INITIAL ASSESSMENT OF POTENTIAL IMPACTS ON AMBIENT AIR QUALITY RELATIVE TO EMISSIONS FROM KOSOVO'S THERMAL POWER PLANTS A AND B

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ACRONYMS AND ABBREVIATIONS

AIO	All-In-One
^{o}C	Celsius
Ca	Calcium
CaO	Calcium oxide
$CaCO_3$	Calcium carbonate
$CaSO_4$	Calcium sulfate
CO_2	Carbon dioxide
cm	Centimeters
EMEP/EEA	European Monitoring and Evaluation Programme/European Environment Agency
EMT	Easy maintenance target
EN	European Normalization
EPRI	Electric Power Research Institute
ESP	Electrostatic precipitator
EU	European Union
FUG	Fugitive
GoK	Government of Kosovo
HMI	Hydro Meteorological Institute
hr	Hour
KEK	Korporata Energjetike e Kosovës
km	Kilometers
LED	Light-emitting diode
lb	Pound
LPTAP	Lignite Power Technical Assistance Project
m	Meters
m^3	Cubic meter
mm	Millimeter
m/s	Meters per second
MW	Megawatt
MWh	Megawatt hour

mtpy	Metric tons per year
NA	No sampling or modeling data available
NE	Northeast
NH_4SO_4	Ammonium sulfate
Nm^3	Normal meter cubed
NW	Northwest
NH_3	Ammonia
NO_x	Nitrogen oxides
NO_2	Nitrogen dioxide
PM_{10} and $PM_{2.5}$	Particulate matter 10 and 2.5 (less than 10 microns or micrometers [µm] and < 2.5 µm aerodynamic diameter)
%	Percent
QA	Quality assurance
SE	Southeast
SOP	Standard operating procedure
SO_2	Sulfur dioxide
SW	Southwest
TAS	Tactical Air Sampler
TPP	Thermal power plant
TPP A	Thermal Power Plant A
TPP B	Thermal Power Plant B
TPPAB	Thermal Power Plants A and B
TSP	Total suspended particles
US	United States
USEPA	United States Environmental Protection Agency
µ	Micron (10^{-6} meter)
µg	Microgram (10^{-6} gram)
$\mu g/m^3$	Micrograms per cubic meter (air)
µm	Micrometers

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1.0 INTRODUCTION

1.1 Background

Since 2010 USAID/Kosovo has commissioned a series of activities to better understand and characterize the environmental issues that may need to be addressed as part of the rehabilitation and potential life extension of Kosovo Thermal Power Plant (TPP) B. As part of this effort, a project was undertaken to implement a capacity building program to expand the Government of Kosovo's (GoK) ambient air quality management capabilities and to conduct an initial assessment of the potential impacts on ambient air quality associated with emissions from Kosovo TPP A and TPP B.

The first phase of the initial assessment was undertaken from July through December 2011. During this period of time, equipment was purchased to gather ambient air samples, demonstration workshops were undertaken to train GoK professionals in the use and maintenance of sampling equipment, and the Kosovo Hydro-Meteorological Institute (HMI), under the direction of The Cadmus Group, gathered ambient air samples for analysis from three sites located in close proximity to the power plants. From January through July 2012, HMI continued to gather samples of ambient air from the three sampling locations.

The second phase of the USAID/Kosovo ambient air quality sampling activities commenced in July 2012 and ended in February 2013. The assessment undertaken during this phase was based on a combination of indicative field sampling data gathered through the deployment of mobile monitoring equipment and dispersion modeling to estimate concentrations of pollutants in the ambient air.

Dispersion models are computerized tools designed to simulate the effects of pollutant dispersion as a plume is emitted from a stationary source and dissipates in the ambient air as a function of: stack temperatures and velocities (plume buoyancy); wind direction and speed; and movement around buildings, mountains, and valleys, etc.

This two-tiered assessment approach reflects general practices implemented by regulatory agencies, such as the United States Environmental Protection Agency (USEPA), to better understand environmental impacts associated with industrial operations.

1.2 Purpose of Assessment

The objectives of the first and second phases of the initial assessment were to:

- Obtain representative data concerning the concentrations in the ambient air of particulate matter less than 10 microns or micrometers (µm) in size and particulate matter less than 2.5 µm in size (PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2); and
- Evaluate the data to identify potential impacts relative to European Union (EU) ambient air quality standards.

These pollutants are considered the primary combustion by-products associated with burning coal.

1.3 Objectives of this Report and Organization

Activities at Kosovo TPP A were initiated more than 40 years ago. Unit A3 was commissioned in 1970, A4 in 1971, and A5 in 1975. TPP Units A1 and A2 are not operational. Kosovo TPP B has two operating units. Unit B1 started operations in 1983 and Unit B2 in 1984. Efforts have been made over the past several years to increase the operational efficiencies of Kosovo TPP A and TPP B and to reduce air emissions. For example, electrostatic precipitators (ESPs) were upgraded on Kosovo TPP Units A3 and A5 during late 2012 and during the first quarter of 2013.

The purpose of this report is to provide a detailed description of the initial assessment approach and results. Specifically, this report focuses on highlighting the ambient air quality sampling data gathered during 2011 through early 2013 and describing how it relates to the modeling data generated as part of this project. This report is organized in the following manner:

- Section 2.0 outlines the approach taken and the equipment used for gathering and analyzing ambient air quality sampling data.
- Section 3.0 details the results from the modeling and sampling data.
- Section 4.0 outlines several recommendations related to this project.
- The Appendix contains standard operating procedures established for the sampling activities.

The information and results generated through the initial assessment provide a foundation for developing ambient air quality policies associated with Kosovo TPP A and TPP B.

For more detailed information about the air dispersion modeling results, see the report prepared for USAID/Kosovo entitled *Air Dispersion Modeling for Emissions from Coal-Fired Thermal Power Plants A and B Obiliq, Kosovo*.

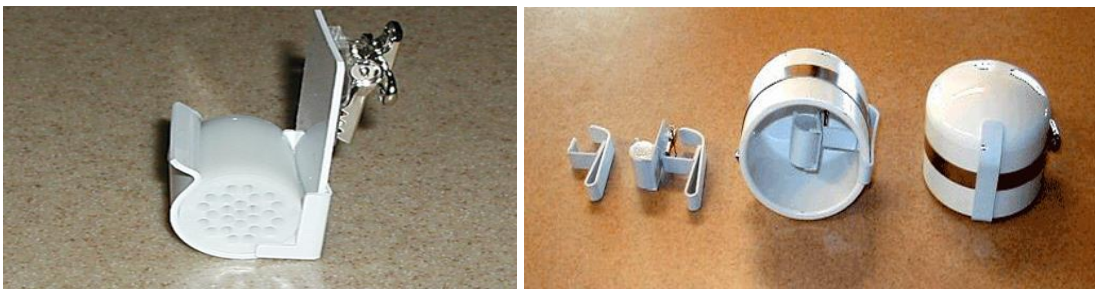
2.0 PROJECT APPROACH

This section outlines the two-tiered approach undertaken to assess potential impacts from Kosovo TPP A and TPP B on ambient air quality in the areas surrounding the power plants.

2.1 Ambient Air Quality Sampling Equipment

The Ogawa Passive Sampler was selected to gather samples of ambient air to measure concentrations of SO_2 and NO_2. The Ogawa Passive Sampler contains two gas collection pads in its dual-inlet configuration. The pads are 14.5 millimeters (mm) in diameter and are specially coated to react chemically with a selected gas or gases. The sampling devices have protective shelters for use outdoors. (See Figure 1 for a photograph of the equipment [right] and shelter [left].)

Figure 1: Ogawa Passive Sampling Equipment[1]



Towards the end of the assessment activities, samples of ambient were gathered using the Ogawa passive sampling equipment to measure concentrations of air ammonia (NH_3). The NH_3 sampling was undertaken to obtain preliminary data to inform the analysis of fine particle ($PM_{2.5}$) formation and SO_2 concentration levels.

The Airmetrics MiniVol™ Tactical Air Sampler (TAS) was used to collect ambient air samples of PM_{10} and $PM_{2.5.}$ The Airmetrics MiniVol™ TAS:

- Draws air through a particle size separator and then through Teflon filters to measure PM. Particle size separation is achieved by impaction. The impactors are available with a 10 micron cut-point (PM_{10}) and a 2.5 micron cut-point ($PM_{2.5}$).
- Critical to the collection of the correct particle size is the correct flow rate through the impactor. For the MiniVol™ TAS, the actual volumetric flow rate must be 5 liters per minute at ambient conditions.

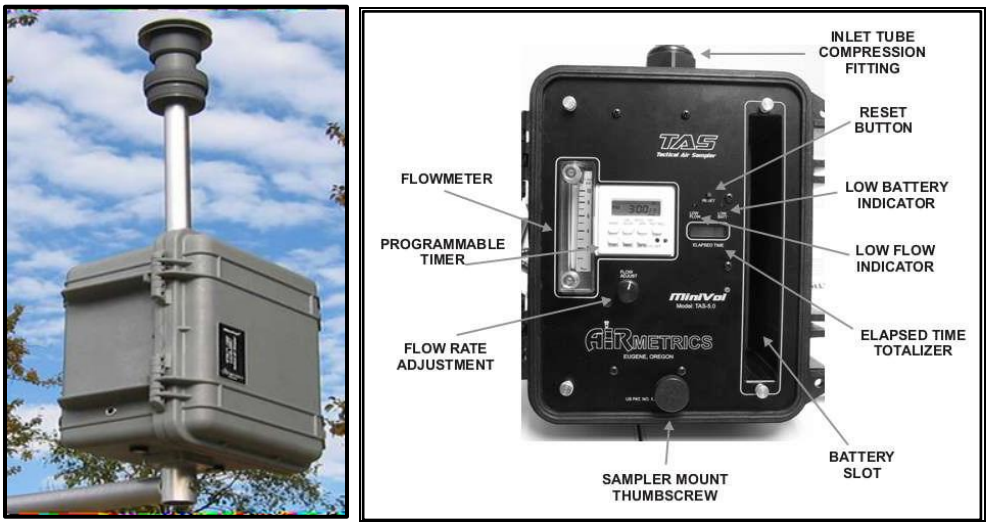
Figure 2 provides a photograph of the Airmetrics TAS sampling equipment.

After being exposed to the ambient air, the filters from the Ogawa and Airmetrics equipment are analyzed to determine pollutant concentrations. Concentrations of PM_{10} and $PM_{2.5}$ are based on

[1] For additional information about the Ogawa sampling equipment and analytical procedures, see http://www.ogawausa.com/passive.html.

the differences in the filter weights before and after exposure to the ambient air. SO_2, NO_2, and NH_3 concentrations are determined on the basis of a chemical analysis of the filters.

Figure 2: Air Metrics Mobile PM Monitoring Equipment[2]



Portable mobile monitoring equipment was chosen for:

- Ease of use in the field,
- Low maintenance, and
- Avoiding issues related to the potential lack of readily available electricity at sampling sites.

Several academic studies have been undertaken to evaluate the Ogawa and Airmetrics mobile sampling devices relative to fixed monitoring equipment. The conclusions presented in published documents indicate general comparability in the measurement results between fixed and mobile equipment. The main difference noted in the published papers is that samples gathered with mobile equipment may slightly underestimate the concentrations of pollutants in the ambient air.[3]

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[2] For additional information see http://www.airmetrics.com.

[3] Supporting articles include:
Sather, Mark E.; Slonecker, E. Terrance; Mathew, Johnson; Daughtrey, Hunter; Williams, Dennis D.: *Evaluation of Ogawa Passive Sampling Devices as an Alternative Measurement Method for the Nitrogen Dioxide Annual Standard in El Paso, Texas*. Environ Monit Assess (2007) 124:211–221, DOI 10.1007/s10661-006-9219-4.
Baldauf, Richard W.; Lane, Dennis D.; Marotz, Glen A.; Wiener, Russel W.: *Performance Evaluation of the Portable MiniVOL Particulate Matter Sampler*. Atmospheric Environment 35 (2001) 6087–6091.
Chen, Fu-Lin; Vanderpool, Robert; Williams, Ronald; Dimmick, Fred; Grover, Brett D.; Long, Russel; Murdoch Robert: *Field Evaluation of Portable and Central Site PM Samplers Emphasizing Additive and Differential Mass Concentration Estimates*. Atmospheric Environment 45 (2011) 4522-4527.

2.2 Sampling Analytics

Ambient air samples were gathered over a period of 24 hours, 7 days, and 14 days. Each 24-hour, 7-day, and 14-day period of time is referred to as a sampling event. (Seven-day and 14-day samples were gathered for SO_2, NO_2, and NH_3 so as to better understand ambient air concentrations related to the potential for fine particle formation.)

Over 820 samples of ambient air were analyzed from July 2011 through February 2013. Of this total, 354 samples were analyzed for PM_{10}, 18 for $PM_{2.5,}$ 329 for $NO_{2,}$ and 92 for SO_2. In addition, 28 samples were analyzed for NH_3. These sample numbers were gathered through the completion of 84 sampling events. During these events the filters were exposed to the ambient air for at least 18 hours in accordance with the Quality Assurance (QA) data quality provisions, properly labeled and traceable to the sampling locations, and included many collected by HMI during January through July 2012.[4]

The sampling events and the ambient air quality samples gathered and analyzed as part of this project are detailed in Table 1.

Table 1: Ambient Air Quality Samples Gathered and Analyzed

	July-December 2011	January through July 11, 2012	July 24 through September 30, 2012	October 1, 2012 through February 15, 2013	Total
Number of Sampling Events	13	22	16	33	84
24-hour PM_{10} Samples	29	33	96	196	354
24-hour $PM_{2.5}$ Samples	0	8	0	10	18
24-hour SO_2 Samples	26	34	3	1	64
24-hour NO_2 Samples	25	40	88	170	323
7-day SO_2 Samples	0	0	2	20	22
7-day NO_2 Samples	0	0	2	4	6
14-Day SO_2 Samples	0	0	0	7	7

Kinghama, Simon; Duranda, Michael; Aberkaneb, Teresa; Harrison, Justin; Wilson, J. Gaines; Epto, Michael Winter: *Comparison of TEOM, MiniVol and DustTrak PM_{10} Monitors in a Wood Smoke Environm*ent. Atmospheric Environment 40 (2006) 338–347.
Hill, Jason S.; Patel, Prateek D.; Turner Jay R.: *Performance Characterization of MiniVol $PM_{2.5}$ Sampler*. Washington University; Air Quality Report No. WUAQL-0399-01.
Mason, J Brooks; Fujita, Eric M.; Campbell, David E.; Zielinska, Barbara: *Evaluation of Passive Samplers for Assessment of Community Exposure to Toxic Air Contaminants and Related Pollutants*. Environ. Sci. Technol. 2011, 45, 2243–2249.

[4] Approximately 300 samples were gathered by HMI from July 2011 through July 2012. Some of these samples were not analyzed because the equipment did not sample the ambient air for at least 18 hours.

	July-December 2011	January through July 11, 2012	July 24 through September 30, 2012	October 1, 2012 through February 15, 2013	Total
24-hour NH_3 Samples	0	0	0	17	17[5]
7-Day NH_3 Samples	0	0	0	11	11

The exposed filters from the Ogawa and Airmetrics sampling devices were sent to RTI International for analysis. RTI International was selected to perform the SO_2, NO_2, NH_3, and PM_{10} and $PM_{2.5}$ analyses for the following reasons:

- The company has a well-established reputation for its environmental chemistry and analytical services.
- Since 1998, RTI has served as the US support laboratory for analyzing Ogawa & Co passive sampler equipment filters.
- RTI is USEPA's laboratory for $PM_{2.5}$ chemical speciation laboratory analysis.
- RTI International has previously undertaken work for USAID.

2.3 Sampling Sites

During the first phase of the assessment, ambient air quality samples were gathered at KEK Metal Works (KEK MW), the Obiliq Health Center, and a residential location in Dardhishte. KEK MW represents a site located downwind from Kosovo TPP B; Dardhishte and the Obiliq Health Center represent areas where sensitive populations, including children and elders, live in close proximity to the power plants.

Additional sites were added to the sampling program during the second phase of the assessment. These sites included: KEK A, which lies within the operational boundaries of Kosovo TPP A; the US Ambassador's Residence and a residential area in Shkabaj,[6] both of which are located east of the power plants; and Germia Park, located east of the power plants and used for recreational purposes. On an intermittent basis throughout the duration of the initial assessment, ambient air quality samples were also gathered at the HMI facility located in Prishtina, Kosovo.

The primary sampling sites represent receptors that are within areas predicted to have the highest ambient air quality concentrations associated with emissions from the power plants. The modeling scenario used to identify these areas was based on 5 years of meteorological data

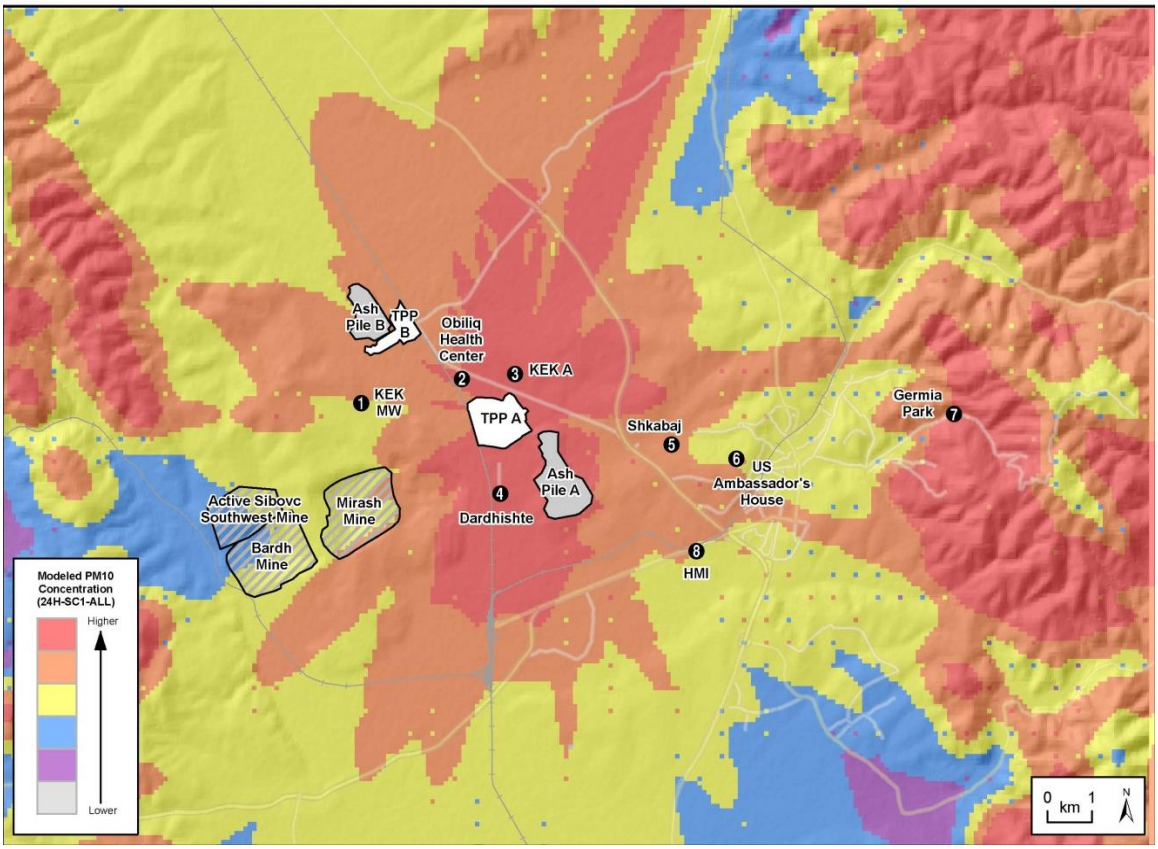
[5] Additional NH_3 samples were taken and analyzed during the assessment but were not included in Table 1 numbers below because the blank filters associated with the sampling events were much higher than the concentrations on the exposed filters.

[6] The US Ambassador's Residence was deemed a better sampling location relative to Shkabaj; the sampling equipment could be located in such a manner to minimize dispersion issues related to structural interferences. Samples were obtained from the Shkabaj site through October 2012.

obtained from the Prishtina Airport and the 2011 operating schedule (megawatts [MW] generated) for all five of Kosovo TPP operating units (A3, A4, A5, B1, and B2). See Figure 3 for the location of the sampling sites relative to the power plants. The sites are numbered on the Figure as follows:

1. KEK MW
2. Obiliq Health Clinic
3. KEK A
4. Dardhishte
5. Shkabaj
6. US Ambassador's Residence
7. Germia Park
8. HMI facility

Figure 3: Ambient Air Quality Sampling Locations



2.4 Meteorological Information for Sampling Activities

Meteorological data from World Weather Online[7] were recorded for each of the sampling events (days sampled) undertaken as part of the initial assessment. This information consisted of temperature, wind direction, wind speed, humidity, percent (%) cloud cover, rain, gusts, and pressure.

World Weather data are represented in 3-hour increments, with the designated time blocks: 1:00-4:00, 4:00-7:00, 7:00-10:00, 10:00-13:00, 13:00-16:00, 16:00-19:00, and 22:00-1:00. To provide "best-fit" 24-hour averages of meteorological data during sampling periods[8], an average sampling start time was determined based upon a review of sampling start times at all sampling locations.[9]

In the event the average sampling start time corresponded with the beginning of one of the 3-hour increments provided by World Weather (i.e., 10:00 or 13:00), an average was calculated of the eight appropriate time increments comprising the 24-hour sampling period. When sampling began in the midst of a 3-hour increment (e.g., 9:00 or 11:00), a weighted average[10] was calculated to provide the "best-fit" 24-hour average.

To augment World Weather data and to obtain meteorological information around the power plants, a Climatronics All-In-One (AIO) weather station was installed at several sampling locations. The AIOs were used to measure temperature, relative humidity, wind speed, wind direction, and barometric pressure during sampling events occurring in 2012 and 2013. See Figure 4 for a photograph of the AIO.

[7] World Weather Online, a weather service providing data from multiple sources. See http://www.worldweatheronline.com/pristina-weather/vojvodina/rs.aspx?day=6.

[8] For 7-day and 14-day sampling events, meteorological data were averaged across the 7 or 14-day period of time to ensure that the data were representative of actual conditions. No weighted averages were used in these averages.

[9] Because sampling locations are distributed throughout Prishtina, start times across sampling locations for a given sampling date could be as much as 3 hours apart.

[10] The weighted average would weigh the 1st and 9th period by 1.5, and the 2nd through 8th periods by 3.

Figure 4: Climatronics Weather Monitoring Equipment

2.5 Dispersion Modeling

To augment the ambient air quality data gathered at the sampling sites, the following dispersion modeling activities were undertaken:

- AERMOD was run to estimate hourly, daily, and annual pollutant concentration levels in the ambient air associated with power plant emissions during 2011 using meteorological data from 2011 and 2005-2009 for all primary pollutants included in the scope of the initial assessment. AERMOD is a dispersion model for predicting concentration levels at distances less than 50 kilometers (km) from source and when plumes disperse in more of a steady-state "Gaussian" format.

- SCIPUFF/SCICHEM - 2012 Beta was run to generate estimates of daily concentrations of pollutants during 2011 sampling events. SCIPUFF/SCICHEM is a modeling program that treats dispersions as "puffs," allowing for non-steady state treatment of concentrations of pollutants during calm wind hours and days, typical in and around Kosovo TPP A and TPP B. The development of the model was funded by the Electric Power Research Institute (EPRI). SCIPUFF/SCICHEM is capable of generating three-dimensional terrain-following winds. The model was not used to simulate plume chemistry due to lack of background concentration data. The final public version of SCIPUFF/SCICHEM was released on June 28, 2013 (after the completion of the modeling analysis). The model and is available to the public for use at the following download location: http://sourceforge.net/projects/epri-dispersion/.

- AERMOD was used to estimate PM_{10} and $PM_{2.5}$ concentrations associated with power plant emissions during 2011 using meteorological data from 2011 and 2005-2009 as a function of the different ESP efficiency scenarios that are identified in Table 2.

SCIPUFFF/SCICHEM modeling was undertaken on a limited basis to assess calm weather conditions.

Table 2: ESP Efficiencies Used in Dispersion Modeling[11]

Unit	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	ESP % Control	ESP % Control	ESP % Control	ESP % Control
A3	80	95	98.734	98.415
A4	90	95	98.734	98.527
A5	85	95	98.734	98.014
B[12]	99	95	99.419	98.982

Unless otherwise stated, the PM_{10} and $PM_{2.5}$ modeling data presented in this summary report were generated under Scenario 1 ESP efficiencies using 2011 meteorological data.

To estimate downwind concentrations, dispersion models require input data including:

- Meteorological data such as upper and lower wind speeds, wind direction, temperature, pressure, and cloud cover.
- Terrain elevation and land use information.
- The location, height, and width of any obstructions (such as buildings or other structures) in the path of the emitted plume that may influence the dispersion process.
- Stack heights, velocities, and exit temperatures.
- Operational data such as fuel type and rate of use, hours of operation, and efficiency of control equipment to estimate the mass emission rate of air pollutants from the stacks.

The dispersion modeling input data were obtained as follows:

- KEK provided information on:
  - Stack heights, velocities, and exit temperatures for each of the operating units – A3, A4, A5, B1, and B2.
  - Actual or realized MW generation during 2011-2013 on an hourly, daily, and monthly basis for each of the five operating units.
  - 2011 coal consumption per MW generated by each of the operating units.

[11] Estimates were based on: *Environment Impact Assessment and Action Plan for Kosovo A and B Power Plants and Coal Mines,* prepared by Carl Bro Intelligent Solutions on behalf of the European Agency for Reconstruction (EAR), June 2003 (Scenario 1); USEPA AP-42 (Scenario 2); and information provided by KEK (Scenarios 3 and 4). Scenario 3 represents the design specifications for the ESP prior to the upgrades in 2012 and 2013. Scenario 4 was calculated based on dust emissions included in the *2011 KEK Environmental Report*.

[12] Units B1 and B2 share a common stack.

- Building heights and plot plans for Kosovo TPP A and TPP B.
- Design efficiencies of the ESPs installed in Kosovo TPP A and TPP B.
- 2011 monthly average coal content to estimate ash generation, SO_2, and NO_2 emissions.

- Lorik Haxhiu provided terrain elevation and land use data.
- Meteorological data were obtained from Trinity Consultants. The surface meteorological data were from the Prishtina Airport and upper air data from Beograd Kosutnjak (44.77N, 20.42E).

  The upper air weather station was approximately 242 km north of the power plants. Trinity Consultants stated this was the closet upper air station and that there is little missing data that cannot be filled using USEPA-approved dispersion modeling methods; however, the surface station was missing a significant amount of data 18% for 2011.

  Only 2.54% of the surface data were missing for the period of 2005 through 2009; therefore these years were used in the dispersion modeling analyses to identify sampling locations. Data from World Weather Online were obtained to augment the missing 2011 surface data to provide a sufficient set of inputs for modeling. (Note: 2010 data from the Prishtina Airport were not used due to the issue of missing data.)

- Control efficiencies for SO_2 were based on an approach used in an earlier environmental assessment of the emissions from the power plants.[13] This approach assumes that SO_2 emissions are scrubbed as a function of the ratio of calcium oxide (CaO) to sulfur in the coal. The control efficiency estimated for Kosovo TPP A was approximately 64% and for TPP B 60%. For NO_2 a number of published reports by consultants and European donor agencies state that there are no existing controls in place for reducing NO_2 emissions from Kosovo TPP A or TPP B; thus no control efficiencies were assigned for this pollutant.[14] However, an USEPA emission factor, which considers fuel and combustion technology, was applied to estimate NO_2 emissions.

These dispersion modeling input data were incorporated into algorithms to:

- Calculate atmospheric turbulence characteristics, mixing heights, and surface heat flux, which influences the degree to which the plume mixes with the ambient air.
- Generate location and height data for each receptor, which allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills at various receptor locations such as homes, schools, or other locations.

[13] Estimates were based on information included in the *Environment Impact Assessment and Action Plan for Kosovo A and B Power Plants and Coal Mines*. This report was prepared by Carl Bro Intelligent Solutions on behalf of the EAR, June 2003.

[14] *Pre-Feasibility Study for Pollution Mitigation Measures at Kosovo B Power Plant – Draft Final, 2006;* this report was prepared by EAR. *Strategic Environmental and Social Assessment Executive Summary Report, 2008*; this report was prepared by the Lignite Power Technical Assistance Project (LPTAP).

- Model the effects of downwash (plume being pushed to the ground), that is created by the plume flowing over nearby buildings.
- Calculate the degree of plume buoyancy or the ability of the plume to rise in the atmosphere and mix with upper layers of the atmosphere.

Dispersion modeling estimates were prepared for pollutant concentrations in the ambient air associated with emissions from:

- Kosovo TPP A,
- Kosovo TPP B,
- The ash pile and conveyor drop (fugitive emissions),
- Kosovo TPP Units A and TPP B, and
- Kosovo TPP A and TPP B with fugitive emissions.

The dispersion plots included in this report are referenced with regard to these five categories. The modeled concentrations were based on calculated hourly emissions. Table 3 contains the annualized hourly emissions from Kosovo TPP A and TPP B during 2011.

Table 3: 2011 Annualized Hourly Estimated Stack Emissions

Unit	PM_{10}[15] and $PM_{2.5}$[16] Metric tons per year (mtpy)								NO_2[17] mtpy	SO_2[18] mtpy
	Scenario 1		Scenario 2		Scenario 3		Scenario 4			
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$		
A3	24,326	11,352	6,081	2,838	1,540	719	1,928	900	3,013	8,049

[15] The hourly emission rates were based on 2011 hourly MW data, monthly tons of coal consumed per megawatt hours (MWh), monthly ash content in coal, and the four ESP scenarios. This approach assumes 75% of Total Suspended Particulates (TSP) is PM_{10} based on Table 3-12 of Chapter 1.A.1 *Energy Industries: Combustion in Energy and Transformation Industries* of the European Monitoring and Evaluation Programme/European Environment Agency (EMEP/EEA) air pollutant emission inventory guidebook factors. See http://eea.europa.eu/emep-eea-guidebook.

[16] The hourly emission rates were based on 2011 hourly MW data, monthly tons of coal consumed per MWh, monthly ash content in coal, and the four ESP scenarios. This approach assumes 35% of TSP is $PM_{2.5}$ based on Chapter 1.A.1 *Energy Industries: Combustion in Energy and Transformation Industries* of the EMEP/EEA air pollutant emission inventory guidebook factors. See http://eea.europa.eu/emep-eea-guidebook.

[17] The hourly emission rates were based on 2011 hourly MW data, monthly tons of coal consumed per MWh, and USEPA AP-42 emission factor of 7.1 pound (lbs)s/short ton from Table1.7-1. This approach assumes 75% of the NO_X is NO_2 based on USEPA's Guideline on Air Quality Models as codified in Appendix W in 40 CFR 51.

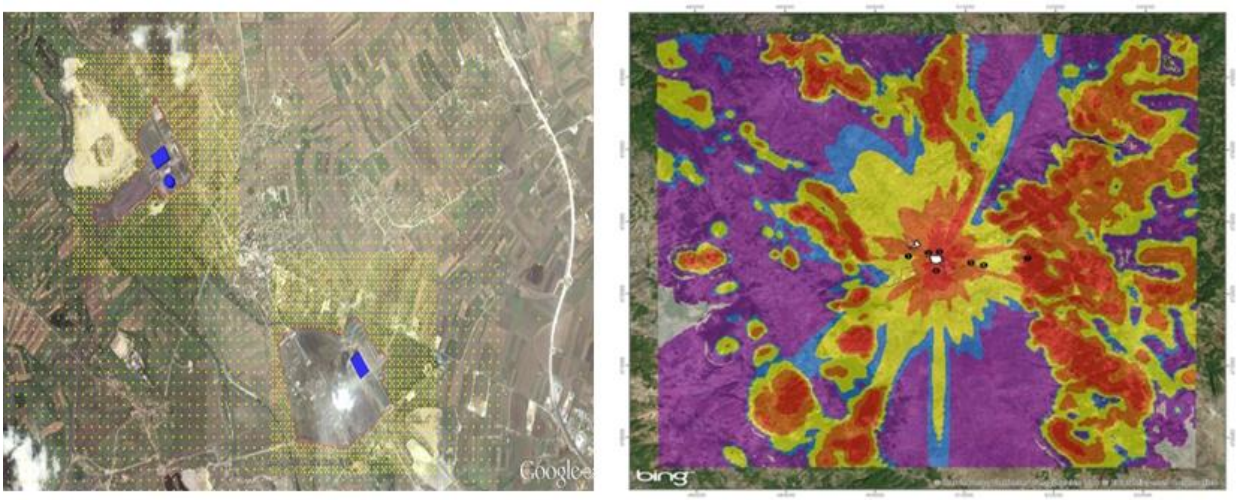
[18] The hourly emission rates were based on 2011 hourly MW data, monthly tons of coal consumed per MWh, monthly sulfur content in coal, and assumed control efficiencies based on CaO in the coal (interpolated from Carl Bro % control versus % Ca/S ratio - recalculated on a monthly basis). The dispersion modeling report describes this approach in greater detail.

Unit	PM_{10}[15] and $PM_{2.5}$[16] Metric tons per year (mtpy)								NO_2[17] mtpy	SO_2[18] mtpy
	Scenario 1		Scenario 2		Scenario 3		Scenario 4			
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$		
A4	7,452	3,478	7,452	3,478	1,887	881	2,195	1,024	3,663	8,986
A5	14,986	6,994	4,995	2,331	1,265	590	1,984	926	2,494	6,309
B	3,834	1,789	19,170	8,946	2,229	1,040	3,902	1,821	10,486	30,752

Using a grid system, dispersion modeling outputs generate contour maps to show the spatial variation in contaminant levels over the geographic area under study (e.g., 50 km).

See Figure 5 for an example of a grid system (right) and contour map (left). For this project the AERMOD concentration estimates were based on a receptor grid spanning 30 km or a 60 by 60 km plot centered at the power plants. The contours are shaded on the plots as light tan, purple, blue, yellow, orange, or red indicating different concentration levels. For each plot included in this report, the legend provides the concentration associated with the contour color. For SCIPUFF/SCICHEM, the domain was 45 km by 35 km.

Figure 5: Example of Dispersion Model Grid System and Contour Map



2.6 Scope of Impact Assessment

The ambient pollutant concentration data obtained through sampling and dispersion modeling were compared to EU Limit Values[19] to assess potential impacts. These limit values, codified in

[19] A limit value refers to a level fixed on the basis of scientific knowledge with the aim of avoiding, preventing, or reducing harmful effects on human health and/or the environment. The limit value should not be exceeded once attained. (Excerpt from Directive 2008/50/EC, Article 2)

EU Directive 2008/50/EC, can be found in Table 4. The limit values are expressed in micrograms per meter cubed (µg/m^3).

Table 4: Applicable EU Limit Values for Ambient Air Quality

Pollutant	Averaging Period	Limit Value
SO_2	1-hour	350 µg/m^3, not to be exceeded more than 24 times a calendar year
	24-hour	125 µg/m^3, not to be exceeded more than 3 times a calendar year
NO_2	1-hour	200 µg/m^3, not to be exceeded more than 18 times a calendar year
	Calendar year	40 µg/m^3 (not to be exceeded)
PM_{10}	24-hour	50 µg/m^3, not to be exceeded more than 35 times a calendar year
	Calendar year	40 µg/m^3 (not to be exceeded)
$PM_{2.5}$	Calendar year	25 µg/m^3, Stage 1 compliance date is January 2015

The 2011-2013 sampling results and 2011 modeling estimates were also analyzed relative to one another to assess comparability. To identify any potential trends the ambient air quality sampling results were evaluated relative to:

- Average pollutant concentrations calculated for each sampling site.
- Average pollutant concentrations calculated as a function of the predominant wind direction and wind speed.
- Average pollutant concentrations calculated relative to four ranges of MW generation.
- Average pollutant concentrations calculated on a monthly and seasonal basis.

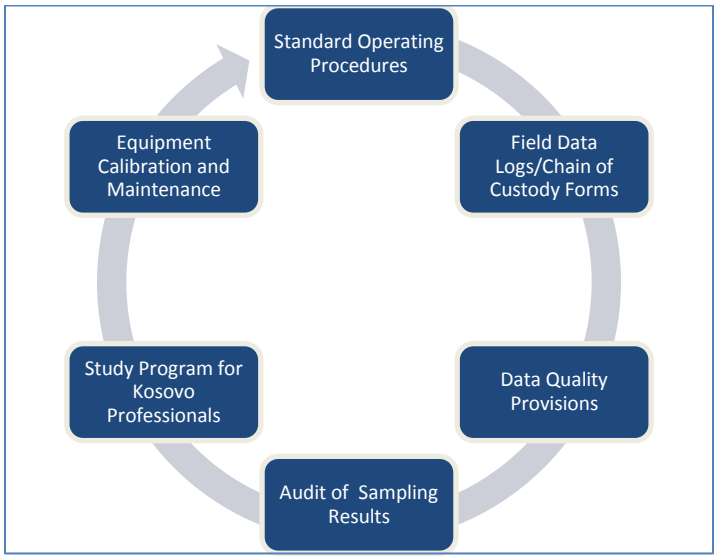
The realized MW data provided by KEK included hourly MW generation for each of A3, A4, A5, B1, and B2. In order to determine MWs generated during a given sampling period, the average sampling start time (as determined in collection of meteorological data) was used. Total 24-hour generation was then calculated for each stack and aggregated to determine MW[20] generation for a given sampling event.[21]

2.7 Project QA Program

To help ensure consistency and comparability in the sampling results, the QA program depicted in Figure 6 was undertaken.

