Indiana Harbor and Canal Air Monitoring:
Background Phase Ambient Summary &
Construction Phase Ambient Air Monitoring Program

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Preface

The purpose of this document is to set forth atmospheric sampling procedures for Ambient Air Monitoring during the Construction Phase of the Indiana Harbor and Canal (IHC) Confined Disposal Facility (CDF). The recommendations made herein are based upon technical information gained from the Background Phase of the current Ambient Air Monitoring Program (AAMP), in combination with established scientific principles. All statements and proposals represent the best available knowledge of sampling procedures, results, and implications.

All courses of action regarding the modification of sampling methods or procedures made within this document pertain only to the Ambient Air Monitoring Program. The purpose of the Background Phase of the AAMP was to collect a comprehensive database of atmospheric contaminants of concern (COCs) in the vicinity of the CDF site, prior to any U.S Army Corps of Engineers (USACE) activity at the site. The continuation of an appropriately modified AAMP throughout the Construction and Dredge/Disposal Phases will support a trend-based analysis of certain COCs. It is important to note that individual construction contracts will maintain a separate regimen of action-level based Emissions Air Monitoring activities that are protective of both site workers and off-site populations. This health-based air monitoring is construction contract-specific and is not addressed in, or modified by, this report.

This document will outline the purpose and intent for Ambient Monitoring throughout the Construction Phase of IHC CDF. Specifically, this text reviews the location, duration, and purpose of the current Background Phase sampling campaign. These factors are then incorporated into the creation and justification of an appropriate format for the collection of ambient atmospheric samples during the Construction Phase of the Indiana Harbor Project. The AAMP will continue to be reevaluated throughout the Construction Phase and into the Dredge/Disposal Phase, and will be modified as appropriate for site conditions and activities.

Introduction

In November 2001, an Ambient Air Monitoring Program (AAMP) was implemented by the U.S. Army Corps of Engineers (USACE) at the area identified as the Energy Cooperative, Inc. (ECI) Site, located in East Chicago, Indiana. Formerly a petroleum refinery, the ECI Site is the future location of the Confined Disposal Facility (CDF) for the Indiana Harbor and Canal Environmental Dredging Project. The goal of the Background Phase of the AAMP, which is discussed in further detail in the following pages, was to characterize the atmospheric conditions prior to any USACE activity in the area. The primary objective for this phase was to obtain information on the occurrence – including possible seasonal variations – of potential contaminants of concern (COCs) in air samples in the vicinity of the proposed CDF.

Four atmospheric sampling stations, shown in Figure 1, were set up to surround the perimeter of the CDF site – each one corresponding to an ordinal direction (i.e. north,

Figure 1: Location of Ambient Air Sampling Stations and major project features at the Indiana Harbor CDF site.

east, south, and west). Additionally, a monitoring station was established adjacent to the East Chicago Central High School (Figure 1). Atmospheric samples were analyzed for 62 different contaminants, outlined in Table 1. These analytes included seventeen (17) individual polycyclic aromatic hydrocarbons (PAHs), nineteen (19) different polychlorinated biphenyl (PCB) congeners, seven (7) volatile organic compounds (VOCs), eighteen (18) trace metals, and total suspended particulates (TSP).

Table 1: IHC Perimeter Air Monitoring Analytes

PAHs	PCB Congeners	VOCs	Metals
acenaphthene	8	1,2,4-trimethylbenzene	aluminum
acenaphthylene	15	1,3,5-trimethylbenzene	antimony
anthracene	18	benzene	arsenic
benzo(a)anthracene	28	ethylbenzene	barium
benzo(a)pyrene	31	m-xylene & p-xylene	beryllium
benzo(b)fluoranthene	77	o-xylene	cadmium
benzo(e)pyrene	81	toluene	chromium
benzo(g,h,i)perylene	105		cobalt
benzo(k)fluoranthene	114		copper
chrysene	118		iron
dibenz(a,h)anthracene	123		lead
fluoranthene	126		manganese
fluorene	156		nickel
indeno(1,2,3-cd)pyrene	157		selenium
naphthalene	167		silver
phenanthrene	169		thallium
pyrene	170		vanadium
	180		zinc
	189		(Tot Susp Particulate)

The specifics pertaining to the Ambient Monitoring Program, including sampling media, sample collection schedule, analytical methods, and quality assurance methods can be found in the *Indiana Harbor and Canal Dredging and Disposal Project, Ambient Air Monitoring Plan: Volume 1* (USACE, 2003). Briefly, 24-hour air samples are collected once every six days. PAH and PCB samples are obtained using a high-volume (Hi-Vol) vacuum pump air sampler. This apparatus draws air through a glass fiber filter (GFF), and a sandwich of polyurethane foam (PUF) and adsorbent resin (XAD-2) media. The combination of filter and adsorbent media allows for the evaluation of the collective gas and particulate phases of the PAHs and PCBs. Metals and suspended particulates are collected using a separate Hi-Vol sampler, employing GFF media. Volatile organics (VOCs) are obtained using specially treated stainless steel canisters, which utilize a bellows-type pump to draw in ambient air. Currently accepted analytical methods, detailed laboratory quality-assurance procedures, and state-of-the-art equipment are all employed to obtain atmospheric COC data from these environmental samples.

The information obtained during the Background Phase of the Ambient Air Monitoring Program is used to establish an ambient air quality database. This inventory serves as a reference for outlining the background levels of the above constituents in the vicinity of the CDF site and the East Chicago Central High School. Additionally, on-site meteorological data has been obtained so that an assessment of the impact of weather conditions on air pollution measurements could be possible. The data gathered over the duration of the Background Phase of monitoring is also used to respond to public inquiries regarding ambient air quality in the vicinity of the future CDF.

Air Monitoring at the CDF Site – Past, Present, and Future

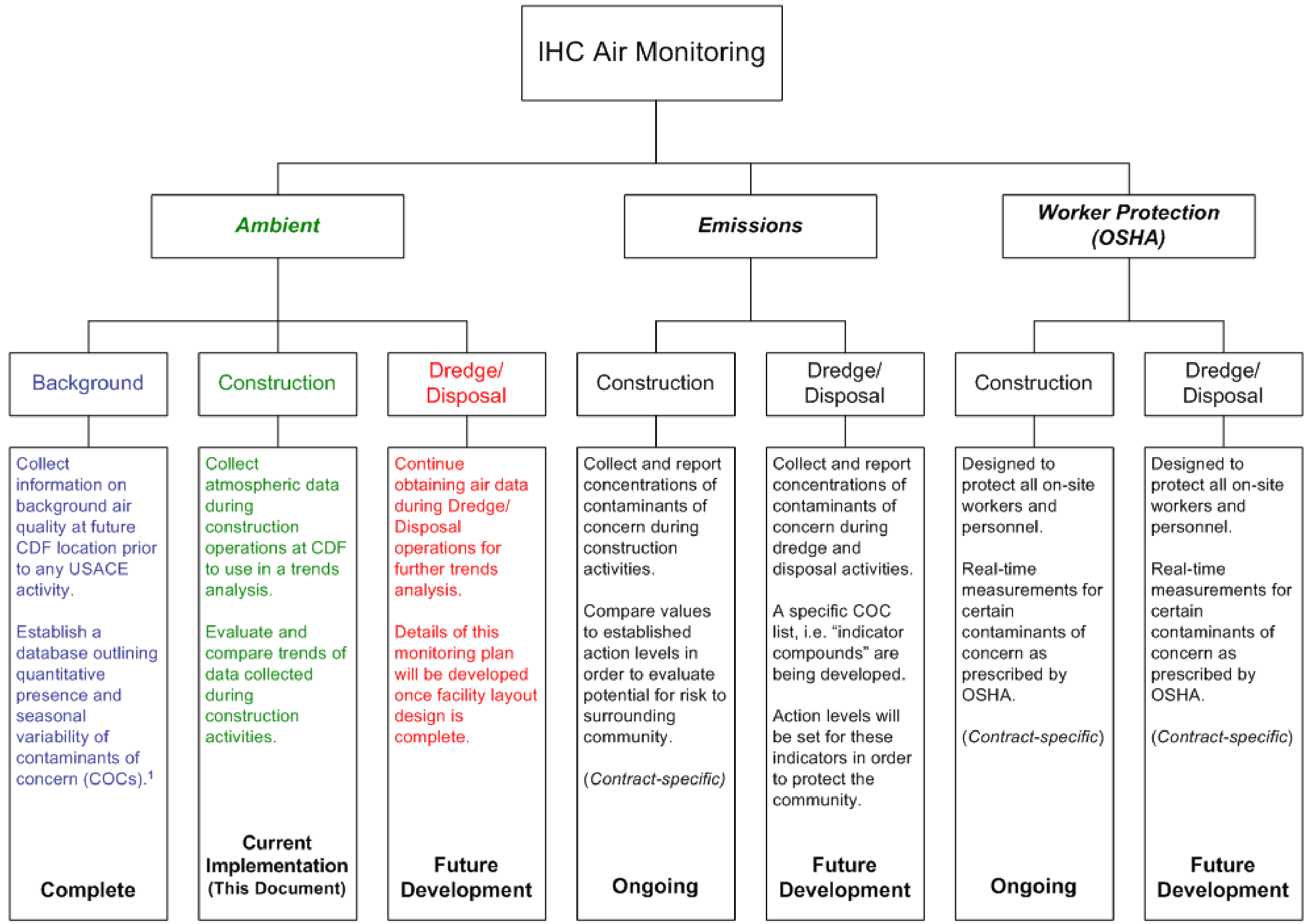
Although ambient air monitoring is the focus for this technical paper, two other distinct types of air sampling are implemented in conjunction with the construction and operation of the Confined Disposal Facility. At this point in the presentation of ambient air monitoring activities, it is important to identify and define the other different types and phases of air monitoring, for sake of clarity. The following varieties of monitoring have been, or will be, taking place at the CDF site throughout the various project phases. These activities are also outlined on the flow diagram, shown in Figure 2.

