INDIANA HARBOR AND CANAL

AIR MONITORING DATA ANALYSIS

Prepared by U.S. Army Corps of Engineers – Chicago District

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Introduction

In November 2001, the U.S. Army Corps of Engineers (USACE) implemented an air monitoring program at the property known as the Energy Cooperative, Inc. (ECI) site, located in East Chicago, Indiana. The ECI site is the location of a confined disposal facility (CDF), which was constructed to hold sediment dredged from the Indiana Harbor and Canal (IHC). In July 2003, CDF construction was initiated and the construction phase of the air monitoring program was implemented. CDF construction activities were substantially complete in 2011, and dredging of the IHC started in October 2012. Air monitoring continued during the post-construction, pre-dredging period. The air monitoring program results, including the background phase, construction phase, and post-construction/pre-dredging phase monitoring through 2012 are presented in several reports (USACE 2003b, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013). A summary of the air monitoring program at the IHC CDF is presented in Table A.

Table A: IHC CDF Air Monitoring Program

Phase	Dates	Activities during Phase	Monitor Locations	Sampling Frequency
Background	Nov 2001 – July 2003	No major construction activities on site or canal	HS and 4 CDF on-site points	6 day monitoring frequency
CDF Construction	July 2003 – May 2004 (SW) May – Sep 2005 (D) July – Nov 2006 (D, SW) April – Sep 2007 (D, TP) March – Dec 2008 (TP, GCS, CW) Jan – Nov 2009 (GCS, CW) July – Nov 2010 (D, TP) May – Sep 2011 (D, TP, SEF)	Slurry wall (SW) construction CDF dike (D) construction Interim wastewater treatment plant (TP) operation Gradient control system (GCS) construction South cutoff wall (CW) construction South end facility (SEF) construction	HS and 4 CDF on-site points through April 2004; HS and CDF South Parcel afterwards	6 day monitoring frequency through October 2008; 12 day frequency afterwards
Idle Periods during Construction Phase	June 2004 – April 2005 Oct 2005 – June 2006 Dec 2006 – Mar 2007 Oct 2007 – Feb 2008 Dec 2009 – June 2010 Dec 2010 – Apr 2011	No major construction activities on site or canal	HS and CDF South Parcel	6 day monitoring frequency through October 2008; 12 day frequency afterwards
Post Construction/ Pre-Dredging	Oct 2011 – Oct 2012	No major construction activities on site or canal	HS and CDF South Parcel	12 day monitoring frequency
Active Dredging	Oct – Dec 2012 April – Aug 2013	Dredging and disposal of dredged material to CDF	HS and 4 CDF on-site points	6 day monitoring frequency
No Dredging/ Material in CDF	Jan – Mar 2013 Sep – Dec 2013	Idle periods between dredging events	HS and 4 CDF on-site points	12 day monitoring frequency

The annual air monitoring reports include detailed information on the selection of the monitoring sites, an evaluation of meteorological data, and statistical analyses of the air monitoring data collected through the pre-dredging period. These reports serve as a compilation of all data collected prior to the start of dredging in the IHC and therefore document conditions prior to dredging start. Interested readers are referred to the above referenced documents for details.

The purpose of this report is to present a statistical analysis of the air monitoring data collected from the start of dredging of the IHC and disposal of dredged material into the CDF cells starting in October 2012 through December 2013. Data analysis also includes comparison of post-dredging data with pre-dredging data. To this purpose, this report will serve as a start of an evaluation of potential impacts of dredging and sediment disposal activities and dredged material storage at the CDF site on ambient air conditions at the study area.

2012 and 2013 Dredging and Dredged Material Disposal

The new air monitoring data presented in this report span two dredging events at the IHC – loosely corresponding to fall 2012 and spring/summer 2013. The fall 2012 IHC dredging commenced on October 23, 2012, with a limited amount of material removed for equipment placement. Dredging includes mechanical removal of sediment from the canal using a closed clamshell (environmental) bucket. The initially dredged quantity was a few hundred cubic yards, which was stored in a barge adjacent to the CDF site until the continuous operation started in November 2012.

The continuous dredging operation and hydraulic off-loading operation started on November 14, 2012, with sediment removal in the Lake George Branch of the canal. Continuous dredging in the Lake George Branch occurred from November 14, 2012 through November 26, 2012. The dredging operation then moved to the harbor, and occurred from December 1, 2012 to December 19, 2012.

The hydraulic off-loading operation was conducted from barges set up in the Lake George Branch. Sediment and water were slurried from a barge and pumped into the CDF through double walled piping. Sediment was distributed within the CDF by a manifold of discharge pipes. Sediment was placed in the east cell of the CDF during the 2012 dredging.

Sediment disposal continued until seasonal shut-down of the dredging operation on December 21, 2012. The total volume of dredged material removed from the canal in 2012 is 93,937 cubic yards, which includes 23,806 from the Lake George Branch and 70,131 from the harbor area.

No dredging or sediment disposal occurred between December 21, 2012 and April 1, 2013. The spring/summer 2013 dredging commenced on April 2, 2013 and continued through August 2, 2013. Dredging occurred in the harbor and entrance channel areas. Dredging and sediment disposal were mostly continuous during this dredging event, with some interruption of work due to bridge construction and/or bridge malfunctioning preventing movement at IHC. Annual shut-down of the spring/summer 2013 dredging operation started on August 2, 2013.

The total volume of dredged material removed from the canal in 2013 is 305,947 cubic yards. Of that quantity, the majority, 237,379 cubic yards was dredged from the federal channel and non-federal areas outside the channel in Reach 2. The remaining volume, 68,568 cubic yards, came from Reaches 3, 4 and 5 of the IHC. Dredged material was disposed to the east and west cells of the CDF.

Approximately 200,000 cubic yards of dredged material was placed into each cell of the CDF during the 2012 and 2013 dredging events. The material is allowed to settle and consolidate with a layer of water on top during the non-dredging period. Groundwater pumped from the site is continuously added to the east cell pond; water is added to the west cell during sediment off-loading or as needed to maintain the water over the sediment.

Air Monitoring Data

Locations, Schedule, and Parameters

The air monitoring data used for the statistical analysis for the pre-dredging period were collected at two locations, referred to as the "south" site and as the "high school" site. During the first part of the pre-dredging period (2001 to mid 2004), data were collected from five monitors, four onsite and one offsite at the high school. However, the four onsite monitors were scaled back to one after statistical analysis indicated no significant difference between the 4 onsite monitors during this period. The pre-dredging south site is located adjacent to the Lake George Branch of the Indiana Harbor Canal on the south parcel of the ECI site and represents the CDF site conditions. The high school (HS) site is located approximately 1700 feet south of the south sampler, on the East Chicago High School property, and represents an off-site receptor location. The rationale for these monitoring locations is discussed in previous reports.

Immediately prior to the start of dredging, the two air sampling stations were operating in tandem, on a 12-day rotational schedule. Sampling had been conducted every 6 days from 2001 through September 2008. The sampling schedule was changed to every twelve days in October 2008 until the start of the dredging /disposal phase to continue establishing the trends database, but on a less frequent schedule.

Each air monitoring sample is a 24 hour sample. Parameters measured include polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), metals, and Total Suspended Particulates (TSP). Selection of the "chemicals of concern" for measurement and analysis is discussed in previous reports. Parameters used in the statistical analysis are listed in Table B.

Table B: Air Monitoring Analytes

PAHs	**Metals**
Acenaphthene	Aluminum
Acenaphthylene	Arsenic
Fluoranthene	Barium
Fluorene	Chromium
Naphthalene	Cobalt
Phenanthrene	Copper
Pyrene	Iron
PCBs	Lead
Congener 8	Manganese
Congener 15	Nickel
Congener 18	Selenium
Congener 28	Zinc
Congener 31	
VOCs	Total Suspended Particulates (TSP)
Benzene	
Toluene	

The PAH and PCB samples are obtained using a high-volume vacuum pump air sampler, with a glass fiber filter, a polyurethane foam (PUF) and adsorbent resin (XAD-2) media. Total suspended particulates and metals are collected using a separate high-volume vacuum pump air sampler, with a glass fiber filter medium. VOCs are collected using specially treated stainless steel canisters, which utilize a bellows-type pump to draw in air. More detailed description of the sampling methodologies including sampling media, 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, 2003a). The sampling methodology and analytes remained consistent after the post dredging air monitoring phase was initiated in October 2012.

In October 2012, the ambient air monitoring program was changed back to five sampling sites to monitor the dredging and sediment disposal activities which started on October 23, 2012. The five monitors include 4 new monitors (in the four cardinal directions) on top of the earthen dikes that form CDF disposal cells and the existing monitor at East Chicago High School. The monitoring frequency was changed to a six-day rotational schedule at the same time. The rationale for the additional monitors and higher sampling frequency is to observe the effects (if any) of the dredging and dredged material disposal activities on the ambient air.

The six-day sampling schedule was employed during both the fall 2012 and spring/summer 2013 dredging events and through approximately one month after sediment disposal ended for both events. Outside of these periods, air monitoring samples were collected on a 12-day schedule.

Data Organization

For analyzing the ambient air monitoring data, the data are subdivided into two main groups: Pre-dredging and post-dredging. Pre-dredging refers to all data collected prior to sediment disposal to the CDF in November 2012 back to the start of 2010, when most of the construction activities at the CDF were substantially complete. The entire monitoring data set collected from 2001 to November 2012 was initially considered as the pre-dredging data set. However, trend analyses performed on the PCB data sets, and some of the PAH and metals data sets over this extended period of time indicate statistically significant evidence of decreasing or increasing trends. The changing trends in ambient air levels of some of the studied parameters in the project area over the pre-dredging period may potentially be attributed to industry/source changes, regulation changes, climate change, etc., over the extended sampling period between 2001 and 2012. Identification of the exact cause(s) is beyond the scope of this analysis. However, recognizing these trends, the pre-dredging data set was reduced to data collected between January 2010 and November 2012 to be more representative of a "background" period. This period coincides with the period after most of the CDF construction activities were substantially complete and the start of sediment disposal to the CDF. The data collected earlier are not used in this current evaluation of air emissions for comparison with the post-dredging data.

As discussed previously, the pre-dredging south site was located on the south side of the Lake George Branch of the Indiana Harbor Canal. For practical reasons, the pre-dredging south monitor was not located on the CDF site because the area was an active construction site from 2004 to 2010 with various activities such as dike building, grading, slurry wall installation, which would have been physically obstructed by the monitor. On-site monitors were installed in 2012. Therefore, it is worthy to note that pre- and post-dredging "on-site" conditions are represented by monitors that are in different locations, albeit within relatively close proximity (the new south monitor is less than 1000 feet away from the old south monitor site).

Post-dredging refers to all data collected after sediment disposal to the CDF started in November 2012 through December 2013. In the future, this data set can potentially be further divided into Active and Idle, with Active signifying periods when dredging and dredged material disposal are actively occurring, and Idle signifying shutdown periods with no dredging or dredged material disposal. Currently, subdividing the post dredging data set into Active and Idle will not be performed because of the relatively small set of data available, and the potential for false trend or bias due to analysis of a small population of sampling data.

Air data, particularly for volatile compounds, show temperature related trends. For this reason, the data were broken down by season: spring/fall (March, April, May, October, November), summer (June, July, August, September), and winter (December, January, February). These groups correspond to mean monthly temperatures of $<40^oF$ (winter), $40 – 60^oF$ (spring/fall), and $>60^oF$ (summer). Data analysis was performed for the entire data set aggregated, as well as data subdivided by seasons: spring/fall, winter, and summer.

Post-dredging data from the four on-site sampling locations were analyzed as one data set. The purpose of the four CDF stations was to assess potential effect of wind direction and/or localized CDF activities on the on-site air monitoring program. However, as with the Active and Idle designation, subdividing the post dredging data set into the four on-site sampling locations will not be performed for this report because of the relatively small set of data available. In the future, the individual on-site data sets from the four monitors can potentially be analyzed separately to evaluate whether data collected at the four CDF stations are statistically similar or whether wind direction or localized work activities at the site may affect samples collected from the different locations.

Based on location, the status of site activities, and seasonal subgroups, there are a total of 16 data subsets for each parameter:

- CDF (South site), Pre-dredging (Jan 2010-Nov 2012), all data
- CDF (South site), Pre-dredging, spring/fall
- CDF (South site), Pre-dredging, summer
- CDF (South site), Pre-dredging, winter
- HS site, Pre-dredging (Jan 2010-Nov 2012), all data
- HS site, Pre-dredging, spring/fall
- HS site, Pre-dredging, summer
- HS site, Pre-dredging, winter
- CDF (all sites), Post-dredging (Nov 2012-Dec 2013), all data
- CDF (all sites), Post-dredging, spring/fall
- CDF (all sites), Post-dredging, summer
- CDF (all sites), Post-dredging, winter
- HS site, Post-dredging (Nov 2012-Dec 2013), all data
- HS site, Post-dredging, spring/fall
- HS site, Post-dredging, summer
- HS site, Post-dredging, winter

Statistical Analysis

All post-dredging statistical analyses presented in this report were performed with the ProUCL statistical software (version 4.1) developed by USEPA for use in environmental data analysis and application.

The two-sample nonparametric Wilcoxon-Mann-Whitney (WMW) rank sum test was used for statistical comparison of the data. The WMW tests the null hypothesis that two populations have identical distribution functions against the alternative hypothesis that the two distribution functions differ, i.e., whether measurements from one population consistently tend to be larger (or smaller) than those from the other population. The test is performed at the 95% confidence level.

To prepare the data for statistical analysis, non-detect data were given the same value (median value of the reporting limit) for each constituent. (Different volumes of air pass through each sampler during a sampling event which results in each sample having a slightly different reporting limit. If the reporting limits are not all adjusted to the same value for a given constituent, then each of these reporting limits will be given a different ranking in a nonparametric statistical analysis. This could result in a bias in the statistical test based on concentrations that is not valid.)

The Theil-Sen trend estimate method was used to assess the time trend of the air monitoring data over the pre-dredging period and the pre- and post-dredging periods combined. The Theil-Sen estimator is a nonparametric method that estimates the slope of a time series data population. The Theil-Sen trend analysis was performed at the 95% level of significance.

It should be noted that in order to include all of 2013 data for the analyses presented in this report, some of the data had not undergone quality assurance review prior to being used. Furthermore, some of the data that were used had holding time exceedances. The data will be reviewed at a later time when sufficient additional data have been generated to assess usability and inclusion for analysis.

PCB Data Analysis

All statistical analysis are performed on congeners 8, 15, 18, 28, 31, and the sum of the 18 congeners originally reported when the ambient air monitoring program started in 2001 (presented as Total PCBs in this report). Congeners 8, 15, 18, 28, 31 were previously selected for statistical analysis because they have lower molecular weight and therefore are relatively more volatile than other congeners reported, because they are detected most frequently of the congeners reported, and because they are generally detected at higher concentrations than other congeners that were reported.

The analytical laboratory for the ambient air monitoring program began reporting 13 additional congeners in late 2011. However for consistency, subsequent data analysis and data presentation were performed using the sum of 18 originally reported PCB congeners even after additional congeners were added to be consistent with previous analysis and presentation of Total PCBs.

Summary of Pre-Dredging Data Analysis

A brief summary of the pre-dredging data analysis collected from 2001 to November 2012 is presented herein for understanding background ambient air conditions prior to dredging start. The air monitoring data used for the statistical analysis for the pre-dredging period were collected at two locations, the south site, representing the CDF, and the high school site. Pre-dredging data were analyzed by site, by season, and by period of construction activities at the CDF.

Pre-Dredging PCBs Analysis

HS vs. CDF

PCB congeners 15, 18, 28, 31, and the total PCB concentration were statistically higher at the south site than at the high school site during the pre-dredging period. The higher concentrations of PCBs at the south site are attributed to the known concentrations of PCBs in the canal sediment and water column, although other unidentified sources may also contribute PCBs.

Figures 1a through 6a present atmospheric PCB data at the CDF south site. Figures 1b through 6b present atmospheric PCB data at the high school site. The higher atmospheric PCB concentrations at the south site compared to the high school site can be readily observed in these figures.

Seasonal

The PCB data showed a temperature-dependent expected trend, with the summer concentrations being statistically greater than the spring/fall concentrations, which were in turn statistically greater than the winter concentrations for both the south and high school sites. These trends are consistent with greater volatility of the compounds with warmer temperatures. It is likely that volatilization from a constant source (e.g., canal sediments) is a source of PCBs to the air in this area. The seasonal trend of atmospheric PCB concentrations at both sites can be readily observed in Figures 1a through 6b.

CDF Construction Active vs. Idle

At both the south and high school sites, the concentrations of congeners 8, 15, 18, 28, 31, and total PCBs were all statistically higher during active periods of the CDF construction. The higher concentrations of these PCB congeners and total PCBs during the active periods are attributed to the prevalence of summer data (when the PCB concentrations are highest – see Seasonal Dependence discussion) in the active period data set, rather than actual impact from CDF construction activities. This is confirmed by the finding that the active vs. idle comparisons of PCBs by season do <u>not</u> show any statistical differences.

Pre- IHC Dredging Trend

The Theil-Sen trend analysis method was used to assess the trend of the PCB data for the south site and the high school site over the entire pre-dredging period (2001 to November 2012). Both the south and high school site Total PCBs (sum 18 PCB congeners) data sets had statistically significant decreasing trends at the 95% level of significance over the pre-dredging period. As for individual PCB congeners, of the 5 congeners that are included in the analysis, congeners 8 and 18 had statistically significant decreasing trends over the pre-dredging period at the south site. At the high school site, congeners 8, 18, and 31 had statistically significant decreasing trends over the pre-dredging period.

Pre-Dredging PAHs Analysis

HS vs. CDF

For PAHs, acenaphthylene and fluorene were statistically higher at the south site than at the high school during the pre-dredging period. Acenaphthene is statistically higher at the south site in spring/fall and winter, but higher at the high school in summer. Fluoranthene and naphthalene are statistically higher at the high school than at the south site in the summer and overall, but are not statistically different between the two sites for spring/fall or winter. Phenanthrene and pyrene are not significantly different between the south site and the high school during the pre-dredging period.

The higher concentrations of acenaphthene, acenaphthylene, and fluorene at the south site during the pre-dredging period are attributed to the known concentrations of PAHs in IHC sediment and water column and also possibly from other unidentified local sources. The higher concentrations of acenaphthene, fluoranthene, and naphthalene at the high school during summer are likely from a local source of PAH emissions nearer the high school than the south monitoring site.

Figures 7a through 13a present atmospheric PAH data at the CDF south site. Figures 7b through 13b present atmospheric PAH data at the high school site. It is interesting to note that atmospheric concentrations of several PAHs (acenaphthene, fluoranthene, fluorene, phenanthrene, pyrene) have markedly *increased* at the high school site during the warmer seasons starting in 2009. The pre-dredging summer season concentrations of these PAHs are also markedly higher at the high school than at the south site post-2008. An explanation for those trends has not been identified.

Seasonal

In general, the PAHs had statistically greater concentrations during the summer period than during the spring/fall or winter at both the south and high school sites. Most of the PAHs also show a significant difference between the spring/fall concentration and the winter concentration (higher during the spring/fall). Although the concentrations may be different between location and period, the tendency for seasonally higher concentrations holds true for all the data except for acenaphthylene and naphthalene at both sites. These compounds may have local sources that account for the temperature-independent concentration trends.

Naphthalene concentrations were not statistically different between the seasons for either site. The spring/fall and winter acenaphthylene concentrations were higher than the summer concentration at the south site, and the winter acenaphthylene concentration is higher than the summer acenaphthylene concentrations at the high school. This is not consistent with greater volatility of the compounds during warmer months and points to potentially active emission sources rather than passive volatilization such as from the Canal for these two parameters. The seasonal trend of atmospheric PAH (except acenaphthylene and naphthalene) concentrations at both sites can be readily observed in Figures 7a through 13b. These compounds may have local sources that are not temperature dependent.

CDF Construction Active vs. Idle

Several PAHs showed statistical differences between CDF construction active and idle conditions. At the south site and high school, acenaphthene, acenaphthylene and naphthalene were statistically higher in the summer and/or overall during idle conditions. Fluoranthene, fluorene, phenanthrene, and pyrene were higher overall during active conditions. Higher concentrations during idle conditions and summer months may indicate that these compounds are originating from other local sources, possibly seasonal sources such as warm weather maintenance or operations, rather than construction at the CDF site. Higher concentrations of some PAHs (fluoranthene, fluorene, phenanthrene, and pyrene) during the active periods are attributed to the prevalence of summer data (when most PAH concentrations are highest – see Seasonal Dependence discussion above) in the active period data set, rather than actual impact from construction activities. This is confirmed by the finding that the active vs. idle comparisons of these PAHs by season do not show statistical differences.

Pre- IHC Dredging Trend

Only acenaphthene and naphthalene data had statistically significant trends over the pre-dredging period of 2001 to November 2012. Trend analysis of all other PAH data sets showed of no significant trend over the pre-dredging period. Acenaphthene had statistically significant increasing trend at the 95% level of significance over the pre-dredging period for the high school site data set. The acenaphthene south site pre-dredging data set had no significant increasing or decreasing trend. Naphthalene data at both the south site and high school had statistically significant decreasing trends over the pre-dredging period. The acenaphthene and naphthalene pre-dredging trend findings support the hypothesis that sources of these two parameters to the air may be different from that of other PAHs in the study area.

Pre-Dredging VOCs Analysis

HS vs. CDF

Toluene is statistically higher at the high school than at the south site in the winter and overall, but is not statistically different between the two sites for spring/fall or summer. Benzene is not significantly different between the south site and the high school during the pre-dredging period. The higher concentrations of toluene at the high school during the winter and overall are likely from a local source of toluene emissions nearer the high school than the south monitoring site.

Figures 14a and 15a present atmospheric benzene and toluene data at the CDF south site. Figures 15b and 15b present atmospheric benzene and toluene data at the high school site. The higher atmospheric toluene concentrations at the high school site compared to the south site can be observed in figures 15a and 15b.

Seasonal

The toluene data for both the south site and the high school were statistically greater during the summer than during the spring/fall and during the winter. The benzene data showed no significant difference between the seasons for either the south or high school site. It is likely that the benzene data do not show as much seasonal trend for two reasons: first benzene is quite volatile, even at lower temperatures and so is already in the air regardless of the air temperature, and second, there are probably many local sources of benzene and the multiple emissions may have a greater impact than temperature or other climactic factors. The non-seasonal nature of atmospheric benzene data at the south and high school sites can be observed in Figures 14a and 14b. The toluene seasonal trends can be seen in Figures 15a and 15b for the south site and high school, though the toluene season trends are not as pronounced as the PCB and PAH trends.

CDF Construction Active vs. Idle

Benzene at the south site was not statistically different between the CDF construction active and idle periods. For the high school site, benzene is statistically higher during the idle than the active period. Compounds with higher concentrations during idle conditions may be emitted from industry or other local sources. At the south site and at the high school, the overall toluene concentration is statistically higher for the active period than for the idle period. The higher active overall toluene concentration is attributed to the prevalence of summer data when toluene concentrations are highest.

Pre- IHC Dredging Trend

The south and high school site benzene data sets, and the south toluene data set had statistically significant decreasing trends at the 95% level of significance over the pre-dredging period. Trend analysis of the high school site toluene data over the pre-dredging period resulted in a finding of no significant trend.

Pre-Dredging Metals Analysis

HS vs. CDF

Only one metal, copper, showed any statistical difference between the two monitoring sites during the pre-dredging period. Copper concentrations were higher at the high school than at the south site. The higher concentrations of copper at the high school are likely from a local source of copper emissions nearer the high school than the south monitoring site.

No other metals showed statistical differences between the south and high school sites during the pre-dredging period. TSP is also not statistically different between the south site and the high school during the pre-dredging period.

Figures 16a through 28a present atmospheric TSP and metals data at the CDF south site. Figures 16b through 28b present atmospheric TSP and metals data at the high school site. The higher atmospheric copper concentrations at the high school site compared to the south site can be observed in figures 22a and 22b. Copper air concentrations at the high school were notably high during the earlier years of the monitoring period – 2002 through 2008.

Seasonal

The metals data showed some seasonal trends. It should be noted that metals are not expected to show as many temperature dependent trends as organic compounds, since the atmospheric transport of metals is driven by particulate concentration (except for mercury) rather than volatilization. There is some seasonal correlation to metal concentrations in the air, which may be attributed to other factors such as more anthropogenic activity during the warm seasons, or to seasonal wind patterns. In general, the summer concentrations were statistically higher than the spring/fall and winter concentrations for most (aluminum, arsenic, chromium, iron, lead, manganese, zinc) but not all metals.