[20] For the 7-day and 14-day sampling events, MW generation was determined by calculating the average MW generation for the entire 7 or 14-day sampling event.
[21] See MW data in Section 3.2

Figure 6: QA Program for TPP Kosovo Ambient Air Monitoring



Standard Operating Procedures (SOPs) were used to conduct assessment activities. For example:

- RTI International follows:
  - Environmental and Industrial Sciences Division (EISD) Gravimetry Laboratory (Grav Lab) Standard Operating Procedure for Particulate Matter (PM) Gravimetric Analysis, 2008.
  - Ogawa's NO, NO_2, NO_x, SO_2, and NH_3 Sampling Protocol System developed by Yokohama City Research Institute of Environmental Science, Yokohama, Japan, Report No. 128, March 1997.
  - Standard Operating Procedure for the X-Ray Fluorescence Analysis of Particulate Matter Deposits on Teflon Filters. RTI International, Revision 5, August 19, 2009.
- Project SOPs were developed for gathering samples, maintaining equipment, completing field data logs, and handling and analyzing exposed filters. These project SOPs can be found in the Appendix 1.

Field Data Sheets/Chain of Custody Forms were prepared to confirm the traceability of the data to each sampling location and sampling event. In particular, to facilitate an appropriate analysis of the measurement data, the weather conditions and PM filter numbers were recorded on the sheets. This information was compared relative to the data obtained from the AIO equipment. In addition, at the initiation of this project, the Cadmus Team reviewed with HMI and the local professional the importance of accurately completing the filed data sheets and chain-of-custody forms.

Data Quality Provisions were applied such that only filters exposed to the ambient air for 18 hours or more were analyzed to determine pollutant concentrations.

Audits of Sampling Results were conducted following receipt of the analytical results from RTI International. The data were reviewed relative to the field data sheets, and any issues identified were discussed and resolved with the staff conducting the monitoring and RTI International. (See Appendix 2.)

A Study Program for Kosovo Professionals was undertaken**.** The study program was offered to three HMI staff members and the local consultant assisting with the sampling activities in Kosovo. The study program lasted five days and consisted of visiting the RTI International Laboratory and USEPA. The purpose of the study tour was to obtain a detailed understanding of the laboratory methods used to detect concentrations of the NH_3, SO_2, NO_2, PM_{10}, and $PM_{2.5}$ on the exposed filters, reinforce the importance of conducting consistent monitoring activities, and introduce Kosovo professionals to ambient air quality experts at USEPA.

Equipment Calibration and Maintenance was scheduled and undertaken to maintain the functioning of the sampling devices**.** The Ogawa mobile monitoring equipment does not need to be calibrated. However, the equipment was maintained (i.e., periodic cleaning) in accordance with the manufacturer's recommendations to ensure full operability. For the Airmetrics equipment, the equipment was examined by the local professional following the maintenance procedures provided by the manufacturer. In addition, surplus monitoring equipment was available for use if any of the Airmetrics or Ogawa equipment was found to be malfunctioning.

2.8 Sampling Environmental Brief

Prior to the initiation of the July 2012 sampling program, the environmental brief contained in Figure 7 was prepared for local stakeholders who might request information about the ambient air quality sampling activities. The brief describes the purpose and scope of the initial assessment and the equipment used for gathering samples of ambient air.

Figure 7: Ambient Air Monitoring Sampling Brief

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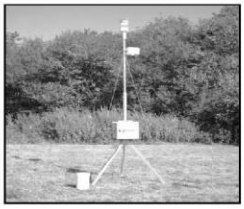
NGA POPULLI AMERIKAN
OD AMERIČKOG NARODA

ACTIVITY BRIEF

The ambient air monitoring equipment being used as part of this sampling program is depicted below. In addition, a weather station, manufactured by Climatronics, will be co-located with the monitoring equipment to gather information on temperature, wind speed, and wind direction which are needed to help interpret the analytical results.

Particulate Matter Sampler

Sulfur Dioxide /Nitrogen Dioxide Sampler



Weather Monitor

We thank you for your interest and support in the ambient air quality sampling program.

2012

U.S. Agency for International Development
www.usaid.gov

Ambient Air Quality Sampling Program

USAID/Kosovo, with the assistance of Kosovo's Hydro Meteorological Institute (HMI), is undertaking an environmental sampling program to measure the concentrations of pollutants in the ambient air related to emissions from Thermal Power Plant (TPP) Units A and B.

The sampling program is scheduled to be implemented from July 2012 through March 31, 2013. The program will focus on measuring the concentrations of particulate matter, sulfur dioxide, and nitrogen dioxide in the ambient air. These pollutants are considered the primary contaminants associated with the combustion of coal from TPP Units.

Six sites in and around Pristina, Kosovo have been selected to sample ambient air quality to measure the concentrations of pollutants. These include the following:

- Obiliq Health Clinic
- Dardhishte
- KEK Metal Works
- Germia Park
- Shkabaj
- North side of TPP A property

These sites were selected because they are located within the general dispersion of the air emissions from TPP Units A and B.

Sampling will be undertaken approximately two times per week at each of the six sites. The Airmetrics MiniVol will be used to sample particular matter; while the Ogawa Passive Sampler will be used to sample sulfur dioxide and nitrogen dioxide in the ambient air.

The results obtained through this sampling program will be shared with the Government of Kosovo and potential investors to help determine an appropriate approach for reducing emissions from the power plants to achieve conformance with Kosovo and European Union ambient air quality standards.

3.0 AMBIENT AIR QUALITY SAMPLING AND DISPERSION MODELING OBSERVATIONS

The initial assessment of potential impacts on ambient air quality revealed a number of observations that provide:

- Insights regarding plume dispersion and potential impacts on ambient air quality; and
- Analytical data to consider in developing plans for integrating environmentally sound design and management principles into strategies for reducing air emissions associated with Kosovo TPP A and TPP B.

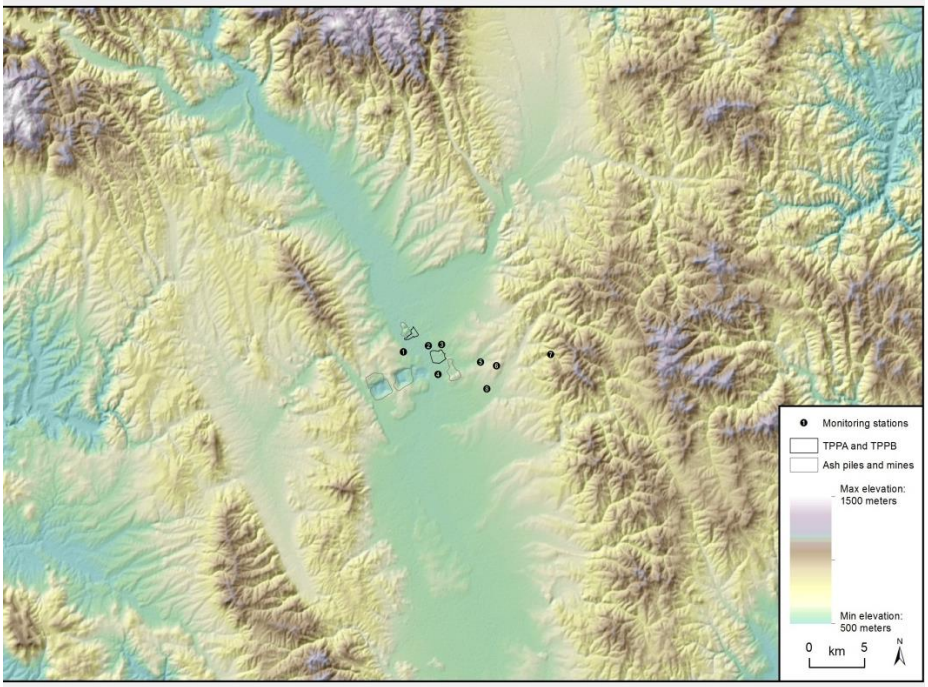
The information and observations presented in this section should be viewed collectively to best understand the issues influencing ambient air quality around the power plants.

3.1. Context for Understanding Results

The following conditions influence the dispersion of the emission plumes exiting the power plants' stacks and the concentrations of pollutants measured and modeled in the ambient air.

- Kosovo TPP A and TPP B are located within a valley. Valleys are prone to inversions, which reduce mixing and influence both the movement of air and emission plumes. Figure 8 shows the valley where the power plants are located and the terrain around the power plants. The dots represent the sampling locations; the boundaries of the power plants are shown on the map.

Figure 8: Local Terrain around Kosovo TPP A, TPP B, and Sampling Locations



- Kosovo TPP A and B stack heights, temperature, and exit velocities are not generally high, hot, or fast enough to increase the buoyancy of the plume to rise and mix with the upper wind patterns. These stack parameters are listed in Table 5.

Table 5: Kosovo TPP Unit Stack Characteristics

Source	Stack Height[22]	Stack Diameter[23]	Stack Flow Rate at Full Load[24]	Stack Temperature[23]
	Meters (m)	(m)	Normal meter cubed (Nm^3)/hour	Celsius (^oC)
A3	100	6.5	743,400	185
A4	100	6.5	743,400	185
A5	120	6.3	743,400	185
B	182	11.37	1,908,300	150

- Periodically the emission plumes from Kosovo TPP A and B loop (see Figure 9). These types of plumes occur due to the rapid overturning of air during turbulent/unstable air conditions. While unstable conditions are generally favorable for pollutant dispersion, momentarily high ground-level concentrations can occur if the plume loops downward to the surface.

Figure 9: Looping Effect of the Plumes

[22] Based on discussions with KEK, and information in the *Pre-Feasibility Study for Pollution Mitigation Measures at Kosovo B Power Plant Final Draft – 2006*, prepared by EAR.
[23] Based on data in a presentation prepared by Professor Sabri Limari, dated 25 October 2007.
[24] Based on an e-mail from KEK to The Cadmus Group dated 22 May 2012. The flow rate was adjusted on an hourly basis for partial load conditions.

- Kosovo TPP A and TPP B utilize tangential, stoker, wall-fired, and cyclone furnaces. The average temperature range reached in the furnaces for TPP A is 800°C and 850°C for TPP B.[25] It has been suggested that tangential and stoker furnaces and lower furnace temperatures (characteristic of TPP A and TPP B) potentially reduce nitrogen oxides (NO_x)/NO_2 formation.[26]

3.2 Sampling Results

The tables provided in this section include the ambient air quality results for samples collected and analyzed between July 2011 and February 2013. Separate tables for each parameter (PM_{10}, $PM_{2.5}$, NO_2, SO_2, and NH_3) have been prepared. These data met the data quality provisions of at least 18 hours of exposure time to the ambient air.

With each sampling result the following information is provided: MW generation data per TPP operating unit; meteorological conditions; average sampling start time; and average sampling duration.

The sampling data can be found in the following tables:

- Table 6 includes the 24-hour PM_{10} sampling results.
- Table 7 summarizes the 24-hour $PM_{2.5}$ sampling results.
- Table 8 presents the 24-hour and 7-day NO_2 sampling results.
- Table 9 presents the SO_2 sampling results for the 24-hour, 7-day and 14-day sampling results.
- Table 10 covers the 24-hour and 7-day NH_3 sampling results.

In reviewing these tables:

- NE refers to northeast
- NW refers to northwest
- SE refers to southeast
- SW refers to southwest

The results for SO_2, NO_2, and NH_3 have been adjusted for blanks. The PM_{10} and $PM_{2.5}$ filters are pre-weighed by RTI prior to being exposed to the ambient air.

Overall trends regarding the 2011 to 2012 sampling results are presented in Sections 3.3-3.8. Specific observations regarding the sampling results from January through February 2013 are presented in these sections, where appropriate.

[25] Information from KEK sent in an e-mail to The Cadmus Group on 1 February 2013.
[26] *Emission Factor Documentation for AP-42 Section 1.7, Lignite Combustion*; USEPA. April 1993.

Table 6: 24-Hour PM_{10} Sampling Results – 2011 through 2013

Sampling Date	Obiliq Health Center	Dardhishte	KEK MW	Germia Park	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temperature	Average Wind Speed (m/s)	Predominant Wind Direction	Average Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour PM_{10} ($\mu g/m^3$)								Meteorological Conditions				Operating Conditions							
27-28 July 2011	34.17	44.03	1	1	1	1	1	1	20.40	0.89	SW	7.00	2846	3026	0	5828	5803	17503	10:30	24
1 -2 September 2011	40.14	115.28	113.84	1	1	1	1	1	20.90	1.25	SW, NW	10.00	3076	2216	0	461	3569	9322	13:00	23.6
8-9 September 2011	48.34	71.11	66.67	1	1	1	1	1	20.10	1.48	NE	12.00	2916	2766	0	0	5639	11321	11:00	24
15-16 September 11	46.81	41.25	43.47	1	1	1	1	1	22.10	1.52	NW, NE	8.00	1597	2953	3167	5405	0	13122	9:30	24
22-23 September 2011	56.39	30.69	49.58	1	1	1	1	1	14.75	1.97	NW	17.00	0	2844	3130	5371	0	11345	10:30	24
3-4 October 2011	50.28	35.00	65.00	1	1	1	1	1	15.42	1.16	NW, NE	0.00	0	2986	2836	5381	0	11203	11:00	24
17-18 October 2011	3	3	3	1	1	1	1	1												
14-15 November 11	88.01	42.77	77.78	1	1	1	1	1	-0.25	1.65	NW, NE	15.33	0	3084	3183	5967	0	12234	12:00	24
24-25 November 2011	69.86	2	53.19	1	1	1	1	1	2.00	1.79	NE	31.00	2777	2984	3286	0	0	9047	15:30	24
9-10 December 2011	162.21	2	108.12	1	1	1	1	1	3.00	2.28	SW, SE	9.00	2919	2974	3100	5582	2226	16801	9:30	24.8
14-15 December 2011	2	54.44	39.31	1	1	1	1	1	4.90	1.92	SW	12.00	2877	2691	0	5910	6025	17503	10:30	23.5
21-22 December 2011	2	34.03	36.69	1	1	1	1	1	-2.10	2.24	NW, NE	53.00	0	2762	3202	5925	6490	18379	11:00	24.6
28-29 December 2011	2	2	59.30	1	1	1	1	1	-2.90	1.25	SE	15.00	3149	0	3173	6371	6505	19198	11:30	24.8

1 - No samples collected for analysis at this location on this date.

2 - Sampling conducted at this location on this date, but sampling did not last for at least 18 hours due to equipment malfunction.

3 - Sampling conducted and collected by HMI; filter numbers received by RTI did not match with filters originally sent. Data were not analyzed.

Two samples were collected at one or some of Obiliq Health Center, Dardhishte, and KEK MW for many of the 2011 sampling events. For those cases, PM_{10} data presented above represent the average of those two samples.

Sampling Date	Obiliq Health Center	Dardhishte	KEK MW	Germia Park	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temperature	Average Wind Speed (m/s)	Predominant Wind Direction	Average Percent Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour PM_{10} ($\mu g/m^3$)								Meteorological Conditions				Operating Conditions							
05-06 January 2012	2	28.49	30.54	1	1	1	1	2	0.67	3.26	SE	70.78	2813	2166	2941	5974	6049	19943	12:00	24
11-12 January 2012	2	44.72	1	1	1	1	1	2	-2.22	1.79	NW	62.78	3038	0	3183	2727	6270	15218	11:00	24
17-18 January 2012	2	1	82.21	1	1	1	1	2	-5.22	1.04	NW, SW	47.89	2980	1259	2972	2175	6572	15958	14:00	24
23-24 January 2012	2	272.73	247.22	1	1	1	1	1	-0.56	1.14	NE, SW	50.00	2865	0	2932	6028	6215	18040	10:00	22
31 January - 01 February 2012	2	1	260.21	1	1	1	1	2	-11.33	1.59	NE	62.22	2662	3049	3192	0	6473	15376	10:00	21
09-10 February 2012	2	42.35	1	1	1	1	1	2	-13.44	1.94	NE	80.44	0	2708	3115	6063	6470	18356	13:00	23
14-15 February 2012	2	138.19	97.51	1	1	1	1	2	-12.89	1.39	NW, NE	42.89	2038	0	2894	6072	6430	17434	11:00	24
22-23 February 2012	2	1	64.44	1	1	1	1	2	0.11	1.59	NE	3.56	2898	3018	0	6120	6447	18483	10:00	24
28-29 February 2012	2	53.42	29.61	1	1	1	1	2	-2.44	2.24	SW, NW	59.56	0	2879	0	6150	6399	15428	11:00	23
05-06 March 2012	2	2	1	1	1	1	1	2	0.67	1.79	NW, NE	22.56	0	2932	3292	6050	6197	18471	13:00	24
12-13 March 2012	2	60.09	52.61	1	1	1	1	2	0.78	2.93	NW	43.56	3284	0	3416	6103	6316	19119	15:00	23
02-03 April 2012	2	1	80.14	1	1	1	1	2	7.00	1.98	SE	23.67	3183	3493	0	5839	0	12515	12:00	24
18-19 April 2012	2	31.25	36.65	1	1	1	1	2	5.56	2.58	NW, SW	54.22	2125	3062	0	6100	6283	17570	9:00	24
24-25 April 2012	2	37.92	1	1	1	1	1	2	13.44	3.23	SW, SE	18.78	0	3329	0	6039	6270	15638	11:00	24
03-04 May 2012	39.31	2	79.83	1	1	1	1	27.18	17.78	1.84	SW	14.89	0	2444	0	5330	6197	13971	11:00	24
07-08 May 2012	2	39.86	2	1	1	1	1	2	14.89	2.68	SW	20.67	0	3111	0	6019	5919	15049	12:00	24
14-15 May 2012	2	3.99	2	1	1	1	1	2	7.11	2.28	NW, NE	100.00	0	2864	0	5953	6158	14975	10:00	24
21-22 May 2012	1	33.33	2	1	1	1	1	2	16.11	2.83	SE	36.56	3428	3039	0	6061	0	12528	10:00	24
28-29 May 2012	2	52.01	2	1	1	1	1	2	12.00	1.64	NW	15.78	3213	0	0	6040	0	9253	8:00	24

1 - No samples collected for analysis at this location on this date.

2 - Sampling conducted at this location on this date, but sampling did not last for at least 18 hours due to equipment malfunction.

3 - Sampling conducted and collected by HMI, however filter numbers received by RTI did not match numbers of filters originally sent. Data were not analyzed.

4 - PM_{10} and $PM_{2.5}$ samples were collected at this sampling location on this date. Concentrations sampled on the two filters associated with this location were 69.58 and 52.78 $\mu g/m^3$. However, due to a transcription error, it is uncertain as to which parameter concentration value pertains to each of the sampled parameters.

Sampling Date	Obiliq Health Center	Dardhishte	KEK MW	Germia Park	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temperature	Average Wind Speed (m/s)	Predominant Wind Direction	Average Percent Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour PM_{10} ($\mu g/m^3$)								Meteorological Conditions				Operating Conditions							
27-28 June 2012	2	50.28	52.64	1	1	1	1	2	16.56	2.19	NW, NE	5.56							9:00	24
04-05 July 2012	2	102.78	88.43	1	1	1	1	2	23.67	1.04	SW	6.11	2974	2986	0	0	6613	12573	9:00	24
10-11 July 2012	2	47.26	66.81	1	1	1	1	65.14	25.22	1.39	NW, SW	4.44	2661	2861	0	0	6509	12031	8:00	29
24-25 July 2012	25.42	27.22	26.53	22.36	23.89	35.14	1	1	20.13	1.45	NW, NE	40.63	2839	2846	0	0	5927	11612	10:00	24
30-31 July 2012	28.61	46.94	33.47	16.94	27.78	37.08	1	1	22.00	2.83	NW	22.67	2878	0	3439	0	6601	12918	14:00	24
02-03 August 2012	46.53	64.60	87.50	28.47	43.61	59.03	1	1	22.78	1.14	NW, NE	10.11	0	0	3522	0	6560	10082	11:00	24
07-08 August 2012	51.11	52.64	55.14	35.69	46.67	48.89	1	1	23.63	2.85	NW, NE	5.25	0	0	3424	0	6488	9912	11:00	24
09-10 August 2012	29.31	39.58	29.31	19.44	32.36	25.00	1	1	20.13	2.82	NW, NE	10.50	0	0	3500	0	6632	10132	14:00	24
15-16 August 2012	43.06	1	92.92	26.39	49.03	52.64	33.33	1	20.00	1.06	NE	11.50	0	19	0	0	1856	1875	15:00	24
21-22 August 2012	106.39	1	117.50	38.06	65.42	115.00	45.56	1	24.94	0.75	SW, SE	0.25	0	3036	3585	0	6372	12993	11:00	24
23-24 August 2012	156.25	144.58	160.14	69.72	110.42	156.25	1	1	27.00	0.70	SW, SE	1.50	0	3280	3511	0	6432	13223	10:00	24
27-28 August 2012	31.53	1	39.31	13.61	34.72	34.44	26.25	1	15.94	3.07	NW	39.50	0	2619	3562	0	6307	12488	10:00	24
30-31 August 2012	80.83	102.78	115.00	36.53	84.17	97.08	1	1	20.06	1.17	NE	2.75	0	3196	3559	0	6553	13308	10:00	24

1 - No samples collected for analysis at this location on this date.

2 - Sampling conducted at this location on this date, but sampling did not last for at least 18 hours due to equipment malfunction.

3 - Sampling conducted and collected by HMI, however filter numbers received by RTI did not match numbers of filters originally sent. Data were not analyzed.

4 - PM_{10} and $PM_{2.5}$ samples were collected at this sampling location on this date. Concentrations sampled on the two filters associated with this location were 69.58 and 52.78 $\mu g/m^3$. However, due to a transcription error, it is uncertain as to which parameter concentration value pertains to each of the sampled parameters.

Sampling Date	Obiliq Health Center	Dardhishte	KEK MW	Germia Park	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temperature	Average Wind Speed (m/s)	Predominant Wind Direction	Average Percent Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour PM_{10} (µg/m^3)								Meteorological Conditions				Operating Conditions							
05-06 September 2012	62.64	1	74.31	41.11	55.56	56.11	49.86	1	20.44	1.40	SW	63.19	0	3166	3510	0	6496	13172	10:00	24
10-11 September 2012	70.28	1	74.58	33.61	70.97	76.25	51.53	1	18.38	1.34	SE	5.38	0	3126	3443	0	6399	12968	11:00	24
13-14 September 2012	84.44	1	44.72	27.22	36.39	88.75	37.08	1	18.56	2.29	SE	31.00	0	3252	3280	0	6559	13091	10:00	24
18-19 September 2012	77.64	1	79.17	21.81	58.75	125.14	40.42	1	16.56	1.09	NE, SE	31.63	0	3224	2003	0	6692	11919	11:00	24
24-25 September 2012	92.08	1	105.14	37.18	182.22	150.69	54.17	1	19.31	2.63	SW	11.56	0	3061	0	0	6456	9517	10:00	24
26-27 September 2012	72.92	65.42	106.11	28.19	85.28	112.78	1	1	19.81	1.79	SW	7.13	0	3010	0	0	6653	9663	11:00	24
02-03 October 2012	51.25	1	53.47	38.75	71.53	134.17	58.06	1	15.13	1.40	SW	7.31	0	3074	3437	0	6665	13176	10:00	24
08-09 October 2012	29.03	52.22	45.42	13.61	1	37.78	28.19	1	7.25	1.73	NW, NE	12.06	0	3215	3432	0	6720	13367	10:00	24
10-11 October 2012	126.94	1	139.17	26.53	63.75	115.00	49.17	1	9.50	0.78	NE, SE, SW	25.56	0	3119	3350	1464	6581	14514	10:00	24
15-16 October 2012	50.56	28.61	43.75	18.47	1	80.56	26.67	1	15.75	2.96	SW, SE	22.31	0	2964	3446	0	6596	13006	11:00	24
18-19 October 2012	98.75	122.36	80.69	45.00	1	140.28	67.08	1	10.75	0.73	SE	2.44	0	1886	3261	6020	6607	17774	10:00	24
23-24 October 2012	64.44	76.81	58.19	44.72	1	68.75	58.59	1	8.38	1.40	NW	7.69	0	2788	3353	0	6562	12703	10:00	24
29-30 October 2012	11.39	12.08	9.17	7.50	1	15.97	10.42	1	7.44	1.93	NE, SW	42.38	0	2983	0	6147	0	9130	11:00	24
01-02 November 2012	28.75	3	24.17	8.89	1	33.89	18.47	1	9.56	2.40	SW, SE	77.38	0	2172	0	6232	6238	14642	10:00	24
05-06 November 2012	18.75	19.86	21.67	8.89	1	39.58	19.58	1	13.63	2.74	SW	56.56	0	0	3145	6686	6611	16442	11:00	24
07-08 November 2012	70.14	62.36	56.94	10.42	1	75.69	50.42	1	3.94	2.15	NW	20.81	0	0	3435	6725	6524	16684	11:00	24
13-14 November 2012	25.83	29.44	33.33	22.78	1	26.25	26.53	1	9.50	2.51	NW	53.31	0	3066	3182	6628	6150	19026	11:00	24
15-16 November 2012	32.64	37.08	29.31	20.83	1	28.33	40.28	1	6.44	1.37	NE	81.56	0	2846	2868	6725	6255	18694	14:00	24
19-20 November 2012	70.97	79.44	55.83	27.22	1	74.31	81.53	1	7.13	1.73	NE	58.44	0	2690	0	6729	6230	15649	10:00	24
21-22 November 2012	32.36	32.50	30.97	22.08	1	22.22	53.61	1	8.56	1.31	NE	85.06	0	0	192	6851	6486	13529	10:00	24
29-30 November 2012	41.53	30.97	33.75	15.56	1	53.33	32.22	1	6.19	3.38	SW	35.44	0	2880	3220	6824	6182	19106	12:00	24

1 - No samples collected for analysis at this location on this date.

2 - Sampling conducted at this location on this date, but sampling did not last for at least 18 hours due to equipment malfunction.

3 - Sampling conducted and collected by HMI, however filter numbers received by RTI did not match numbers of filters originally sent. Data were not analyzed.

4 - PM_{10} and $PM_{2.5}$ samples were collected at this sampling location on this date. Concentrations sampled on the two filters associated with this location were 69.58 and 52.78 µg/m^3. However, due to a transcription error, it is uncertain as to which parameter concentration value pertains to each of the sampled parameters.

Sampling Date	Obiliq Health Center	Dardhishte	KEK MW	Germia Park	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temperature	Average Wind Speed (m/s)	Predominant Wind Direction	Average Percent Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour PM_{10} ($\mu g/m^3$)								Meteorological Conditions				Operating Conditions							
11-12 December 2012	131.11	117.92	104.72	23.19	1	121.81	74.17	1	-6.56	2.07	NW	56.50	0	3105	3540	6833	6493	19971	11:00	24
13-14 December 2012	250.14	131.25	237.08	45.42	1	200.14	260.00	1	-7.38	1.59	SE	21.19	0	3014	3468	6721	6500	19703	12:00	24
17-18 December 2012	52.50	53.47	31.25	50.69	1	43.89	42.78	1	1.63	1.48	NE	93.19	0	3035	3412	6244	6512	19203	11:00	24
19-20 December 2012	29.03	37.64	17.36	7.50	1	12.92	11.39	1	-1.94	2.71	NW	90.63	0	3071	2756	3875	6487	16189	11:00	24
27-28 December 2012	99.17	84.44	85.69	73.06	1	98.06	101.25	1	3.81	1.70	SW	43.56	0	2860	3575	6820	6513	19768	14:00	24
03-04 January 2013	124.58	101.53	114.31	75.00	1	102.50	109.58	1	0.81	1.15	NW	27.13	736	3131	3433	6454	6349	20103	11:00	24
08-09 January 2013	111.11	88.75	83.47	25.28	1	91.39	81.25	1	-5.50	1.06	NE, SW	31.63	3280	2872	0	6603	6458	19213	11:00	24
10-11 January 2013	70.97	68.75	62.36	78.75	1	94.17	69.58	1	-0.63	2.35	SE	50.56	3204	3116	0	6386	6489	19195	11:00	24
14-15 January 2013	34.72	25.69	24.86	15.14	1	33.75	23.06	1	1.56	3.74	SE	88.25	3331	0	1345	6441	6454	17571	11:00	24
16-17 January 2013	34.86	29.03	50.56	7.22	1	52.50	17.78	1	3.13	2.60	SW	41.25	3368	28	0	6632	6464	16492	11:00	24
21-22 January 2013	40.83	23.61	32.64	13.89	1	68.06	22.50	1	4.25	2.88	SW	71.13	3245	2764	0	6640	6480	19129	11:00	24
23-24 January 2013	69.44	43.19	56.53	11.39	1	82.08	34.72	1	2.06	2.21	SW, SE	31.88	3463	2825	0	6621	6496	19405	10:00	24
29-30 January 2013	150.56	127.36	141.81	65.56	1	126.11	120.42	1	-0.81	1.06	SW	28.50	0	2936	1899	6641	6366	17842	13:00	24
31 January - 01 February 2013	133.06	112.22	123.75	26.67	1	119.31	4	1	-1.31	1.82	SW	24.50	0	3049	3360	6751	6436	19596	11:00	24
04-05 February 2013	127.36	97.92	80.69	0.28	1	105.97	78.61	1	2.25	1.01	SW	10.75	0	3081	3467	5783	6439	18770	10:00	24
07-08 February 2013	22.50	17.78	17.36	0.42	1	19.31	18.19	1	1.25	3.46	NW	84.56	3296	0	3388	6706	6662	20052	11:00	24
11-12 February 2013	72.36	59.86	64.17	0.14	1	111.39	52.50	1	0.44	2.37	SW	33.75	3204	0	3099	6706	6694	19703	11:00	24
14-15 February 2013	20.97	13.75	12.50	0.56	1	10.56	13.47	1	2.38	2.51	NW	92.13	3230	0	3429	6755	6671	20085	13:00	24

1 - No samples collected for analysis at this location on this date.

2 - Sampling conducted at this location on this date, but sampling did not last for at least 18 hours due to equipment malfunction.

3 - Sampling conducted and collected by HMI, however filter numbers received by RTI did not match numbers of filters originally sent. Data were not analyzed.

4 - PM_{10} and $PM_{2.5}$ samples were collected at this sampling location on this date. Concentrations sampled on the two filters associated with this location were 69.58 and 52.78 $\mu g/m^3$. However, due to a transcription error, it is uncertain as to which parameter concentration value pertains to each of the sampled parameters.

Table 7: 24-Hour $PM_{2.5}$ Sampling Results – 2011 through 2013

Sampling Date	Dardhishte	KEK MW	KEK A	Germia Park	US Ambassador's Residence	Averag Temperature	Averge Wind Speed (m/s)	Predominant Wind Direction	Average Percent Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour $PM_{2.5}$ ($\mu g/m^3$)					Meteorological Conditions				Operating Conditions							
11-12 January 2012	1	89.44	1	1	1	-2.22	1.79	NW	62.78	3038	0	3183	2727	6270	15218	11:00	24
17-18 January 2012	89.44	1	1	1	1	-5.22	1.04	NW, SW	47.89	2980	1259	2972	2175	6572	15958	14:00	24
23-24 January 2012	1	1	1	1	1	-0.56	1.14	NE, SW	50.00	2865	0	2932	6028	6215	18040	10:00	22
31 January - 01 February 2012	252.29	1	1	1	1	-11.33	1.59	NE	62.22	2662	3049	3192	0	6473	15376	10:00	21
09-10 February 2012	1	40.14	1	1	1	-13.44	1.94	NE	80.44	0	2708	3115	6063	6470	18356	13:00	23
22-23 February 2012	71.11	1	1	1	1	0.11	1.59	NE	3.56	2898	3018	0	6120	6447	18483	10:00	24
05-06 Mar 2012	1	40.53	1	1	1	0.67	1.79	NW, NE	22.56	0	2932	3292	6050	6197	18471	13:00	24
02-03 April 2012	57.24	1	1	1	1	7.00	1.98	SE	23.67	3183	3493	0	5839	0	12515	12:00	24
24-25 April 2012	1	22.36	1	1	1	13.44	3.23	SW, SE	18.78	0	3329	0	6039	6270	15638	11:00	24
10-11 October 2012	1	47.78	1	1	1	9.50	0.78	NE, SE, SW	25.56	0	3119	3350	1464	6581	14514	10:00	24
29-30 October 2012	6.81	1	1	1	1	7.44	1.93	NE, SW	42.38	0	2983	0	6147	0	9130	11:00	24
15-16 November 2012	18.19	1	1	1	1	6.44	1.37	NE	81.56	0	2846	2868	6725	6255	18694	14:00	24
13-14 December 2012	252.64	1	1	1	1	-7.38	1.59	SE	21.19	0	3014	3468	6721	6500	19703	12:00	24
17-18 December 2012	1	21.94	1	1	1	1.63	1.48	NE	93.19	0	3035	3412	6244	6512	19203	11:00	24
27-28 December 2012	66.39	1	1	1	1	3.81	1.70	SW	43.56	0	2860	3575	6820	6513	19768	14:00	24
10-11 January 2013	1	1	58.89	1	1	-0.63	2.35	SE	50.56	3204	3116	0	6386	6489	19195	11:00	24
14-15 January 2013	1	1	1	4.44	1	1.56	3.74	SE	88.25	3331	0	1345	6441	6454	17571	11:00	24
23-24 January 2013	1	1	1	1	21.94	2.06	2.21	SW, SE	31.88	3463	2825	0	6621	6496	19405	10:00	24
31 January - 01 February 2013	1	1	1	1	2	2.06	2.21	SW, SE	31.88	3463	2825	0	6621	6496	19405	10:00	24

1 - No samples collected for analysis at this location on this date.

2 - PM_{10} and $PM_{2.5}$ samples were colleceted at this sampling location on this date. Concentrations sampled on the two filters associated with this location as 69.58 and 52.78 µg/m3. However, due to a transcription error, it is uncertain as to which parameter concentration value pertains to each of the sampled parameters.

Table 8: 24-Hour and 7-Day NO_2 Sampling Results – 2011 through 2013

Sampling Date	Obiliq Health Center	Dardhishte	KEK MW	Germia Park	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temp	Average Wind Speed (m/s)	Predominant Wind Direction	Average Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour NO_2 (µg/m^3)								Meteorological Conditions				Operating Conditions							
27-28 July 2011	5.05	9.80	1	1	1	1	1	1	20.40	0.89	SW	7.00	2846	3026	0	5828	5803	17503	10:30	24
1 -2 September 2011	17.29	20.77	11.99	1	1	1	1	1	20.90	1.25	SW, NW	10.00	3076	2216	0	461	3569	9322	13:00	23.6
8-9 September 2011	19.50	14.33	13.12	1	1	1	1	1	20.10	1.48	NE	12.00	2916	2766	0	0	5639	11321	11:00	24
15-16 September 2011	16.80	15.57	12.08	1	1	1	1	1	22.10	1.52	NW, NE	8.00	1597	2953	3167	5405	0	13122	9:30	24
22-23 September 2011	17.08	15.95	15.73	1	1	1	1	1	14.75	1.97	NW	17.00	0	2844	3130	5371	0	11345	10:30	24
3-4 October 2011	2	2	2	1	1	1	1	1	15.42	1.16	NW, NE	0.00	0	2986	2836	5381	0	11203	11:00	24
17-18 October 2011	2	2	2	1	1	1	1	1												
14-15 November 2011	2	2	2	1	1	1	1	1	-0.25	1.65	NW, NE	15.33	0	3084	3183	5967	0	12234	12:00	24
24-25 November 2011	2	2	2	1	1	1	1	1	2.00	1.79	NE	31.00	2777	2984	3286	0	0	9047	15:30	24
9-10 December 2011	43.34	44.09	38.42	1	1	1	1	1	3.00	2.28	SW, SE	9.00	2919	2974	3100	5582	2226	16801	9:30	24.8
14-15 December 2011	42.86	1	29.30	1	1	1	1	1	4.90	1.92	SW	12.00	2877	2691	0	5910	6025	17503	10:30	23.5
21-22 December 2011	24.47	28.73	29.59	1	1	1	1	1	-2.10	2.24	NW, NE	53.00	0	2762	3202	5925	6490	18379	11:00	24.55
28-29 December 2011	14.38	9.93	15.12	1	1	1	1	1	-2.90	1.25	SE	15.00	3149	0	3173	6371	6505	19198	11:30	24.8

1 - No samples collected for analysis at this location on this date.

2 - NO_2 data were not available during October and November 2011 due to lack of sampling filters.

Sampling Date	Obiliq Health Center	Dardhishte	KEK MW	Germia Park	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temp	Average Wind Speed (m/s)	Predominant Wind Direction	Average Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour NO_2 (µg/m^3)								Meteorological Conditions				Operating Conditions							
05-06 January 2012	1	14.96	18.02	1	1	1	1	1	0.67	3.26	SE	70.78	2813	2166	2941	5974	6049	19943	12:00	24
11-12 January 2012	1	25.83	13.81	1	1	1	1	1	-2.22	1.79	NW	62.78	3038	0	3183	2727	6270	15218	11:00	24
17-18 January 2012	1	28.04	19.29	1	1	1	1	1	-5.22	1.04	NW, SW	47.89	2980	1259	2972	2175	6572	15958	14:00	24
23-24 January 2012	1	37.76	26.34	1	1	1	1	1	-0.56	1.14	NE, SW	50.00	2865	0	2932	6028	6215	18040	10:00	22
31 January - 01 February 2012	1	69.96	48.81	1	1	1	1	1	-11.33	1.59	NE	62.22	2662	3049	3192	0	6473	15376	10:00	21
09-10 February 2012	1	23.81	10.63	1	1	1	1	1	-13.44	1.94	NE	80.44	0	2708	3115	6063	6470	18356	13:00	23
14-15 February 2012	1	40.95	19.86	1	1	1	1	1	-12.89	1.39	NW, NE	42.89	2038	0	2894	6072	6430	17434	11:00	24
22-23 February 2012	1	25.82	14.24	1	1	1	1	1	0.11	1.59	NE	3.56	2898	3018	0	6120	6447	18483	10:00	24
28-29 February 2012	1	19.44	15.65	1	1	1	1	1	-2.44	2.24	SW, NW	59.56	0	2879	0	6150	6399	15428	11:00	23
05-06 March 2012	1	1	11.94	1	1	1	1	1	0.67	1.79	NW, NE	22.56	0	2932	3292	6050	6197	18471	13:00	24
12-13 March 2012	1	11.75	10.06	1	1	1	1	1	0.78	2.93	NW	43.56	3284	0	3416	6103	6316	19119	15:00	23
02-03 April 2012	1	23.73	16.18	1	1	1	1	1	7.00	1.98	SE	23.67	3183	3493	0	5839	0	12515	12:00	24
18-19 April 2012	1	16.78	13.68	1	1	1	1	1	5.56	2.58	NW, SW	54.22	2125	3062	0	6100	6283	17570	9:00	24
24-25 April 2012	1	12.83	1	1	1	1	1	22.27	13.44	3.23	SW, SE	18.78	0	3329	0	6039	6270	15638	11:00	24
03-04 May 2012	18.78	1	12.17	1	1	1	1	1	17.78	1.84	SW	14.89	0	2444	0	5330	6197	13971	11:00	24
07-08 May 2012	1	7.05	1	1	1	1	1	1	14.89	2.68	SW	20.67	0	3111	0	6019	5919	15049	12:00	24
14-15 May 2012	1	6.55	1	1	1	1	1	1	7.11	2.28	NW, NE	100.00	0	2864	0	5953	6158	14975	10:00	24
21-22 May 2012	1	13.06	1	1	1	1	1	1	16.11	2.83	SE	36.56	3428	3039	0	6061	0	12528	10:00	24
28-29 May 2012	1	13.37	1	1	1	1	1	1	12.00	1.64	NW	15.78	3213	0	0	6040	0	9253	8:00	24

1 - No samples collected for analysis at this location on this date.