Ambient air monitoring describes the overall investigative program (AAMP), established by the Corps, implemented to characterize the atmospheric conditions at the CDF throughout the life of the Indiana Harbor Environmental Dredging project. The Ambient Program is divided into three separate phases:

- *Background Phase:* The Background Phase of the AAMP was established to characterize the site for potential COCs prior to any USACE activity in the area. The pollutants measured (outlined in Table 1) were selected because of their possible presence in Indiana Harbor and Canal sediments and potential environmental significance. A database outlining the quantitative presence and seasonal variability is being established, containing approximately two year's worth of data. As of the publication of this document, the goals and objectives of the Background Phase of the Ambient Air Monitoring Program have been fulfilled, and thus the future of the program calls for reevaluation for the Construction Phase.

- *Construction Phase:* Ambient air monitoring during CDF construction will continue as prescribed by this document. The sampling effort during the Construction Phase will be adapted from the Background Phase monitoring regime, and will be based upon the evaluation of Background Phase data. These modifications are occurring because the goals of the Background Phase have been met. To this effect, several adjustments will be made to the analyte list and sampler locations, as appropriate for the ongoing construction activities at the site. The information collected during the Construction Phase will be used to perform a trend-based analysis utilizing both current and historic air data. The AAMP will be periodically reevaluated throughout the course of the Construction Phase.

- *Dredge/Disposal Phase:* The Ambient Air Monitoring Program for the Dredge/Disposal phase will be finalized once the Facility Layout for the



[1] Approximately three months of ground-invasive construction activities (i.e. trenching and obstruction removal) took place during the Background Phase of Ambient Air Monitoring. This information has been parsed from the Background data (when no activity was occurring), and can be used to evaluate the trends of COCs observed during the Construction Phase.

Figure 2: Conceptual flow diagram of all IHC air monitoring activities, past, present, and future.

CDF is complete, and will reflect a program appropriate to meet the goals and objectives of this phase. The ambient air data collected during the Dredge/Disposal Phase will also be incorporated into the trends analysis. Again, the AAMP will be periodically reevaluated, as appropriate, throughout the course of the Dredge/Disposal Phase.

Emissions air monitoring is performed on-site at the CDF, adjacent to any activities that have the potential to cause releases into the atmosphere. The intent of Emissions air monitoring is to assess any potential risks to receptor (human) populations. Emissions air monitoring is not detailed in this document, but is addressed in the individual construction contract packages. Two phases of monitoring activities fall into this category of Emissions air monitoring:

- *Construction Phase:* The purpose of construction Emissions air monitoring is to assure that releases caused by construction activities do not exceed regulatory levels that are established to protect the surrounding community. To this effect, a monitoring program including the pollutants to be measured, sampling frequency, analytical methods, and sample turnaround times is outlined for each construction contract. Additionally, action levels for each pollutant and basis of corrective action are established. This effort is mandated by the Air Registration granted to the Corps by the Indiana Department of Environmental Management (IDEM) Office of Air Quality (Permit no. 089-15320-00471).

- *Dredge/Disposal Phase:* A similar principle will be reflected in the establishment of the Dredge/Disposal Phase of the Emissions air monitoring. Upon the initiation of the Dredge/Disposal Phase, the Emissions monitoring effort will be modified to reflect appropriate protective measures governing volatile releases during the long-term dredging and operation of the CDF. The framework for the reporting requirements during this phase is also outlined in the IDEM Air Registration. Details for the Dredge/Disposal Phase of the Emissions monitoring plan (i.e. contaminants of concern, action levels, and corrective measures) will be developed once the facility layout design has been completed.

Worker Protection air monitoring is prescribed by the Occupational Safety and Health Administration (OSHA), and is specifically designed to protect all on-site workers and personnel. Again, it is not the intent of this document to detail the specifics of worker protection air monitoring, which is addressed by OSHA and applied to contract-specific construction activities.

- *Construction* and *Dredge/Disposal Phases:* Real-time measurements for contaminants of concern determine job-specific safety elements such as necessity for respirator use or exposure duration. This air monitoring effort is modified, as prescribed by OSHA, dependent on the type and extent of construction or operational conditions. Compliance with these OSHA regulations is strictly the responsibility of the individual contractor. Worker Protection air monitoring will be ongoing, as necessary, throughout the life of the project in any situations where site personnel may potentially be exposed to COCs.

It is particularly important to note that the on-site *Emissions* air monitoring, as stipulated by the Corps' Registration with the Office of Air Quality of the Indiana Department of Environmental Management (IDEM), and the *Worker Protection* air monitoring, as regulated by OSHA, are taking place whenever construction activity is present at the site. Both types of monitoring are designed specifically to protect people – both on- and off-site – and are thus indispensable while activity (construction or dredge/disposal) is ongoing. Therefore, modifications to the *Ambient* air sampling program do not impact the monitoring requirements in place for the protection of site workers, personnel, or the surrounding community.

Background Phase Summary

The current phase of the AAMP (Background Phase) monitors a number of constituents within four distinct classes of atmospheric pollutants, (PAHs, PCBs, VOCs, and Metals), outlined in Table 1. These analytes were originally chosen due to their presence within environmental samples obtained at either the Indiana Harbor or ECI sites, or because of their significance as potential contaminants of concern. As a consequence, during the Background Phase, the overall goal of this program deemed it important to monitor each of these pollutants in order to obtain a comprehensive contaminant database of the existing air quality in the vicinity of the ECI site. Additionally, the spatial and temporal variation of these contaminants at the future CDF site were previously unknown. Therefore, it was also considered appropriate to establish a perimeter layout surrounding the proposed CDF site, combined with a satellite monitoring station at the High School. The station at the High School provides information representing ambient concentrations at the nearest human receptor population.

The project life of the Background Phase of the Ambient Air Monitoring Plan was only anticipated to last for one year. Despite this timeline, Background Phase monitoring is still ongoing at the time of publication of this document, and has thus surpassed its second full year of existence. As a result of this program, an extensive background dataset has been compiled. Accordingly, the goals and objectives outlined for the Background Phase of the ambient air monitoring effort have been attained. Since October 2002, intermittent construction activities have commenced at the future CDF site. Therefore, although air monitoring is still continuing, it could be contended that conditions at the site – from a technical standpoint – have been altered from their original "background" state. The purpose of this document is to outline a rationale for modifications in Ambient Monitoring efforts during the Construction Phase of the CDF, and develop a strategy for future ambient air monitoring endeavors.

Since the goals and objectives of the original Background Phase of the AAMP have been attained, it is now practical to reevaluate and modify the structure of this program. Primarily, the necessity of obtaining samples at all five monitoring stations during the Construction Phase is addressed. Additionally, the analyte list will also be examined to determine if it is reasonable and appropriate to continue monitoring such a large number of constituents. To this effect, several statistical analyses and comparative evaluations will be discussed. The ultimate goal of this text is to arrive at a suitable Construction Phase ambient sampling campaign, through use of numeric and statistical analyses, given the information obtained during the Background Phase.

Background Phase Dataset Description

Background Phase ambient air monitoring at the future site of the CDF began in November of 2001. At that time, atmospheric samples were collected and analyzed for PAHs, PCBs, and VOCs. In April 2002, samplers were installed to measure total suspended particulates (TSP) – small particles that normally exist in the air – and trace metals that are bound to these particulates. Background conditions, operationally defined as the absence of surface-disturbing events – such as excavation, boring, or other earth-moving activities – existed until October of 2002. As can be seen from Figure 3, trenching for pilot-scale tests and obstruction removal activities marked the end of the first "background" period. These construction activities lasted until mid-December 2002, when the site again fell dormant for a period of approximately 6 months. Since mid-June of 2003, construction activities have been taking place intermittently, making "background" samples increasingly harder to delineate.

For the purpose of discussion and analysis within this document, the information obtained during the Background Phase is broken into two datasets: the **Idle** dataset and the **Active** dataset. The Idle dataset is defined as samples gathered at the CDF site between November 2001 to October 2002, and January to June in 2003. These samples were collected when no earth-disturbing actions were taking place at the CDF, and truly identify "background" ambient conditions. The samples collected between October 2002 to January 2003, and June to July 2003 are labeled as the Active dataset (due to on-site construction activity). Although technically obtained during the Background Phase of the ambient program, these samples are unique because they are able to describe atmospheric conditions during construction activities at the site. Idle and Active phases are delineated in Figure 3.

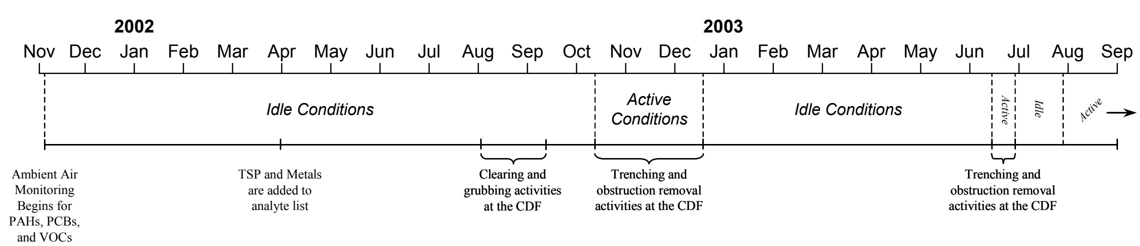


Figure 3: Ambient Air Monitoring timeline, through September 2003.

At the time of compilation of atmospheric data for publication in this document, quality checked and assured data existed through early-July 2003. Samples collected beyond that point are still in the process of laboratory extraction, analysis, quality assurance, and publication. As a result, the numeric and statistical analysis presented within this document reflects Idle and Active datasets compiled between November 6, 2001 and July 8, 2003.