The non-seasonal nature of atmospheric data of several of the metals at the south and high school sites can be observed in Figures 19a and 19b (barium), Figures 21a and 21b (cobalt), Figures 22a and 22b (copper), Figures 26a and 26b (nickel), Figures 27a and 27b (selenium). The atmospheric metal seasonal trends can be seen in Figures 17a and 17b (aluminum), Figures 18a and 18b (arsenic), figures 20a and 20b (chromium), Figures 23a and 23b (iron), Figures 24a and 24b (lead), Figures 25a and 25b (manganese), Figures 28a and 28b (zinc), though the metal season trends are not as pronounced as the PCB and PAH trends.

CDF Construction Active vs. Idle

At the south site, aluminum, arsenic, barium, chromium, iron, lead, manganese, and TSP concentrations were statistically higher during active conditions than during idle conditions. At the high school site, aluminum, chromium, iron, lead, manganese, and TSP concentrations were statistically greater during active conditions. As with PAHs and PCBs, the higher active overall concentrations of some metals and TSP are attributed to the prevalence of summer data (when metal and TSP concentrations are higher – see Seasonal Dependence discussion above) in the active period data set, rather than actual impact from CDF construction activities. This is generally confirmed by the finding that the active vs. idle comparisons of metals and TSP by season do not show any statistical differences. Copper does not follow this trend – copper was higher during idle periods at the high school for spring/fall, summer, and overall. The copper trends suggest that the sources of copper to the air may be different from that of other metals in this area, with a copper source closer to the high school that the CDF as discussed in the HS vs. CDF section.

Pre- IHC Dredging Trend

Only barium and copper data had statistically significant trends over the pre-dredging period of 2001 to November 2012. Trend analysis of all other metals and TSP data over the pre-dredging period resulted in a finding of no significant trend for these data sets. Barium had statistically significant decreasing trends at the 95% level of significance over the pre-dredging period for both the south and high school site data sets. Copper data at the high school had a statistically significant decreasing trend over the pre-dredging period. Conversely, copper data at the south site had a statistically increasing trend over the same period. The copper pre-dredging trend finding further supports the hypothesis that sources of copper to the air may be different from that of other metals in the study area, as well as that there may be different copper sources between the CDF and high school sites.

Summary of Post-Dredging Data Analysis

The primary purpose of post-dredging air data analysis is to assess the effect of dredging and dredged material disposal activities and dredged material storage at the CDF site on the atmospheric conditions at the CDF site and off site at the selected potential receptor location at the high school. To this end, post-dredging data at the CDF were compared to post-dredging data at the HS to assess whether pre-dredging observed trends have changed, potentially due to site activities. In addition, pre-dredging data (from 2010 to 2012) were compared to post-dredging data and a trend analysis was performed for both the CDF and the HS sites for the entire monitoring period (2001 through 2013).

At this point, it is important to recognize that except for dredging in the Lake George Branch (which occurred in October and November 2012), dredging activities in the IHC are not expected to impact the air at the High School or the CDF site primarily due to the distance between the dredge sites outside the Lake George Branch and the project air monitors. The impact of this project on the air quality at the High School and CDF is likely more from the placement of dredged material into the CDF cells and the presence of the dredged material stored in the cells. (The designation of pre-dredging and post-dredging periods may be more appropriately re-designated pre- and post-sediment placement periods.) It is also important to note that the post-dredging/sediment placement period can further be broken down to an active sediment placement period, and periods when there is no sediment placement, or the 'quiescent pond' period. The statistical difference between these two data sets, active placement versus quiescent pond, may be explored in the future with additional data.

Post-Dredging PCBs Analysis

HS vs. CDF

CDF post-dredging data were compared with the HS post-dredging data. The entire data set, and the data set subdivided into seasonal periods were compared for the two locations. PCB congeners 8, 15, 18, 28, 31, and the total PCB concentration were statistically higher at the CDF site than at the high school site during the post-dredging period overall, as well as for each seasonal period. Except for congener 8, these trends are consistent with the pre-dredging data trends for HS vs. CDF. The higher concentrations of PCBs at the CDF site are attributed to the known concentrations of PCBs in the canal sediment and water column adjacent to the CDF, as well the dredged material disposal activities, and possibly the PCBs in the dredged material disposed in the CDF and other unidentified local sources.

Congener 8 was not observed to be statistically higher at the CDF than at the high school for the pre-dredging period. It is assumed that due to its lower molecular weight, and therefore relatively higher volatility, congener 8 is more ubiquitous in the air at the study area. The newly observed trend of statistically higher concentrations of congener 8 at the CDF than at the high school for the post-dredging period is likely due to the dredged material disposal activities and/or sediment storage at the CDF site.

Results of this analysis are presented on Table 1 along with mean PCB concentrations for each data set.

Figures 1a through 6a present atmospheric PCB data at the CDF south site. Figures 1b through 6b present atmospheric PCB data at the high school site. The higher atmospheric PCB concentrations at the south site compared to the high school site for the post-dredging period can be readily observed in these figures.

Pre-Dredging vs. Post-Dredging

CDF. CDF pre-dredging data was compared with CDF post-dredging data. The entire data set, and the data set subdivided into seasonal periods were compared for the two dredging regimes. CDF post-dredging PCB congeners 15, 18, 28, 31, and total PCB concentration were statistically higher than pre-dredging PCB concentrations when the aggregated data sets were used. PCB congener 8 was not statistically different between the pre- and post-dredging periods for the entire data set (Table 2).

The CDF pre- and post-dredging data comparison by season reveals the following. For the spring/fall season, the five PCB congeners and total PCBs were not statistically different between the pre- and post-dredging periods. For the winter season, post-dredging PCB congeners 18, 28, 31, and total PCB concentration were statistically higher than pre-dredging concentrations. Congeners 8 and 15 were not statistically different between the pre- and post-dredging periods for the winter season. For the summer season, post-dredging concentrations of all 5 PCB congeners and total PCBs were statistically higher than the pre-dredging concentrations (Table 2). The higher post-dredging atmospheric PCB concentrations at the CDF compared to pre-dredging conditions can be observed in Figures 1a through 6a.

Active sediment disposal to the CDF was occurring during 50% of the summer sampling dates, which likely accounts for the difference in PCB concentrations being statistically significant when comparing the summer post-dredging period with the summer pre-dredging period. Sediment disposal occurred during a smaller subset of days for the spring/fall and winter seasons; therefore, the PCB trend was not observed consistently for these two seasons during the post-dredging period. The higher post-dredging concentrations of PCBs for the CDF aggregated data set are attributed to sediment disposal activities at the site, and possibly the PCBs in the dredged material stored in the CDF. As discussed previously, as additional data are generated in the future, it may be possible to distinguish the effect of sediment disposal activities versus the effect of the quiescent CDF pond on the atmospheric conditions of PCBs at the CDF site.

HS. HS pre-dredging data were compared with HS post-dredging data. The entire data set, and the data set subdivided into seasonal periods were compared for the two dredging regimes. Post-dredging PCB congeners 15, 18, 28, 31, and total PCB concentration were not statistically different between the pre- and post-dredging periods for the entire data set at the HS. PCB congener 8 was statistically higher during the pre-dredging than the post-dredging period when the aggregated data sets were used (Table 3). This is consistent with the decreasing trend of atmospheric PCBs in the study area observed since this air monitoring effort began in 2001.

For the spring/fall and winter seasons, the five PCB congeners and total PCBs were not statistically different between the pre- and post-dredging periods. For the summer season, the PCB congeners and total PCBs also did not show significant difference between the pre- and post-dredging periods, except for congener 18, which was statistically higher during the pre-dredging than the post-dredging period (Table 3). The pre- and post-dredging atmospheric PCB concentrations at the high school can be observed in Figures 1b through 6b. The lower observed post-dredging summer congener 8 levels compared to pre-dredging conditions can be seen in Figure 3b.

The lack of significant difference between the pre- and post-dredging PCB concentrations at the HS, coupled with higher PCB post-dredging concentrations at the CDF than at the high school suggest that sediment disposal activities and dredged material storage at the CDF have not impacted the atmospheric PCB conditions at the off-site location of the high school. This trend will be revisited as additional data is generated in the future.

Trend Analysis

Trend analysis was performed for PCB data over the entire monitoring period (2001 to December 2013). As discussed in the pre-dredging section, both the south and high school site Total PCBs (sum 18 PCB congeners) pre-dredging data sets, as well as some individual PCB congeners (8, 18, 31) had statistically significant decreasing trends at the 95% level of significance. When the trend analysis was expanded to include the post-dredging data, the high school total PCB (sum 18 congeners) data maintained a statistically significant decreasing trend, and one additional congener at the high school was observed to have a decreasing trend, resulting in all PCB congeners except congener 15 having a decreasing trend at the high school (Table 4). On the other hand, inclusion of the post-dredging data for the south site resulted in a finding of insufficient evidence to identify a significant trend for the total PCB and congener 18 data set which both previously had decreasing trends. These findings are consistent with the pre-dredging/post-dredging comparisons discussed above, and further support that sediment disposal activities and the presence of dredged material at the CDF may have impacted the atmospheric PCB conditions at the CDF site, but have not impacted the atmospheric PCB conditions at the high school.

(It should be noted that the post-dredging data analysis for the south site only includes the data from the new CDF monitor on the south side of the site, and not data from all CDF monitors as with the CDF data analyses above.)

Post-Dredging PAHs Analysis

HS vs. CDF

Fluorene, phenanthrene, and pyrene were statistically higher at the CDF site than at the high school during the post dredging period spring/fall season. Pyrene was also statistically higher at the CDF than at the high school during the post-dredging period overall.

Only the fluorene trend is consistent with the pre-dredging period. Phenanthrene and pyrene were not observed to be statistically different between the CDF and the high school during the pre-dredging period. The new phenanthrene and pyrene trends are preliminarily attributed to disposal/sediment storage activities at the CDF.

Pre-dredging findings of statistically greater acenaphthene (summer), fluoranthene (summer and overall), and naphthalene (also summer and overall) concentrations at the high school than at the south site were not observed for the post-dredging data set. A possible explanation is that the sediment disposal activities and dredged material storage at the CDF have elevated the levels of these parameters at the CDF to levels comparable to or higher than those at the high school. Additional data are needed to confirm this hypothesis.

Results of the high school vs. CDF post-dredging data analysis are presented on Table 5. Figures 7a through 13a present pre- and post-dredging PAH data at the CDF south site. Figures 7b through 13b present pre- and post-dredging PAH data at the high school site. The higher atmospheric concentrations of some PAHs (acenaphthene, fluorene, phenanthrene, pyrene) at the south site compared to the high school site for the post-dredging summer period can be readily observed in these figures.

Pre-Dredging vs. Post-Dredging

CDF. CDF pre-dredging data were compared with CDF post-dredging data. The entire data set, and the data set subdivided into seasonal periods were compared for the two dredging regimes. CDF post-dredging fluoranthene, phenanthrene, and pyrene concentration were statistically higher than pre-dredging concentrations of these parameters for the summer season, and also when the aggregated data sets were analyzed (Table 6). These findings are consistent with the observations above (HS vs. CDF post-dredging section) that sediment disposal activities and/or sediment storage at the CDF may have elevated the levels of these parameters at the CDF. Additional data and analyses in the future will be needed to confirm this trend, since wind direction and the 4 monitors can potentially show significant differences if the CDF is a source of emissions.

To further elucidate this observation, active sediment disposal to the CDF were occurring during 50% of the summer sampling dates, which likely accounts for fluoranthene, phenanthrene, and pyrene concentrations being statistically higher during the summer post-dredging period compared with the summer pre-dredging period. Sediment disposal into the CDF occurred during a smaller subset of days for the spring/fall and winter seasons; therefore, the higher post-dredging trend was not observed for these two seasonal comparisons.

Acenaphthene, acenaphthylene, fluorene, and naphthalene were not statistically different between the pre- and post-dredging periods either by season, or for the aggregated data (Table 6). These PAHs were detected in IHC sediment dredged in 2012 and 2013 (USACE 2013—Indiana Harbor and Canal Confined Disposal Facility Emission - May 2013), but at relatively low concentrations.

The higher post-dredging atmospheric concentrations of some PAHs (fluoranthene, phenanthrene, and pyrene) at the CDF compared to pre-dredging conditions can be observed in Figures 9a, 12a and 13a, respectively.

<u>HS</u>. The analyzed PAHs were not statistically different between the pre- and post-dredging periods at the high school either by season, or for the aggregated data (Table 7). The lack of significant difference between the pre- and post-dredging PAH concentrations at the HS suggests that sediment disposal activities and dredged material storage at the CDF have not impacted the atmospheric PAH conditions at the off-site location of the high school. This trend will be revisited as additional data is generated in the future. The pre- and post-dredging atmospheric PAH concentrations at the high school can be observed in Figures 7b through 13b.

Trend Analysis

Trend analysis was performed for PAH data over the entire monitoring period (2001 to December 2013). As discussed in the pre-dredging section, only acenaphthene and naphthalene data had statistically significant trends over the pre-dredging period of 2001 to November 2012 (high school acenaphthene with an increasing trend, and naphthalene with a decreasing trend at both the south site and high school). When the trend analysis was expanded to include the post-dredging data, all of the trends observed during the pre-dredging period were maintained. In addition, inclusion of the post-dredging data resulted in acenaphthene having an increasing trend at the south site (pre-dredging data had no statistically significant trend) (Table 8). This further supports that sediment disposal activities and the presence of the dredged material at the CDF may have impacted the atmospheric conditions of some PAHs at the site, but have not impacted the atmospheric PAH conditions at the high school.

(It should be noted that the post-dredging data trend analysis for the CDF site only includes data from the new CDF monitor on the south side of the site, and not data from all CDF monitors as with the CDF data analyses above. Additional future data and analysis will help identify and verify trends.)

Post-Dredging VOCs Analysis

HS vs. CDF

Neither benzene nor toluene is statistically different between the south site and the high school for the post-dredging period (Table 9). The post-dredging benzene trend is consistent with pre-dredging trend. Toluene was statistically higher at the high school than at the CDF for the pre-dredging period, but this trend was not observed with the post-dredging data. Figures 14a and 15a present pre- and post-dredging benzene and toluene data at the CDF south site. Figures 14b and 15b present pre- and post-dredging benzene and toluene data at the high school site.

Pre-Dredging vs. Post-Dredging

CDF. CDF pre-dredging data was compared with CDF post-dredging data. The entire data set, and the data set subdivided into seasonal periods were compared for the two dredging regimes. Benzene and toluene were not statistically different between the pre- and post-dredging periods at the CDF either by season, or for the aggregated data (Table 10).

The lack of significant difference between the pre- and post-dredging benzene and toluene concentrations at the CDF suggests that sediment disposal activities and dredged material storage at the CDF have not impacted the atmospheric benzene and toluene conditions at the CDF. This trend will be revisited as additional data is generated in the future. Figures 14a and 15a illustrate the lack of difference between pre- and post-dredging benzene and toluene concentrations at the CDF.

HS. Benzene and toluene were not statistically different between the pre- and post-dredging periods at the high school either by season, or for the aggregated data (Table 11).

The lack of significant difference between the pre- and post-dredging benzene and toluene concentrations at the HS suggests that sediment disposal activities and dredged material storage at the CDF have not impacted the atmospheric benzene and toluene conditions at the off-site location of the high school. This trend will be revisited as additional data is generated in the future. Figures 14b and 15b illustrate the lack of difference between pre- and post-dredging benzene and toluene concentrations at the high school.

Trend Analysis

Trend analysis was performed for benzene and toluene data over the entire monitoring period (2001 to December 2013). As discussed in the pre-dredging section, the south and high school benzene data, and the south toluene data had statistically significant decreasing trends over the pre-dredging period of 2001 to November 2012. When the trend analysis was expanded to include the post-dredging data, all of the trends observed during the pre-dredging period were maintained. In addition, inclusion of the post-dredging data resulted in toluene having a decreasing trend at the high school site also (pre-dredging data had no statistically significant trend) (Table 12). This further supports that sediment disposal activities and the presence of the dredged material at the CDF have not impacted the atmospheric benzene and toluene conditions at the CDF nor at the high school.

(It should be noted that the post-dredging data trend analysis for the CDF site only includes data from the new CDF monitor on the south side of the site, and not data from all CDF monitors as with the CDF data analyses above. Additional future data and analysis will help identify and verify trends.)

Post-Dredging Metals Analysis

HS vs. CDF

Copper concentrations are higher at the high school than at the CDF site during the post-dredging period – consistent with the pre-dredging period (Table 13). Aluminum (spring/fall, summer, overall), iron (overall), manganese (spring/fall, overall) concentrations were higher at the CDF than at the high school during the post-dredging period (Table 13). TSP (spring/fall, summer, overall) is also statistically higher at the CDF than at the high school during the post-dredging period. These trends were not observed in the pre-dredging data set and it is possible that sediment disposal activities and/or dredged material storage in the CDF is resulting in higher levels of these parameters in the air at the CDF site. However, as sediment disposal into the CDF is being conducted hydraulically and the dredged material is always below a pond of water in the CDF – making an increase in dust or TSP being unlikely, the correlation of increase in metals and TSP with these activities is not as readily apparent as with volatile compounds. Some activities associated with dredging and disposal such as placement of debris into the CDF cells may result in an increase of dust (operating large equipment on the CDF dikes). However, these activities are of short duration (days) and should not have a high impact on long-term trends. These trends will be re-assessed in the future with additional data.

Figures 16a through 28a present pre- and post-dredging TSP and metals data at the CDF south site. Figures 16b through 28b present pre- and post-dredging TSP and metals data at the high school site. The higher atmospheric concentrations of TSP and some metals (aluminum, iron, manganese) at the south site compared to the high school site for the post-dredging period can be readily observed in these figures. The higher copper concentrations at the high school compared to the CDF site during the post-dredging period can be seen in Figures 22a and 22b.

Pre-Dredging vs. Post-Dredging

CDF. CDF pre-dredging data was compared with CDF post-dredging data. The entire data set, and the data set subdivided into seasonal periods were compared for the two dredging regimes. Post-dredging arsenic (during spring/fall), chromium (spring/fall), and cobalt (overall) concentrations were statistically higher than pre-dredging concentrations (Table 14). These findings may be indications that sediment disposal activities and/or sediment storage at the CDF have elevated the levels of these parameters at the CDF. The higher post-dredging atmospheric concentrations of arsenic, chromium, and cobalt at the CDF compared to pre-dredging conditions can be observed in Figures 18a, 20a and 21a, respectively.

Copper (spring/fall, summer, winter, and overall), iron (overall), lead (summer and overall), and TSP (winter and overall) were statistically higher during the pre-season period than the post-dredging period (Table 14). Pre-dredging copper levels at the CDF had a statistically increasing trend, which may not be consistent with the finding of higher pre-season concentrations than post-season. The findings of other metals (iron and lead) and TSP being higher during pre-dredging than the post-dredging are also difficult to explain. Additional data may clarify the trends in the future. The higher pre-dredging atmospheric concentrations of TSP, copper, iron at the CDF compared to pre-dredging conditions can be observed in Figures 16a, 22a and 23a, respectively.

HS. HS pre-dredging data were compared with HS post-dredging data. Only one metal, copper during the summer season, was statistically higher during the post-dredging period than the pre-dredging period at the high school site. Several metals were found to be statistically higher during the pre-dredging than the post-dredging period: aluminum (spring/fall, summer, overall), barium (summer, overall), copper (winter), iron (spring/fall, summer, overall), lead (overall), and manganese (spring/fall, summer, overall) (Table 15). TSP (spring/fall, summer, winter, and overall) was also higher during the pre-dredging than the post-dredging period at the high school (Table 15). Figures 16b through 28b present pre- and post-dredging TSP and metals data at the high school site.

Barium and copper levels had decreasing trends at the HS over the pre-dredging period. It is possible that metal levels are decreasing in the atmosphere in the study area, evidenced by statistically lower concentrations of several metals at both the CDF and HS for the post-dredging period. The sole summer copper trend of being higher during the post-dredging period than pre-dredging is not consistent with all other metal and TSP trends at the high school. This copper trend finding further supports the hypothesis (discussed in the pre-dredging section) that sources of copper to the air may be different from that of other metals in the study area, as well as that copper sources may vary by season. These trends will be re-assessed in the future with additional data.

Trend Analysis

Trend analysis was performed for the TSP and metals data over the entire monitoring period (2001 to December 2013). As discussed in the pre-dredging section, only barium and copper data had statistically significant trends over the pre-dredging period of 2001 to November 2012 (barium with a decreasing trend at both the south site and high school, and copper increasing at the south site and decreasing at the high school). When the trend analysis was expanded to include the post-dredging data, the barium trend at the south site and high school, and the high school copper trend were maintained (Table 16). However, inclusion of the post-dredging data resulted in a finding of insufficient evidence to identify a significant trend for the south site copper data set which previously had an increasing trend. In addition, inclusion of the post-dredging data resulted in two more metals (lead and nickel) and TSP having a decreasing trend at the high school site (pre-dredging data had no statistically significant trend) (Table 16). These findings further support that the levels of several metals are decreasing in the atmosphere in the study area.

(It should be noted that the post-dredging data trend analysis for the CDF site only includes data from the new CDF monitor on the south side of the site, and not data from all CDF monitors as with the CDF data analyses above. Additional future data and analysis will help identify and verify trends.)

Conclusions

The air monitoring data presented were statistically analyzed based on location and by pre- and post-dredging periods. The data and statistical significance are presented in tables. The main findings of the analysis are:

PCBs

- CDF post-dredging PCB congeners 8, 15, 18, 28, 31, and total PCB concentration were statistically higher than post-dredging high school concentrations overall, as well as for each seasonal period. This trend is consistent with the pre-dredging data trends for HS vs. CDF, except for congener 8, which were not statistically different between the two locations during the pre-dredging period.
- CDF post-dredging PCB congeners 15, 18, 28, 31, and total PCB concentration were statistically higher than CDF pre-dredging PCB concentrations overall. This trend was also observed for all but two congeners for the winter season, and for all five PCB congeners and Total PCBs for the summer season.
- HS pre-dredging data and HS post-dredging PCB data are not statistically different, except for two PCB congeners (congener 8 overall and congener 18 in summer) which were statistically lower for the post-dredging period than the pre-dredging period.
- Trend analysis of both the south and high school site Total PCBs pre-dredging data had statistically significant decreasing trends. With inclusion of the post-dredging data, the high school data maintained a statistically significant decreasing trend, but the south site did not.
- These findings suggest that dredged material disposal activities and the presence of dredged material at the CDF may have impacted (increased) the atmospheric PCB conditions at the CDF site, but have not impacted the atmospheric PCB conditions at the high school.

PAHs

- Post-dredging fluorene, phenanthrene, and pyrene were statistically higher at the CDF site than at the high school for some seasonal period and/or for all data. Only the fluorene trend is consistent with the pre-dredging period trend. The new phenanthrene and pyrene trends are attributed to sediment disposal activities and/or sediment storage at the CDF. Pre-dredging findings of statistically greater acenaphthene, fluoranthene, and naphthalene concentrations at the HS than at the south site were not observed for the post-dredging data set.
- CDF post-dredging fluoranthene, phenanthrene, and pyrene concentration were statistically higher than pre-dredging concentrations of these parameters for the summer season, and also when the aggregated data sets were analyzed. Acenaphthene, acenaphthylene, fluorene, and naphthalene were not statistically different between the pre- and post-dredging periods at the CDF.
- The analyzed PAHs were not statistically different between the pre- and post-dredging periods at the high school either by season, or for the aggregated data.

- The pre-dredging trends of increasing acenaphthene at the high school, and decreasing naphthalene at both the south site and high school were maintained with inclusion of the post-dredging data. In addition, inclusion of the post-dredging data resulted in acenaphthene having an increasing trend at the south site. The other analyzed PAHs did not have statistically significant trends over the pre-dredging period or the pre- and post-dredging periods combined.
- These findings suggest that dredged material disposal activities and the presence of dredged material at the CDF may have impacted (increased) the atmospheric conditions of some PAHs at the CDF site, but have not impacted the atmospheric PAH conditions at the high school.

