

# MONITORING OF PCB AND OTHER SEMIVOLATILE ORGANIC COMPOUND AIR EMISSIONS IN SITES RECEIVING STABILIZED HARBOR SEDIMENT

## PROPOSED SCOPE OF WORK

By

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Submitted to:

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### Introduction

The prohibition of ocean disposal of dredged sediment has negated placement of these materials in overland sites. The sediment is stabilized by mixing with stabilization agents (cement, lime etc.) and is placed as controlled fill in construction projects. Concerns have been raised recently with the potential for volatilization of PCBs and other SVOCs at sites receiving stabilized sediment with traces of organic contaminants. These concerns are based on past laboratory studies which have shown PCB volatilization from sediments. Volatilization of organic compounds from soils and sediments depends on several parameters including climatic conditions (temperature, relative humidity, wind speed), chemical properties (fugacity coefficient, water solubility, vapor pressure) and soil properties and surface conditions (grain size, moisture content, vegetation cover, wetting-drying cycles). A limited number of experimental studies have shown that under laboratory drying conditions as much as 76% of certain PCB congeners are volatilized from raw sediment (Chiarenzelli et al., 1996, Chiarenzelli et al., 1997(a), Chiarenzelli et al., 1997(b)). These studies have also shown that the PCB volatilization flux is correlated closely with the water vaporization flux and diminishes as water vaporization is reduced over time. Similar observations have been reported very recently by Bushart et al. (1998). Most of these studies have been conducted in Saint Lawrence river sediment which is quite different than the NY/NJ Harbor sediment both in grain size distribution and levels of contamination. Field studies of other SVOCs such as pesticides have shown that volatilization may be an important pathway for loss from the soil to atmosphere (Majewski et al., 1993).

The literature review performed by the principal investigator has not revealed any monitoring studies or field data on PCB or other SVOC volatilization resulting from the placement and compaction of stabilized sediment. The purpose of the proposed study is to obtain such data.

### **Study Objectives**

The objectives of the proposed study are to:

- Develop and execute a field monitoring program to investigate the potential volatilization of SVOCs, including PCBs, at two sites in New Jersey where placement and compaction of sediment from the NY/NJ Harbor region is taking place.
- Based on the results of the monitoring program estimate SVOC fluxes to the atmosphere at these sites both in the form of vapor and particulate matter, under different climatic conditions.

### **Study Methodology**

The study intends to investigate SVOC volatilization at two sites in New Jersey. Site 1 will be the Kearny Point Site which receives cement treated sediment from the NY/NJ Harbor. Site 2 will be the OENJ Site in Elizabeth which is due to receive cement and cement/flyash treated sediment from the Union Drydock dredging activities for an embankment construction demonstration project.

### **Data Acquisition Methods**

Each site will include four monitoring stations as follows:

Station 1: This station will be located outside the area that receives the sediment, at a distance greater than 500 feet in the upwind direction and will serve as ambient control.

Station 2: This station will be located within the aeration area that receives treated sediment for drying before compaction. The monitoring will commence immediately upon placement of the treated sediment.

Station 3: This station will be located within an area that compacted sediment is placed. Monitoring will commence immediately after compaction of the sediment has been completed.

Station 4: This station will be located on an area that receives untreated raw sediment and will serve as a control to compare volatilization rate differences between treated and raw sediment.

Monitoring will be performed at four stations of each site for three seasons winter, spring and summer. The duration of each monitoring event will be determined on the basis of a calibration run that will be performed before the monitoring program begins.

Monitoring will consist of measurement of SVOC (PCBs and PAHs) concentrations and climatic conditions prevailing at the site. A schematic of the monitoring station is shown in Figure 1. The monitoring station consists of two modules:

a) *Air contaminant sample collection module*: This module consists of a dual sample collection assembly. Samples will be collected simultaneously at two different heights to establish a contaminant concentration gradient, which will be used in the computation of contaminant fluxes. The lower sampling port will be located at approximately 0.15 - 0.25 meters and the upper port at approximately 1.5-1.8 meters from the ground surface. Contaminant samples will be collected in two phases, following a procedure similar to the USEPA TO-9A method, particulate matter will be trapped in a 2 micron quartz-fiber filter and gaseous contaminants will be adsorbed on polyurethane foam (PUF) adsorbent. An air stream will be drawn via a metering pump at a flow rate to be determined by field calibration.

