Proposal Submitted to EPA in Response to RFA No. OAR-MEAD-05-16

Title: Monitoring of Air Toxic Particulate Pollutants from Heavily Trafficked New Jersey Turnpike: An Urban Community-wide Project

Category: Community Scale Monitoring

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Fund Requested: $400,000

Total Cost: $700,000. The remaining costs will be covered in-kind by the applicant.

Period: October 2005- March 2007

1. Introduction

Road traffic has become the greatest source for airborne particulate mass in many urban areas (Gillies and Gertler, 2000). Any gains in air quality through cuts in the amount of pollution emitted per mile, particularly for NOx and small particles ($PM_{2.5}$), have been offset in recent years by growth in miles driven (Repogle, 2002). This project is designed to provide the necessary local air quality monitoring data and contribute to EPA's strategic objective to reduce the risk from toxic air pollutants. The proposed work will analyze and monitor the concentration gradients and composition of hazardous air pollutants (HAP's) from one of the most heavily traveled highways in the United States, the New Jersey Turnpike (NJTPK). By monitoring air quality at set distances from the turnpike for an entire year, we expect to collect much needed data that will enable efforts by the North New Jersey Transportation Planning Authority and other air pollution control agencies to model and project distribution of HAP's associated with the NJTPK. The data obtained from this local monitoring effort will be used to support the existing initiatives by the North New Jersey Transportation Planning Authority tasks 06/206 and

06/207 and by state agencies to determine conformity and assess human exposure and risk through transportation modeling and epidemiological studies.

The main trunk of the New Jersey Turnpike runs from Deepwater, New Jersey in the south to Ridgefield, New Jersey in the north covering 148 miles and in some areas it is 14 lanes wide. In 2000, the total number of miles driven on the turnpike was in the order of 5 billion (5, 513,290,891) and the number of vehicles was 219, 966,881. By the year 2002, the number of miles driven had increased by 13.6% and the number of vehicles by 8.8%(www.state.nj.us/turnpike). Some of the heaviest traffic flows between exit 15w and exit 16 where the turnpike divides into the western and eastern spurs. In between these two spurs lays the town of Secaucus, NJ with 15,900 residents who are continuously exposed to emissions from the turnpike system regardless of the direction of the wind. Profiling air toxics from the turnpike at this specific location is especially important for this community, which is in turn representative of many other communities along the 148 mile stretch of the NJTPK. The New Jersey Meadowlands Commission owns approximately 900 acres of open space that is bisected by the turnpike system in between these two exits. The proposed study area constitutes an ideal location for monitoring emissions from the turnpike that impacts a representative New Jersey community.

2. Background and Related Projects

The New Jersey Meadowlands Commission (NJMC), in collaboration with the Environmental and Occupational Health Sciences Institute (EOSHI) and UMDNJ- Robert Wood Johnson Medical School, is currently involved in a three-year air quality study to establish a base-line air-quality for this 32 square mile District of mixed land use. The program (funded by the NJMC: $700,000 over three years), targeting on volatile organic carbon (VOC), black carbon (BC) and organic carbon (OC), is designed to monitor and measure air quality at a number of locations in the District that are slated for re-development. The program is designed to understand the current ambient levels and human exposure through continuous monitoring and modeling. In addition, the Meadowlands Environmental Research Institute (MERI), which is the scientific arm of the NJMC, is currently funding ($65,000) a comprehensive study on nitrogen-containing air pollutants over the Meadowlands District of New Jersey, mainly NO and NO_2 (ozone) precursors. Therefore, tremendous efforts are already in place on air pollution monitoring in this area. However, monitoring of particulate matter and associated toxic chemicals has been a gap.

The project being proposed through this RFA focusing on air monitoring of toxic particulate matter and the projects currently under execution greatly complement each other and benefit each other from the established capability and existing know-how on air monitoring and analysis. Many of the sampling and analytical methods for particles, VOC's and elemental species are already in place. We have developed a methodology and have trained staff in collecting and analyzing samples and maintaining air monitoring equipment. Because of our location and our expertise and infrastructure currently in place, we are in a good position to effectively implement a study that will adequately characterize air pollution coming from the turnpike and impacting our local communities.

