INDIANA HARBOR AND CANAL

2019 AIR MONITORING DATA ANALYSIS

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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). Post-dredging period (late 2012 through 2013) air monitoring results are first reported in USACE (2014). Table A presents a summary of the air monitoring program at the IHC CDF through 2019.

Table A: IHC CDF Air Monitoring Program Covered in this Report

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 May – July 2014 May – Aug 2015 Sep – Nov 2016	Dredging and discharge of dredged material to CDF	HS and 4 CDF on-site points	6 day monitoring frequency

	Oct – Nov 2017 Jun – Sep 2018 Late Jun 2019 – Oct 2019			
No Dredging/ Material in CDF	Jan – Mar 2013 Sep 2013 – April 2014 Aug 2014 – April 2015 Sep 2015 – Aug 2016 Mid Nov 16 – Sep 2017 Dec 2017 – May 2018 Oct 2018 – Jun 2019 Late Oct 2019 – Dec 2019	Idle periods between dredging events; CDF is a quiescent pond	HS and 4 CDF on-site points	12 day monitoring frequency

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 (see list of references for report titles and dates).

The purpose of this annual report is to follow up the last annual report that presents statistical analysis of 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 September2019. By comparing post-dredging data with pre-dredging data from 2010 through October 2012, this report aims to evaluate 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 – 2019 Dredging and Dredged Material Disposal

Post-dredging air monitoring data presented in this report span eight dredging events at the IHC corresponding to fall 2012, spring/summer 2013, late spring/early summer 2014, late spring/summer 2015, fall 2016, fall 2017, summer/early fall 2018, and summer 2019.

The fall 2012 IHC dredging commenced on October 23, 2012 with a limited amount of material removed for equipment placement. Dredging included 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 included 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. Dredged material was disposed to the east and west cells of the CDF.

The 2014 dredging began on May 23, 2014 and continued through July 10, 2014. The total volume of dredged material removed from the IHC in 2014 is 210,099 cubic yards. Sediment was disposed of continuously into the CDF except for one interruption between June 4 and June 10. All 2014 dredged material was disposed in the CDF west cell. Shut down of the 2014 dredging operation started July 10, 2014, and no additional dredging was performed the rest of the year.

The 2015 dredging/sediment disposal to the CDF began on May 2, 2015 and continued through August 19, 2015. The total volume of dredged material removed from the IHC in 2015 is 323,202 cubic yards. Sediment was disposed of continuously into the CDF except for three interruptions between May 23 and 27, July 1 and 9, and August 1 and 6. All of the 2015 dredged material was disposed in the CDF east cell. Shut down of the 2015 dredging operation started August 19, 2015, and no additional dredging was performed the rest of the year.

The 2016 dredging/sediment disposal to the CDF began on September 12, 2016 and continued through November 9, 2016. The total volume of dredged material removed from the IHC in 2015 is 226,821 cubic yards. Sediment was disposed of continuously into the CDF except for three interruptions between October 18 and 23, October 25 and 26, and October 28 and 31. All of the 2016 dredged material was disposed in the CDF west cell. Shut down of the 2016 dredging operation started November 9, 2016, and no additional dredging was performed the rest of the year.

The 2017 dredging/sediment disposal to the CDF began on October 1, 2017 and continued through December 2, 2017. The total volume of dredged material removed from the IHC in 2017 is 89,054 cubic yards. Sediment was disposed continuously into the CDF except for two interruptions between October 20 and 25, and November 21 to 27. All of the 2017 dredged material was disposed in the CDF west cell. Shut down of the 2017 dredging operation started December 2, 2017, and no additional dredging was performed the rest of the year.

The 2018 dredging/sediment disposal to the CDF began on June 1, 2018 and continued through September 22, 2018. The total volume of dredged material removed from the IHC in 2018 is 157,061 cubic yards. Sediment was disposed continuously into the CDF except for three interruptions between July 4 and July 10, August 10 to August 13, and September 1 to September 4. All of the 2018 dredged material was disposed in the CDF east cell. Shut down of the 2018 dredging operation started September 22, 2018, and no additional dredging was performed the rest of the year.

The 2019 dredging/sediment disposal to the CDF began on June 27, 2019 and continued through October 22, 2019. The total volume of dredged material removed from the IHC in 2019 is 167,845 cubic yards. Sediment was disposed continuously into the CDF except for four interruptions between July 4 and July 7, July 19 and July 22, August 3 and 13, and August 29 to September 22. All of the 2019 dredged material was disposed in the CDF east cell. Shut down of the 2019 dredging operation started October 22, 2019, and no additional dredging was performed the rest of the year. TSCA material was dredged in 2019 prior to the long break between August 29 and September 22. This report covers data collected through the TSCA dredging period (through September 12, 2019).

In summary, approximately 1,571,000 cubic yards of dredged material was placed into the two cells of the CDF from 2012 through 2019. Approximately 729,000 cubic yards was placed into the CDF west cell and 842,000 cubic yards into the CDF east cell. 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 was 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 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. Figure 0 shows the location of the air monitors and meteorological stations (during current and pre-dredging monitoring periods).

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.

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 (South, East, North, and West) 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 the 2012 through 2019 dredging events and through approximately one month before dredging started and one month after sediment disposal ended for the events. Outside of these periods, air monitoring samples were collected on a 12-day 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 included in the statistical analysis are listed in Table B.

Table B: Air Monitoring Analytes Included in 2019 Annual Report

PCBs (2019 Analysis included in USACE 2020)	**PAHs**
Congener 8 (PCB 8) Congener 15 (PCB 15) Congener 18 (PCB 18) Congener 28 (PCB 28) Congener 31 (PCB 31)	Acenaphthene (Ace) Acenaphthylene (Acy) Fluoranthene (Fla) Fluorene (Flo) Naphthalene (Nap) Phenanthrene (Phe) Pyrene (Pyr)
VOCs Benzene (Benz) Toluene (Tol)	**Total Suspended Particulates** (TSP) **Metals** Aluminum (Al) Arsenic (As) Barium (Ba) Chromium (Cr) Copper (Cu) Iron (Fe) Lead (Pb) Manganese (Mn) Nickel (Ni) Selenium (Se) Zinc (Zn)

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 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. The analytical laboratory was changed in September 2013, and there were some changes in reporting methods and limits at that time.

Data Organization and Preparation

Pre-dredging data

The ambient air monitoring data can be 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 October 2012 back to the start of 2010, when construction activities at the CDF were substantially complete. The entire monitoring data set collected from 2001 to October 2012 was initially considered as the pre-dredging data set. However, trend analyses performed over this extended period of time indicate statistically significant evidence of decreasing or increasing trends for several parameters. The changing trends in ambient air levels of these 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 October 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 prior to the start of sediment disposal to the CDF. Thus the data collected earlier are not used as the main basis for this evaluation.

As discussed previously, the pre-dredging south monitoring station 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 including a new south station monitor that was located on the north or 'CDF' side of the canal. Therefore, it is worthy to note that pre- and post-dredging "on-site" conditions are represented by monitors that are in different locations relative to the canal and other potential sources, albeit with the same naming convention (south station) and within relatively close proximity (the new south monitor is less than 1000 feet away from the old south monitor site).

Post-dredging data

Post-dredging data collected after sediment disposal to the CDF started in November 2012 to September 2019 were further divided into active Discharge and idle Quiescent Pond periods, with Active Discharge signifying periods when dredging and dredged material disposal are occurring, and Quiescent Pond signifying shutdown periods with no dredging or disposal but the presence of the ponded CDF. See Table A for active dredging and quiescent pond dates. In this report Active and Idle refers to the sediment disposal activities during the post-dredging period, not the construction activities that occurred prior to 2010 and were reported on in previous reports.

Temperature correction

Atmospheric concentrations of semi-volatile and volatile compounds (i.e. PAHs, PCBs, and VOCs) depend on temperature because volatilization from sources like soil, sediment, and water bodies is a temperature-controlled process. The Clausius-Clapeyron equation was used to model temperature-dependence of the measured data. When a significant negative trend was observed for PAH, PCB, and VOC partial pressures with the inverse of ambient temperature, regression parameters were used to 'temperature-correct' the data to a reference temperature of 15 deg C. Removing this temperature-dependence allows greater discernment of underlying trends in the data. PAH, PCB and VOC data were temperature-corrected for the entire study period (January 2010 through September 2019). Data analyses were performed using temperature-corrected data sets, except as noted herein.

Non-detect data

Previous years' statistical analyses assigned one value (typically median reporting limit value for all data) for non-detect results for each parameter. The detection/reporting limits have changed over the 15 years of data collection due to various reasons: change in laboratories, change in reporting procedures, and/or change in analytical procedures. In addition, because the air volume drawn through the samplers varies from sample to sample, the concentration detection limit which is calculated by dividing the mass of chemical (lowest mass that can be detected is the mass detection limit) by the air volume also varies from sample to sample.

Starting with the 2016 analysis, a new statistical analytical method is used for the data analysis which allows non-detect data with different reporting limits. The current data analysis was performed using the USEPA ProUCL software that can analyze data sets with multiple detection limits. All data, including pre-2016 data, were presented with the actual detection/reporting limit provided by the laboratory in the data analyses.

Metals Filter Blank Contamination

An issue arose when there was a change of laboratories for the air data analysis in Fall 2013. The new laboratory used blank filters for air sample collection (for metals and total suspended particulates analysis) that were discovered to be have detectable concentrations of several metals. It should be noted that some metals contamination existed in the blank filters used by the previous laboratory (prior to Fall 2013). However, the metals in the blank filters used by the previous laboratory were either detected at low concentrations compared to the environmental sample metals concentrations and/or were not detected above the respective metal detection limits. Therefore, no correction was performed on metals data previous to Fall 2013.

To address the filter blank contamination issue for metals data after Fall 2013, USGS developed a procedure to adjust the measured concentrations of selected metals in the environmental samples based on the masses measured on the method filter blanks. The data adjustment consists of subtracting metals concentrations detected on blanks from the environmental samples collected. This procedure is described in further details in Appendix A.

Additional data groups

Data from the five (high school and on-site) sampling locations were analyzed as one data set as well as by individual monitor to assess potential effect of localized CDF activities on the on-site air monitors plus the high school location. Analyses were performed to evaluate whether data collected at the high school and four CDF stations are statistically similar or whether localized work activities at the site may affect samples collected from the different locations.

Data were also broken down by season: Spring/fall (March, April, May, October, November), summer (June, July, August, September), and winter (December, January, February) corresponding to mean monthly temperatures of <40°F (winter), 40 – 60°F (spring/fall), and >60°F (summer) in order to investigate seasonal effects on air quality. In summary, based on monitor station location (All, High School, South CDF, East CDF, North CDF, West CDF), sampling period (Entire/2001-2019, Recent/2010-2019), season (all, spring/fall, summer, winter), dredging status (all, background/pre-dredging, active/discharge, idle/quiescent pond), and temperature-correction (measured, temp-corrected), a total of 27 sub-groups were analyzed for each parameter:

- All monitoring stations, Entire sampling period, all data, measured
- All monitoring stations, Recent sampling period, all data, measured
- All monitoring stations, Entire sampling period, all data, temp-corrected
- All monitoring stations, Recent sampling period, all data, temp-corrected
- High School station, Recent sampling period, all data, temp-corrected
- South CDF station, Recent sampling period, all data, temp-corrected
- East CDF station, Recent sampling period, all data, temp-corrected
- North CDF station, Recent sampling period, all data, temp-corrected
- West CDF station, Recent sampling period, all data, temp-corrected
- All monitoring stations, Recent sampling period, spring/fall data, temp-corrected
- All monitoring stations, Recent sampling period, summer data, temp-corrected
- All monitoring stations, Recent sampling period, winter data, temp-corrected
- All monitoring stations, Recent sampling period, background data, temp-corrected
- All monitoring stations, Recent sampling period, discharge data, temp-corrected
- All monitoring stations, Recent sampling period, quiescent pond data, temp-corrected
- High School station, Recent sampling period, background data, temp-corrected
- High School station, Recent sampling period, discharge data, temp-corrected

- High School station, Recent sampling period, quiescent pond data, temp-corrected
- South CDF station, Recent sampling period, background data, temp-corrected
- South CDF station, Recent sampling period, discharge data, temp-corrected
- South CDF station, Recent sampling period, quiescent pond data, temp-corrected
- East CDF station, Recent sampling period, discharge data, temp-corrected
- East CDF station, Recent sampling period, quiescent pond data, temp-corrected
- North CDF station, Recent sampling period, discharge data, temp-corrected
- North CDF station, Recent sampling period, quiescent pond data, temp-corrected
- West CDF station, Recent sampling period, discharge data, temp-corrected
- West CDF station, Recent sampling period, quiescent pond data, temp-corrected

Statistical Analysis

All statistical analyses presented in this report were performed with Microsoft Excel and the integrated Analyse-it statistical software (version 3.90.7), and the statistical package ProUCL 5.1 developed by USEPA for environmental data analysis.

Air quality data were plotted over time and descriptive statistics were tabulated to summarize the measured data. The nonparametric Kaplan-Meier (KM) method was used to calculate general statistics for data sets with multiple detection limits and NDs exceeding detected observations. The Mann Kendall trend statistics were computed to determine long term trends in concentrations with time. Statistical comparisons between sub-groups (monitoring stations, sampling periods, season, and dredging status or activity) were made using the two-sample nonparametric Gehan test for data sets consisting of NDs with multiple reporting/detection limits. The Wilcoxon-Mann-Whitney nonparametric test was used for statistical comparison of data with no NDs (sum of PCB congeners). Statistical tests were performed at the 95% confidence level. Except where noted, tests were performed on temperature-corrected data to identify trends unrelated to temperature (i.e., dredging activities). Spearman rank correlations were also performed using actual data to determine relationships between compounds.

Summary of Pre-Dredging and Post-Dredging Data Analysis

A summary of the pre-dredging data analysis collected from 2001 to November 2012 is available in USACE 2014. The air monitoring data used for the statistical analysis for the pre-dredging period were collected at the south site (representing the CDF) and the high school site, and analyzed by site, season, and period of construction activities at the CDF to understanding background ambient air conditions prior to dredging start.

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, pre-dredging background data are compared to post-dredging data to identify significant differences and identify temporal trends at all CDF stations and the HS station. More ‘recent’ pre-dredging data from 2010 to 2012 were utilized as representative of background for most statistical analyses rather than the entire pre-dredging monitoring period starting 2001. The post-dredging period is broken down into ‘active’ periods of discharge / sediment placement and ‘idle’ periods with quiescent pond only / no sediment placement to explore the potential effects of CDF operations and whether pre-dredging background trends have changed at the CDF stations or high school. This report analysis focuses on the subdivided post-dredging data sets (active discharge and idle quiescent pond) and individual monitoring station data (south, east, north, west, and high school) rather than aggregate post-dredging and CDF data sets for detailed results.

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 would be likely more from the placement of dredged material into the CDF cells and the presence of the dredged material stored in the cells (in the future the designation of pre-dredging and post-dredging periods may be more appropriately re-designated pre- and post-sediment placement periods).

PCB Analysis

The 2019 PCB analysis was presented in a separate report (USACE 2020).

PAH Analysis

Atmospheric PAH concentrations vary by well over an order of magnitude over the entire monitoring period (Figures 7-13). Table 1b shows naphthalene (Nap) composes over half the PAH load (Oct 2012-2019 or post-dredging onsite median concentration of 50 to 55.35 ng/m^3) followed in decreasing order by phenanthrene (Phe – 12.93 to 19.66 ng/m^3), acenaphthene (Ace – 7.65 to 11.8 ng/m^3), fluorene (Flo – 6.86 to 10.97 ng/m^3), fluoranthene (Fla – 3.28 to 3.47 ng/m^3), pyrene (Pyr – 1.52 to 1.985 ng/m^3), and acenaphthylene (Acy – 1.44 to 1.62 ng/m^3). High school median concentrations of Ace and Flo are lower than onsite monitors median concentrations. High school median concentrations of other PAHs (Fla, Nap, Phe, Pyr) are in the range of the onsite median concentrations. The high school median concentration of Acy is greater than the onsite median concentrations.

All PAHs exhibit a cyclical pattern similar to PCBs, except for Acy which exhibits a negative relationship with temperature (higher in cooler temperatures and lower in warmer temperatures). Regression analysis of Nap data does not show significant temperature dependence, though seasonal analysis shows some significant trends. Temperature-corrected concentrations of Ace, Fla, Flo, Nap, Phe, and Pyr are used in the analyses. For Acy, all analyses were performed on measured (not corrected for temperature) data.