VOCs

- Neither benzene nor toluene is statistically different between the south site and the high school for the post-dredging period. The post-dredging benzene trend is consistent with pre-dredging trend. Toluene was statistically higher at the high school than at the CDF for the pre-dredging period, but this trend was not observed with the post-dredging data.
- Benzene and toluene were not statistically different between the pre- and post-dredging periods at the CDF either by season, or for the aggregated data.
- Benzene and toluene were not statistically different between the pre- and post-dredging periods at the high school either by season, or for the aggregated data.
- The pre-dredging trends of decreasing benzene at the south site and high school, and decreasing toluene at the south site were maintained with inclusion of the post-dredging data. In addition, inclusion of the post-dredging data resulted in toluene having a decreasing trend at the high school also.
- These findings suggest that dredged material disposal activities and the presence of dredged material at the CDF have not impacted the atmospheric benzene and toluene conditions at the CDF nor at the high school. Most likely, benzene and toluene air concentrations are controlled by other factors not identified in this study.

Metals

- Copper concentrations are higher at the high school than at the CDF site during the post-dredging period – consistent with the pre-dredging period. Post-dredging TSP, aluminum, iron, and manganese concentrations were higher at the CDF than at the high school for some seasonal period and/or for all data. These trends were not observed in the pre-dredging data set.
- CDF post-dredging arsenic, chromium, and cobalt concentrations were statistically higher than pre-dredging concentrations for some seasonal period and/or for all data. CDF copper, iron, lead, and TSP were statistically higher during pre-season than post-dredging for some seasonal period and/or for all data. Pre-dredging copper levels at the CDF had a statistically increasing trend, which may not be consistent with the finding of higher pre-season concentrations than post-season.
- At the HS, only one metal, copper during the summer season, was statistically higher during the post-dredging period than the pre-dredging period. TSP and several metals (aluminum, barium,

copper, iron, lead, and manganese) were statistically higher during the pre-dredging than the post-dredging period for some seasonal period and/or for all data.

- The pre-dredging trends of decreasing barium at the south site and high school, and decreasing copper at the high school were maintained with inclusion of the post-dredging data. However, inclusion of the post-dredging data resulted in a finding of insufficient evidence to identify a significant trend for the south site copper data set which previously had an increasing trend. In addition, inclusion of the post-dredging data resulted in two more metals (lead and nickel) and TSP having a decreasing trend at the high school site (pre-dredging data had no statistically significant trend)
- These findings suggest that the levels of several metals are decreasing in the atmosphere at both the CDF and high school. Because of the decreasing trends, it is difficult to determine whether sediment disposal activities and dredged material storage at the CDF have impacted the atmospheric conditions of TSP and metals at the site. Additional data may clarify the trends in the future.

Future Analysis

The air monitoring program is currently continuing at the four CDF monitors and the high school monitor, at a rate of one sample per monitor every 12 days during the non-dredging period, and one sample per monitor every 6 days during the dredging/dredged material disposal period. The data will be re-evaluated on an annual basis to re-assess the currently observed trends.

As additional post-dredging data is generated, future analyses can potentially include the following comparisons (in addition to the current analyses):

- Analysis and comparison of individual on-site air monitors; possible correlation with on-site wind data and confirmation of CDF as a source of emissions
- Analysis and comparison of post-dredging Active (active dredged material) and Idle (quiescent pond) periods
- Further long-term trend analysis of air data

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Table 1: Comparison of Mean PCB Concentrations between CDF site and High School site during IHC Post-Dredging Period

Analyte & Location		**Spring/Fall**		**Summer**		**Winter**		**Overall**	
		pg/m^3	S/D*	pg/m^3	S/D*	pg/m^3	S/D*	pg/m^3	S/D*
Congener 8	CDF	26.79	yes	67.98	yes	29.26	yes	40.77	yes
	HS	11.10		22.59		7.29		13.98	
Congener 15	CDF	7.86	yes	18.92	yes	6.66	yes	11.17	yes
	HS	3.47		6.54		2.85		4.34	
Congener 18	CDF	48.85	yes	106.66	yes	33.96	yes	64.09	yes
	HS	13.03		19.24		6.74		13.53	
Congener 28	CDF	35.18	yes	104.14	yes	21.21	yes	54.26	yes
	HS	10.93		23.23		5.42		13.66	
Congener 31	CDF	32.77	yes	94.27	yes	19.01	yes	49.48	yes
	HS	9.69		19.73		4.74		11.80	
Sum PCBs	CDF	151.87	yes	403.68	yes	108.44	yes	223.35	yes
	HS	46.16		96.02		23.01		56.99	

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 2: Comparison of Mean PCB Concentrations between Pre-dredging and Post-dredging Periods at the IHC CDF Site

Analyte & Period		**Spring/Fall**		**Summer**		**Winter**		**Overall**	
		pg/m^3	S/D*	pg/m^3	S/D*	pg/m^3	S/D*	pg/m^3	S/D*
Congener 8	Pre	21.43		34.01		9.03		23.06	
	Post	26.79		67.98	yes	29.26		40.77	
Congener 15	Pre	5.50		9.16		2.94		6.20	
	Post	7.86		18.92	yes	6.66		11.17	yes
Congener 18	Pre	29.61		51.72		8.57		32.64	
	Post	48.85		106.66	yes	33.96	yes	64.09	yes
Congener 28	Pre	25.00		46.36		6.88		28.40	
	Post	35.18		104.14	yes	21.21	yes	54.26	yes
Congener 31	Pre	25.43		42.09		6.95		27.15	
	Post	32.77		94.27	yes	19.01	yes	49.48	yes
Sum PCBs	Pre	108.31		193.47		30.85		120.75	
	Post	151.87		403.68	yes	108.44	yes	223.35	yes

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 3: Comparison of Mean PCB Concentrations between Pre-dredging and Post-dredging Periods at the High School Site

Analyte & Period		**Spring/Fall**		**Summer**		**Winter**		**Overall**	
		pg/m^3	S/D*	pg/m^3	S/D*	pg/m^3	S/D*	pg/m^3	S/D*
Congener 8	Pre	17.73		34.74		8.49		22.05	yes
	Post	11.10		22.59		7.29		13.98	
Congener 15	Pre	3.88		7.39		2.85		4.95	
	Post	3.47		6.54		2.85		4.34	
Congener 18	Pre	14.23		36.41	yes	5.58		20.54	
	Post	13.03		19.24		6.74		13.53	
Congener 28	Pre	12.27		30.81		4.52		17.44	
	Post	10.93		23.23		5.42		13.66	
Congener 31	Pre	11.74		27.25		4.52		15.92	
	Post	9.69		19.73		4.74		11.80	
Sum PCBs	Pre	59.96		144.90		20.97		82.95	
	Post	46.16		96.02		23.01		56.99	

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 4: Significant Trend of Combined Pre-Dredging and Post-Dredging Data (2001-2013 Data)

Analyte	**South Site**	**High School Site**
Congener 8	Decreasing	Decreasing
Congener 15	No Trend	No Trend
Congener 18	No Trend	Decreasing
Congener 28	No Trend	Decreasing
Congener 31	No Trend	Decreasing
Sum PCBs	No Trend	Decreasing

Table 5: Comparison of Mean PAH Concentrations between CDF site and High School site during IHC Post-Dredging Period

Analyte & Location		Spring/Fall		Summer		Winter		Overall	
		ng/m^3	S/D*	ng/m^3	S/D*	ng/m^3	S/D*	ng/m^3	S/D*
Acenaphthene	CDF	11.37		17.83		4.33		11.79	
	HS	6.87		19.77		2.63		10.11	
Acenaphthylene	CDF	1.97		1.56		2.10		1.87	
	HS	1.74		1.52		1.76		1.67	
Fluoranthene	CDF	2.91		7.23		1.72		4.03	
	HS	2.50		8.32		1.85		4.28	
Fluorene	CDF	9.77	yes	17.33		3.89		10.83	
	HS	5.71		17.26		2.65		8.80	
Naphthalene	CDF	52.24		47.16		45.89		49.07	
	HS	56.35		54.13		52.60		54.67	
Phenanthrene	CDF	14.83	yes	35.52		6.41		19.55	
	HS	9.83		36.03		5.58		17.50	
Pyrene	CDF	2.25	yes	4.51		1.63		2.84	yes
	HS	1.68		3.80		1.54		2.35	

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 6: Comparison of Mean PAH Concentrations between Pre-dredging and Post-dredging Periods at the IHC CDF Site

Analyte & Period		**Spring/Fall**		**Summer**		**Winter**		**Overall**	
		ng/m^3	S/D*	ng/m^3	S/D*	ng/m^3	S/D*	ng/m^3	S/D*
Acenaphthene	Pre	8.67		13.25		3.36		9.10	
	Post	11.37		17.83		4.33		11.79	
Acenaphthylene	Pre	2.01		1.57		2.37		1.94	
	Post	1.97		1.56		2.10		1.87	
Fluoranthene	Pre	2.77		5.73		2.05		3.62	
	Post	2.91		7.23	yes	1.72		4.03	
Fluorene	Pre	7.99		14.47		3.52		9.24	
	Post	9.77		17.33		3.89		10.83	
Naphthalene	Pre	51.84		49.15		62.24		53.16	
	Post	52.24		47.16		45.89		49.07	
Phenanthrene	Pre	14.39		28.12		7.07		17.51	
	Post	14.83		35.52	yes	6.41		19.55	
Pyrene	Pre	1.99		2.94		1.72		2.26	
	Post	2.25		4.51	yes	1.63		2.84	yes

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 7: Comparison of Mean PAH Concentrations between Pre-dredging and Post-dredging Periods at the High School Site

Analyte & Period		**Spring/Fall**		**Summer**		**Winter**		**Overall**	
		ng/m^3	S/D*	ng/m^3	S/D*	ng/m^3	S/D*	ng/m^3	S/D*
Acenaphthene	Pre	10.19		21.49		3.36		12.70	
	Post	6.87		19.77		2.63		10.11	
Acenaphthylene	Pre	1.84		1.50		2.53		1.87	
	Post	1.74		1.52		1.76		1.67	
Fluoranthene	Pre	3.43		9.69		2.28		5.40	
	Post	2.50		8.32		1.85		4.28	
Fluorene	Pre	8.61		20.71		3.34		11.73	
	Post	5.71		17.26		2.65		8.80	
Naphthalene	Pre	62.29		66.78		70.30		64.44	
	Post	56.35		54.13		52.60		54.67	
Phenanthrene	Pre	16.50		44.04		7.43		24.22	
	Post	9.83		36.03		5.58		17.50	
Pyrene	Pre	2.02		4.34		1.82		2.80	
	Post	1.68		3.80		1.54		2.35	

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 8: Significant Trend of Combined Pre-Dredging and Post-Dredging Data (2001-2013 Data)

Analyte	**South Site**	**High School Site**
Acenaphthene	Increasing Trend	Increasing Trend
Acenaphthylene	No Trend	No Trend
Fluoranthene	No Trend	No Trend
Fluorene	No Trend	No Trend
Naphthalene	Decreasing Trend	Decreasing Trend
Phenanthrene	No Trend	No Trend
Pyrene	No Trend	No Trend

Table 9: Comparison of Mean VOC Concentrations between CDF site and High School site during IHC Post-Dredging Period

Analyte & Location		**Spring/Fall**		**Summer**		**Winter**		**Overall**	
		ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*
Benzene	CDF	0.96		0.91		0.80		0.90	
	HS	0.89		0.64		0.73		0.77	
Toluene	CDF	1.92		2.00		1.62		1.88	
	HS	2.05		1.93		1.47		1.87	

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 10: Comparison of Mean VOC Concentrations between Pre-dredging and Post-dredging Periods at the IHC CDF Site

Analyte & Period		**Spring/Fall**		**Summer**		**Winter**		**Overall**	
		ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*
Benzene	Pre	1.82		0.92		0.82		1.20	
	Post	0.96		0.91		0.80		0.90	
Toluene	Pre	2.16		4.47		1.30		3.03	
	Post	1.92		2.00		1.62		1.88	

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 11: Comparison of Mean VOC Concentrations between Pre-dredging and Post-dredging Periods at the High School Site

Analyte & Period		**Spring/Fall**		**Summer**		**Winter**		**Overall**	
		ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*
Benzene	Pre	1.10		0.94		1.06		1.03	
	Post	0.89		0.64		0.73		0.77	
Toluene	Pre	2.50		27.37		1.91		11.75	
	Post	2.05		1.93		1.47		1.87	

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 12: Significant Trend of Combined Pre-Dredging and Post-Dredging Data (2001-2013 Data)

Analyte	**South Site**	**High School Site**
Benzene	Decreasing Trend	Decreasing Trend
Toluene	Decreasing Trend	Decreasing Trend

Table 13: Comparison of Mean Metal and Total Suspended Particulate Concentrations between CDF site and High School site during IHC Post-Dredging Period

Analyte & Location		Spring/Fall		Summer		Winter		Overall	
		ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*
Aluminum	CDF	0.382	yes	0.519	yes	0.215		0.387	yes
	HS	0.237		0.273		0.175		0.232	
Arsenic	CDF	0.0052		0.0014		0.0012		0.0030	
	HS	0.0049		0.0014		0.0012		0.0026	
Barium	CDF	0.023		0.017		0.021		0.021	
	HS	0.021		0.015		0.018		0.018	
Chromium	CDF	0.0109		0.0058		0.0024		0.0071	
	HS	0.0077		0.0057		0.0022		0.0055	
Cobalt	CDF	0.00080		0.00081		0.00084		0.00081	
	HS	0.00089		0.00065		0.00069		0.00075	
Copper	CDF	0.051		0.056		0.045		0.051	
	HS	0.099	yes	0.114	yes	0.061		0.093	yes
Iron	CDF	0.95		1.03		0.43		0.85	yes
	HS	0.62		0.77		0.38		0.60	
Lead	CDF	0.040		0.028		0.012		0.029	
	HS	0.017		0.013		0.011		0.014	
Manganese	CDF	0.102	yes	0.117		0.036		0.091	yes
	HS	0.058		0.078		0.030		0.057	
Nickel	CDF	0.0017		0.0015		0.0015		0.0016	
	HS	0.0015		0.0014		0.0014		0.0014	
Selenium	CDF	0.0018		0.0015		0.0013		0.0016	
	HS	0.0014		0.0014		0.0014		0.0014	
Zinc	CDF	0.085		0.071		0.062		0.075	
	HS	0.077		0.053		0.050		0.061	
Total Suspended	CDF	4.72E-05	yes	5.92E-05	yes	2.79E-05		4.65E-05	yes
Particulates (g/m^3)	HS	2.99E-05		4.05E-05		2.57E-05		3.24E-05	

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 14: Comparison of Mean Metal and Total Suspended Particulate Concentrations between Pre-dredging and Post-dredging Periods at the IHC CDF Site

Analyte & Location		Spring/Fall		Summer		Winter		Overall	
		ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*
Aluminum	Pre	0.382		0.477		0.175		0.381	
	Post	0.382		0.519		0.215		0.387	
Arsenic	Pre	0.0015		0.0018		0.0013		0.0016	
	Post	0.0052	yes	0.0014		0.0012		0.0030	
Barium	Pre	0.017		0.019		0.015		0.018	
	Post	0.023		0.017		0.021		0.021	
Chromium	Pre	0.0049		0.0057		0.0029		0.0048	
	Post	0.0109	yes	0.0058		0.0024		0.0071	
Cobalt	Pre	0.00076		0.00078		0.00060		0.00074	
	Post	0.00080		0.00081		0.00084		0.00081	yes
Copper	Pre	0.086	yes	0.115	yes	0.132	yes	0.105	yes
	Post	0.051		0.056		0.045		0.051	
Iron	Pre	1.01		1.24		0.53		1.01	yes
	Post	0.95		1.03		0.43		0.85	
Lead	Pre	0.043		0.028	yes	0.010		0.032	yes
	Post	0.040		0.028		0.012		0.029	
Manganese	Pre	0.101		0.123		0.044		0.099	
	Post	0.102		0.117		0.036		0.091	
Nickel	Pre	0.0017		0.0016		0.0013		0.0016	
	Post	0.0017		0.0015		0.0015		0.0016	
Selenium	Pre	0.0015		0.0017		0.0015		0.0016	
	Post	0.0018		0.0015		0.0013		0.0016	
Zinc	Pre	0.086		0.072		0.066		0.077	
	Post	0.085		0.071		0.062		0.075	
Total Suspended Particulates (g/m^3)	Pre	5.20E-05		6.33E-05		3.68E-05	yes	5.35E-05	yes
	Post	4.72E-05		5.92E-05		2.79E-05		4.65E-05	

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 15: Comparison of Mean Metal and Total Suspended Particulate Concentrations between Pre-dredging and Post-dredging Periods at the HS Site

Analyte & Location		**Spring/Fall**		**Summer**		**Winter**		**Overall**	
		ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*	ug/m^3	S/D*
Aluminum	Pre	0.397	yes	0.470	yes	0.178		0.379	yes
	Post	0.237		0.273		0.175		0.232	
Arsenic	Pre	0.0015		0.0017		0.0013		0.0015	
	Post	0.0049		0.0014		0.0012		0.0026	
Barium	Pre	0.018		0.020	yes	0.015		0.018	yes
	Post	0.021		0.015		0.018		0.018	
Chromium	Pre	0.0043		0.0053		0.0027		0.0043	
	Post	0.0077		0.0057		0.0022		0.0055	
Cobalt	Pre	0.00091		0.00074		0.00060		0.00078	
	Post	0.00089		0.00065		0.00069		0.00075	
Copper	Pre	0.076		0.077		0.119	yes	0.085	
	Post	0.099		0.114	yes	0.061		0.093	
Iron	Pre	0.99	yes	1.18	yes	0.53		0.97	yes
	Post	0.62		0.77		0.38		0.60	
Lead	Pre	0.025		0.024		0.010		0.021	yes
	Post	0.017		0.013		0.011		0.014	
Manganese	Pre	0.092	yes	0.111	yes	0.042		0.089	yes
	Post	0.058		0.078		0.030		0.057	
Nickel	Pre	0.0016		0.0017		0.0014		0.0016	
	Post	0.0015		0.0014		0.0014		0.0014	
Selenium	Pre	0.0014		0.0016		0.0014		0.0015	
	Post	0.0014		0.0014		0.0014		0.0014	
Zinc	Pre	0.088		0.077		0.063		0.079	
	Post	0.077		0.053		0.050		0.061	
Total Suspended Particulates (g/m^3)	Pre	5.31E-05	yes	6.64E-05	yes	3.70E-05	yes	5.47E-05	yes
	Post	2.99E-05		4.05E-05		2.57E-05		3.24E-05	

*S/D indicates a statistically significant difference between the two values at a 95% confidence interval. The significant designation is associated with the data subset with the statistically higher concentration.

Table 16: Significant Trend of Combined Pre-Dredging and Post-Dredging Data (2001-2013 Data)

Analyte	**South Site**	**High School Site**
Aluminum	No Trend	No Trend
Arsenic	No Trend	No Trend
Barium	Decreasing Trend	Decreasing Trend
Chromium	No Trend	No Trend
Cobalt	No Trend	No Trend
Copper	No Trend	Decreasing Trend
Iron	No Trend	No Trend
Lead	No Trend	Decreasing Trend
Manganese	No Trend	No Trend
Nickel	No Trend	Decreasing Trend
Selenium	No Trend	No Trend
Zinc	No Trend	No Trend
Total Suspended Particulates	No Trend	Decreasing Trend