The overall dataset generated by this sampling program is enormous in quantity and breadth. In principle, over 28,000 individual data points exist; comprised of the 62 combined various PAH, PCB, VOC, and metal analytes, obtained at the five measurement stations, over the duration of the 92 individual sampling days for which quality-assured data are currently available. Certainly, due to occurrences such as missed sampling days, sample loss, or any other variety of qualifiers inherent with such a large endeavor, not all of these samples have been reported. However, this statistic provides insight into the overall magnitude of this undertaking and emphasizes the ability of the dataset to characterize the atmospheric conditions at the CDF site.

With two years of atmospheric data collected at the CDF and High School sites, various informative assessments of COC concentrations can be performed. However, the difficulties inherent in gleaning pertinent and significant information from a large atmospheric dataset are considerable. Confounding factors including seasonal variations and outside influence from industry (i.e. emissions from refineries, steel mills, foundries, or contaminated environmental sites) contribute the largest amount of uncertainty to this type of air sample dataset analysis. For example, analytes such as PAHs and PCBs are classified as semi-volatile organic compounds (SVOCs), and exhibit various properties under the influence of environmental conditions. Thus, a trait such as susceptibility to volatilization is significantly influenced by meteorological factors including temperature, precipitation, and wind speed. Additionally, the project area has historically been home to a myriad of heavy industrial tenants because of its strategic location as a major port city on Lake Michigan. Industries such as steel mills, foundries, refineries, and associated commerce have all had a strong lineage to this vicinity. As a result, the background concentrations of many atmospheric toxics, including PCBs, PAHs, VOCs, and metals is elevated in this region, as compared to non-industrial areas. Accordingly, these details must be considered when comparing information obtained during comprehensive monitoring program of such a lengthy temporal scale.

Various computational and statistical software packages have the capacity to break down and model a data series, taking into consideration disruptions and seasonal factors. This type of modeling could be applied to the data collected by the AAMP, in order to determine tendencies of contaminant levels at the CDF site or High School. For example, it may be possible to utilize the information gathered to observe the effect of Construction Phase activity on the Background Phase air data, or examine the temporal effects of seasonality on the concentrations of contaminants of concern. However, it should be noted that the inherent variability in the atmospheric data collected by any atmospheric monitoring program influences the quantity of data necessary to perform such a trend-based analysis. Initial research into comprehensive trends modeling suggests that additional data – perhaps an additional one to two year's worth – should be collected before a statistically valid model can be developed.

At the time of publication, the utilization of any particular software package remains in an exploratory phase. The need for additional atmospheric data to fully utilize the potential of trend-based analysis calls for the focused and practical continuation of the Ambient Air Monitoring Program. It is expected that once a quantity of data has been collected to satisfy the capabilities of leading software packages, a detailed trend-based analysis of the Background and Construction Phases can be presented. A similar analysis would continue into the Dredge/Disposal Phase, and throughout the conceivable lifetime of the Ambient Monitoring Program. This analysis would include an evaluation of the entire dataset to attempt to determine the causality of concentration trends, comparison of observed results, and the effects of seasonal variability.

Until a trend-based analysis can be accomplished, a more fundamental and practical evaluation, but one similar in strength and capability, can be performed on the data collected to date. This analysis can be utilized to evaluate existing information and, in turn, to develop an appropriate monitoring scheme for Ambient Air Monitoring during the Construction Phase. The remainder of this document presents such an assessment of the Background Phase information, including a thorough statistical evaluation describing the tendencies observed within the atmospheric dataset.

Evaluation of Atmospheric Data – Non-Detect Data Analysis

An aspect of environmental sampling that requires close scrutiny is the applicability of quantitation limits, and their ability to validate the measurement of the analytes in question. For example, a particular sampling and analytical method should be chosen so that the limits of analyte detection are able to sufficiently describe the concentration of a contaminant of concern, appropriate to the extent of the scope of the project. Only then, can the information obtained be applied to a relevant numeric, comparative, or statistical analysis. Optimally, detection (quantitation) limits would approach zero, so that even the smallest quantity of a chemical could be enumerated. However, due to physical, technical, or practical constraints, it is necessary to arrive at a compromise between practicality and ultimate detection, while still maintaining confidence in a reported dataset.

The US Environmental Protection Agency (EPA) is one of several organizations that publishes, and periodically updates, a Compendium of Methods (U.S. EPA, 1999) for the determination of toxic organic compounds in atmospheric samples. This list is written to assist Federal, State, and local regulatory personnel in developing and maintaining necessary expertise and up-to-date monitoring technology for characterizing organic pollutants in the ambient air. Prior to the development of the Ambient Air Monitoring Program, a group of technical experts were consulted to select analytical methods appropriate for the sampling and evaluation of the COCs identified at the Indiana Harbor site. This task group utilized the most current analyte-dependant EPA Compendium Methods as a framework and, where appropriate, made modifications to optimize the relationship between the type of contaminants, number of analytes, and sufficient levels of quantitation. The complete sampling and analytical plan can be found in the *Indiana Harbor and Canal Dredging and Disposal Project, Ambient Air Monitoring Plan: Volume 1* (USACE, 2003).

Methodology

The range of quantitation limits for the four different analyte groups are listed in Table 2. The limits shown in Table 2 are comparable to other atmospheric sampling programs, and are appropriate to the scope and magnitude of this sampling effort. Additionally, the quantitation limits for the Ambient Air Monitoring Program fall well below the majority of the highly conservative risk-based atmospheric concentrations published by various EPA Regions.[1] The exceptions to this statement are for benzene, (PRG/RBC concentration of 0.23 $\mu g\ m^{-3}$), and dibenz(a,h)anthracene (RBC concentration of 0.86 ng m^{-3}). It should be reiterated that the purpose of the AAMP is to evaluate trends of

Table 2: Range of Quantitation Limits for PAH, PCB, VOC, TSP, and Metal Analytes

Target Group and Analytes	Quantitation Limits
PAHs (ng m^{-3})	
All (except naphthalene)	1.14-3.13
naphthalene	4.50-6.27
PCB Congeners (pg m^{-3})	
All	2.25-3.13
VOCs ($\mu g\ m^{-3}$)	
1,2,4-trimethylbenzene	1.476
1,3,5-trimethylbenzene	1.70
benzene	0.64
ethylbenzene	0.87
m-xylene & p-xylene	1.74
o-xylene	2.17
toluene	0.75
Metals ($\mu g\ m^{-3}$)	
aluminum, iron	0.029-0.031
vanadium	0.0059-0.0062
zinc	0.0029-0.0031
antimony, arsenic, chromium, copper, nickel, selenium, silver	0.00118-0.00124
barium, beryllium, cadmium, cobalt, lead, manganese, silver, thallium	0.00059-0.00061
Total Suspended Particulates - TSP (g m^{-3})	
	2.44E-7-2.56E-7

[1] Primary Remediation Goals (PRGs) are published by EPA Region 9, and Risk-Based Concentrations (RBCs) are published by EPA Region 3. Neither set of values constitutes regulation or guidance. These risk-based values are founded on a relatively simple screening-level model, and the concentrations generated represent a hazard based upon a lifetime of chronic exposure. A formal site-specific risk analysis is the primary means to accurately draw any conclusions with regard to the actual level of risk to the surrounding community.

contaminants of concern. The Emissions Monitoring Program has a different set of analytes and quantitation limits that ensure protection for the health and safety of the community.

One factor immediately and clearly identifiable from a qualitative examination of the Background Phase contaminant dataset is the relative presence (or absence) of non-detect data. Often, some amount of confusion exists in defining the difference between laboratory detection limits and quantitation limits. Although decidedly beyond the scope of this document, the term "detection limit" is most often associated with the threshold ability of an instrument to measure a contaminant signal, whereas the "quantitation limit" is related to the capacity of a sample to be accurately measured via a standard method. In the context of this report, a "non-detect" sample result is one that could not accurately be enumerated above the calculated quantitation limit.

As mentioned previously, 62 different analytes were linked to this program as possible atmospheric contaminants because of either their presence in historic IHC environmental samples (sediment, water) or significance as a present-day contaminant of concern. However, not all of these were detected – or detected with significant reproducibility – in the atmospheric samples obtained throughout the duration of the Background Phase of the Ambient Air Monitoring Program.

Methods of dealing with non-detect data vary widely. In this instance, since only basic numeric and statistical analyses are desired, non-detect (ND) data are dealt with in a straightforward manner. Guidance published by the Army Engineer Waterways Experiment Station (Clarke and Brandon, 1996), suggests that datasets that are 60-80% non-detect should be deemed highly censored. Subsequently, any ensuing numeric or statistical analysis would be considered tenuous. Additionally, this text recommends outright avoidance of any analysis of a dataset for which the number of non-detect data is greater than 80%. Based upon this information, it is determined that if a specific sample sequence reports over 60% non-detect responses, that particular analyte train was deemed unsuitable for further analysis.

An evaluation of each PAH, PCB, VOC, and metal sample sequence from each sampling station, (62 analytes by 5 stations yields 310 sample sequences) was performed to determine the percentage of non-detect values for each specific analyte at a particular station. For clarification, it should be indicated that a sample sequence involves the aggregate of all samples for a particular analyte, at a specific station, throughout the duration of the ambient air monitoring program (i.e., each sample sequence can contain up to 92 individual sampling days).