3. Scientific Background and Justification

Hitchins et al. (2000) studied the effects of wind direction on the transport of vehicle-emitted pollutants. They measured fine and ultra fine particle counts at increasing distances from a road approximately 50 meters apart and up to a distance of 300m. When the wind was blowing towards the monitoring stations the concentrations of particles decayed to half the maximum at 100-150m. When the wind was blowing parallel to the road, the concentrations of particles decayed to half the maximum at 50-100m. No influence of vehicle-emitted pollutants was observed when wind was blowing towards the road opposite to the monitoring stations. Another study (Janssen et al., 2001) measured particle mass concentration and elemental composition of particles at two sites near a major road and at two sites at background locations. The authors concluded that near roads the concentrations of $PM_{2.5}$ and PM_{10} were 1.3 times higher than background locations. In the city of Los Angeles, aerosol gradients near a highway were recently studied by Zhu et al. (2002). A steep gradient was found in total particle concentration, black carbon and CO concentrations up to distances of 150 m from a highway. Overall, studies focusing specifically on the airborne concentrations and fate of particles in the air near highways are short term, few and their results somewhat inconsistent. There is very little information on the seasonal variability, the day to night variability and the relationship between particle size and air toxic loadings of ambient particulate matter. This data is critical to better understanding the impact of ambient toxic pollutants on human health since pollution derived toxic elements are known to be concentrated on fine particles but the extent of their enrichment on different sizes of particles is largely unknown. Because of the growth in miles driven and the large human population concentrated around the NJTPK, it's extremely important to measure and characterize the traffic pollution from the NJTPK.

4. Objectives

The primary goal of this project is to characterize urban particulate air pollution derived from heavy traffic. The specific objectives are: (1) to determine the ambient concentration gradients of $PM_{2.5}$ and associated PAH's and selected toxic trace metals that have their source mainly from NJTPK vehicle emissions, (2) to determine the temporal and spatial profiles of these air toxics, (3) to determine the relationships between the particle-size distributions and concentrations of toxic trace elements, and (4) to establish the relationships among these toxic air pollutants derived from NJTPK. Results from this project will not only help characterize the degree and extent of the current air pollution problem and the risks to the local communities but also establish a baseline to model and project air pollution from the NJTPK into the future.

5. Methods

5.1. Sampling Sites:

The sampling strategy is designed to capture the local concentrations Hazardous Air Pollutants (HAP) by sampling along a gradient at 50, 100 and 150m from the median strip of the NJTPK (Figure 1). These three sampling sites are located along an unobstructed flat plain perpendicular to NJTPK, designed to capture a motor vehicle emissions gradient from the NJTPK.

The sampling platforms at these three sites will be fenced-in and constructed at a height of ~3 m above the ground and at least 5m away from any obstructions.

Figure1. Proposed air pollution monitoring stations as indicated by red dots.

5.2. Sampling Periods:

Two air-sampling approaches will be used for determining the ambient concentration gradients of $PM_{2.5}$, size distributions of particulate matter, PAHs and selected toxic trace metals from the NJTPK. First, there will be a long-term routine sampling, and second, a short-term intensive sampling. In addition, the average of meteorological parameters including temperature, wind direction and wind speed will be measured during each sampling periods using weather sensors attached to data loggers and used to interpret the air quality measurements.

- ***Long term air pollution sampling***- A 24-hour air pollution sample will be collected every sixth day for $PM_{2.5}$, trace metals and specific polycyclic aromatic hydrocarbons (PAHs) at three sites and for a period of one year starting in March 2006 and ending February 2007. This schedule is consistent with that of our existing studies and with the existing statewide monitoring network by the New Jersey State Department of Environmental Protection. This allows for the data collected under this study to be integrated and compared to concurrent studies by the NJMC and NJDEP.