Figure 1a. Atmospheric PCB Congener 8 Concentration at IHC CDF Site

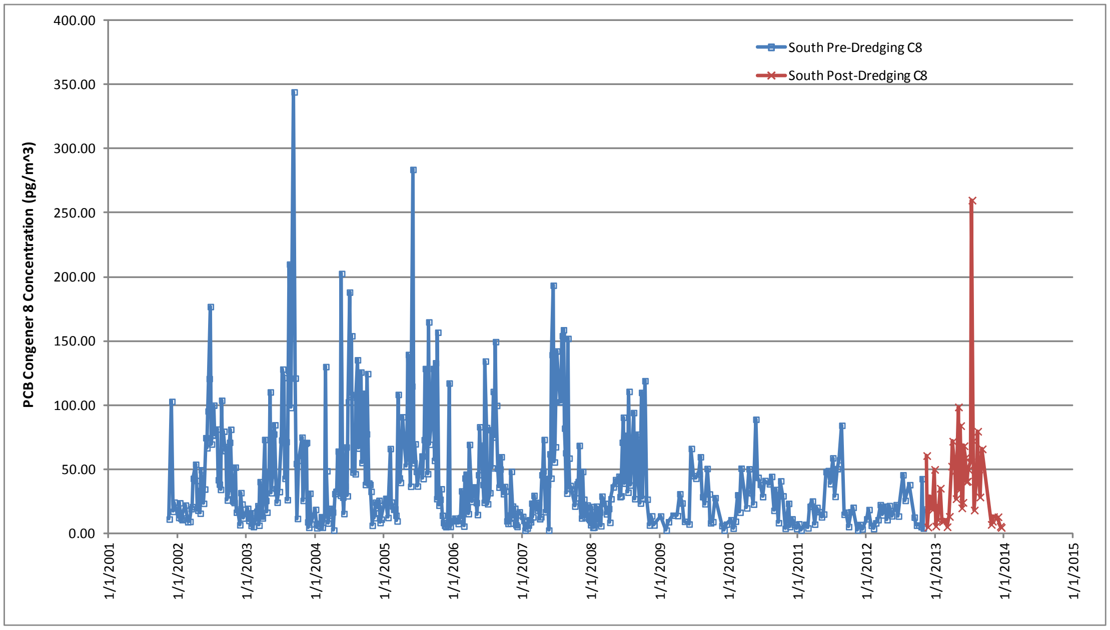

Figure 1b. Atmospheric PCB Congener 8 Concentration at High School Site

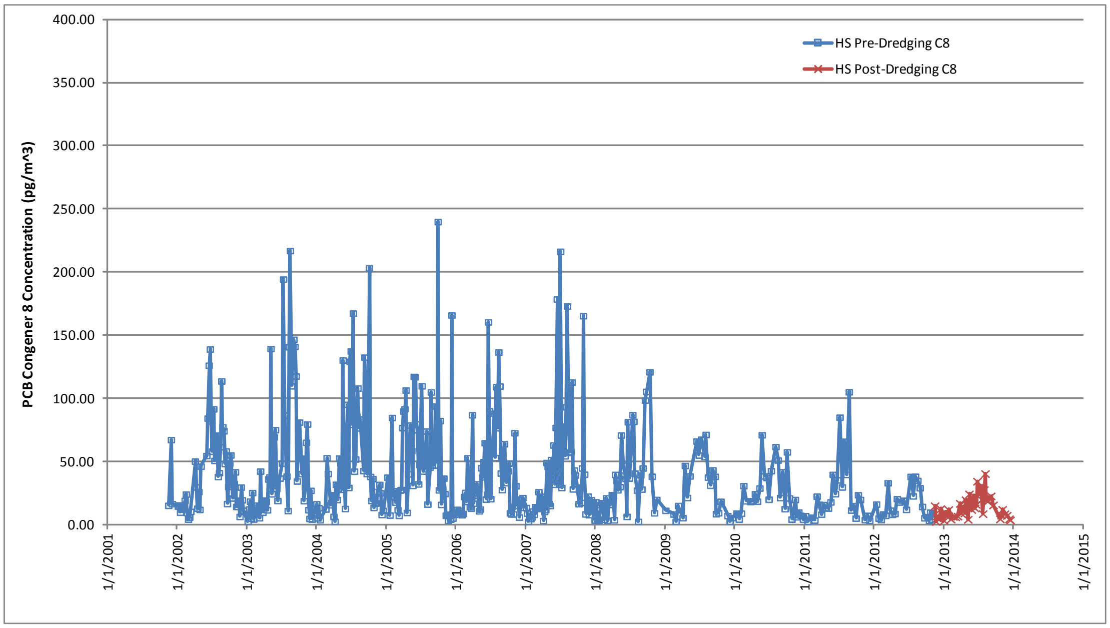

Figure 2a. Atmospheric PCB Congener 15 Concentration at IHC CDF Site

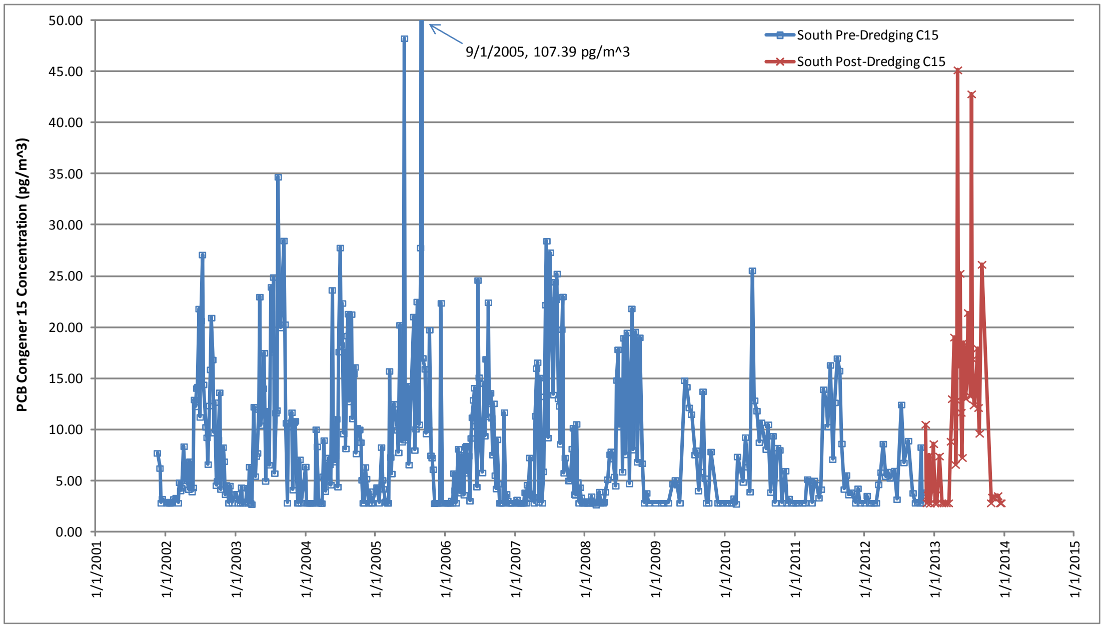

Figure 2b. Atmospheric PCB Congener 15 Concentration at High School Site

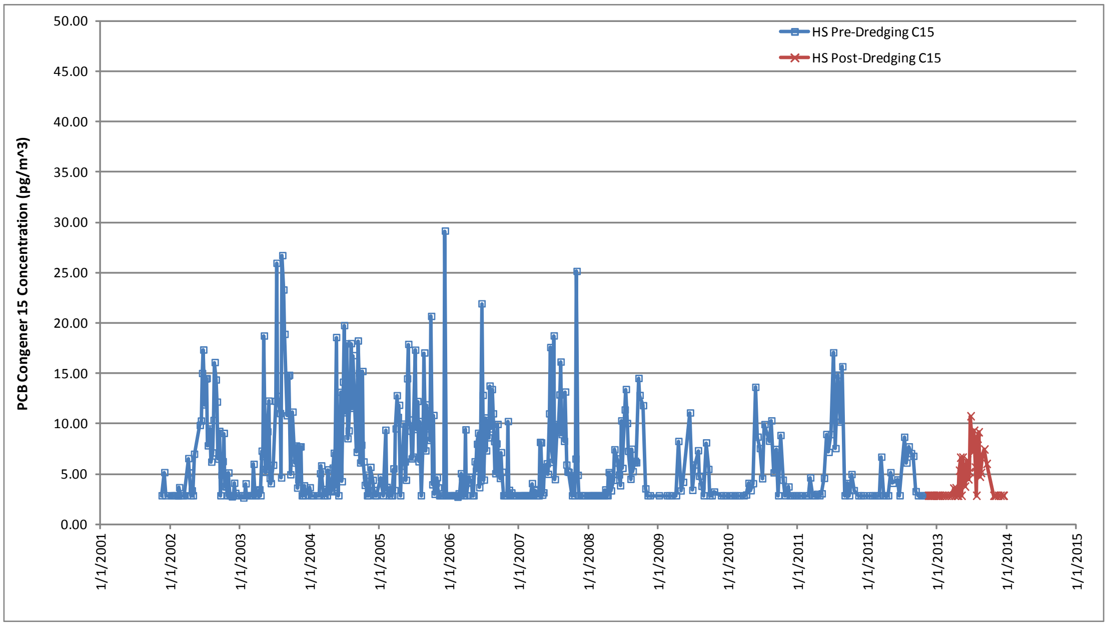

Figure 3a. Atmospheric PCB Congener 18 Concentration at IHC CDF Site

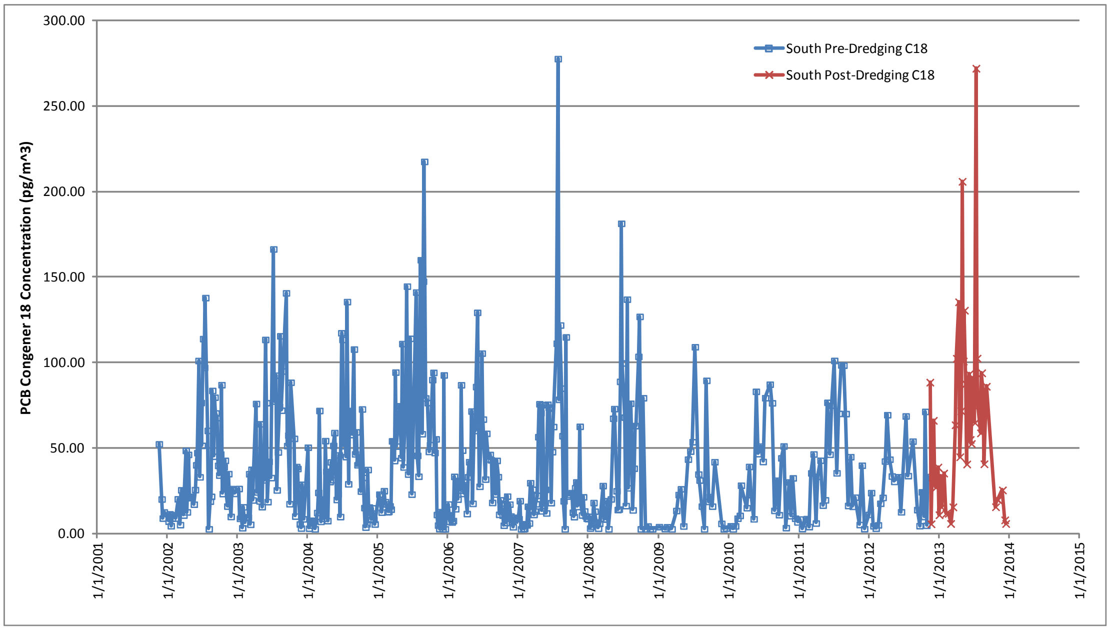

Figure 3b. Atmospheric PCB Congener 18 Concentration at High School Site

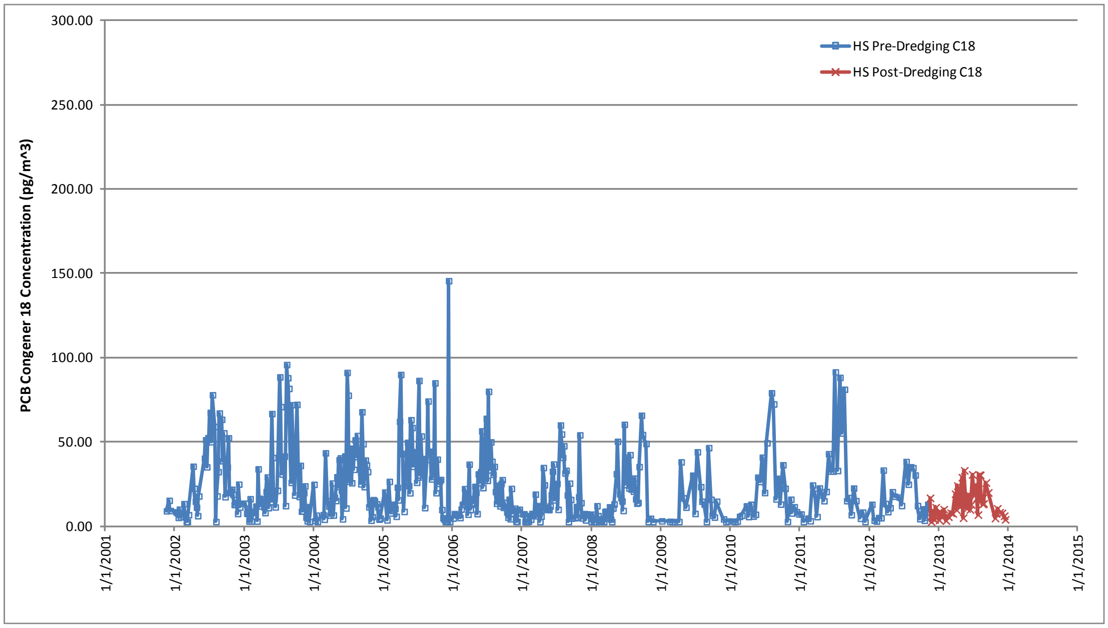

Figure 4a. Atmospheric PCB Congener 28 Concentration at IHC CDF Site

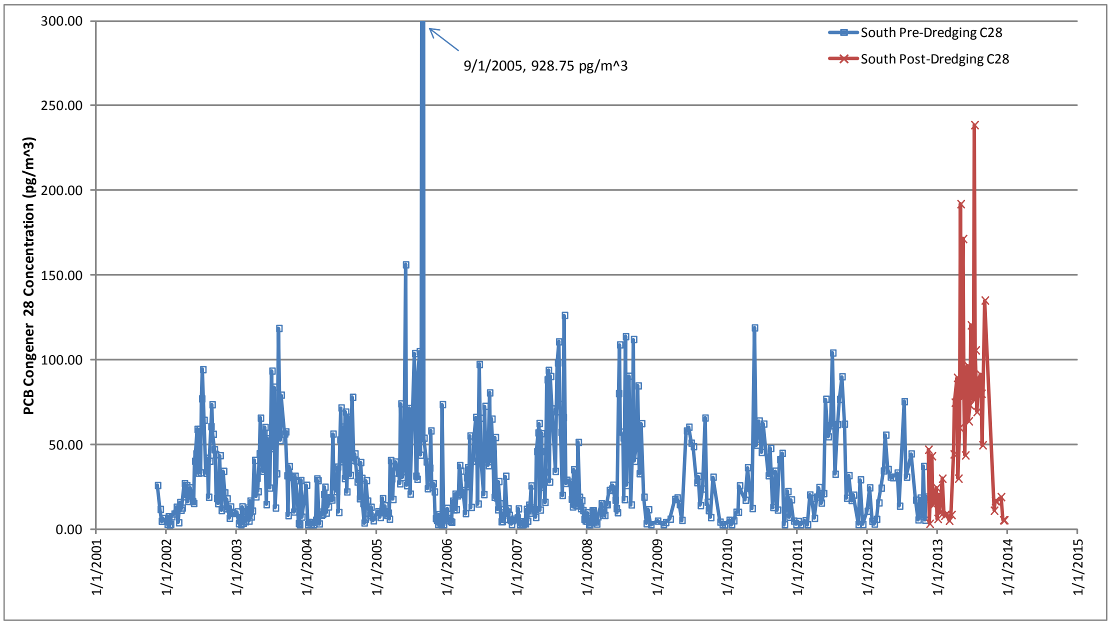

Figure 4b. Atmospheric PCB Congener 28 Concentration at High School Site

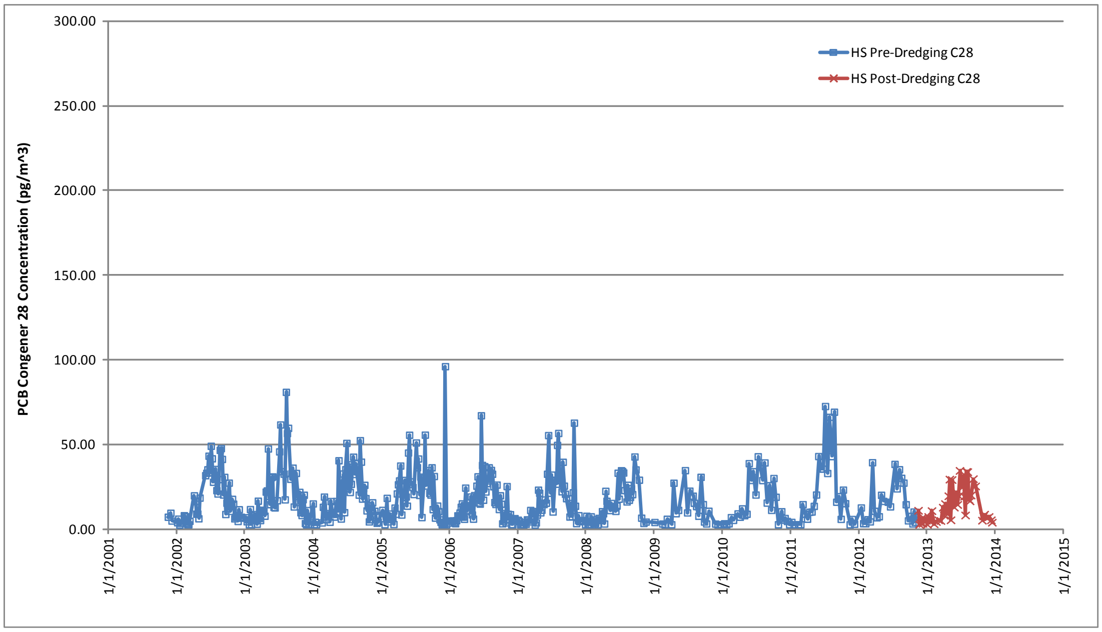

Figure 5a. Atmospheric PCB Congener 31 Concentration at IHC CDF Site

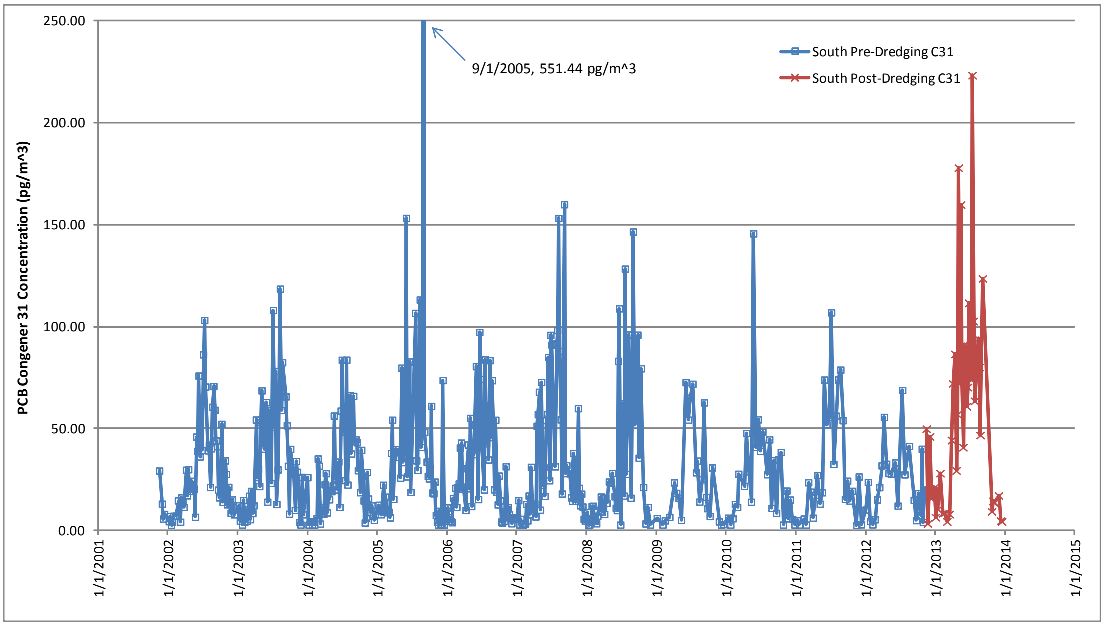

Figure 5b. Atmospheric PCB Congener 31 Concentration at High School Site

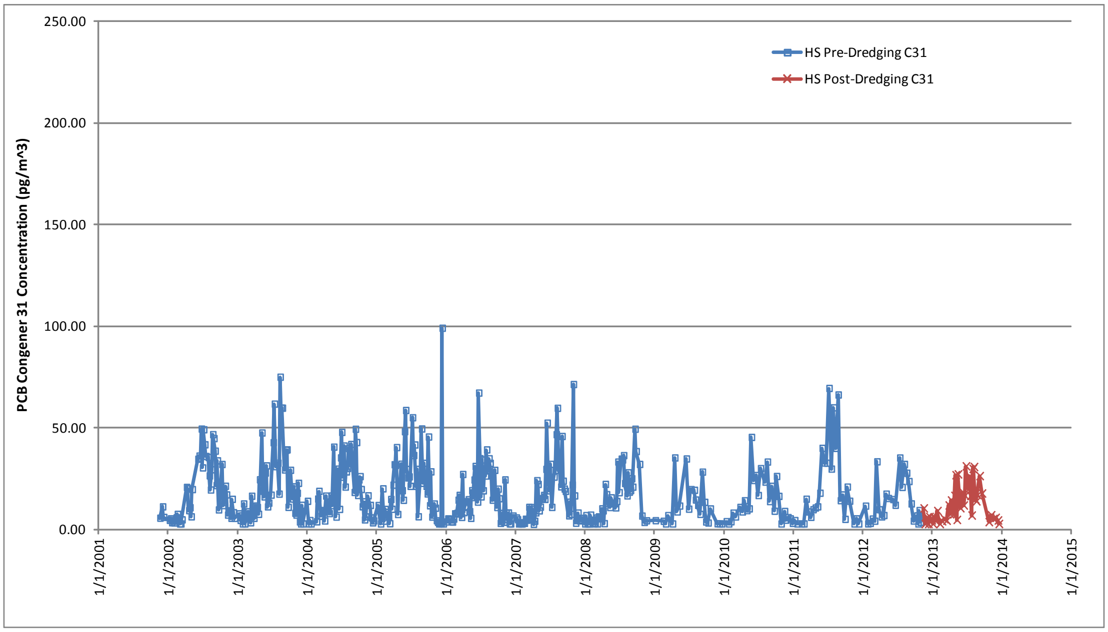

Figure 6a. Atmospheric Sum 18 PCB Congeners at IHC CDF Site

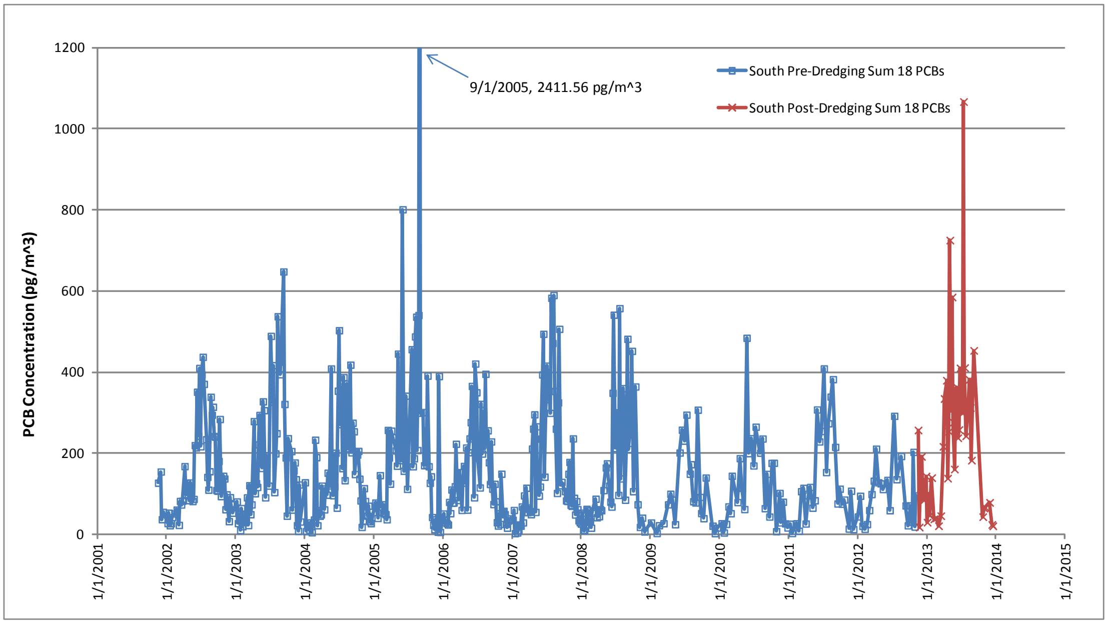