<u>Results</u>

In general, the percentage of ND data among all ambient atmospheric analytes in the Background Phase (Idle and Active datasets) was bimodal; the majority of the sample sequences fell into one of two extremes, 0-10% non-detect or 91-100% non-detect, as can be seen in Figure 4. When separated from the Background Phase dataset, a very similar

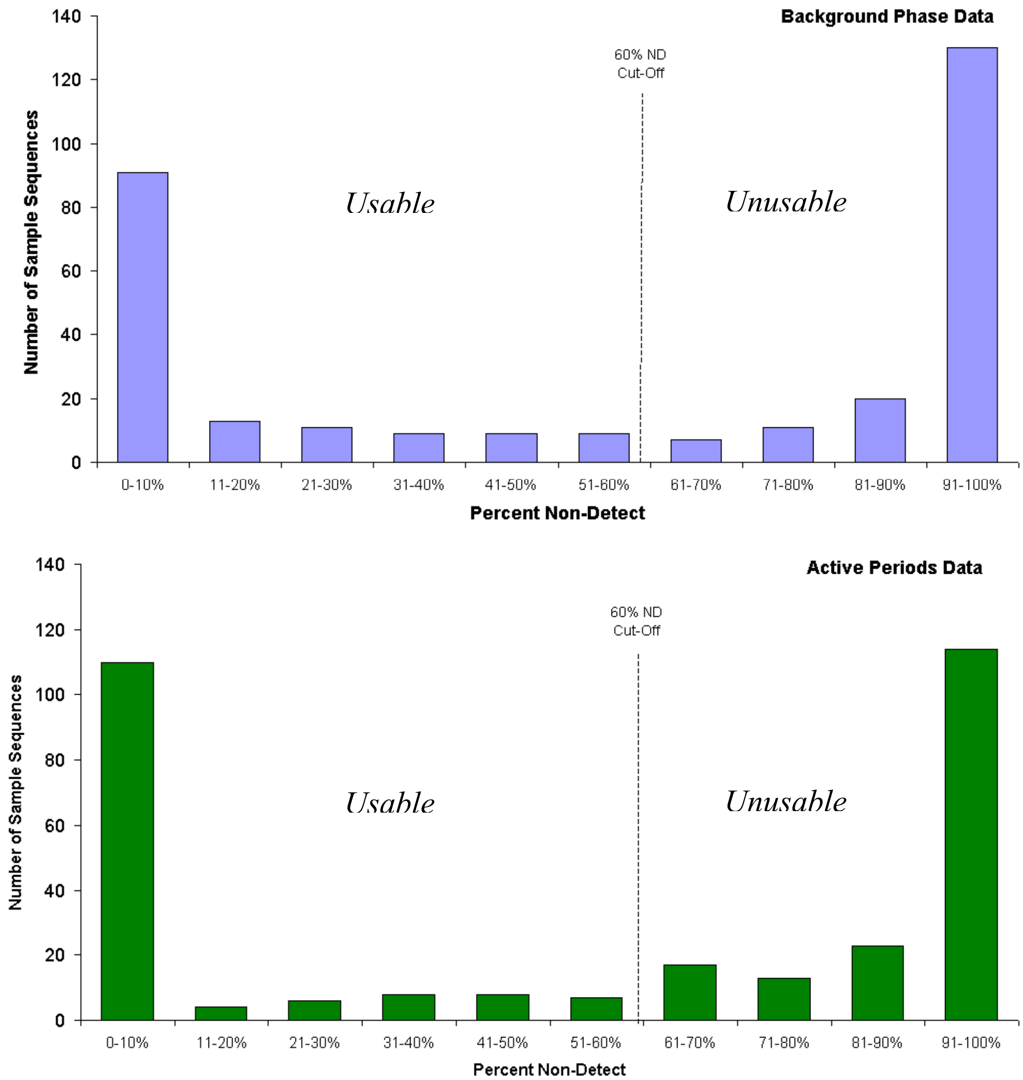


Figure 4: Non-Detect Data Statistics for Entire Background Phase (top) and Active Periods (bottom).

dichotomization can be observed for those samples collected during the Active dataset (October 5 – December 16, 2002 and June 17-27, 2003). For the entire Background Phase, 71% of the sample sequences fell into either the top-tenth or bottom-tenth percentile, and 72% fell into this statistic for the Active dataset.

As can be observed in Figure 4, utilizing the 60% ND criteria to eliminate sample sequences yields 46% (142 sample sequences) that are justified for further analysis. Although the purpose of this exercise generally pertains to statistical evaluations, it also allows insight into the "sampleabilty" of a particular environmental contaminant. Since the future of the AAMP focuses on the collection of information toward the evaluation of COC trends, it makes sense to gather data that can be reported and evaluated with statistical confidence. As mentioned previously, the Background Phase included several months of extensive trenching and excavating (i.e. construction) activities – identified by the Active dataset. It should be noted that these are likely to be the most intrusive of earth-disturbing activities, thus have the highest potential to impact air quality via volatilization of subsurface contaminants. Therefore, if during the 20-month duration of the Background Phase an analyte has not been reported in accordance with the 60% cutoff, it is highly likely that this behavior will continue through the Construction Phase. Given that the Background Phase (which has generated an extensive COC database) has been completed, the continued collection of those analytes which do not fall within the <60% criteria <u>does not</u> benefit the goals and objectives of the AAMP.

In summary, the primary goal of the Background Phase of the Ambient Air Monitoring Program was to compile a comprehensive database regarding the relative presence of a number of airborne contaminants of concern at the CDF site, prior to any USACE activity. Atmospheric samples were evaluated for a list of 62 various PAH, PCB, VOC, and metals analytes (see Table 1), which were identified as possible COCs because of their incidence in environmental samples obtained from the Indiana Harbor and Canal. The Background Phase also obtained atmospheric data incorporating periods of construction activity at the site. As a result of this monitoring program, a number of analytes were not quantified with a statistically significant frequency of detection. Table 3 displays a list of these analytes, along with the percent-occurrence of non-detect values.

It can be observed from this table that the majority of the analytes were reported as non-detects with a high rate of incidence (>90%). It is also important to note that the relative absence of these compounds was evident during both Idle and Active monitoring portions of the Background Phase (Figure 4). As a result, the tendency concerning the

Table 3: Analytes Collected During Background Phase with > 60% Non-Detect Values

Analyte	ND	Analyte	ND
PAHs		VOCs	
Anthracene	84%	1,2,4-trimethylbenzene	96%
Benzo(a)anthracene	98%	1,3,5-trimethylbenzene	99%
Benzo(b)fluoranthene	95%	Ethylbenzene	91%
Benzo(k)fluoranthene	95%	m-xylene & p-xylene	86%
Benzo(ghi)perylene	93%	o-xylene	90%
Benzo(a)pyrene	97%	PCB Congeners	
Benzo(e)pyrene	96%	77	100%
Chrysene	84%	81	100%
Dibenz(a,h)anthracene	100%	105	95%
indeno(1,2,3-cd)pyrene	98%	114	100%
Metals		118	63%
Antimony	64%	123	100%
Beryllium	100%	126	100%
Cadmium	64%	156	100%
Silver	100%	157	100%
Thallium	98%	167	100%
Vanadium	67%	169	100%
		170	99%
		180	87%
		189	100%

comparative presence/absence of each analyte was similar when the overall atmospheric dataset (entire Background Phase) was compared to the construction-intensive Active dataset samples.

These results from the Background Phase can be integrated into the formulation of the Construction Phase of the Ambient Air Monitoring Program. In order to create a sampling regime that is scientifically appropriate, only those COCs that can contribute to a statistically significant analysis of concentration trends will be evaluated during the Construction Phase. Recognizing that the list of contaminants evaluated during the Background Phase (Table 1) represents the most comprehensive estimate of possible COCs at the CDF site, the Construction Phase analytes will be based upon this inventory, less those contaminants which were not reported at a statistically significant frequency of detection (Table 3).[2] The list of contaminants of concern that will be utilized for sampling and analysis during the Construction Phase are presented at the conclusion of this document, in Table 10.

Evaluation of Atmospheric Data – Meteorological Data

Meteorological data was collected concurrently with the PAH, PCB, VOC, and TSP/metals data throughout the majority of the Background Phase of the AAMP. A ten-meter meteorological tower was constructed adjacent to the South site monitoring station to record climactic conditions. Variables collected at the weather station included wind speed and direction, temperature, barometric pressure, rainfall, and solar radiation. Monitoring of meteorological conditions, coupled with pollutant monitoring, allows the potential to assess the correlation of contaminant behavior, such as volatility or transport, to site-specific conditions.

Wind direction is a principal factor that can provide insight into to the possible sources of atmospheric contaminants of concern. A set of statistical analyses will be presented in the following sections of this text. The purpose of this discussion will be to evaluate the statistical similarity/difference between the samples collected at the monitoring stations at each of the four CDF sites, in addition to the High School. This analysis can also be related to meteorological data collected concurrently with the atmospheric data. In cases where a statistical similarity exists among samples, it can be assumed that the air mass over the site is homogeneous, thus effectively inhibiting any assessment of pollutant transport. However, if a particular site (or sites) demonstrates a statistically higher concentration as compared to the remainder of the monitoring stations, wind direction information allows for the possible determination of contaminant plume profiles.

Wind direction data at the meteorological station was recorded continuously and reported as a 5-minute average. This information can then be compiled into a 24-hour average wind rose, corresponding with the 24-hour sample time of a particular COC.

[2] It is important to note that the Ambient Air Monitoring Program will be periodically reevaluated throughout its lifetime, particularly during the transition into the Dredge/Disposal Phase. Appropriate sampling regimes will be based upon previously gathered information and operational conditions at the site.

A compilation of the 5-minute averages was examined for the duration of one year, August 2002-2003, to determine if a prevalent wind direction existed at the CDF site. Direction is recorded in tenths of a degree, clockwise from due north, which is designated as 0-360 degrees. The wind direction is operationally defined as blowing **from** a particular cardinal direction (N, E, S, W) if it falls within $\pm 45^o$ of the respective degree designation (0^o, 90^o, 180^o, 270^o). Figure 5 identifies the degree coordinates and abbreviations utilized for describing the wind direction through the remainder of this document.

