

Statement of Work

Evaluation of the Emission, Transport, and Deposition of Mercury, Arsenic, and Fine Particulate Matter from Coal Based Power Plants in the Ohio River Valley Region

A. OBJECTIVES:

The overall objective of the project is to quantitatively evaluate the emission, transport, and deposition of mercury, fine particulate matter (PM), and air toxics (arsenic) in the Ohio River Valley region. This evaluation will involve two interrelated areas of effort: regional-scale modeling analysis and ambient air monitoring.

The objective of the regional modeling studies is to develop a comprehensive budget of arsenic, elemental mercury (Hg^0) and reactive gaseous mercury (RGM), and fine particulate matter including sources, sinks, atmospheric lifetimes, burdens, and advective fluxes across the Ohio Valley Region. Updated emissions inventories for mercury and arsenic within the region will be developed to support this objective. The second objective will be to develop and operate an air monitoring site in southeastern Ohio with the capability to monitor mercury in ambient air and in precipitation. Short-term and seasonal simulations with the refined model will be compared to field measurements from the monitoring site, and the results will be used to develop a decision-support tool. A supplemental objective of the analysis is to evaluate the impacts of long-range transport from regions outside the Ohio Valley as well as biospheric recycling of elemental Hg on the measured and modeled reactive and total mercury concentration levels in the Ohio Valley region.

B. SCOPE OF WORK:

Ohio University, in collaboration with CONSOL Energy, Advanced Technology Systems, Inc (ATS) and Atmospheric Environmental Research, Inc. (AER) as subcontractors will evaluate the impact of emissions from coal-fired power plants in the Ohio River Valley region as they relate to the transport and deposition of mercury, arsenic, and associated fine particulate matter. This evaluation will involve two interrelated areas of effort: regional-scale modeling analysis and ambient air monitoring.

The scope of work for the modeling analysis will include (1) development of updated inventories of mercury and arsenic emissions from coal plants and other important sources in the modeled domain; (2) adapting an existing 3-D atmospheric chemical transport model to incorporate recent advancements in the understanding of mercury transformations in the atmosphere; (3) analyses of the flux of Hg^0 , RGM, arsenic, and fine particulate matter in the different sectors of the study region to identify key transport mechanisms; (4) comparison of cross correlations between species from the model results to observations in order to evaluate characteristics of specific air masses associated with long-range transport from a specified source region; and (5) evaluation of the sensitivity

of these correlations to emissions from regions along the transport path. This will be accomplished by multiple model runs with emissions simulations switched on and off from the various source regions.

The scope of work for the ambient air monitoring will include the deployment of a surface air monitoring (SAM) station in southeastern Ohio. The SAM station will contain sampling equipment to collect and measure mercury (including speciated forms of mercury and wet and dry deposited mercury), arsenic, particulate matter (PM) mass, PM composition, and gaseous criteria pollutants (CO, NO_x, SO₂, O₃, etc.). If possible, the SAM station will be co-located with an existing ambient air quality monitoring station operated by a state or local air pollution regulatory agency or another ongoing air quality research project. This will minimize the costs of establishing, operating, and maintaining the SAM site. Laboratory analysis of time-integrated samples will be used to obtain chemical speciation of ambient PM composition and mercury in precipitation. Near-real-time measurements will be used to measure the ambient concentrations of PM mass and all gaseous species including Hg⁰ and RGM. Approximately of 18 months of field data will be collected at the SAM site to validate the proposed regional model simulations for episodic and seasonal model runs. The ambient air quality data will also provide mercury, arsenic, and fine particulate matter data that can be used by Ohio Valley industries to assess performance on multi-pollutant control systems.

To the greatest extent possible, model results will also be compared to field data collected at other air monitoring sites in the Ohio valley region, operated independently of this project. These sites may include (1) DOE-NETL's monitoring site at its suburban Pittsburgh, PA facility; (2) sites in Pittsburgh (Lawrenceville) PA and Holbrook, PA operated by ATS; (3) sites in Steubenville, OH and Pittsburgh, PA operated by U.S. EPA and/or its contractors; and (4) sites operated by State or local air regulatory agencies. An assessment will be made of the availability of appropriate data from these external monitoring stations; where feasible, these data will be obtained and compared to the modeling results.