Figure 6b. Atmospheric Sum 18 PCB Congeners at High School Site

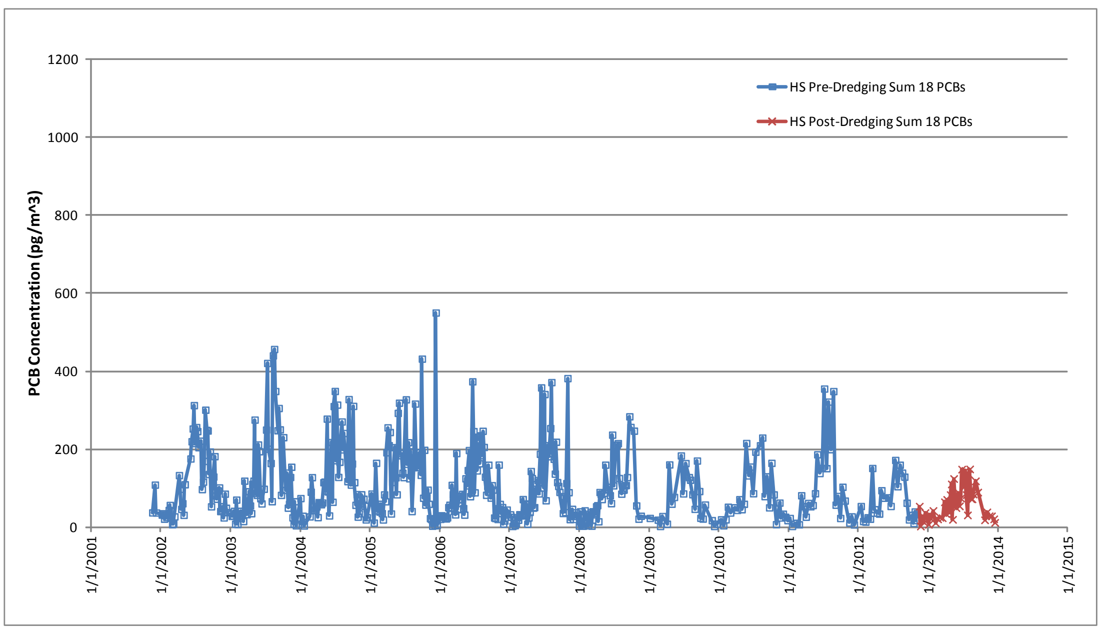

Figure 7a. Atmospheric Acenaphthene Concentration at IHC CDF Site

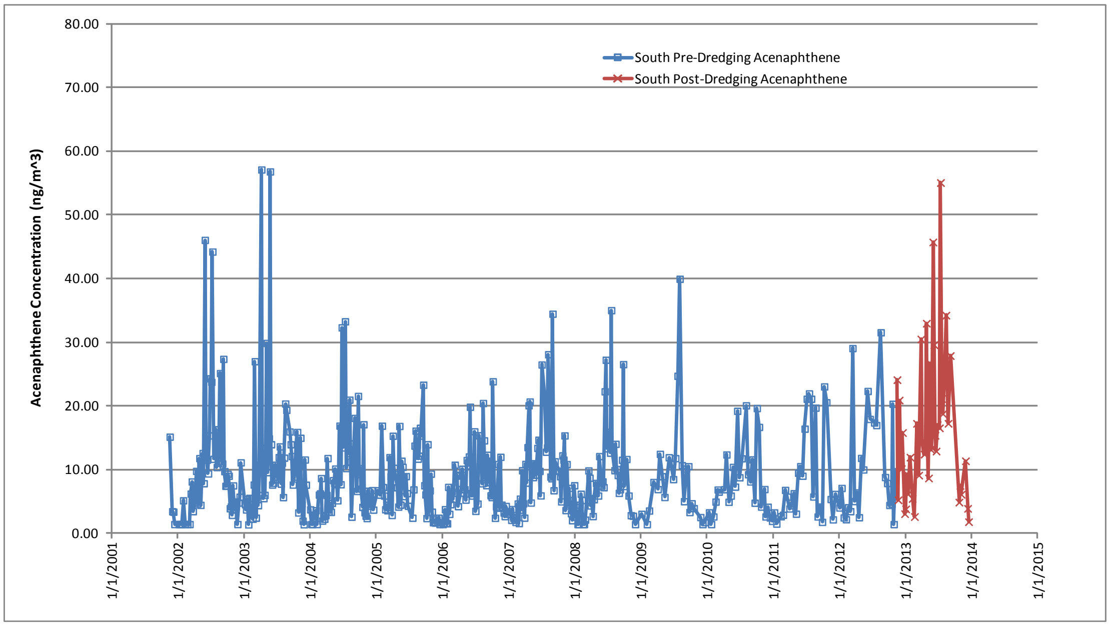

Figure 7b. Atmospheric Acenaphthene Concentration at High School Site

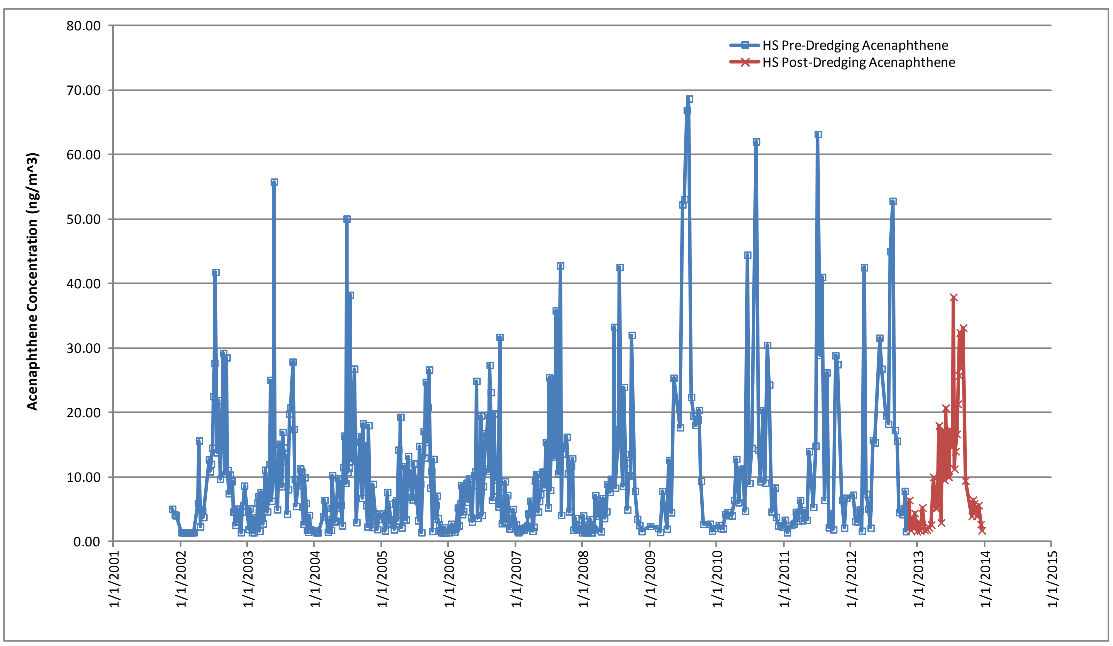

Figure 8a. Atmospheric Acenaphthylene Concentration at IHC CDF Site

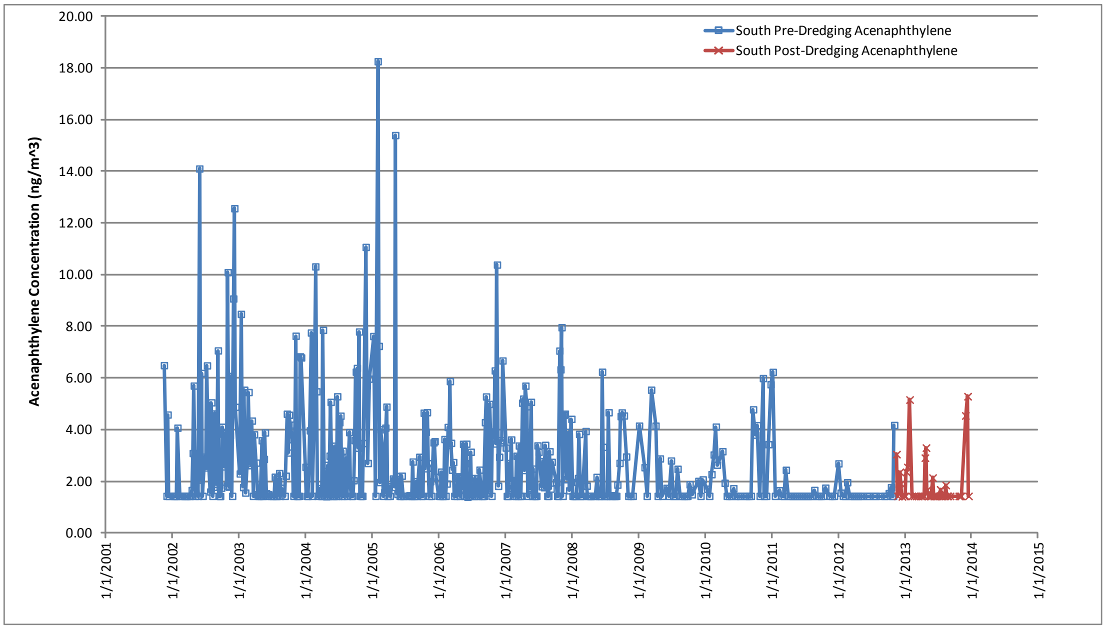

Figure 8b. Atmospheric Acenaphthylene Concentration at High School Site

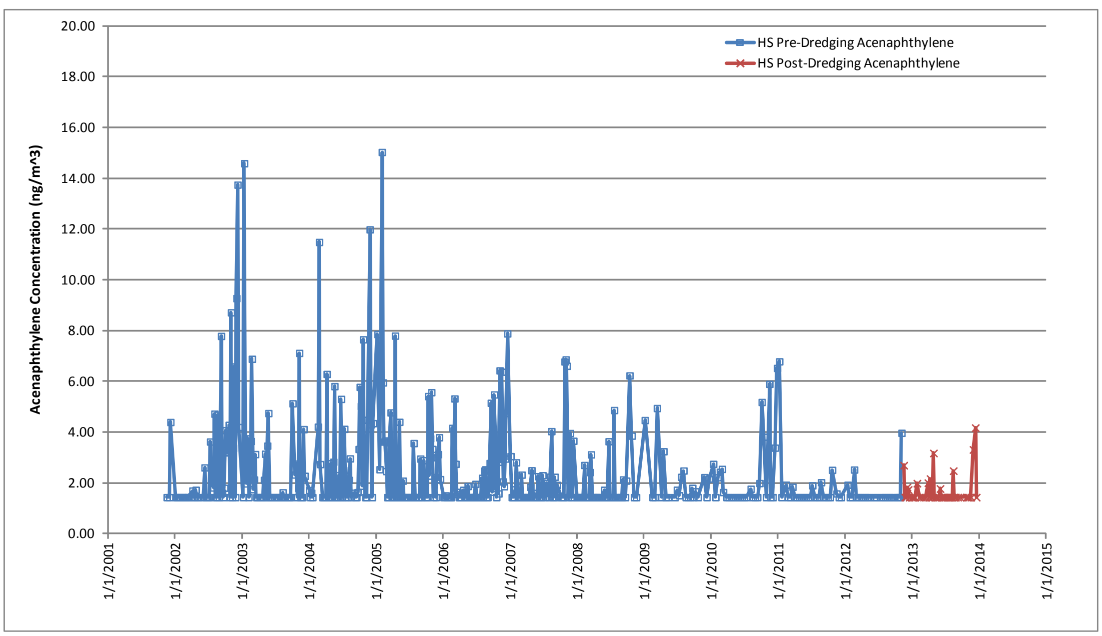

Figure 9a. Atmospheric Fluoranthene Concentration at IHC CDF Site

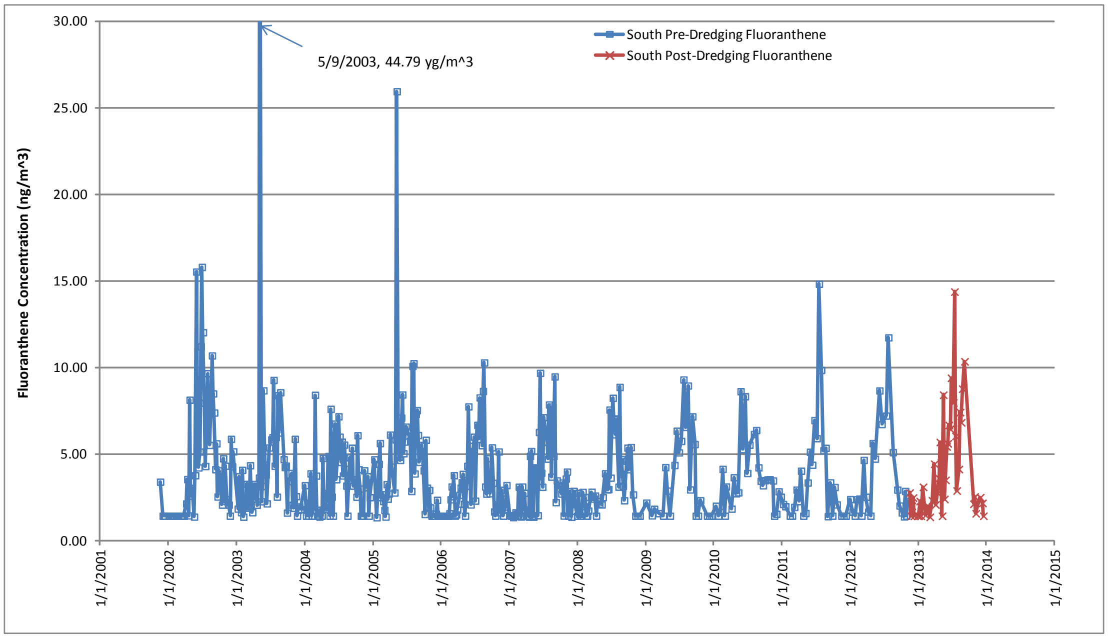

Figure 9b. Atmospheric Fluoranthene Concentration at High School Site

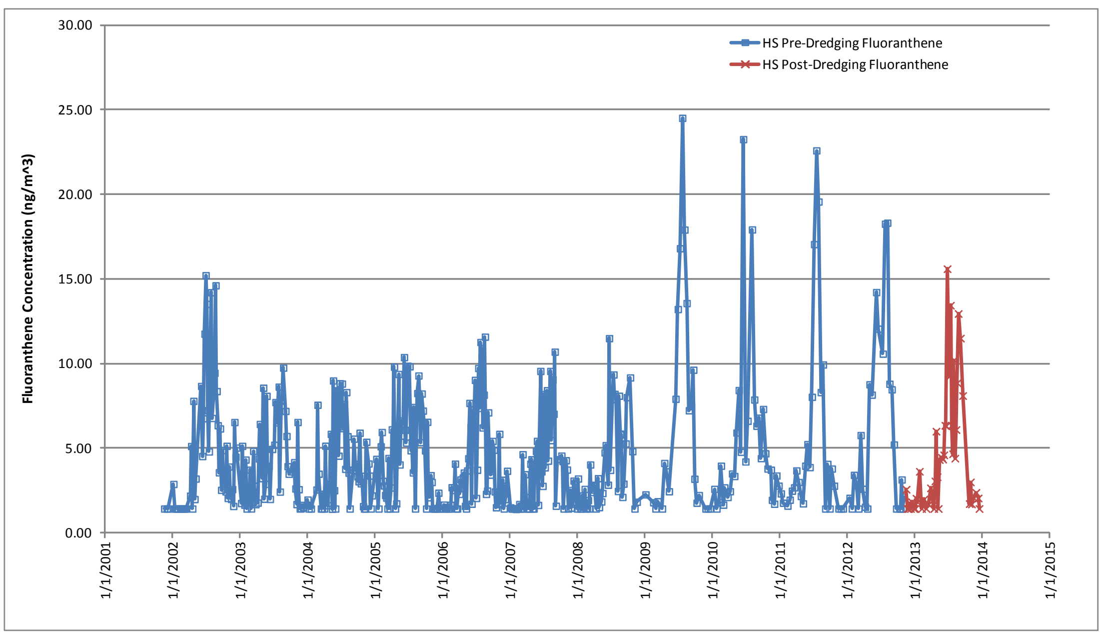

Figure 10a. Atmospheric Fluorene Concentration at IHC CDF Site

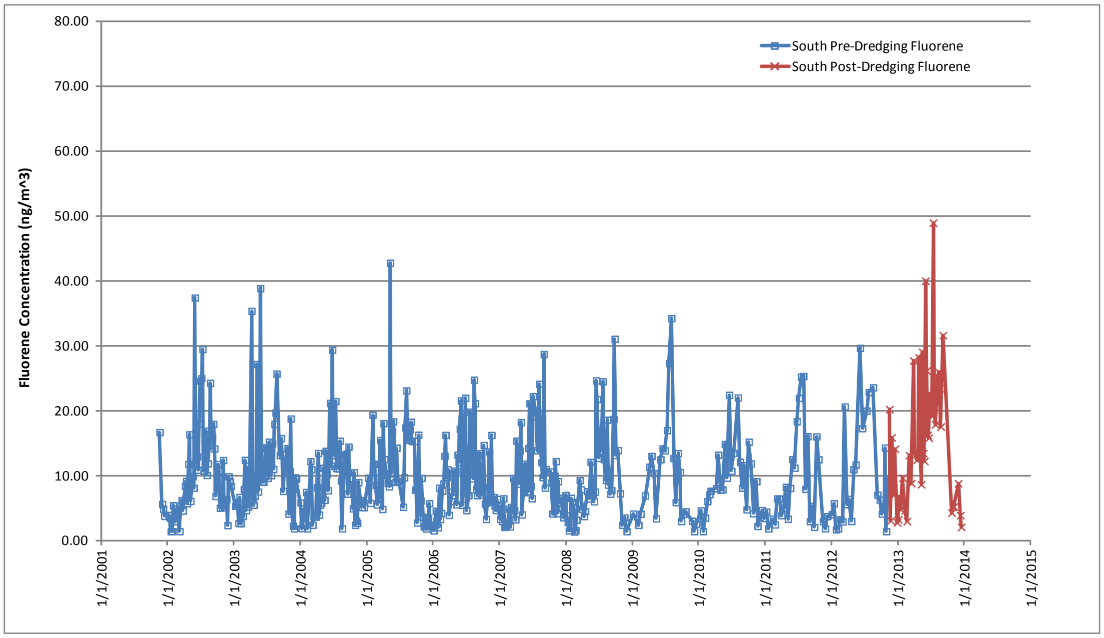

Figure 10b. Atmospheric Fluorene Concentration at High School Site

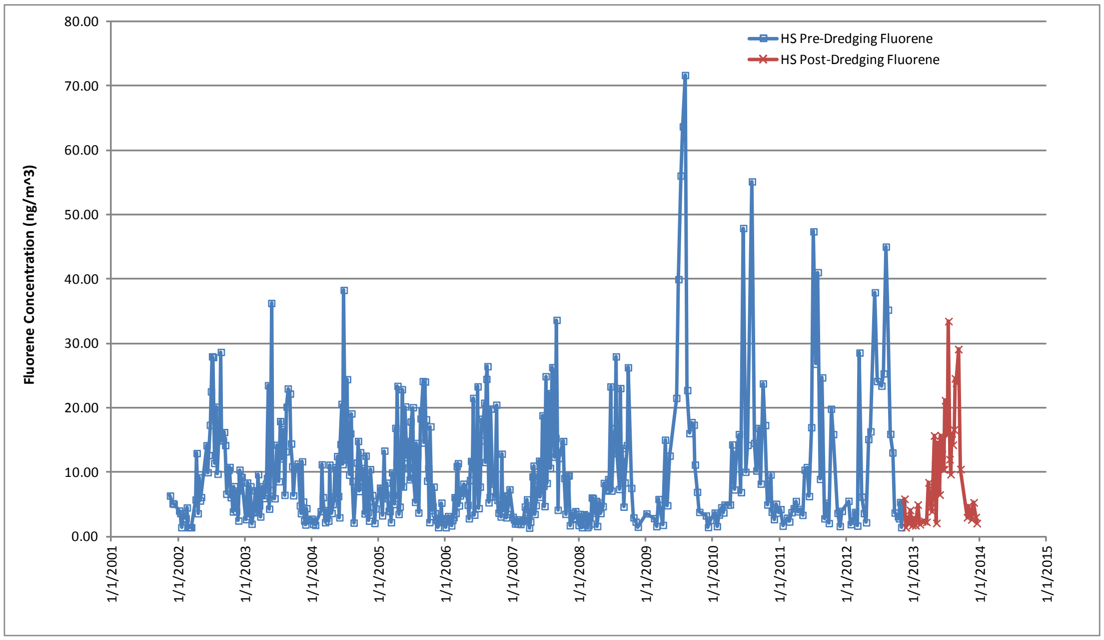

Figure 11a. Atmospheric Naphthalene Concentration at IHC CDF Site

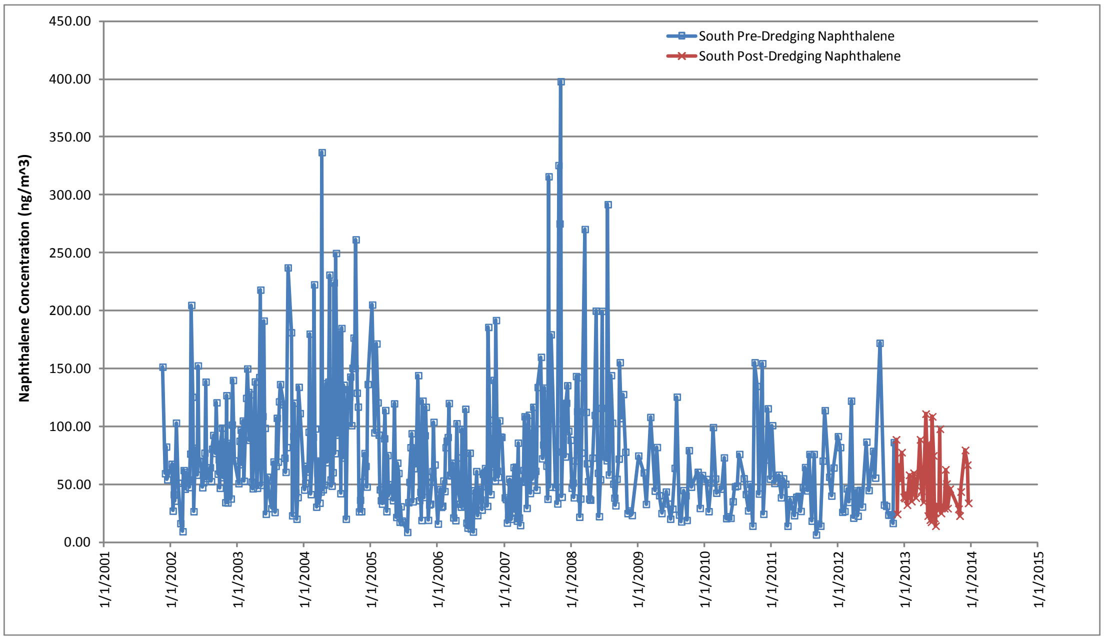

Figure 11b. Atmospheric Naphthalene Concentration at High School Site

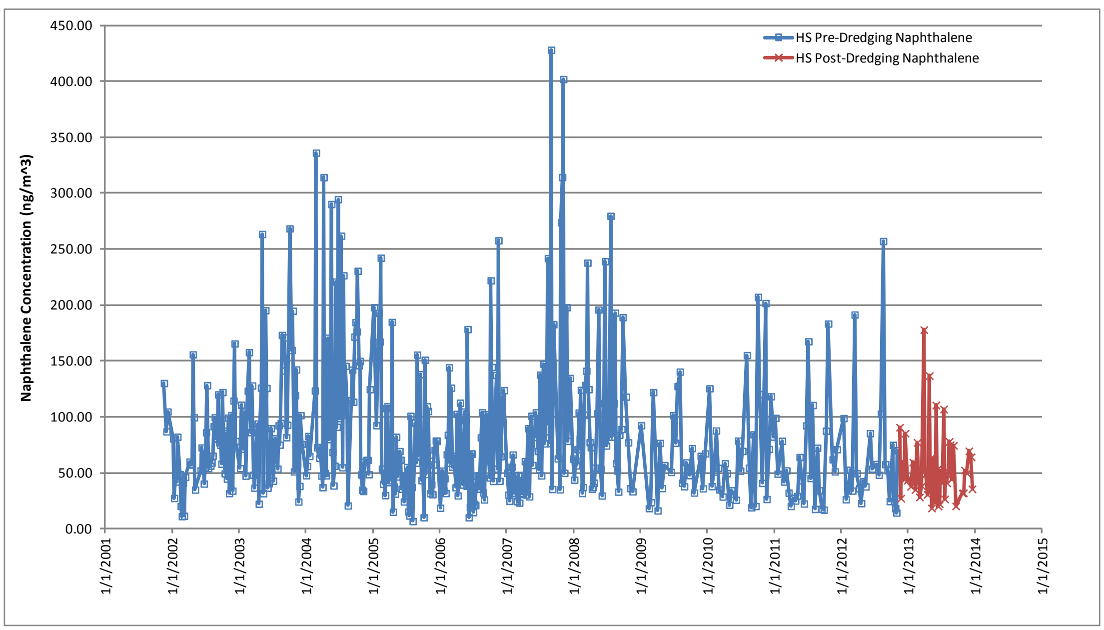

Figure 12a. Atmospheric Phenanthrene Concentration at IHC CDF Site