- ***Short Term intensive sampling*** – Intensive sampling will be conducted for two weeks with samples being collected twice per day for diurnal and nocturnal patterns. Samples will be collected from 08:00 to ~ 20:00 and then from ~20:00 to 08:00 (the next day). We plan to carry out two intensive sampling experiments: the first one during the warm season (July 2006) and the second one during the cold season (January 2007). Sampling for $PM_{2.5}$, selected PAHs and toxic trace metals under this approach will be made at all three sampling sites. Samples to determine particle size-distributions and selected toxic trace elements will be carried out at a single site. The intensive sampling will provide seasonal and day and night particle load information for the targeted toxic trace element species.

5.3. Sampling Target Air Pollutants and Chemical Analyses:

5.3.1. $PM_{2.5}$:

$PM_{2.5}$ samples at each site will be collected with a Partisol 2000 Air sampler (Rupprecht & Patashnick Co., Inc, NY) with a flow rate of 16.7 l/min. This sampler contains a built in active volumetric flow control system to maintain accurate flow rate from ambient temperature and pressure sensors. This system has become a standard for audits and multi-point flow calibration in the US EPA $PM_{2.5}$ national sampling network. The sampling interval will be ~12 hours for intensive sample collection and ~24 hours for every six-day sample collection. Each sampler includes ChemComb Cartridge that is composed of a 47mm filter pack. The Teflon membrane filter (TMF) is designated for $PM_{2.5}$ analysis as well as chemical composition.

The $PM_{2.5}$ mass will be measured in an EPA certified weighing room at EOHSI, Rutgers University (Bush Campus). Selected toxic trace metals associated with $PM_{2.5}$ suspended particulate matter, including Cd, Cr, Pb, Sb, V, and Zn, will be determined by ICP-MS at Inorganic Chemistry Facilities at the Institute of Marine and Coastal Sciences at Rutgers University (Cook Campus), following the analytical procedures by Gao et al. (2002).

5.3.2. Size distributions of Particulate Matter (PM) and its Elemental Concentrations:

We plan to measure the size distributions of particulate matter during the intensive sampling period. The goal is to characterize the particle size – concentration relationships of suspended particulate matter in the ambient air. The selected air toxic elements associated with PM to be measured are Cr, Cu, Cd, Pb, Sb, Se, V and Zn. We will also determine the concentrations of Al, Fe, Ca and Sc, which will be used in the calculation of enrichment factors to assist in source identification.

An Eight Stage Non-Viable Impactor (Thermo Electron Corp.) will be used to generate the information on the particle size distributions of suspended particulate matter in the ambient air. This impactor will give a range of particle fractionation from 10.0 to 0.4 micrometer (um), aerodynamic diameters at 1 CFM (or 28.3 LPM). Three sets of cascade impactor samples will be collected at one site during each intensive sampling period. Chemical composition of PM will be obtained by ICP-MS, using the same analytical procedures as that for $PM_{2.5}$. In addition, we plan to use instrumental neutron activation analysis (INAA) for the determination of targeted trace elements as an external check of the ICP-MS analytical results; the INAA procedure will be performed at Rhode Island Nuclear Science Research Reactor housed at Narragansett Bay Campus of the University of Rhode Island following the procedures described in Gao et al. (1992).

5.3.3. Polycyclic Aromatic Hydrocarbons (PAH_S):

Table 1 describes representative target PAHs species that will be identified and measured in this study. Samples will be extracted and analyzed at the Meadowlands Environmental Research Institute (MERI) laboratory.

Table1. The list for the PAHs

Fluorene	Pyrene	Naphthacene
Phenanthrene	3,6-Dimethylphenanthrene	Benzo[b+k]fluoranthene
Anthracene	Benzo[a]fluorene	Benzo[e]pyrene
1Methylfluorene	Benzo[b]fluorene	Benzo[a]pyrene
Dibenzothiophene	Retene	Perylene
4,5Methylenephenanthrene	Benzo[b]naptho[2,1-d]thiophene	Indeno[1,2,3-cd]pyrene
Methylphenanthrenes	Cyclopenta[cd]pyrene	Benzo[g,h,i]perylene
Methyldibenzothiophenes	Benz[a]anthracene	Dibenzo[a,h+a,c]anthracene
Fluoranthene	Chrysene/Triphenylene	Coronene

PAHs samples will be collected by a modified Tisch High Volume Sampler (Model TE - PNY 1123). The samplers operate at 0.5 to 0.8 m^3 and calibrate frequently to ensure constant flow rates over the sampling periods. Air samples will be collected for 24-hour intervals for long term sampling periods and 12-hour day and night samples during each intensive experiment.