Table 2 shows that measured Ace, Fla, Flo, Phe, and Pyr concentrations are positively correlated (Spearman correlation coefficients ranging from 0.740 to 0.943) while Acy and Nap do not correlate highly with any PAHs (Spearman correlation coefficients between Acy and other PAHs range from 0.271 to 0.414, and between Nap and other PAHs range from 0.365 to 0.487). These results suggest Acy and Nap are emitted from different sources (without the same temperature-dependence) than other PAHs.

Trend Analysis

Table 3 presents results from a Mann-Kendall trend analysis of PAH concentrations over different monitoring periods and combinations of monitoring stations. The high school and south sites were analyzed over the entire sampling period (2001-2019), using the original PAH data (no temperature correction). More recent temperature-corrected data (2010-19 for the high school and south sites, and 2012-19 for the north, east, and west sites) were also examined for trends, except for Acy, where the original data were analyzed.

Over the entire sampling period (2001 through 2019), at the high school, Ace increases with time, Nap and Acy decrease with time, while Fla, Flo, Phe, and Pyr exhibit no significant trend. Over the same 2001-2019 period, at the south site (note as previously discussed, the "south" site is located south of the Lake George Branch prior to dredging start, and located north of the Lake George Branch after dredging started – see Figure 0), Ace, Flo, and Phe increase with time, Acy and Nap decrease, while Fla and Pyr exhibit no significant trend. Appendix B includes Mann-Kendall trend analyses for PAHs at the high school and south stations from 2001 through 2019.

Over the recent monitoring period (2010-2019), Acy decreases, and all other PAHs have no observable trends at the high school. Acy had the same decreasing trend at the south site during the 2010-2019 period. South site Fla, Phe, and Pyr increase over this period, and Ace, Flo, and Nap have no observable trends.

At the north and east stations, Pyr and Phe increase over time over the 2012-2019 period. Ace, Fla, Flo, Nap exhibit no observable trend at the north and east stations during the 2012-2019 period, while Acy decreases over the 2012-2019 period. At the west station, Nap, Phe and Pyr increase over the 2012-2019 time period, while remaining PAHs exhibit no observable trend during the 2012-2019 period.

In summary, several PAH levels increase over time (2012-2019) at at least one of the CDF stations, however no PAH increases (and Acy levels decreases) at the high school during this time period. This supports the finding that sediment discharge and storage activities impact PAH concentrations at the disposal site but have a minor effect at the high school monitoring site. Sediment discharge impacts PAH concentrations at the CDF but not equally across the site. More sediment has been discharged to the east cell than the west cell through 2019, i.e., there are more active disposal days associated with the east cell than with the west cell. The effect of active disposal cell has not been tested in this report and may be analyzed in the future. Over the entire sampling period (2001-2019), Acy and Nap exhibit different (decreasing) trends from the other PAHs at the south station, and are thought to be driven by sources outside the canal and CDF.

Season

Table 4 compares PAH concentrations between summer, winter, and spring/fall. Temperature-corrected PAHs generally are not expected to show significant differences between seasons, however a majority of the analyzed PAHs (Ace, Fla, Flo, and Pyr) exhibit statistically higher concentrations during summer than winter and/or spring/fall at the site. Conversely, Fla is statistically higher in the winter than spring/fall.

Acy levels are higher in winter than summer, and higher in spring/fall than summer. The trends are generally different between the site monitors and the high school data, with several PAHs being statistically higher in winter than in spring/fall. Future analysis with wind and/or source data may elucidate what seasonal or temporal events explain these patterns. Temperature-corrected Nap data generally show no seasonal differences.

Monitoring stations

Table 5 compares PAH concentrations between monitoring stations. During the period after dredging started, Ace, Acy, Flo, and Phe are statistically less at the high school than at the south site; Fla, Nap, and Pyr are not significantly different between the high school and south site. Conversely, PAHs show no statistical difference between the high school and the east CDF station, and some PAHs (Ace, Nap, Pyr) are statistically higher at the high school than at the north and west CDF stations.

The south station has the statistically higher levels of several PAHs (Ace, Acy, Flo, Phe, Pyr) when compared with the other CDF stations. Ace, Flo, and Phe are statistically higher at the east station than the north station. The west and north stations PAH levels are lower than the south and east stations.

In summary, PAH levels vary considerably by site. Generally, PAHs are highest at the south station and lowest at the west station. Four PAHs are higher at the south station than at the high school. On the other hand, several PAHs are higher at the high school than the north and west CDF stations. The lack of clear trends, and some PAHs having higher levels at the HS than CDF site monitors indicate PAHs are impacted by multiple sources unrelated to the CDF, or other confounding factors not identified in this report.

Differences are explored further in Table 6 considering active dredging data (eight events between October 2012 and December 2019), idle quiescent pond data (inactive periods between October 2012 and December 2019), and pre-dredging background data (January 2010 through October 2012). Because the east, north and west stations began operating once dredging commenced in October 2012, only high school and south stations are compared for the pre-dredging background phase.

Active/Discharge

During sediment discharge into the CDF, Ace, Flo, and Phe levels are higher at south stations than all other stations including the high school (Table 6). PAH levels are not statistically different among the other CDF stations. PAH levels are not statistically different between the high school and the east, north and west CDF stations, except for Acy and Phe which are statistically higher at the east station than at the high school.

In summary, during sediment discharge PAH concentrations are often higher at the south station than other stations including the high school. These results indicate dredging activities may impact local atmospheric conditions at the disposal site more than at the high school.

Idle/Quiescent pond

During quiescent pond conditions, Ace, Flo, and Phe levels are higher at the south station than all stations, including the high school (Table 6). One unexpected trend is Ace levels are statistically higher at the high school than the east, west, and north stations. Acy levels are higher at the south station compared to the high school, east and west stations. Fla and Nap exhibit no difference between any monitoring stations, except for high school Nap being higher at the high school than the south and west stations.

In summary, during idle quiescent pond conditions PAH concentrations, except for Nap, are often higher at the south station than other stations. The high school has higher levels of some PAHs (Ace, Flo, Nap, Pyr) than some or all of the CDF stations. The north and west stations have the lowest levels of PAHs of all monitors. These results indicate the CDF pond have little impact on atmospheric PAHs at the high school.

Pre-dredging/Background

Most pre-dredging background PAH concentrations are not statistically different between the south station than the high school station. In the post-dredging period, levels of several PAHs are statistically higher at the CDF than at the high school during dredging, but several PAHs are higher at the high school than at some CDF stations during the quiescent period. There is no evidence to suggest CDF activities are significantly impacting the high school.

Dredging activity

Table 7 compares PAH levels between pre-dredging background, active discharge, and idle quiescent pond data. All PAHs except Acy are greater during discharge periods than background phase, and all except Acy and Nap levels are greater during quiescent pond periods than background phase at the south station. At the high school, there is no statistical difference between PAH levels during background, discharge, or quiescent pond periods, except Acy levels are statistically lower during quiescent pond periods than background period. These results confirm that dredging activities have a localized effect on PAH concentrations near the CDF, but not at the high school. Differences between activities are examined further in Table 7 considering monitoring station.

High school

All PAHs are similar between background, discharge, and quiescent pond periods at the high school, except Acy being statistically lower during quiescent pond periods than background period. The lack of significant differences between the pre-dredging and post-dredging PAH concentrations at the high school suggest that sediment disposal and storage at the CDF have minimal impact on atmospheric PAH conditions off-site.

South

All PAHs except Acy are greater during discharge periods than background phase, and all except Acy and Nap levels are greater during quiescent pond periods than background phase at the south station. Ace, Fla, Flo, Phe, and Pyr levels are greater during active discharge than the quiescent pond period at the south station. These results indicate dredging activities affect concentrations at the south station significantly.

East, north, west

Ace, Acy, Fla, Flo, Phe, and Pyr levels are greater during active discharge than the quiescent pond period at at least one of the east, north, west stations. The west station is the station least impacted by active dredging with Ace, Fla, and Pyr being statistically higher during dredging compared to the quiescent pond periods (Table 7).

In summary, all PAHs (except Acy and Nap) are statistically higher during post-dredging than pre-dredging at the south station, while no PAHs are statistically different at the high school based on dredging activity. This is consistent with the finding that sediment placement and storage impacts CDF atmospheric conditions and not high school atmospheric conditions, and that Acy and Nap have different sources than the other PAHs.

VOC Analysis

Atmospheric concentrations of VOCs vary about an order of magnitude over the entire monitoring period (Figures 14-15). Benzene in particular appears higher during the early years of monitoring than later years, and has a higher proportion of non-detects from 2007 – 2013 than other periods (Figures 14-15). However, the benzene reporting limit changed several times throughout the sampling period (e.g., in 2007, in 2012, and in Fall 2013 when the analytical laboratory was changed). Although the Clausius-Clapeyron analysis showed the VOCs exhibit some temperature dependence, a strong seasonal pattern is not as clear as with PCBs and many PAHs.

Table 1 shows toluene concentrations (median concentration of ranging from 1.48 to 1.83 ug/m^3 at the five monitors) are about 50% higher than that of benzene (median concentrations ranging from 1.02 to 1.12 ug/m^3). High school median concentrations of benzene and toluene are in the range of the onsite median concentrations. The VOC data are highly right-skewed due to numerous non-detects and long tails with outliers.

Table 2 shows measured benzene and toluene concentrations are statistically correlated with a spearman correlation coefficient of 0.669. A correlation analysis by site (high school, south, east, north, and west) indicated only 5 out of 45 correlations (including benzene-toluene, benzene-benzene, and toluene-toluene comparisons) have coefficients over 0.6 (results not shown). The five relationship pairs with coefficients over 0.6 are benzene and toluene at each station; all cross station relationships (e.g., east benzene – HS benzene, east benzene – HS toluene, etc.) have low spearman correlation coefficients. These results indicate VOCs often behave differently at different stations and possibly come from different sources.

Trend Analysis

Table 3 presents results from a Mann-Kendall trend analysis of measured as well as temperature-corrected VOC concentrations over time. The high school and south station were analyzed over the entire sampling period (2001-2019), using the original VOC data (no temperature correction). More recent temperature-corrected data (2010-2019 for the high school and south stations, and 2012-19 for the north, east and west stations) were also examined for trends.

Over the 2001-2019 period, both benzene and toluene decrease with time at the high school and at the south station. Over the recent monitoring period (2010-2019), toluene decrease with time at the high school and the south station. Benzene exhibits no trend at the high school and decreases at the south station over the 2010-2019 period. Appendix C includes Mann-Kendall trend analyses for benzene and toluene at the high school and south stations from 2001 through 2019.

Over the 2012-2019 period (post-dredging period), toluene decreases with time at the north station. At the west station, benzene increases with time over the 2012-2019 period.

In summary, benzene and toluene do not increase over any time period at any station, except for benzene at the west station from 2012-2019. More significantly, with a few exceptions, benzene and toluene have decreased over the entire monitoring period (2001-2019), and toluene has decreased as well as over the recent monitoring period since dredging started (2010-2019) at the high school and at two CDF stations. Benzene exhibits no trend at the high school and at the CDF stations over the recent monitoring period (2010-2019). Except for the increase in toluene at the west station from 2012-2019, there is no evidence to indicate that sediment disposal activities or the presence of dredged material at the CDF have impacted the atmospheric benzene and toluene concentrations at the CDF or the high school.

Season

Table 4 compares VOC concentrations between summer, winter, and spring/fall. With temperature effects removed from the dataset, benzene and toluene show no significant differences between seasons at the high school. Benzene is statistically higher in the summer than the spring/fall and the winter at the site (2012-2019 data). Toluene also shows some seasonal effects, with statistically higher levels in the summer than winter and spring/fall, for the CDF stations.

Monitoring stations

Table 5 compares VOC concentrations between monitoring stations. During the period after dredging started, benzene levels are highest at the south and east stations, and similar at the high school, north and west stations. Relatively higher levels of benzene at the south and east stations may be related to year-round groundwater discharge into the southwest corner and east side of the east cell. Toluene levels are highest at the high school and east station, and similar at south, north and west stations.

Active/Discharge

During sediment discharge to the CDF, Table 6 shows benzene levels are similar at all CDF monitoring stations, except at the west station which has statistically lower levels that the other CDF stations. Benzene levels are also lower at the high school than at east, north, and south stations during sediment discharge. Toluene levels are similar between the CDF stations and the high school during sediment discharge.

Idle/Quiescent pond

During quiescent pond periods, benzene levels are higher at the east station than the high school, west and the north stations, and higher at the south station than at the west station (Table 6). Because these results indicate the quiescent pond impacts the CDF air-shed more than active discharge, it is thought sources other than sediment disposal may be responsible for these differences. Ongoing groundwater discharge to the east cell may also influence higher levels at the east station. Toluene levels at the east station are higher than other CDF stations; and are higher at the high school than south, north and west stations.

Pre-dredging/Background

Pre-dredging (2010-2012) levels of toluene are statistically similar between the high school and south stations (note as previously discussed, the “south” site is located south of the Lake George Branch prior to dredging start, and located north of the Lake George Branch after dredging started – see Figure 0)). Pre-dredging benzene levels are higher at the south station than the high school.

Dredging Activity

Table 7 compares VOC levels between pre-dredging background, active discharge, and idle quiescent pond data. Benzene and toluene levels are not different between the background and discharge or quiescent pond periods, with one exception: background benzene levels are higher than quiescent pond levels. Benzene levels are higher during active sediment discharge than the idle quiescent periods at the south and north stations, and toluene levels are higher during active sediment discharge than idle quiescent pond periods at the west station.

High school

At the high school, there are no significant differences in benzene levels and toluene levels between background, discharge, and quiescent pond periods. Thus dredging activities show no effect on VOC concentrations at the high school.

South

At the south station, there are also no significant differences in VOC levels between background, discharge, and quiescent pond periods. The only exception is background benzene levels are statistically higher than quiescent pond levels, and higher during discharge than quiescent pond periods. Thus sediment disposal may increase benzene concentrations at the south station, but has no impacts on quiescent periods.

East, north, west

Benzene is higher at the north station during discharge over quiescent pond periods, and toluene is higher at the west station during discharge over quiescent pond periods. VOCs are statistically similar between active discharge and quiescent pond periods for east monitoring station (Table 7).

In summary, sediment disposal activities may increase VOC levels at some onsite stations during active disposal but not during the non-disposal periods. Sediment disposal activites and dredged material storage at the CDF have not impacted the atmospheric benzene and toluene conditions at the high school.

TSP Analysis

Atmospheric concentrations of Total Suspended Particulates (TSP) vary in level and pattern (Figure 16). Total Suspended Particulates exhibit slightly cyclical behavior. While not dependent on temperature-controlled volatilization and thus not temperature corrected, TSP may still follow a seasonal trend likely due to drying and wind conditions. The median TSP value ranges from 3.81E-5 to 4.45E-5 g/m^3 (Table 1) over the 2010 to 2019 period.

Trend Analysis

Table 3 presents results from a Mann-Kendall trend analysis of TSP concentrations over time. Over the entire sampling period as well as the recent sampling period, TSP decreases statistically with time at the high school (Appendix Figure D1). TSP exhibits no trend over the entire sampling period at the south station (Appendix Figure D2) and the recent sampling period at the south, north and west stations. At the east station, TSP increases statistically over the Oct 2012-2019 sampling period. Because TSP concentrations decrease at the high school but not at the CDF stations, the source of TSP is likely not the same for the high school and the CDF.

Season

Table 4 compares TSP concentrations between summer, winter, and spring/fall. Although not subject to temperature-controlled volatilization, TSP exhibits seasonal atmospheric behavior and is statistically higher in the summer than in the spring/fall and higher in the spring/fall than in the winter at all monitoring stations. This seasonality may be related to precipitation, drying, freezing, or wind conditions that have not been examined in this report.

Monitoring stations

Table 5 compares TSP concentrations between monitoring stations. TSP concentrations are higher at the south, east and north stations than at the high school, but are not statistically different between the CDF stations.

Active/Discharge

During sediment offloading and placement into the CDF, TSP concentrations TSP concentrations are higher at the south, east and north stations than at the high school, but are not statistically different between the CDF stations. (Table 6).

Idle/Quiescent pond

During sediment storage quiescent pond periods, TSP is no longer different between the south and high school, but still higher at the east and north stations than at the high school(Table 6). Sediment storage does not affect TSP levels at the monitoring sites differently.

Pre-dredging/Background

TSP levels are not statistically different at the high school station and the south station during pre-dredging (Table 6). This result changes during post-dredging, with lower levels of TSP at the high school. Thus there may be a dredging effect on TSP levels because levels at the south station become elevated compared to the high school from pre-dredging to post-dredging periods (high school and south station are the same during background and quiescent pond, and south station is higher during active discharge).