C. TASKS TO BE PERFORMED:

This section provides a brief summary of the planned approach for this project, which will be broken into seven separate tasks to be completed over a 27-month performance period. The following project schedule is based on a nominal project start date of April 3, 2003:

Project Performance Schedule		2003							2004							2005												
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Months after Project Start		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Task #	Description																											
1	Establish and operate ambient monitoring station																											
2	CTM setup/grid system development																											
3	Develop and refine emission inventories																											
4	Short period CTM runs																											
5	Sensitivity model simulations																											
6	Development of decision-support tool																											
7	Project management, data analysis, and reporting																											

Task 1 consists of establishing and operating the SAM site in southeastern Ohio. It is anticipated that approximately 6 months will be required before the SAM site is completely set up and operational; data collection will occur over the following 18 months.

Tasks 2 through 6 comprise the modeling process, which will continue throughout the first 24 months of the project. Throughout Tasks 2 through 6, the project team will keep abreast of ongoing research and newly-published literature pertaining to atmospheric behavior of mercury. Whenever possible, new findings concerning mercury speciation and transport will be incorporated into the model algorithms.

Task 2 consists of the selection and evaluation of a 3-D regional-scale chemical transport model (CTM) for an application focused on the Ohio River valley region. It is anticipated that the setup of the CTM and development of its grid system will be completed within the first 5 months of the project. Also a one year base case simulation will be conducted for North America. This simulation will be completed by the end of the first year of the project.

Task 3 involves the refinement and update of emission inventories (EIs) for sources of mercury and arsenic within and upwind of the modeled domain. It is anticipated that information on emissions will continue to be collected and processed into the model structure throughout the modeling effort.

Task 4 consists of short period model runs that will be made for comparison with field data. It is anticipated that the summer of 2001 will be used for initial comparisons because of the vast amount of field data on particulate matter that is likely to be available for the Ohio River valley region during that time period. These initial comparisons will be followed by short-term model runs for comparison with the speciated mercury and arsenic data collected at the SAM for the 2002 and 2003 sampling periods. Meteorological simulations for the short-term model runs will begin during the 3rd month of the project; short-term model runs will be made intermittently for approximately 15 months.

Task 5 involves seasonal-scale simulations that focus on the identification of significant sources and source regions contributing to the deposition of mercury and ambient concentrations of arsenic and fine particulate matter over time periods of several months

or more. The modeling will also examine the efficacy of emission reduction strategies specifically for coal-fired power plants. In addition, an analysis of the long-range transport from regions outside the Ohio Valley and biospheric recycling of elemental Hg on the measured and modeled reactive and total mercury in the Ohio Valley Region will be conducted.

Task 6 will consist of the development of web-based model interface technologies to provide industry and government agencies a user friendly decision-support tool to facilitate the evaluation of source-receptor relationships and the efficacy of emission reduction strategies.

Task 7 consists of project management, data analysis, and reporting functions.

Detailed Task Descriptions

Task 1 - Establish and operate surface air monitoring (SAM) station in Ohio

Consol Energy will be responsible for establishing, operating, and performing data analysis, QA/QC, and data reduction for the SAM.

The air monitoring station will include sampling equipment to collect and measure mercury (including total, elemental, reactive, particulate and wet/dry deposited mercury), arsenic, fine particulate matter, pollutant gases, and weather data over a two-year period.

Total mercury will be measured using a Tekran Mercury Vapor Analyzer. This instrument is a real-time, continuous analyzer capable of measuring total mercury in the ambient air. The Tekran uses gold amalgamation coupled with cold-vapor atomic-fluorescence technology to measure ppt (by volume) concentrations of total mercury. In addition, the Tekran Mercury Vapor Analyzer will be equipped with the speciation and particulate modules that speciate the total mercury into elemental, reactive, and particulate concentrations. This will help to evaluate mercury concentrations attributed to the urban background or from fluxes due to industrial and geological sources in the Ohio Valley.

The wet deposition behavior of mercury will be studied using an Aerochem Mercury Precipitation Collector identical to that being used by The National Ambient Mercury Deposition Network. Conversely, the dry deposition behavior of mercury will be studied through fine particulate collected on a Teflon filter with a PM2.5 Speciation Sampler operating on an every-third-day frequency. The particulate will be leached and measured using a cold vapor atomic absorption spectrometer configured with a gold amalgamation pre-concentration unit. Collection of these samples will add to our understanding about a number of issues associated with mercury deposition, including the potential impact on local water and eco-systems, re-entrainment of mercury in the environment, and conversion of mercury to methyl mercury.