Each sampler is equipped with 20 x 25cm glass fiber filter (GFF) having nominal pore size of 0.7um and backup adsorbent consisting of a polyurethane foam (PUF) plug (98.5 x 10cm). The GFFs are precombusted at 550°C for overnight, sealed by aluminum wrap and kept -20°C until sampling. Washing with Alconox detergent, rinsing with tap water, deionized water, MilliQ water, and air-drying overnight before sampling will clean the PUF plugs. The plugs will be sequentially extracted with acetone for 48 hours in a Soxhlet apparatus with solvent change after 24 hours. The PUF plugs will then be extracted for 24 hours with petroleum ether and dried in vacuum desiccators for 3 days to remove all traces of solvent (Davis et al., 1987). The filter designated for PAH analysis also will be used to determine total suspended particulate (TSP) matter.

GFF and PUF samples representing particulate and vapor phase PAHs, respectively will be extracted differently. The filters will be Soxhlet-extracted with dichloromethane (DCM) and PUF samples will be Soxhlet-extracted with petroleum ether for 24 hours, reduced in volume by Rotary evaporator, cleaned, fractioned by alumina and analyzed by using Gas Chromatography Mass Selective Detector (Agilent 5975 GC/MSD) (Baker et al., 1991; Eisenreich et al., 2002).

6. Project Tracking and Research Schedule

We plan to track progress by following the project time line shown in Table 2. The 18-month project is divided into six tasks. The first task starts October 2005 and ends January 2006. This task involves setting up the accounts, finalizing contracts and procurement, establishing the infrastructure and calibrating the instruments through programmed dry runs and measurements of blanks and spiked samples.

The actual long-term sampling starts February 2006 and continues every sixth day until February 2007. The short- term sampling takes place July 2006 and January 2007. Chemical and data analysis takes place from February 2006 until the end of both sampling terms in February 2007. Data integration and reporting takes place at the middle of the project -August 2006- and towards the end, February and March 2007

During the project, a sampling episode translates into a series of samples and chemical measurements, the results of which end up populating an on-line interactive database that will show the results in a context of federal, state and health standards. Verifying that sampling results are posted accordingly no later than three weeks after the sampling event and according to the timetable will track progress.

Table 2.- Listing of tasks over the 18 month period of the project.

Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.- Purchase and installation of samplers	x	x	x	x	x	x												
2.- $PM_{2.5}$, Trace Metal Monitoring & Analysis						x	x	x	x	x	x	x	x	x	x	x	x	
3.- PAH's Monitoring & Analysis						x	x	x	x	x	x	x	x	x	x	x	x	
4.- PM size Distribution and elemental composition										x						x		
5.- Chemical and data analysis						x	x	x	x	x	x	x	x	x	x	x	x	x
6.- Data integration and reporting											x						x	x

7. Associated Products and Data Analysis

There are National Ambient Air Quality Standards (NAAQS) for six specific air pollutants ("criteria pollutants") and these are the indicators of overall air quality that are currently used. The NAAQS are based both on health effects (for the primary standards) and welfare effects (for the secondary standards). This proposal will specifically measure (among others) particulates and lead, which are designated criteria pollutants at different distances from the NJTPK and which have not been measured before.

During the long-term air pollution monitoring, 24-hour $PM_{2.5}$ samples will be collected every sixth day during a twelve-month period for each of the three sampling stations (50, 100 and 150 m from the turnpike). During each sampling date, weather parameters such as wind direction, speed, temperature and humidity will be measured and integrated as the mean and standard deviation for each sampling period. Normalized particle concentrations (Y axis) will be plotted against distance from NJTPK (X axis) for each wind direction (i.e. parallel to the road and perpendicular to the road). Medians of particle distributions and associated air toxics from $PM_{2.5}$ samples will be compared among sampling stations and between seasons using the non-parametric Mann-Whitney U-test for comparison of medians.