Dredging activity

Table 7 compares TSP concentrations between pre-dredging background, active discharge, and idle quiescent pond periods. TSP levels are lower under quiescent pond conditions than pre-dredging and active discharge conditions. Because levels are statistically no different between the discharge and pre-dredging period (south station) and statistically less during active discharge than pre-dredging period (high school), it appears that TSP is not significantly impacted by sediment disposal. These results are in contrast to PCBs, PAHs, and VOCs.

High school

At the high school, TSP is greater during the pre-dredging than during the post-dredging (both active discharge and quiescent pond periods), suggesting no effects from dredging activities on TSP levels at the high school.

South

At the south station, TSP levels are less under quiescent pond conditions than active discharge or pre-dredging conditions. TSP levels are not statistically different between active discharge and background periods. Because TSP levels during post-dredging activities are statistically less than or similar to pre-dredging period, sediment disposal does not significantly impact concentrations at the south station.

East, north, west

TSP concentrations between post-dredging activities (quiescent pond and active discharge periods) are not significantly different at the east, north, and west stations.

Metals Analysis

Atmospheric concentrations of the metals that were analyzed for the IHC project vary in level and pattern (Figures 17-27). Some metals (Al, Ba, Cr, Fe, Mn) exhibit slightly cyclical behavior. Two metals (Se, Zn) exhibit no observable pattern. Metals are not expected to be dependent on temperature-controlled volatilization and thus are not temperature corrected. However, metals are likely associated with suspended particulates and may still follow a seasonal trend likely due to drying and wind conditions. Seasonal trends of metals are discussed further below.

The statistical data summary of metals are presented on Table 1d. Over the 2010 to 2019 period, Iron (onsite monitors median concentrations ranging from 0.63 to 0.73 mg/m^3), Aluminum (0.26 to 0.28 mg/m^3), Copper (0.046 to 0.051 mg/m^3), Manganese (0.051 to 0.061 mg/m^3), and Zinc (0.055 to 0.058 mg/m^3) are the highest detected metals. Arsenic, Barium, Chromium, Cobalt, Lead, Nickel, and Selenium are detected at lower levels. Arsenic and Selenium are not detected over 50% of the time; Cobalt is not detected over 80% of the time and is not discussed further in this report.

Table 2 shows the Spearman correlation coefficients for TSP and metals. Unlike PCBs, PAHs, and VOCs, TSP and metals are not highly correlated (only 9 out of 66 correlations between TSP and metals, and between metals have coefficients over 0.6). The Spearman correlation coefficients between TSP and metals range from 0.117 (with Cu) to 0.733 (with Al). Spearman correlation coefficients are lowest between Cu and other metals and range from 0.039 (with Al) to 0.373 (with Ba). Spearman correlation coefficients between other metals range from 0.304 (Ba and Cr) to 0.753 (Al and Fe). These results indicate metals likely come from different sources.

Trend Analysis

Table 3 presents results from a Mann-Kendall trend analysis of metals concentrations over different monitoring periods and combinations of monitoring stations. The high school and south stations were analyzed over the entire sampling period (2001-2019). More recent data (2010-19 for the high school and south stations, and 2012-19 for the north, east, and west sites) were also examined for trends.

Over the 2001-2019 period, at the high school, similar to TSP, all metals except As, Cu, and Se, decrease statistically with time, while Cu exhibits no significant trend, and As and Se increase over this period. Over the same 2001-2019 period, at the south site, five metals Ba, Cu, Pb, Ni, and Zn decrease statistically with time, while four metals Al, Cr, Fe, Mn exhibit no significant trend similar to TSP. As and Se increase over this period at the south site, as at the high school. The detection limits for As and Se increased in 2018, and the increasing trends for these metals may be due to the new higher detection limits. Appendix D includes Mann-Kendall trend analyses for TSP and metals at the high school and south stations from 2001 through 2019.

Over the recent monitoring period (2010-2019), the trends were different when compared to the 2001-2019 trends for three metals at the high school and at the south station. At the high school, Al, Cr, and Ni decrease statistically with time over the 2001-19 period, and exhibit no trend for 2010-2019. At the south station, Ba, Ni, and Zn decrease statistically with time for over the 2001-19 period, and exhibit no trend for 2010-2019. TSP and other metals exhibit the same trend at the high school and south station over the two monitoring periods.

Over the 2012-19 time period, TSP, Al, As, and Se increase statistically with time at at least 2 out of the north, east, and west site stations. Conversely, Cu and Pb decrease statistically with time at at least 2 out of the three north, east, and west site stations over the same time period. The remaining metals Ba, Cr, Fe, Mn, Ni, Zn exhibit no signifanct trend at at least 2 out of the three north east and west stations over this period. As discussed above, the increasing trends for As and Se may be due to the new higher detection limits starting in 2018.

In summary, more metals along with TSP exhibit decreasing trend at the high school than at the CDF onsite stations over the entire monitoring period (2001-2019), and over the recent monitoring period since dredging started (2012-2019). Fewer metals exhibit decreasing trends over the recent monitoring period (2012-2019) than over the entire monitoring period (2001-2019). Arsenic and Selenium increase at all monitoring stations over all monitoring periods. However, these increasing trends may be due to the new higher detection limits starting in 2018. The dissimilar trends between the high school and onsite stations indicate that dredging and sediment and placement activities are likely not impacting metals concentrations at the high school.

Season

Table 4 compares metals concentrations between summer, winter, and spring/fall. Although not subject to temperature-controlled volatilization, most metals, similar to TSP, exhibit seasonal atmospheric behavior and are statistically higher in the summer than in the spring/fall and higher in the spring/fall than in the winter. This seasonality may be related to precipitation, drying, freezing, or wind conditions that have not been examined in this report. At the high school, Cu, Pb, Se and Zn do not exhibit notable seasonal trends; at the CDF site, Cu and Pb exhibit fewer notable seasonal trends than other metals.

Monitoring stations

Table 5 compares metals concentrations between monitoring stations. Before dredging started (2001-2012), all metals, except Cu, are not significantly different between the high school and south stations. Cu was statistically less at the high school than at the south station during the pre-dredging period. For the period after dredging started (2012-2019), 3 metals (Al, Fe, Mn) are statistically less at the high school than at all of the CDF stations. Ba, Cr, and Se are statistically less at the high school than at least one of the CDF stations. Conversely, Cu which was statistically less at the high school than at the south station during the pre-dredging period, is statistically higher at the high school than at any of the CDF stations during the period after dredging started (2012-2019).

Metals concentrations are not statistically different among the CDF stations, with a very few exceptions. Differences are explored further (Table 6) considering active dredging data (eight events between October 2012 and September 2019), idle quiescent pond data (inactive periods between October 2012 and September 2019), and pre-dredging background data (January 2010 through October 2012).

Active/Discharge

During sediment offloading and placement into the CDF, there is no statistical difference between any of the metals (except Cu) among the CDF monitoring stations. The exception is Cu which is statistically lower at the south than at the east station during the sediment offloading period. Comparison of the high school to the onsite stations indicates that Al, Fe, Mn and Ni are statistically less at the high school than at at least one of the CDF stations. Conversely, Cu is statistically higher at the high school than at the north, south, east, and west stations. There is no statistical difference between the high school and any of the CDF stations for the remaining metals.

Idle/Quiescent pond

During sediment storage quiescent pond periods, there is no statistical difference between any of the metals (except Cu) among the CDF monitoring stations. The exception is Cu which is statistically lower at the south than at the west station and the east station. Comparison of the high school to the onsite stations indicates that Al, Fe, and Mn are statistically less at the high school than at at least one of the CDF stations. Conversely, Cu is statistically higher at the high school than at the north, south, east, and west stations. There is no statistical difference between the high school and any of the CDF stations for the remaining metals.

With a few exceptions, the trends for metals hold for the CDF onsite comparison, as well as for the high school and CDF comparison, between the sediment offloading period and the quiescent pond period. Except for Cu, there is no difference among the onsite stations for metals. The high school having statistically lower levels of some metals (Al, Fe, Mn) than the onsite monitors during sediment offloading as well as the idle periods suggest the source of these parameters is closer to the CDF, and that the source is likely not the sediment offloading activity. The higher Cu level at the high school than the CDF stations suggests that the source of Cu is closer to the HS.

Pre-dredging/Background

Before dredging started (2001-2012), all metals, except Cu, are statistically similar between the high school and south station. Cu was statistically less at the high school than at the south station during the pre-dredging period. The result reverses for Cu during post-dredging, with higher levels at the high school. There may be a source of Cu near the high school during the more recent monitoring period. Al, Fe, and Mn are lower at the high school than onsite during the post-dredging period. Thus there may be a dredging effect on the levels of these parameters because levels at the south station become elevated compared to the high school from pre-dredging to post-dredging periods.

Dredging activity

Table 7 compares metals concentrations between pre-dredging background, active discharge, and idle quiescent pond periods. Several metals are statistically greater during the pre-dredging background than the post-dredging period. At both the high school and south station, Al, Ba, Fe, Pb, Mn are statistically greater during the background phase than the post-dredging quiescent periods. As and Ni are not statistically different between the background and the poste-dredging periods at the high school and the south station. Cu conversely has opposing trends at the high school and south station: Cu is statistically greater during the post-dredging phase than during the background phase at the high school and greater during the background phase than the post-dredging phases at the south station. Al, Ba, and Mn are statistically greater during active discharge than during quiescent pond periods for all monitoring stations. Fe, Pb, and Ni are greater during active discharge than during the quiescent pond periods for one out of four onsite stations. There is no statistical difference between the active discharge and the quiescent pond periods for any other metal at any of the monitoring stations.

Because levels of TSP and most metals are statistically no different or statistically less during the discharge than the pre-dredging period (and statistically less during quiescent pond period than pre-dredging period), it appears that TSP and metals are not significantly impacted by sediment disposal. These results are in contrast to PCBs, PAHs, and VOCs.

High school

At the high school, all metals except As, Cu, and Ni are greater during pre-dredging than post-dredging (during discharge and/or quiescent pond periods). As and Ni are not statistically different during pre-dredging and post-dredging,suggesting no effects from dredging activities on most metals levels at the high school. Cu is statistically greater during the post-dredging phase than during the background phase at the high school, but is greater during the background phase than the post-dredging phases at the south station, suggesting a different source than dredging/CDF activities of Cu at the high school.

South

At the south station, Ba, Cu, Fe, Pb, Mn are greater during pre-dredging than post-dredging, and other metals are not statistically different during pre-dredging and post-dredging, suggesting no effects from dredging activities on TSP and most metals levels at the south station. Al is statistically greater during active discharge than during the background phase at south station, thus dredging activities may increase Al levels compared to background, though Al is statistically less during the quiescent periods than the background phase at the south station.

East, north, west

Al, Ba, and Mn are statistically greater during active discharge than during quiescent pond periods for the east, north and west stations. Fe and Ni are greater during active discharge than during the quiescent pond periods for one out of the east, north, west stations. There is no statistical difference between the active discharge and the quiescent pond periods for any other metal at any of the 3 monitoring stations.

Conclusions

The air monitoring data presented were statistically analyzed based on location and by pre-dredging (background) and quiescent pond and active discharge post-dredging periods. Tables present the data and statistical significance. The following conclusions summarize the main findings from the analysis.

PCBs (presented in USACE 2020)

PAHs

- All PAHs exhibit a cyclical pattern similar to PCBs, except for Acy. Temperature-corrected concentrations of Ace, Fla, Flo, Nap, Phe, and Pyr are used in the analyses. For Acy, all analyses were performed on measured (not corrected for temperature) data.
- PAH levels vary considerably by site. Generally, PAHs are highest at the south station and lowest at the west station. Four PAHs are higher at the south station than at the high school. On the other hand, several PAHs are higher at the high school than the north and west CDF stations. The lack of clear trends, and some PAHs having higher levels at the HS than CDF site monitors indicate PAHs are impacted by multiple sources unrelated to the CDF.
- All PAHs except Acy are greater during discharge periods than background phase, and all except Acy and Nap levels are greater during quiescent pond periods than background phase at the south station. Several PAHs are also statistically higher during active discharge than quiescent pond periods at the south, east, north, stations between discharge and quiescent pond periods.
- All PAHs are similar between background, discharge, and quiescent pond periods at the high school, except Acy being statistically lower during quiescent pond periods than background period. The lack of significant differences between the pre-dredging and post-dredging PAH concentrations at the high school suggest that sediment disposal and storage at the CDF have minimal impact on atmospheric PAH conditions off-site.
- Temporal analysis shows several PAH levels increase over time (2012-2019) at at least one of the CDF stations, however no PAH increases (and Acy levels decreases) at the high school during this time period.
- These findings suggest that dredged material disposal activities and the presence of dredged material at the CDF impact (increase) the localized atmospheric conditions of some PAHs at the CDF site (Fla, Nap, Phe and Pyr) but do not impact the atmospheric PAH conditions at the high school. The data suggest that Acy has different sources than the other PAHs.

VOCs

- Benzene and toluene exhibit some temperature dependence, but a strong seasonal pattern is not as clear as with PCBs and many PAHs.

- During sediment discharge to the CDF, benzene levels are similar at all CDF monitoring stations, except at the west station which has statistically lower levels that the other CDF stations. Benzene levels are also lower at the high school than at east, north, and south stations during sediment discharge. Toluene levels are similar between the CDF stations and the high school during sediment discharge.
- At the high school, there are no significant differences in benzene levels and toluene levels between background, discharge, and quiescent pond periods. Benzene and toluene are higher at some of the CDF stations during discharge than background and quiescent pond periods.
- Benzene does not increase over any time period at any station, except for the west station. More significantly, with a few exceptions, benzene and toluene have decreased over the entire monitoring period (2001-2019), as well as over the recent monitoring period since dredging started (2010-2019) at the high school and the CDF stations.
- These findings suggest that sediment disposal and storage at the CDF do not significantly impact atmospheric benzene and toluene concentrations at the CDF or at the high school.

Total Suspended Particulates (TSP)

- TSP exhibit slightly cyclical pattern, not based on temperature-controlled volatilization as for the organic parameters, but more likely based on drying and wind conditions.
- TSP concentrations at the CDF stations are higher than the high school during discharge and during quiescent pond. High school and south station TSP concentrations were similar during pre-dredging.
- South station TSP concentrations are higher during the pre-dredging phase than quiescent pond period. TSP concentrations are higher during active discharge than quiescent pond period at all CDF stations.
- At the high school, TSP concentrations are statistically higher during pre-dredging period than active discharge, and higher during pre-dredging than quiescent pond period. HS TSP concentrations are not different during discharge and quiescent pond periods.
- Over the entire sampling period (2001-2019) as well as the recent sampling period (2010-2019), TSP decrease statistically with time at the high school. TSP exhibits no trend over the entire sampling period at the south station and over the recent sampling period at the south and north stations). At the east and west station, TSP increases statistically over the Oct 2012-2019 sampling period.
- These findings suggest that dredging activities do not impact atmospheric TSP concentrations at the high school or the CDF site, mainly because TSP levels do not increase during sediment placement or storage compared to pre-dredging.

Metals

- Some metals (Al, Ba, Cr, Fe, Mn) exhibit slightly cyclical behavior. Two metals (Se, Zn) exhibit no observable pattern. Metals are not expected to be dependent on temperature-controlled volatilization and are not temperature corrected. However, metals are likely associated with suspended particulates and follow a seasonal trend due to drying and wind conditions.

- Comparison of the high school to the onsite stations indicates that Al, Fe, and Mn are statistically less at the high school than at at least two of the CDF stations during active discharge and quiescent pond periods. Conversely, Cu is statistically higher at the high school than at the CDF stations. There are few statistical differences between the high school and any of the CDF stations for the remaining metals.
- Levels of most metals are statistically no different or statistically less during the discharge than the pre-dredging period, and statistically less during quiescent pond period than pre-dredging period at all monitoring stations.
- More metals exhibit decreasing trend at the high school than at the CDF onsite stations over the recent monitoring period since dredging started (2012-2019). Conversely, Copper decreases at the three CDF stations, but exhibits no significant trend at the high school.
- The findings that most metals are statistically no different or statistically less during the discharge and quiescent pond period at all monitoring stations than the pre-dredging period, and that most metals are statistically less at the high school than any of the CDF stations after dredging started suggest that dredging activities do not drive atmospheric metals concentrations at the high school.