Fine particulate matter and arsenic will be collected using a Federal Reference Method PM2.5 filter-based sampler. The filter-based sampler will collect an integrated 24-hour particulate sample on an every-third-day frequency. The particulate on the filter will then be analyzed for mass and calculation of fine particulate matter concentration.

Composition of the fine particulate matter will be measured through a combination of laboratory techniques including 1) elemental composition (including As) by inductively coupled plasma mass spectroscopy and 2) ions (SO₄²⁻, NO₃⁻, Cl⁻, NH₄⁺) by ion chromatography. The PM2.5 speciation sampler, which will collect a particulate sample for mercury determination, will also be equipped to collect a quartz filter to be used to determine the carbon concentration of the particulate. Total as well as elemental and organic carbon concentration will be determined by analyzing the quartz filter with a thermal optical carbon aerosol analyzer. In addition to the filter-based fine particulate measurements, continuous gas analyzers and a 10-meter weather station at the SAM will provide data to clarify how ambient pollutant concentrations (SO₂, NO_x, CO, O₃, THC) and weather are associated with the formation of fine particulate. All sampling data will be collected from the site operator, checked for QA/QC, and archived into a common database for reduction, analysis, and modeling.

Task 2 - Evaluate and select a 3-D regional-scale atmospheric chemical transport model (CTM) and conduct a base case simulation.

Ohio University and AER will be responsible for establishing the 3-D modeling framework. AER will conduct the base case simulation.

There are several 3-D regional-scale CTMs with the ability to simulate tropospheric ozone, visibility, and fine particulate matter. These models will be appropriate for application to the Ohio River Valley Region to evaluate total fine particulate matter mass and the arsenic component of the fine particulate matter. A comprehensive regional modeling study focusing on the mass and composition of particulate matter in the Pittsburgh, PA region is currently being performed for DOE-NETL by Carnegie-Mellon University (CMU). The project team will meet with the CMU researchers in the initial stages of the modeling effort to determine potential synergies, and take advantage of experience gained by CMU researchers with respect to modeling various emission reduction scenarios.

However, the 3-D regional-scale CTM used in this study will have to be refined to evaluate mercury. The following is a brief description of some of the methodologies that will be used for making the 3-D regional-scale model for atmospheric chemistry into a model for mercury chemistry, transport, and deposition on a global scale.

The models available include the Community Multi-scale Air Quality (CMAQ) model developed for air-pollution studies on a regional scale by the EPA and its collaborators (Byun & Ching, 1999) and a model developed at National Oceanic and Atmospheric Administration's (NOAA) Forecast Systems Laboratory with on-line meteorology and chemistry (Grell et al., 2002). The latter model is also suitable for longer seasonal scale simulations. Both these models use the non-hydrostatic Penn State/NCAR mesoscale

model (MM5)V3-derived dynamics for transport. In the CMAQ model, the meteorology is off-line, whereas the NOAA model has on-line meteorology.

Mercury Chemistry Scheme. The chemistry of mercury in the homogeneous gas phase and heterogeneous liquid water phase will be modeled in the regional-scale chemistry transport model. The role of particles, either as mediators of chemistry or as a sink for atmospheric mercury, is not established. It was suggested that mercury undergoes an ‘atmospheric distillation’ process in a fashion similar to that of persistent organic pollutants (POPs). This assumes that mercury volatilizes in the hotter tropical atmosphere and condenses onto particles in the colder mid and upper latitudes; over a few seasonal cycles, this process will lead to accumulation in the colder arctic atmosphere, oceans, and biosphere. However, there is little evidence suggesting that the total particulate mercury is higher than the gas phase reactive mercury in higher latitudes. As a result, even though the amount of mercury in the particulate phase (Hgp) will be calculated, the role of particles as a mediator for this type of ‘distillation’ will not be a focus of the study.