Short-term intensive sampling will be conducted for two weeks during summer (July) and winter (January). Samples will be collected during day and night cycles and during weekdays and weekends. Air particle loading with PAHs and trace metals will be correlated with particle size and enrichment ratios for these will be calculated. Medians of air toxics will be compared between day and night and between week and weekday by means of the non-parametric Mann-Whitney U-test for comparison of medians. The analysis will show if there are significant differences between air toxic loadings between day and night, weekdays and weekends, warm or cold weather and the distance from the NJTPK.

8. Quality Assurance/Quality Control (QA/QC)

The Meadowlands Environmental Research Institute will implement this project following submittal and approval of a detailed QA/QC plan. The Quality System will include all of the appropriate elements listed in the Table of Contents of "Quality Assurance Project Plan for the Air Toxics Monitoring Program," EPA-454/R-01-007. Data Quality Objectives will be derived using the process described in "Guidance for the Data Quality Objectives Process," EPA/600/R-96/055.

Overall Quality Control will be the responsibility of the QA Officer at MERI. Sample custody will be tracked via protocols outlined in the QAPP. The following laboratories will provide SOPs and QA/QC procedures that will be incorporated into the QAPP:

- EOHSI, Rutgers University, Busch Campus, Piscataway - $PM_{2.5}$ mass measured in an EPA certified weighing room;
- Inorganic Chemistry Facilities, Institute of Marine and Coastal Sciences at Rutgers University, New Brunswick - Selected trace metals in the particulate phase determined by ICP-MS;
- Rhode Island Nuclear Science Research reactor - Instrumental neutron activation analysis (alternative method for trace element analysis)
- The Meadowlands Environmental Research Institute (MERI)- PAH species.

9. Benefits to the Public

- Provide reliable local air quality data so that researchers and public health officials can make recommendations to state and federal agencies to reduce the exposure to air pollutants by New Jersey residents living near the NJTPK.

- Provide the basic monitoring data on air toxic exposure to promote the use and development of new low emission technologies.

- Measure the current air quality conditions along the NJTPK and identify areas that may currently be violating state and federal standards.

- Facilitate access to local air quality data presented in the context of health effects so that the general public understands them. Provide the general public with information on the toxicity of pollutants, health and environmental effects.

- Facilitate the exchange of air quality information between state and federal employees, trade associations and conservation groups. Facilitate exchange of information with local governments regarding air quality, land use and zoning.

- Provide local air quality data so the economic modeling and analysis can take place and environmental decisions can be based upon sound economic principles.

10. Transferability of Outcomes

The outcomes of this program are directly transferable to other localities where large numbers of people live within a few miles of heavy traffic highways. The measurements obtained from this study are directly applicable to locations with similar traffic volumes and weather conditions. Our state-of-the-art monitoring and measuring methodology follows standard operating procedures that are transferable to other locations. The way results are presented on-line so that non-scientists understand them and our on-line data visualization techniques can also be effectively transferred. .

11. Roles and Responsibilities

Dr. Francisco Artigas, Director of the Meadowlands Environmental Research Institute (MERI) will be the Principal Investigator (PI) and oversee all aspects of the project. His supporting professional staff at MERI will facilitate project reporting and his administrative staff will handle grant accounting and procurement and the sub-contracting to specialized laboratories. Dr. Jin Young (Co-PI and Chief chemist of the Meadowlands Environmental Research Institute) and his staff (lab technicians and Post-Doc) will handle all Polycyclic Aromatic Hydrocarbon (PAHs) determinations as well as the transfer of samples to sub-contracting laboratories (i.e. $PM_{2.5}$ mass measurement; EOSHI-Rutgers (Bush Campus); Toxic trace metals, Institute of Marine and Costal Sciences, Rutgers University (Cook Campus)). Dr. Yuan Gao (Co-PI) and her graduate student will be responsible for the determination of targeted trace metals in all samples and characterization of particle size-distributions of ambient particulate matter through the use of ICP-MS and INAA, and they will also take the responsibility of data analysis and interpretation of the trace metal results. Ed Konsevick will be the Quality Assurance officer responsible for maintaining and verifying QA/QC procedures and preparing and updating the corresponding documents. Experimental design and Statistical analysis of the data will be the responsibility of Dr. Larry Nelson from North Carolina State University. Data management, database design, on-line publication and data visualization will be the responsibility of Dom Elefante. The final report will be created by Dr. Artigas, Dr. Shin and Dr. Gao.