Air Monitoring Status

USACE is currently extending the IHC CDF exterior dikes by 11 feet to increase storage capacity. The 11-foot dike expansion will be performed in two stages due to funding constraints, with the first stage 3-foot expansion over a two to three year construction period, and the second stage expansion (the remaining 8-foot) sometime in the future as funding becomes available. Construction will start Spring/Summer 2021. During the dike construction period, onsite air monitoring equipment from the top of the dikes will be moved to a temporary gravel pad in the southwest corner of the site. This monitoring is consistent with the single ambient air monitoring location on the site during CDF construction. Throughout the period, the ambient air monitoring at the East Chicago High School will continue. The air monitoring program at the CDF monitor and the high school monitor at a rate of one sample per monitor every 12 days. The data will be re-evaluated on an annual basis to re-assess the currently observed trends.

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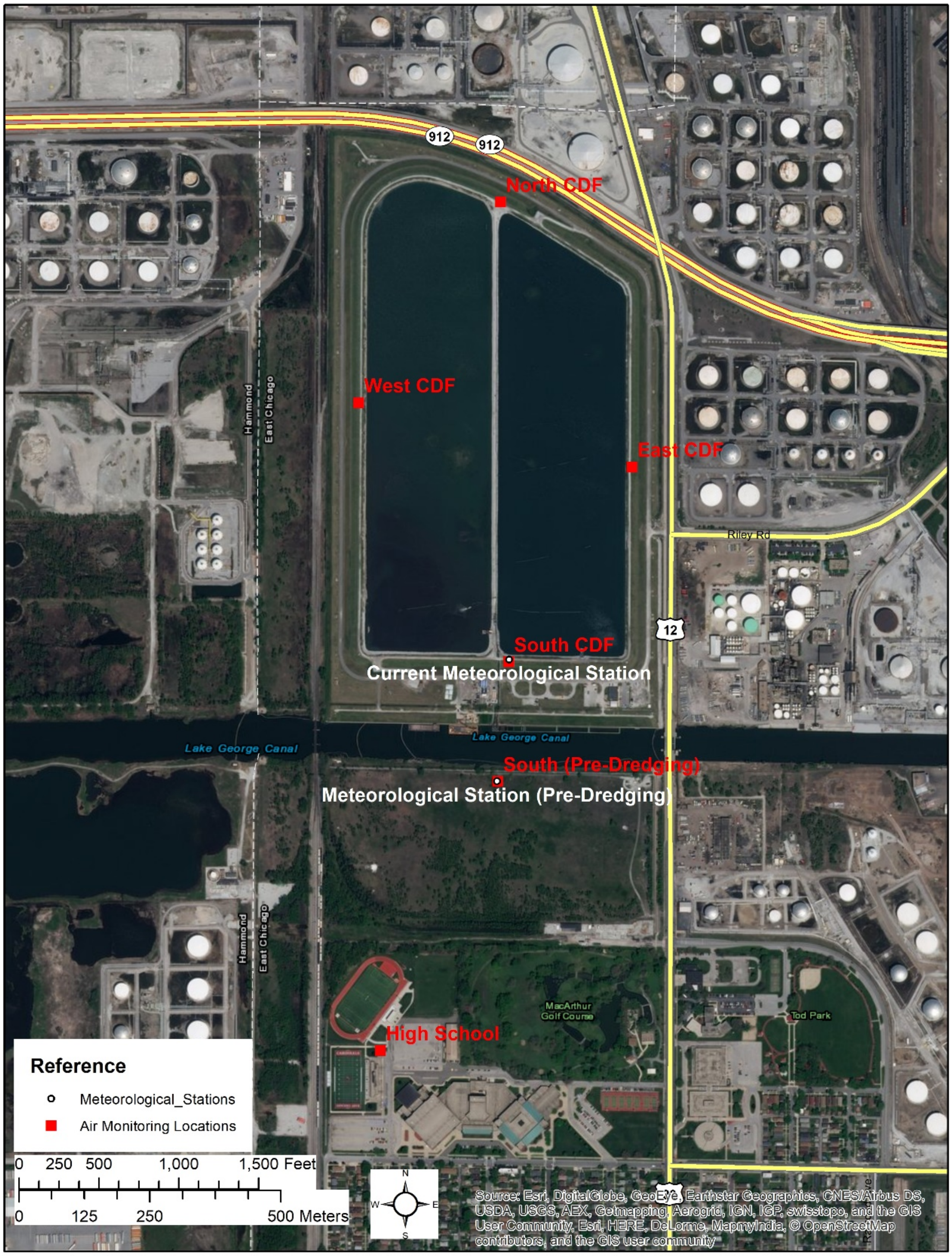
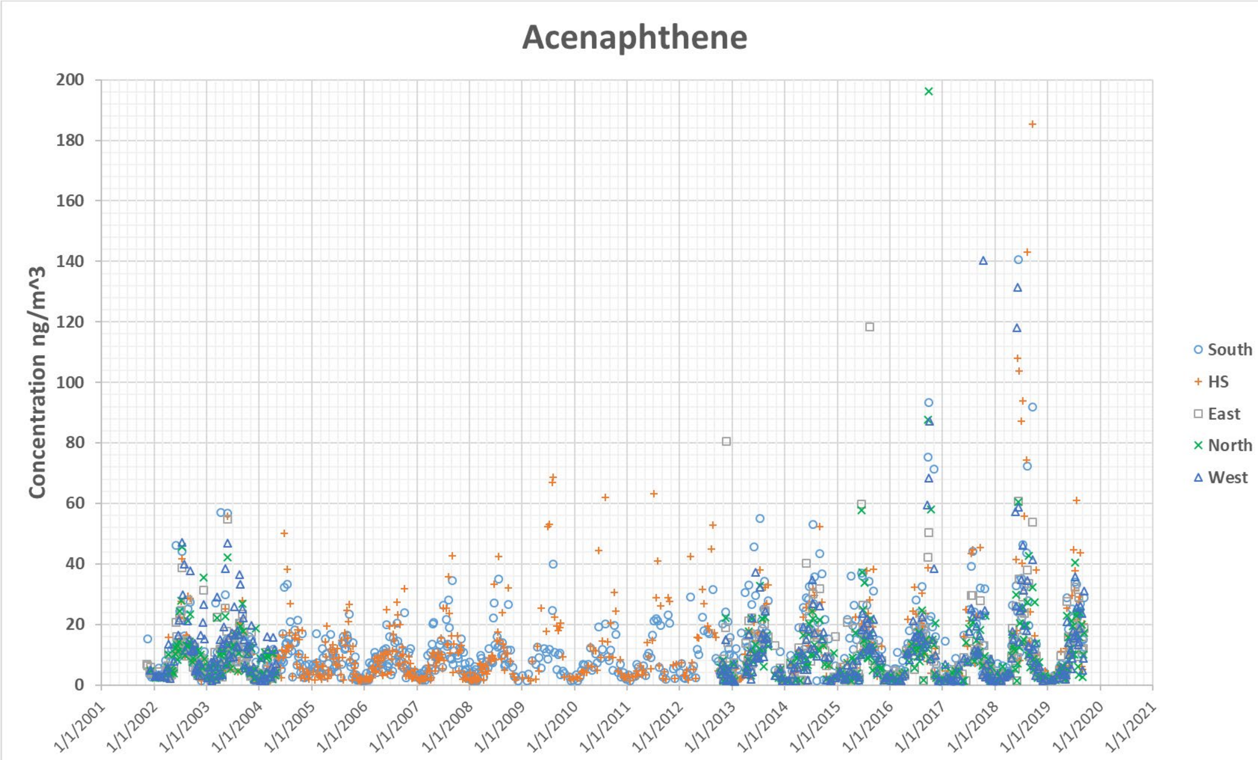


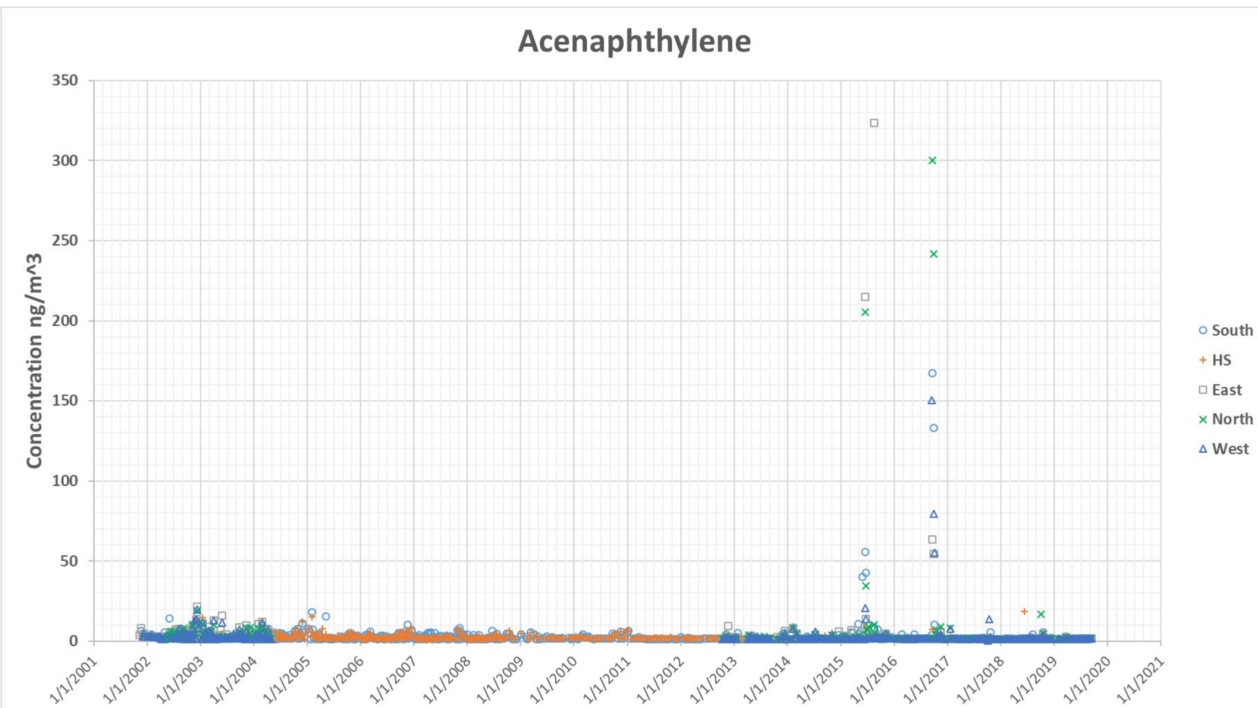
Figure 0. Location of IHC CDF Air Monitors and Meteorological Stations

Figures 1 and 2. Atmospheric concentrations of PCB 8 and PCB 15 (pg/m^3) from all stations over the entire monitoring period. Presented in USACE 2020.

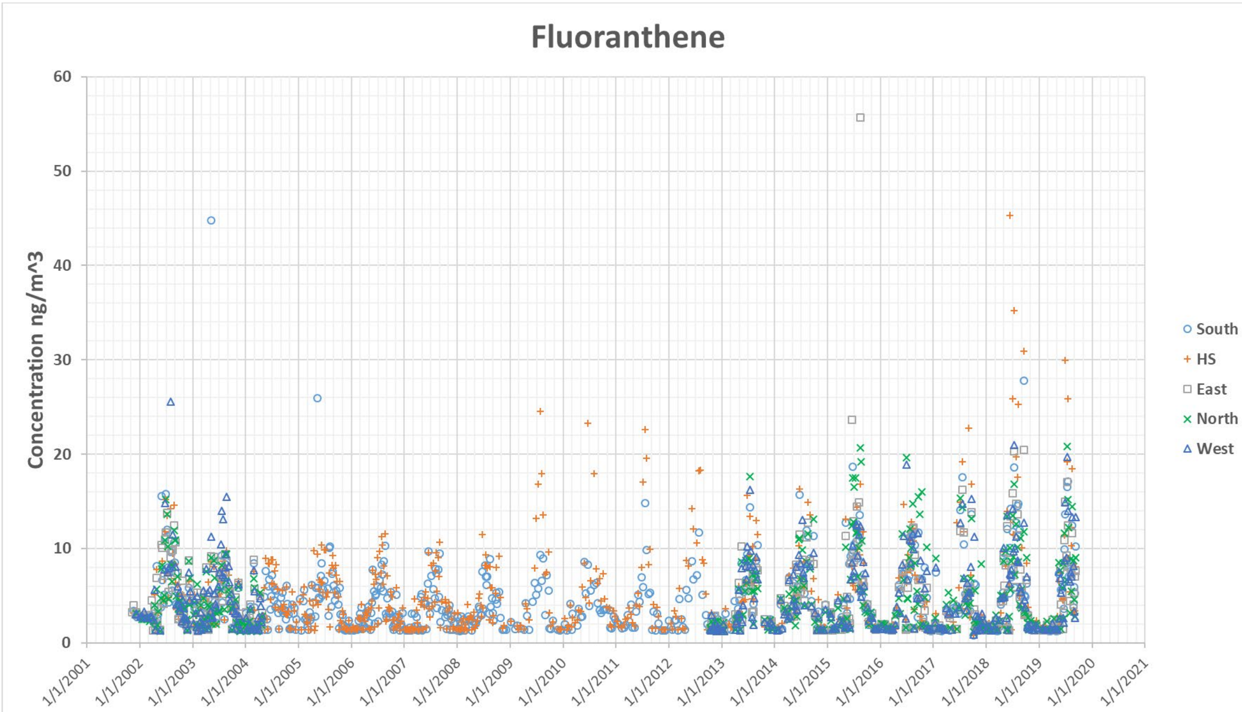
Figures 3 and 4. Atmospheric concentrations of PCB 18 and PCB 28 (pg/m^3) from all stations over the entire monitoring period. Presented in USACE 2020.

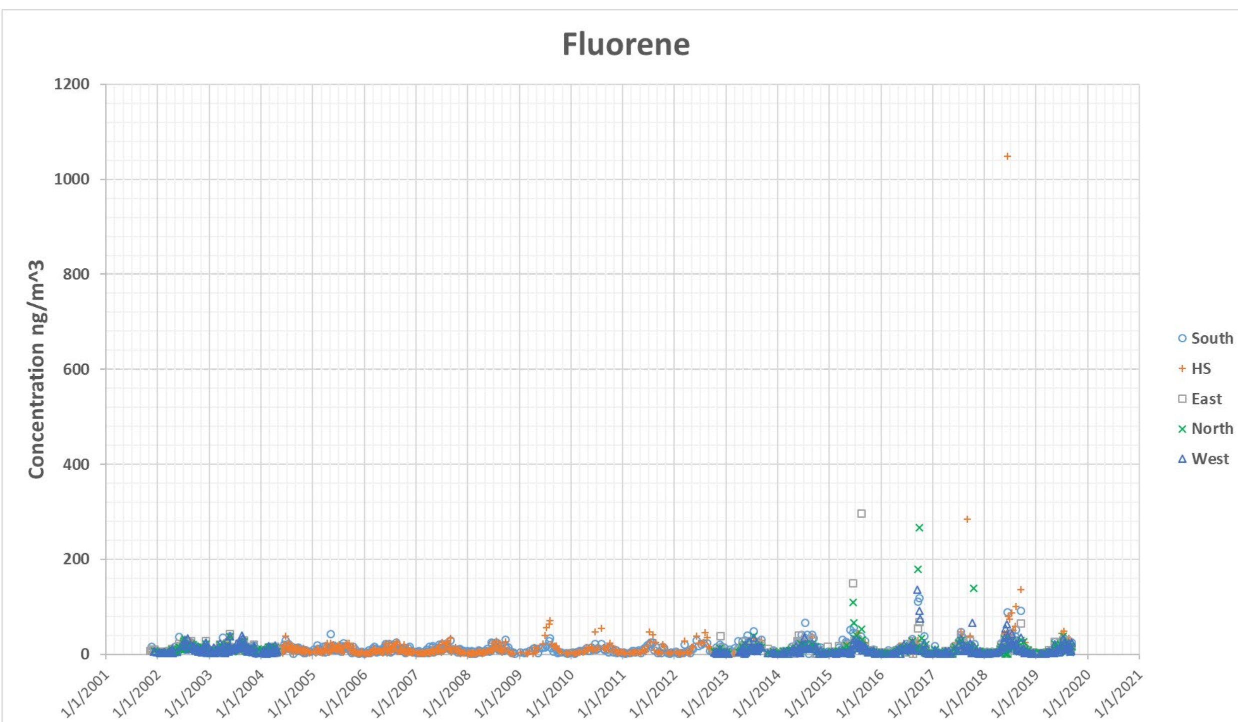
Figures 5 and 6. Atmospheric concentrations of PCB 31 and Sum 18 PCBs (pg/m^3) from all stations over the entire monitoring period. Presented in USACE 2020.