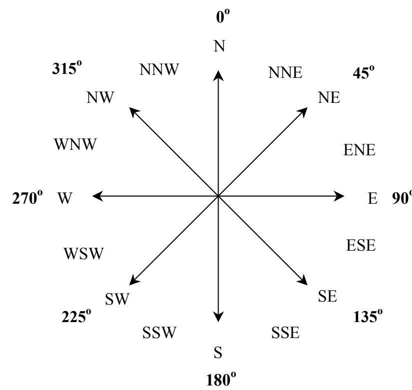


Figure 5: Directional designations

Table 4 displays the results for the yearlong wind data compilation. This data indicates that the relative frequency of wind from the north, south, and west is similar, with a variability of only ± 2.3%. Conversely, the incidence from the easterly direction is more than 10% lower than any of the three other readings. This meteorological data spans only one year of measurements at the CDF monitoring site. Since meteorological trends are highly susceptible to variation over time, the data does not demonstrate a marked prevailing wind direction that can be observed over the course of a year. However, the comparatively low frequency of readings from the easterly direction may be indicative of a typical trend. Additionally, insufficient data exists at this time to make any conclusions with respect to specific seasonal trends. For general discussion, the wind pattern at the site could be considered variable, thus no overall transport trends can be identified from this information.

Table 4: Percent Frequency of Wind Direction from Aug '02-'03 at the CDF Site

Direction	Degrees*	Percent Frequency
North	315^o-45^o	27.1 %
East	45^o-135^o	16.2 %
South	135^o-225^o	29.4 %
West	225^o-315^o	27.3 %

* Degrees measured clockwise from north, (0^o-360^o)

As mentioned previously, further interpretation of the wind direction data will be included periodically in the following sections. For example, it is possible to correlate wind direction to sample-specific contaminant values in order to identify potential sources. These types of analyses will be performed on a site-specific or sample-specific basis, in order to support statistical comparisons and resultant assertions.

Evaluation of Atmospheric Data – Statistical Analysis

Statistical tests provide an avenue to evaluate the degree to which the qualities of one group of data differ from those of another group. Any statistical test is based upon certain assumptions about the population from which the data are drawn. The two types of statistical tests are known as parametric and nonparametric evaluation. Parametric tests are based upon a number of critical assumptions, all of which must be realized, in order to retain the robustness of the evaluation. If these assumptions are not met, the probability of incurring a Type I error – the detection of a significant difference when one does not exist – increases, and the robustness of the test decreases (Clark and Brandon, 1996).

Nonparametric tests are often utilized when the parametric test assumptions cannot be met, when very small numbers of data are used, and when no basis exists for assuming certain types (or shapes) of distributions. Nonparametric tests are performed on the data ranks, rather than the actual data values. Ranking the data avoids the assumption of a normal distribution, which is required by parametric statistics, and minimizes the effects of data outliers (Clark and Brandon, 1996).

A statistical test can never establish the truth of a hypothesis with 100% certainty. Typically, this hypothesis is specified in the form of a "null hypothesis," i.e. the score characterizing one group of measurements does not differ (within an allowable margin of error) from the score characterizing another group. Therefore, performing a statistical test helps arrive at the decision that either the scores are not different (the hypothesis is confirmed) or the difference in scores is too large to be explained by chance (the hypothesis is rejected). For the statistical tests described hereon, a confidence level of 95% (significance level $\alpha = 0.05$) was used to test the null hypothesis.

The United States Geological Survey (USGS) performed a preliminary statistical evaluation of both the Idle and Active ambient datasets. This analysis incorporated data from the initiation of ambient monitoring through December of 2002. A follow up to this analysis was performed by USACE utilizing the most recently available data (through July 8, 2003), and these results are presented within this discussion. The USGS analysis was utilized as a general method of maintaining quality-assurance of the USACE evaluation. This statistical evaluation compared the analytical results among the four sampling stations surrounding the future CDF site, (designated the North, East, South, and West Samplers in Figure 1), and the High School site. Additionally, comparisons were performed between Idle and Active periods among various sites. The methodology utilized for these comparisons is outlined below.

Methodology

For each particular PAH, PCB, VOC, or metal analyte, the reported concentrations for a certain period (Idle or Active) were compiled. Subsequently, the results from each sampling station were separated according to seasonal similarity. The average temperature record was obtained for East Chicago IN (*The Weather Channel On-line*), and the samples were split into three temperature-dependant groups based upon the average temperature of the month of sample collection. Table 5 identifies the three sample subgroups (Winter, Spring/Fall, and Summer) and the respective monthly mean temperatures.

Table 5: Monthly Mean Temperatures of Sample Subgroups

Winter	Mean Temp* (°F)	Spring/Fall	Mean Temp* (°F)	Summer	Mean Temp* (°F)
December	30	March	40	June	71
January	25	April	50	July	75
February	31	May	61	August	74
		October	55	September	67
		November	42		

*Obtained from *The Weather Channel On-line* webpage; http://www.weather.com

Once parsed into their respective seasonal groups, the samples were subjected to a basic statistical analysis, including identification of the number of samples, mean, and standard deviation. This operation was accomplished for the Idle dataset, for each seasonal sampling group, per respective sampling station, on each of the four analyte-specific data sets. A similar operation was performed on the Active dataset, with one slight caveat. Although there were several (3-4) sampling dates that overlapped into other seasonal groups, the majority (8-10) of the Active dataset fell into the Spring/Fall subgroup. Therefore, it was decided to combine all of the Active data together so that a statistically robust population could be maintained. A schematic diagram of the sample set arrangement is shown in Figure 6.

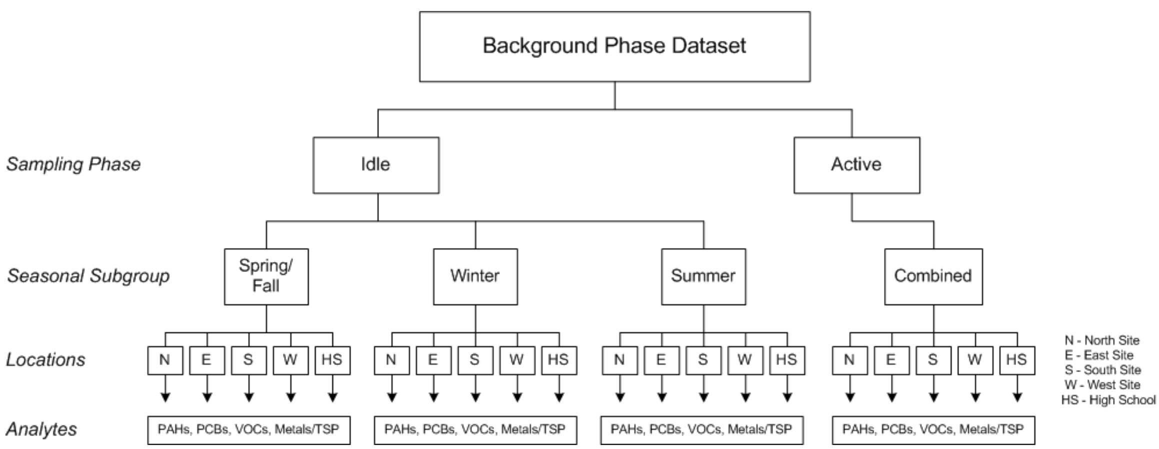
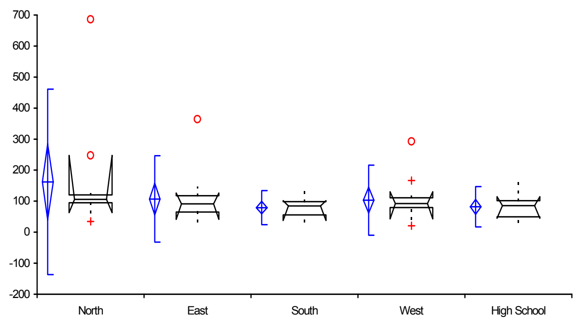


Figure 6: Schematic diagram of atmospheric dataset sample arrangement.

<u>Statistical Variation Among Sample Sites</u>

To determine if a statistical difference exists among the sites, a Kruskal-Wallis (Ott and Longnecker, 2000) test was performed on all samples from each seasonal subgroup for the Idle and Active datasets. The comparison was performed among the four perimeter sites, with and without the High School data. In the example below (Figure 7), the sample data for one particular analyte (naphthalene) during a sampling phase (Active), utilizing the seasonal (Combined) data, was compared among the four sampling stations (North, East, South, West), with and without the High School site. The example sample

	Naphthalene (Const)				
	North	East	South	West	High School
10/5/2002	105.87	110.26	84.88	88.11	122.04
10/11/2002	123.06	126.14	98.76	93.40	87.52
10/17/2002		40.02	55.92	43.13	49.34
10/23/2002		100.19	86.56	110.57	85.54
10/29/2002	112.06	65.04	34.31	92.47	44.62
11/4/2002	247.45	91.29	126.79	93.71	99.16
11/10/2002	34.78	41.41	34.06	20.42	31.70
11/16/2002	84.24	83.45	72.99	87.34	50.57
11/22/2002	116.98	117.56	85.60	130.37	101.44
11/28/2002	62.68	34.16	37.54	41.42	33.90
12/4/2002	104.64	145.41	101.39	166.37	114.46
12/10/2002	685.99	364.03	139.93	292.63	165.47
12/16/2002	104.81	70.85	70.46	79.50	78.26



Kruskal-Wallis statistic	4.48
p	0.3453

Naphthalene (Const)	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
North	11	162.051	181.5805	54.7486	40.064 to 284.039	105.872	25.582	62.680 to 247.450
East	13	106.908	84.6756	23.4848	55.739 to 158.077	91.290	52.518	41.411 to 126.140
South	13	79.168	33.4164	9.2680	58.975 to 99.362	84.883	42.840	37.540 to 101.390
West	13	103.035	68.4871	18.9949	61.649 to 144.421	92.470	31.067	43.130 to 130.371
High School	13	81.848	39.4203	10.9332	58.027 to 105.670	85.541	52.097	44.624 to 114.460

Figure 7: An Example of the Input/Output for the Statistical Analysis of the Ambient Data

grouping (in this case the High School is included) and output result are shown in Figure 7. It is important to note again that an analysis was only performed on data sets that had <60% non-detect values for the sampling period.