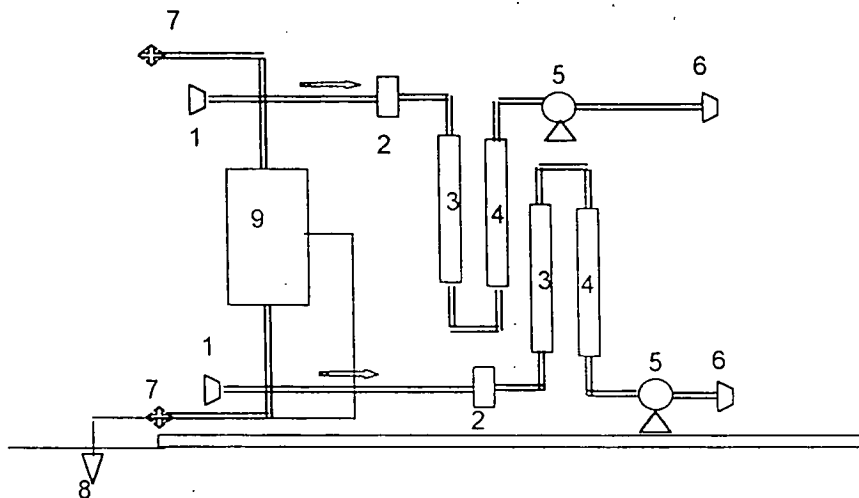


Figure 1. Schematic of monitoring station (1: air inflow ports, 2: quartz-fiber filters, 3,4: polyurethane foam columns, 5: air metering pumps, 6: effluent ports, 7: climatic sensors, air speed, temperature, relative humidity), 8: soil moisture probe, 9: data acquisition system)

b) *Climatic data collection module*: This module consists of climatic sensors for temperature, relative humidity and wind speed and direction located at the same

height as the contaminant sampling inlets. Data will be stored in a data logger and will be retrieved at the end of each sampling event. A soil moisture probe will also be installed at each monitoring site to collect data on soil moisture. Climatic data are needed for the estimation and correlation of contaminant fluxes.

The entire instrument assembly will be enclosed in a waterproof chamber for deployment in the field.

### Analytical Methods

Analysis will be performed on the collected samples (both particulate and PUF adsorbed phase) for the 10 PCB congener groups and for Base/Neutral Compounds by Quanterra Inc. of Knoxville Ten.

Polychlorinated Biphenyls will be determined by Isotope Dilution and Internal Standard High Resolution Gas Chromatography (HRGC)/High Resolution Mass Spectrometry (HRMS). Table 1 shows the PCB congeners and corresponding method detection limits. It must be noted that this is not an EPA standard method but has been used extensively. The SOP for this method is available from Quanterra Inc.

Table 1: PCB Congener Groups

PCBs Congener Group	DL ng
Total Monochlorobiphenyls	0.25
Total Dichlorobiphenyls	0.25
Total Trichlorobiphenyls	0.25
Total Tetrachlorobiphenyls	0.25
Total Pentachlorobiphenyls	0.25
Total Hexachlorobiphenyls	0.25
Total Heptachlorobiphenyls	0.25
Total Octachlorobiphenyls	0.25
Total Nonachlorobiphenyls	0.25
Deca PCB	0.25

Base/Neutrals will be analyzed in accordance with EPA 8270C method for the compounds shown in Table 2.

All analyses will be performed by Quanterra Inc., an EPA certified laboratory.

### Estimation of Contaminant Fluxes

The mass flux of each contaminant detected in the monitoring program will be computed by the Aerodynamic Gradient (AG) method. The AG method is the most frequently used technique for measuring pesticide emission rates from soils

surfaces. It is based on a modified form of the Thornthwaite-Holtzman equation corrected for atmospheric stability (Majewski et al., 1993).