Gas Phase. The main oxidant for mercury in the atmosphere is ozone, and if one assumes a global average ozone of about 30 ppb, the lifetime of mercury in the atmosphere is about 1.5 years (Schroeder and Munthe, 1998). Recent measurements have shown that H₂O₂ could also act as an important oxidant in the gas phase for mercury, yielding mercury lifetimes on the same order as ozone. The importance of two additional oxidants, Cl and NO₃, in the nighttime planetary boundary layer is an additional pathway and remains highly uncertain (Tokos et al., 1998). In this study, ozone and H₂O₂ mixing values from a full-chemistry run of the regional-scale model, saved every hour, will be used for making the regional-scale mercury calculations. The complete chemistry scheme would follow those proposed by Xu et al. (2000) and Lin et al. (1999).

Aqueous Phase. The rapid removal of reactive gaseous mercury from the atmosphere through aqueous phase reactions is a central aspect determining the total atmospheric burden of mercury and its reactive products. The processes that need to be included in the model are 1) the transfer of elemental mercury and Hg(II) across the gas-liquid interface into the cloud water droplets and 2) subsequent reactions within the water droplets followed by possible washout precipitation. The regional-scale models being evaluated for this study have an existing methodology for calculating the transfer of gases from gas to liquid phase, depending on the Henry’s law constant for a given gas. These modules are based on those developed for the Regional Acid Deposition Model (RADM) for evaluating formation and deposition of sulfate and nitrate in cloud water. As a part of this proposal, the team will use concepts similar to those adopted in RADM to develop a liquid phase reaction module for mercury. The aqueous phase chemistry will be modeled following the scheme proposed by Petersen et al. (1998), and will be expected to include 10 to 15 reactions.

Surface Exchange Processes. One significant uncertainty in developing and implementing a model for mercury transport is in developing parameterizations for the surface processes. The exchange of mercury and its degradation products between the

atmosphere and the lower boundary - soil, biosphere, and lakes - is potentially the largest sink term. It is generally accepted that Hg(II) deposited either by wet deposition or dry deposition onto soils and forested areas is a one-way process (i.e., there is no re-emission of Hg(II) back into the gas phase). However, the elemental form of mercury (Hg⁰) has been observed recycling through the soils and plants back into the atmosphere.

A number of measurements in marine environments suggest that surface waters are in general supersaturated with mercury and hence facilitate an exchange of mercury from the ocean surfaces to the atmosphere. The exchange of mercury to the atmosphere is highly uncertain with respect to inland water systems. To estimate these fluxes, the research team will adopt parameterizations developed for water-air exchange for similar compounds.

The exchange of mercury between soils and atmosphere has been studied in a wide variety of environments. In general, these studies lead to the conclusion that in temperate and boreal forests there is a net deposition of mercury during the winter months and a net efflux during the summer months. The estimates of these fluxes (Schroeder et al., 1998) will be used to parameterize the exchange between soils and the atmosphere for various regions across the model domain. The dry deposition of mercury will be calculated based on parameterizations developed by Wesely and Hicks (2000). Vegetation also plays a key role in removing mercury from the atmosphere and possibly recycling it back into the atmosphere under certain conditions. The uptake by vegetation of different types of mercury can be calculated if canopy resistance is parameterized from observations. A few observations are available and will be employed for developing these parameterizations (Lindberg et al., 1992). These limited observations also suggest that the canopies can emit mercury under dry conditions and under wet conditions when dry deposition is dominant (Lindberg, 1996). The information on soil wetness from the meteorological model and the National Centers for Environmental Prediction (NCEP) 4-D data assimilation will be used for our model calculations.

A base case simulation will be conducted with a three-level nested grid (36/12/4km) over North America (including Southern Canada and northern Mexico) with a focus on the Ohio River Valley. The base case will be conducted for a year for which an MM5 simulation with 36km resolution is available from EPA. The year 1996 is currently available and 2001 should become available in 2003. MM5 simulations for the 12 and 4km grid domains will be conducted by Ohio University.

Task 3 - Refine and update emission inventories (EIs)

ATS will be responsible for refining, processing and updating the emission inventories.

Projections based on the U.S. EPA's 1996 Interim Emission Inventories will be utilized for the model simulations. This inventory was developed by the U.S. EPA to support regional-scale modeling efforts. This inventory will be refined with additional EI data obtained from the NETL-sponsored Pittsburgh Air Quality Study. Finally, the EIs will be enhanced to include mercury and arsenic emissions.