2 - NO_2 data were not available during October and November 2011 due to lack of sampling filters.

3 - 7-day samples were collected.

4 - Ogawa provided incorrect filters, no sampling data.

Sampling Date	Obiliq Health Center	Dardishte	KEK MW	Germia Park	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temp	Average Wind Speed (m/s)	Predominant Wind Direction	Average Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour NO_2 (µg/m^3)								Meteorological Conditions				Operating Conditions							
27-28 June 2012	1	11.44	20.86	1	1	1	1	1	16.56	2.19	NW, NE	5.56							9:00	24
04-05 July 2012	1	13.70	13.72	1	1	1	1	1	23.67	1.04	SW	6.11	2974	2986	0	0	6613	12573	9:00	24
10-11 July 2012	1	11.17	16.76	1	1	1	1	31.81	25.22	1.39	NW, SW	4.44	2661	2861	0	0	6509	12031	8:00	29
24-25 July 2012	11.42	8.27	7.79	6.45	9.01	13.56	1	1	20.13	1.45	NW, NE	40.63	2839	2846	0	0	5927	11612	10:00	24
30-31 July 2012	10.66	9.13	9.33	9.40	7.39	9.11	1	1	22.00	2.83	NW	22.67	2878	0	3439	0	6601	12918	14:00	24
02-03 August 2012	14.79	11.15	8.34	9.26	12.71	15.09	1	1	22.78	1.14	NW, NE	10.11	0	0	3522	0	6560	10082	11:00	24
07-08 August 2012	14.09	12.41	11.93	9.24	11.02	10.11	1	1	23.63	2.85	NW, NE	5.25	0	0	3424	0	6488	9912	11:00	24
09-10 August 2012	13.22	9.57	8.34	7.63	8.37	14.47	1	1	20.13	2.82	NW, NE	10.50	0	0	3500	0	6632	10132	14:00	24
15-16 August 2012	21.01	1	14.74	18.51	6.08	18.08	17.26	1	20.00	1.06	NE	11.50	0	19	0	0	1856	1875	15:00	24
21-22 August 2012	20.34	1	13.18	11.95	1	21.64	19.97	1	24.94	0.75	SW, SE	0.25	0	3036	3585	0	6372	12993	11:00	24
23-24 August 2012	27.29	21.77	13.80	19.65	7.90	29.46	1	1	27.00	0.70	SW, SE	1.50	0	3280	3511	0	6432	13223	10:00	24
27-28 August 2012	21.39	1	19.40	13.07	1	13.45	15.78	1	15.94	3.07	NW	39.50	0	2619	3562	0	6307	12488	10:00	24
30-31 August 2012	23.45	23.95	19.11	23.95	8.73	21.81	1	1	20.06	1.17	NE	2.75	0	3196	3559	0	6553	13308	10:00	24
05-06 September 2012	19.85	1	9.54	16.87	1	19.48	15.13	1	20.44	1.40	SW	63.19	0	3166	3510	0	6496	13172	10:00	24
10-11 September 2012	16.29	1	12.81	12.90	3	20.97	27.61	1	18.38	1.34	SE	5.38	0	3126	3443	0	6399	12968	11:00	24
13-14 September 2012	13.16	19.17	12.31	9.72	1	12.19	1	1	18.56	2.29	SE	31.00	0	3252	3280	0	6559	13091	10:00	24
18-19 September 2012	19.42	1	9.51	11.25	3	21.04	19.30	1	16.56	1.09	NE, SE	31.63	0	3224	2003	0	6692	11919	11:00	24
24-25 September 2012	20.27	1	14.61	18.24	1	22.28	22.22	1	19.31	2.63	SW	11.56	0	3061	0	0	6456	9517	10:00	24
26-27 September 2012	13.49	13.06	11.06	13.80	1	25.29	1	1	19.81	1.79	SW	7.13	0	3010	0	0	6653	9663	11:00	24

1 - No samples collected for analysis at this location on this date.

2 - NO_2 data were not available during October and November 2011 due to lack of sampling filters.

3 - 7-day samples were collected.

4 - Ogawa provided incorrect filters, no sampling data.

Sampling Date	Obiliq Health Center	Dardhishte	KEK MW	Germia Park	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temp	Average Wind Speed (m/s)	Predominant Wind Direction	Average Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour NO_2 (µg/m^3)								Meteorological Conditions				Operating Conditions							
02-03 October 2012	15.17	1	7.21	17.15	3	11.91	12.56	1	15.13	1.40	SW	7.31	0	3074	3437	0	6665	13176	10:00	24
08-09 October 2012	19.64	11.76	3	14.26	1	16.06	13.34	1	7.25	1.73	NW, NE	12.06	0	3215	3432	0	6720	13367	10:00	24
10-11 October 2012	23.04	1	14.02	13.89	19.41	25.65	25.86	1	9.50	0.78	NE, SE, SW	25.56	0	3119	3350	1464	6581	14514	10:00	24
15-16 October 2012	20.51	17.08	14.93	13.90	1	21.79	29.10	1	15.75	2.96	SW, SE	22.31	0	2964	3446	0	6596	13006	11:00	24
18-19 October 2012	29.98	23.17	18.08	23.15	1	25.59	26.20	1	10.75	0.73	SE	2.44	0	1886	3261	6020	6607	17774	10:00	24
23-24 October 2012	22.07	16.64	3	11.97	1	19.11	13.05	1	8.38	1.40	NW	7.69	0	2788	3353	0	6562	12703	10:00	24
29-30 October 2012	12.69	13.44	21.78	12.43	1	14.27	16.16	1	7.44	1.93	NE, SW	42.38	0	2983	0	6147	0	9130	11:00	24
01-02 November 2012	10.75	10.15	12.43	5.00	1	20.66	12.48	1	9.56	2.40	SW, SE	77.38	0	2172	0	6232	6238	14642	10:00	24
05-06 November 2012	6.96	5.62	2.83	2.01	1	12.66	6.20	1	13.63	2.74	SW	56.56	0	0	3145	6686	6611	16442	11:00	24
07-08 November 2012	24.86	17.66	13.13	4.99	1	23.91	20.43	1	3.94	2.15	NW	20.81	0	0	3435	6725	6524	16684	11:00	24
13-14 November 2012	15.20	10.38	14.46	7.89	1	13.96	11.71	1	9.50	2.51	NW	53.31	0	3066	3182	6628	6150	19026	11:00	24
15-16 November 2012	11.34	12.45	8.92	6.70	1	21.32	9.31	1	6.44	1.37	NE	81.56	0	2846	2868	6725	6255	18694	14:00	24
19-20 November 2012	17.32	15.41	11.54	6.59	1	21.10	16.64	1	7.13	1.73	NE	58.44	0	2690	0	6729	6230	15649	10:00	24
21-22 November 2012	16.09	14.49	13.97	11.92	1	29.56	13.58	1	8.56	1.31	NE	85.06	0	0	192	6851	6486	13529	10:00	24
29-30 November 2012	10.38	12.82	7.86	4.49	1	21.64	12.78	1	6.19	3.38	SW	35.44	0	2880	3220	6824	6182	19106	12:00	24
11-12 December 2012	25.80	14.26	17.67	7.52	1	22.79	24.57	1	-6.56	2.07	NW	56.50	0	3105	3540	6833	6493	19971	11:00	24
13-14 December 2012	52.34	43.73	19.96	11.00	1	46.71	51.51	1	-7.38	1.59	SE	21.19	0	3014	3468	6721	6500	19703	12:00	24
17-18 December 2012	32.63	27.63	15.29	32.73	1	30.44	38.59	1	1.63	1.48	NE	93.19	0	3035	3412	6244	6512	19203	11:00	24
19-20 December 2012	15.44	15.86	4.08	4.21	1	6.00	8.71	1	-1.94	2.71	NW	90.63	0	3071	2756	3875	6487	16189	11:00	24
27-28 December 2012	45.28	39.86	30.91	32.50	1	42.56	48.39	1	3.81	1.70	SW	43.56	0	2860	3575	6820	6513	19768	14:00	24

1 - No samples collected for analysis at this location on this date.

2 - NO_2 data were not available during October and November 2011 due to lack of sampling filters.

3 - 7-day samples were collected.

4 - Ogawa provided incorrect filters, no sampling data.

Sampling Date	Obiliq Health Center	Dardhishte	KEK MW	Germia Park	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temp	Average Wind Speed (m/s)	Predominant Wind Direction	Average Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour NO_2 (µg/m^3)								Meteorological Conditions				Operating Conditions							
03-04 January 2013	20.67	24.09	14.94	17.53	1	19.47	32.47	1	0.81	1.15	NW	27.13	736	3131	3433	6454	6349	20103	11:00	24
08-09 January 2013	29.66	22.37	16.65	14.91	1	27.26	40.07	1	-5.50	1.06	NE, SW	31.63	3280	2872	0	6603	6458	19213	11:00	24
10-11 January 2013	16.70	13.88	7.94	24.14	1	17.8	37.17	1	-0.63	2.35	SE	50.56	3204	3116	0	6386	6489	19195	11:00	24
14-15 January 2013	4	4	4	4	1	4	4	1	1.56	3.74	SE	88.25	3331	0	1345	6441	6454	17571	11:00	24
16-17 January 2013	4	4	4	4	1	4	4	1	3.13	2.60	SW	41.25	3368	28	0	6632	6464	16492	11:00	24
21-22 January 2013	4	4	4	4	1	4	4	1	4.25	2.88	SW	71.13	3245	2764	0	6640	6480	19129	11:00	24
23-24 January 2013	4	4	4	4	1	4	4	1	2.06	2.21	SW, SE	31.88	3463	2825	0	6621	6496	19405	10:00	24
29-30 January 2013	4	4	4	4	1	4	4	1	-0.81	1.06	SW	28.50	0	2936	1899	6641	6366	17842	13:00	24
31 January - 01 February 2013	4	4	4	4	1	4	4	1	-1.31	1.82	SW	24.50	0	3049	3360	6751	6436	19596	11:00	24
04-05 February 2013	57.47	34.45	23.61	31.53	1	39.98	46.10	1	2.25	1.01	SW	10.75	0	3081	3467	5783	6439	18770	10:00	24
07-08 February 2013	30.45	19.86	15.01	13.61	1	17.09	35.99	1	1.25	3.46	NW	84.56	3296	0	3388	6706	6662	20052	11:00	24
11-12 February 2013	15.48	17.23	12.91	9.54	1	16.12	28.43	1	0.44	2.37	SW	33.75	3204	0	3099	6706	6694	19703	11:00	24
14-15 February 2013	7.67	5.39	3.64	2.06	1	6.74	5.32	1	2.38	2.51	NW	92.13	3230	0	3429	6755	6671	20085	13:00	24

1 - No samples collected for analysis at this location on this date.

2 - NO_2 data were not available during October and November 2011 due to lack of sampling filters.

3 - 7-day samples were collected.

4 - Ogawa provided incorrect filters, no sampling data.

Sampling Date	7-Day NO_2 ($\mu g/m^3$)		Meteorological Conditions				Operating Conditions							
	KEK MW	Shkabaj	Average Temp	Average Wind Speed (m/s)	Predominant Wind Direction	Average Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
11-18 September 2012	1	5.55	17.12	4.25	SE	34.33	0	3065	3359	0	6573	12997	11:00	168
18-26 September 2012	1	-0.93	15.18	3.96	SW, SE, NW	19.89	0	3205	306	0	6632	10143	11:00	168
02-09 October 2012	1	10.83	15.09	3.80	NW, SW	12.88	0	3118	3512	0	6703	13333	10:00	168
09-16 October 2012	10.17	1	13.43	3.91	SE	34.34	0	3038	3398	1189	6235	13860	10:00	168
23-30 October 2012	9.72	1	11.50	4.84	SE, SW	27.98	0	3007	2467	5249	1265	11988	10:00	168
06-13 November 2012	11.21	1	6.17	4.06	NW, SE	21.38	0	985	3466	6705	4190	15346	11:00	168

1 - No sample collected on this date.

Table 9: 24-Hour, 7 and 14-Day SO_2 Sampling Results – 2011 through 2013

Sampling Date	Obiliq Health Center	Dardhishte	KEK MW	Gemia	Shkabaj	KEK A	US Ambassador's Residence	HMI	Average Temperature	Average Wind Speed (m/s)	Predominant Wind Direction	Average Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
	24-Hour SO_2 ($\mu g/m^3$)								Meteorological Conditions				Operating Conditions							
27-28 July 2011	2.65	2.30	1	1	1	1	1	1	20.40	0.89	SW	7.00	2846	3026	0	5828	5803	17503	10:30	24
1 -2 Septemberr 2011	-2.06	3.34	2.74	1	1	1	1	1	20.90	1.25	SW, NW	10.00	3076	2216	0	461	3569	9322	13:00	23.6
8-9 Septemberr 2011	20.32	18.34	20.82	1	1	1	1	1	20.10	1.48	NE	12.00	2916	2766	0	0	5639	11321	11:00	24
15-16 Septemberr 2011	14.52	14.93	17.65	1	1	1	1	1	22.10	1.52	NW, NE	8.00	1597	2953	3167	5405	0	13122	9:30	24
22-23 Septemberr 2011	15.48	18.57	14.32	1	1	1	1	1	14.75	1.97	NW	17.00	0	2844	3130	5371	0	11345	10:30	24
3-4 October 2011	2	2	2	1	1	1	1	1	15.42	1.16	NW, NE	0.00	0	2986	2836	5381	0	11203	11:00	24
17-18 October 2011	2	2	2	1	1	1	1	1												
14-15 November 2011	2	2	2	1	1	1	1	1	-0.25	1.65	NW, NE	15.33	0	3084	3183	5967	0	12234	12:00	24
24-25 November 2011	2	2	2	1	1	1	1	1	2.00	1.79	NE	31.00	2777	2984	3286	0	0	9047	15:30	24
9-10 December 11	18.02	15.18	14.48	1	1	1	1	1	3.00	2.28	SW, SE	9.00	2919	2974	3100	5582	2226	16801	9:30	24.8
14-15 December 2011	13.06	17.60	8.46	1	1	1	1	1	4.90	1.92	SW	12.00	2877	2691	0	5910	6025	17503	10:30	23.5
21-22 December 2011	-1.13	38.88	8.46	1	1	1	1	1	-2.10	2.24	NW, NE	53.00	0	2762	3202	5925	6490	18379	11:00	24.55
28-29 December 2011	25.22	43.39	30.21	1	1	1	1	1	-2.90	1.25	SE	15.00	3149	0	3173	6371	6505	19198	11:30	24.8

1 - No samples collected for analysis at this location on this date.

2 - SO_2 data were not available during October and November 2011 due to lack of sampling filters.

Sampling Date	Obiliq	Dardhishte	KEK MW	HMI	Average Temperature	Average Wind Speed (m/s)	Predominant Wind Direction	Average Percent Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Averge Sampling Event Duration
	24-Hour SO_2 (µg/m^3)				Meteorological Conditions				Operating Conditions							
05-06 January 2012	1	37.23	104.44	1	0.67	3.26	SE	70.78	2813	2166	2941	5974	6049	19943	12:00	24
11-12 January 2012	1	7.11	2.09	1	-2.22	1.79	NW	62.78	3038	0	3183	2727	6270	15218	11:00	24
17-18 January 2012	1	-11.09	-5.77	1	-5.22	1.04	NW, SW	47.89	2980	1259*	2972	2175	6572	14699	14:00	24
23-24 January 2012	1	-10.22	-10.95	1	-0.56	1.14	NE, SW	50.00	2865	0	2932	6028	6215	18040	10:00	22
31 January - 01 Feb 2012	1	2.37	-3.83	1	-11.33	1.59	NE	62.22	2662	3049	3192	0	6473	15376	10:00	21
09-10 February 2012	1	-6.32	-7.24	1	-13.44	1.94	NE	80.44	0	2708	3115	6063	6470	18356	13:00	23
14-15 February 2012	1	-4.70	-2.62	1	-12.89	1.39	NW, NE	42.89	2038	0	2894	6072	6430	17434	11:00	24
22-23 February 2012	1	-2.55	-4.65	1	0.11	1.59	NE	3.56	2898	3018	0	6120	6447	18483	10:00	24
28-29 February 2012	1	-6.13	-8.22	1	-2.44	2.24	SW, NW	59.56	0	2879	0	6150	6399	15428	11:00	23
05-06 March 2012	1	1	-9.11	1	0.67	1.79	NW, NE	22.56	0	2932	3292	6050	6197	18471	13:00	24
12-13 March 2012	1	-7.63	-7.74	1	0.78	2.93	NW	43.56	3284	0	3416	6103	6316	19119	15:00	23
02-03 April 2012	1	-9.26	-6.24	1	7.00	1.98	SE	23.67	3183	3493	0	5839	0	12515	12:00	24
18-19 April 2012	1	-3.01	-6.85	1	5.56	2.58	NW, SW	54.22	2125	3062	0	6100	6283	17570	9:00	24
24-25 April 2012	1	-7.52	-7.87	-5.85	13.44	3.23	SW, SE	18.78	0	3329	0	6039	6270	15638	11:00	24
03-04 May 2012	-0.94	1	-21.46	1	17.78	1.84	SW	14.89	0	2444	0	5330	6197	13971	11:00	24
07-08 May 2012	1	-2.60	1	1	14.89	2.68	SW	20.67	0	3111	0	6019	5919	15049	12:00	24
14-15 May 2012	1	-7.01	1	1	7.11	2.28	NW, NE	100.00	0	2864	0	5953	6158	14975	10:00	24
21-22 May 2012	1	-6.66	1	1	16.11	2.83	SE	36.56	3428	3039	0	6061	0	12528	10:00	24
28-29 May 2012	1	-6.22	1	1	12.00	1.64	NW	15.78	3213	0	0	6040	0	9253	8:00	24

1 - No samples collected for analysis at this location on this date.

Sampling Date	KEK MW	Germia Park	Shkabaj	KEK A	Average Temperature	Average Wind Speed (m/s)	Predominant Wind Direction	Average Percent Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Avg Sample Start Time	Average Sampling Event Duration
	24-Hour SO_2 (µg/m^3)				Meteorological Conditions				Operating Conditions							
15-16 August 2012	1	1	7.59	1	20.00	1.06	NE	11.50	0	19	0	0	1856	1875	15:00	24
23-24 August 2012	1	1	6.96	1	27.00	0.70	SW, SE	1.50	0	3280	3511	0	6432	13223	10:00	24
30-31 August 2012	1	1	7.39	1	20.06	1.17	NE	2.75	0	3196	3559	0	6553	13308	10:00	24
10-11 October 2012	4.14	1	1	1	9.50	0.78	NE, SE, SW	25.56	0	3119	3350	1464	6581	14514	10:00	24

1 - No samples collected for analysis at this location on this date.

Sampling Date	KEK MW	Germia Park	Shkabaj	KEK A	Average Temperature	Average Wind Speed (m/s)	Predominant Wind Direction	Average Percent Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MWh	Average Sample Start Time	Average Sampling Event Duration
Sampling Date	**7-day SO_2 (µg/m^3)**				**Meteorological Conditions**				**Operating Conditions**							
10-17 September 2012	1	1	-0.38	1	17.12	4.25	SE	34.33	0	3065	3359	0	6573	12997	11:00	168
19-26 September 2012	1	1	0.30	1	15.18	3.96	SW, SE, NW	19.89	0	3205	306	0	6632	10143	11:00	168
02-09 October 2012	1	1	0.37	1	15.09	3.8	NW, SW	12.88	0	3118	3512	0	6703	13333	10:00	168
23-30 October 2012	0.43	1	1	1	11.5	4.84	SE, SW	27.98	0	3007	2467	5249	1265	11988	10:00	168
05-12 November 2012	0.44	1	1	1	6.17	4.06	NW, SE	21.38	0	985	3466	6705	4190	15346	11:00	168
15-22 November 2012	0.88	0.49	1	0.08	6.93	3.42	NE	53.7	0	2069	1355	6746	6350	16520	14:00	168
13-20 Dec 2012	0.30	0.37	1	0.63	-1.47	4.84	SE	72.58	0	3022	3163	4824	6500	17509	11:00	168
20-27 December 2012	2.74	0.53	1	0.52	-0.39	3.75	SE, SW	30.93	0	3142	3350	6684	6508	19684	11:00	168
3-10 January 2013	1	1.03	1	0.67	-0.96	4.07	NW	44.98	2894	2930	783	6559	6461	19627	10:00	168
14-21 January 2013	1	0.34	1	0.47	2.44	5.89	SE	65.19	3370	1610	192	6605	3769	15546	10:00	168
22-29 January 2013	1	-0.08	1	0.59	-0.18	4.81	SE, NW	53.46	3284	2917	200	6593	6432	19426	10:00	168
31 January - 07 February 2013	1	2	1	2	1.9	5.17	SE	39.08	168	2949	3400	5130	6422	18069	14:00	168
02-07 February 2013	1	0.06	1	0.04	1.14	4.68	SE, NW	67.29	3241	0	3247	6654	6668	19810	12:00	168
Sampling Date	**14-day SO_2 (µg/m^3)**				**Meteorological Conditions**				**Operating Conditions**							
15-29 November 2012	1.07	0.44	1	0.38	6.73	3.84	SE	41.42	0	1894	2124	6070	5939	16027	14:00	336
13-27 December 2012	1.74	1.89	1	1.23	-0.94	4.30	SW, SE	51.94	0	3082	3256	5754	6504	18596	12:00	336

1 - No samples collected for analysis at this location on this date

2. Sample collected but could not be analyzed due to labeling issues.

Table 10: 24-Hour and 7-Day NH_3 Sampling Results – 2013

Sampling Date	Germia Park	KEK A	Average Temp	Average Wind Speed (m/s)	Predominant Wind Direction	Average Cloud Cover	A3 MW	A4 MW	A5 MW	B1 MW	B2 MW	Total MW	Average Sample Start Time	Average Sampling Event Duration
Sampling Date	**24-Hour NH_3 (µg/m^3)**		**Meteorological Conditions**				**Operating Conditions**							
03-04 January 2013	48.80	39.30	0.81	1.15	NW	27.13	736	3131	3433	6454	6349	20103	11:00	24
08-09 January 2013	27.60	44.60	-5.50	1.06	NE, SW	31.63	3280	2872	0	6603	6458	19213	11:00	24
10-11 January 2013	9.10	30.5	-0.63	2.35	SE	50.56	3204	3116	0	6386	6489	19195	11:00	24
14-15 January 2013	31.4	39.6	1.56	3.74	SE	88.25	3331	0	1345	6441	6454	17571	11:00	24
16-17 January 2013	22	13.2	3.13	2.60	SW	41.25	3368	28	0	6632	6464	16492	11:00	24
21-22 January 2013	42.6	45.6	4.25	2.88	SW	71.13	3245	2764	0	6640	6480	19129	11:00	24
23-24 January 2013	18	40.1	2.06	2.21	SW, SE	31.88	3463	2825	0	6621	6496	19405	10:00	24
29-30 January 2013	0.6	7.4	-0.81	1.06	SW	28.50	0	2936	1899	6641	6366	17842	13:00	24
31 January - 01 February 2013	1	14	-1.31	1.82	SW	24.50	0	3049	3360	6751	6436	19596	11:00	24
Sampling Date	**7-Day NH_3 (µg/m^3)**		**Meteorological Conditions**				**Operating Conditions**							
03-10 January 2013	1.20	5.00	-0.96	4.07	NW	44.98	2894	2930	783	6559	6461	**19627**	10:00	336
14-21 January 2013	5.3	8.4	2.44	5.89	SE	65.19	3370	1610	192	6605	3769	**15546**	10:00	336
22-29 January 2013	0.8	3.1	-0.18	4.81	SE, NW	53.46	3284	2917	200	6593	6432	**19426**	10:00	336
31 January - 07 February 2013	1	6.5	1.90	5.17	SE	39.08	168	2949	3400	5130	6422	**18069**	10:00	336

1- No samples collected for analysis at this location on this day.
The January data have been adjusted for blanks.
During February the blanks registered high concentrations of NH_3. Thus the data were not meaningful to include in the table.

3.3 Overall Observations

3.3.1 Similarities in Modeling and Sampling Data

In general, the dispersion modeling estimates and ambient air quality sampling data were similar. This similarity was observed in the highest[27] 24-hour concentrations modeled for the PM_{10}, $PM_{2.5}$, SO_2, and NO_2 based on 2011 meteorological and operating data, and the highest 24-hour concentrations measured at the sampling sites during the period 2011 through 2012.

In addition, the sampling data and dispersion modeling results were generally reflective of the concentration levels previously measured and reported by professionals within Kosovo using fixed monitoring equipment and employing EU standard methods. The published report includes sampling data from the HMI facility in Prishtina, Kosovo.[28]

Although background data on ambient air quality were not readily available for use and evaluation in this project, the similarity in the dispersion modeling and sampling results provide a basis for suggesting the data generated through this initial assessment are representative of conditions in and around the power plants in Kosovo.

This similarity is illustrated in Table 11, which compares the 2011 AERMOD modeling data relative to 2011-2012 sampling data from mobile equipment and 2009 sampling data from fixed equipment deployed in Prishtina, Kosovo. “NA” refers to no sampling or modeling data available.

[27] Highest refers to maximum concentration modeled or sampled.

[28] *Quality of Air in Urban and Suburban Area of Prishtina and Meteorological Impact Conditions in Distribution of Pollution;* BALWOIS 2010 – Ohrid, Republic of Macedonia – 25, 29 May 2010.These standards included European Normalization (EN) 14212: 2005 for SO_2, EN 14211: 2005 for NO_2, EN 12341:1999 for PM_{10}, and EN 14907:2005 for $PM_{2.5}$.

Table 11: Comparison of 24-Hour Modeling and Sampling Data

Highest 24-hour Dispersion Modeling Estimates[29]		Highest 24-hour Sampling Results Using Mobile Equipment[30]		Maximum 24-hour Sampling Results Using Fixed Equipment[31]	
2011 PM_{10} Concentration Scenario 1	161.68 $\mu g/m^3$	2011 PM_{10} Concentration	162.21 $\mu g/m^3$	2009 PM_{10} Concentration	164.6 $\mu g/m^3$
2012 NA		2012 PM_{10} Concentration	272.73[32] $\mu g/m^3$	2012 NA	
2011 PM_{10} Concentration Scenario 2	80.88 $\mu g/m^3$	NA		NA	
2011 $PM_{2.5}$ Concentration Scenario 1	75.45 $\mu g/m^3$	2012 $PM_{2.5}$ Concentration	252.64 $\mu g/m^3$	2009 $PM_{2.5}$ Concentration	148.7 $\mu g/m^3$
2011 SO_2 Concentration	87.62 $\mu g/m^3$	2011 SO_2 Concentration	43.39 $\mu g/m^3$	2009 SO_2 Concentration	23 $\mu g/m^3$
2011 NO_2 Concentration	37.81 $\mu g/m^3$	2011 NO_2 Concentration	44.09 $\mu g/m^3$	2009 NO_2 Concentration	62.4 $\mu g/m^3$

3.3.2 Plume Dispersion Patterns and Ambient Air Quality Impacts

The dispersion modeling data indicated that the highest 24-hour pollutant concentration levels in the ambient air are within 5-10 km of the power plants, following the orientation of the valley, and in the high terrain elevations of the nearby mountains. The plume dispersion pattern reflects meteorological conditions within valleys, the relative lack of plume buoyancy reducing the mixing of the pollutants with upper wind patterns, and potential impacts from boiler building downwash (conditions that force the plume to the ground).

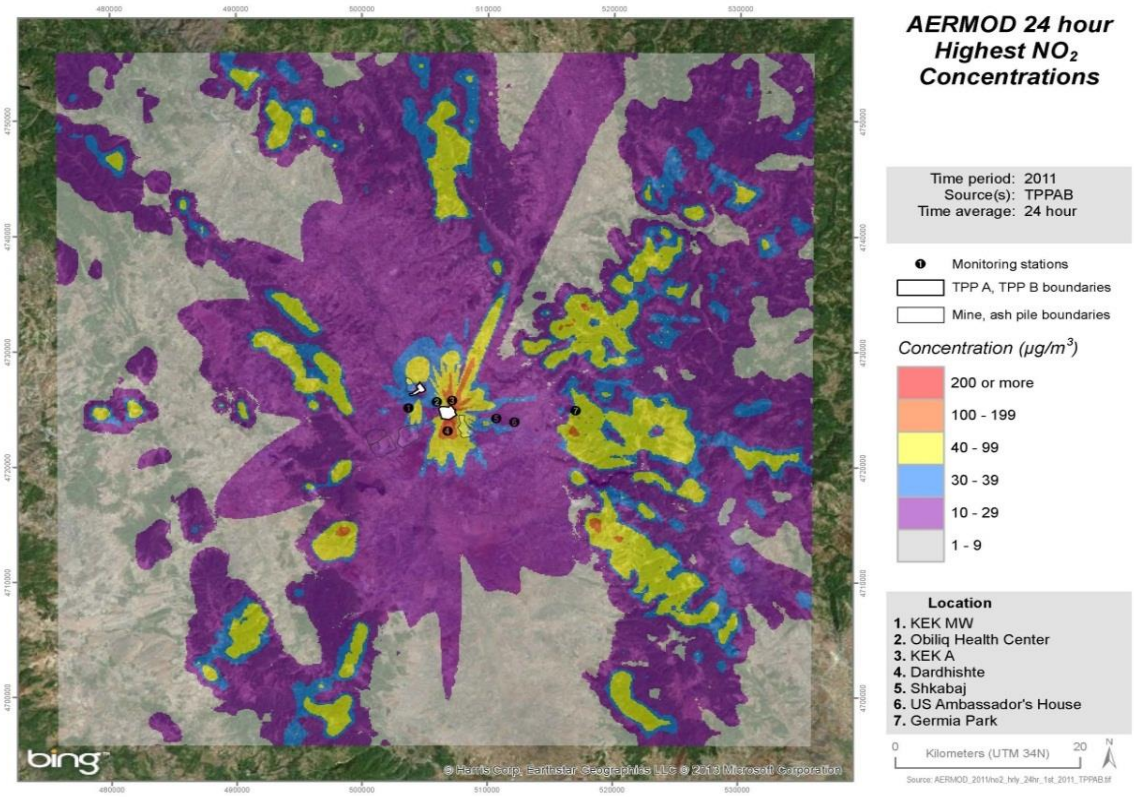
[29] The data represent the highest 24-hour concentrations modeled by AERMOD at KEK MW, Dardhishte, or Obiliq Health Center for 2011 sampling events.
[30] The 2011 data represent the highest 24-hour concentration measured at KEK MW, Obiliq Health Center, or Dardhishte. The 2012 data reflect the highest 24-hour concentration measured at KEK MW, Obiliq Health Center, Dardhishte, KEK A, US Ambassador's Residence, Shkabaj, or Germia Park.
[31] Ambient air concentrations measured during January, February, March, September, October, November, and December 2009 using fixed equipment in HMI Prishtina, Kosovo. See *Quality of Air in Urban and Suburban Areas of Prishtina and Meteorological Impact Conditions in Distribution of Pollution;* BALWOIS 2010 – Ohrid, Republic of Macedonia – 25, 29 May 2010.
[32] No higher concentration was measured in 2013.

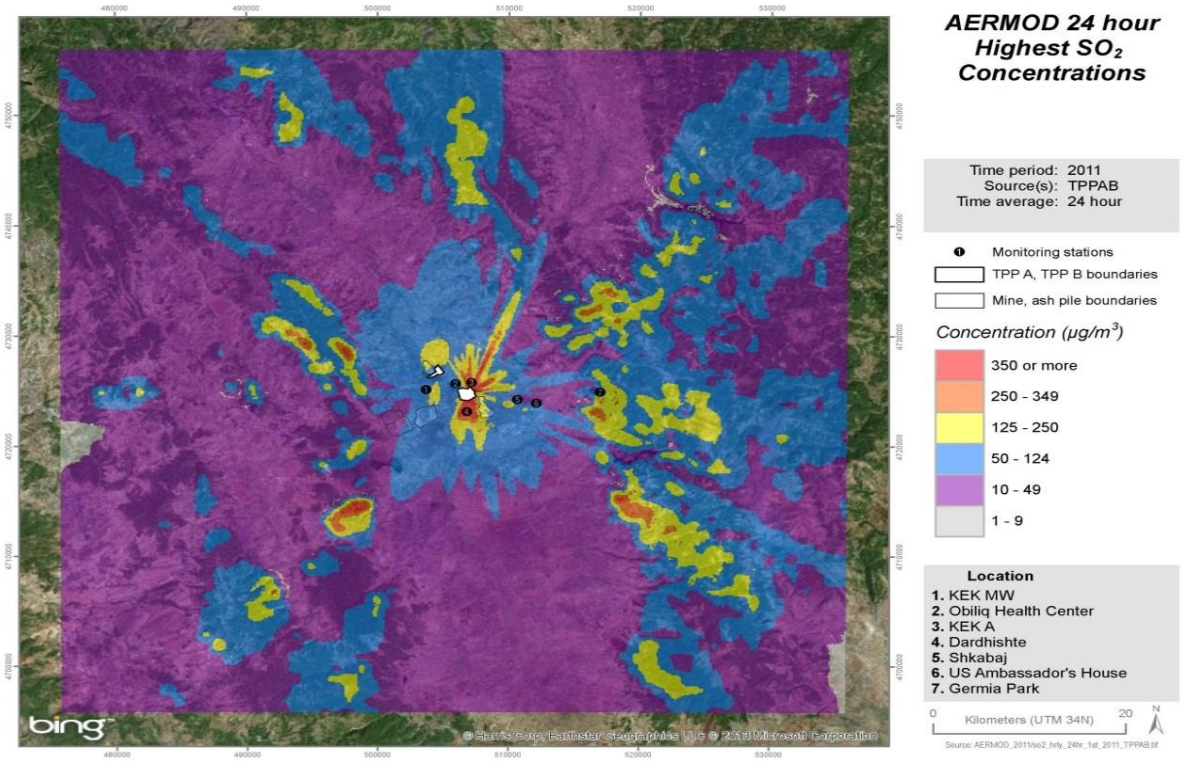
Figure 10 illustrates the emission plume dispersion patterns within close proximity to the power plants:

- The first plot depicts the highest modeled 24-hour concentrations of NO_2 associated with emissions from Kosovo TPP A and TPP B (referred on the plot as source - TPPAB) for 2011.
- The second plot depicts the highest modeled 24-hour concentrations of SO_2 associated with emissions from Kosovo TPP A and TPP B (referred to as TPPAB) for 2011.
- The third plot depicts the highest modeled 24-hour concentrations of PM_{10} associated with emissions from Kosovo TPP A and TPP B and fugitive emissions from the conveyor drop at the ash pile and the ash pile (referred to as TPPAB & FUG) for 2011.

Areas shaded in yellow, orange, and red indicate higher pollutant concentrations. The areas shaded in purple and blue represent lower concentrations of pollutants. The power plants are shaded as white.

