador en dirección de las manijas del reloj para apretar la abrazadera de montaje (ver la Figura 2-1). Cierre la puerta de la caja gris y póngale candado.

4.3.4 Para Sacar los Filtros Expuestos. Los filtros expuestos deberán ser sacados el día después del muestreo.

4.3.4aRemueva el muestreador de la agarradera de montaje universal.

4.3.4b Verifique la lectura Final del Tiempo Transcurrido y apunte la lectura final de tiempo transcurrido en la hoja de datos de campo (Figura 2-5).

4.3.4cApunte el Flujo Final. Encienda la bomba oprimiendo el botón "ON/AUTO/OFF" y poniéndolo en modalidad “ON”. Deje calentar la bomba por un minuto para obtener una lectura estable del flujo. Apunte el flujo final indicado en el rotámetro al 0.1 lpm más cercano, en la hoja de datos de campo (tome la lectura al centro de la bolita). El flujo final no deberá variar más de ± 10% del flujo inicial en el transcurso de un período de muestreo de 24 horas.

4.3.4d Saque el Paquete de Filtros Expuestos. Saque del muestreador el paquete de filtros expuestos. Desenrosque la ensambladura del orificio de entrada del paquete del filtro. Saque el portafiltros, colóquelo en un paquete plástico protectivo, y almacénelo en una bolsa ziplock marcada adecuadamente con la hoja de datos de campo completa. Asegúrese de que el número de identificación sea el mismo para los filtros y los datos de campo.

4.3.4eSaque el Paquete de Baterías Descargadas e instale un Paquete de Baterías Cargadas. Encienda la bomba durante un minuto para calentarla.

4.3.4f Saque el impactador usado e instale un impactador limpio.

4.3.4g Vea la Sección 4.3.3 para comenzar un nuevo grupo de muestreos.

4.3.5 Una lista de verificación de 11 pasos se muestra enseguida y deberá ser utilizada en cada visita al sitio:

1. Verifique que el paquete de filtros expuestos haya muestreado correctamente. Apunte una nota si la luz indicadora de Carga Baja de la Batería o Flujo Bajo está encendida (es decir, en modalidad "ON").
2. Apunte la lectura “Final” del Tiempo Transcurrido y verifique que se haya muestreado por 24 horas.
3. Encienda la bomba (es decir, póngala en modalidad “ON”), apunte la Lectura “Final” del Flujo en la hoja de datos, y apague la bomba (es decir, póngala en modalidad “OFF”).
4. Coloque las tapaderas en el paquete de filtros expuestos después de sacarlo del muestreador.
5. Coloque el paquete de filtros expuestos y la hoja completa de datos de campo dentro de una bolsa ziplock debidamente marcada.
6. Instale el paquete de baterías cargadas y encienda la bomba al menos por un minuto.
7. Saque el impactador usado e instale un impactador limpio.
8. Instale un paquete de filtros no expuestos. Asegúrese de que la identificación de la muestra corresponda al sitio apropiado y la fecha adecuada escritos en la hoja de datos de campo. Inspeccione la Hora que aparece en el Cronómetro Programable para verificar que sea el día y la hora actual. Verifique la fecha y hora de encendido y apagado (es decir, "ON/OFF").
9. Encienda la bomba, mida el Flujo "Inicial", apúntelo en la hoja de datos de campo, y luego apague la bomba.
10. Apunte la Hora “Inicial” de Tiempo Transcurrido en la hoja de datos de campo.
11. Oprima el botón "ON/AUTO/OFF" y póngalo en modalidad automática "AUTO".

4.4 Apagado

Al final de cada mes, haga un conjunto de pruebas para fugas y rendimiento. Escriba la condición del muestreador en el cuaderno de registro. Verifique todo el equipo y las partes contra la hoja de registro de salida y asegúrese que todo haya sido empacado para su envío de vuelta a NMSU.

5.0 CUANTIFICACIÓN

5.1 Procedimientos de Calibración

5.1.1 Marque las Escalas del Rotámetro con las Lecturas de los Puntos de Ajuste: El flujo verdadero a través de cada rotámetro es el siguiente:

$$Q_{ver} = (aQ_i + b)((760/P_2)(T_2/298))^{0.5}$$

donde

Q_{ver} = flujo verdadero a una temperatura T_2 y presión P_2 en litros por minuto

Q_i = lectura indicada del rotámetro en litros estándar por minuto

a = pendiente de regresión lineal para la relación entre la lectura del rotámetro y el flujo verdadero en condiciones estándar

b = Intercepto de regresión lineal para la relación entre la lectura del rotámetro y el flujo verdadero en condiciones estándar

El punto de ajuste de lpm se obtiene de la ecuación anterior, sustituyendo el 5 por Q_{act} y resolviendo para Q_i. El punto de ajuste se escribe en un pedazo de cinta adhesiva que se pega al lado de la escala del rotámetro para temperaturas y presiones típicas en el área de muestreo.

5.1.2 La bomba se “ENCIENDE” usando el botón "ON/AUTO/OFF" (encendido/automático/apagado). El flujo se ajusta al valor del punto establecido usando el botón de ajuste del flujo (Flow Rate Adjustment) (ver la Figura 2-1).

6.0 CONTROL DE CALIDAD

6.1 Verificación de Fugas

Cada 30 días se llevará a cabo una verificación de fugas, de la manera que se describe en la Sección 4.2.8.

6.2 Verificaciones de Calibración

La medición del flujo será verificada mensualmente contra un estándar de transferencia.

7.0 AUDITORÍA DE CALIDAD

Las auditorías de las tasas de flujo serán llevadas a cabo por parte de un auditor independiente, con estándares independientes, al principio y al final del estudio, o anualmente.