Emissions of mercury and arsenic into the atmosphere include a variety of anthropogenic sources. In the case of mercury, these emissions are recycled between the various compartments of the earth system. The EI for the regional model will include 1) anthropogenic emissions of arsenic, Hg^0 , and RGM from the portion of the North American continent within the modeling domain and 2) natural emission and re-emission of Hg^0 over the continental and oceanic regions in the domain. The U. S. Environmental Protection Agency (USEPA) National Toxics Inventory database will be used for the regional-scale Ohio Valley studies to specify annual anthropogenic mercury and arsenic emissions at the county and point level across the U.S.

For the larger continental scale studies, the primary resource for anthropogenic mercury emissions from Canada will be the National Pollutant Release Inventory published annually by Environment Canada. Although atmospheric emissions data are not available from the Mexican government, Pai et al. (2000) developed a valuable inventory of more than 200 individual facilities in northern Mexico and then estimated emissions by analogy with patterns observed in U.S. and Canadian inventory data. The mercury and arsenic modeling efforts will be greatly enhanced as the USEPA continues the development of a comprehensive data set for all North American emissions.

Natural emissions and re-emissions of mercury will also require special attention. Initially, natural emission and re-emission of Hg^0 from soils, vegetative canopies, and surface water will be calculated according to the formulation presented by Xu et al. (1999). Following the approaches of Kim et al. (1995) and Carpi and Lindberg (1998), the soil-to-air flux will be parameterized as a function of soil temperature. As more information becomes available, the soil-to-air emission parameterization will be expanded to include dependence on solar radiation, soil moisture, and mercury concentration in the substrate to distinguish areas of natural soil enrichment. The canopy-to-air emission will be parameterized to depend upon the Hg^0 concentration in the soil solution and upon the rate of evapotranspiration, which is a function of soil moisture. Emissions of Hg^0 from surface water to air will be calculated according to the mercury concentration in the water and a mass transfer coefficient, which will depend on the friction velocity. In the regional modeling approach, the deposition of mercury is computed in the CTM, and the emission and deposition fluxes will be parameterized in a consistent manner.

The Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system will be used to process the emissions data for input to the 3-D regional-scale CTM. SMOKE will be coupled to a graphic information system for data layering and visualization, which will enable mapping of the results with geographic data. These visualization techniques will enhance the quality control and quality assurance of the input data sets. In addition, these EI maps will be made available on the World Wide Web.

The emission inventories for Mercury and Arsenic will continue to be refined throughout the course of this task, reflecting ongoing research efforts sponsored by the National

Energy Technology Laboratory and regulatory reporting requirements in the United States, Mexico, and Canada.

Task 4 - Perform short-period model runs for comparison with field data

Ohio University will conduct the simulations for model verification.

A series of model runs will be conducted to evaluate the system against field observations. First, the model will be set up along with an observational database for the Ohio Valley Region collected during the summer of 2001. The model run will correspond to the NETL-sponsored intensive sampling campaigns centered in Pittsburgh, Pennsylvania. The extensive datasets collected during this campaign will be combined with other relevant datasets in this region. Meteorological input data for these simulations will be derived diagnostically using MM5 V3. The model evaluations will involve short-time-period runs for the field-intensive periods, storing hourly averaged fluxes and production-and-loss rates for ozone, hydrocarbons, arsenic, Hg^0 , and RGM for direct comparison with field data. In addition, long range transport events will be identified from the short-term CTM runs and evaluated with the observational data set.

In addition to the model evaluations conducted from field observations obtained from the 2001 NETL-sponsored sampling campaigns, the model will be set up and evaluated against the observational data sets, including the speciated mercury and arsenic data collected at the SAM for the 2002 and 2003 sampling period. These simulations will be vital for model verification because the SAM will be one of the few sites providing measurements on individual mercury species and arsenic. The model evaluations will involve short-time-period runs for the field intensive periods, storing hourly averaged fluxes and production-and-loss rates for ozone, hydrocarbons, arsenic, Hg^0 , and RGM for direct comparison with field data. In addition, long-range transport events will be identified from the short-term CTM runs and evaluated with the observational data set.

Task 5 - Seasonal scale simulations

Ohio University will be responsible for the seasonal scale simulations.

A major focus of the modeling effort is to identify significant sources and source regions contributing to the deposition of mercury and ambient concentrations of arsenic and fine particulate matter. The modeling will also examine the efficacy of reduction strategies specifically for coal-fired power plants. In addition, an analysis of the long-range transport from regions outside the Ohio Valley and biospheric recycling of elemental Hg on the measured and modeled reactive and total mercury in the Ohio Valley Region will be conducted.