Figure 10: Plume Dispersion Patterns




AERMOD 24 hour
Highest SO_2
Concentrations
Time period: 2011
Source(s): TPPAB
Time average: 24 hour
Monitoring stations
TPP A, TPP B boundaries
Mine, ash pile boundaries
Concentration (μg/m³)
350 or more
250 - 349
125 - 250
50 - 124
10 - 49
1 - 9
Location
1. KEK MW
2. Obiliq Health Center
3. KEK A
4. Dardhishte
5. Shkabaj
6. US Ambassador's House
7. Germia Park
0
Kilometers (UTM 34N)
20
N
bing
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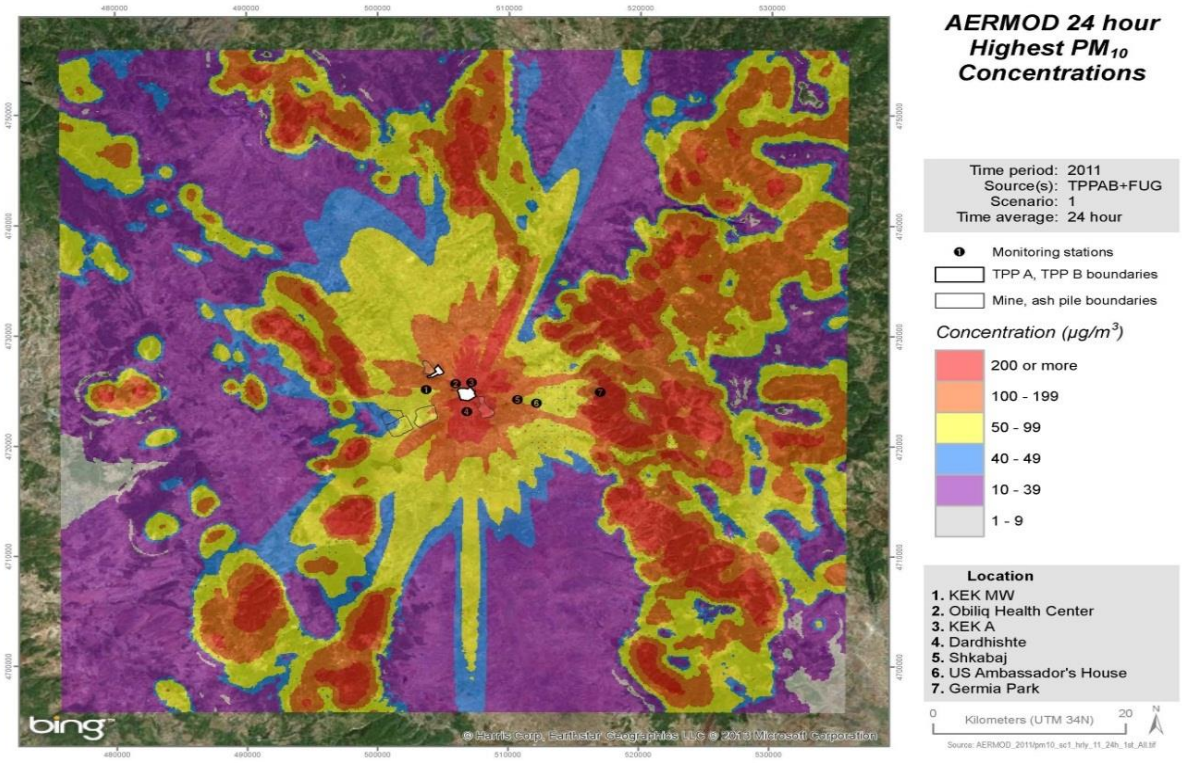
AERMOD 24 hour
Highest PM_{10}
Concentrations
Time period: 2011
Source(s): TPPAB+FUG
Scenario: 1
Time average: 24 hour
Monitoring stations
TPP A, TPP B boundaries
Mine, ash pile boundaries
Concentration (μg/m³)
200 or more
100 - 199
50 - 99
40 - 49
10 - 39
1 - 9
Location
1. KEK MW
2. Obiliq Health Center
3. KEK A
4. Dardhishte
5. Shkabaj
6. US Ambassador's House
7. Germia Park
0
Kilometers (UTM 34N)
20
N
bing
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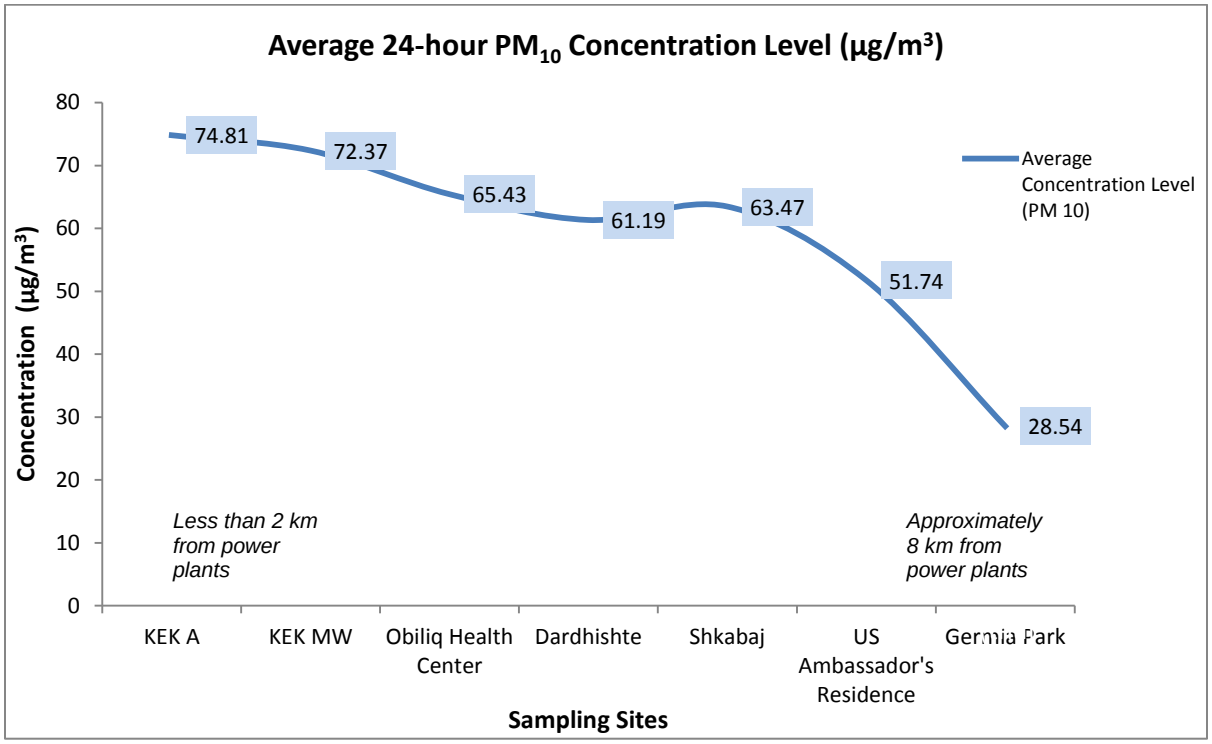
Similar observations were identified in the 2011-2013 sampling data. For example, the average 24-hour PM_{10} pollutant concentrations measured in the ambient air decrease as the distance from the power plants increases. See Figure 11 for the average PM_{10} concentrations measured during 2011-2012 at the sampling locations.

Figure 11: Average 24-Hour PM_{10} Concentrations[33]



In addition, Figure 12 contains the results of simple regression analyses examining the relationship between the proximity of a sampling location to the average pollutant concentration measured in the ambient air.

- The strength of the correlation is related to the R-squared value, with 1.0 representing a perfect correlation between concentration and distance to the power plants. In other words, the higher the R-squared value, the greater the correlation that exists in predicting the concentration at a sampling location as a function of distance from the power plants.
- To determine the distance of a sampling location from the power plants, the distances from the given sampling location to Kosovo TPP A and Kosovo TPP B were averaged.

The first linear regression graph in Figure 12 depicts a strong correlation between PM_{10} concentratrions and proximity to the power plants. With an R-squared value of .89, the graph

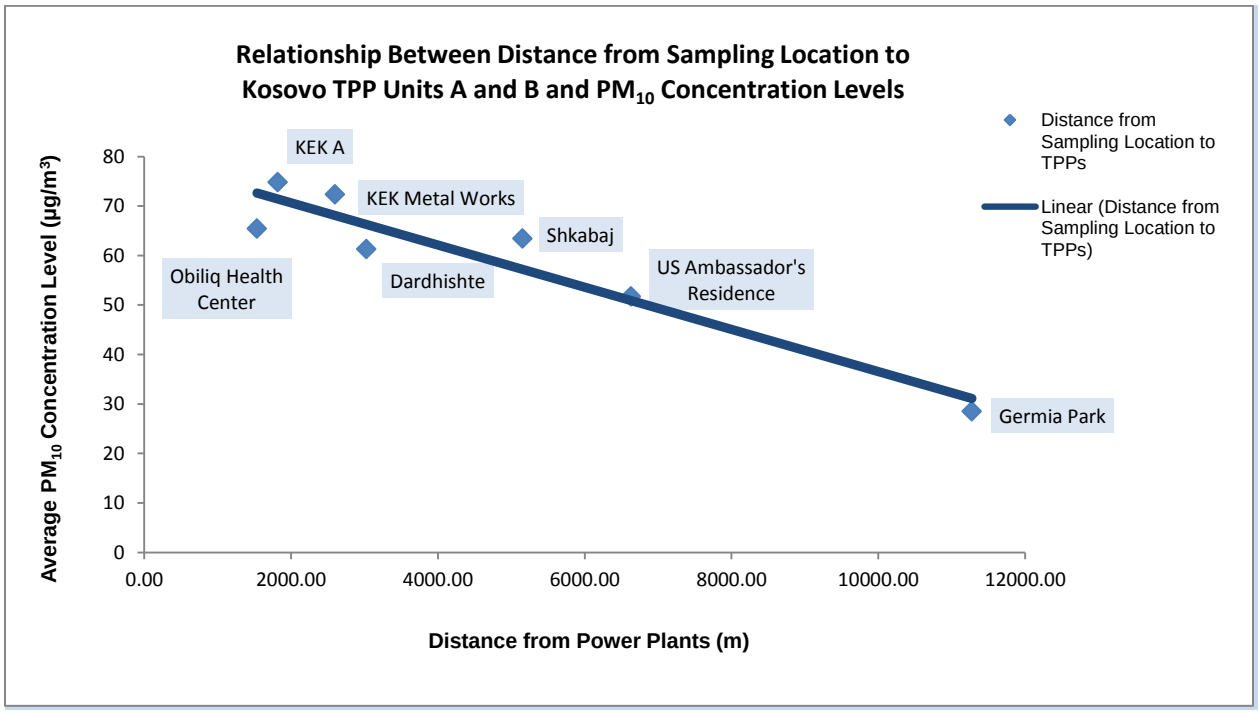
[33] 2011 data were obtained from the KEK MW, Obiliq Health Center, and Dardhishte sampling locations, and 2012 data from these three sites and KEK A, Shkabaj, US Ambassador's Residence, and Germia Park.

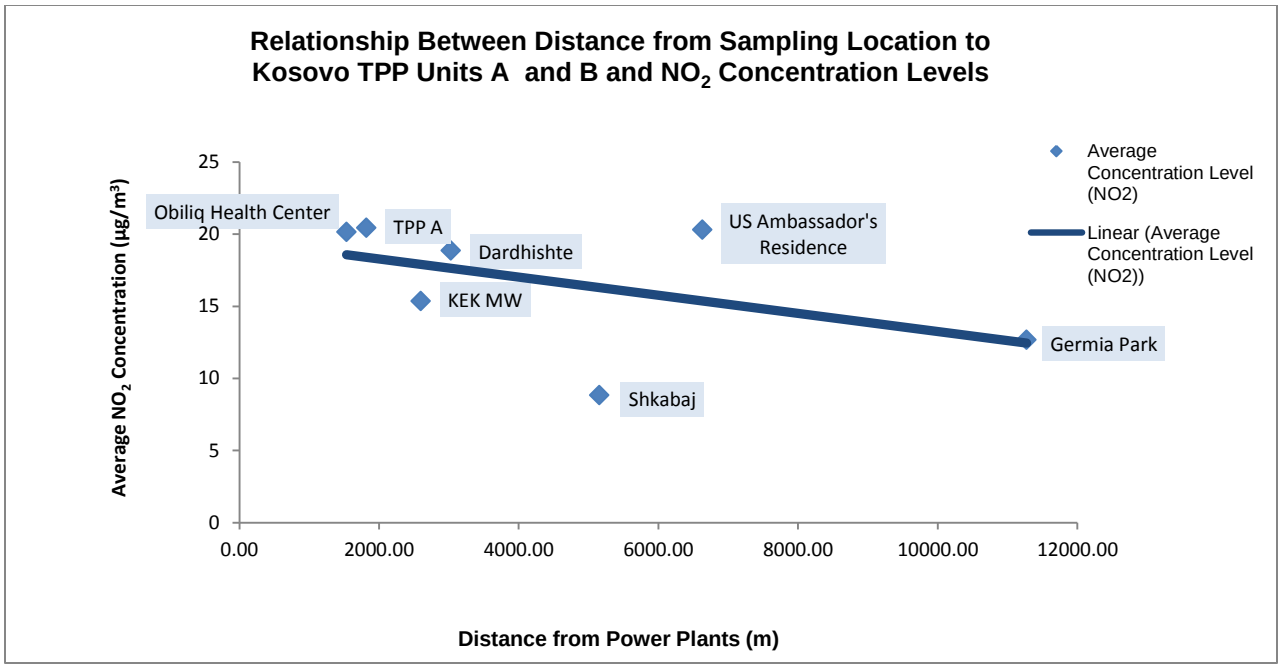
shows that the PM_{10} concentrations measured in the ambient air are closely linked to the distance from the power plants.

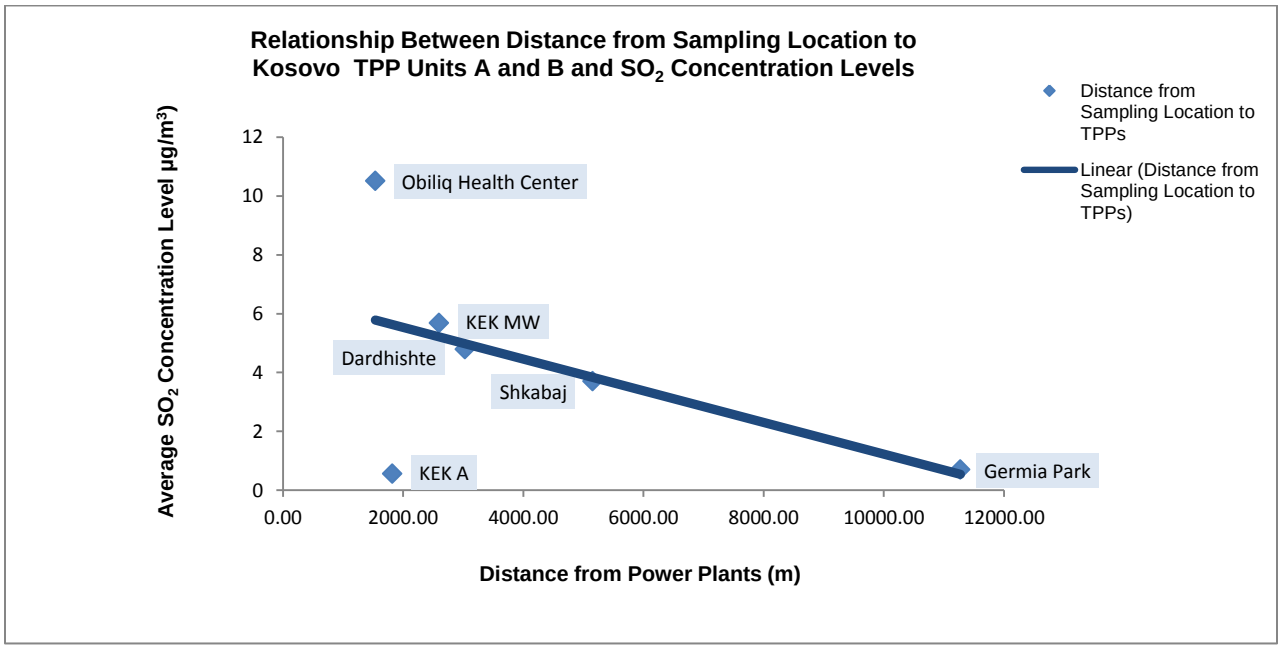
The NO_2 concentrations measured in the ambient air show less of a relationship relative to the distance from the power plants. The R-squared value was .23. The NO_2 concentrations measured at the US Ambassador's Residence were notably higher, and the concentrations measured at Shkabaj notably lower, than would be predicted by the linear regression model.

The SO_2 concentrations measured in the ambient air showed a slightly higher correlation relative to NO_2. The R-squared value was .28. However, deviations from expected concentration levels were observed at Obiliq Health Center and KEK A.

Figure 12: Sampling Data Correlations with Distance from Power Plants







3.3.3 Meteorological Influences and Sampling Results

The average pollutant concentration levels measured at KEK A, KEK MW, Dardhishte, and the Obiliq Health Center varied somewhat over the same 24-hour period of time. In other words, the pollutant concentration levels differed in that some were higher than others even though the sampling locations are generally the same distance from the power plants.

Although these differences might be related to equipment sampling variability, the differences in the concentration levels measured at the sampling locations, in part, reflect the effects of wind

direction and low wind speed. That is, the dispersion often reflects the predominant wind direction, orientation of the valley, and calm wind conditions such that some areas receive more of an impact than others on any given day.

These directional effects were observed to the north, east, west, and south of the power plants during 2011 as illustrated in Figure 13. This figure represents SCIPUFF/SCICHEM modeled PM_{10} concentrations in the ambient air for several 24-hour sampling events in 2011. For PM_{10}, "source TPPAB & FUG" refers to emissions modeled from Kosovo TPP A, TPP B, and fugitive emissions from the conveyor drop and ash pile. Similar dispersion patterns were observed with the other pollutants using SCIPUFF/SCICHEM and with AERMOD.

The first plot in Figure 13 represents plume dispersion during the 27-28 July 2011 sampling event, the second plot 22-23 September 2011, and the third plot 28-29 December 2011. The winds were blowing towards the northeast during the July sampling event (i.e., the winds predominately[34] originated out of the southwest), towards the southeast during the September sampling event (i.e., the winds predominately originated from the northwest), and towards the northwest during the December sampling event (i.e., the winds predominately originated from the southeast).

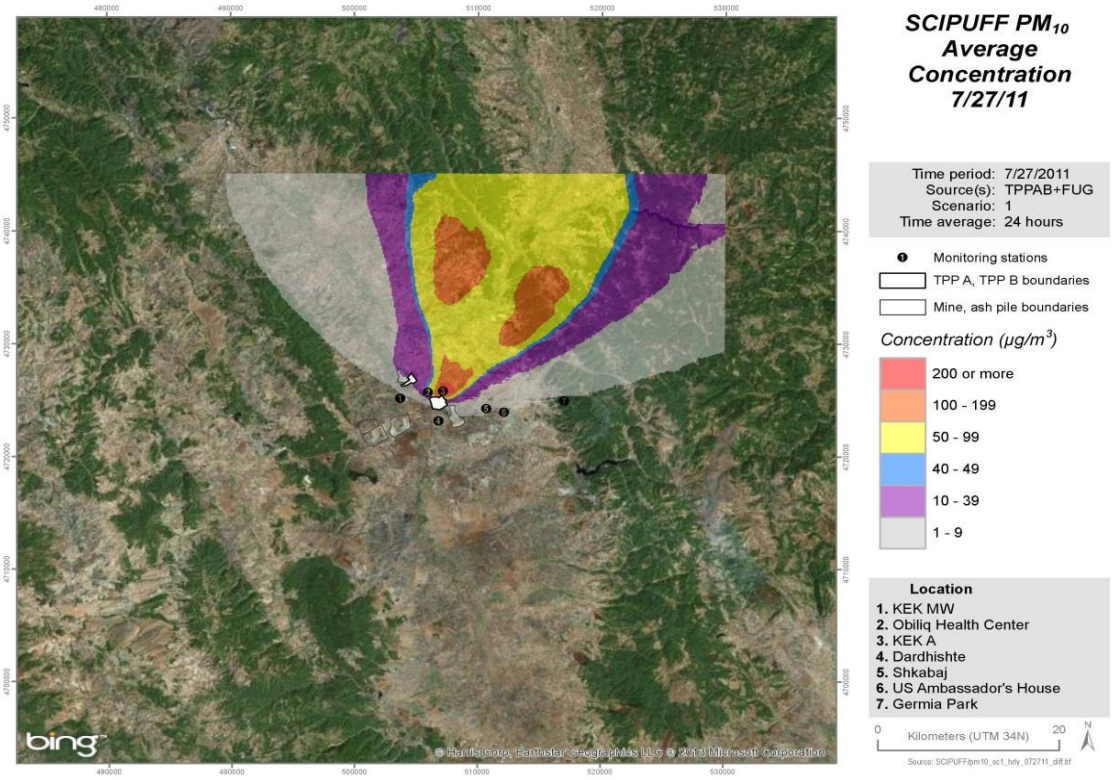
In each instance, KEK MW, Obiliq and Dardhishte were not in the direct path of plume dispersion as noted in Table 12, which contains the PM_{10} sampling results for these three sampling events. In addition, Table 12 provides information on the wind direction (predominate originating direction of the wind) as well as wind speed for each of the sampling events. Additional information about wind direction can be found in Section 3.7.3.

Table 12: Predominant Wind Direction, Wind Speed and PM_{10} Concentrations Measured During Selected 2011 Sampling Events

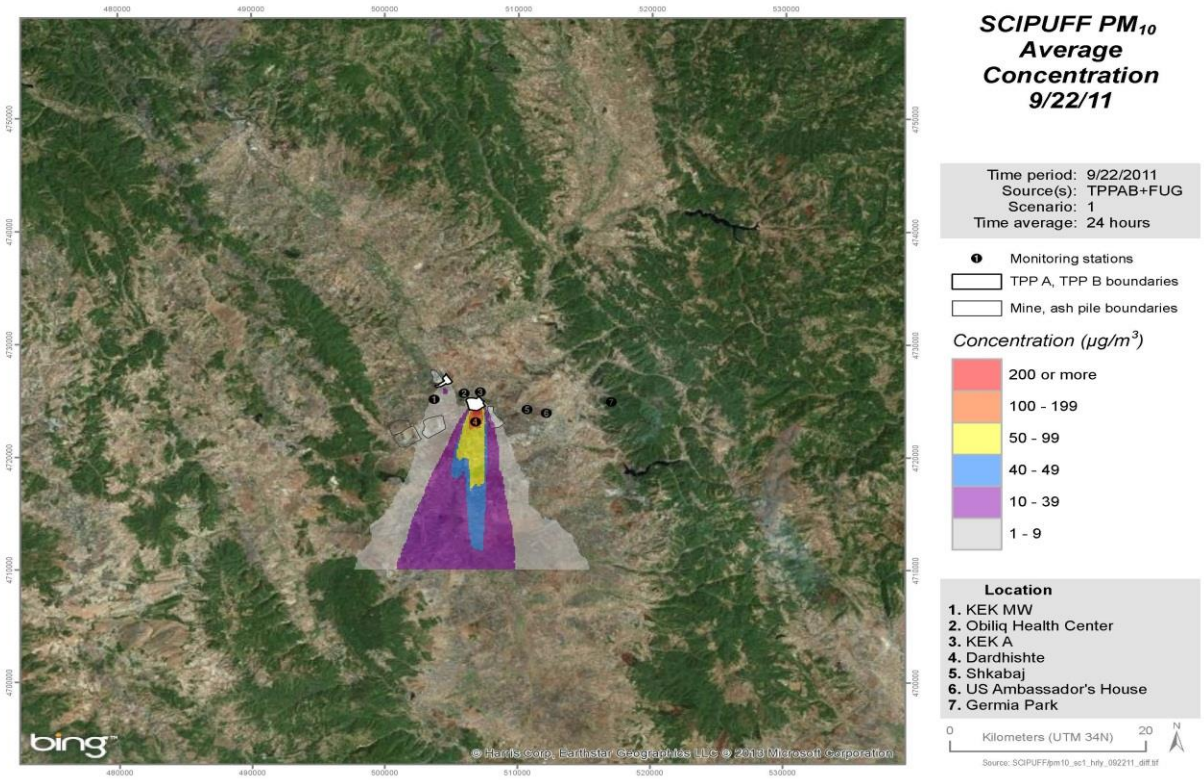
Date	27-28 July 2011		22-23 September 2011		28-29 December 2011	
Meteorological Data/ Sampling Location	Predominate Originating Wind Direction	Wind Speed m/s	Predominant Originating Wind Direction	Wind Speed m/s	Predominant Originating Wind Direction	Wind Speed m/s
	SW	.89	NW	1.14	SE	1.21
Obiliq Health Center	34.17 µg/m^3		56.39 µg/m^3		NA	
Dardhishte	44.03 µg/m^3		30.69 µg/m^3		NA	
KEK MW	NA		49.59 µg/m^3		59.30 µg/m^3	

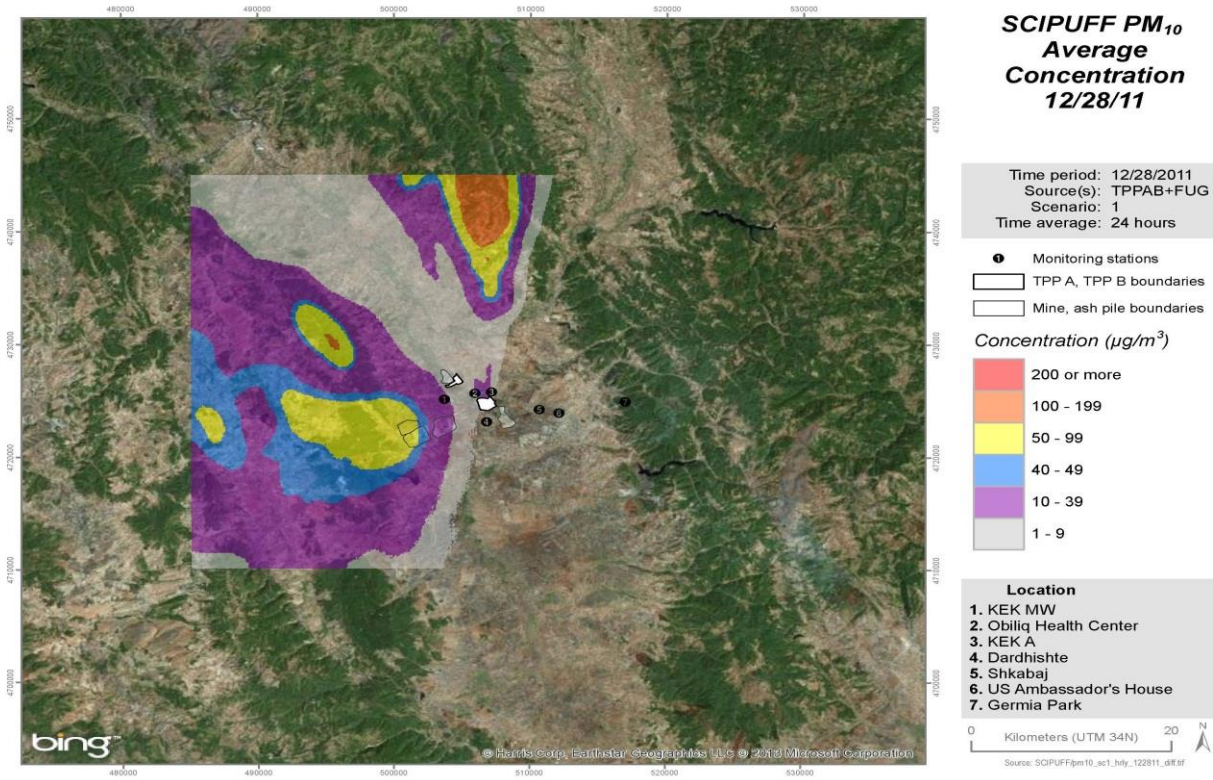
[34] Predominate refers to more than 50% of the time.

Figure 13: Effect of Wind Direction on Plume Dispersion During Selected Sampling Events[35]



[35] SCIPUFF/SCICHEM calculated the average pollutant concentration and plume dispersion in areas near the power plants over a 24-hour period of time for 2011 sampling events. For PM_{10} source refers to emissions modeled from Kosovo TPP A, TPP B, and fugitives from the conveyor drop and ash pile.


SCIPUFF PM10
Average
Concentration
9/22/11
Time period: 9/22/2011
Source(s): TPPAB+FUG
Scenario: 1
Time average: 24 hours
Monitoring stations
TPP A, TPP B boundaries
Mine, ash pile boundaries
Concentration (μg/m3)
200 or more
100 - 199
50 - 99
40 - 49
10 - 39
1 - 9
Location
1. KEK MW
2. Obiliq Health Center
3. KEK A
4. Dardhishte
5. Shkabaj
6. US Ambassador's House
7. Germia Park
0
Kilometers (UTM 34N)
20
N
Source: SCIPUFF/pm10_sc1_hrly_092211_diff.tif
bing
© Harris Corp, Earthstar Geographics LLC © 2013 Microsoft Corporation


SCIPUFF PM10
Average
Concentration
12/28/11
Time period: 12/28/2011
Source(s): TPPAB+FUG
Scenario: 1
Time average: 24 hours
Monitoring stations
TPP A, TPP B boundaries
Mine, ash pile boundaries
Concentration (μg/m3)
200 or more
100 - 199
50 - 99
40 - 49
10 - 39
1 - 9
Location
1. KEK MW
2. Obiliq Health Center
3. KEK A
4. Dardhishte
5. Shkabaj
6. US Ambassador's House
7. Germia Park
0
Kilometers (UTM 34N)
20
N
Source: SCIPUFF/pm10_sc1_hrly_122811_diff.tif
bing
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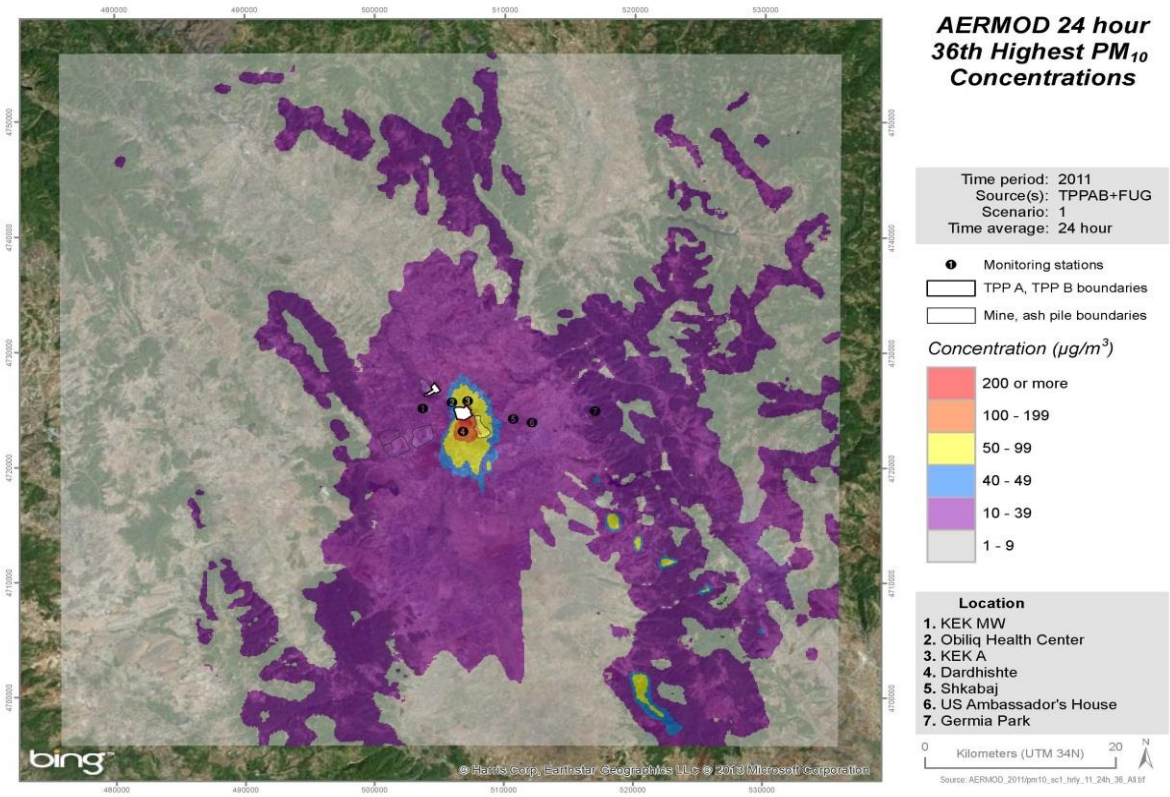
3.4 PM_{10} Observations

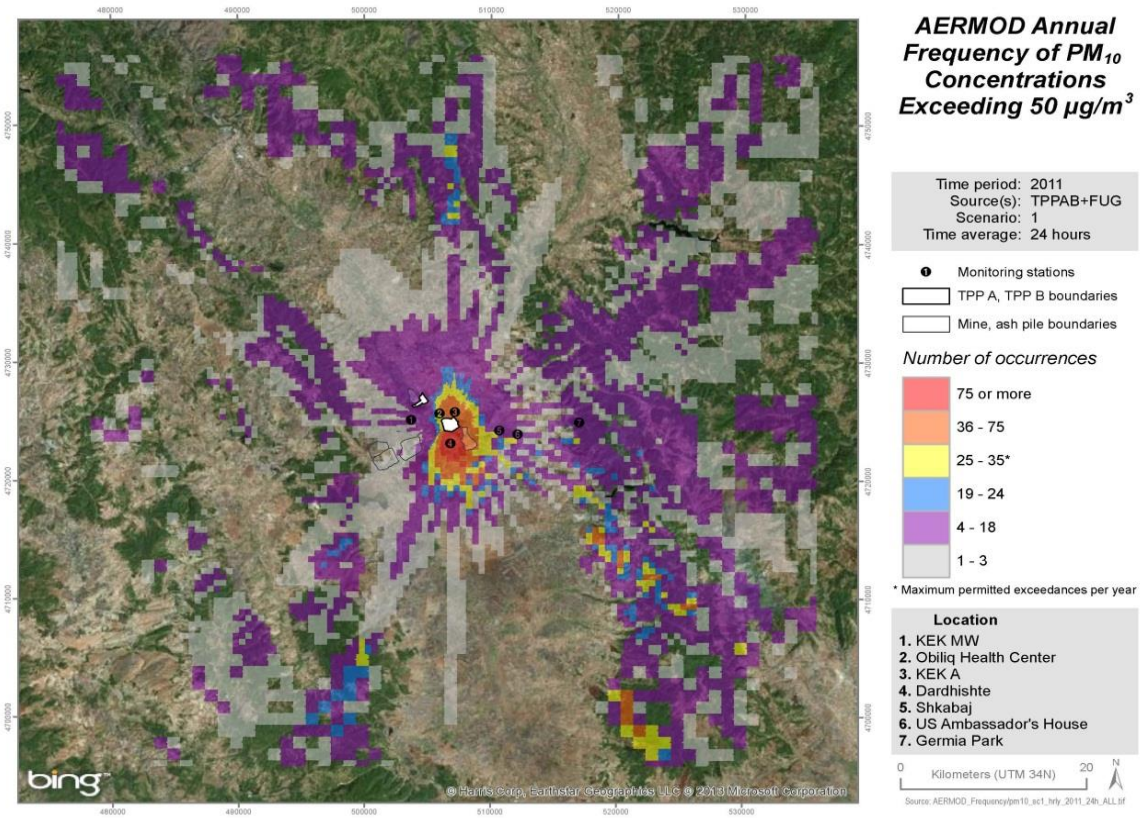
3.4.1 24-Hour PM_{10} Modeling and Sampling Results

The 2011 dispersion modeling estimates suggest that 24-hour concentrations of PM_{10} in the ambient air are above the EU Limit Value. The EU Limit Value is exceeded when the 24-hour PM_{10} concentrations in the ambient air are 50 µg/m^3 or greater more than 35 times in a calendar year.

The first plot under Figure 14 shows the areas where PM_{10} concentrations are estimated to be 50 µg/m^3 or greater more than 35 days in a calendar year (referred to as 36th highest). These areas are shaded in yellow, orange, and red. The second plot shows the annual estimated frequency of the 24-hour average PM_{10} concentrations above the EU Limit Value. The areas above the EU Limit Value are shaded in orange and red. The emission sources used to estimate PM_{10} concentrations were Kosovo TPP A, TPP B, and fugitive emissions from the ash pile and conveyor drop.

Figure 14: 36th Highest Modeled 24-Hour PM_{10} Concentrations





The sampling results indicated a similar trend based on data gathered at the monitoring sites. See Tables 13-15 for the average monthly PM_{10} concentrations during 2011-2013, and the number of times the EU Limit Value was exceeded on a monthly basis and at each sampling site.

Table 13: Average Monthly PM_{10} Concentrations Measured in the Ambient Air[36]

Sampling Month and Year	Number of Samples Obtained	Average PM_{10} Concentrations (µg/m^3)
July 2011	2	39.1
August 2011	NA	NA
September 2011	12	60.3
October 2011	3	50.1
November 2011	5	66.32
December 2011	7	70.58
January 2012	7	117.65
February 2012	6	70.92
March 2012	2	56.35

[36] 2011 data were obtained from the KEK MW, Obiliq Health Center, and Dardhishte sampling locations, and 2012-2013 data from these three sites and KEK A, Shkabaj, US Ambassador's Residence, and Germia Park.

Sampling Month and Year	Number of Samples Obtained	Average PM_{10} Concentrations (µg/m^3)
April 2012	4	46.49
May 2012	7	37.35
June 2012	2	51.46
July 2012	17	42.46
August 2012	48	64.04
September 2012	36	70.29
October 2012	42	56.54
November 2012	47	36.41
December 2012	30	87.63
January 2013	53	68.83
February 2013	24	42.44
Total Samples	354	
Average PM_{10} Concentration		66.17

Table 14: Number of Samples above EU Limit Value on a Monthly Basis

Sampling Month and Year	Number of Samples Obtained	Number of Samples above 24-hour EU Limit Value	% of Samples above 24-Hour EU Limit Value
July 2011	2	0	0
August 2011	NA	NA	NA
September 2011	12	5	42
October 2011	3	2	67
November 2011	5	4	80
December 2011	7	4	57
January 2012	7	4	57
February 2012	6	4	67
March 2012	2	2	100
April 2012	4	1	25
May 2012	7	2	29
June 2012	2	2	100
July 2012	17	4	24
August 2012	48	23	48
September 2012	36	25	69
October 2012	42	22	52
November 2012	47	12	26
December 2012	30	19	63
January 2013	53	33	62
February 2013	24	10	42
Total	354	178	>50

Table 15: Number of Samples above EU Limit Value per Sampling Location

Sampling Locations	Number of Samples Obtained	Number of Samples above 24-hour EU Limit Value	% of Samples above 24-Hour EU Limit Value

Sampling Locations	Number of Samples Obtained	Number of Samples above 24-hour EU Limit Value	% of Samples above 24-Hour EU Limit Value
Obiliq	59	34	58
Dardhishte	63	31	49
KEK MW	74	47	64
Germia Park	49	6	12
Shkabaj	18	10	6
KEK A	49	32	65
US Ambassador's Residence	40	17	43
HMI	2	1	50
Total	354	178	50

As noted in the 24-hour PM_{10} tables in Section 3.2 and Table 13 above, the average PM_{10} concentrations measured in the ambient air during January 2013 were similar to the results obtained during 2011-2012. In general, Units A4 and A5 and both of the TPP B units were operating when ambient air samples were gathered during the sampling events.