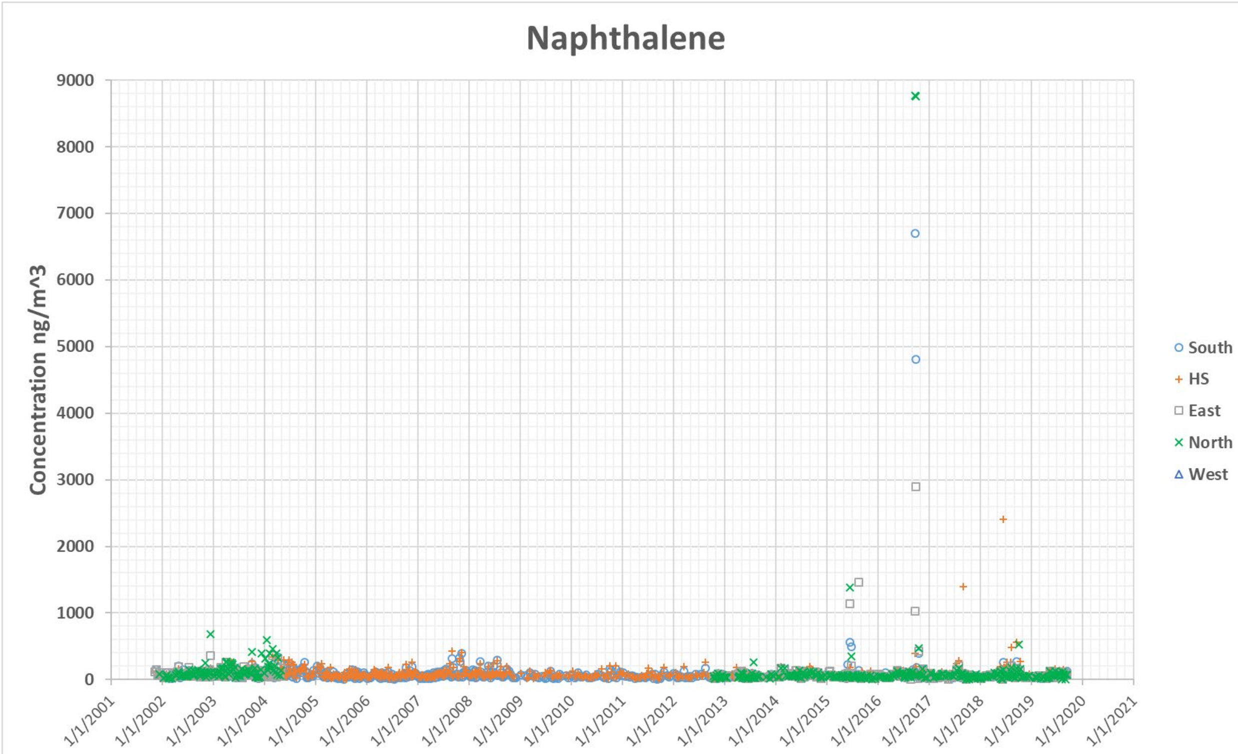


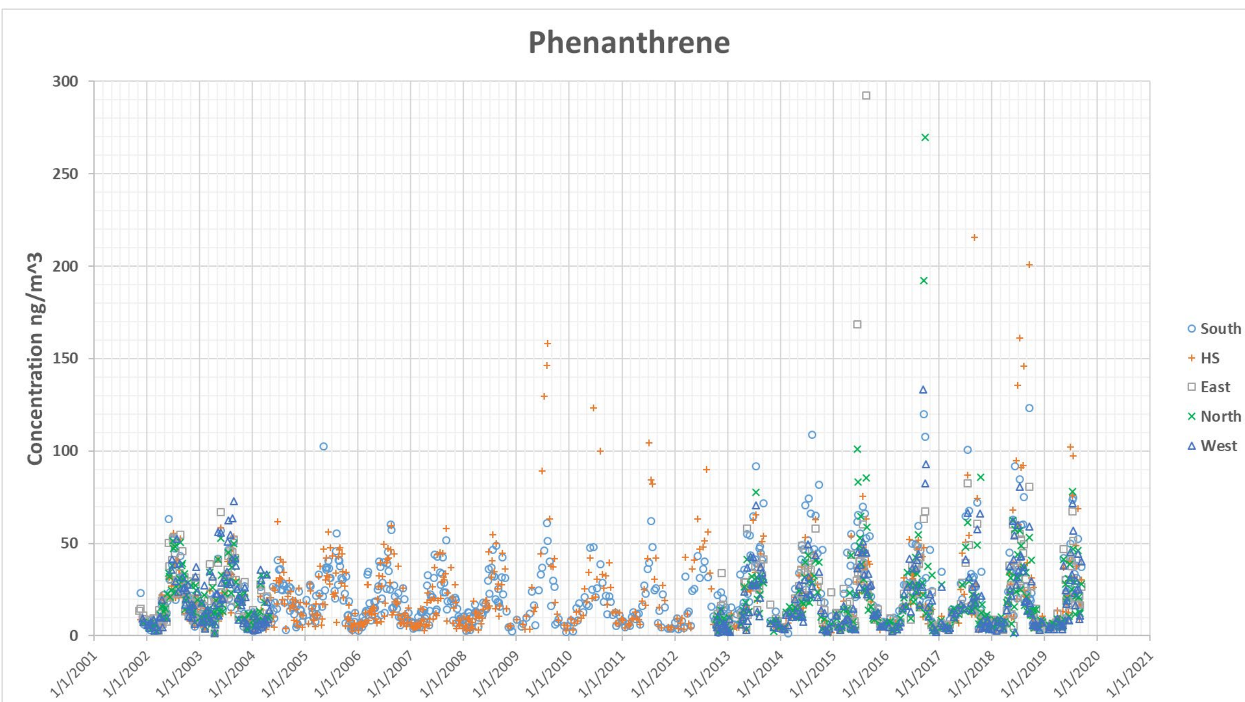
Figures 7 and 8. Atmospheric concentrations of Acenaphthene and Acenaphthylene (ng/m^3) from all stations over the entire monitoring period.





Figures 9 and 10. Atmospheric concentrations of Fluoranthene and Fluorene (ng/m^3) from all stations over the entire monitoring period.





Figures 11 and 12. Atmospheric concentrations of Naphthalene and Phenanthrene (ng/m^3) from all stations over the entire monitoring period.

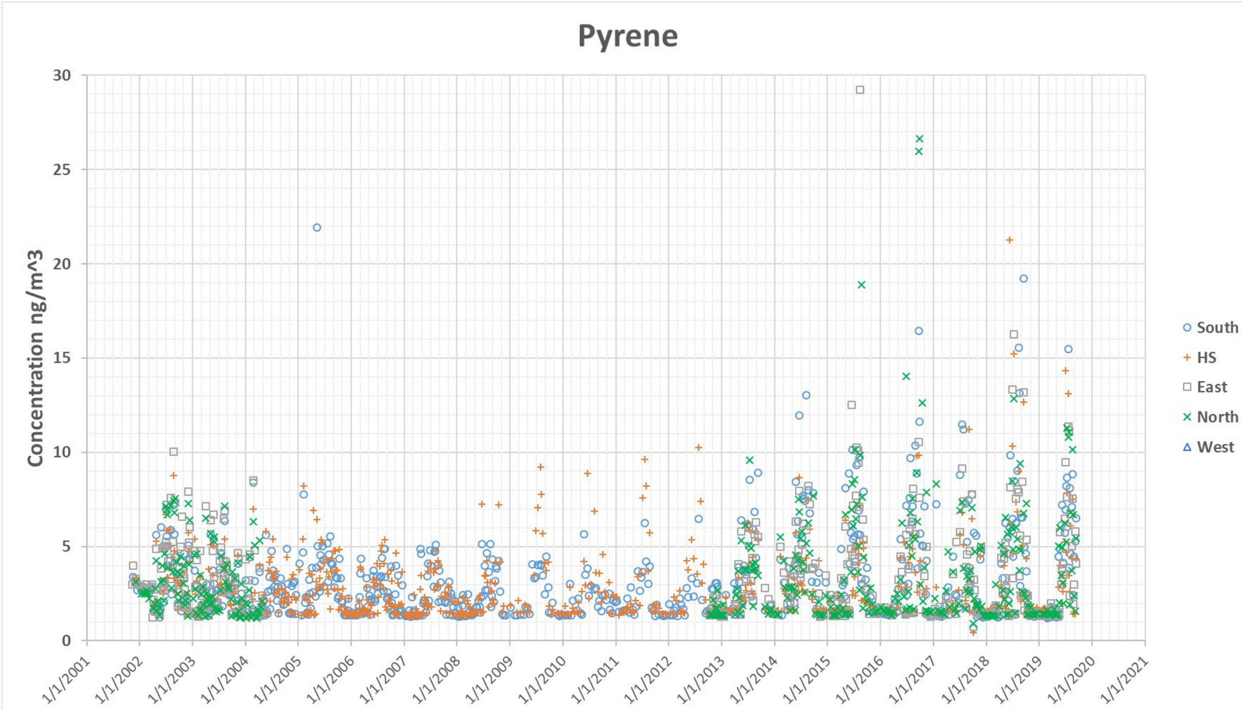
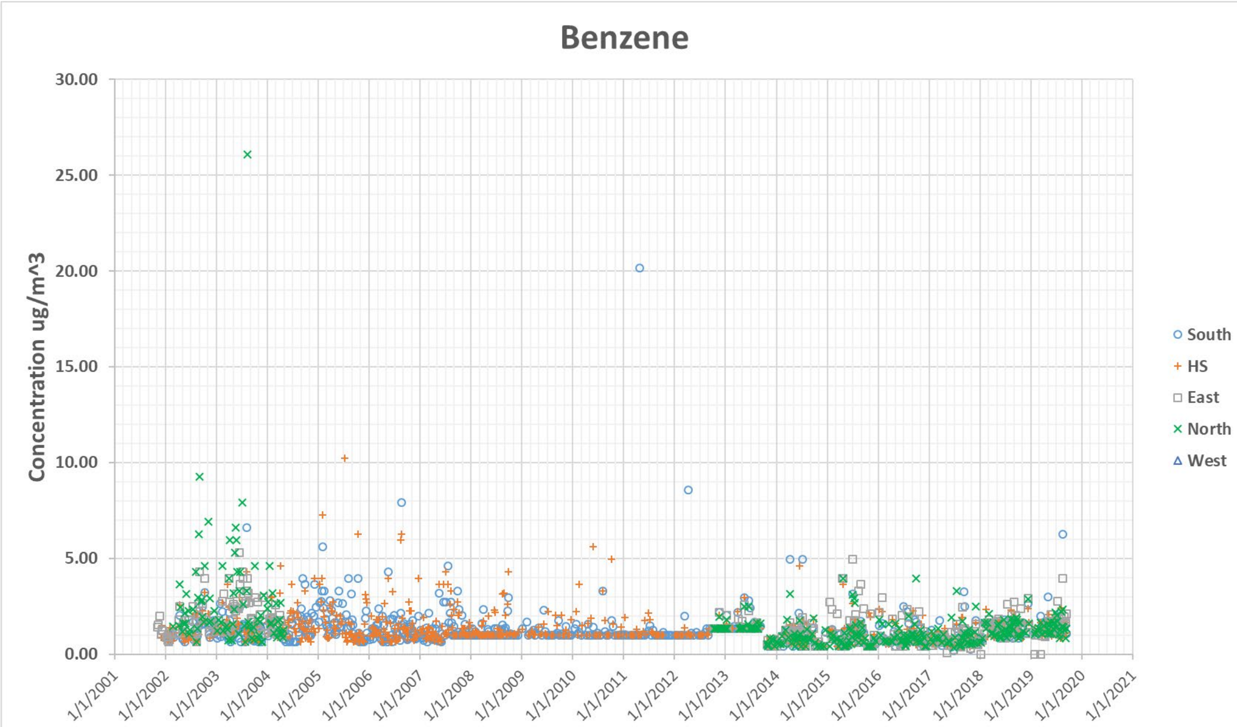
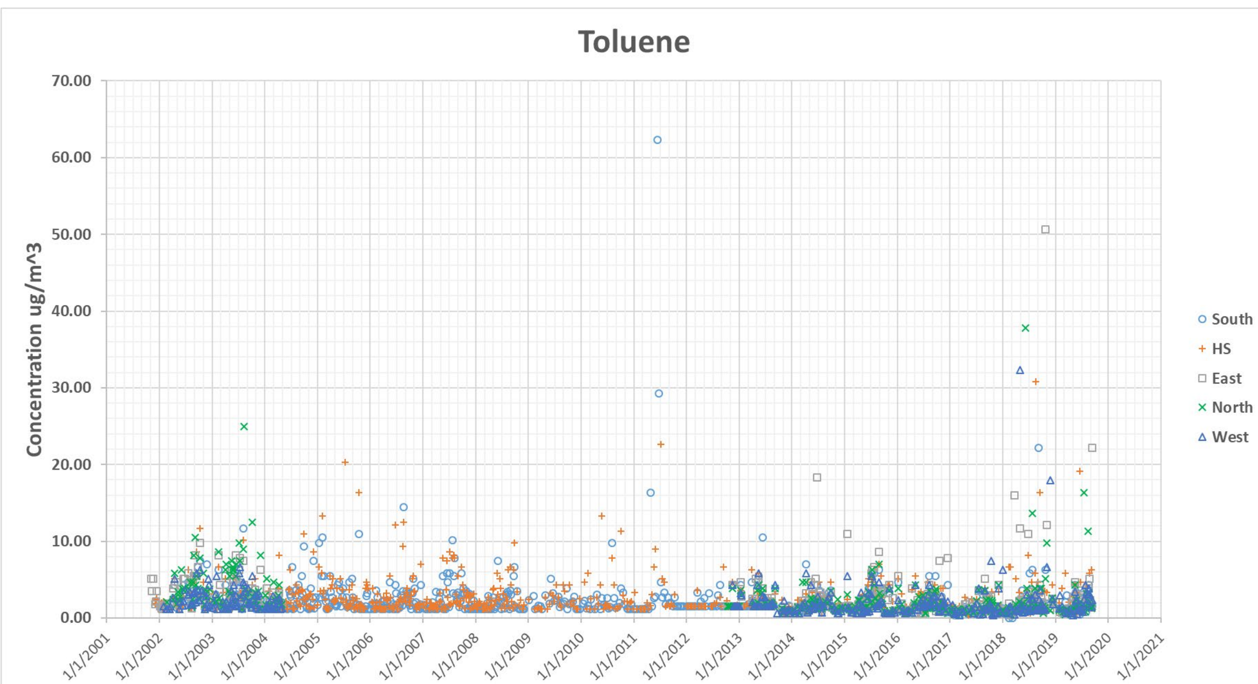
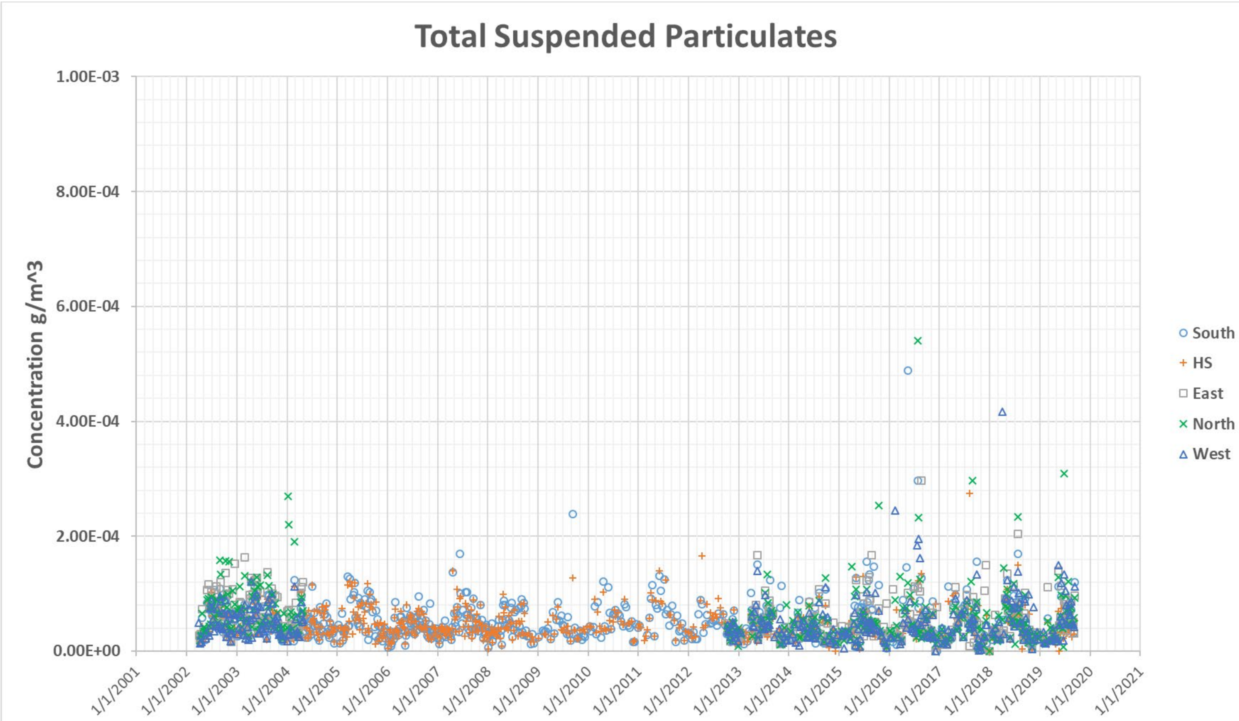