The Kruskal-Wallis test is a nonparametric analysis of variance (ANOVA), which compares distributions for each site and determines if there is a statistical difference among the sites. However, this analysis of variance will not indicate which site, or sites, is different. If the result of the Kruskal-Wallis test demonstrated a statistical difference in constituent concentrations, a Tukey test (Ott and Longnecker, 2000) was performed to determine which of the sites were different. The results of the Tukey examination were also verified by performing a nonparametric independent two-group comparison, known as the Mann-Whitney test (Ott and Longnecker, 2000). The Mann-Whitney is analogous to the parametric t-test, which tests the null hypothesis between two independent groups. In the example shown in Figure 7, the p-value calculated (0.345) indicates that no statistical difference exists for the analyte naphthalene, during the Active period, between any of the sampling stations. The statistical software plug-in for Microsoft Excel, *Analyse-It (http://www.analyse-it.com)*, was utilized to facilitate this statistical analysis.

Table 6 provides a concise summary of the results of the statistical comparisons between the site samplers. An evaluation was performed comparing solely the North, East, South, and West sampling stations (*Site*), and another including the four stations plus the High School monitor (*Site+HS*). Each seasonal sample set from both the Idle (*Winter*, *Spring/Fall*, and *Summer*) and *Active* periods were evaluated on a per-analyte basis, for those samples which met the 60% ND criteria. A blank space corresponding to the

Table 6a-d: Results of statistical analysis comparing four sampling stations and High School site. A blank space indicates statistical similarity, while a statistical difference is indicated under the appropriate analyte, site comparison, and seasonal subgroup. Results obtained during the Active (construction) periods – as opposed to Idle ("background") phase – are distinguished by the shaded cells.

a.

PAHs	Acenaphthene		Acenaphthylene		Fluoranthene		Fluorene		Naphthalene		Phenanthrene		Pyrene	
Dataset	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS
Winter														
Spring/Fall														
Summer														
Active														

b.

PCBs	PCB 8		PCB 15		PCB 18		PCB 28		PCB 31	
Dataset	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS
Winter										
Spring/Fall					S>N,E,W	S>HS	S>N	S>HS	S>N,W	S>HS
Summer							S>N,W E>W	S>HS E>HS	S>N,W E>W	S>HS E>HS
Active										

c.

VOCs	Benzene		Toluene	
Dataset	Site	Site+HS	Site	Site+HS
Winter				
Spring/Fall	N>S,W E>S,W	N>HS E>HS HS>S	N>S,W E>S,W	N>HS E>HS
Summer	N>S,W E>S,W	N>HS E>HS	N>S,W E>S,W	
Active	N>S,W			

d.

Metals	Aluminum		Arsenic		Barium		Chromium		Cobalt		Copper		Iron	
Dataset	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS
Winter												HS>N,S,W		
Spring/Fall					N>S E>S,W	E>HS					N>S W>S	HS>S		
Summer	N>S,W E>S	N>HS E>HS			N>S,W E>S,W	N>HS E>HS						HS>S,W		
Active														

	Lead		Manganese		Nickel		Selenium		Zinc		TSP	
Dataset	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS	Site	Site+HS
Winter			N>S,W	N>HS E>HS								
Spring/Fall												
Summer											N>S,W E>S,W	N>HS E>HS
Active												

particular analyte, sampler comparison, and seasonal data set indicates statistical similarity. If a difference is evaluated, the statistically significant locations – and their respective differences – are indicated within the appropriate space.

PAHs:
Analysis showed that during both the Idle (Winter, Spring/Fall, and Summer) and Active phases, **none** of the viable PAH analytes demonstrated a statistical difference among the four (North, East, South, West) sampling stations or at the High School.

PCBs:
During the Spring/Fall sampling period, a statistically higher concentration at the South site, as compared to all other sites, was exhibited by PCB 18. At the same time period (Spring/Fall) a statistically higher concentration of PCB 28 and PCB 31 was again reported at the South site, when compared to the North, West, and High School sites. Additionally, during the Summer season, PCBs 28 and 31 exhibited a statistically higher concentration at the South and East sites, when compared to the North, West, and High School sites. Predominantly, the highest frequency of a statistically elevated PCB concentration was reported at the South site during the warmer months. This sampling station is located adjacent to the Indiana Harbor Canal. Since the Canal is known to be contaminated with PCBs, it is highly likely that the observed signal at the South site is directly related to volatilization of PCBs from the Canal.

VOCs:
For both viable VOC samples (benzene and toluene), a statistically higher concentration was reported at the North and East sites, when compared to the South, West, and High School locations, during the Spring/Fall season. The same trend was observed for benzene during the Summer seasonal period. Toluene reported at statistically higher levels at the South and West sites during the Summer seasonal period. It is likely that these trends can be explained by the location of the North and East samplers. The North station is located adjacent to a busy thoroughfare, Cline Avenue, and is likely picking up a VOC signal from vehicle emissions. The East sampler is situated near the BP (Amoco) refinery, and is probably reflecting emissions from that industry. Benzene also shows a statistically greater concentration at the High School when compared to the South site, during the Spring/Fall period. Since the High School station is located adjacent to the school's parking lot, it is again likely that this signal is a response to vehicle emissions. The South site, on the other hand is relatively isolated from any roadways or parking lots, and would therefore be less likely to exhibit a VOC signal. Only one statistical difference occurred among samplers during the Active period. Concentrations of benzene at the North site were again found to be greater than those at the South or West sites.

Metals/TSP:
Atmospheric concentrations of total suspended particulates (TSP) during the Summer seasons were found to be statistically greater at the North and East Sites when compared to the remainder of the stations. During the same time period, the concentrations of aluminum and barium were statistically greater at the North and East sites when

compared to the rest of the stations. Also during the Summer, the atmospheric levels of copper were higher at the High School, when compared to the South and West sites. During the Spring/Fall seasons, the concentration of barium was found to be higher at the North and East sites, and the levels of copper were elevated at the North, West, and High School stations. During the Winter season, copper concentrations at the High School were statistically higher at the North, South, and West stations, and the concentration of manganese was higher at the North and East monitors when compared to the rest of the sites. Metals concentrations can be positively correlated to suspended particulates in the atmosphere. Therefore, elevated concentrations of aluminum and barium at the North and East sites during the Summer months are easily explained by the correlation to increased levels of TSP during this same period. During all periods, statistically elevated concentrations are sporadically reported at any given site, with the exception of the South site. Since the South site is the most isolated, this pattern suggests some kind of anthropogenic influence, such dust or emissions from sources such as roads or parking lots.

Meteorological Comparisons:
A number of the VOC samples (benzene and toluene) demonstrated a consistent, statistically higher concentration at the North and East sites, as compared to the rest of the monitoring stations. In cases such as these, it is possible to use sample-specific wind direction data in an attempt to correlate potential sources of these contaminants. A hypothesis could be formulated to relate the highest readings of an analyte concentration to some consistent prevailing wind direction, and thus the conclusion could be drawn that a source exists upwind of the sampler, in the opposite direction. Alternatively, instances of a consistent prevailing wind direction, with respect to a certain monitoring station, could be correlated with the incidence of the some point (or area) acting as a potential source of a particular contaminant of concern.

The table below provides an example utilizing benzene data collected during the Idle period. A selection of samples with markedly higher reported concentrations at the North site (as compared to the South, West, and High School sites) are presented and compared to the 24-hour average wind direction during that sampling period. Samples were obtained from the Spring/Fall and Summer seasons, where benzene reported a statistically higher concentration at the North site.

Table 7: Benzene Concentrations with Respect to Sampler Site and Wind Direction

Date	North*	South	West	High School	Wind Direction
8/6/02	4.15	0.96	1.15	0.70	NE
8/30/02	6.06	1.44	1.72	0.99	E
9/5/02	8.93	1.91	2.04	1.47	ENE
4/9/03	5.74	1.69	1.60	1.56	NNE
5/21/03	6.38	1.15	1.60	1.28	NE
5/27/03	5.74	1.24	1.18	1.60	NNE
9/17/02	2.74	1.50	2.01	1.69	SSE
5/9/03	2.26	1.05	1.02	1.47	SE
6/2/03	4.15	1.21	1.47	1.82	SSE

* Concentration at North site statistically greater than South, West or High School sites.

Concentrations of benzene appear to correlate well with wind direction. A statistically higher concentration at the North monitoring station, in combination with a north to northeasterly wind, indicates that the benzene is coming from off-site. Likely sources include State Route 912 (Cline Avenue) to the north, Indianapolis Boulevard to the east, and the large BP refinery, located to the north and east. The bottom three samples in Table 7 indicate prevailing winds from a southeasterly direction. Although relative maximum of the North site concentrations during these prevailing winds are not as pronounced, they serve as examples of variability with wind direction correlation. Careful examination of the detailed meteorological data through the duration of one sample period, indicates that wind directions are highly variable (as demonstrated previously with the year-long dataset). A breakdown of the 24-hour average data indicates that, in a number of cases, throughout some expanse of time during the 24-hour sample, the wind direction prevailed from the north or east. These results further indicate the increased susceptibility of the North and East sampling to off-site contamination, due to their proximity to a number of anthropogenic sources of contaminants of concern.

Active period dataset information can be evaluated with respect to wind direction to determine if any contaminant signal is observed leaving the CDF site. Benzene was the only analyte that demonstrated any statistical difference among sample sites during the Active phase of sampling. During this period, concentrations at the North site were statistically greater than those at the South and West sites. Samples for which relevant information exists are shown in Table 8.