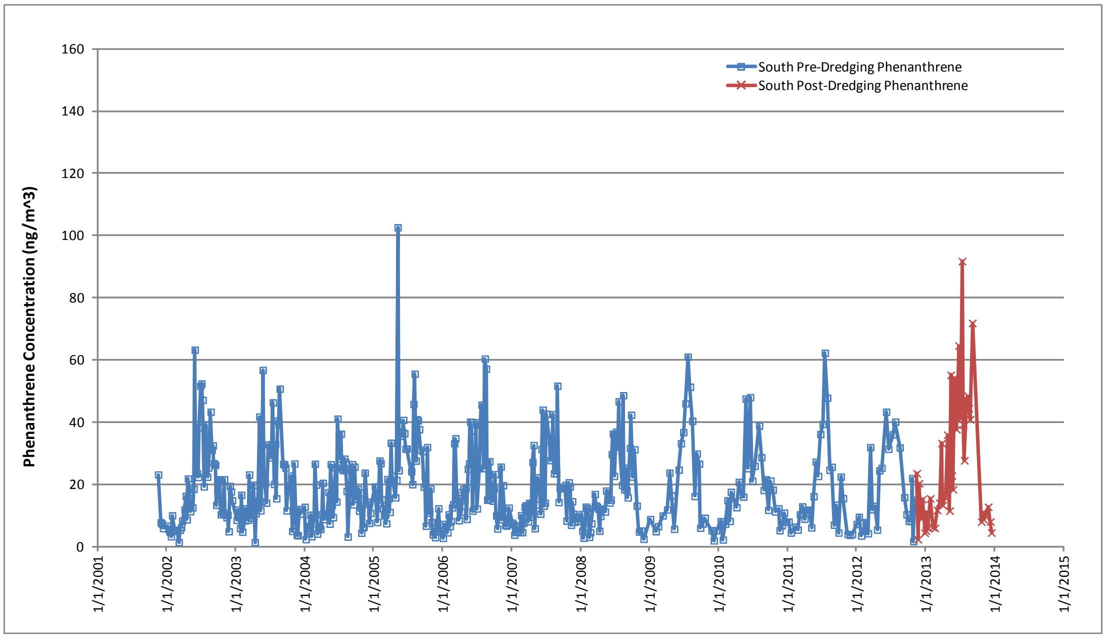

Figure 12b. Atmospheric Phenanthrene Concentration at High School Site

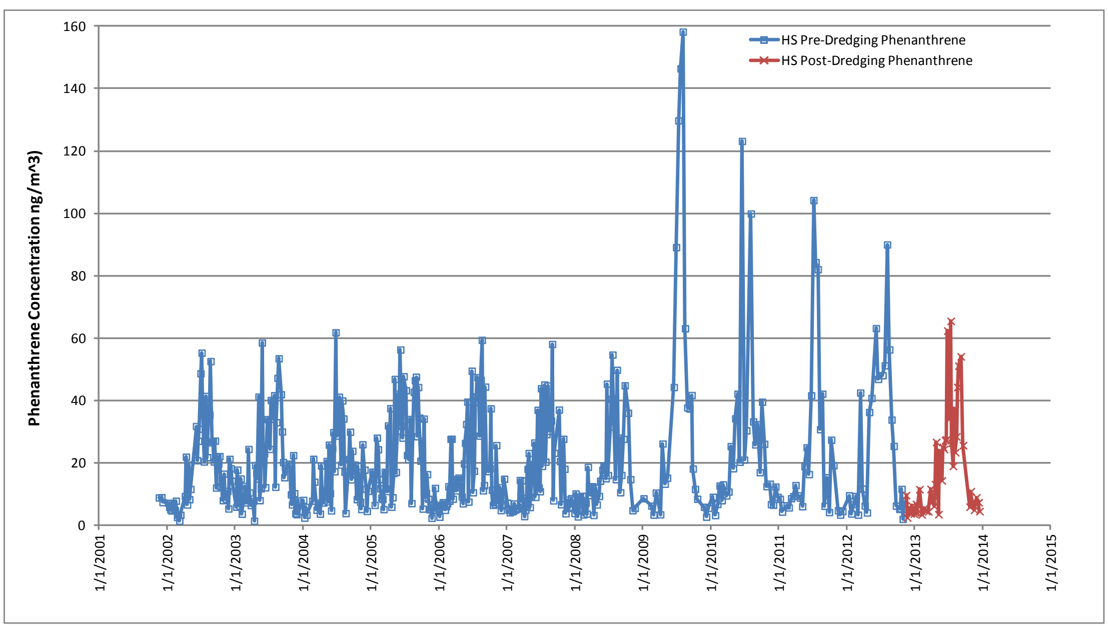

Figure 13a. Atmospheric Pyrene Concentration at IHC CDF Site

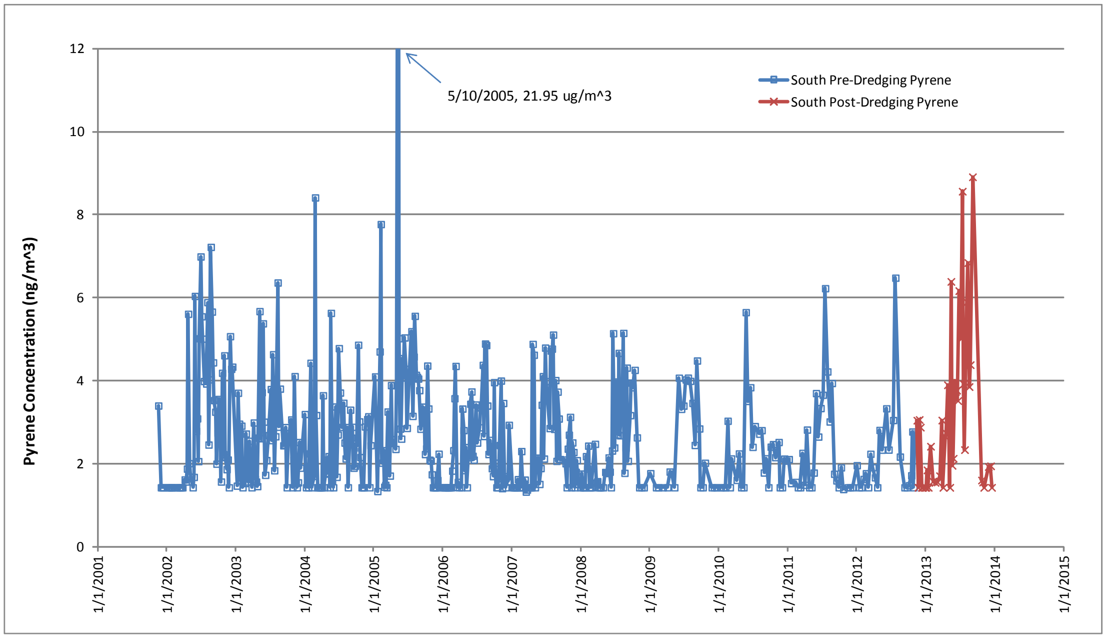

Figure 13b. Atmospheric Pyrene Concentration at High School Site

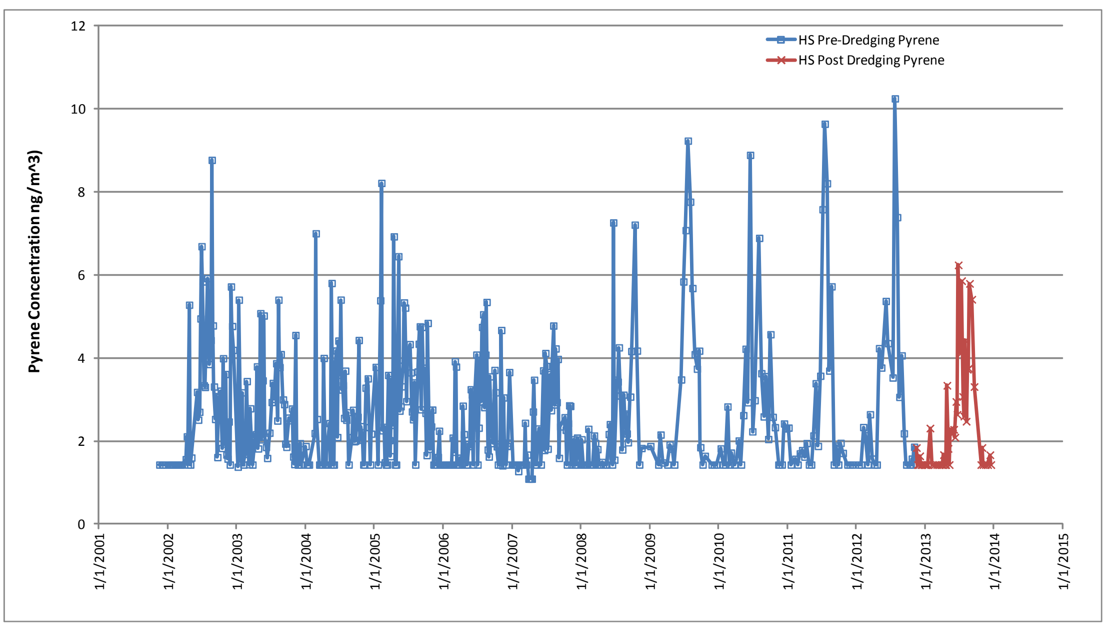

Figure 14a. Atmospheric Benzene Concentration at IHC CDF Site

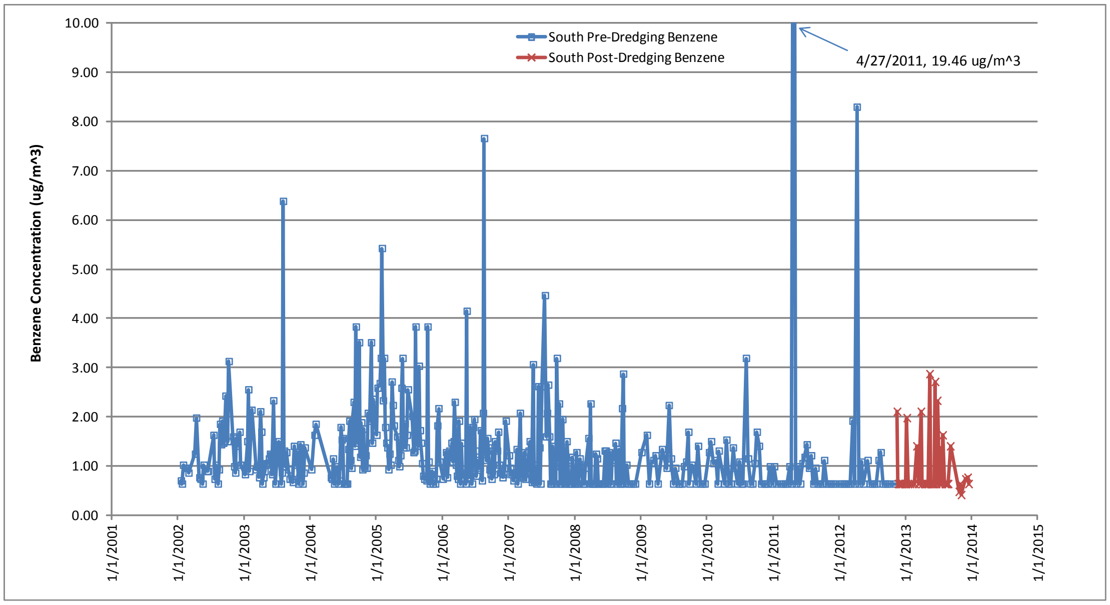

Figure 14b. Atmospheric Benzene Concentration at High School Site

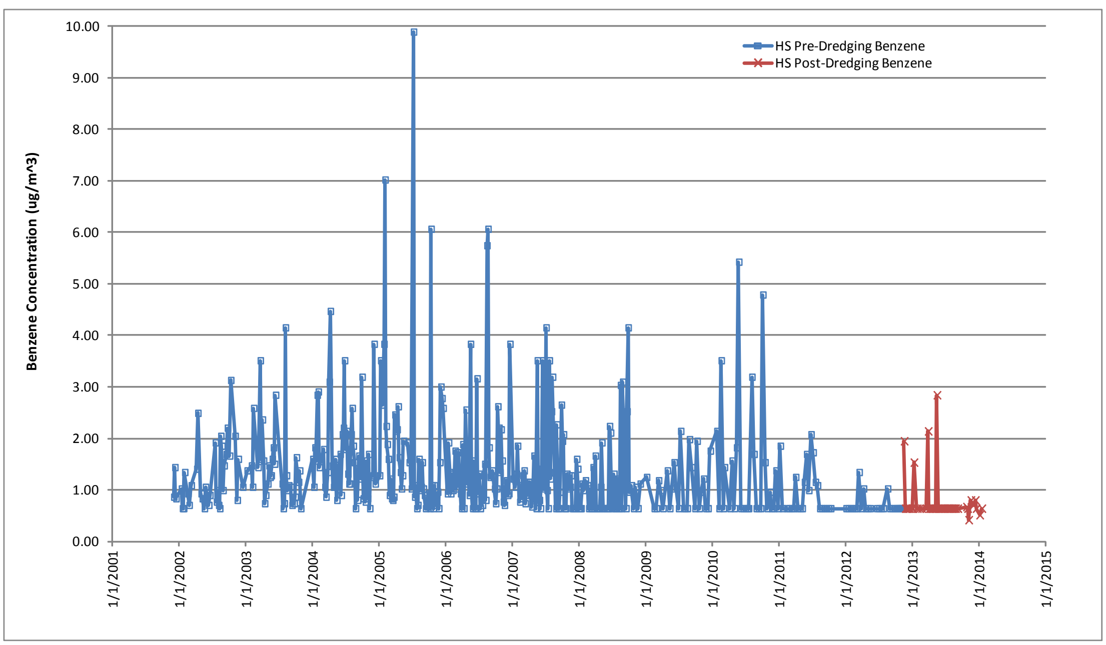

Figure 15a. Atmospheric Toluene Concentration at IHC CDF Site

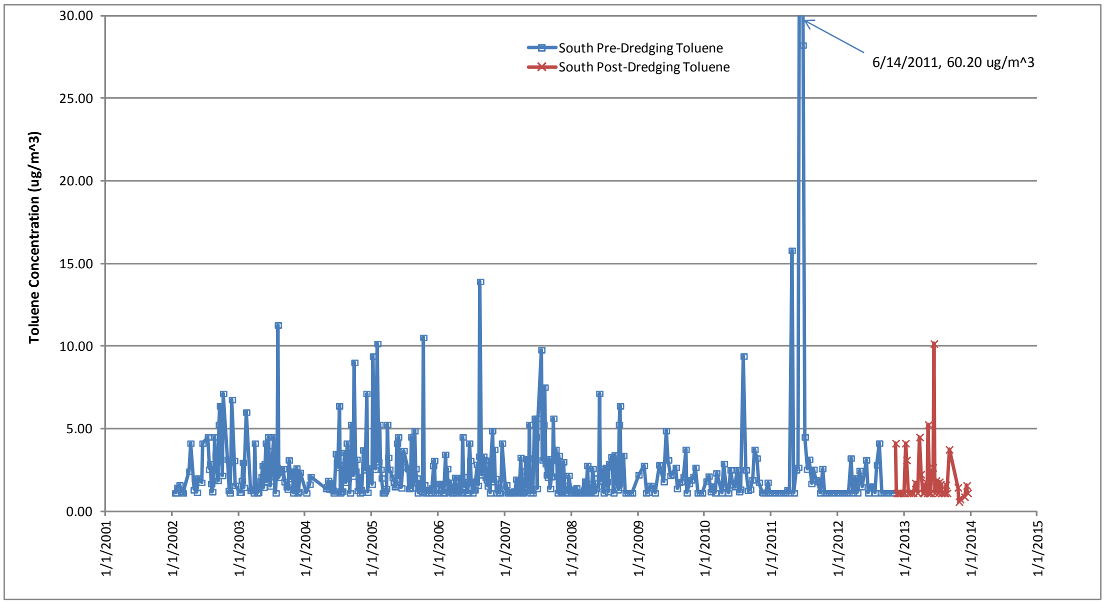

Figure 15b. Atmospheric Toluene Concentration at High School Site

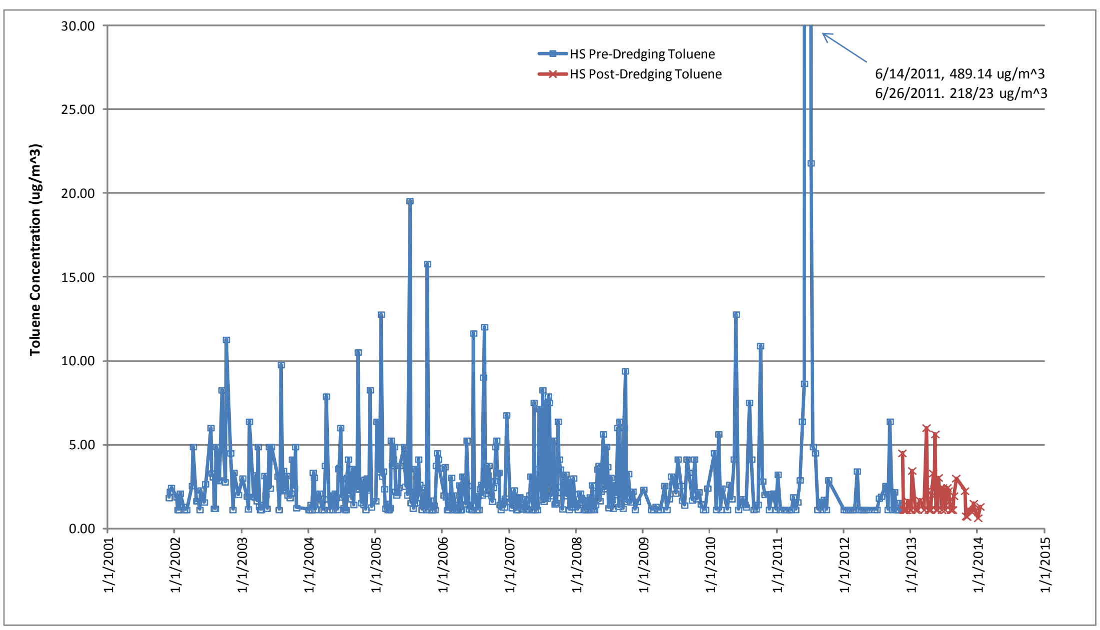

Figure 16a. Atmospheric Total Suspended Particulate Concentration at IHC CDF Site

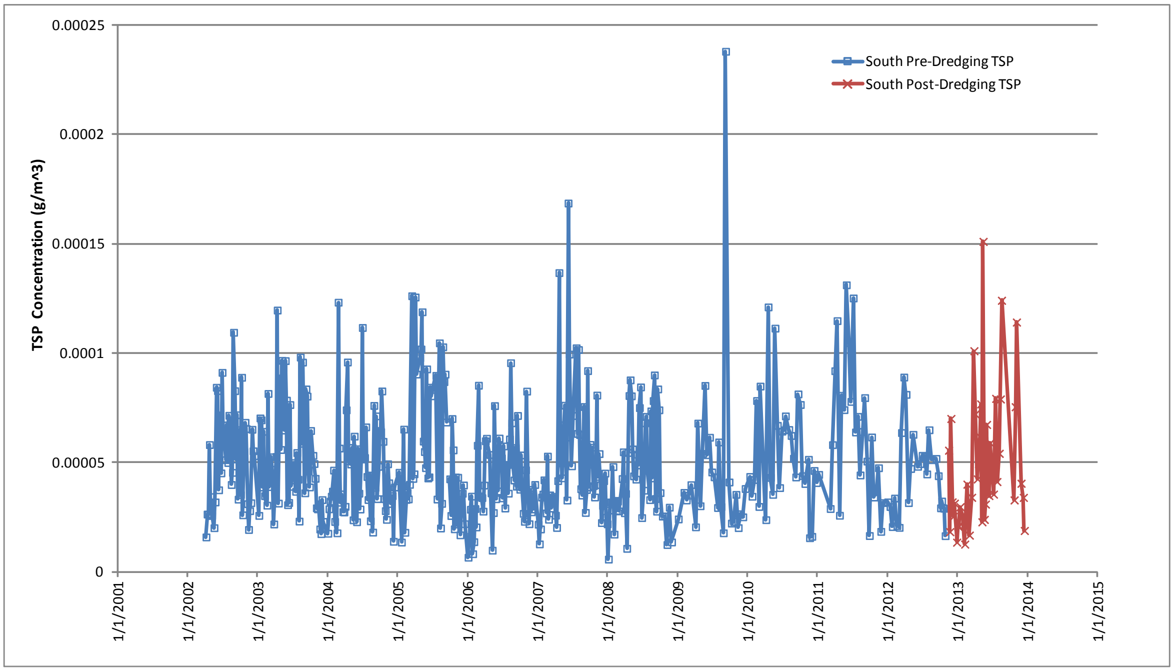

Figure 16b. Atmospheric Total Suspended Particulate Concentration at High School Sit

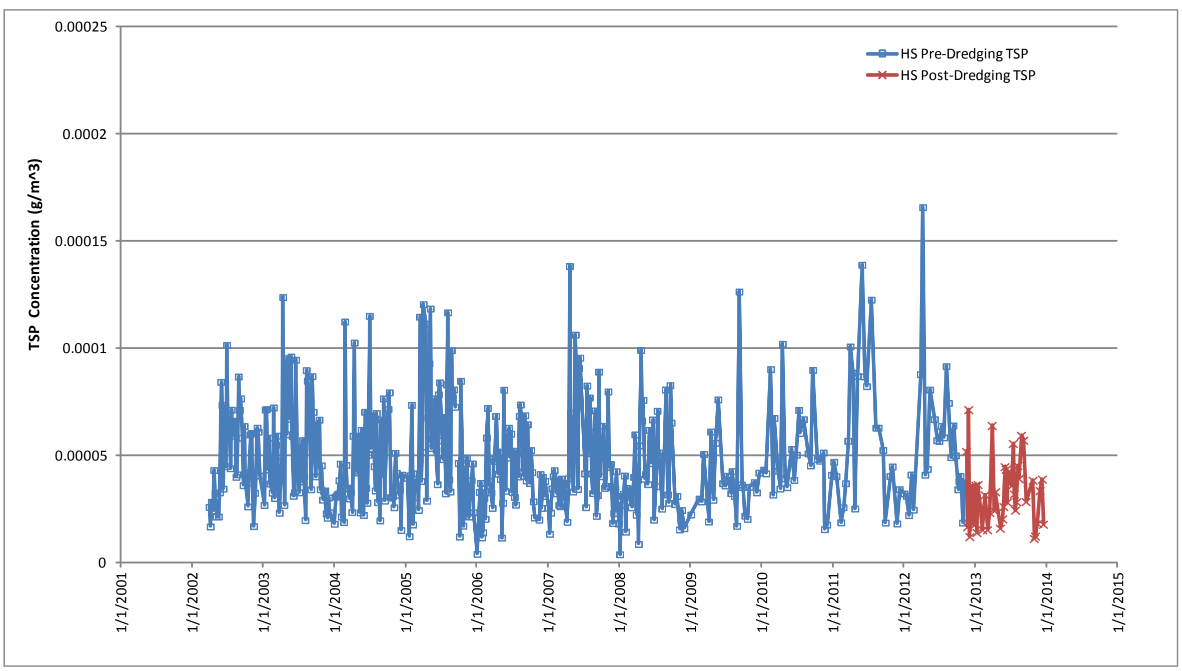

Figure 17a. Atmospheric Aluminum Concentration at IHC CDF Site

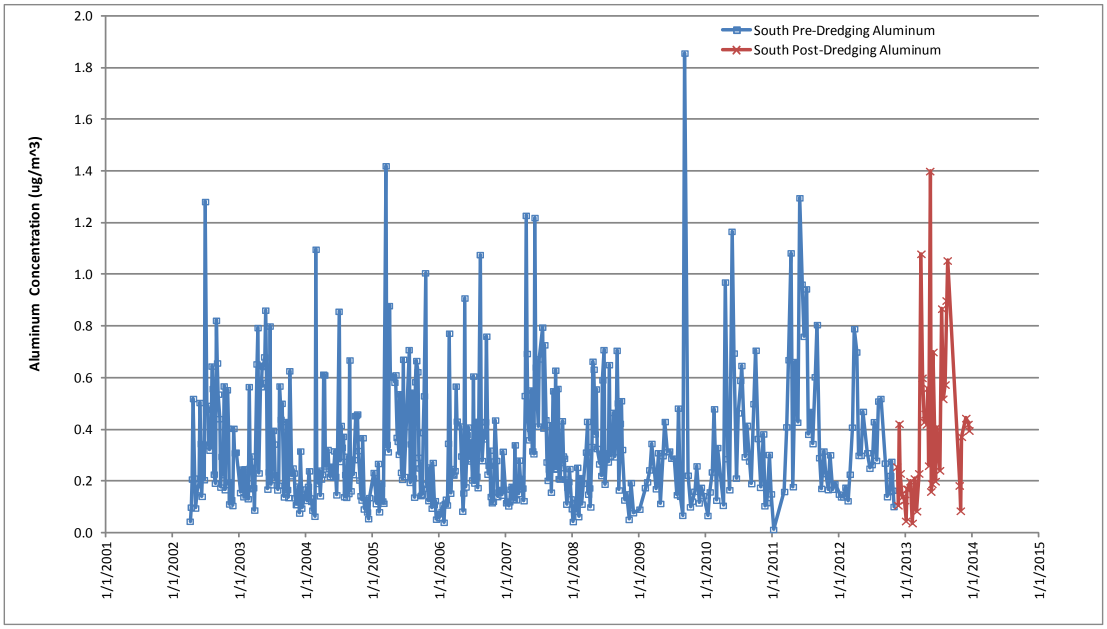

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Figure 17b. Atmospheric Aluminum Concentration at High School Site