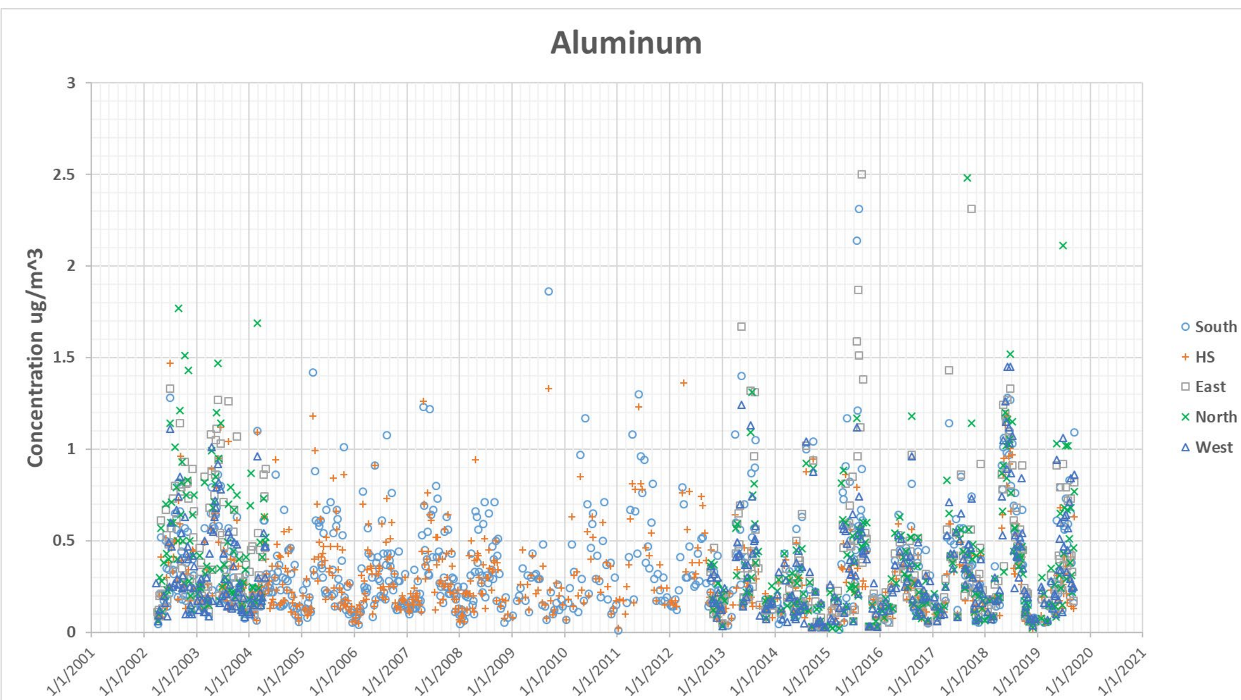
Figure 13. Atmospheric concentrations of Pyrene (ng/m^3) from all stations over the entire monitoring period.



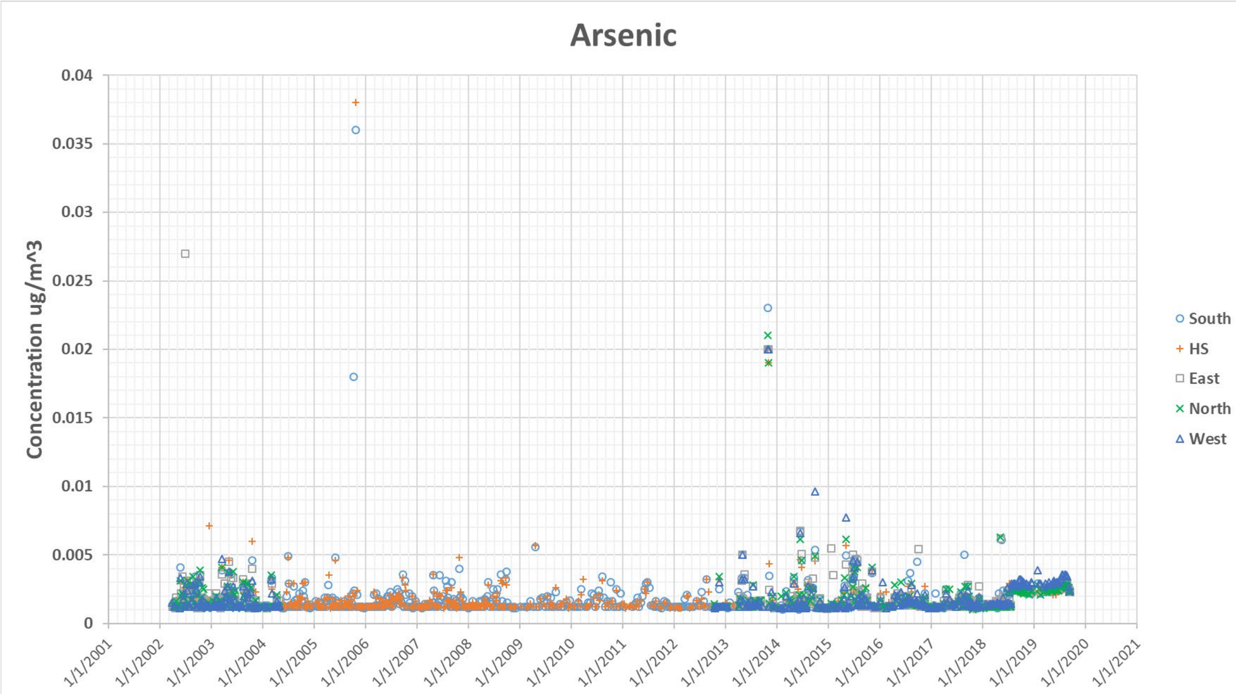


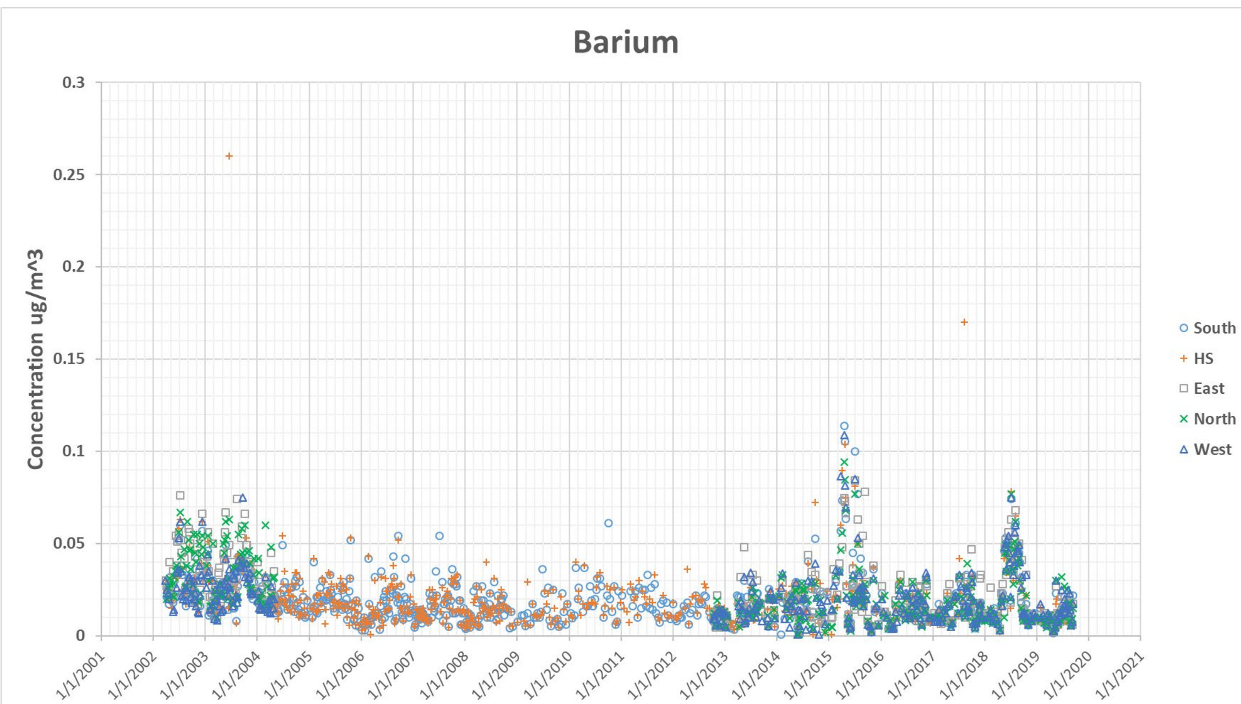
Figures 14 and 15. Atmospheric concentrations of Benzene and Toluene (ug/m^3) from all stations over the entire monitoring period.



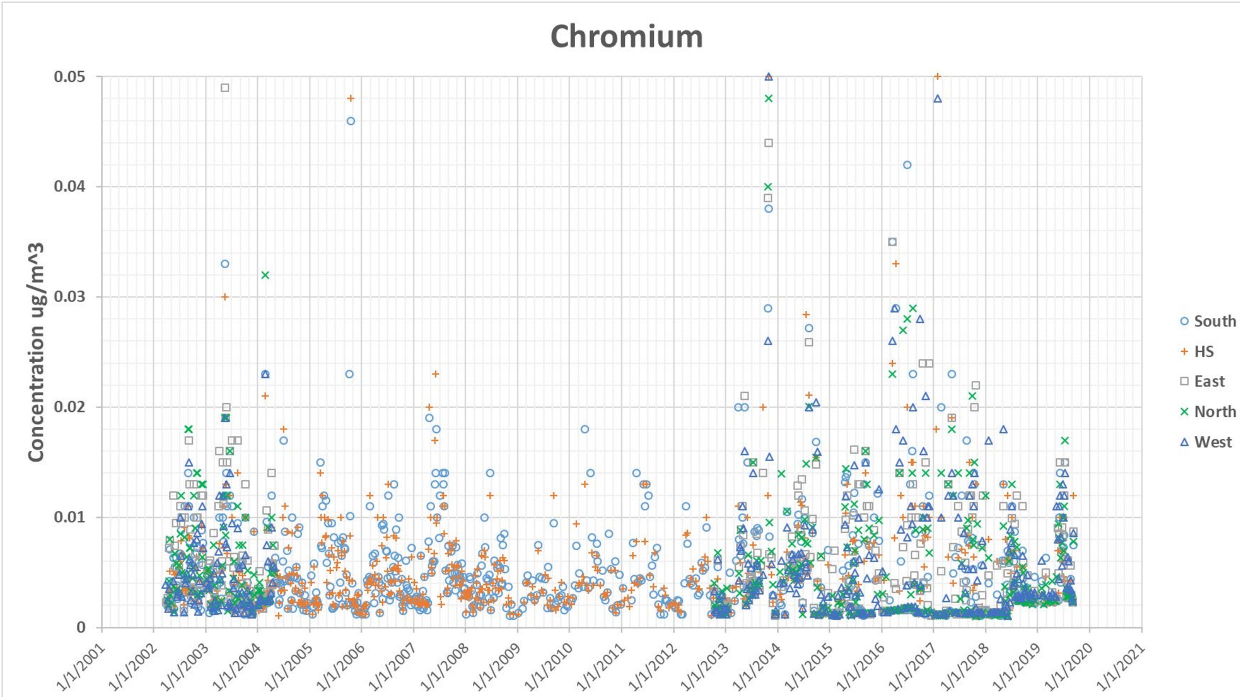


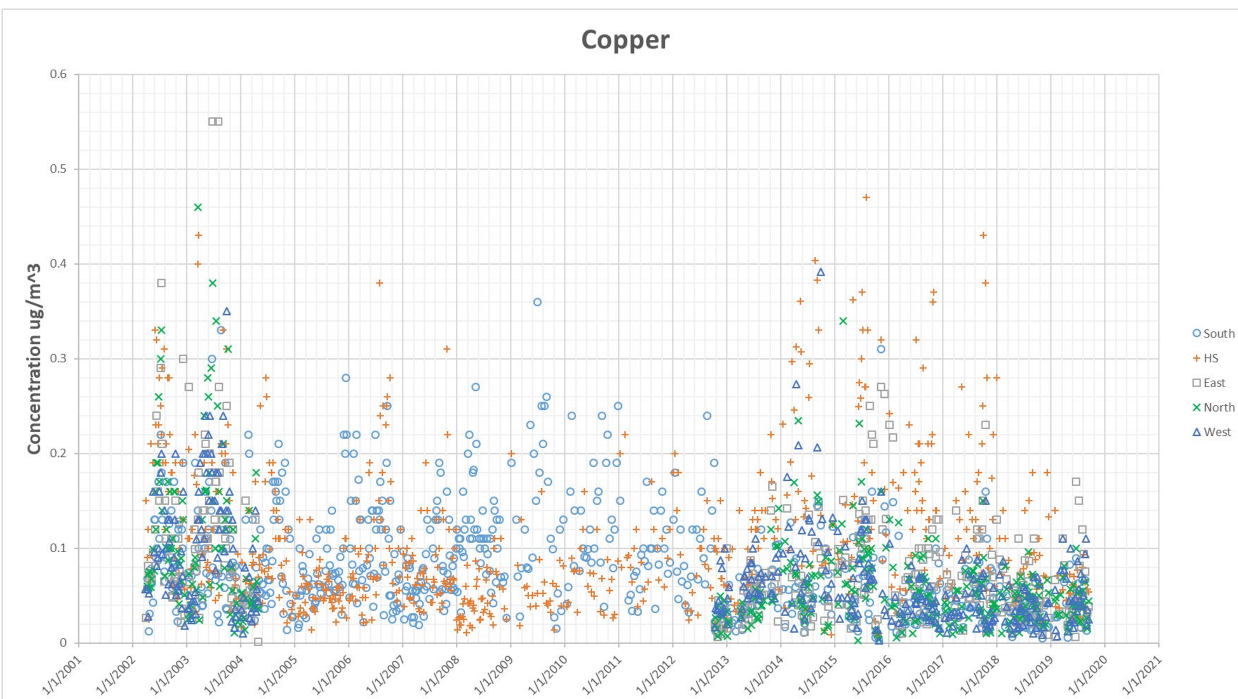
Figures 16 and 17. Atmospheric concentrations of Total Suspended Particulates (g/m^3) and Aluminum (ug/m^3) from all stations over the entire monitoring period.