Table 2: Base/Neutral List of Analytes

BNA	DL ug
Acenaphene	10
Acenaphthylene	10
Anthracene	10
Benzo(a)anthracene	10
Benzo(a)pyrene	10
Benzo(b)fluoranthene	10
Benzo(ghi)perylene	10
Benzo(k)fluoranthene	10
Crysene	10
Fluoranthene	10
Fluorene	10
Indeno(1,2,3-cd)pyrene	10
Naphalene	10
Phenanthrene	10
Pyrene	10

The equation is:

$$F = \kappa^2 (C_{z1} - C_{z2}) (U_{z1} - U_{z2}) / \phi_m \phi_p [\ln(z_1/z_2)]^2 \dots\dots\dots \text{Eq. (1)}$$

Where:  $\kappa$  is the von Karman constant  
 $C_{z1}$ -  $C_{z2}$  are the average concentrations of a contaminant at distances  $z_1$  and  $z_2$  from the ground surface  
 $U_{z1}$ -  $U_{z2}$  are the average wind speeds at distances  $z_1$  and  $z_2$  from the ground surface  
 $\phi_m, \phi_p$  are atmospheric stability correction functions

**Project Tasks**

The proposed project will be executed in the following Tasks:

*Task 1: Monitoring Station Construction and Calibration:* This Task entails the construction and calibration of the monitoring stations. Since these stations are not off-the-self items they will be assembled at our laboratory. Calibration entails an optimization of the air flow rates and the appropriate duration between replacement of the glass filter PUF adsorption columns of the contaminant sampling module. The air flow calibration will be performed in the field. An unsaturated flow mass transport model developed by the principal investigator

(Korfiatis and Talimcioglu, 1994) will be used to estimate surface fluxes on the basis of PCB sediment concentration. These estimates will be used as the starting point of the calibration process. It is estimated that data will be collected for at least three different air flow rates. The calibration phase will also be used to investigate breakthrough of contaminants through the first PUF adsorption column and PCB partitioning between particulate and gaseous phases. In order to reduce analytical costs the analysis for these tests will be performed on the basis of total PCBs without performing high resolution congener analysis. The results of the calibration test will be used for the final design of the monitoring.

*Task 2. Execution of Monitoring Program:* The monitoring program will consist of installation of four monitoring stations at Site 1. The same stations will be used for monitoring at four location of Site 2. The duration of each sampling event will be determined in the calibration runs. The monitoring stations will be installed at the site immediately after a fresh layer of sediment is spread or compacted. A total of three samples will be collected from each station at three time intervals. Climatic conditions will be measured continuously and the data will be stored in a data logger. The monitoring at each site will be repeated three times (winter, spring and summer) to capture seasonal variations. Samples will be shipped to the analytical laboratory in accordance with EPA recommended procedures as described in TO-9A. PUF columns will be supplied by the analytical laboratory cleaned and spiked with the appropriate surrogates. Laboratory results will have a 30 day turnaround time. To minimize analytical costs we plan to determine contaminant mass partitioning between particulates (captured in the quartz filters) and PUF adsorbent only in limited number of samples. In the remaining samples only gaseous contaminant mass will be determined (PUF).

*Task 3. Computation of Contaminant Surface Fluxes:* Computations of fluxes for each of the contaminants detected in the monitoring program will be performed using Eq. 1 shown above. Climatic data will be averaged over the sampling period and will be used for the computation. Contaminant fluxes will be correlated with soil moisture, contaminant sediment concentrations and estimated water vapor fluxes. Sediment concentrations will not be measured. The investigators will rely on existing sediment concentration data. The results will be presented as time histories of volatilization rates at each station. Correlation of the data between stations will also be made. The total number of samples to be collected is shown on Table 3 below.

*Task 4. Final Report and Publication:* All data, correlations, computations, methods description and conclusions of the study will be reported in a final report. A paper will be prepared for publication in a peer reviewed journal.