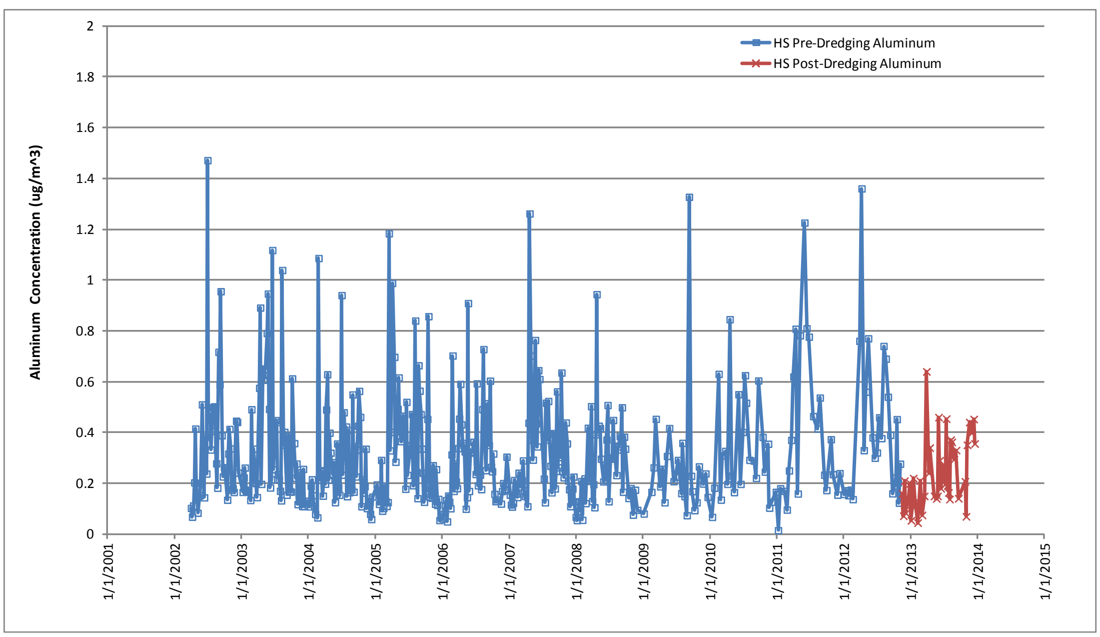

Figure 18a. Atmospheric Arsenic Concentration at IHC CDF Site

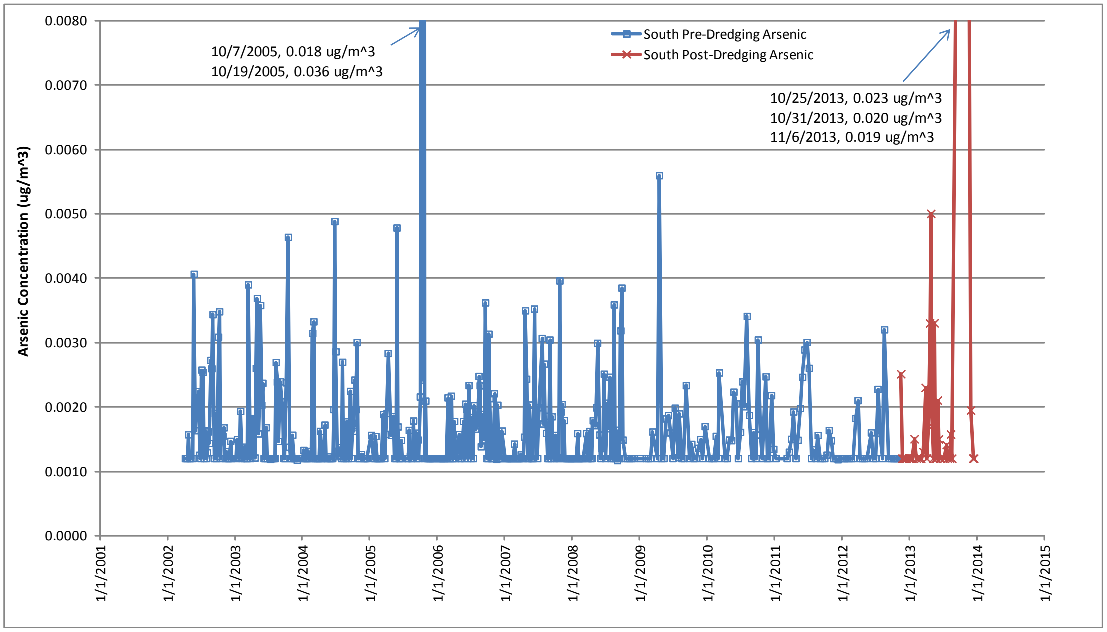

Figure 18b. Atmospheric Arsenic Concentration at High School Site

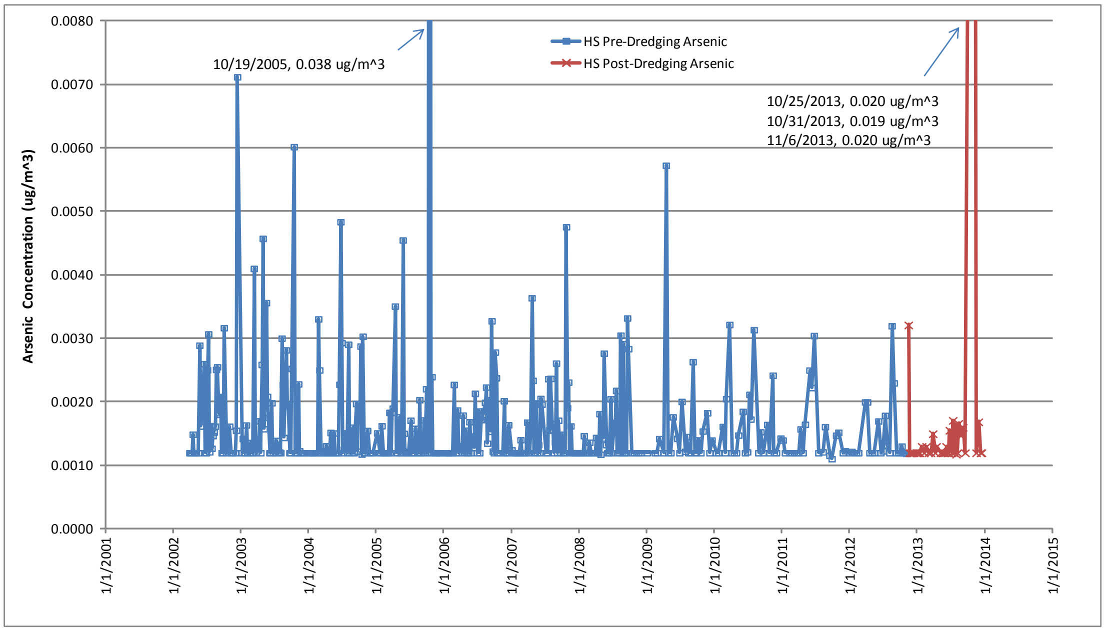

Figure 19a. Atmospheric Barium Concentration at IHC CDF Site

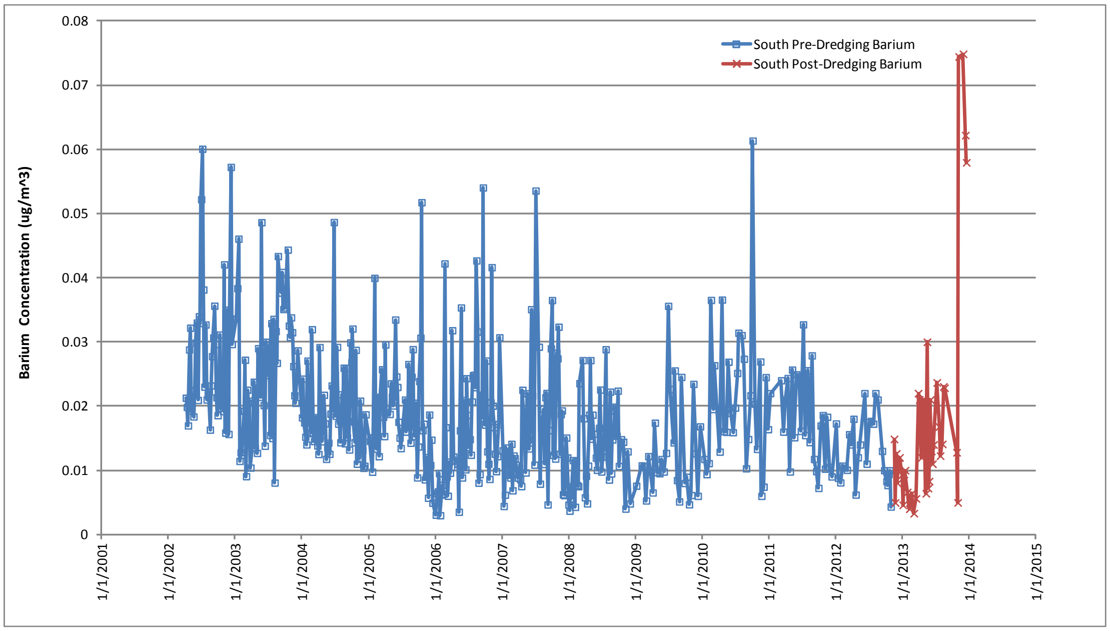

Figure 19b. Atmospheric Barium Concentration at High School Site

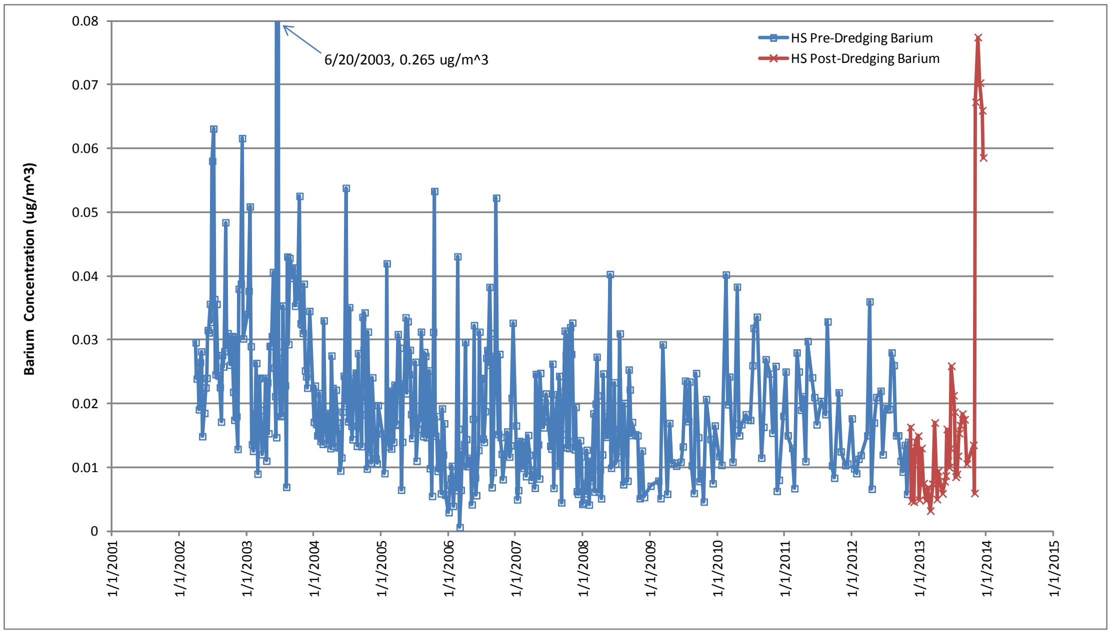

Figure 20a. Atmospheric Chromium Concentration at IHC CDF Site

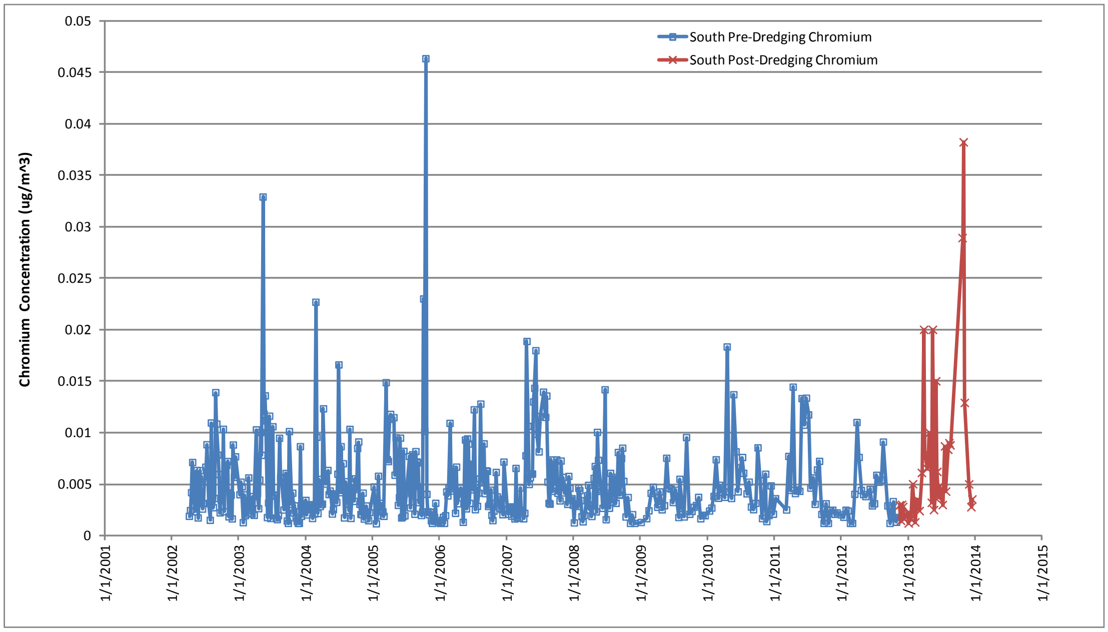

Figure 20b. Atmospheric Chromium Concentration at High School Site

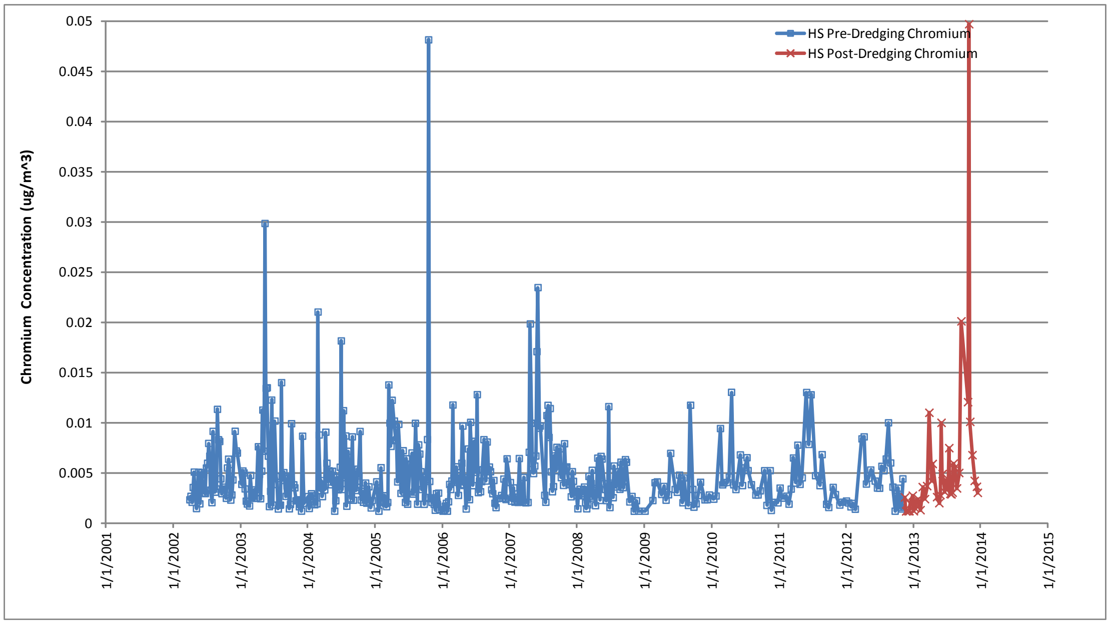

Figure 21a. Atmospheric Cobalt Concentration at IHC CDF Site

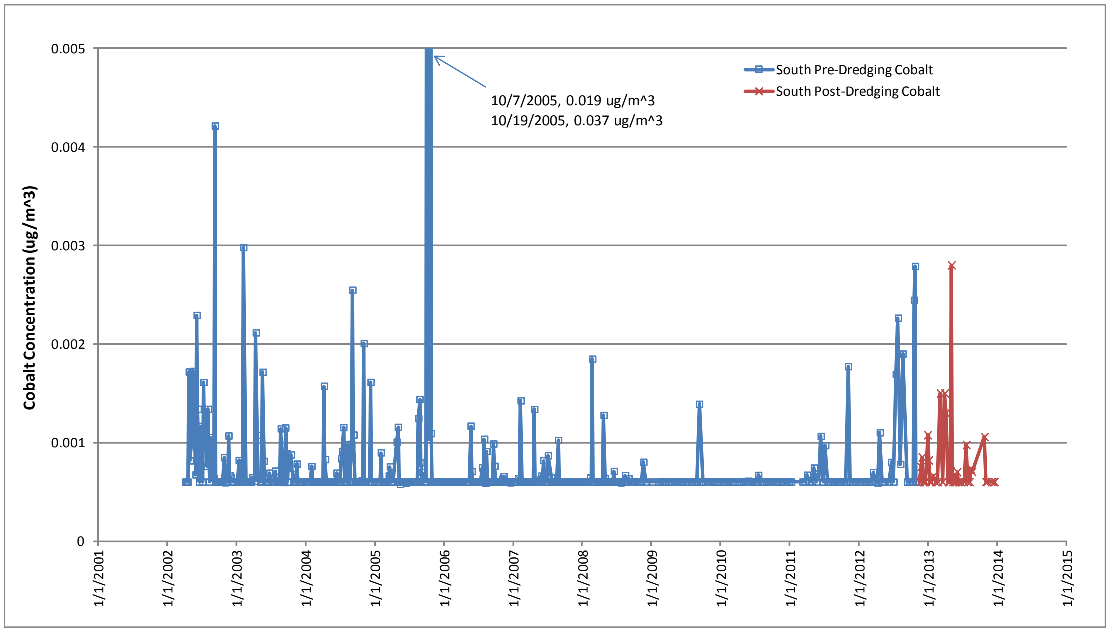

Figure 21b. Atmospheric Cobalt Concentration at High School Site

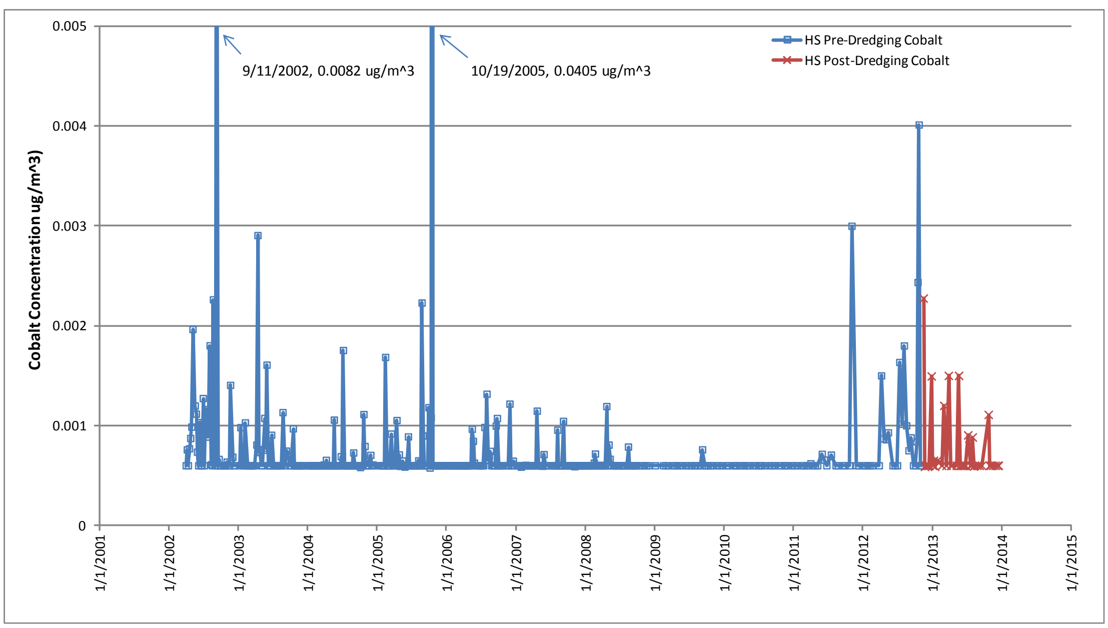

Figure 22a. Atmospheric Copper Concentration at IHC CDF Site

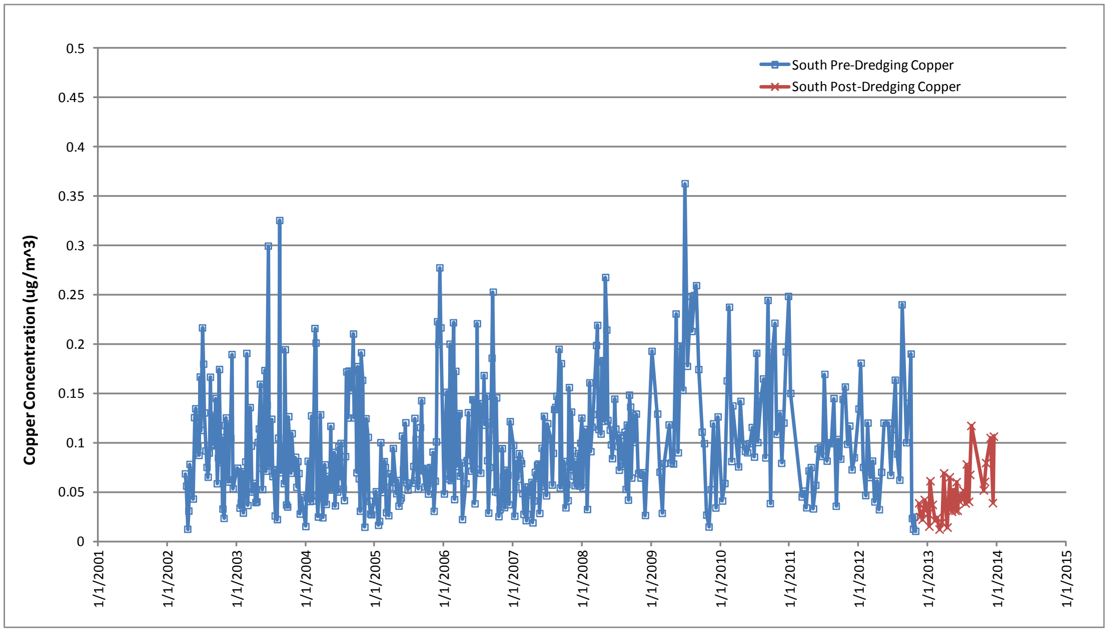

Figure 22b. Atmospheric Copper Concentration at High School Site

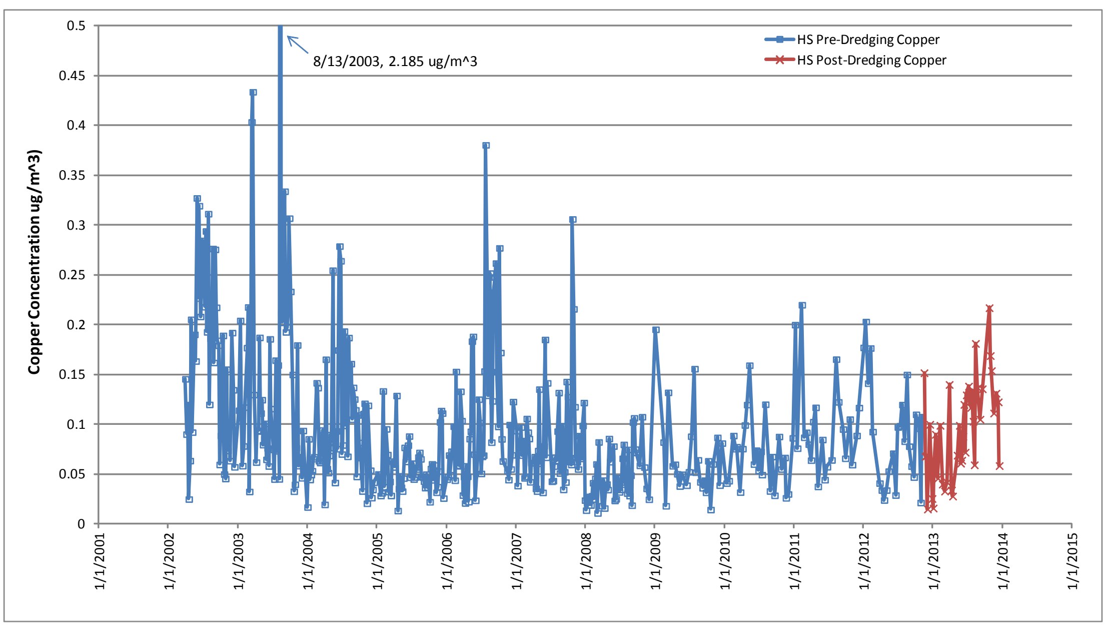

Figure 23a. Atmospheric Iron Concentration at IHC CDF Site