For a limited number of sampling events during January and February 2013, Units A3, A5, and the B units were operating. Units A3 and A5 have new ESPs. The average PM_{10} concentration is lower in February 2013; however, the results were variable during the February sampling events. When the wind direction was from the NW, the concentrations were below the 24-hour EU Limit Value. When the wind originated from other directions, in particular, the SW the concentrations were above the 24-hour EU Limit Value. Although there were only a limited number of sampling events in February 2013, the results support the notion that increased ESP efficiencies reduce pollutant concentrations in the ambient air.

3.4.2 24-Hour PM_{10} Modeling Results - Operational Considerations

Figure 15 shows the 24-hour dispersion modeling estimates for PM_{10} concentrations associated with emissions either from Kosovo TPP A, TPP B, or fugitive emissions from the conveyor drop and ash pile. These plots illustrate the areas and concentrations of PM_{10} in the ambient air that are 50 $\mu g/m^3$ or greater more than 35 days in a calendar year (referred to as 36th highest) as a function of Kosovo TPP A, TPP B, or fugitive emissions.

As shown in the dispersion plots, the three emission sources have different influences on the pollutant concentration levels estimated in the ambient air. Emissions from Kosovo TPP A are estimated to have more impacts on ambient air quality than TPP B or fugitives. One of the factors most likely underlying the differing impacts is the lower stack heights at Kosovo TPP A.[37]

In reviewing Figure 15 note that:

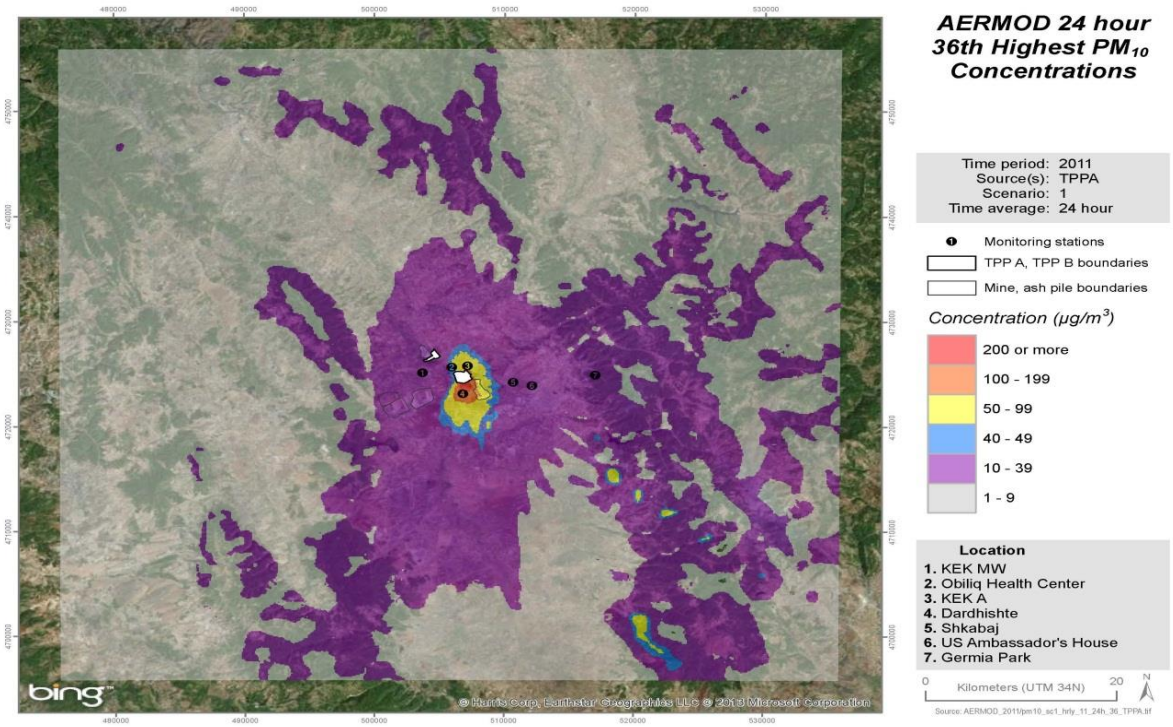
- The first plot depicts modeled PM_{10} concentrations related to emissions from Kosovo TPP A (referred to on the plot as source - TPPA) during 2011;

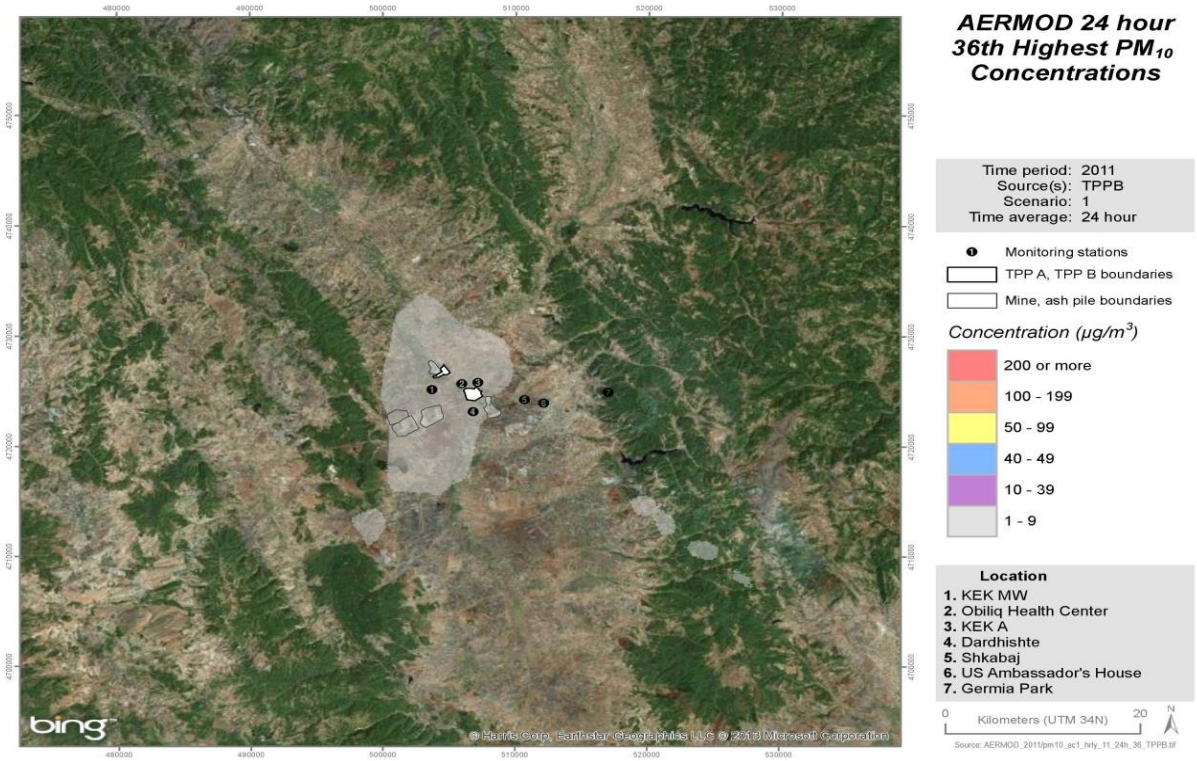
[37] For additional information on the influence of stack heights and plume dispersion, see the air dispersion modeling report referenced in Section 1.0.

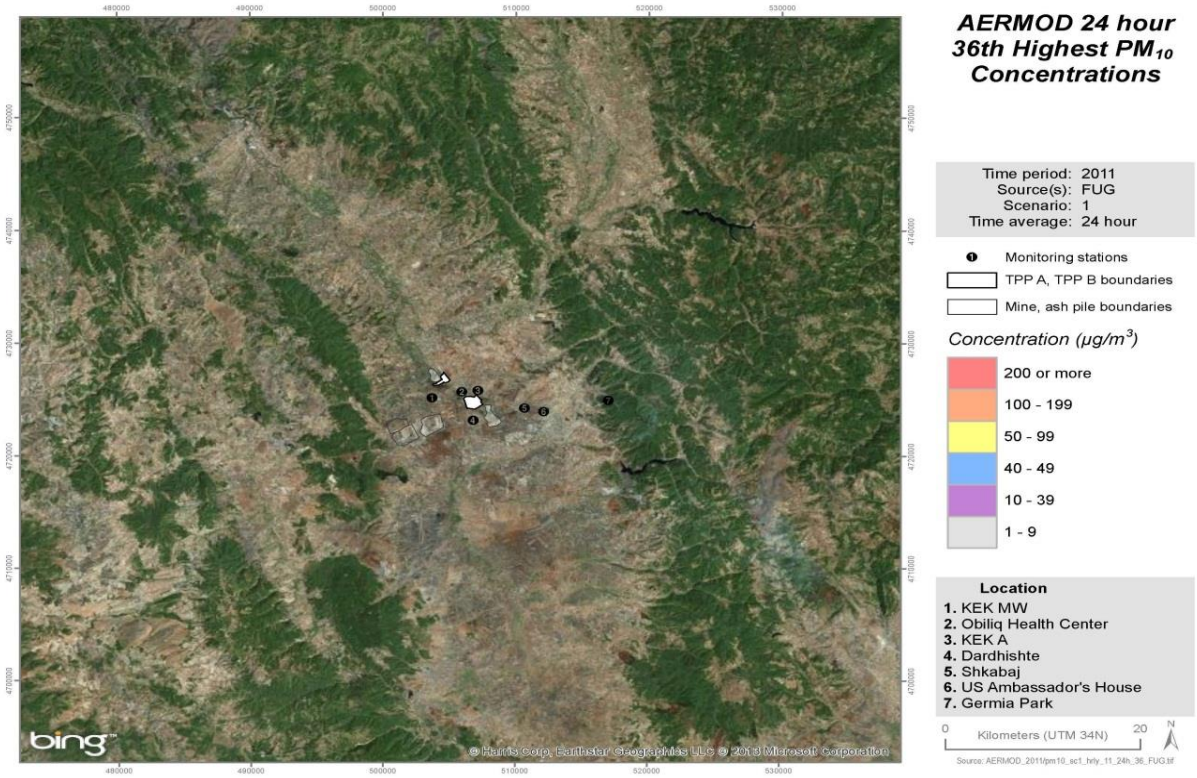
- The second plot depicts modeled PM_{10} concentrations related to emissions from Kosovo TPP B (referred to as TPPB) during 2011; and
- The last plot depicts modeled PM_{10} concentrations related to fugitive emissions from the conveyor drop at the ash pile and from the ash pile (referred to as FUG) during 2011.

In the first plot the areas shaded in yellow, orange, and red indicate modeled concentrations above the 24-hour EU Limit Value for PM_{10}. There are no shaded areas above the EU Limit Value in the second and third plots.

Figure 15: Modeled PM_{10} Concentrations in the Ambient Air from Kosovo TPP A, TPP B, and Fugitive Emissions




AERMOD 24 hour
36th Highest PM10
Concentrations
Time period: 2011
Source(s): TPPB
Scenario: 1
Time average: 24 hour
Monitoring stations
TPP A, TPP B boundaries
Mine, ash pile boundaries
Concentration (µg/m3)
200 or more
100 - 199
50 - 99
40 - 49
10 - 39
1 - 9
Location
1. KEK MW
2. Obiliq Health Center
3. KEK A
4. Dardhishte
5. Shkabaj
6. US Ambassador's House
7. Germia Park
0
Kilometers (UTM 34N)
20
N
bing
© Harris Corp, Earthstar Geographics LLC © 2013 Microsoft Corporation

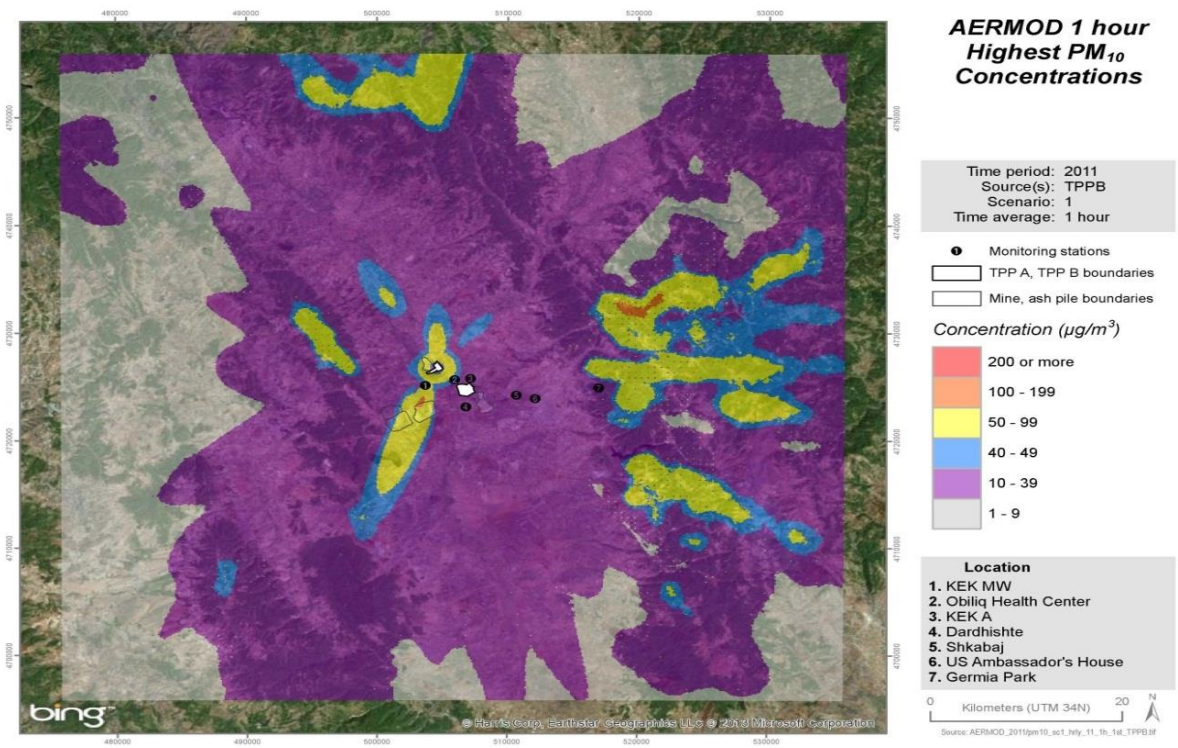

AERMOD 24 hour
36th Highest PM10
Concentrations
Time period: 2011
Source(s): FUG
Scenario: 1
Time average: 24 hour
Monitoring stations
TPP A, TPP B boundaries
Mine, ash pile boundaries
Concentration (µg/m3)
200 or more
100 - 199
50 - 99
40 - 49
10 - 39
1 - 9
Location
1. KEK MW
2. Obiliq Health Center
3. KEK A
4. Dardhishte
5. Shkabaj
6. US Ambassador's House
7. Germia Park
0
Kilometers (UTM 34N)
20
N
bing
© Harris Corp, Earthstar Geographics LLC © 2013 Microsoft Corporation

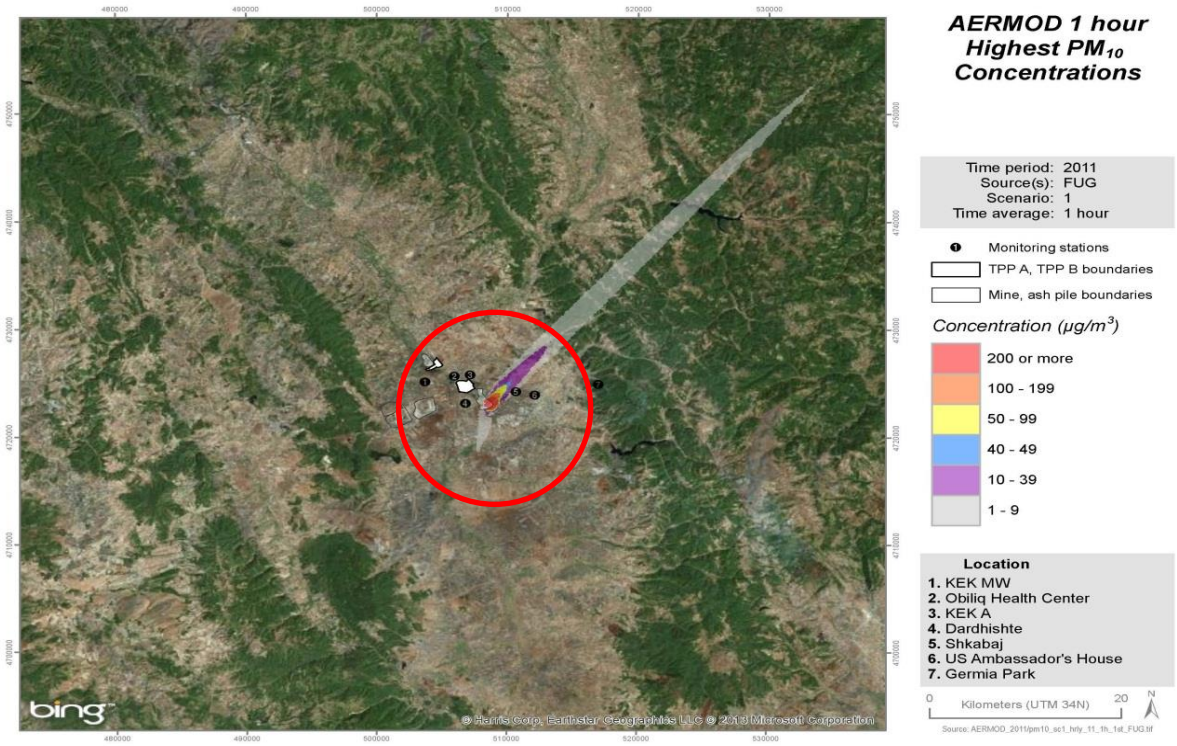
Although the modeled 24-hour concentrations of PM_{10} are impacted primarily by Kosovo TPP A, and TPP B is not modeled to be above the 24-hour EU Limit Value, the hourly modeled pollutant concentrations associated with emissions from Kosovo TPP B and fugitives, as shown in Figure 16, contribute to the overall 24-hour modeled concentrations of PM_{10}.

The first plot shows the areas and highest 1-hour modeled concentrations of PM_{10} in the ambient air associated with emissions from Kosovo TPP B. The second plot shows 1-hour modeled concentrations of PM_{10} from fugitive emissions from the ash pile and conveyor drop.

Yellow, orange, and red shading indicate areas where the modeled concentrations are equal to or greater than 50 µg/m^3. There is no 1-hour PM_{10} EU Limit Value.

Figure 16: Highest 1-Hour PM_{10} Concentrations Associated with Emissions from Kosovo TPP B and Fugitives





3.4.3 24-Hour PM_{10} Sampling Results as a Function of Wind Speed

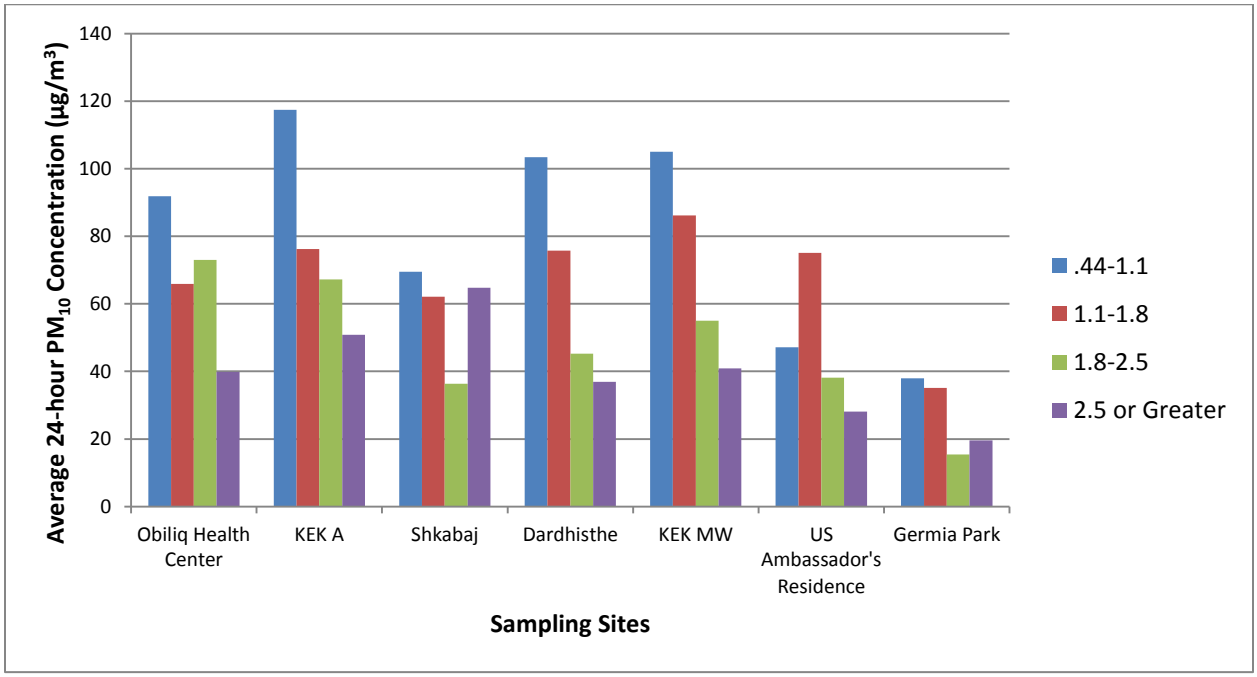
On average, the PM_{10} concentrations measured in the ambient air increase at each of the sampling locations when the wind speed is low. The meteorological data from Trinity Consultants indicate that wind speed was within the range of 1-3 m/s about 40% of the time during 2005-2009 and about 28.7% of the time in 2011. The AIO data gathered at the sampling locations as well as the World Weather data indicate a similar trend. (See Section 3.8 for a comparison of the AIO and World Weather data for selected sampling events.)

To illustrate this point see Table 16 for the average PM_{10} concentrations measured during 2011-2012 at each sampling location and corresponding wind speed ranges, and Figure 17 which depicts the information in the form of a bar graph.

Table 16: Average 24-Hour PM_{10} Concentrations and Wind Speeds

Sampling Location	Wind Speed (m/s)			
	.44-1.1	1.1-1.8	1.8-2.5	2.5 or Greater
	Concentrations of PM_{10} (µg/m^3)			
Obiliq Health Center	91.89	65.93	72.97	39.83
KEK A	117.39	76.27	67.22	50.87
Shkabaj	69.47	62.14	36.39	64.75
Dardhishte	103.44	75.80	46.16	36.90
KEK MW	105.03	86.17	55.05	40.93
US Ambassador's Residence	47.11	75.06	38.11	28.12
Germia Park	37.92	35.11	15.44	19.61

Figure 17: Average 24-Hour PM_{10} Concentrations and Wind Speeds

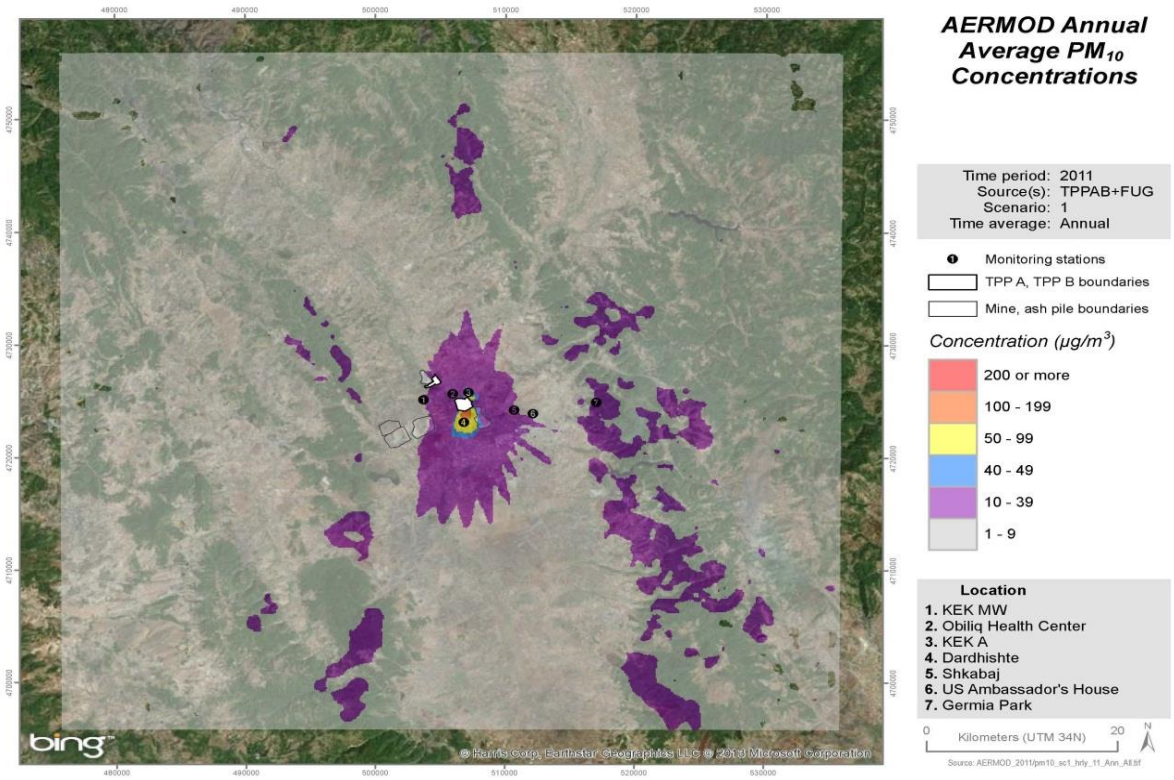


3.4.4 Annual PM_{10} Modeling Results

As reflected in Figure 18, the annual[38] PM_{10} concentrations modeled at receptor sites located in close proximity to the power plants are above the EU Limit Value of 40 µg/m^3; the modeled PM_{10} concentrations are below the annual EU Limit Value at receptor sites farther away from the power plants. The areas above the EU annual limit value are shaded in blue, yellow, orange, and red.

[38] Annual dispersion modeling results reflect the average of all hourly pollutant concentration estimates.

Figure 18: Annual PM_{10} Modeling Results



3.4.5 Modeled PM_{10} Concentrations Relative to ESP Considerations

The PM_{10} concentrations were modeled relative to four ESP efficiencies (discussed in Section 2.0) and the 24-hour EU Limit Value of 50 µg/m^3. The modeling results are summarized in Table 15 and plotted in Figure 19. Table 17 also includes the highest PM_{10} concentrations measured during 2011-2012.

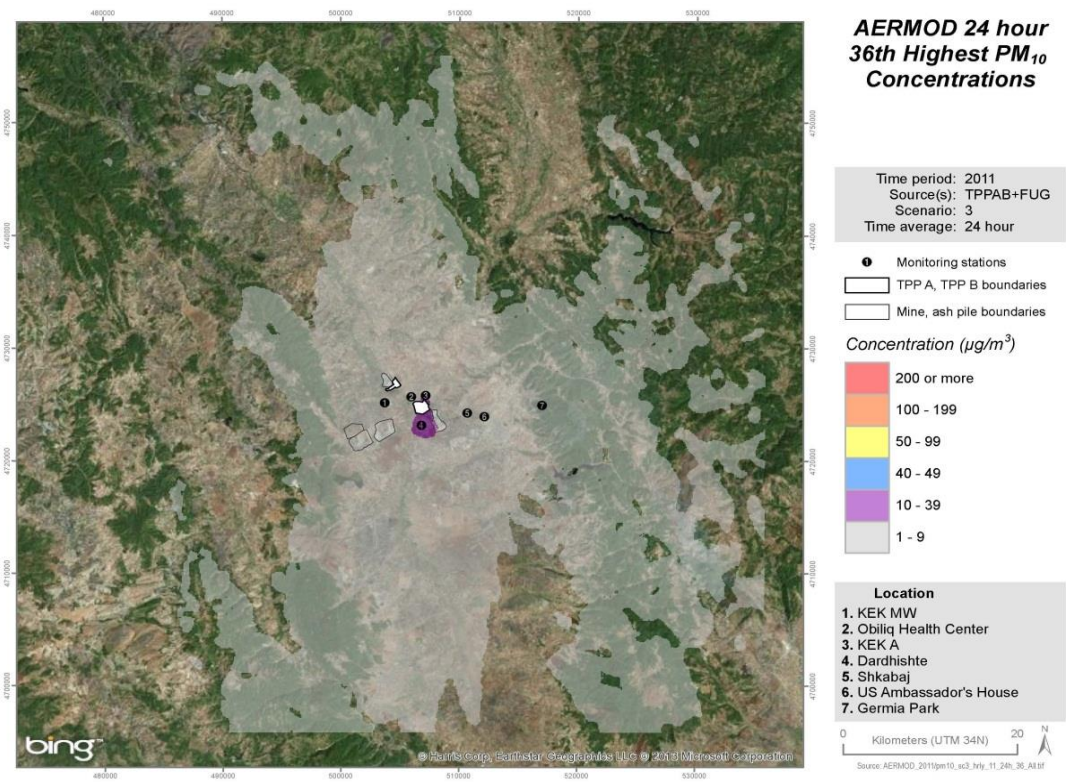
As suggested in Table 17 and shown in Figure 19, when Scenario 3 ESP efficiencies are in effect, the modeled results show no instances when the PM_{10} concentrations exceed 50 µg/m^3 more than 35 times in a calendar year. This suggests that if the power plants' ESP efficiencies were increased, the PM_{10} concentrations might be reduced below the 24-hour EU Limit Value.

The first plot in Figure 19 contains information on modeled concentrations of PM_{10} for 2011. The second plot contains information on the annual modeled concentrations of PM_{10} for 2011. The emission sources for both plots are Kosovo TPP A, TPP B, and fugitive emissions from the ash pile and conveyor drop.

Table 17: 24-Hour PM_{10} Modeling[39] and Sampling Concentrations

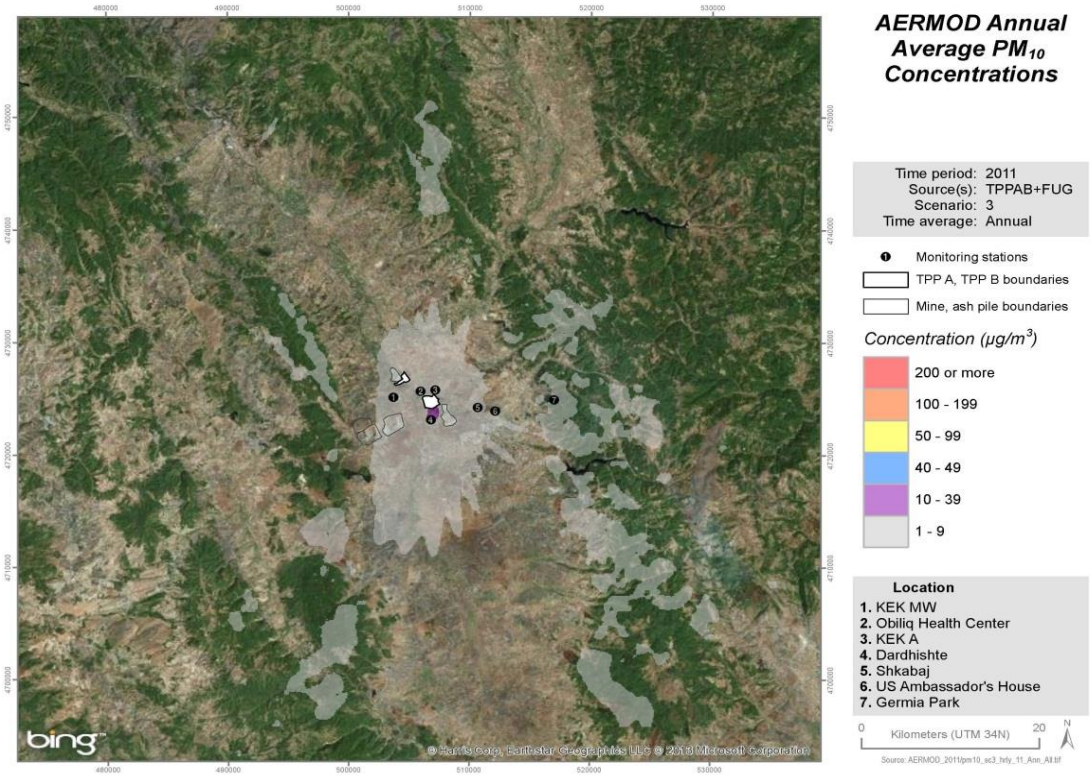
Modeling Scenario or Sampling Timeframe	Highest 24-hour PM_{10} Concentrations ($\mu g/m^3$)
2011 Dispersion Estimate Scenario 1	316.4
2011 Dispersion Estimate Scenario 2	148.0
2011 Dispersion Estimate Scenario 3	36.8
2011 Dispersion Estimate Scenario 4	46.41
Highest Sampled Concentration in 2011	162.21
Highest Sampled Concentration in 2012	272.73[40]

Figure 19: 36th Highest Modeled 24-Hour PM_{10} Concentrations under Scenario 3



[39] AERMOD estimated the highest 24-hour PM_{10} concentrations in the ambient air related to emissions from Kosovo TPP A, TPP B, and fugitive emissions from the ash pile and conveyor drop under Scenarios 1 - 4. The values listed represent the highest 24-hour PM_{10} concentrations for the sampling location during the 2011 sampling events.

[40] No higher concentration was measured in 2013.

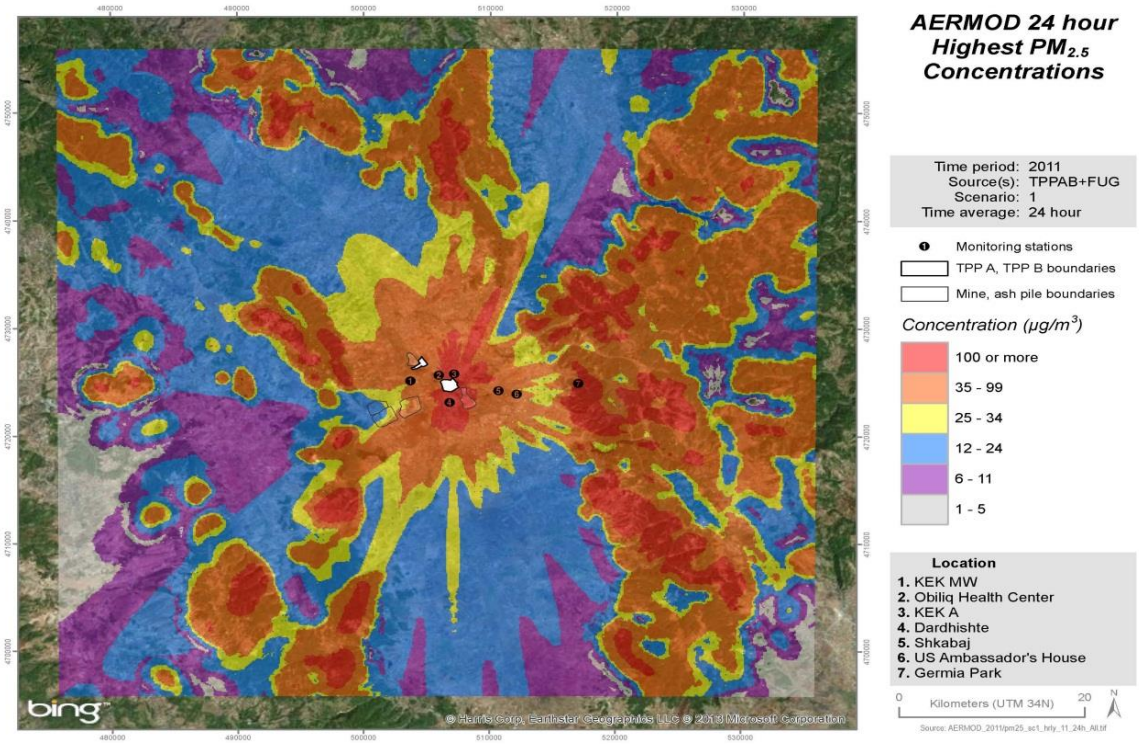


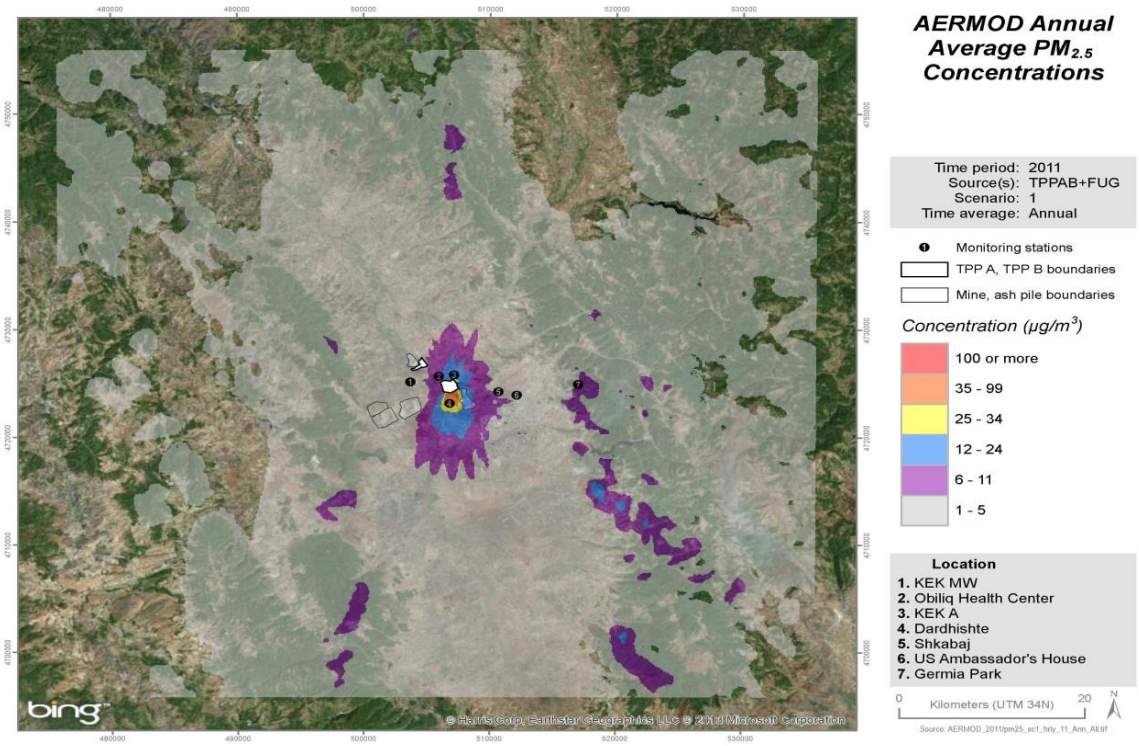
3.4.6 $PM_{2.5}$ Modeling and Sampling Results

The 24-hour $PM_{2.5}$ concentrations measured in the ambient air range from 4 to 253 µg/m^3. This range is similar to the modeled 24-hour and annual $PM_{2.5}$ concentrations for 2011 as shown in Figure 20.