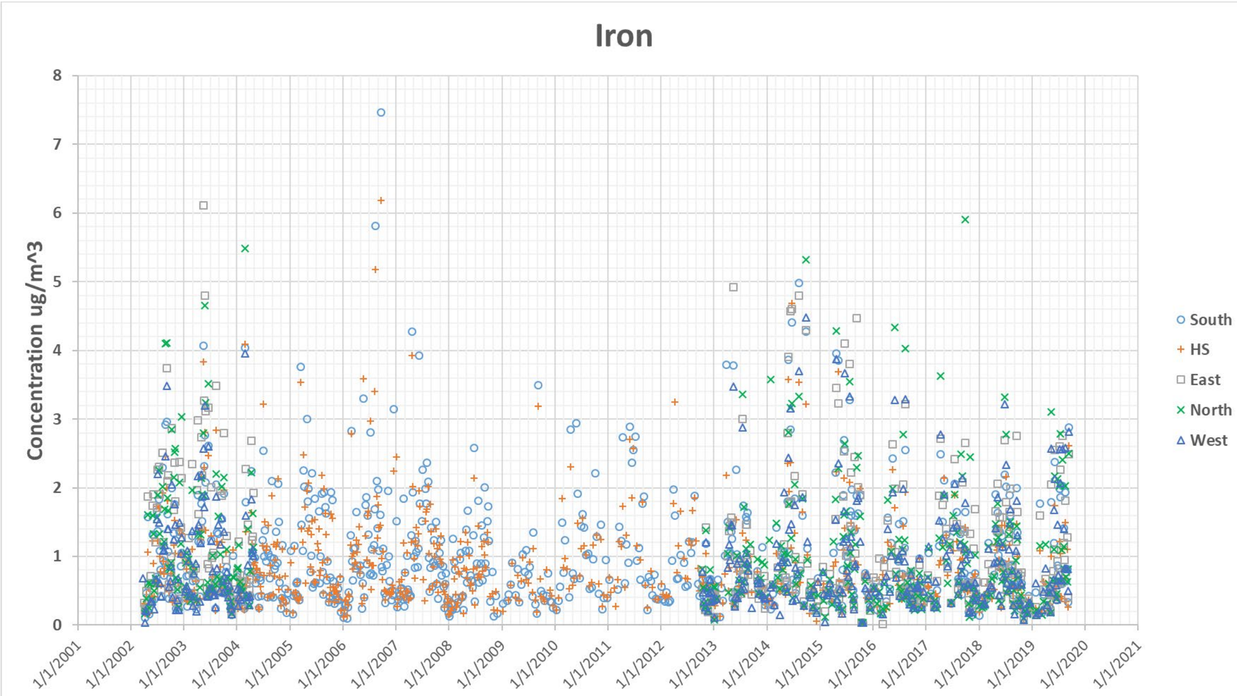


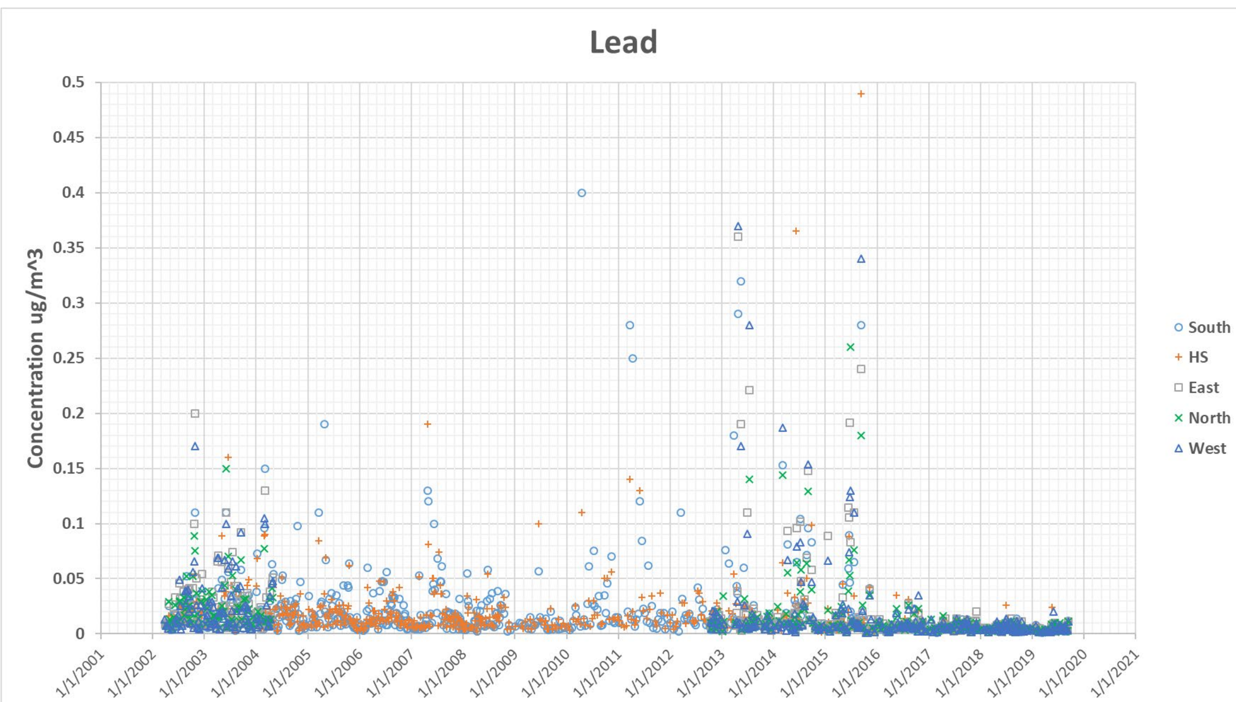
Figures 18 and 19. Atmospheric concentrations of Arsenic and Barium (ug/m^3) from all stations over the entire monitoring period.



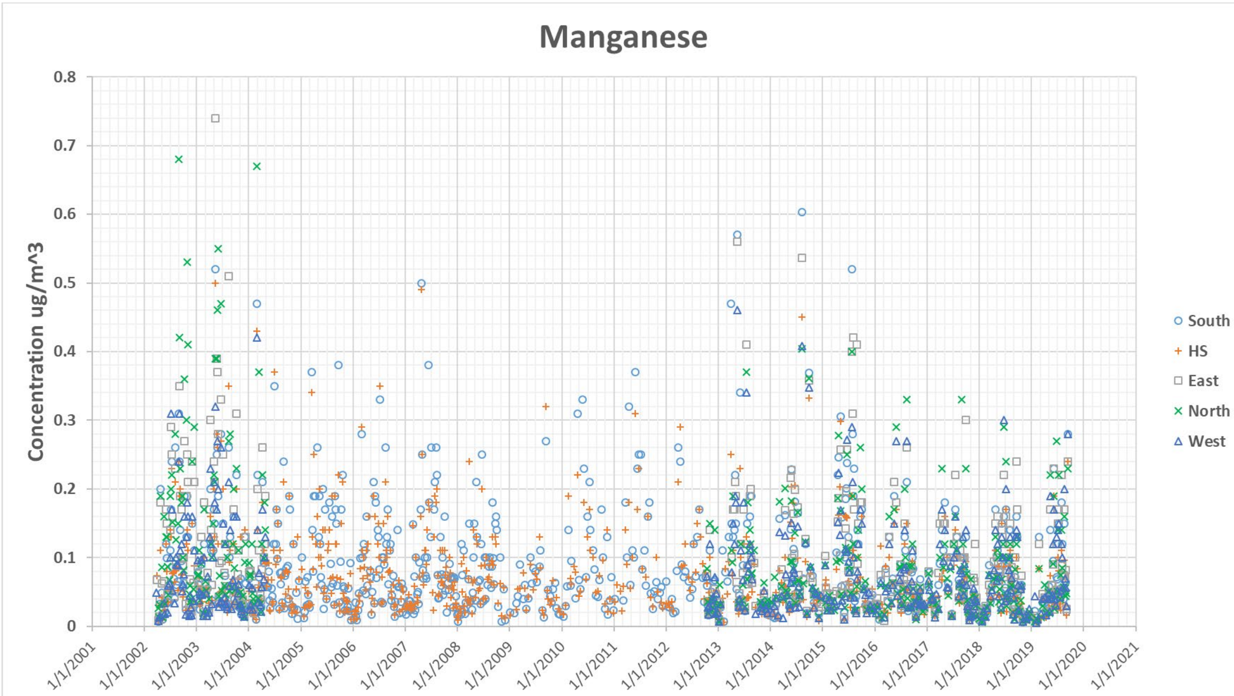


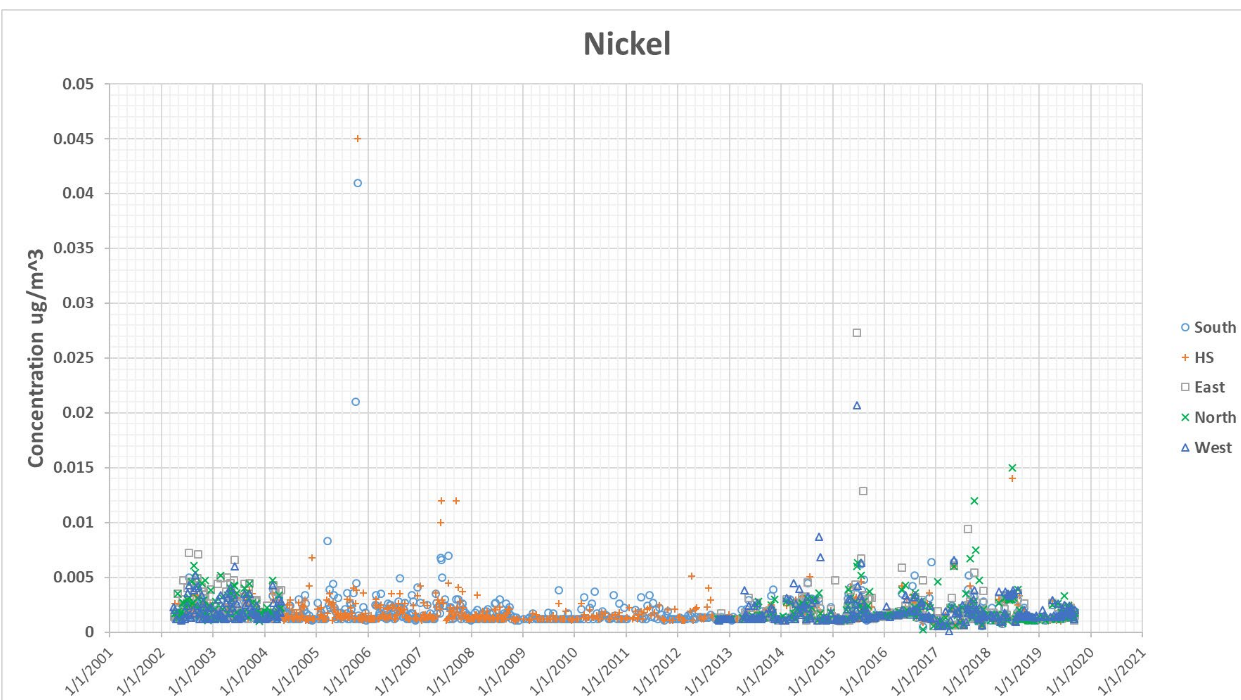
Figures 20 and 21. Atmospheric concentrations of Chromium and Copper (ug/m^3) from all stations over the entire monitoring period.



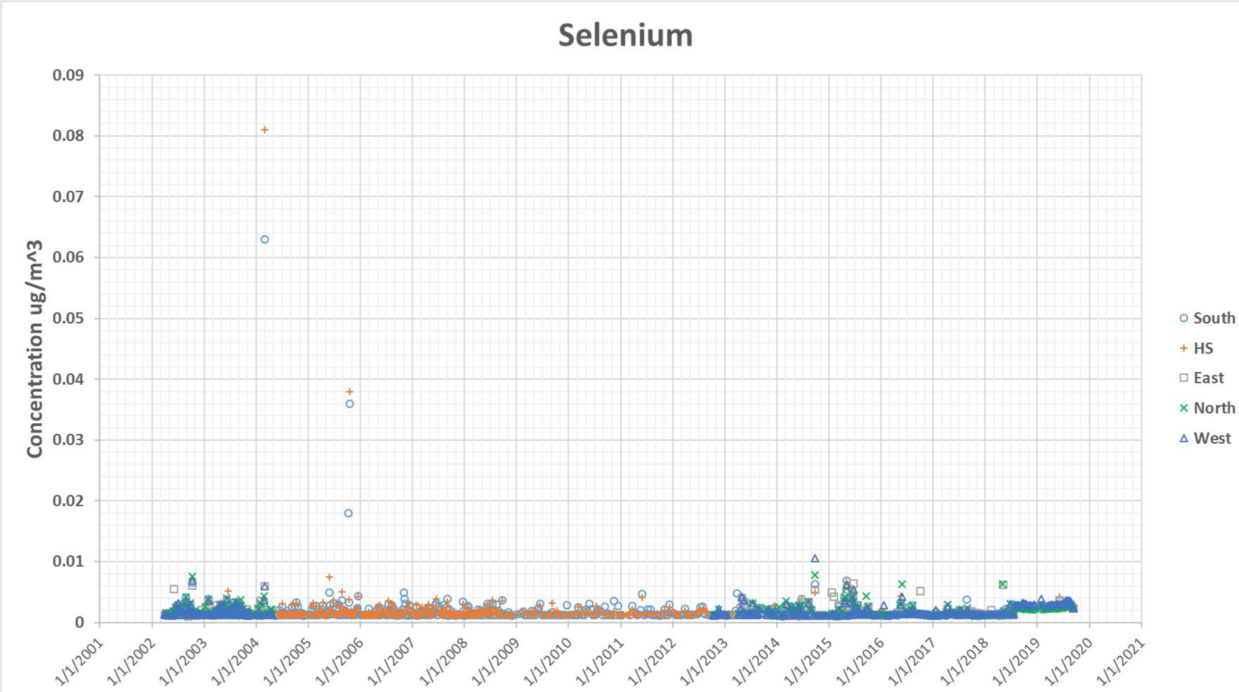


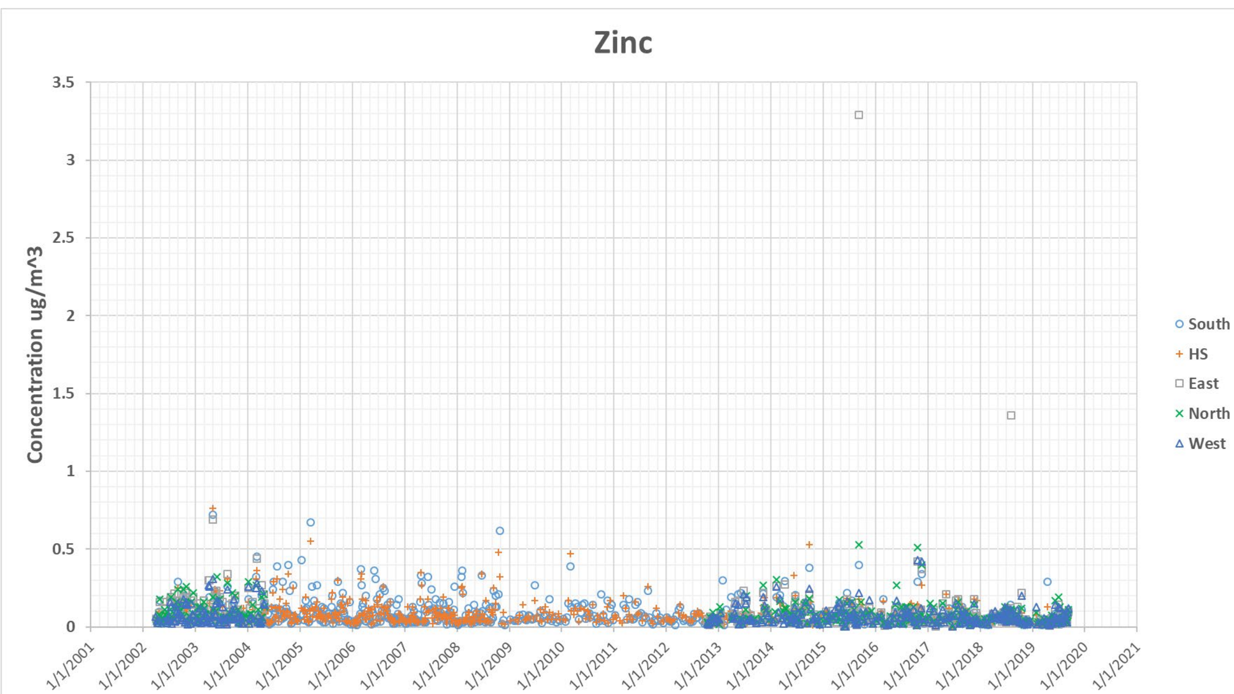
Figures 22 and 23. Atmospheric concentrations of Iron and Lead (ug/m^3) from all stations over the entire monitoring period.





Figures 24 and 25. Atmospheric concentrations of Manganese and Nickel (ug/m^3) from all stations over the entire monitoring period.





Figures 26 and 27. Atmospheric concentrations of Selenium and Zinc (ug/m^3) from all stations over the entire monitoring period.

Table 1a. Statistical description of measured PCB (pg/m^3). Presented in USACE 2020.

Table 1b. Statistical description of measured PAH (ng/m^3) concentrations from 2010-2019.