12. Appendices

Vita Dr. Artigas
Vita Dr. Gao
Vita Dr. Shin

13. Literature Cited

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Budget for Air Quality Monitoring

PERSONNEL			**Salary ($)**	**Fringe Benefits ($)**	**Total ($)**
	Dr. Yuan Gao		16,800	0	16,800
	Post-Doc		55,000	18,150	73,150
	Graduate Student		40,400	9,906	50,306
	Data Analyst		25,000	8,250	33,250
				Sub Total	**173,506**
CONTRACTUAL COSTS	**Sampler**	**Species for**	**No.**	**Price ($)**	**Total Cost ($)**
	Cascade Impactor[3]	Particle size distribution	1	9,500	9,500
	Target Parameters	**EPA Method**	**Sample Number/yr**	**Cost ($)/ sample**	**Total Cost ($)**
	Metal (10 elements) & Analytical Cost (ICPMS/INAA)	IO-3.5	260	150	50,000
	Construction				
	Monitoring station platforms & fencing				15,000
				Sub Total	**74,500**
TRAVEL					**Total Cost($)**
	MERI/Rutgers Travel Expenses				6,000
				Sub Total	**6,000**
EQUIPMENT(Capital Cost)	**Sampler**	**Species for**	**No.**	**Price($)**	**Total Cost($)**
	$PM_{2.5}$ Sampler[1]	$PM_{2.5}$, Metal	3	8,400	25,200
	Hi Volume Sampler[2]	SVOC	3	4,800	14,400
				Sub Total	**39,600**
SUPPLIES	Sampling and Lab Operation				**Total Cost ($)**
	Lab Supply/ chemicals, filter				22,000
	Field Materials and Supplies				10,000
				Sub Total	**32,000**

OTHER					
Analysis	**Target Parameters**	**EPA Method**	**Sample Number/yr**	**Cost($)/ sample**	**Total Cost($)**
	$PM_{2.5}$	~[4]	210	20	4,200
Repair & Maintenance					
	Station Maintenance				12,000
Tuition					
	1 Graduate Student				34,129
				Sub Total	**50,329**
			Total Direct Cost		**375,935**
PERSONNEL			**Salary ($)**	**Fringe Benefits ($)**	**Total ($)**
	Chief Chemist		36,000	11,880	47,880
	QA/QC Officer		30,000	9,900	39,900
	Lab Technician		30,000	9,900	39,900
	Administrative Assistant		24,000	7,920	31,920
	Accountant		24,000	7,920	31,920
	Principal Investigator		54,000	17,820	71,820
ANALYSIS	**Target Parameters**	**EPA Method**	**Sample Number/yr**	**Cost($)/ sample**	**Total Cost($)**
	PAHs	TO-4A, TO-13A	210	40	8,400
	VOCs	Passive Sampler Extraction	210	20	4,200
			MERI Indirect Cost		275,940
			Overhead Cost (15%)		41,391
FACILITIES & ADMINISTRATIVE COSTS					
	Rutgers University				33,568
			Total Indirect Cost		**350,899**
			Total Project Cost		**726,834**

1. Partisol-FRM PM2.5 sampler, Rupprecht & Patashnick Co., Inc. NY
2. TE-PNY1123 ACCUVOL Modified HI Vol Sampler, TISCH, OH
3. Thermo Corp.
4. EPA Federal Register FRL-5997-6