Table 8: Active Dataset Benzene Concentrations with Respect to Wind Direction

Date	North*	South	West	Wind Direction
10/11/02	4.47	3.13	3.03	ESE
11/4/02	6.70	1.60	1.50	W
11/10/02	1.60	0.99	0.80	WSW
11/16/02	2.81	0.86	1.21	NNE
12/16/03	2.20	1.02	1.08	E
6/20/03	4.15	1.31	1.08	NNE

* Concentration at North site statistically greater than South, West or High School sites.

The directional values presented in Table 8 suggest that at least half of the statistically higher reported benzene values are coming from off-site sources similar to those assessed during the Idle period. This tendency is indicated by a prevalent wind direction ranging from north to east (i.e. from off-site). The remainder of the wind directions varied considerably, prevailing from both the westerly and easterly directions. It is possible that these readings could be interpreted as benzene volatilization originating from the CDF site. However, during the Active phase, there were no reported exceedences of action levels as reported by Emissions Monitoring at the site. Therefore, at no time was there any risk to site workers or the surrounding community.

Similar assessments of wind direction to PCBs and metals concentrations were also made. Both PCBs and metals exhibited only a moderate correlation to wind direction. The Indiana Harbor Canal was assumed to be the major source of PCBs in the vicinity of the South site. Approximately 50% of the 24-hour wind roses for the PCBs did not support the statistically higher concentrations at the South monitor. However the relative proximity of the sampler to the Canal may diminish the potential for correlation based upon wind direction. Metals and TSP also varied in terms of correlation with prevalent wind direction. Again, the lack of correlation is most likely attributed to the variability of the winds in the vicinity of the CDF. PAHs were not evaluated because none of these analytes demonstrated a statistically higher concentration at any one monitoring station.

Summary:
With the exception of the elevated benzene concentration at the North site, no instances of a statistical difference among sampling stations occurred during the Active phases. Additionally, Winter season samples were statistically similar for all analytes, with the exception of two metals, copper and manganese. A majority of the statistical differences indicated for the PCBs showed a greater concentration at the South site. This signal is likely to originate from the volatilization of PCBs from the Indiana Harbor Canal. A high percentage of statistical differences demonstrated for VOCs indicated an elevated level benzene or toluene at the North and East sites. This phenomenon may be explained by the proximity of the North and East sampling stations to Cline Avenue and the BP Refinery, respectively. A similar relation was found with the metals aluminum, barium, manganese, and total suspended particulates. Although not simply explained, the relative proximity of the North and East samplers to anthropogenic sources of contamination provide a possible explanation to the consistency with which these two sites are the sole sources of any statistically significant difference. It should also be noted that although the consistency with which the North and East sites are statistically different is high, the overall frequency of this incidence is low.

<u>Selection of Construction Phase CDF Air Monitoring Location</u>

These analyses show that a large majority of the samples collected at the four CDF ambient air monitoring stations are statistically similar. The implication of this finding is that the four sampling stations are not able to resolve, with any significant reproducibility, a variation in analyte concentration among locations. In the majority of cases the four ambient air monitors at the CDF sample the same air mass. As a result, their function could be adequately served by one monitoring station. <u>Therefore, future Construction Phase Ambient Air Monitoring at the CDF site will consist of a sampler at the South site location.</u>

The South site is chosen to be the representative monitoring station for a variety of reasons, including location, variability of samples, wind direction, and comparability to the High School station. The South site is positioned in a relatively isolated location, which is farthest from most anthropogenic sources (see Figure 1). The comparisons discussed above show that the North and East sampling sites are biased by off-site sources, and do not demonstrate an accurate representation of on-site conditions. Although the wind is highly variable at the site, a year's record of wind data indicated that a prevailing wind direction from the east occurred with significantly less frequency than from the other directions. Therefore, the West site – although a potentially suitable location – is less preferable to the South site because it less likely to obtain a signal from the CDF. The South site is advantageously located directly between the CDF site and the nearest sensitive human receptor population (the High School), and is thus better suited to characterize potential volatile emissions from the CDF and other on-site sources.

Another factor to consider when choosing a monitoring location to represent the CDF site (North, East, South, or West) is comparability to the High School site. It should be noted that the direct comparison of reported values obtained at the High School to those collected at the CDF is beyond the scope of the Ambient Program. This is because the variability of atmospheric concentrations of COCs, for any specific sample date, introduces complexity into drawing any substantive conclusions from a sample-to-sample assessment. However, at some point during a trend-based analysis of the analytes of concern, a comparison of the temporal tendencies between the CDF and High School may be desired. Consequently, it is preferable to choose a site that is representative of atmospheric conditions from the CDF site, while minimizing confounding factors unique to a particular sampler location.

Choice of the South sampler to represent CDF site conditions adequately fulfills these criteria. As mentioned previously, the North and East samplers are influenced by off-site sources to a level greater than that of any bias experienced at the High School. This assertion is evident in the heightened frequency of statistically greater concentrations of VOCs, and several metals, at the North and East sites. The West site, although it is statistically the most consistent station, would not likely convey a contaminant signal analogous to that of the one obtained at the High School. This is because Indiana Harbor Canal (IHC) represents a potential on-site source for certain contaminants of concern, such as PCBs. For example, assume a point source originating from anywhere within the CDF boundary. This air mass *must* cross IHC before it is recorded at the High School. Conversely, the West site can measure the same point source from within the CDF with no influence by IHC. Therefore, the possibility exists that the total contribution to COCs by the Canal, as measured at the High School, might bias the comparability when matched against the West site. The same type of IHC-introduced bias can be applied to signals obtained at the North and East sites. The South site, on the other hand, would be subject to a proportionally equal COC influence by the Indiana Harbor Canal (i.e. the same contaminants, although at differing magnitudes). Thus, a the comparison between trends at the High School and the South site would yield the greatest amount of information with regard to temporal trends at and near the CDF site.

Consequently, the South sampler is chosen as the representative site for Ambient Monitoring at the CDF. Future Construction Phase ambient air monitoring samples will be taken at the South monitor in order to reduce the confounding factors of variation for a trend-based analysis. It should be noted that Ambient sampling at the High School will continue to serve as a monitor of the nearest off-site sensitive receptor population.

<u>Comparative Analysis between Idle and Active Periods</u>

Once statistical similarity had been assessed among the sampling stations, a comparative analysis between the Idle and Active Phases was performed. Three individual tests were completed, and the results are displayed in Table 9 (page 26). The first two tests are fundamentally related, and are used to show the similarity between using a compilation of four sampling stations (North, East, South, West) versus using only one location (South) to represent the CDF, when making comparisons between the Idle and Active phases. The third test assesses the difference between Idle and Active period data collected at the High School monitoring site.

The first test (*Combined Site*) groups Active phase data, on a per-analyte basis, from the North, East, South, and West sampling stations and compares it to a similar compilation of the four monitors during the Spring/Fall Idle period. The Spring/Fall seasonal phase was chosen because it is the most climactically similar to the Active period data, and represents a sensible estimate of Idle period concentrations over a number of months.

The second test (*South Site*) is performed to emulate the Combined Site test, and further demonstrate the ability of the South site to represent overall conditions at the CDF. Therefore, a similar assessment is performed comparing analyte-specific South site Active phase data to the Spring/Fall seasonal Idle phase data collected at the South site. Again, the Spring/Fall data from the Idle period is chosen because it is climactically similar to the Active period and is most representative of the variability of atmospheric concentrations over a number of months.

Finally, the third test (*High School*) incorporates data collected at the High School during the Active phase. For each analyte, the Active phase data from the High School is compared to the corresponding Idle phase data obtained during the Spring/Fall season.

PAHs:
For the *Combined Site* test, concentrations of acenaphthylene, phenanthrene, and pyrene, were statistically higher during the Active phase than the Idle phase. A similar response was seen for the *South Site* test with acenaphthylene and pyrene. However, concentrations of phenanthrene at the South site were statistically similar between Idle and Active periods. PAHs, in general, are common byproducts of combustion processes, with the largest synthetic contributors being the burning of wood in homes, along with emissions from gasoline and diesel engines (ATSDR, 2003). Each of the PAH compounds evaluated to be statistically significant (acenaphthylene, phenanthrene, and pyrene) can be found in emissions of diesel engines from sources such as transit and school buses, and semi-tractors (Lev-On, *et al.*, 2002). Subsequently, elevated concentrations of these constituents during construction could potentially be positively correlated with the presence of diesel-burning machinery on-site. Acenaphthene demonstrated idiosyncratic behavior by exhibiting a greater concentration during the Idle phase at the South site when compared to the Active phase. Additionally, at the High School, an elevated concentration of acenaphthene was reported during the Active phase. Acenaphthene is also a byproduct of diesel fuel combustion, found in both the gaseous and particulate phases (ATSDR, 2003). Therefore, emissions from mobile sources such as school buses at the High School have the potential to affect these samples. Because of its isolated location, a greater concentration of acenaphthene at the South site during the Idle phase (Spring/Fall season) as compared to the Active phase (during a similar

Table 9a-d: Results of statistical analysis comparing the Idle and Active phases among the combined CDF Site samplers, the South site, and the High School. A blank space indicates statistical similarity, while the statistical difference between the Idle and Active phases is indicated under the appropriate analyte and site comparison.

a.
PAHs

Comparison **Bkg v. Con**	Acenaphthene	Acenaphthylene	Fluoranthene	Fluorene	Naphthalene	Phenanthrene	Pyrene
Combined Site		Active > Idle				Active > Idle	Active > Idle
South Site	*Idle > Active*	Active > Idle					Active > Idle
High School	Active > Idle						

b.
PCBs

Comparison **Bkg v. Con**	PCB 8	PCB 15	PCB 18	PCB 28	PCB 31
Combined Site			Active > Idle		
South Site					
High School					

c.
VOCs

Comparison **Bkg v. Con**	Benzene	Toluene
Combined Site		Active > Idle
South Site		Active > Idle
High School		

d.
Metals

Comparison **Bkg v. Con**	Aluminum	Arsenic	Barium	Chromium	Cobalt	Copper	Iron
Combined Site			Active > Idle	Active > Idle	*Idle > Active*		Active > Idle
South Site			Active > Idle				
High School			Active > Idle		*Idle > Active*		

Comparison **Bkg v. Con**	Lead	Manganese	Nickel	Selenium	Zinc	TSP
Combined Site	Active > Idle	Active > Idle			Active > Idle	
South Site	Active > Idle					
High School	Active > Idle					

climactic period) could be an artifact attributed to a number of sources including volatilization of petroleum products from the Canal, or increased bus and automotive traffic at the school.