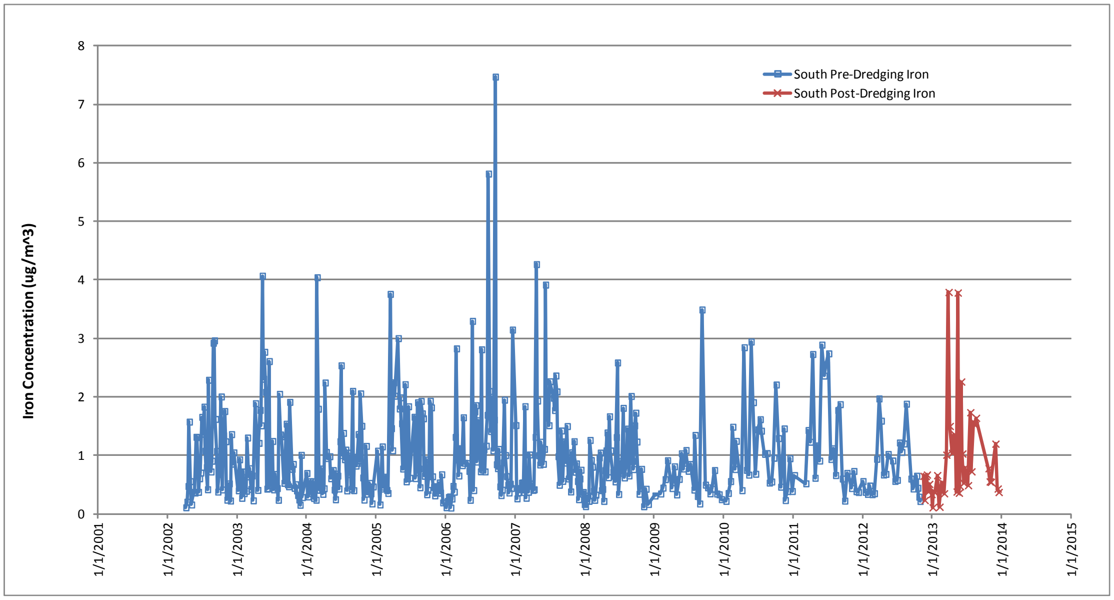

Figure 23b. Atmospheric Iron Concentration at High School Site

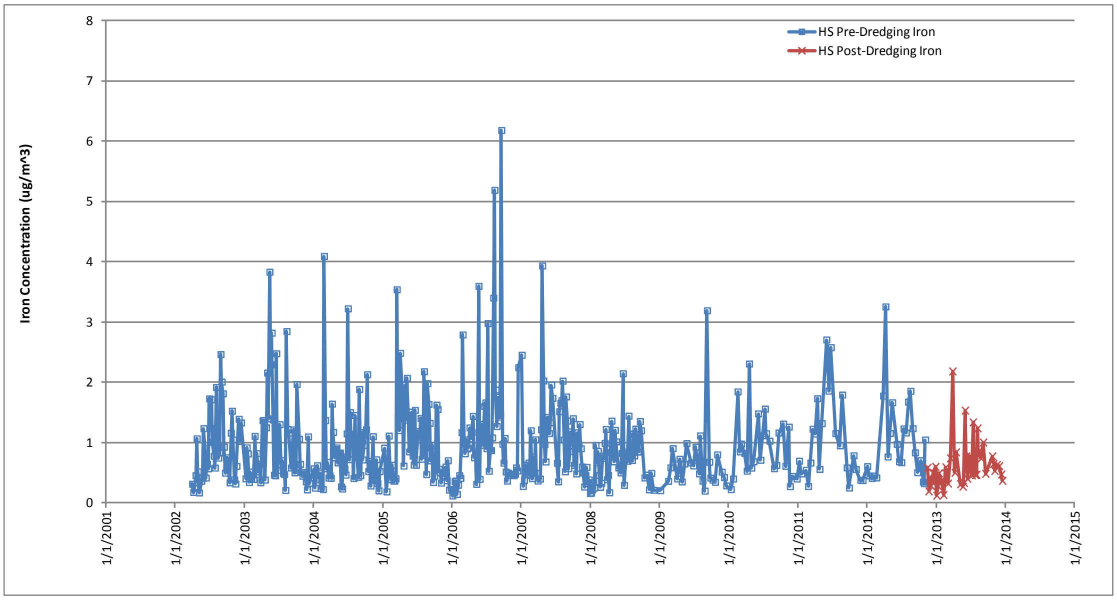

Figure 24a. Atmospheric Lead Concentration at IHC CDF Site

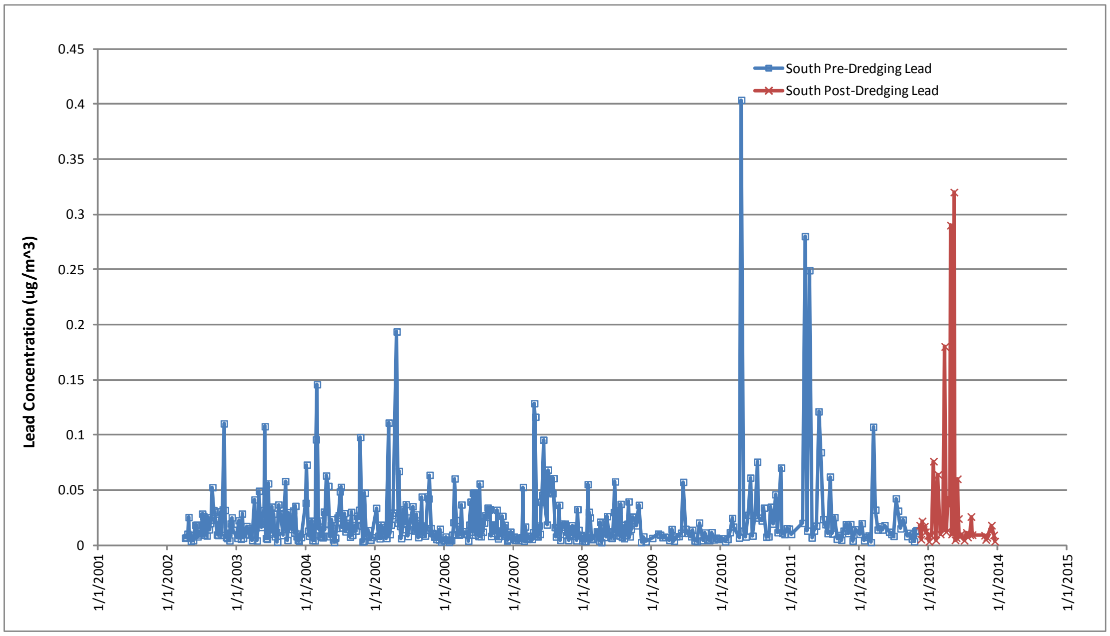

Figure 24b. Atmospheric Lead Concentration at High School Site

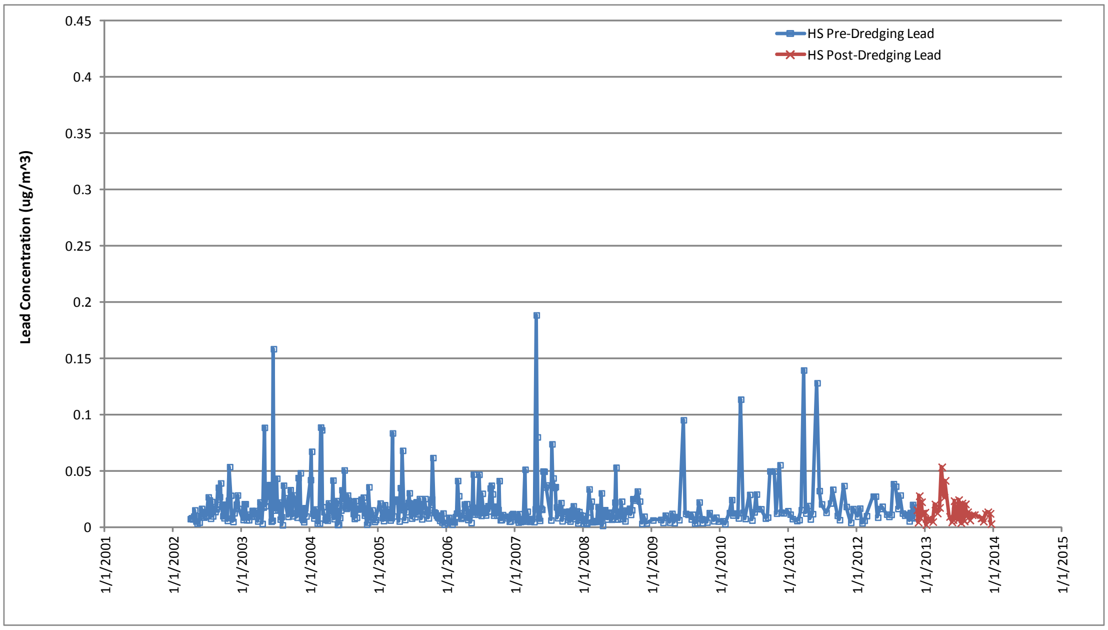

Figure 25a. Atmospheric Manganese Concentration at IHC CDF Site

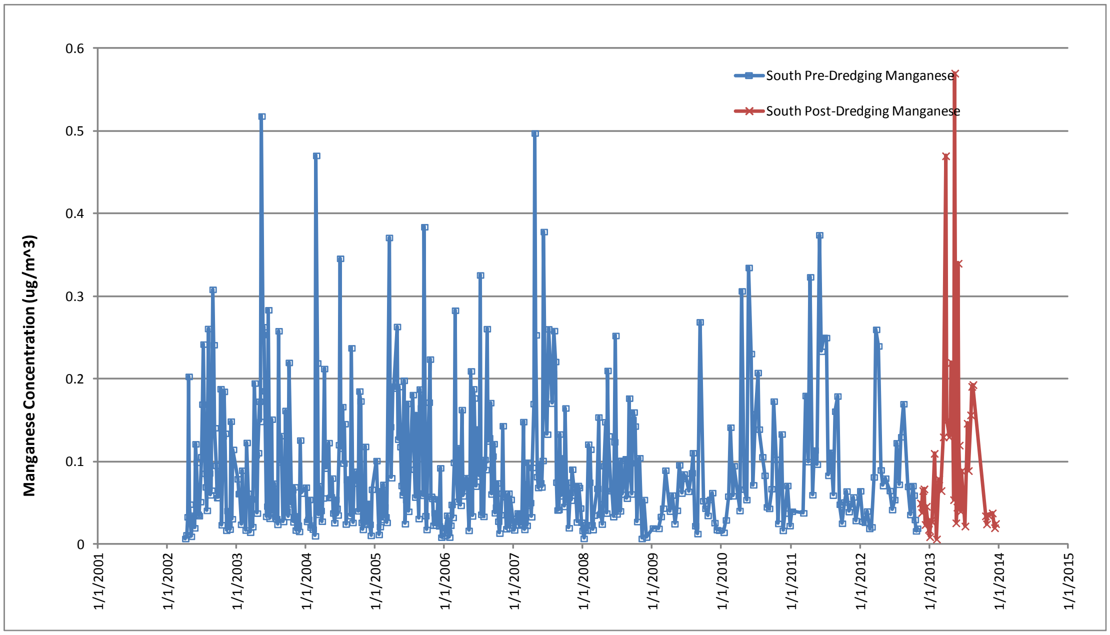

Figure 25b. Atmospheric Manganese Concentration at High School Site

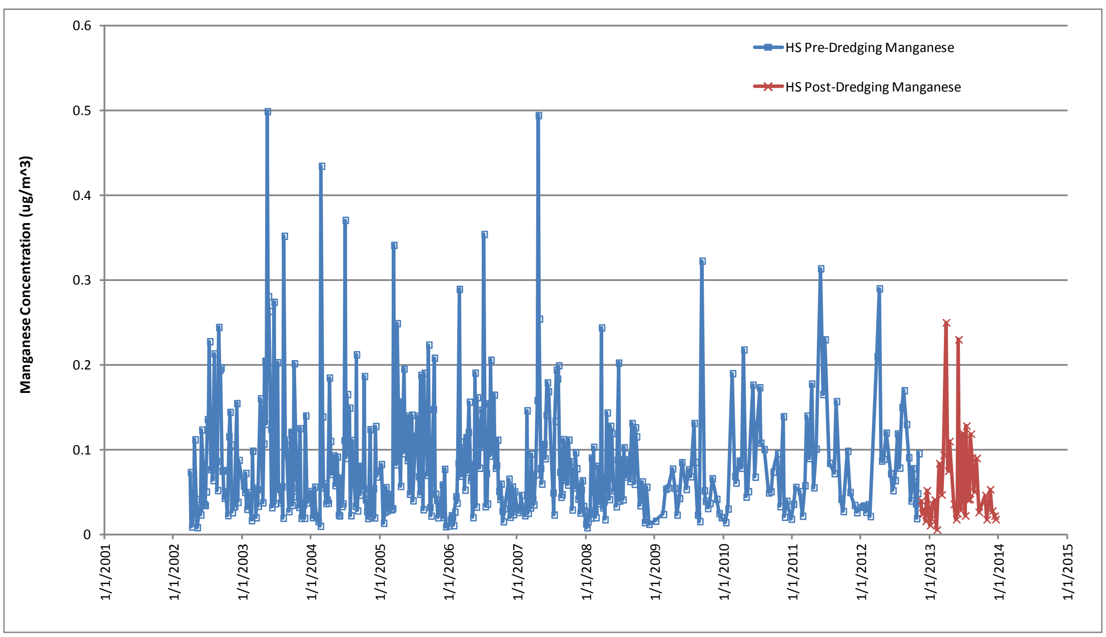

Figure 26a. Atmospheric Nickel Concentration at IHC CDF Site

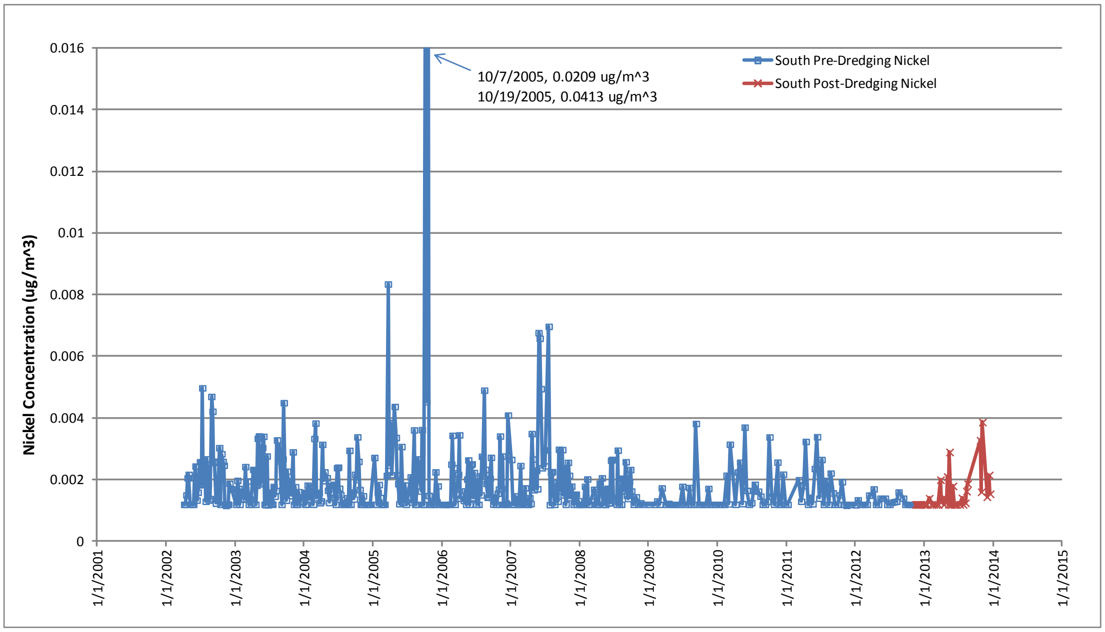

Figure 26b. Atmospheric Nickel Concentration at High School Site

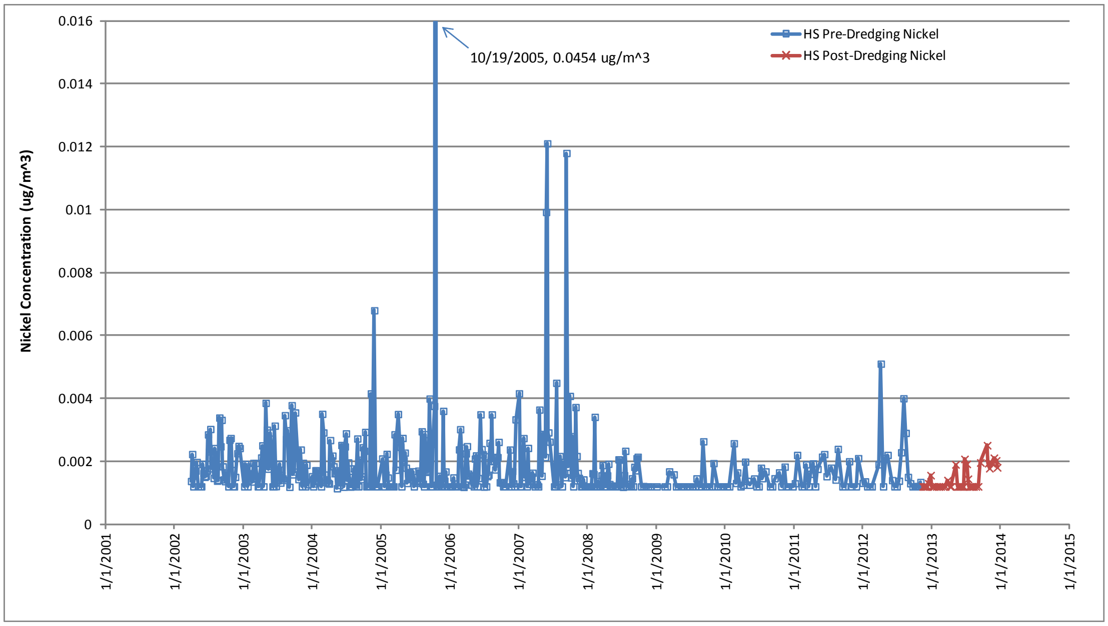

Figure 27a. Atmospheric Selenium Concentration at IHC CDF Site

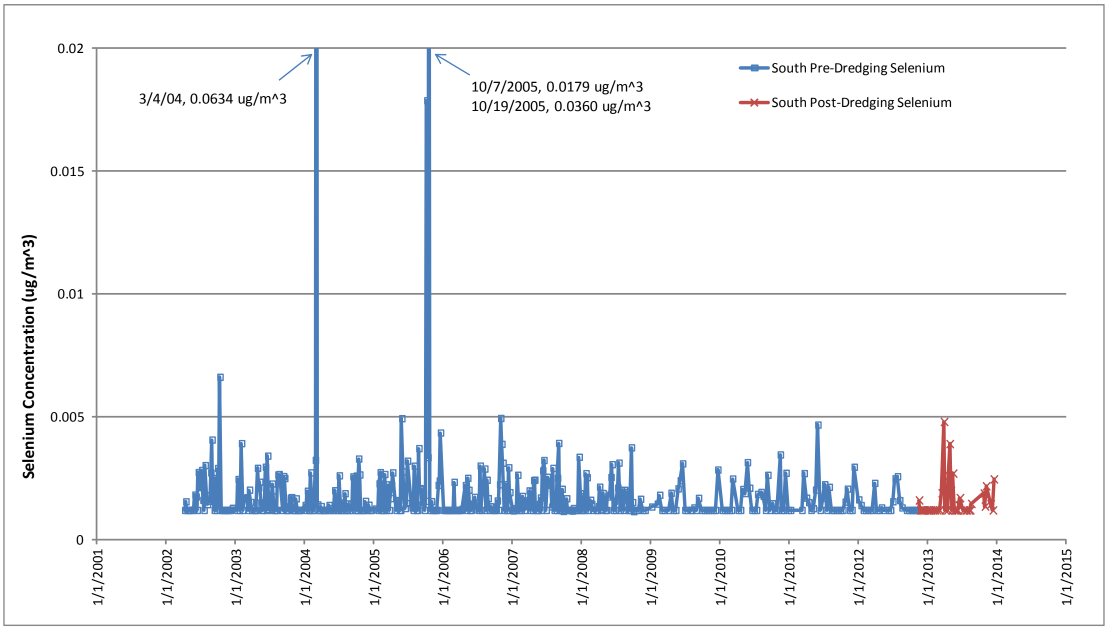

Figure 27b. Atmospheric Selenium Concentration at High School Site

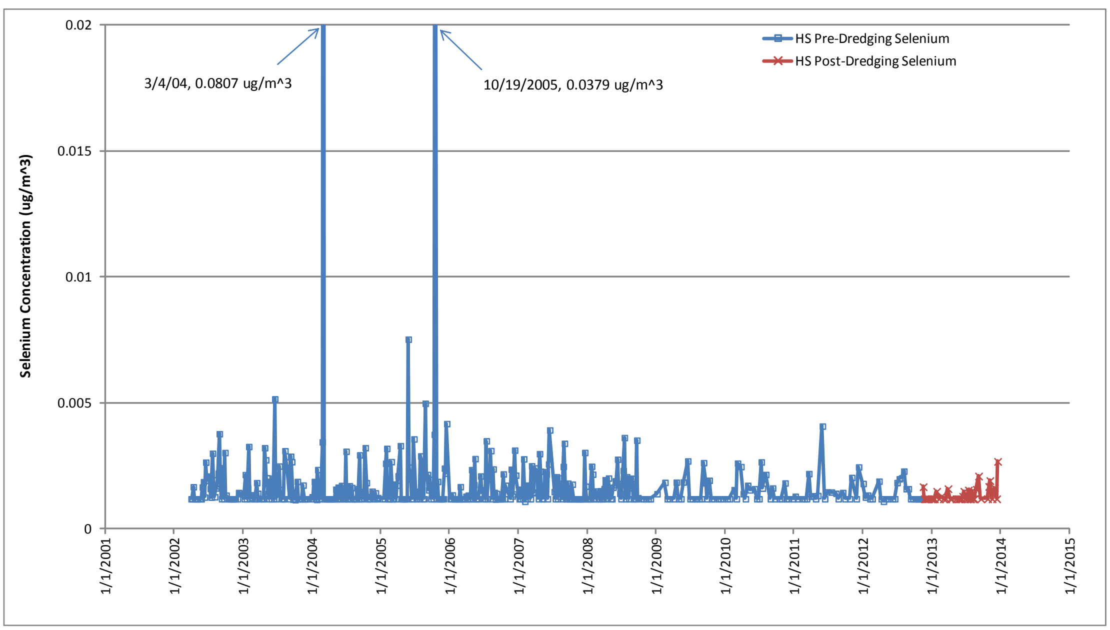

Figure 28a. Atmospheric Zinc Concentration at IHC CDF Site

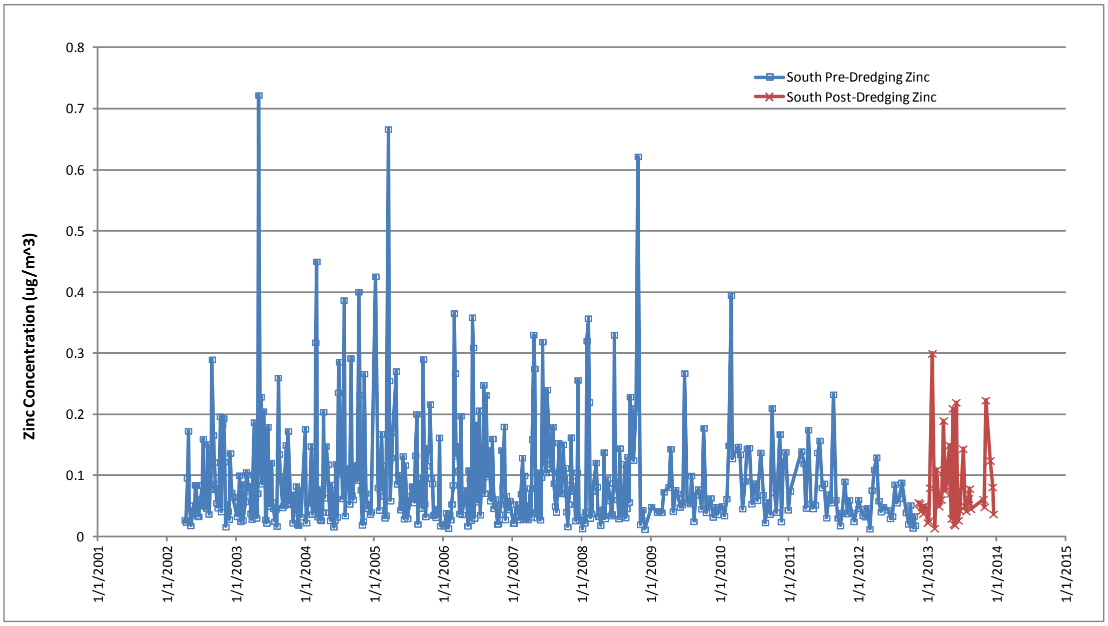

Figure 28b. Atmospheric Zinc Concentration at High School Site