Table 3. Summary of Samples for the proposed program

Stations/Sites	Station 1 (control)		Station 2		Station 3		Station 4		Total	
	Part.	PUF	Part.	PUF	Part.	PUF	Part.	PUF	Part.	PUF
(calibration run) Site 1			12	12					12	12
Site 1	3	18	3	18	3	18	3	18	12	72
Site2	3	18	3	18	3	18	3	18	12	72
Total	6	36	18	48	6	36	6	36	36	156

Part. Analysis on particulate matter trapped on glass filters

PUF: Analysis on gaseous phase adsorbed in PUF

### Project Timeline

The estimated schedule per task including analytical lab turnaround time of 30 days is as follows:

Month	1	2	3	4	5	6	7	8	9	10	11	
Task												
Task 1	████████████████████											
Task 2				██								
Task 3				██								
Task 4									████████████████			

### Bibliography

Bushart, S.P., Bush, B., Barnard, E.L. and Bott, A., ***"Volatilization of Extensively Dechlorinated Polychlorinated Biphenyls from Historically Contaminated Sediments"***, Environmental Toxicology and Chemistry, Vol. 7, 1998, pp. 1927-1933

Chiarenzelli, J., Scudato, R., Arnold, G., Wunderlich, M. and Rafferty, D., ***"Volatilization of Polychlorinated Biphenyls from Sediment during Drying at Ambient Conditions"***, Chemosphere, Vol. 33, No. 5, 1996, pp. 899-911

Chiarenzelli, J., Scudato, R., Bush, B., Carpenter, D. and Bushart, S., ***"Do Large-scale Remedial and Dredging Events Have the Potential to Release Significant Amounts of Semivolatile Compounds to the Atmosphere?"***, Environmental Health Perspectives, Vol. 106, No. 2, Feb. 1998, pp. 47-49

Chiarenzelli, J.R., Scudato, R.J. and Wunderlich, M.L., ***"Volatile Loss of PCB Aroclors from Subaqueous Sand"***, Environmental Science and Technology, Vol. 31, No. 2, 1997, pp. 597-602  
 Chiarenzelli, J.R., Scudato, R.J., Wunderlich, M.L., Oenga, G.N. and Lashko, O.P., ***"PCB Volatile Loss and the Moisture Content of Sediment During Drying"***, Chemosphere, Vol. 34, No. 11, 1997, pp. 2429-2436

Hamer, T., Mackay, D. and Jones, K.C., ***"Model of the Long-Term Exchange of PCBs between Soil and the Atmosphere in the Southern U.K."***, Environmental Science and Technology, Vol. 29, No. 5, 1995, pp. 1200-1209

Korfiatis, G.P. and Talimcioglu, M., "**IMPACT: A Model for Calculation of Soil Cleanup Levels**", Remediation, Spring 1994, pp. 175-187

Larsson, P., "**Contaminated Sediments of Lakes and Oceans Act as Sources of Chlorinated Hydrocarbons for Release to Water and Atmosphere**", Nature, Vol. 317 26, Sep. 1985, pp. 347-349

Majewski, M., Desjardins, R., Rochette, P., Pattey, E., Seiber, J. and Glotfelty, D., "**Field Comparison of an Eddy Accumulation and an Aerodynamic-Gradient System for Measuring Pesticide Volatilization Fluxes**", Environmental Science and Technology, Vol. 27, No. 1, 1993, pp. 121-128



## Proposed Budget

### **I Personnel**

#### **Direct Labor**

1-1 Principal Investigators	15,000
1-2 Machinist	10,000
1-3 Post Doctoral Associate	20,000
1-4 Graduate Research Assistant (1)	15,000