Initially, set up a seasonal scale simulation for the entire North American continent on a coarse grid (30 km X 30 km), with a nested grid of 10 km over the Midwestern USA and 3.3 km over the Ohio Valley region. The NCEP-4D assimilation data set will be used to drive the regional-scale meteorology model (MM5 V3) to develop dynamic inputs for the

CTM. (Note: If we choose to use the NOAA CTM, the chemistry will run on-line with the meteorological model.)

The model analysis will be completed for the seasonal run to establish a ‘base case’ simulation or the most likely current-day simulation for the season. Uncertainty ranges will be developed for critical parameters in the model, such as emissions and deposition rates. Additional seasonal scale simulations will be performed to develop an ‘uncertainty envelope’ of the model-generated estimates of deposition rates and fluxes.

Task 6 - Development of a decision-support tool

Ohio University and ATS will be responsible for the development of the decision-support tool.

A series of model runs will be conducted to perform a matrix analysis of the sensitivity of point sources to deposition patterns in the region. In addition, the analysis will also include selective emission reduction scenarios for these point sources. This matrix will be coupled with a GIS and the emission pre-processor to provide a detailed spatial analysis of the source–receptor relationships. In addition, this entire system will be supported by web-based technologies to provide industry and government agencies a user friendly decision-support tool that will evaluate source-receptor relationships and the efficacy of emission reduction strategies.

Task 7 - Project management, data analysis, and reporting

This task involves all communication between the project team members, DOE-NETL, and external collaborating parties and includes all meetings, presentations, and DOE-required reports pertaining to the project. A project kickoff meeting will be held within 60 days after project award, at a location specified by the DOE Contracting Officer’s Representative (COR). Technical progress reports and other presentations/reports required by DOE will be prepared and submitted according to the schedule provided in the terms of the Cooperative Agreement between Ohio University and DOE. It is expected that quarterly reporting of technical progress will be performed. In addition, the project team will seek opportunities to prepare manuscripts and make presentations on interim results of the project at technical conferences or workshops sponsored by DOE or other organizations. It is anticipated that at least one such technical manuscript/presentation will be made during the course of the project; funding for this activity has been included in the project cost estimate.

To facilitate data analysis, the data from the SAM and the results of the model runs will be archived into a user-friendly database, which will provide functionality to help calculate final mercury, arsenic, and fine particulate matter mass and composition concentrations. It will also allow the delineation of basic trends and the evaluation of variables. The data from the SAM site will be incorporated, to the greatest extent possible, into the ambient air quality database being compiled for DOE-NETL by ATS and Ohio University under project DE-FC26-02NT41476. However, the primary

function of the database will be to reduce data efficiently for evaluation of the proposed model simulations. At the conclusion of the project, the database containing the SAM information, results of model runs, and comparison statistics will be submitted to DOE-NETL along with a comprehensive final report.

D. DELIVERABLES

The periodic, topical, and final reports shall be submitted in accordance with the “Federal Assistance Reporting Checklist” and the instructions accompanying the checklist. It is expected that semi-annual reporting of technical progress will be performed.

At the conclusion of the project, the database containing the SAM information, results of model runs, and comparison statistics will be submitted to DOE-NETL along with a comprehensive final report.

The following is a schedule of key deliverables/milestones associated with the project, based on a nominal start date of April 3, 2003:

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Milestone Schedule	2003									2004									2005								
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Description																											
Project Kickoff Meeting		▲																									
Complete setup of ambient monitoring station							▲																				
Complete CTM setup/grid system development						▲																					
Complete short-term CTM runs																			▲								
Complete seasonal CTM and sensitivity simulations																								▲			
Complete development of decision support tool																								▲			
Complete ambient monitoring program																								▲			
Semiannual Technical Progress Reports							▲						▲							▲						▲	
Final Report																											★

E. BRIEFINGS/TECHNICAL PRESENTATIONS :

A project kickoff meeting will be held within 60 days after project award, at a location specified by the DOE Contracting Officer’s Representative (COR).

A technical manuscript and/or presentation on the interim results of the project will be delivered at a technical conference or workshop sponsored by DOE or other organizations.