PCBs:
Only one statistically significant instance of differences between Idle versus Active phase PCB concentrations was reported. In the *Combined Site* test, PCB 18 demonstrated a statistically greater concentration among the four CDF monitoring stations in the Active period as compared to Idle. No other PCBs demonstrated a statistically significant difference between the Idle and Active phases. Due to the batch nature of PBC mixtures, it is unlikely that construction activities would cause the release of a single congener (PCB 18). Therefore, this instance of statistical significance appears to be an artifact of the environmental sample collection, analysis, or quantitation procedures.

VOCs:
Toluene exhibited a statistically greater concentration during the Active period for both the *Combined Site* and *South Site* tests. This result indicates that, during this particular time period, construction activity at the site positively correlates with an increase in ambient toluene concentrations at the site. An increase in ambient toluene concentrations was not observed at the High School. Since the future CDF site is located on an open Resource Conservation and Recovery Act (RCRA) property, which previously accommodated the ECI, Inc. Refinery, it is possible that the extensive excavating and trenching activities during the Active phase may have caused releases of this VOC from sub-surface contamination. It should also be noted that toluene is used as an additive to gasoline, and found commonly as a constituent of fuel refining processes. The construction activities, which took place during October-December 2002, consisted of exploratory trenching that was very extensive in nature. These construction activities are expected to be the most invasive of the entire project duration. Therefore, if excavation and trenching of contaminated soils was the source of the toluene volatilization, this Active phase has been likely to cause peak releases to the atmosphere, when compared with future construction activities.

Metals/TSP:
Barium and lead showed a statistically higher concentration in the Active phase for all three sample groupings (*Combined Site*, *South Site*, and *High School*). Both barium and lead have an association with the oil refining industry. Barium and lead have been used as additives to oil and gasoline, (more prevalently in the past, but still to some extent today), and are released into the atmosphere from the combustion of coal and oil (ATSDR, 2003). A statistically increased concentration at both CDF and High School sites is likely to be indicative of some off-site source, potentially originating from a combustion process (i.e. refining, power generation, incineration, etc.), since no such combustion takes place at the CDF during construction. Chromium, iron, manganese, and zinc demonstrated a statistically elevated concentration for only the comparison involving the four stations at the CDF (*Combined Site*). Industries such as steel production, fossil fuel refining, and incineration, as well as combustion of coal and oil can all produce releases of these metals (ATSDR, 2003). Due to the highly industrial

nature of area surrounding the future CDF site, and the fact that the South and High School sites did not indicate a statistical significance, it is likely that the increase in concentration of these metals during the Active phase is due to off-site sources, at or near one (or more) of the perimeter samplers (i.e. North and East samplers). If an actual overall increase in concentration were observed, it is likely that the *South Site* or *High School* comparison would indicate a statistical difference between Active and Idle phases. Curiously, concentrations of cobalt were greater during the Idle phase, as opposed to the Active phase, for the *Combined Site* and *High School* samples. This attribute suggests that some intermittent atmospheric source of cobalt is likely to exist during the Idle period, which is not detected during the Active period. The chemical industry utilizes a large amount of cobalt in chemical and petroleum processing, thus the industrial nature of the vicinity surrounding the CDF is a likely source of this cobalt release.

Summary:
The *Combined Site* evaluation indicated that three PAHs, one PCB, one VOC, and six metals demonstrated an elevated concentration among samples compiled from the four monitoring stations at the CDF, during the Active phase, as compared to the Idle phase. The *South Site* assessment mirrored this trend for two PAHs, one VOC, and two metals. The remainder of the *South Site* comparisons did not show a statistical difference between the Idle and Active phases. The instances of a statistical **difference** exhibited by the *Combined Site* evaluation, as opposed by a statistical **similarity** demonstrated by the *South Site* assessment, are most likely a result of the affectation of samples by anthropogenic sources (i.e. North and East sites for VOCs and metals, South site for PCBs, etc.), which is then reflected in the results of the *Combined Site* test. This may be causing the *Combined Site* sample to report a statistically higher COC concentration during the Active phase – as compared to the Idle phase – when one does not actually exist. This theory is supported by the fact that the *South Site* (alone) never indicates a statistically greater concentration in the Active phase that is not mirrored by the *Combined Site*. Therefore, of the list above, only five of all the analytes (acenaphthylene, pyrene, toluene, barium, and lead) exhibited any substantive increase in concentration at the CDF site during the Active phase.

Only two of the analytes (barium and lead) demonstrated a statistically greater Active period concentration at the High School, in conjunction with a similarly elevated Active period concentration at the CDF site. As mentioned previously, one of the primary routes of release of barium and lead to the atmosphere is through the combustion of coal or oil. Since this type of activity is not related to construction at the CDF, it is likely that this signal results from an off-site source. Since no other contaminant of concern exhibited an elevated Active phase concentration both at the CDF and at the High School, it is not likely that construction activity at the CDF plays a major role in contributing to atmospheric concentrations of COCs at the High School.

Construction Phase Ambient Air Monitoring Plan

As a result of the analyses presented within this document, it is possible to outline a strategy for the collection of pertinent Ambient atmospheric data during the Construction Phase. The following sampling plan for the Construction Phase of the AAMP is identified:

- *Purpose* – Ambient air monitoring will continue throughout the Construction Phase in order to continue building a sample database for a trend-based (or similar) analysis. Comparisons and trends modeling will be made between AAMP data collected in the Construction Phase, and eventually the Dredge/Disposal Phase, to that assembled during the Background Phase. Once a sufficient quantity of data is collected for a statistically sound trend-based analysis, it is likely that this type of summary and evaluation will be conducted and reported on a yearly basis (Annual Report). Atmospheric data collected during the Construction Phase may also be utilized for revising the Ambient Air Monitoring Program during the Dredge/Disposal Phase. Data collected could also possibly be assimilated into Dredge/Disposal action level development for the Emissions Monitoring Program.

- *Analytes* – The continued collection of non-detect datasets does not fall in line with the goals and objectives of the Construction Phase of the AAMP, (i.e. the determination of trend-based behaviors of contaminants of concern). Therefore, Table 10 outlines the list of analytes to be reported during the Construction Phase.

Table 10: Analyte List for Analysis During Construction Phase Ambient Monitoring

PAHs	PCB Congeners	VOCs	Metals
acenaphthene	8	benzene	aluminum
acenaphthylene	15	toluene	arsenic
fluoranthene	18		barium
fluorene	28		chromium
naphthalene	31		cobalt
phenanthrene			copper
pyrene			iron
			lead
			manganese
			nickel
			selenium
			zinc
			(Tot Susp Particulate)

- *Location* – Atmospheric samples will be collected at two locations: The South site and the High School. As discussed previously, for the majority of the Idle and Active phase samples, the four perimeter stations were found to be statistically similar. Data quality issues were identified at the North and East sites due to off-site influences. Subsequently, the South site was identified as the leading location for the collection of on-site Ambient data. The High School sampler will remain in operation due to its off-site presence near a sensitive receptor population.

- *Schedule* – The two samplers will continue to operate on a six-day schedule throughout the year (twelve months). Air monitoring will continue during times of inactivity at the CDF so as to continue to provide a consistent dataset for future trend-based analysis. Additionally, data collected during non-construction phases will be utilized to update the Background dataset to account for variability generated by other off-site anthropogenic sources. Both samplers (South Site and High School) shall operate concurrently to ensure availability of data in case of some anomaly. Additionally, a concurrent schedule will allow for the comparison of trends between the two sites.

- *Annual Report* – A report summarizing Construction Phase Ambient Air Monitoring data, including applicable trend-based analysis will be assembled on a yearly basis. Until a sufficient dataset is collected to satisfy the statistical requirements of leading software packages, an Annual Report will published utilizing statistical and analytical methods similar to those employed in this document. This annual assessment will also allow for further reevaluation of the Ambient Monitoring Program, as necessary. The Ambient Air Monitoring Annual Report is expected to be released yearly during the spring quarter.

- *Implementation* – This Construction Phase plan of the Ambient Air Monitoring Program is expected to be implemented in Winter 2003.

Future Monitoring at the CDF Site

The Ambient Air Monitoring Program will be continued through the Construction Phase and into the Dredge/Disposal (Operations) Phase of the CDF. The current Ambient Air Monitoring Program, as outlined by this document, will undergo reevaluation throughout the Construction Phase and may be modified for the Dredge/Disposal Phase. The AAMP for the Dredge/Disposal phase will be finalized once the Facility Layout is complete, and will reflect a program appropriate to meet the goals and objectives of this phase.

Although mentioned briefly at the beginning of this text, a detailed future of Emissions Monitoring beyond the scope of this document. Nevertheless, the protection of the health and safety of site workers the community will be the top priority throughout the life of the Indiana Harbor Environmental Dredging Project. Emissions Monitoring, as outlined previously, will continue throughout the Construction Phase. Beyond this, it is likely the initial years of Emissions Monitoring during the Dredge/Disposal Phase of this project will reflect a conservative approach to atmospheric monitoring. The possibility exists that an appropriate regimen of sampling stations and analytes, similar to the Background Phase of the AAMP, could be utilized during the formative period of Emissions Monitoring of the Dredge/Disposal Phase.

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