#### **Fringe Benefits**

(31% on 1-1, 1-2 & 1-3) 13,950

**TOTAL LABOR 73,950**

### **II Supplies**

Field 15,000

Laboratory/Machine Shop 6,000

**TOTAL SUPPLIES 21,000**

### **III. Travel**

Personnel Travel 1,000

**TOTAL TRAVEL 1,000**

**TOTAL DIRECT COSTS 95,950**

**OVERHEAD (47% on Total Direct Cost) 45,097**

### **IV. Equipment**

8 Anemometers 5,960

8 Relative Humidity Sensors 2,000

8 Temperature Sensors 2,000

4 Soil Moisture Sensors 2,100

4 Data Loggers with Power Supply 8,000

8 Air Metering Pumps 24,000

1 Barometric Pressure Sensor 700

8 Glass Filter and PUF Sampling Assemblies 8,000

4 Weather Proof Equipment Shelters and Stands 5,000

1 Heat and Vapor Flux Measuring System 16,000

**TOTAL EQUIPMENT 73,760**

**VI. Graduate Research Assistant Fringe Benefits  
(Tuition) 10,200**

### **V. Laboratory Analysis (subcontract)**

24 Samples Total PCBs 4,200

168 samples High Res. PCB Congener Group @ \$900 per sample 151,000

168 Samples for Base-Neutrals Analysis @ \$265 per Sample 44,520

200 PUF/ Filter Cartridges Spiked for Sampling @ \$130 each 26,000

**TOTAL ANALYTICAL COSTS 225,720**

**TOTAL PROJECT COST 450,727**

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SEDIMENT**

Response to Review Comments

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**GENERAL COMMENTS**

The investigators would like to state clearly that the objective of the proposed study is to investigate if PCBs are emitted during the placement of cement treated sediment from the NY/NJ harbor in upland sites in NJ and quantify those emissions. The investigators fully understand that the method of data collection, chemical analyses and data reduction and conclusions must be performed in such a way that withstand scientific scrutiny. To this end, the investigators express their appreciation to the reviewers for the constructive comments.

The investigators would like to point out that the cost of analysis is dominating the budget of this project. The choice to go to a commercial certified analytical facility to perform the analysis, was made for two reasons. First we feel that high resolution GC/MS analysis is required because of the relatively low concentrations expected in the vapor phase and secondly, the appropriate analytical QA/QC procedures must be followed. The large cost of analysis and the fact that the investigators have no control over the characteristics of the sediments that will be monitored, prevents this from being a parametric study. This means that, although it would be desirable, this study will not provide the data to perform rigorous parameter sensitivity analyses and derive generalized prediction models. However the investigators are committed to obtaining statistically significant results within the range of parameters that characterize the specific treatment/placement methods of the sediment. These results may be suitable for calibration of existing flux computation models. To a minimum, this study will show the amount of PCBs and other SVOCs emitted from treated sediment application to land.

Specific reviewer comments are addressed below:

## RESPONSE TO SPECIFIC COMMENTS

### Reviewer 1.

#### ***1-a The proposal does not present information showing that Stevens has existing expertise in this type of work.....***

There will be four co-investigators from Stevens responsible for the execution of this project. Each brings unique expertise that is necessary for the successful completion of the project. All four co-investigators have extensive experience in executing large-scale field studies for industry, private consulting firms and government:

Dr. George P. Korfiatis has over 18 years experience in research and consulting in the environmental engineering field and has participated in over 60 large-scale research projects funded by government, and the private sector. His expertise is in the area of fate and transport of contaminants in soils and sediments, investigation and modeling of soil-water-contaminant interactions and remediation of contaminated soil, water and sediment. He has published over 75 papers in the open literature on these topics. He will be responsible for the overall coordination and management of the project.

Dr. Chris Christodoulatos is an associate professor of environmental engineering with over 10 years research and consulting experience. His expertise is in the areas of physicochemical and biological contaminant interactions and processes in water, soil and air and statistical and regression techniques. He will be responsible for day to day execution of the program and supervision of field personnel, data acquisition and reduction.

Dr. Richard I. Hires is a professor with over 25 years experience in field investigations of ocean, estuarine and water-atmosphere dynamics and transport processes. Dr. Hires has worked extensively with consultants in these areas. His responsibility will be the design of the field monitoring program and data interpretation.

Dr. Thomas Herrington is a research assistant professor with expertise on meteorologic instrumentation and monitoring of near-surface climatic parameters. His responsibilities include equipment and instrument acquisition, development of a field monitoring protocol, field installation of monitoring stations and data acquisition.

A graduate research assistance will assist in the installation and operation of the monitoring stations.