The first plot in Figure 20 is of the highest modeled 24-hour concentrations, the second plot is of the modeled annual $PM_{2.5}$ concentrations. Both plots are based on emissions from Kosovo TPP A, TPP B, and fugitive emissions from the conveyor drop and ash pile. The areas shaded in yellow, orange, and red are above the annual EU Limit Value of 25 µg/m^3. (For comparison, the areas shaded in blue are above the USEPA annual standard of 12 µg/m^3.)

Figure 20: Modeled Concentrations of $PM_{2.5}$





3.5 NO_2 Observations

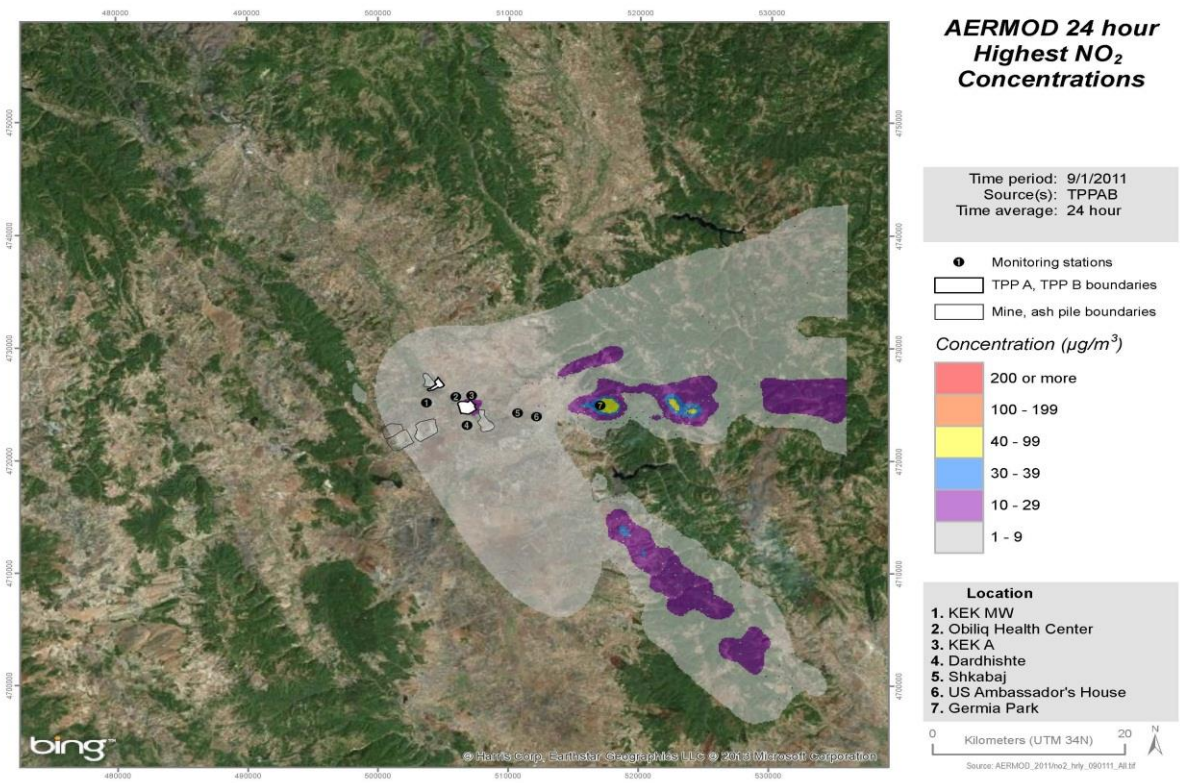
3.5.1 24-Hour NO_2 Modeling and Sampling Results

The 24-hour NO_2 sampling results indicate the concentrations in the ambient air are within the range of 2-70 µg/m^3.[41] These sampling results are similar to the 24-hour dispersion modeling results.

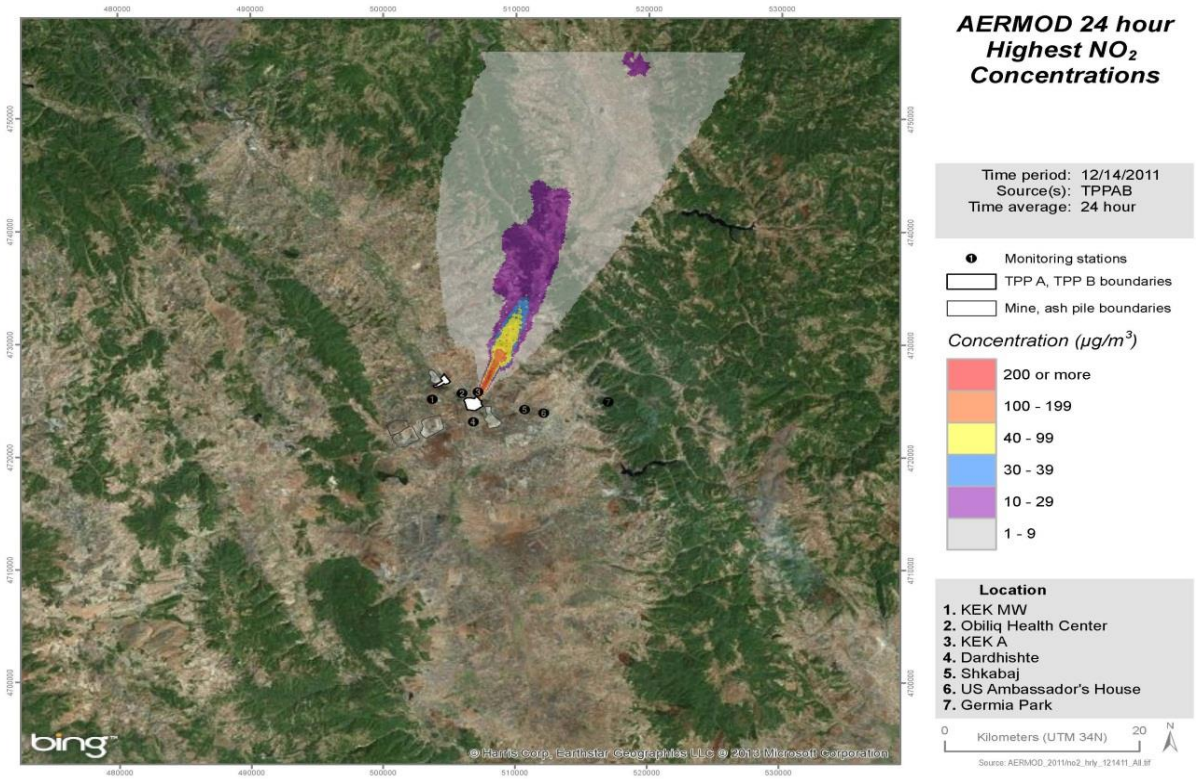
As shown in Figure 21, the modeled 24-hour concentrations for 2011 range from 1 to over 200 µg/m^3. The first plot is for the modeled concentrations for the sampling event that occurred on 1-2 September 2011 and the second plot is for the modeled concentrations for the sampling event on 14-15 December 2011. The areas shaded in purple, blue, yellow, orange, and red are above 10 µg/m^3. The emission sources for both plots are Kosovo TPP A and TPP B.

The EU has not established a 24-hour limit value for NO_2.

Figure 21: Highest Modeled 24-Hour NO_2 Concentrations



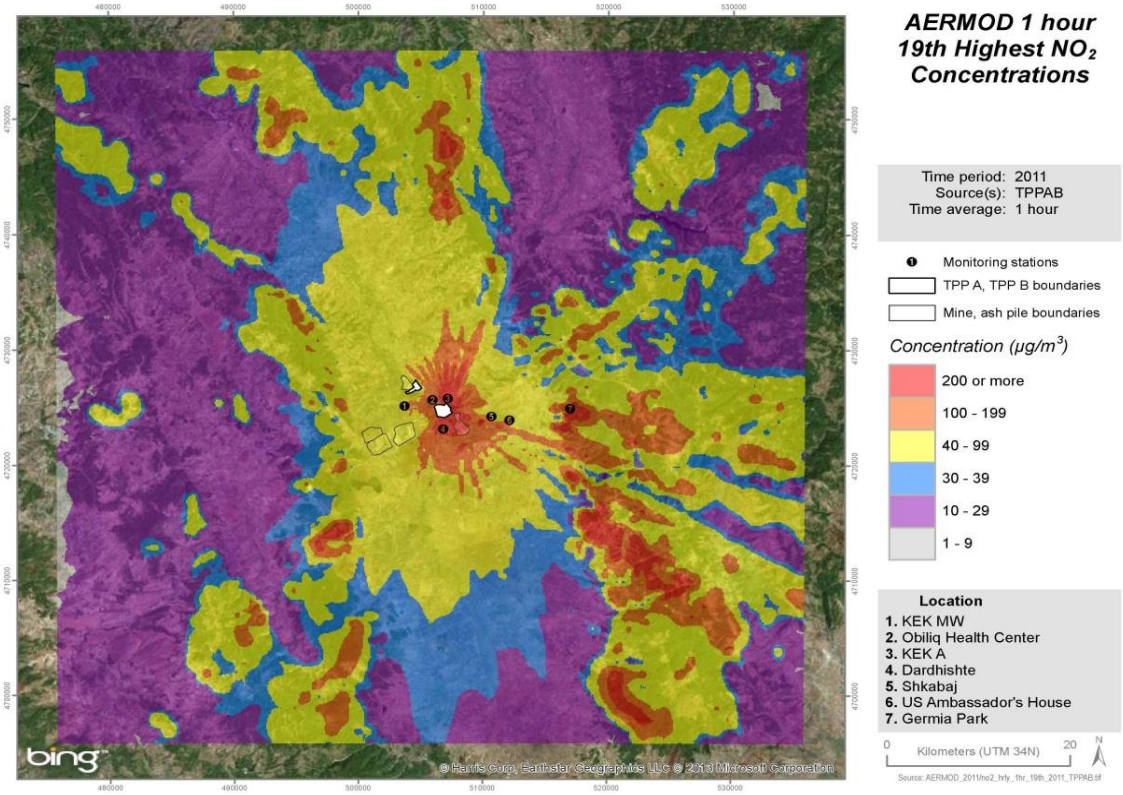
[41] The range doesn't reflect an adjustment for blanks.



3.5.2 Hourly NO_2 Modeling Results

The 2011 hourly dispersion modeling estimates indicate the NO_2 levels are higher than the EU limit value. The red areas in Figure 22 represent modeled NO_2 concentrations that are 200 µg/m^3 or greater more than 18 times in a calendar year (referred to as 19th highest). These concentration estimates are based on emissions from Kosovo TPP A and TPP B.

Figure 22: 19th Highest 1-Hour Modeled NO_2 Concentrations

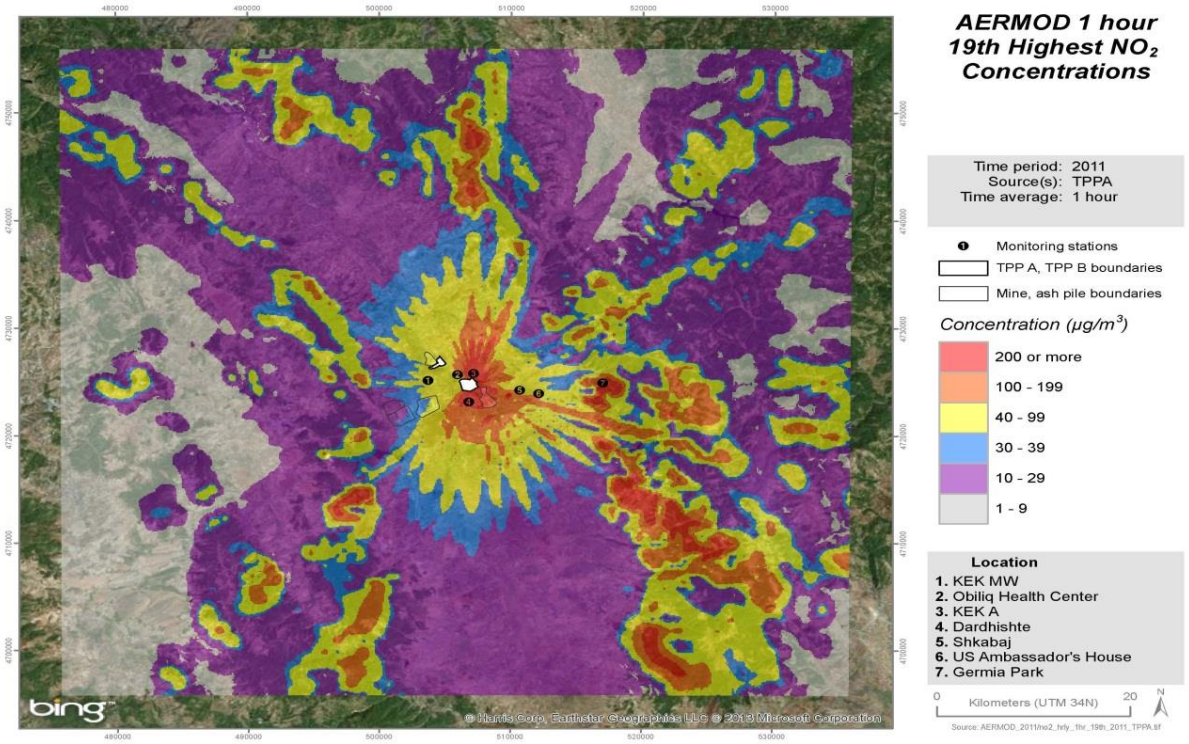


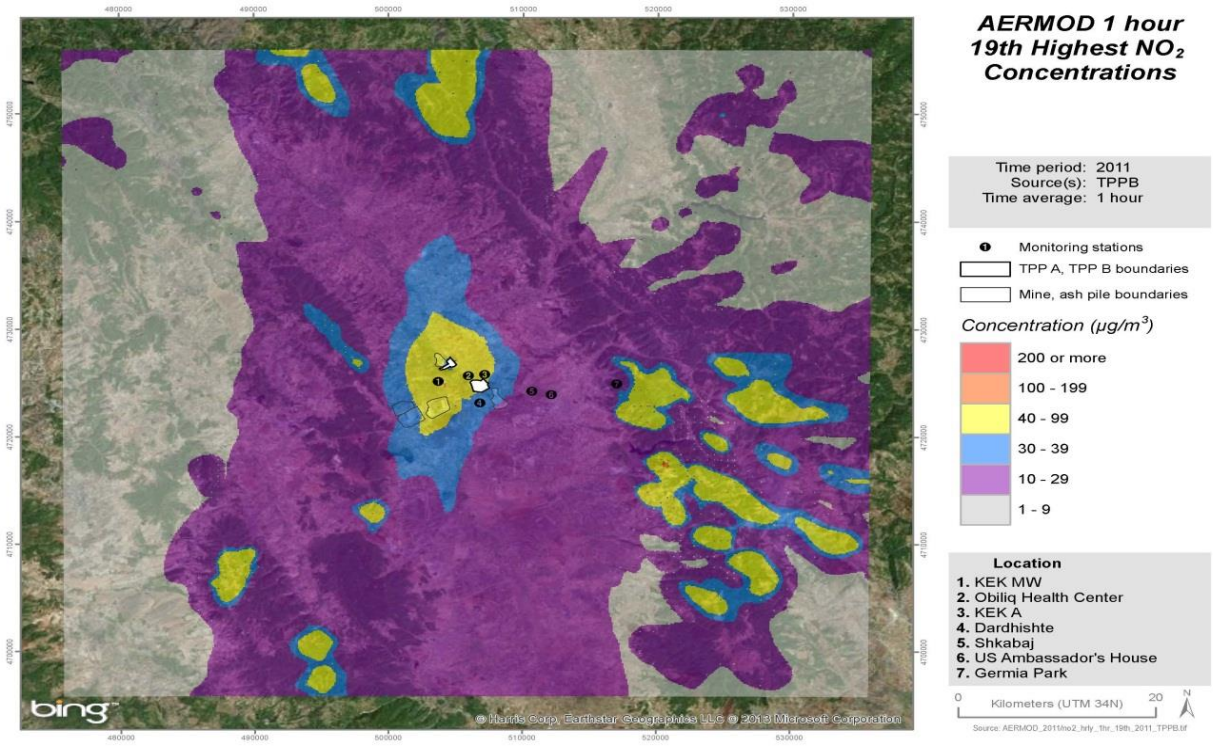
3.5.3 1-Hour NO_2 Modeling Results - Operational Considerations

As noted earlier, the 2011 dispersion modeling results suggest that the emissions from the power plants have different impacts on the pollutant concentrations in the ambient air. This same trend was noted with NO_2, as illustrated in Figure 23.

The first plot represents estimated NO_2 concentrations in the ambient air related to emissions from Kosovo TPP Unit A, and the second plot Kosovo TPP B. The areas shaded in red depict modeled concentrations above the 1-hour EU limit value of 200 µg/m^3 that occur more than 18 times in a calendar year (referred to as the 19th highest).

Figure 23: 19th Highest 1-Hour Modeled NO_2 Concentrations Related to Individual Kosovo TPP Operations

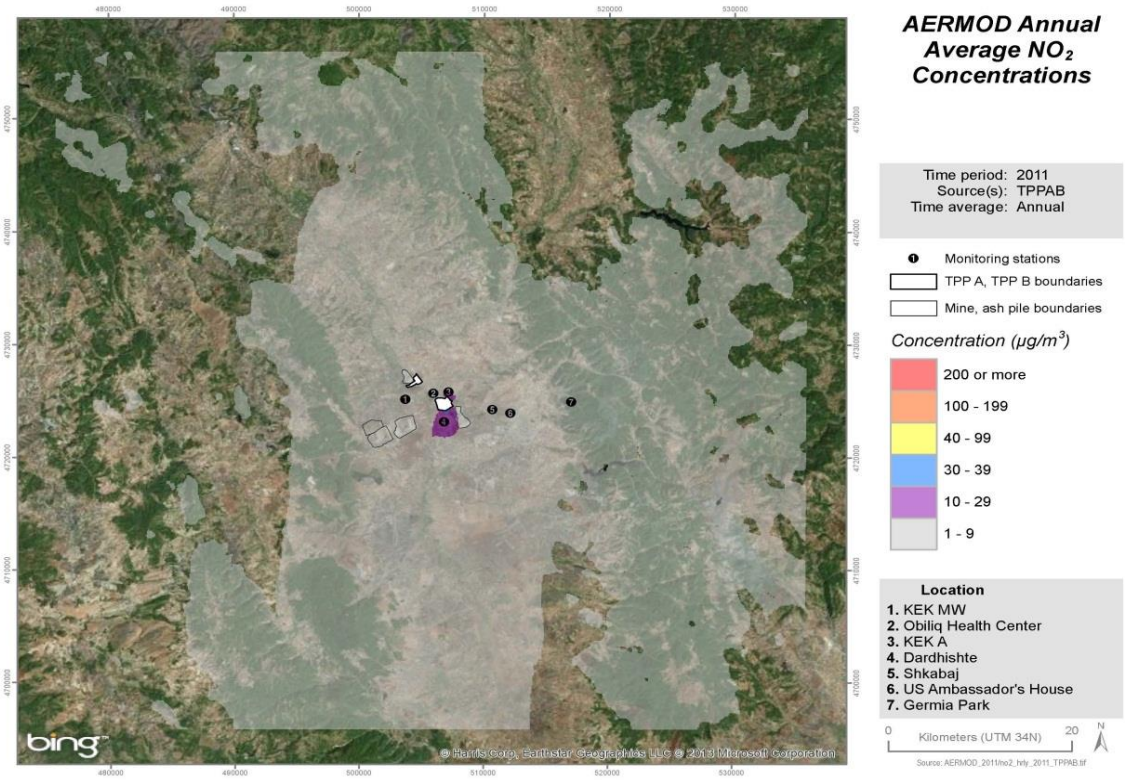




3.5.4 Annual NO_2 Modeling Results

The 2011 modeled annual concentrations of NO_2 in the ambient air are slightly below the EU Limit Value of 40 µg/m^3 as depicted in Figure 24. The highest annual modeled NO_2 concentration in 2011 was 35.87 µg/m^3. These concentration estimates are based on emissions from Kosovo TPP A and TPP B.

Figure 24: Modeled Annual NO_2 Concentrations



3.5.5 Seven-Day NO_2 Samples

Seven-day NO_2 samples gathered during 2012 were not significantly different in concentration levels in comparison to the 24-hour samples. This suggests that the 24-hour NO_2 concentrations measured throughout the assessment roughly approximate ambient air conditions.

3.6 SO_2 Observations

3.6.1 24-Hour Data Variability

The 24-hour SO_2 sampling data gathered during 2011 through 2012 varied considerably from the dispersion modeling estimates. The SO_2 sampling results suggest that the levels in the ambient air are below the 24-hour EU Limit Value while the 2011 dispersion modeling estimates of SO_2 concentrations in the ambient air are higher than the 24-hour (125 µg/m^3) and 1-hour (350 µg/m^3) EU Limit Values. These differences might be related to one or all of the following:

- The coal has a low percentage of sulfur (less than 1%)[42]. The ash has a relatively high percentage of CaO (approximately 37%). Natural scrubbing might be occurring, reducing the sulfur emitted through the stacks. Since the dispersion modeling used a 2011 monthly coal analysis rather than updated daily or monthly analyses, the control efficiency related to CaO might have been underestimated;
- A metals scan[43] of several $PM_{2.5}$ filters indicated the presence elements.[44] The elements that were most predominant are listed in Table 18. The incremental elevated sulfur on the exposed $PM_{2.5}$ filters might be ammonium sulfate (NH_4SO_4) or sulfur bound in calcium sulfate ($CaSO_4$) resulting from calcium carbonate ($CaCO_3$) in the ash[45] and SO_2 in the stack gas;
- Issues with the monitoring equipment. At times the blank filters contained higher concentrations of SO_2 in comparison to the exposed filters. This situation was investigated with the equipment manufacturer but not fully resolved; or
- The modeling did not take into account the transformation of SO_2 to sulfuric acid, inorganic sulfate, or NH_4SO_4 aerosols.

Table 18: Analysis of $PM_{2.5}$ Filters

Sample Date	Location	Sampling Event Pollutant Concentrations (µg/m^3), Filter Analysis and Meteorological Data					
		$PM_{2.5}$	Elements[46] with Highest Filter Intensities	SO_2	NO_2	Wind Direction	Wind Speed (m/s)
January 11-12, 2012	KEK MW	89.44	Calcium, Sulfur, Potassium, Silicon	2.09	13.81	NW	1.80
January 31 - February 1, 2012	Dardhishte	252.29	Calcium, Sulfur, Potassium, Silicon, Sodium, Chlorine	2.37	69.96	NE	1.56

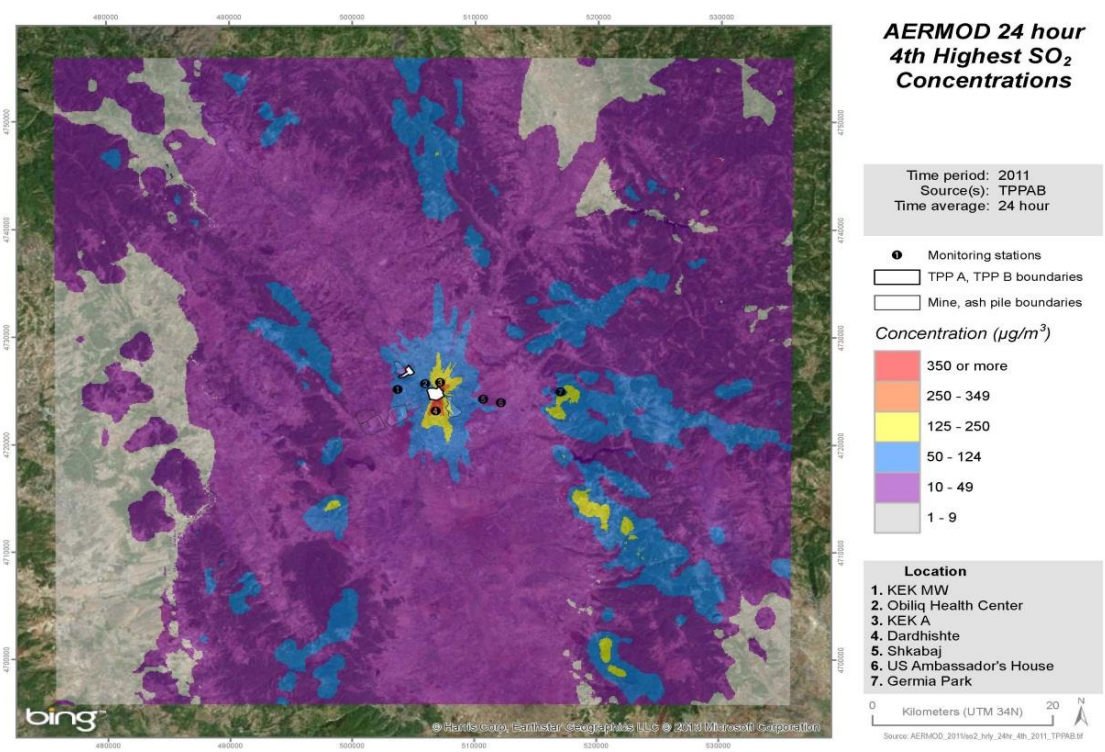
[42] See the air dispersion modeling report referenced in Section 1.0 for additional information about the composition of the lignite coal.
[43] The metal scan analysis was undertaken based on the overall framework of the USEPA $PM_{2.5}$ speciation program. Among other things, this program examines the nature of the metals contributing to fine particle formation.
[44] Similar constituent compounds were found in the ash piles. See Raporti, Gjendja e Mbeturinave në Kosovë, AMMK 2009 (Report, State of Waste in Kosovo, KEPA 2009).
[45] *Chemical Characteristics of Lignite Ash from Power Plant Kosovo TPP Unit A and Local Geological Settings in Kosovo near Prishtina*; Ilir Morina, Bedri Dragusha, Sami Dvorani, Frank Riesbeck. E-ISSN: 2224-3496, Issue 4, Volume 8, October 2012. Elektrowatt Ekono (EEO). Draft Report. LOT 2: Prefeasibility study for Pollution 07.Jan.06 Mitigation Measures at Kosovo B TPP Appendix 4.
[46] RTI used the X-Ray Fluorescence Analysis method to identify the presence of elements. The intensity of the result provides a measure of the amount of the element present. See Standard Operating Procedure for the X-Ray Fluorescence Analysis of Particulate Matter Deposits on Teflon Filters. RTI International, Revision 5, 19 August 2009.

Sample Date	Location	Sampling Event Pollutant Concentrations (µg/m^3), Filter Analysis and Meteorological Data					
		$PM_{2.5}$	Elements[46] with Highest Filter Intensities	SO_2	NO_2	Wind Direction	Wind Speed (m/s)
February 9-10, 2012	KEK MW	40.14	Sulfur, Potassium, Iron, Aluminum	NA	10.63	NE	1.90
October 10-11, 2012	KEK MW	47.78	Calcium, Sulfur, Potassium, Silicon, Iron, Aluminum	4.14	10.17	NE-SE-SW	.80

3.6.2 24-Hour SO_2 Modeling Results

The 2011 24-hour concentrations of SO_2 modeled near the power plants are above the EU Limit Value of 125 µg/m^3. That is, the concentrations in the ambient air are 125 µg/m^3 or greater more than three times in a calendar year (referred to as 4th highest). These areas are shaded in Figure 25 as yellow, orange, and red. These concentration estimates are based on emissions from Kosovo TPP A and TPP B.

Figure 25: 4th Highest 24-Hour Modeled SO_2 Concentrations



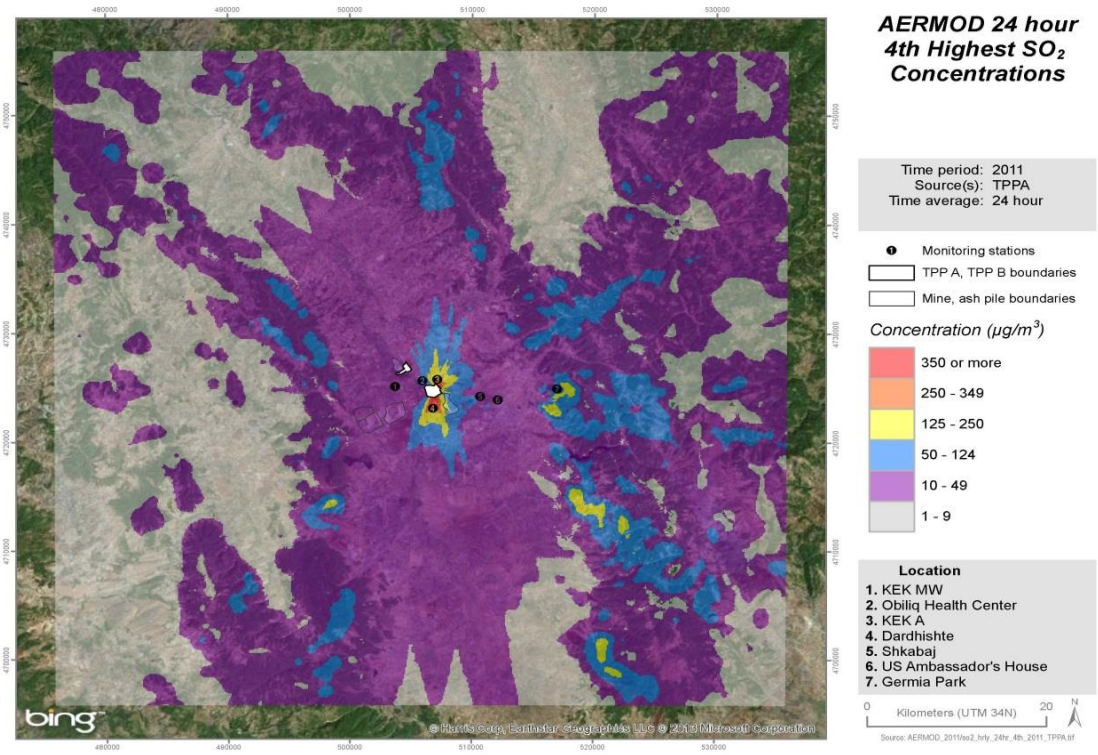
3.6.3 24-Hour SO_2 Modeling Results – Operational Considerations

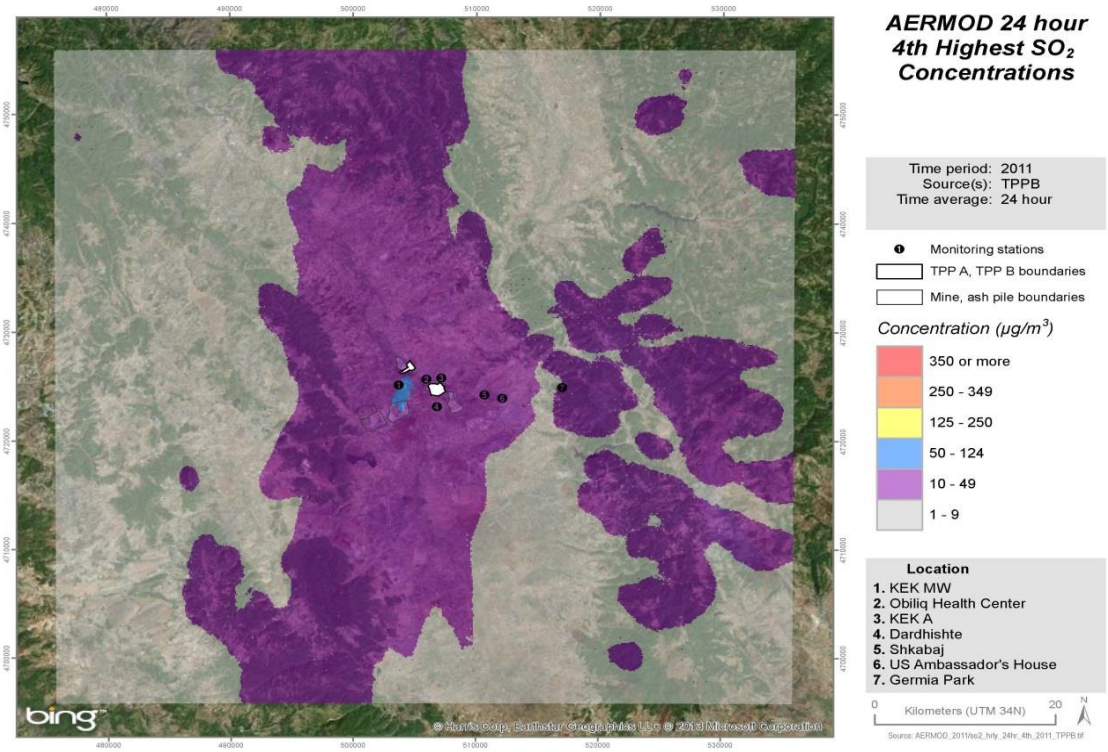
In terms of relative contributions to the 2011 modeled 24-hour SO_2 concentrations in the ambient air, Kosovo TPP A had more of an impact than Kosovo TPP B.

Figure 26 illustrates this point. The first plot contains 2011 modeling information on 24-hour SO_2 concentrations related to Kosovo TPP A. The second plot contains the same information but for Kosovo TPP B.

The Kosovo TPP A plot includes more areas shaded in yellow, orange, and red, than in the Kosovo TPP B plot, representing concentrations that are 125 µg/m^3 or greater more than 3 times in a calendar year (referred to as 4th highest).

Figure 26: 4th Highest 24-Hour Modeled SO_2 Concentrations Related to Related to Individual Kosovo TPP Operations

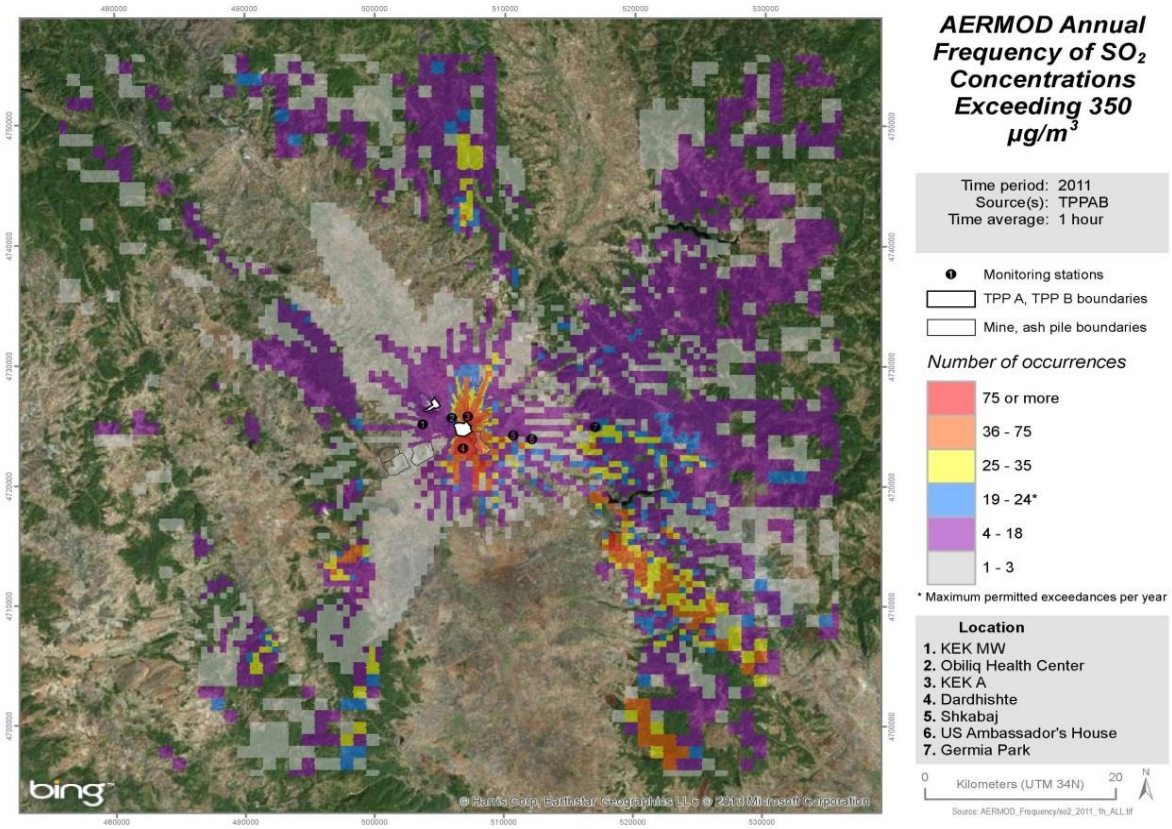




3.6.4 Hourly SO_2 Modeling Results

AERMOD estimates that the 2011 hourly concentrations of SO_2 are above the EU Limit Value. That is, the modeled concentrations in the ambient air are 350 µg/m^3 or greater more than 24 times in a calendar year (referred to as 25th highest). These areas are shaded yellow, orange, and red on Figure 27. This figure plots the frequency of modeled 1-hour SO_2 concentrations over the course of a year. These concentration estimates are based on emissions from Kosovo TPP A and TPP B.