**1-b Use of a non-standard PCB analysis protocol should be justified.....**

There is no High-Resolution GC/MS EPA standard method available. The proposed method however has been accepted by many government organizations including DOE. NJ and NY states are embarking on a multi-million water quality analysis project where this method will be extensively used. Recently the US EPA has encouraged the use of this method for the NY/NJ contaminated sediment source track-down work.

**1-c .....The approach to be used for calculation of fluxes is not justified in the proposal narrative.....**

There are not many ways to measure contaminant fluxes from the soil surface. The proposed method is called the Aerodynamic-Gradient (AG) Technique in the literature, and has been used extensively in the field. Recently, the AG technique has been compared with the Relaxed Eddy Accumulation (REA) technique in field soils contaminated with triallate and trifluralin (Majewski et al., 1993, Env. Sc. and Tech., vol. 27, no. 1). The two methods were found to produce similar results. The REA method however is much more complicated to apply in the field.

The monitoring stations are designed to measure the following parameters: Contaminant concentrations, (Cz1, Cz2), wind speed (Uz1, Uz2), and humidity (Qz1, Qz2). Simultaneously with these measurements, the vertical flux of water vapor will be directly measured with a vapor flux measuring system. This flux will be determined by finding the correlation between the turbulent fluctuations in the vertical velocity component w' and the specific humidity Q' such that:

$$\text{Vapor Flux} = \rho_a \{Q'w'\}$$

Where:  $\rho_a$  is the air density  
 { } denotes time average

Comparison of this directly measured vapor flux with that computed by equation (1) for water vapor i.e.:

$$F = \kappa^2 (Q_{z1} - Q_{z2}) (U_{z2} - U_{z1}) / \phi_m \phi_Q [H(z_1/z_2)]^2 \dots\dots\dots \text{Eq. (1)}$$

will serve to obtain values for the stability factors  $\phi_m$  and  $\phi_p$  suitable for the specific sampling site. A further check for our methodology will be to compare these factors to those reported in the literature. The water vapor fluxes will be correlated with the SVOC concentration fluxes.

The use of the direct measurement of the water vapor flux at the sampling sites eliminates most questions concerning the use of equation (1) and limits the assumptions to just the use of the stability factor for water vapor ( $\phi_a$ ) as equivalent to the factor for SVOCs ( $\phi_p$ ). This assumption is commonly made for measuring the flux of pesticides and appears justified from laboratory studies.

The investigators believe that the AG technique is more suitable for these measurements.

***1-d the budgeted amount is not justified for the flux computations...***

The reviewer computed approximately \$100,000 as the cost for flux computations. We do not really know how this computation was made since in our proposal the total labor cost is only \$73,950. We will be glad to provide a task breakdown of the budget if requested by MR.

Reviewer 2.

**2-a ...As the sampling design now stands, degrees of freedom for each treatment are essentially zero which will obviously confound any attempt to apply statistical algorithms to the data...**

The investigators believe that the reviewer has a valid point. As was pointed out by the reviewer, the cost of analysis dominates the budget. We have budgeted three congener group specific analyses for each sampling event. The investigators believe that an additional two concentration measurements per sampling station will enhance the statistical significance of the data. The budget has been modified to reflect this change. This reviewer, however, alludes to the fact that this study may not provide useful results because a parametric analysis (effects of different parameters such as soil moisture, grain size etc. on contaminant flux) will not be performed. Although such an analysis may be desirable, the cost of conducting it in a field setting will be prohibitive. The investigators believe that the proposed study will produce useful, scientifically defensible results and a resolution to the pending question "does the practice of placing treated NY/NJ harbor sediment on land results in degradation of the air quality at those sites?".

**2-b ..Perhaps you can screen with cheaper analyses..**

The additional analyses proposed above are for total PCBs as opposed to congener specific analysis. The investigators, however, would like to keep the three congener specific analysis per sampling event as proposed initially in order to verify laboratory and field observations which indicate that lower chlorinated PCBs will volatilize at higher rates.