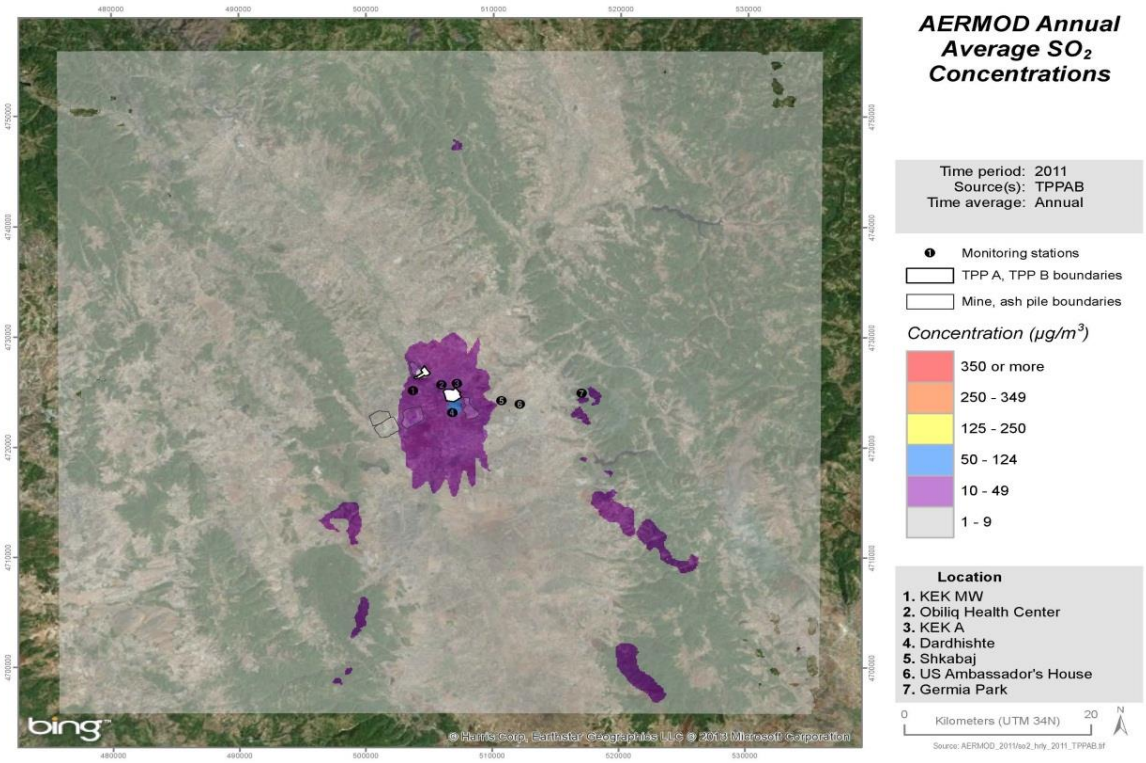
Figure 27: Frequency of 1-Hour Modeled SO_2 Concentrations



3.6.5 Annual SO_2 Modeling Results

There is no annual EU Limit Value for SO_2; the 2011 annual dispersion modeling results indicate a concentration range between 1-124 µg/m^3 in and around the power plants. AERMOD estimated the annual SO_2 concentration in the ambient air relative to emissions from Kosovo TPP A and TPP B. See Figure 28.

Figure 28: Modeled Annual SO_2 Concentrations



3.6.6 7-Day and 14-Day SO_2 and NH_3 Samples

Based on the low 24-hour concentrations of SO_2 measured in the ambient air during 2011-2012, Ogawa recommended longer sampling periods to enhance the filter loading characteristics. Several 7-day and 14-day samples were gathered during 2012 and in the beginning of 2013 to measure SO_2. The 7-day and 14-day SO_2 sampling results did not show any measurable differences in concentration levels relative to the 24-hour SO_2 sampling results obtained during 2011-2102.

Samples of ambient air were taken during 2013 to measure NH_3 to help inform the analysis of the SO_2 sampling results and fine particle formation. The basis for sampling NH_3 was that if this pollutant were present in the ambient air, NH_3 might be combining with SO_2 to form fine particles as measured by $PM_{2.5}$.

The analysis of the exposed 7-day filters indicated the presence of NH_3 in the ambient air. However, the exposed filter sampling results were difficult to interpret because the blank filters also indicated the presence of NH_3. Notwithstanding this concern, the very preliminary NH_3 sampling results along with the metal scan results for the $PM_{2.5}$ filters suggest that additional research may be needed to more fully understand fine particle formation ($PM_{2.5}$) around the power plants.

3.7 Other Observations

3.7.1 Sampling Results Relative to MW Generation

As noted in Table 19 there were some differences in the pollutant concentration levels measured during 2011-2012 relative to the MW generated and the time of the year (also see Section 3.7.3 related to seasonal observations).

Table 19: Average 24-Hour Pollutant Concentrations per MW Generated[47]

MW Range Generated During Sampling Periods	Average Pollutant Concentrations (µg/m^3)				Average Temperature (°C)
	NO_2	PM_{10}	$PM_{2.5}$	SO_2	
All Sampling Events					
Less than 9000	16.00	50.04	NA	NA	18.28
9001 - 12000	13.87	54.52	6.81	10.56	16.78
12001 - 15000	16.38	59.13	64.82	-2.03[48]	14.79
15001+	20.78	68.94	87.50	7.40	2.12
Average	17.64	60.97	76.88	6.23	9.86[49]
Fall Sampling Events					
Less than 9000	NA	NA	NA	NA	NA
9001 - 12000	NA	63.87	6.81	12.43	15.14
12001 - 15000	16.05	52.89	47.78	12.81	12.78
15001+	14.03	46.61	18.19	NA	8.22
Average	15.47	53.95	24.26	12.55	12.40
Spring Sampling Events					
Less than 9000	NA	NA	NA	NA	NA
9001 - 12000	13.37	52.01	NA	-6.22	12.00
12001 - 15000	15.08	43.96	57.24	-8.60	12.00
15001+	13.30	43.06	31.45	-6.46	7.07
Average	14.01	44.17	40.04	-7.25	9.53

[47] The averages include the sampling data from KEK MW, Obiliq Health Center, and Dardhishte during 2011. During 2012 data from these three sites and KEK A, Shkabaj, US Ambassador's Residence, and Germia Park were used to calculate averages.
[48] Sometimes the blank filters registered higher concentrations of SO_2 than the exposed filters, resulting in a negative concentration. This was investigated with the equipment manufacturer but not fully resolved.
[49] The overall averages were based on all the sampling and meteorological data. The averages for the MW ranges reflect the number of samples and meteorological data gathered within those ranges.

MW Range Generated During Sampling Periods	Average Pollutant Concentrations (µg/m^3)				Average Temperature (°C)
	NO_2	PM_{10}	$PM_{2.5}$	SO_2	
Summer Sampling Events					
<9000	16.00	50.04	NA	7.59	18.28
9001 - 12000	10.76	39.81	NA	NA	21.66
12001 - 15000	16.76	72.65	NA	7.18	22.69
15001+	7.43	39.10	NA	2.48	20.40
Average	14.24	57.63	NA	5.38	21.60
Winter Sampling Events					
Less than 9000	NA	NA	NA	NA	NA
9001 - 12000	NA	NA	NA	NA	NA
12001 - 15000	23.67	82.21	89.44	-8.43	-5.22
15001+	27.28	90.46	113.42	12.21	-2.92
All	27.16	90.29	110.42	10.83	-3.05

The relationship between MW generation and pollutant concentrations can be seen in Figures 29 and 30.

- Figure 29 graphs the average concentration measured in the ambient air during 2011-2012 relative to MW generated. Some changes in pollution concentration levels are noted with increased MW generation. Additional information is needed to more fully understand the rise in the $PM_{2.5}$ concentrations with increased MW generation.
- In Figure 30, the first graph illustrates the relationship between PM_{10} concentrations measured in the ambient air and MW generation, the second and third graphs illustrate this relationship with NO_2 and SO_2. Through these linear regressions, the correlation between pollutant concentrations measured during 2011-2012 and MW generation is not strong with R-squared values ranging from .02 to .08. In other words for a given sampling event, the concentrations changed very little relative to increased MW generation.

Figure 29: Average Pollutant Concentrations and MW Hours Generated[50]

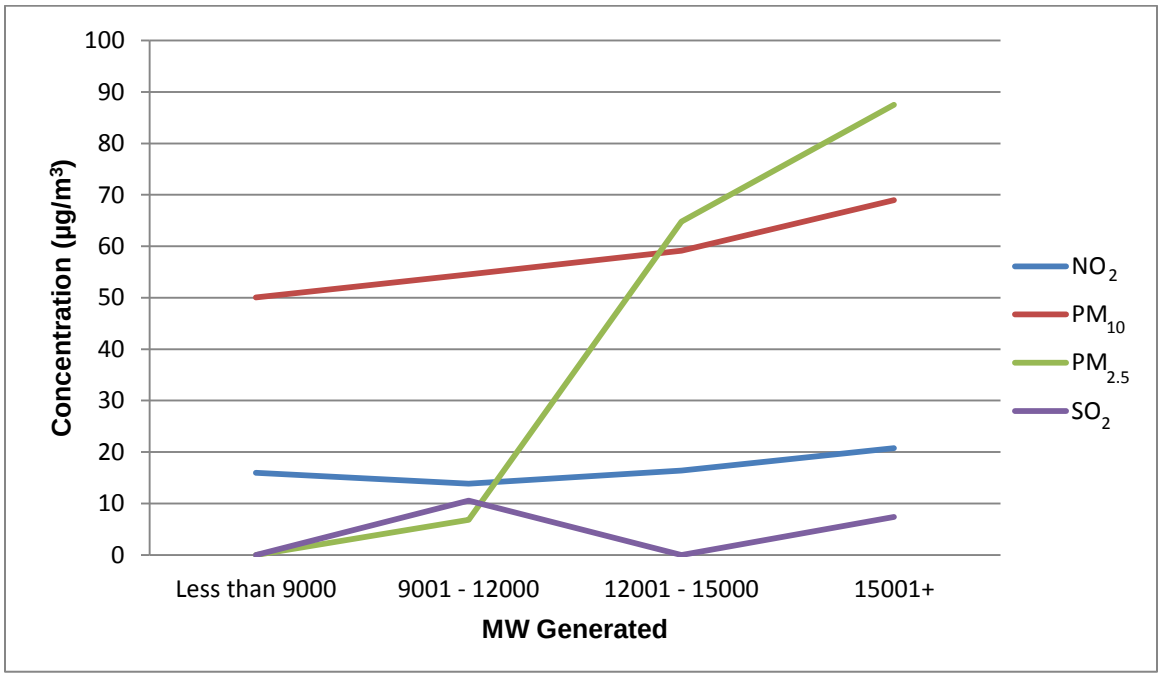
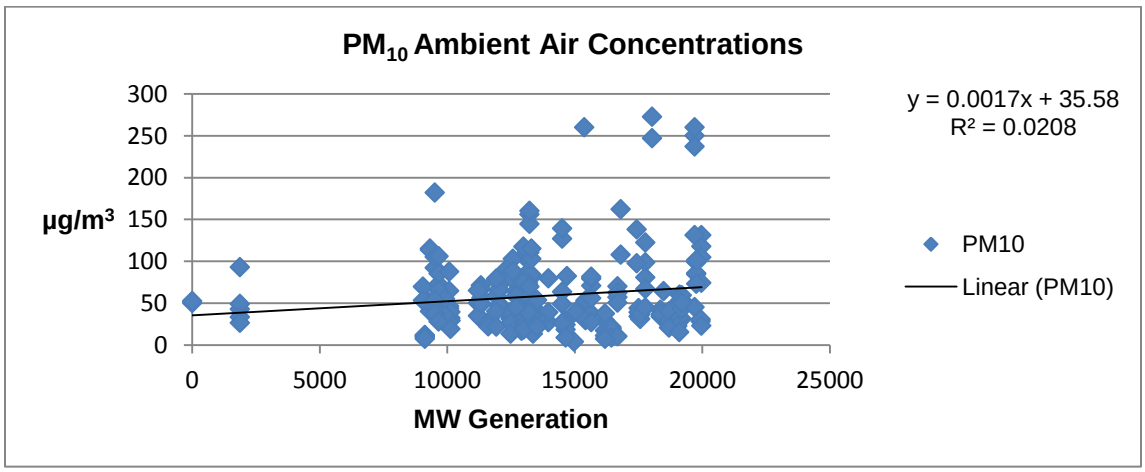
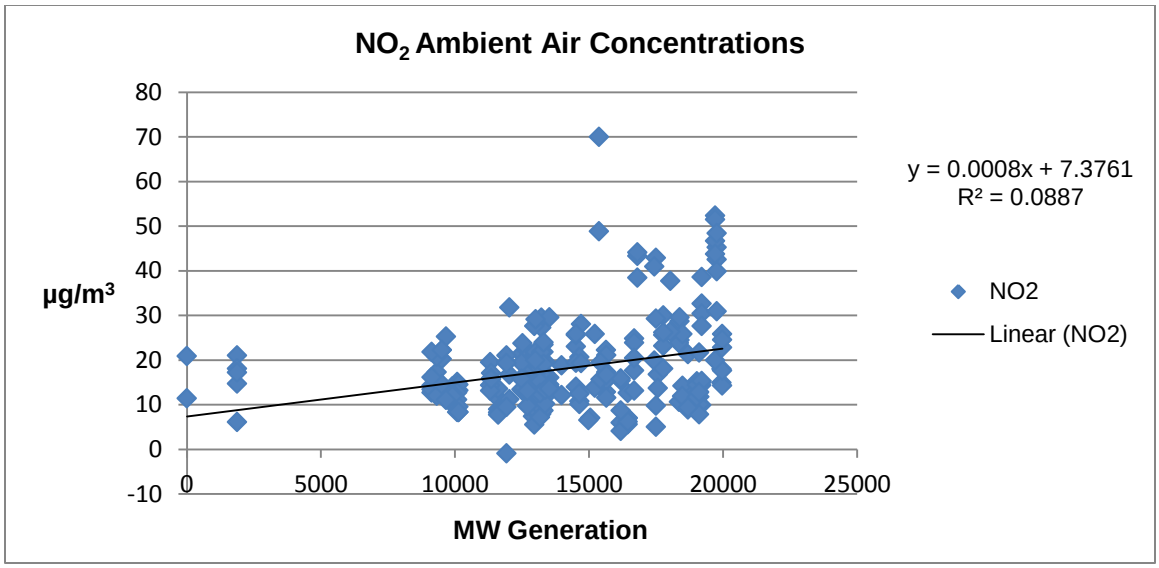
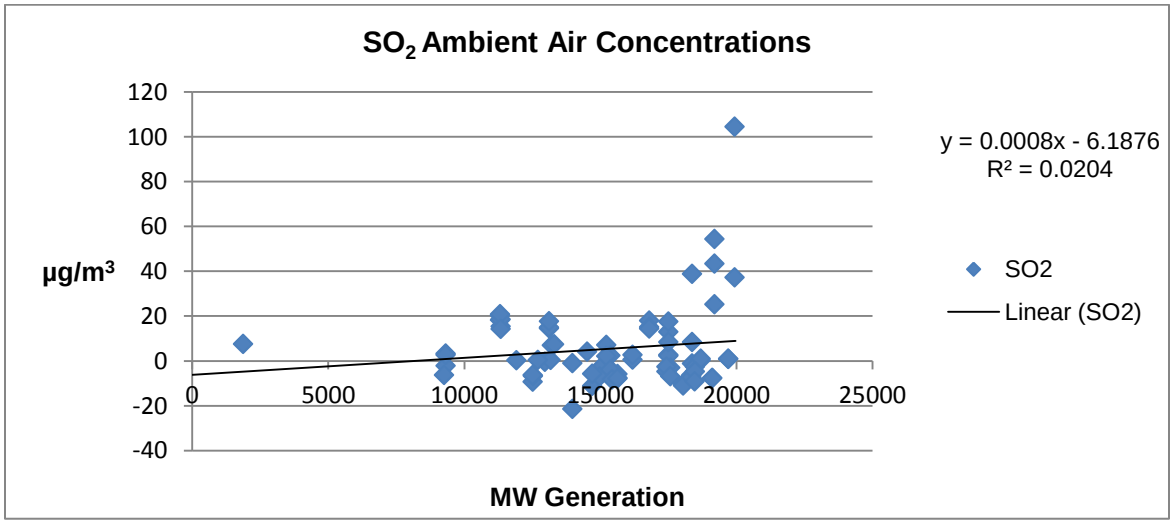


Figure 30: MW Generation and Pollutant Concentrations



[50] The averages include the sampling data from KEK MW, Dardhishte, and Obiliq Health Center during 2011 and from these three sites and KEK A, Shkabaj, US Ambassador's Residence, and Germia Park in 2012.





3.7.2 Predominant Wind Direction Considerations

There appears to be a slight increase in the PM_{10} concentrations measured when the winds originate from NE or SW. There was less of a trend observed with NO_2 and SO_2 when the winds originate from the NE or SW. See Table 20. However, additional information needs to be gathered to determine if such trends exists.

In reviewing Table 20, note the following:

- The predominant wind direction was determined to be the direction in which the winds originate at least 50% of the time during each sampling event. On several sampling days, there was no predominant wind direction. In those instances, the wind directions representing at least 50% of the sampling hours were identified as the predominant wind directions.

- NE refers to winds originating from the north-northeast and east-northeast. SE refers to winds originating from the east-southeast and south-southeast. SW refers to wind originating from the south-southwest and west-southwest. NW refers to winds originating from the west-northwest and north-northwest. These categories are shown in Figure 31.

Figure 31: Wind Direction Categories

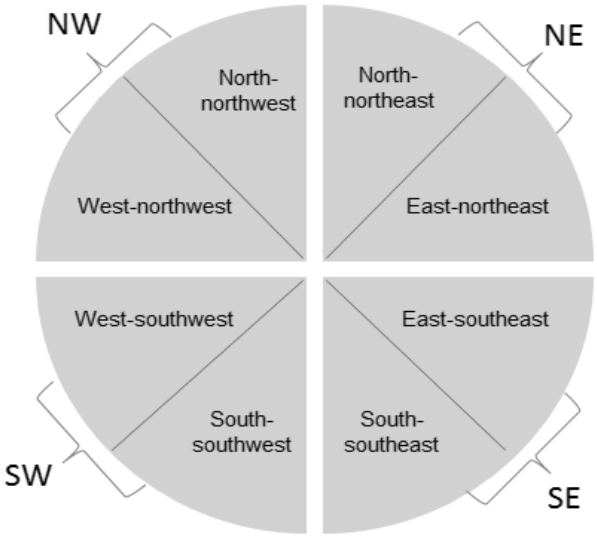


Table 20: Predominant Wind Directions and Average 24-Hour Pollutant Concentration Levels[51]

Predominant Originating Wind Direction	Concentrations (µg/m^3)				Number of Ambient Air Quality Samples
	NO_2	PM_{10}	$PM_{2.5}$	SO_2	
NE	19.83	57.64	80.73	4.75	11
NE-SE	16.10	67.16	NA	NA	1
NE-SE-SW	20.31	86.76	47.78	4.14	1
NE-SW	19.36	73.31	6.81	-10.59[52]	2
NW	14.38	46.27	89.44	4.50	11
NW-NE	13.95	44.90	40.53	6.99	13
NW-SW	19.65	54.89	89.44	-6.68	3
SE	21.79	89.86	154.94	30.31	8
SW	17.39	62.80	66.39	2.38	13
SW-NW	17.03	70.46	NA	-2.07	2
SW-SE	19.88	75.24	22.36	4.77	6

Predominant Originating Wind Direction	Average PM_{10} Concentrations (µg/m^3) at Sampling Location						
	Obiliq Health Center	KEK A	Shkabaj	Dardhishte	KEK MW	US Ambassador's Residence	Germia Park
NE	53.82	53.08	66.60	59.82	79.98	50.31	30.62
NE, SE	77.64	125.14	58.75	NA	79.17	40.42	21.81
NE, SE, SW	126.94	115.00	63.75	NA	139.17	49.17	26.53
NE, SW	11.39	15.97	NA	142.41	128.20	10.42	7.5
NW	54.64	53.85	31.25	55.86	49.50	41.23	19.88
NW, NE	45.81	41.17	36.63	48.48	56.09	28.19	23.91
NW, SW	NA	NA	NA	39.26	61.89	NA	NA
SE	125.90	126.36	53.68	78.86	86.72	103.92	37.81
SW	56.87	92.10	98.65	55.23	68.77	52.52	34.68
SW, NW	40.14	NA	NA	84.35	71.73	NA	NA
SW, SE	100.83	96.43	87.92	70.37	90.74	30.23	33.79

[51] The averages include the sampling data from KEK MW, Dardhishte, and Obiliq Health Center during 2011 and from these three sites and KEK A, Shkabaj, US Ambassador's Residence, and Germia Park in 2012.

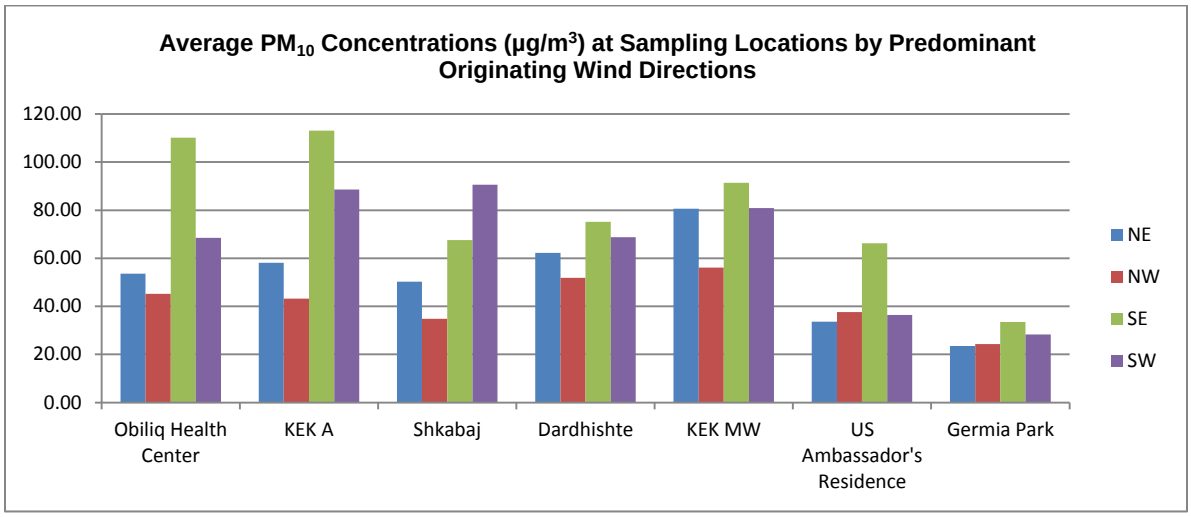
[52] Sometimes the blank filters registered higher concentrations of SO_2 than the exposed filters, resulting in a negative concentration. This was investigated with the equipment manufacturer but not fully resolved.

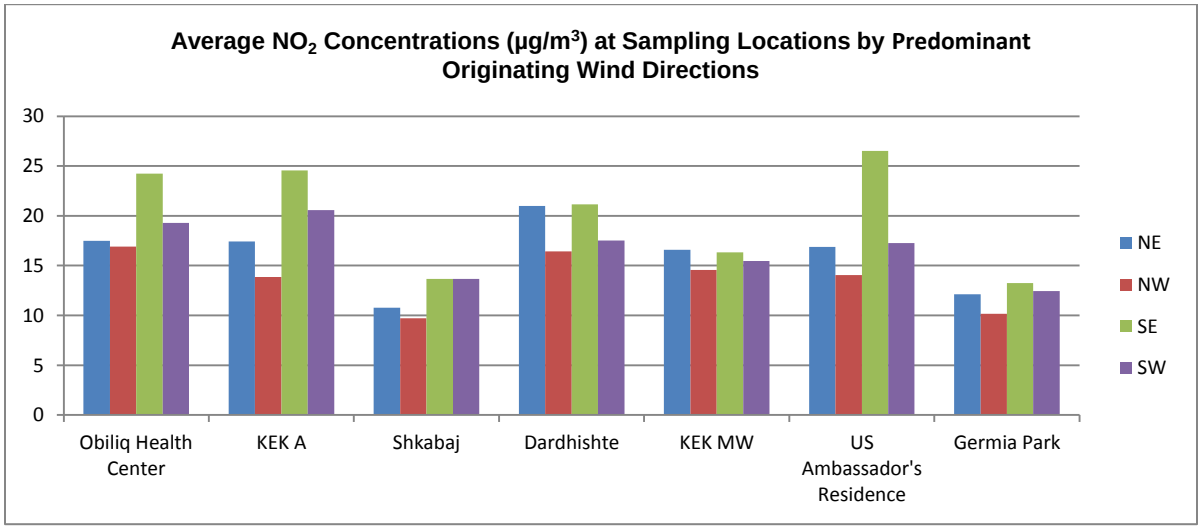
Predominant Originating Wind Direction	Average NO_2 Concentrations ($\mu g/m^3$) at Sampling Location						
	Obiliq Health Center	KEK A	Shkabaj	Dardhishte	KEK MW	US Ambassador's Residence	Germia Park
NE	20.20	23.72	7.41	25.32	17.04	19.08	16.73
NE, SE	19.42	21.04	NA	NA	9.51	19.3	11.25
NE, SE, SW	23.04	25.65	19.41	NA	14.02	25.86	13.89
NE, SW	12.69	14.27	NA	25.6	24.06	16.16	12.43
NW	19.06	15.48	7.39	15.08	13.07	15.71	8.44
NW, NE	16.35	13.86	10.28	15.64	14.53	13.34	9.37
NW, SW	NA	NA	NA	18.66	16.58	NA	NA
SE	25.23	26.36	NA	21.11	16.05	35.11	14.19
SW	19.81	22.26	NA	14.56	13.92	19.55	15.01
SW, NW	17.29	NA	NA	20.11	13.82	NA	NA
SW, SE	24.45	23.39	7.90	21.18	18.55	20.52	12.63

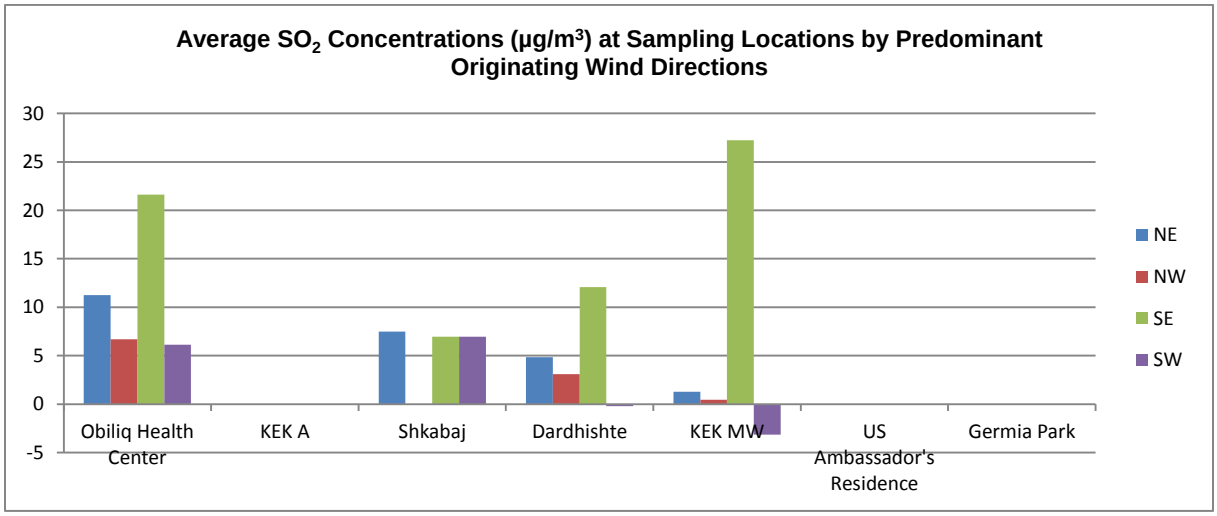
Predominant Originating Wind Direction	Average SO_2 Concentrations ($\mu g/m^3$) at Sampling Location						
	Obiliq Health Center	KEK A	Shkabaj	Dardhishte	KEK MW	US Ambassador's Residence	Germia Park
NE	20.32	NA	7.49	2.96	1.28	NA	NA
NE, SE	NA	NA	NA	NA	NA	NA	NA
NE, SE, SW	NA	NA	NA	NA	4.14	NA	NA
NE, SW	NA	NA	NA	-10.22	-10.95	NA	NA
NW	15.48	NA	NA	2.96	2.89	NA	NA
NW, NE	6.70	NA	NA	10.53	3.60	NA	NA
NW, SW	NA	NA	NA	-7.05	-6.31	NA	NA
SE	25.22	NA	NA	16.18	50.85	NA	NA
SW	4.92	NA	NA	5.77	-6.5	NA	NA
SW, NW	-2.08	NA	NA	-1.40	-2.74	NA	NA
SW, SE	18.02	NA	6.96	3.83	3.31	NA	NA

Figure 32 illustrates these same wind effects and pollutant concentrations in the form of a bar graph.

Figure 32: Average Pollutant Concentration per Sampling Location and Predominant Originating Wind Direction







3.7.3 Sampling Results Relative to Seasonal Variability

The ambient air quality sampling data gathered during 2011-2012 indicated higher 24-hour PM_{10} concentrations during the winter than in the other seasons. See Table 21. This trend was not apparent with the other pollutants. (The higher PM_{10} concentrations in the winter may be impacted by emissions from residential heating units, increased MW generation, and the lower height of the mixing layers during cooler periods of the year.)

Table 21: Average 24-Hour Pollutant Concentrations per Season[53]

Sampling Period	Sampling Locations	Concentrations (µg/m^3)			
		NO_2	PM_{10}	$PM_{2.5}$	SO_2
All Sampling	Obiliq Health Center	20.16	65.43	NA	10.51
	Dardhishte	18.87	61.19	101.76	4.94
	KEK MW	15.46	72.37	43.70	6.23
	KEK A	20.44	74.81	NA	NA
	US Ambassador's Residence	20.31	51.74	NA	NA
	Germia Park	12.67	28.54	NA	NA
	Shkabaj	10.07	63.47	NA	7.31
	All Sampling Average	*17.64*	*60.97*	*76.88*	*6.23*[54]
Fall	Obiliq Health Center	17.17	57.61	NA	12.06
	Dardhishte	14.73	51.86	12.50	13.80
	KEK MW	12.34	59.62	47.78	11.93
	KEK A	20.02	74.09	NA	NA
	US Ambassador's Residence	17.03	42.69	NA	NA
	Germia Park	11.39	24.78	NA	NA
	Shkabaj	19.41	78.06	NA	NA
	Fall Average	*15.47*	*53.95*	*24.26*	*12.55*
Spring	Obiliq Health Center	18.78	39.31	NA	-0.94
	Dardhishte	13.14	36.92	57.24	-6.24
	KEK MW	12.81	62.31	31.45	-9.88
	Spring Average	*13.69*	*45.70*	*41.76*	*-7.07*
Summer	Obiliq Health Center	16.61	57.56	NA	2.65
	Dardhishte	12.94	65.70	NA	2.30
	KEK MW	13.64	74.21	NA	NA
	KEK A	16.68	66.06	NA	NA
	US Ambassador's Residence	17.67	35.05	NA	NA
	Germia Park	12.91	30.72	NA	NA
	Shkabaj	8.90	51.81	NA	7.31
	Summer Average	*14.00*	*57.24*	*NA*	*4.89*

[53] The averages include the sampling data from KEK MW, Dardhishte, and Obiliq Health Center during 2011 and from these three sites and KEK A, Shkabaj, US Ambassador's Residence, and Germia Park in 2012.

[54] The overall averages were based on all the sampling data. The averages for the seasons reflect the number of samples gathered within the season.

Sampling Period	Sampling Locations	Concentrations (µg/m^3)			
		NO_2	PM_{10}	$PM_{2.5}$	SO_2
Winter	Obiliq Health Center	32.95	120.69	NA	13.79
	Dardhishte	30.04	86.55	146.37	9.29
	KEK MW	21.49	95.70	50.51	11.46
	KEK A	29.70	95.36	NA	NA
	US Ambassador's Residence	34.35	97.92	NA	NA
	Germia Park	17.59	39.97	NA	NA
	Shkabaj	NA	NA	NA	NA
	Winter Average	*27.15*	*91.02*	*110.42*	*10.83*

3.8 Comparison of AIO with World Weather Data

Table 22 illustrates the similarity in the meteorological data (i.e., predominate originating wind direction and wind speed) obtained from the AIOs and the weather information obtained from World Weather Online.

Table 22: AIO and World Weather Data

Data Source / Sampling Date	Dituria		Germia Park		KEK A		KEK MW		HMI		World Weather		Sample Start Time
	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	
15-16 August 2012	0.95	NW-SE-SW	NA	NA	NA	NA	NA	NA	NA	NA	1.06	NE	15:00
21-22 August 2012	0.55	NW	NA	NA	NA	NA	NA	NA	NA	NA	0.75	SW-SE	11:00
23-24 August 2012	0.55	SW-SE	NA	NA	NA	NA	NA	NA	NA	NA	0.70	SW-SE	10:00
27-28 August 2012	0.67	NW-SW	NA	NA	NA	NA	NA	NA	NA	NA	3.03	NW	10:00
30-31 August 2012	NA	NA	NA	NA	0.75	SE	1.00	SW	0.90	SE-SW	1.14	NE	10:00
5-6 September 2012	NA	NA	NA	NA	0.99	NE-SE	1.20	NE-SE	1.10	NE-SE	1.36	SW	10:00
10-11 September 2012	NA	NA	NA	NA	0.80	NE-SE	0.95	SW-SE	0.94	SE-NE	1.32	SE	10:00
13-14 September 2012	NA	NA	3.03	NE	1.65	SE	1.85	SE	NA	NA	2.24	SE	10:00
18-19 September 2012	NA	NA	2.25	NE	0.73	NE-SE	1.69 (19 September)	SW	1.05	SW-SE	1.06	NE-SE	11:00
24-25 September 2012	NA	NA	2.48	NE-SW	0.91	SW	2.12	SW	1.63	SW	2.58	SW	10:00
26-27 September 2012	0.78	SW-NW	3.01	NE-SW	0.91	SE-NE	1.14	SW	1.34	NE-SE-SW	1.76	SW	11:00
2-3 Ocotober 2012	NA	NA	NA	NA	1.12	NE-SE	1.7	SW-NW-NE	1.26	SSW-SW	1.58	SW	10:00
8-9 October 2010	NA	NA	NA	NA	1.20	NE	1.63	NE	1.12	NE-NW	1.93	NW-NE	10:00
10-11 October 2012	NA	NA	NA	NA	0.71	NE-NW	0.99	SW-SE	0.81	SW-NE	0.85	NE-SW-SE	10:00
15-16 October 2012	NA	NA	NA	NA	0.73	SW-SE	1.66	SW	1.34	SW-SE	2.33	SW-SE	10:00
18-19 October 2012	NA	NA	NA	NA	0.47	NE	0.61	SW	0.73	NE-SW	0.84	SE	10:00
23-24 October 2012	NA	NA	NA	NA	1.26	NE	1.62	NE	1.08	NW-NE	1.58	NW	10:00
29-30 October 2012	NA	NA	NA	NA	NA	NA	2.66	NE	NA	NA	2.20	NE-SW	11:00

Data Source / Sampling Date	Dituria		Germia Park		KEK A		KEK MW		HMI		World Weather		Sample Start Time
	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	
1-2 November 2012	NA	NA	NA	NA	NA	NA	2	SW	0.99	NE (2 November)	2.63	SW-SE	10:00
5-6 November 2012	NA	NA	2.20	SE-SW	2.00	SW-NE	3.27	SW	2.55	SE	2.53	SW	10:00
7-8 November 2012	NA	NA	1.19	NE	1.05	NE	1.42	NE-SW	0.86	NE	2.20	NW	10:00
13-14 November 2012	NA	NA	1.91	NE	2.21	NE	2.79	NE	1.78	NE	2.42	NW	10:00
15-16 November 2012	NA	NA	1.19	NE	1.33	NE	1.19	NE	0.79	SE-SW	1.37	NE	13:00
19-20 November 2012	NA	NA	NA	NA	0.79	NE-NW	1.25	NE	0.92	SE-NE	1.71	NE	10:00
21-22 November 2012	NA	NA	NA	NA	1.43	NE	1.72	NE	0.92	SE	1.32	NE	10:00
29-30 November 2012	NA	NA	NA	NA	2.40	SE	2.32	SW	2.48	SE	3.26	SW	10:00
11-12 December 2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.09	NW	10:00
13-14 December 2012	NA	NA	NA	NA	NA	NA	0.78	NE-SW	0.48	SW-NW	1.72	SE	10:00
17-18 December 012	NA	NA	NA	NA	0.64	NE	NA	NA	0.89	NW-SW	1.45	NE	10:00
19-20 December 2012	NA	NA	NA	NA	2.24	NE	2.35	NE	1.63	NW	2.68	NW	10:00
27-28 December 2012	NA	NA	NA	NA	0.93	SE-NW	NA	NA	NA	NA	1.67	SW	10:00

Data Source / Sampling Date	Dituria		Germia Park		KEK A		KEK MW		HMI		World Weather		Sample Start Time
	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	Average WS (ms)	Predominant Wind Direction	
14-15 January 2013	NA	NA	NA	NA	NA	NA	2.64	SW	NA	NA	8.38	SE	10:00
16-17 January 2013	NA	NA	NA	NA	NA	NA	1.53	SE	NA	NA	5.81	SW	10:00
21-22 January 2013	NA	NA	NA	NA	NA	NA	2.47	SE	2.72	SE	6.44	SW	10:00
23-24 January 2013	NA	NA	NA	NA	NA	NA	1.93	SE	1.87	SW	6.44	SW, SE	12:30
29-30 January 2013	NA	NA	NA	NA	NA	Na	0.77	SE-NE	0.67	SW-NW	2.38	SW	9:30
31 January - 2-February 2013	NA	NA	NA	NA	NA	NA	1.10	SE-NE	0.88	SW-NW	4.06	SW	10:00
4-5 February 2013	NA	NA	NA	NA	NA	Na	0.88	SE	NA	NA	2.25	SW	9:00

3.9 Summary of Assessment Observations

The similarity between 2011 ambient air dispersion modeling estimates and the 2011-2013 sampling results provides a basis for suggesting the data presented in this report are representative of conditions in and around Kosovo TPP A and TPP B. In addition, during the second phase of the initial assessment there was only one instance in which the mobile monitoring equipment did not sample pollutants in the ambient air for more than 18 hours. Thus the data capture issue experienced during the period January through June 2012 was addressed through more rigorous equipment maintenance procedures resulting in over 820 ambient air quality samples analyzed to assess potential impacts. See Appendix 3 for additional information about data capture results during the second phase of the assessment.

The dispersion modeling data indicated that the highest 24-hour pollutant concentration levels are within 5-10 km of the power plants and in the high terrain elevations in the nearby mountains. This observation was supported by the 24-hour sampling data which indicated a decrease in pollutant concentrations at the sampling sites located farther away from the power plants.

The PM_{10} concentrations in the ambient air are influenced by wind speeds, mixing layer considerations, ESP efficiencies, downwash, and wind direction. This finding was determined though an analysis of the plume dispersion patterns modeled by AERMOD and SCIPUFF/SCICHEM and an evaluation of the sampling results relative to wind speed and direction. The concentrations tend to be higher when wind speeds are low and in areas downwind from the predominant originating wind direction.

The PM_{10} sampling and modeling results suggest that the concentrations in the ambient air are above the 24-hour 50 $\mu g/m^3$ EU Limit Value. This situation occurs when the concentrations in the ambient air equal or exceed the limit value more than 35 times during a calendar year. The sampling results show a slight increase in the 24-hour PM_{10} concentration levels as a function of increased MW generation and when the winds originate predominantly from the NE and SW. (The dispersion modeling report refers to these originating wind directions as north including north-northeast and north-northwest, and south including south-southeast and south-southwest.)

The modeling results indicate that the PM_{10} concentrations in areas located next to Kosovo TPP A and TPP B are above the 40 $\mu g/m^3$ annual EU Limit Value, but below the standard as the distance from the power plants increases.

When the PM_{10} concentrations are modeled relative to differing ESP efficiencies, the results suggest that the 24-hour PM_{10} concentrations in the ambient air relative to emissions from Kosovo TPP Units A and B might be reduced below the EU 24-hour limit value with increased particulate capture (greater efficiency) at current MW operating levels. Although the PM_{10} sampling results obtained in 2013 were variable, the lower average concentration in February supports the notion that increased ESP efficiencies can reduce pollutant concentrations in the ambient air.

The 24-hour NO_2 sampling data suggest that the concentrations in the ambient air are below the annual 40 µg/m^3 limit value. These data were aligned with the modeling results for NO_2. However, the modeling results indicate the 1-hour EU 200 µg/m^3 limit value for NO_2 may be exceeded.

With regard to SO_2, the lignite contains a low percentage of sulfur and the ash has a high percentage of CaO. This suggests that natural scrubbing might be occurring to reduce the sulfur emitted through the stacks. However, the 24-hour SO_2 sampling results varied considerably from the modeling data, even though the scrubbing factor was incorporated into AERMOD.

The 24-hour, 7-day, and 14-day sampling results indicated low to non-existent levels of SO_2 and the 24-hour modeling estimates indicated values above the EU limit of 125 µg/m^3. This variability may be related to underestimating the control efficiency related to CaO or the formulation of fine particles as reflected in the $PM_{2.5}$ sampling results. The $PM_{2.5}$ filter analysis and the NH_3 results suggest additional research is needed to more fully understand fine particle formation.

The modeling results also suggested that the EU 1-hour limit value of 350 µg/m^3 for SO_2 is being exceeded more than 24 times in a calendar year.

Overall, the modeled concentrations for SO_2, NO_2, and PM_{10} in the ambient air are influenced by Kosovo TPP A more so than by Kosovo TPP B, or the fugitive emissions from the ash pile or conveyor drop at the ash pile. One of the factors most likely underlying the differing impacts is the lower stack heights at Kosovo TPP A.

4.0 RECOMMENDATIONS FOR NEXT STEPS

A number of observations related to pollutant concentration levels in the ambient air and plume dispersion were noted in this assessment. To build on USAID/Kosovo's assessment effort, the recommendations listed below are suggested for consideration.

These recommendations focus on developing a more comprehensive data set for evaluating pollution control options for Kosovo TPP A and B and should be undertaken with HMI and local professionals so as to leverage the capacity building activities USAID/Kosovo has engaged in since 2010.

4.1 Enhance Dispersion Modeling Estimates

Enhance the specificity of the AERMOD and SCIPUFF/SCICHEM dispersion modeling estimates[55] for each of the primary pollutants included within the scope of the initial assessment so as to:

- Reflect up-to-date and actual conditions within Kosovo, in particular with respect to hourly emissions;
- Generate estimates for NO_2 and SO_2 that more closely reflect ambient air quality conditions;
- Serve as a base for evaluating potential reductions in PM_{10} concentrations with enhanced ESP efficiencies; and
- Evaluate potential contributions to pollutant concentrations in the ambient air related to new power plant construction.

This effort would include updating model inputs with: 2012 meteorological data; 2012 daily, monthly, and annual coal and oil consumption data; 2012 daily and monthly coal and ash analyses; and 2012 stack temperature and velocity data for each of the stack.

4.2 Expand Mobile Ambient Air Sampling Program

Continue and expand the Airmetrics and Ogawa mobile ambient air sampling program for the primary pollutants so as to:

- Obtain additional ambient air quality samples to evaluate annual averages of pollutants in the ambient air;
- Better understand plume dispersion in and around the power plants;
- Obtain a more complete data set with which to evaluate PM_{10} concentrations relative to ESP upgrades; and
- Evaluate the potential role of background concentrations or other sources of pollutants (e.g., ash pile) relative to the ambient air quality results.

[55] USEPA indicated during the study tour that it is common practice to update dispersion modeling outputs as new data become available.

This sampling effort would augment the data that will be gathered through the fixed monitoring equipment at Dardhishte, KEK MW, and the Obiliq Health Center. As such, the expanded program would feature:

1. Gathering of 24-hour samples of ambient air at:
    - KEK A, the US Ambassador's Residence, Germia Park, a sampling location along the valley ridges to the southwest and west of KEK, and sampling locations near the mine and ash pile to monitor plume dispersion and fugitive emission impacts.
    - Historic or archeological sites near the power plants, such as the Castle of Harilaq, to assess emission levels and plume dispersion.
2. Gathering background ambient air quality data through a coordinated effort with the EU-sponsored ambient air quality programs and/or by assessing background concentrations at a few mobile monitoring stations located outside the main areas of plume dispersion.
3. Installing a cam recorder near the power plants to observe plume dispersion. The information gathered through the cam recorder would augment the meteorological data, and provide insights for interpreting the Gaussian and puff characteristics of plume dispersion from the power plants.

4.3 Further Investigate SO_2 Emissions and Fine Particle Formation

Seek to further understand the deposition and dispersion of sulfur in the stack emissions by:

- Undertaking a more in-depth analysis of the chemical composition of coal and ash relative to stack temperatures to evaluate the potential for sulfur conversion to form fine particulates.
- Engaging in limited stack testing to obtain some data on emissions. This is particularly relevant for Kosovo TPP B to more fully understand how the emissions are impacting pollutant concentrations in the ambient air.
- Developing an inventory of potential emission sources in the valley that might be emitting chemicals that combine with sulfur to form fine particulates.

4.4 Sample Inorganic and Organic Carbon in the Ambient Air

Deploy sampling equipment throughout the year to measure inorganic and organic carbon to evaluate the potential contribution of residential heating devices to PM_{10} and $PM_{2.5}$ concentrations in the ambient air, especially during the winter.

4.5 Obtain Meteorological Data from a 30-Meter Anemometer

Obtain meteorological data from a 30-m anemometer located in close proximity to the power plants to obtain more detailed information about wind speed and direction for dispersion analysis. This information could also be used as the primary source of meteorological data for sampling and for dispersion modeling, supplemented by data from local Prishtina sources.

4.6 Build a Technical Exchange Program

Engage in an effort to build a technical exchange program between Kosovo and USEPA. The purpose of this program would be to obtain a base of knowledge that could be used by HMI to estimate expenses for operating and maintaining ambient air quality monitoring equipment, learn about current and evolving ambient air quality monitoring equipment technologies and methodologies, and possibly obtain guidance as to the types of information that might be helpful in developing a country-wide ambient air quality management program.

APPENDIX 1: KOSOVO MOBILE AMBIENT AIR MONITORING EQUIPMENT MAINTENANCE AND USE PROCEDURES

1.0 Introduction

Data capture, time coverage, and uncertainty are important considerations in sampling air quality and evaluating the concentration data relative to EU standards.

- Data capture refers to the number of days within a given year that ambient air quality data are gathered and on which there were no equipment malfunctions or other situations that resulted in an inability to obtain a sample per the sampling schedule. The EU standards generally require 90% data capture with the appropriate time coverage to calculate annual mean concentrations.
- Time coverage refers to the distribution of samples taken over a given period of time. For example, to determine annual average concentrations, samples would need to be gathered evenly across the year.
- Uncertainty refers to the variability in the sampling procedures that influences the data gathered (e.g., the monitoring equipment does not consistently sample the ambient air, creating gaps in time coverage).

For the purposes of the ambient air assessment program to evaluate potential impacts from Kosovo TPP operations, the provisions of data capture, time coverage, and uncertainty were addressed, on a relative basis, by implementing the maintenance, sampling, and data handling procedures outlined below.

These equipment maintenance, and use provisions are designed to help ensure the mobile monitoring equipment is operating as designed, potential equipment malfunctions are identified early to prevent failure or malfunctions in the field, and potential contamination of unexposed and exposed sampling filters is minimized.

By implementing these procedures, the overall objective is to obtain representative samples of ambient air on a weekly, monthly, quarterly, and annual basis to measure the concentrations of PM_{10}, SO_2, and NO_2.

2.0 PM Sampling and Equipment Maintenance Procedures[56]

The Airmetrics MiniVol™ TAS is a portable monitoring device designed to gather samples of PM_{10} and $PM_{2.5}$ in the ambient air. The monitoring device is basically a pump controlled by a timer and operated by lithium and AA batteries. It is composed of four basic components: impactor/filter holder assembly, flow control system, timer, and battery pack.

[56] The information sources used to prepare this section include The MiniVol™ Tactical Air Sampler (TAS) Operations Manual Rev. 1.2, and information obtained from conversations with the equipment manufacturer.

The procedures for using and maintaining the PM mobile monitoring devices are described in the sections below.

2.1 Assign Each Monitoring Device to a Specific Sampling Location

Each Airmetrics monitoring device and associated batteries should be assigned to a specific sampling location for the entire sampling program in 2012 through 2013. This approach provides a mechanism to track the performance of equipment and to identify early signs of equipment malfunctions or battery issues. This information will be used to assess gaps in data capture and time coverage.

2.2 Handle and Manage Unexposed PM Filters to Minimize Contamination

1. Pre-weighed filters are shipped from RTI International to Kosovo on a monthly basis. Each pre-weighed filter will be housed within a petrislide.
2. The filters need to be used within a 30-day period of time. Therefore, it is important to use the filters in the sequence reflected in the Chain of Custody form provided by RTI International with the filter shipment. For example, with each shipment, the Chain of Custody form will appear as follows:

RTI Chain of Custody

PM_{10} Gravimetric Analyses

Client Name: _____ Project No.: _____

Contact Name: _____ Phone: _____

If you have any questions, please contact RTI.

Part I. Weighing Laboratory

Packaged By: _____ Date: _____

Shipped Via: _____ Airbill No.: _____

Filter ID No.	Cassette No.	Weighing Date	Expiration Date	*Date Sampled**	*Average Flow Rate**	*Total Elapsed Time**	*Sample Volume**

3. As the filters are used for monitoring, record the date sampled on the Chain of Custody form, and also record the filter number on the Field Data Log as illustrated above. This will help ensure the traceability of the filters as part of the QA procedures.
4. Unused filters need to be kept free of contamination. Therefore, they should be kept in closed petrislides, gently handled, and not allowed to become hot.

2.3 Check Flow Rate Prior to Equipment Use in the Field

In order for the MiniVol sampling device to capture samples to measure the concentrations of PM_{10} or $PM_{2.5}$ in the ambient air, the volumetric flow rate through the impactor must be 5 liters per minute at ambient conditions. Therefore the flow rate needs to be checked and the 5 liters

per minute rate verified prior to placing the equipment in the field to gather ambient air quality samples for analysis.

To check the flow rate, the following activities should be undertaken in the laboratory or office immediately before bringing the equipment into the field:

1. Place a pre-weighed PM filter into the MiniVol sampler filter holder and attach the filter holder assembly to the sampler. Record the filter number on the Field Data Log. Use forceps or tweezers to minimize potential contamination to the filter.
2. Remove the impactor/filter holder assembly from the inlet tube. Make sure the inlet tube is fully extended and the compression fitting tight.
3. Turn on the sampler and allow it to warm up to full operating temperature (at least 2 minutes). Under normal conditions the flow rate reaches 5 liters per minute. (Note: The flow rate adjustment knob varies the sampler's flow rate. Turn the knob until the flow rate reaches the desired level. The light-emitting diode (LED) will light as the flow rate is being adjusted. The LEDs will turn off when the microcontroller has stored the set point. (Do not turn the sampler off while the LEDs are lit because it may cause an erroneous set point.)
4. Cover the air inlet tube with the palm of the hand while the pump is running. The ball in the flow meter should drop to zero and remain there without movement.
5. If the ball in the flow meter drops, the Low Flow Indicator LED will activate and the sampler will shut down after 15-20 seconds. Push the reset button twice to reactive the sampler. The equipment is ready for use in the field.
6. Document the Flow Rate Check on the Field Data Log for the specific piece of equipment (see Section 4.1 of this Appendix).
7. If the ball does not drop, a leak exists somewhere in the hoses and fittings between the inlet and the flow meter. Leaks on the inlet side of the pump are especially critical since flow measurement will not accurately reflect the amount of air passing through the filter.
8. To isolate a leak, use the following procedure:
    a. Verify the inlet tube is extended.
    b. Remove the four faceplate screws and the sampler mount screw to assess the sampler pump and plumbing.
    c. Verify that all hose fittings are secure.
    d. Check for cracks in the flow meter inlet and outlet.
    e. Check for cracks in the pulse dampener.
    f. Check and tighten all compression fittings.
9. After securing any loose fittings and if no other problems are noted, reassemble the equipment and repeat Steps 1-8 above:

a. If the flow rate is 5 liters per minute record the flow meter check on the Field Data Log.

b. If flow rate problems persist, follow the guidance in Section 2.12 below. Do not use this monitoring device in the field until the flow rate problem is resolved. Use one of the backup PM monitoring devices and repeat the steps above to verify the flow rate is 5 liters per minute. Record the information, including the equipment number and battery on the Field Data Log.

2.4 Recharge Lithium Batteries Prior to Equipment Use in the Field

1. Recharge the lithium battery providing voltage to the pump before each use. The typical battery pack life is > 500 charging cycles.
2. Do not keep charged batteries in the monitoring equipment when not in use.
3. If the battery cannot be recharged, use the backup battery associated with that particular monitoring device.
4. Record on the Field Data Log that the battery had been fully charged, the battery number, and equipment the battery will be placed in.
5. Note on the Maintenance Log the battery could not be recharged and include the battery number.

2.5 Check Programmable Timer Battery Prior to Equipment Use in the Field

1. A single AA battery located on the back of the circuit board operates the programmable timer. The lifetime for this battery is 6 months. Check to make sure the battery is secure.
2. If the battery looks damaged, replace it with a new AA.
3. Record this check on the Field Data Log for that particular monitoring device.

2.6 Control Impactor Condensation

To control excess condensation in the impactor/filter assembly and possible damage to the filter, make sure the impactor is firmly secured to the equipment and thoroughly air dried prior to use. Annotate the Field Data Log to indicate this check has been done. (Note: If condensation is observed after the sampling run is completed, the exposed filters should be removed and placed in the petrislides as soon as possible.)

2.7 Gather PM Samples in the Field

1. Review the sampling schedule for PM_{10} and $PM_{2.5}$ and bring to the field the appropriate impactors and equipment that have been checked for air flow, batteries, and condensation.
2. Transport the samplers to the field sites with the appropriate impactor/assemblies (PM_{10} or $PM_{2.5}$).
3. Verify that the sampler will be positioned with the intake upward in an unobstructed area at least 30 centimeters (cm) from any obstacle to airflow.

4. Loosen the inlet tube compression nut and extend the inlet tube to the maximum height and re-tighten the nut.
5. Remove the clean impactor/filter holder assembly from the plastic transport bag or case.
6. Attach the assembly to the top of the sampler inlet tube.
7. Record the temperature, wind speed, wind direction, and pressure at the monitoring site at the initiation of sampling activities and record the data on the Field Data Log.
8. Press the ON button and confirm the desired sample day and time have been set.
9. Initiate sampling event at each site in accordance with the sampling plan.

2.8 Check Equipment Error Conditions in the Field

At the end of the sampling event, note whether any of these conditions below are present. Record the applicable conditions on the Field Data Log, and perform the following maintenance activities.

1. If the Low Battery Indicator is on at the end of the sampling period, check the Elapsed Time Totalizer to determine the length of time the sampler ran before shutting down. In the laboratory or office, recharge the battery. If the battery cannot be recharged, replace it with the backup battery and record on the Maintenance Log. If the backup battery performs in the same manner, the pump motor may need to be repaired or replaced (see instructions in Section 2.12).
2. If the Low Flow Indicator is on at the end of the sampling period, check the Elapsed Time Totalizer to determine the length of the time the sampler ran before shutting off. The causes of low flow and subsequent shut down of the pump may be related to:
    a. Insufficient voltage going to the pump. This will usually occur if the pump needs to be rebuilt or replaced. See Section 2.12.
    b. Air restriction. If the battery is sound the problem may be due to a restriction in the air inlet filter holder or tubing. Check for crimps or other restrictions.
    c. Excessive moisture on the filter to cause enough flow resistance for the low flow indicator to come on.
    d. Pump malfunction due to damaged or contaminated pump head components. See Section 2.12.

When the Low Battery or Low Flow Indicator LEDs are flashing, the system can be restarted by pressing the Reset Button twice. The equipment should run enough to perform a field inspection and to obtain final flow rates.

Record problems with the Low Flow Indicator on the Maintenance Log.

2.9 Handle Exposed PM Filters with Care

1. After sampling in the field bring the equipment back to the laboratory or office and unscrew the filter holder and remove the filter cassette.
2. Locate the petrislide with the filter number that matches the number on the side of the filter holder assembly.
3. Use the cassette separator to remove the top half of the filter cassette.
4. Using forceps or tweezers remove the exposed filter from the filter cassette and place it into its original petrislide with the exposed side of the filter facing up, replacing the Petrislide™ lid when finished. (Replace the filter support screen in the filter cassette assembly.)
5. Place the petrislides with exposed filters into a refrigerator until shipping for analysis.

2.10 Blank Filters

For the PM sampling events, blanks will not be prepared or sent to RTI International for analysis. RTI uses blanks to assess any potential contamination in the laboratory during pre-weighing activities.

2.11 Conduct Periodic EMT and Impactor/Filter Holder Assembly Maintenance

Under average conditions, assuming 24-hour sample runtimes, the Easy Maintenance Target (EMT) and the impactor assembly should be cleaned and greased every fifth sample or every two weeks. This frequency can be increased depending on the sample loading.

1. Remove the EMT from the assembly.
2. Clean the EMT by wiping with a clean lint-free cloth or paper towel.
3. Apply a small amount of low vapor grease to the EMT using a spreading or buttering motion.
4. Remove excess grease.
5. After removing the EMT, the impactor assembly should be cleaned using soapy water and rinsed thoroughly.
6. After the impactor assembly has been air dried, the o-rings should be inspected and replaced if necessary.
7. Apply a thin coat of low vapor grease to the o-rings on the impactor and in the filter holder outlet and louvered inlet. Do not grease the o-rings inside the filter holder that seal against the filter cassette. This could contaminate the sample filter.
8. Re-insert the EMT into the impactor assembly.
9. Remove any extraneous material from the exterior of the impactor then re-insert the impactor into the top of the filter holder assembly.

10. Record the Periodic EMT and Impactor Check on the Maintenance Log for the specific piece of equipment (see Section 4.3).

2.12 Conduct Periodic Pump and Diaphragm Checks

After continued use the pump values and diaphragms become dirty and worn. This condition results in irregular flow rate or an inability to adjust the flow rate.

1. Conduct periodic pump and diaphragm checks every 2 weeks.
2. Examine each piece of equipment's pump values and diaphragms for dirt and wear. The side of the pump on which the values are worn or dirty is easily determined by pinching the inlet tubes leading to the pump.
3. Under normal conditions the flow rate will drop by the same amount for both sides as the lines are restricted. If the flow rate drops less for one side, the valves on that side need cleaning or replacing.
    a. Remove the pump head making a note of the orientation of the head and valves.
    b. Inspect and replace the valves and diaphragms that are worn or damaged using the rebuild kit.
    c. Clean the diaphragm and valves that are in good working order with soapy water, rinse, and dry.
    d. Flip each component and replace in the same order.
    e. Screw on the pump head, taking care to match the alignment of the inflow and outflow ports on each pump head.
4. Repeat for opposite side of the pump.
5. Record the Periodic Pump and Diaphragm Checks on the Maintenance Log for the specific piece of equipment (see Section 4.2).

2.13 Replace Programmable Timer AA Batteries Every 5 Months

1. The lifetime for an AA battery that operates the programmable timer is 6 months. To ensure operability, replace every 5 months.
2. Record this maintenance on the Maintenance Log for the specific piece of equipment (see Section 4.3).

2.14 Conduct Annual Flow Recalibrations

Each Airmetrics sampling device should be recalibrated once a year and/or if the flow meter is replaced. Record the annual check on the Maintenance Log.

3.0 SO_2 and NO_2 Sampling and Equipment Maintenance Procedures[57]

The Ogawa Passive Sampling Devices are virtually maintenance-free. However, each sampler should be numbered so that the cleaning activities outlined in Section 3.2 can be tracked and recorded on the Field Data Logs.

3.1 Maintain Shelf Life and Minimize Contamination of Ogawa Filters

1. Unexposed filters for the Ogawa passive sampling equipment will be shipped on a monthly basis to Kosovo for use to ensure an appropriate shelf life (roughly 90 days).
2. The aluminum container holding the unexposed filters should be placed in the refrigerator to maintain shelf life.

3.2 Clean Ogawa Equipment Prior to Use in the Field

1. The Ogawa passive sampling equipment should be clean and ready for use prior to sampling. All sampler components should be carefully rinsed with water and dried before each use.
2. Record the completion of this activity on the Field Data Log for the Sampling Location.

3.3 Gather SO2 and NO2 Samples to Minimize Contamination

1. Using tweezers or forceps remove unexposed Ogawa filters from the aluminum storage container and place in cleaned sampling equipment prior to use in the field.
2. The aluminum filter storage container should be placed back into the refrigerator after the unexposed filters are removed and placed into the sampling devices.
3. The Ogawa sampling equipment should be placed in designated sampling locations with the equipment shelters in place.
4. After the 24-hour sampling event is complete for NO_2 or longer for SO_2, the exposed sampler should be placed into the brown storage container with the lid and brought back to the laboratory to remove the exposed filters.

3.4 Remove the Exposed Ogawa Filters after Completion of Sampling Run

1. In the laboratory or office, remove the exposed Ogawa filters with tweezers, place them into individual vials (one for each sampling location), and refrigerate until shipping for analysis.
2. The vials containing exposed Ogawa filters need to be labeled with the sampling location, date, and pollutant analyzed.

[57] The information sources used to prepare this section include the "NO, NO, NOx and SO_2 Sampling Protocol Using the Ogawa Sampler," and information obtained from conversations with the equipment manufacturer.

3.5 Blanks

Analysis of blank samples is factored into the concentrations of SO_2 and NO_2 in the ambient air as measured on the exposed filters. Therefore, one sampler for NO_2 and one sampler for SO_2 should be loaded with a clean filter and allowed to sit in the laboratory during the sampling event. At the end of the sampling event the equipment should be placed in the brown storage container and the filter removed and place into a shipping vial and appropriately labeled.

4.0 Field Data Logs, Chain of Custody Forms, and Maintenance Logs

4.1 Field Data Logs

Field Data Logs need to be prepared for each sampling event and sampling location. All of the informational requirements in the form need to be completed.

Field Data Log					
Sampling Location:					
Sampling Date: Day/Month/Year		**Sampling Start Time:**			
		Sampling End Time:			
Pollutants Measured (Please check all that apply)	**PM10**		**Weather Conditions**	**Temperature**	
	SO2			**Pressure**	
	NO2			**Wind Speed**	
	PM2.5			**Wind Direction**	

TPP Units Operating on Day of Sampling (please mark each unit operating)				
A3	**A4**	**A5**	**B1**	**B2**

Ogawa Sampler Equipment Number	Ogawa Equipment Cleaned and Dried Prior to Use
	Yes _____ No _____

PM Sampling Equipment Checks and Data			
PM Impactor Type	**PM10 ___ PM2.5 ___**	**Lithium Battery Recharged Prior to Use**	**Yes ___ No ___**
Filter Number		**No Condensation Present in Impactor**	**Yes ___ No ___**
Equipment Number		**Flow Meter Check Conducted**	**Yes ___ No ___**
Check of Operability of AA Timer Battery was conducted	**Yes ___ No ___**	**Flow Meter Reading**	
Lithium Battery Number		**Elapsed Flow Meter Reading**	

PM Sampling Equipment Checks After Sampling Run	
Low Battery Indicator LED On: Yes ___ No ___	**Low Flow Indicator LED on: Yes ___ No ___**
Recharge Button Pressed Twice: Yes ___ No ___	**Recharge Button Pressed Twice: Yes ___ No ___**

4.2 Chain of Custody Form

The RTI International Chain of Custody form for pre-weighed filters should be used to guide the sequence of filters used for shelf life purposes and as a check on the use of the filters. See Section 2.0.

RTI Chain of Custody

PM_{10} Gravimetric Analyses

Client Name: _____ Project No.: _____

Contact Name: _____ Phone: _____

If you have any questions, please contact RTI.

Part I. Weighing Laboratory

Packaged By: _____ Date: _____

Shipped Via: _____ Airbill No.: _____

Filter ID No.	Cassette No.	Weighing Date	Expiration Date	*Date Sampled**	*Average Flow Rate**	*Total Elapsed Time**	*Sample Volume**

4.3 Maintenance Logs

A Maintenance Log should be filled out for each Airmetrics PM mobile sampling device.

The log will serve as a reference point to confirm that the equipment was properly maintained or repaired.

The completion of the form will help demonstrate that the devices were operating in accordance to the design of the equipment and generating results that can be used to assess ambient air quality.

Equipment Maintenance Log			
Equipment Information			
Equipment Number:		**Lithium Battery Numbers:**	
Periodic Cleaning of EMTs and Impactors, and Pump and Diaphragm Checks (Record Day, Month, Year)			
Biweekly EMT and Impactor Cleaning		**Biweekly Pump and Diaphragm Check**	
Record Any Issues Noted During the Monthly Maintenance Checks and Whether the Device was Repaired or Taken out of Service			
AA Battery Replacement (Record Day, Month, Year)			
Record the Number of Malfunctioning Battery (Record Date Taken Out of Service)		**Annual Flow Check (Record Day, Month, Year)**	

5.0 Shipping Filters for Analysis

1. At the end of each month or the completion of 24-hour sampling events, the vials containing Ogawa SO_2 and NO_2 exposed filters, and the petrislides containing exposed PM_{10} and $PM_{2.5}$ filters are to be sent off-site for analysis.
2. Copies of the Field Data Logs should be sent to RTI International with the filters.
3. Cadmus will work with Kosovo to schedule the shipment of exposed filters to RTI International. This will include sending shipping labels and associated documentation that have been prepared by RTI International and placing the vials and petrislides in a box for shipping.
4. The specific address is:

   Microanalytical Sciences
   RTI International
   3040 East Cornwallis Road
   Post Office Box 12194
   Research Triangle Park, NC 27709-2194

APPENDIX 2: AUDITING ACTIVITIES

1.0 Introduction

This section outlines the auditing activities engaged in to confirm the following:

- Ambient air quality sampling results are representative of conditions in Kosovo, in that the sampling equipment was maintained, sampling filters were used in an appropriate sequence and timeframe, relevant weather and operational conditions were recorded to help interpret the ambient air quality results, and the established methodologies for calculating pollutant concentration levels on the sampling filters were used consistently.
- The RTI spreadsheet as prepared accurately calculates relevant information for proper analysis of samples.
- The aggregation of ambient air quality data includes only those analytical results deemed valid and therefore can be used to assess potential impacts from TPP operations.
- The processes for estimating annual concentrations of pollutants in the ambient air reflect the EU's data capture, time coverage, and data quality provisions.

2.0 Auditing Activities

2.1 Audit to Validate Ambient Air Quality Sampling Results

To confirm that the ambient air quality results represent conditions in Kosovo, the following steps were implemented.

Step 1: Verify Completion of Required Field Logs and Chain of Custody Forms. Once field data logs were uploaded to the project web site, the data were reviewed to confirm that there was a corresponding Field Data Log for each recorded sampling result, and vice versa.

The Chain of Custody and Field Data Logs were reviewed verify that:

- The PM filters were used within 30 days and in the order identified in the Chain of Custody form.
- The Field Data Logs were completed. Particular attention was placed on confirming that the following data have been recorded:
    - Sampling start and/or end time
    - Equipment ID number
    - Filter ID number, battery number
    - TPP Units in operation during sampling event

- The weather log was completed and information logged matches source data (http://www.worldweatheronline.com/v2/weather.aspx?q=PRN&day=0).
- The AIO weather data corresponds to the data recorded on the Field Data Logs.
- Sample start and stop time, and flow rate and elapsed flow rate, are at least 18 hours apart within a 24-hour period of time. (Note at least 18 hours of sampling time is required for any sample to be aggregated for trend analysis and relative comparison to EU annual ambient air quality standards.)

If information is missing, the project team implemented actions to obtain it from the sampling team in Kosovo, USAID, and its implementing partners. If data were missing, the project team reiterated the importance of completing all entries on the forms to help validate the analytical results.

Step 2: Verify Accuracy of PM Analytical Results. The Chain of Custody Forms and Field Data Logs were reviewed to verify that the analysis of the exposed filters was conducted within the turnaround time specified in RTI's Standard Operating Procedures (SOPs - Section 1.11).

In addition, the following steps were undertaken:

- The calculations and conversions generated by RTI were viewed to verify accuracy and consistency.
- The initial and duplicate filter weights were spot checked (both initial and final) to ensure that they are within the allowable 3µg deviation (SOPs - Section 1.12.5).
- Comments provided by RTI were reviewed regarding the physical condition of the filters received for analysis to note any particular conditions that may impact the quality of the analytical results.

Step 3: Verify Accuracy of SO_2 and NO_2 Analytical Results. The unit of measurement conversions were reviewed to confirm that they were calculated correctly and in keeping with the procedures outlined in the Sampling Protocol for the Ogawa Sampler provided by RTI, through random checks of RTI's calculations and a duplication of the project team's conversion efforts.

The use of laboratory blanks per sampling event were reviewed to verify they were being used in accordance with the procedures outlined in the Sampling Protocol for the Ogawa Sampler provided by RTI. In addition, comments provided by RTI regarding the physical condition of the blank filters received for analysis were reviewed and evaluated.

RTI was notified of any decisions or actions that did not appear to have been made in keeping with RTI Standard Operating Procedures.

Step 4: Assess the Quality of the Analytical Results. Based on the outcomes of Steps 2-3 above, decisions were made to determine whether to retain or reject analytical results based issues associated with filter conditions, maintenance of sampling equipment, weather conditions, pollutant concentration calculations, or other issues identified in the Field Data Logs.

The results were communicated to RTI regarding any decisions that do not appear to have been made in keeping with RTI Standard Operating Procedures, and any issues that reflect sampling activities in Kosovo.

3.0 Audit to Confirm Ambient Air Quality Trends and Data Quality Provisions

Prior to the completion of project and sampling activities, the data were reviewed to confirm that the process implemented for calculating annual concentrations of pollutants in the ambient air was appropriate. Specifically, the review focused on:

- Confirming that data previously identified as invalid are not included in any trend analysis and that an accurate explanation is provided for their omission.
- Verifying that the ambient air quality sampling data gathered are aligned with the EU's data capture, time coverage, and data quality objectives.

APPENDIX 3: DATA CAPTURE INFORMATION

EU Directive 2008/50/EC stipulates that for ambient air quality averaging, collected data must meet a minimum "Data Capture" threshold of 90%. "Data Capture" in this case refers to the percent of attempted sampling events that returned usable data. Factors that influence the usability of data include the duration of the sampling period,[58] equipment malfunction, battery malfunction, or improper data and/or equipment handling.

The data capture statistics related to the three primary pollutants analyzed during the initial assessment can be found in Tables 23 through 29. The data capture statistics for PM_{10} improved during the second phase of the assessment. This improvement was related to the implementation of enhanced equipment management practices based on information gained during July 2011 through July 2012 sampling activities and results. Overall, there were few data capture issues related to SO_2 and NO_2. Those that did occur were related to labeling issues and traceability of the exposed filters to the sampling locations.

Table 23: Data Capture by Parameter (24-Hour Samples)

Parameter	Total Samples Taken	Total Good Samples[59]	Data Capture
July – December 2011			
PM_{10}	51	38	75%
SO_2	26	26	100%
NO_2	25	25	100%
January – July 2012			
PM_{10}	78	33	42%
SO_2	34	34	100%
NO_2	40	40	100%
July 2012 – February 2013			
PM_{10}	294	292	99%
SO_2	4	4	100%
NO_2	293	251	86%

[58] For 1-hour or 24-hour samples, the sampling event must last for at least 75% of the averaging period (45 minutes, and 18 hours, respectively). If a sample does not meet that 75% threshold, it is not considered usable data, and impacts the data capture requirement.
[59] Good refers to samples meeting the data capture requirements.

Table 24: PM_{10} Data Capture by Month

Month	Total Samples Taken	Total Good Samples	Data Capture
July 2011	3	3	100%
September 2011	16	15	94%
October 2011	8	4	50%
November 2011	8	7	88%
December 2011	16	9	56%
Total	**51**	**38**	**75%**
January 2012	16	7	44%
February 2012	14	6	43%
March 2012	7	2	29%
April 2012	10	4	40%
May 2012	19	7	37%
June 2012	4	2	50%
July 2012	8	5	63%
Total	**78**	**33**	**42%**
July 2012	12	12	100%
August 2012	48	48	100%
September 2012	36	36	100%
October 2012	42	42	100%
November 2012	48	47	98%
December 2012	30	30	100%
January 2013	54	53	98%
February 2013	24	24	100%
Total	**294**	**292**	**99%**

Table 25: NO_2 Data Capture by Month (24-Hour Samples)

Month	Total Samples Taken	Total Good Samples	Data Capture
July 2011	2	2	100%
September 2011	12	12	100%
December 2011	11	11	100%
Total	**25**	**25**	**100%**
January 2012	10	10	100%
February 2012	8	8	100%
March 2012	3	3	100%
April 2012	6	6	100%
May 2012	6	6	100%
June 2012	2	2	100%
July 2012	5	5	100%
Total	**40**	**40**	**100%**
July 2012	12	12	100%
August 2012	48	48	100%
September 2012	31	30	97%
October 2012	39	39	100%
November 2012	48	48	100%
December 2012	30	30	100%
January 2013	54	18	33%
February 2013	24	24	100%
Total	**286**	**249**	**87%**

Table 26: NO_2 Data Capture by Month (7-Day Samples)

Month	Total Samples Taken	Total Good Samples	Data Capture
September 2012	2	2	100%
October 2012	3	3	100%
November 2012	1	1	100%
Total	**6**	**6**	**100%**

Table 27: SO_2 Data Capture by Month (24-Hour Samples)

Month	Total Samples Taken	Total Good Samples	Data Capture
July 2011	2	2	100%
September 2011	12	12	100%
December 2011	12	12	100%
Total	**51**	**38**	**75%**
January 2012	10	10	100%
February 2012	8	8	100%
March 2012	3	3	100%
April 2012	7	7	100%
May 2012	6	6	100%
Total	**34**	**34**	**100%**
August 2012	3	3	100%
October 2012	1	1	100%
Total	4	4	100%

Table 28: SO_2 Data Capture by Month (7-Day Samples)

Month	Total Samples Taken	Total Good Samples	Data Capture
September 2012	3	3	100%
October 2012	2	2	100%
November 2012	4	4	100%
December 2012	6	6	100%
January 2013	8	6	75%
February 2013	2	2	100
Total	**25**	**23**	**92%**

Table 29: SO_2 Data Capture by Month (14-Day Samples)

Month	Total Samples Taken	Total Good Samples	Data Capture
November 2012	3	3	100%
December 2012	3	3	100%
Total	**6**	**6**	**100%**