**2-c "Ambient controls" this baseline may vary widely based on atmospheric deposition.....**

The reason for the ambient control is to measure the relative contribution of the treated sediment versus atmospheric deposition. The investigators feel that the addition of the extra two analyses per sampling event will enhance our ability to make a distinction between ambient and treated areas. If it turns out that a distinction between ambient and sediment can not be made after a total of 72 sampling events at two different sites, the obvious conclusion will be that overland sediment placement does not contribute PCBs to the atmosphere.

***2-d Are there data to support the selection of sampling heights to determine concentration gradients?...***

The data that exist in the literature and support the sampling height selection are based on measurement of pesticide concentrations after spraying of agricultural plots. There is no data in the literature concerning contaminant fluxes and concentration profiles derived from sediment placement areas. The investigators will finalize the sampling height locations after the calibration runs are completed (see 3-d below).

***2-e Sediment concentrations will not be measured.. rely on existing data..***

The investigators assume that the sediment is well characterized as part of the regulatory requirements for treatment and placement. If it proves that this is not the case we will propose to MR to perform targeted sediment analysis.

### Reviewer 3.

#### **3-a .....Field investigation is different from laboratory experiment.....**

The investigators are well aware of the difference between laboratory and field studies. All of them have been extensively involved in performing large scale field studies. Many of these studies have been performed for private consulting firms that do not offer expertise for such specialized work.

#### **3-b Why is the Fall Sampling out?**

In order to minimize analytical costs, the investigators feel that a three season monitoring program will be adequate. Fall was chosen to be left out because the climatic conditions during Fall can be approximated with those in the Spring time.

#### **3-c What is the sampling duration?..**

Laboratory studies have indicated that 20% to 60% of the lower chlorinated PCBs was volatilized from sediments during the first 24 hours of controlled experiments at an air flow rate of 1.2 liters per minute. There is no field data to support these findings for treated sediment placed overland. The only field data that the investigators are aware of are the ones obtained by W. J. Parkhurst et al. (TVA) to measure atmospheric distribution of PCBs near Knoxville Tennessee. In this study, high volume samplers similar to those proposed in this project were used. An air flow rate of 0.12 cubic meters per minute was maintained for a total biweekly sampling volume of 2400 cubic meters. They found an arithmetic mean air PCB concentration of about 400 pg/cubic meter with a range of 80 to 1160 pg/cubic meter. A pronounced seasonal variation with maximum readings occurring during summer and minimum values in the winter was observed. The same high resolution analytical techniques proposed herein were used.

The calibration runs planned for this study will be used as the basis to establish an appropriate sampling period and gas flow rate (see 3-d below).

#### **3-d What does the calibration run include.....**

Calibration runs will be performed at a single sampling location. We plan to vary three sampling parameters, flow rate, duration and sampling heights. We plan to perform the flow rate/duration calibration first. Two monitoring stations will be set side by side to sample the same air stream. The calibration run matrix is shown below:



Rate/Sampling period	24hrs	72 hours	168 hrs
10 liters/min	14,400 L	43,200 L	100,800 L
100 liters /min	144,000 L	432,000 L	1,008,000 L

The two sampling heights for these runs will be 0.15 m and 1.5 m. Depending on the results of these runs and the wind velocity and PCB concentration gradients an assessment will be made if a sampling height calibration run is to be conducted.

**3-e Korfiatis et al. proposed a set of 4 monitoring stations...did not provide the basis for this design...**

The choice of 4 sampling stations is based on the fact that we would like to make observations during the different stages in the life cycle of sediment placement. One station is devoted to ambient measurements. One station is to monitor conditions in locations where raw sediment is stored upland for future processing. The third station is to monitor areas where cement treated sediment is spread for drying before compaction. The fourth monitoring station will monitor areas of compacted treated sediment.

**3-f What is the basis for the design of the monitoring system (wind and concentration gradients)?**

The principle of vertical turbulent diffusion within the boundary layer in the near surface is the basis of the Aerodynamic Gradient Technique. A typical near-surface wind velocity profile is shown in Figure 1 below. Computations on the basis of this logarithmic profile over relatively flat surfaces show that the wind velocity at 1.0 meter above the ground surface is approximately 40% higher than the wind velocity at 0.1 meter and the velocity at 1.5 meters is 45% higher than the velocity at 0.1 meter. This shows that substantial velocity differences occur within 1.5 meters from the ground surface and a gradient can easily be measured. The expected PCB concentration gradient will depend on the actual wind velocity and can not be easily estimated. We expect to determine the order of magnitude of that gradient during the calibration run of this study.

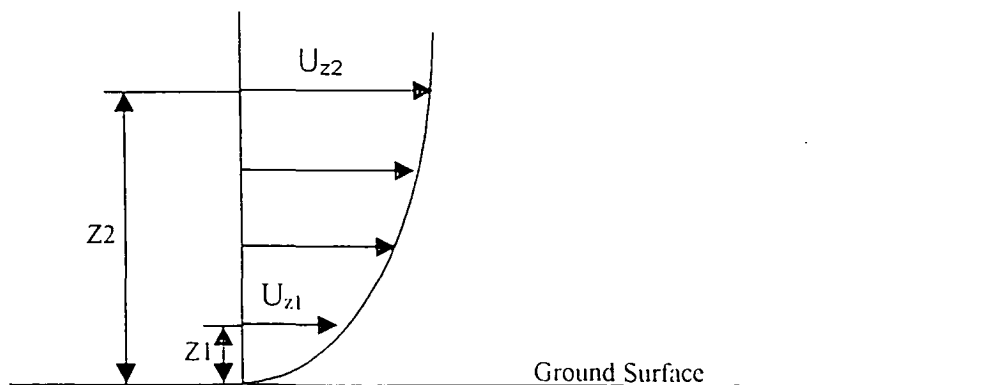


Figure 1. Typical near surface velocity profile

## BUDGET MODIFICATION

The budget has been modified to allow for the addition of two more sampling events per monitoring station. In order to keep costs reasonable, the investigators propose to perform only total PCB analyses for these additional samples. That additional task has resulted in the following increases over the original budget:

Additional direct costs.....	\$ 13,100
Additional analytical costs.....	\$ 41,800

A modified detailed budget follows.

## PROJECT TIME LINE

The project time-line will increase by a month due to additional sampling time required.

## MODIFIED BUDGET

<b>I Personnel</b>	
Direct Labor	
1-1 Principal Investigators	15,000
1-2 Machinist	10,000
1-3 Post Doctoral Associate	30,000
1-4 Graduate Research Assistant (1)	15,000
Fringe Benefits (31% on 1-1, 1-2 & 1-3)	
	17,050
<b>TOTAL LABOR</b>	<b>87,050</b>
II Supplies	
Field	15,000
Laboratory/Machine Shop	10,000
<b>TOTAL SUPPLIES</b>	<b>25,000</b>
III. Travel	
Personnel Travel	1,000
<b>TOTAL TRAVEL</b>	<b>1,000</b>
<b>TOTAL DIRECT COSTS</b>	<b>113,050</b>
<b>OVERHEAD</b>	<b>64,884</b>
IV. Equipment	
8 Anemometers	5,960
8 Relative Humidity Sensors	2,000
8 Temperature Sensors	2,000
4 Soil Moisture Sensors	2,100
4 Data Loggers with Power Supply	8,000
8 Air Metering Pumps	24,000
1 Barometric Pressure Sensor	700
8 Glass Filter and PUF Sampling Assemblies	8,000
4 Weather Proof Equipment Shelters and Stands	5,000
1 Heat and Vapor Flux Measuring System	16,000
<b>TOTAL EQUIPMENT</b>	<b>73,760</b>
VI. Graduate Research Assistant Fringe Benefits (Tuition)	
	10,200
V. Laboratory Analysis (subcontract)	
24 Samples Total PCBs	4,200
96 additional samples for total PCBs	16,800
168 samples High Res. PCB Congener Group @ \$900 per sample	151,000
168 Samples for Base-Neutrals Analysis @ \$265 per Sample	44,520
300 PUF/ Filter Cartridges Spiked for Sampling @ \$130 each	39,000
<b>TOTAL ANALYTICAL COSTS</b>	<b>255,520</b>
<b>TOTAL PROJECT COST</b>	<b>507,214</b>