	Number of Observations	% NDs	Minimum Detected Data	Maximum Detected Data	KM Mean	KM SD	50%ile
North Ace	266	10.90%	1.4	360.6	12.24	26.43	7.65
East Ace	253	5.93%	1.3	118.3	11.89	12.9	9.21
West Ace	255	7.45%	1.3	140.4	12.67	17.36	8.7
South Ace	339	5.60%	1.34	140.6	14.92	14.99	11.8
HS Ace	352	4.83%	1.55	1643	19.85	90.58	7.73
North Acy	266	76.32%	0.6	300.1	4.147	26.62	1.47
East Acy	253	75.89%	1.3	323.6	4.309	24.71	1.44
West Acy	255	81.18%	0.32	150.4	2.148	11.23	1.44
South Acy	339	68.73%	0.46	167.4	2.604	12.33	1.46
HS Acy	352	80.97%	0.24	18.41	0.731	1.646	1.62
North Fla	266	18.05%	1.17	20.84	5.145	4.499	3.28
East Fla	253	16.60%	1.299	55.68	5.174	5.211	3.37
West Fla	255	18.82%	0.9	21.01	4.896	4.064	3.36
South Fla	339	15.34%	0.79	27.81	4.816	4.072	3.47
HS Fla	352	18.75%	0.82	45.32	5.521	5.974	3.365
North Flo	266	7.52%	1.41	266.4	12.12	23.01	7.16
East Flo	253	5.53%	1.44	295.8	12.67	22.22	8.62
West Flo	255	3.53%	1.28	136.2	11.47	14.31	7.31
South Flo	339	3.54%	1.66	118.9	14.43	14.78	10.97
HS Flo	352	4.26%	1.6	1048	16.05	58.91	6.86
North Nap	266	1.50%	8.89	8768	134	757.6	51.63
East Nap	253	1.58%	14.46	2901	87.48	221.3	55.35
West Nap	254	2.36%	7.4	3130	87.44	260.7	50
South Nap	338	0.59%	6.48	6698	97.27	446	50.69
HS Nap	352	1.42%	6.51	2408	80.97	155.2	52.37
North Phe	267	7.49%	2.4	269.9	20.77	25.37	13.68
East Phe	254	3.94%	2.59	292.3	22.03	25.2	15.54
West Phe	256	4.30%	2.05	133.3	19.61	18.37	13.14
South Phe	339	3.83%	2.34	123.3	25	21.22	19.66
HS Phe	352	0.28%	1.95	934.8	26.36	55.95	12.93
North Pyr	266	49.25%	0.91	300.1	5.306	26.54	1.655
East Pyr	253	46.25%	1.34	323.6	5.299	24.69	1.57
West Pyr	255	57.25%	0.61	150.4	3.215	11.2	1.52
South Pyr	339	48.97%	0.69	167.4	3.823	12.39	1.66
HS Pyr	352	42.05%	0.41	21.25	2.547	2.718	1.985

Data are original (not temperature-corrected).

Table 1c. Statistical description of measured VOC (ug/m^3) concentrations from 2010-2019.

	Number of Observations	% NDs	Minimum Detected Data	Maximum Detected Data	KM Mean	KM SD	50%ile
North Benzene	267	19.10%	0.33	3.965	1.07	0.6	1.057
East Benzene	256	19.92%	0.0661	4.956	1.178	0.75	1.189
West Benzene	255	25.88%	0.33	4.956	1.005	0.618	1.057
South Benzene	338	33.14%	0.172	20.15	1.105	1.321	1.024
HS Benzene	345	33.04%	0.396	5.616	1.037	0.656	1.024
North Toluene	267	10.49%	0.468	109.1	2.41	7.12	1.52
East Toluene	253	8.70%	0.335	155.9	3.212	10.4	1.832
West Toluene	255	12.94%	0.359	32.35	1.89	2.496	1.481
South Toluene	342	21.05%	0.366	779.4	5.951	50.13	1.559
HS Toluene	346	17.34%	0.386	506.6	4.844	30.2	1.656

Data are original (not temperature-corrected).

Table 1d. Statistical description of measured TSP (g/m^3) and Metals (ug/m^3) concentrations from 2010-2019.

	Number of Observations	% NDs	Minimum Detected Data	Maximum Detected Data	KM Mean	KM SD	50%ile
North TSP	262	0.38%	3.87E-06	0.067	3.96E-04	0.00436	4.11E-05
East TSP	260	0.38%	9.80E-08	0.0568	3.92E-04	0.00402	4.27E-05
West TSP	258	0.00%	1.04E-07	0.065	3.86E-04	0.00426	3.99E-05
South TSP	339	0.29%	9.48E-08	0.0744	5.16E-04	0.0048	4.45E-05
HS TSP	343	0.87%	3.81E-07	0.0529	3.48E-04	0.00346	3.81E-05
North Al	260	3.46%	0.0227	2.48	0.363	0.33	0.27
East Al	260	3.08%	0.019	2.5	0.401	0.382	0.281
West Al	257	3.50%	0.0298	1.45	0.342	0.278	0.26
South Al	341	2.93%	0.01	2.31	0.381	0.328	0.28
HS Al	342	4.09%	0.019	1.36	0.289	0.234	0.22
North As	263	64.64%	0.00119	0.021	0.00159	0.0018	0.0014
East As	262	63.74%	0.00109	0.02	0.0017	0.00183	0.00145
West As	260	67.31%	0.00122	0.02	0.00168	0.00188	0.0015
South As	341	61.29%	0.0011	0.023	0.00165	0.00176	0.0014
HS As	343	63.27%	0.0012	0.02	0.0015	0.00154	0.0013
North Ba	264	1.14%	0.00164	0.0942	0.0179	0.014	0.014
East Ba	263	0.38%	0.0021	0.084	0.0202	0.0146	0.015
West Ba	260	1.15%	0.0021	0.109	0.0189	0.0152	0.0145
South Ba	343	1.46%	0.0015	0.114	0.0188	0.0151	0.015
HS Ba	345	1.45%	0.0014	0.17	0.0184	0.0161	0.0146
North Cr	264	32.20%	0.001	0.053	0.00535	0.00674	0.003
East Cr	263	27.38%	0.0011	0.051	0.00574	0.00663	0.0038
West Cr	259	32.05%	0.0011	0.05	0.00562	0.00657	0.0034
South Cr	343	27.11%	0.0012	0.056	0.00551	0.00633	0.0037
HS Cr	345	28.70%	0.00118	0.05	0.00481	0.0056	0.0035
North Cu	264	0.00%	0.00278	0.34	0.0543	0.0405	0.0459
East Cu	263	0.00%	0.0061	0.27	0.064	0.0474	0.051
West Cu	260	0.00%	0.0028	0.391	0.0572	0.0427	0.0475
South Cu	343	0.00%	0.0023	0.31	0.0627	0.0474	0.047
HS Cu	344	0.29%	0.00827	0.47	0.115	0.0835	0.092
North Fe	263	0.00%	0.033	5.91	0.99	0.926	0.65
East Fe	262	0.38%	0.0154	4.92	1.062	0.932	0.725
West Fe	259	0.39%	0.037	4.477	0.918	0.787	0.633
South Fe	342	0.58%	0.086	4.986	0.988	0.81	0.67
HS Fe	344	0.29%	0.031	4.685	0.809	0.64	0.59
North Pb	264	2.27%	8.80E-04	0.26	0.0123	0.0255	0.00631

East Pb	263	1.90%	0.0013	0.36	0.0165	0.0382	0.0066
West Pb	260	2.69%	0.0013	0.37	0.0166	0.0418	0.00669
South Pb	343	1.75%	0.0012	0.4	0.0195	0.044	0.00783
HS Pb	345	1.74%	0.0012	0.49	0.015	0.0358	0.00815
North Mn	264	0.00%	0.0061	0.404	0.079	0.0738	0.054
East Mn	263	0.00%	0.0057	0.56	0.0903	0.0858	0.061
West Mn	260	0.00%	0.0051	0.46	0.0746	0.0693	0.0515
South Mn	343	0.00%	0.0063	0.603	0.0892	0.0852	0.062
HS Mn	345	0.00%	0.0059	0.45	0.067	0.0594	0.047
North Ni	262	47.33%	2.20E-04	0.012	0.00149	0.0013	0.0015
East Ni	262	47.71%	0.001	0.0273	0.00165	0.00196	0.0015
West Ni	259	49.42%	1.10E-04	0.0207	0.00149	0.00168	0.0015
South Ni	341	47.51%	5.10E-04	0.0064	0.00146	0.00101	0.0014
HS Ni	343	48.10%	7.40E-04	0.0051	0.0014	8.54E-04	0.0013
North Se	264	69.32%	0.00117	0.00784	0.00143	8.61E-04	0.0014
East Se	261	70.11%	0.00121	0.00638	0.00141	8.36E-04	0.0014
West Se	260	71.54%	0.0012	0.0106	0.00149	9.20E-04	0.0014
South Se	342	67.54%	0.0012	0.00694	0.00144	8.39E-04	0.0013
HS Se	344	68.02%	0.001	0.0067	0.00134	6.89E-04	0.0013
North Zn	264	0.76%	0.0083	0.53	0.0701	0.0636	0.056
East Zn	263	1.14%	0.00614	3.29	0.0867	0.22	0.058
West Zn	260	1.15%	0.012	0.43	0.0686	0.0547	0.0565
South Zn	343	0.58%	0.00806	0.4	0.0725	0.0605	0.0547
HS Zn	345	0.87%	0.00518	0.529	0.0684	0.0567	0.052

Table 2. Spearman correlation coefficients between PCB (upper right), PAH (bottom left), VOC, TSP, and Metals concentrations[a] at all sites from 2010 - 2016.

	8	**15**	**18**	**28**	**31**	**11**	**1**	**S_{18} PCBs**	**S_{209} PCBs**	
		0.895	0.910	0.922	0.927	0.127	0.759	0.896	0.962	**8**
Ace			0.922	0.946	0.940	0.139	0.720	0.913	0.970	**15**
Acy	0.295			0.982	0.981	0.028	0.675	0.944	0.975	**18**
Fla	0.774	0.280			0.995	0.078	0.704	0.953	0.990	**28**
Flo	0.943	0.308	0.828			0.065	0.695	0.951	0.987	**31**
Nap	0.487	0.414	0.365	0.453			0.305	0.074	0.073	**11**
Phe	0.887	0.271	0.914	0.932	0.408			0.699	0.722	**1**
Pyr	0.740	0.352	0.891	0.792	0.409	0.868			0.981	**S_{18} PCBs**
	Ace	**Acy**	**Fla**	**Flo**	**Nap**	**Phe**	**Pyr**			

	Toluene
Benzene	0.669

	TSP	**Al**	**As**	**Ba**	**Cr**	**Cu**	**Fe**	**Pb**	**Mn**	**Ni**	**Se**	**Zn**
TSP		0.733	0.472	0.438	0.359	0.117	0.707	0.446	0.689	0.453	0.462	0.362
Al			0.473	0.452	0.375	0.039	0.753	0.464	0.744	0.447	0.462	0.329
As				0.391	0.447	0.239	0.597	0.483	0.497	0.539	0.676	0.392
Ba					0.304	0.373	0.527	0.451	0.433	0.375	0.314	0.507
Cr						0.134	0.633	0.420	0.538	0.475	0.356	0.417
Cu							0.198	0.289	0.074	0.188	0.158	0.258
Fe								0.636	0.636	0.579	0.508	0.570
Pb									0.564	0.314	0.372	0.578
Mn										0.472	0.455	0.536
Ni											0.493	0.391
Se												0.331

NOTE: a) Measured data (NOT temp corrected)

Table 3. Statistically significant trends[a] of atmospheric PCB (presented in USACE 2020), PAH, VOCs, TSP and metals concentrations over time and by site[b]. 'I' indicates a significant increase, 'D' indicates a significant decrease, and '-' indicates no significant trend.

	H 2001-2019	S 2001-2019	H 2010-2019	S 2010-2019	E 2012-2019	N 2012-2019	W 2012-2019
PCB 8	Presented in USACE 2020						
PCB 15							
PCB 18							
PCB 28							
PCB 31							
Sum 18 PCBs							
Ace	I	I	-	I	-	-	-
Acy	D	D	D	D	D	D	-
Fla	-	-	-	I	-	-	-
Flo	-	I	-	-	-	-	-
Nap	D	D	-	-	-	-	I
Phe	-	I	D	I	-	-	-
Pyr	-	-	-	I	I	I	I
Benz	D	D	-	-	-	-	I
Tol	D	D	D	D	-	D	-
TSP	D	-	D	-	I	-	I
Al	D	-	-	-	I	I	I
As	I	I	I	I	I	I	I
Ba	D	D	D	-	-	-	-
Cr	D	-	-	-	-	-	-
Cu	-	D	-	D	D	D	-
Fe	D	-	D	-	-	-	-
Pb	D	D	D	D	D	D	D
Mn	D	-	D	D	-	-	-
Ni	D	D	-	-	-	I	-
Se	I	I	I	I	I	I	I
Zn	D	D	D	D	D	-	-

Statistically significant trends over time using Mann-Kendall trend analysis at the 5% significance level. [b]All 2010-2019 data except Acy, the metals and TSP are temperature-corrected. The 2001-2019 trends are performed on non-temperature-corrected data.

Table 4. Two-sample two-tailed Gehan test for significant differences[a] in PCBs (presented in USACE 2020), PAHs, VOCs, TSP, and Metals concentrations between seasons from 2010-2019.

	High School			***CDF Site***		
	Sum-Win	Sum-Sp/F	Sp/F-Win	Sum-Win	Sum-Sp/F	Sp/F-Win
PCB 8	Presented in USACE 2020					
PCB 15						
PCB 18						
PCB 28						
PCB 31						
PCB-Sum5						
PCB-Sum18						
PCB-Sum209						
PCB 1						
PCB 11						
Ace	-	-	-	-	-	-
Acy	<	-	-	>	>	-
Fla	-	>	<	>	>	<
Flo	-	>	<	>	>	-
Nap	-	-	<	-	-	-
Phe	-	>	<	-	>	-
Pyr	>	>	-	>	>	-
Benz	-	-	-	>	>	-
Tol	-	-	-	>	>	-
TSP	>	>	>	>	>	>
Al	>	>	>	>	>	>
As	>	>	>	>	>	>
Ba	>	>	>	>	>	>
Cr	>	-	>	>	>	>
Co	>	-	-	-	-	-
Cu	-	>	-	-	>	<
Fe	>	>	>	>	>	>
Pb	>	-	-	>	>	-
Mn	>	>	>	>	>	>
Ni	>	>	>	>	>	>
Se	>	-	-	>	>	>
Zn	>	-	-	>	>	>

[a] > indicates greater than, < indicates less than, and - indicates no significant difference using a significance level of 5%. [b] All data except Acy, Nap, TSP, and metals are temperature-corrected. Two results are shown for Acy and Nap: the first is from temperature-corrected data, the second is from non-temperature corrected data dated.

Table 5. Two-sample two-tailed Gehan test for significant differences[a] in PCBs (presented in USACE 2020), PAHs, VOCs, and TSP[b] concentrations between monitoring stations from 2012-2019.

	H-S	*H-E*	*H-N*	*H-W*	*S-E*	*S-N*	*S-W*	*E-N*	*E-W*	*N-W*
PCB 8	Presented in USACE 2020									
PCB 15										
PCB 18										
PCB 28										
PCB 31										
PCB 1										
PCB 11										
Sum 18 PCBs										
Sum 209 PCBs										
Ace	<	-	>	>	>	>	>	>	-	-
Acy	<	-	-	-	>	>	>	-	-	-
Fla	-	-	-	-	-	-	-	-	-	-
Flo	<	-	-	-	>	>	>	>	-	-
Nap	-	-	-	>	-	-	-	-	-	-
Phe	<	-	-	-	>	>	>	>	>	-
Pyr	-	-	>	>	-	>	>	-	>	-
Benz	<	<	-	-	-	>	>	>	>	>
Tol	>	-	>	>	<	-	-	>	>	>
TSP	<	<	<	<	-	-	-	-	-	-
Al	<	<	<	<	-	-	-	-	-	-
As	-	-	-	-	-	-	-	-	-	-
Ba	-	<	-	-	-	-	-	-	-	-
Cr	-	<	-	-	-	-	-	-	-	-
Cu	>	>	>	>	<	-	<	>	-	-
Fe	<	<	<	<	-	-	-	-	>	-
Pb	-	-	-	-	-	-	-	-	-	-
Mn	<	<	<	<	-	-	-	-	>	-
Ni	-	-	-	-	-	-	-	-	-	-
Se	-	-	<	-	-	-	-	-	-	-
Zn	-	-	-	-	-	-	-	-	-	-

[a] > indicates greater than, < indicates less than, and - indicates no significant difference using a significance level of 5%. [b] All data except Acy, Nap, TSP, and metals are temperature-corrected. Two results are shown for Acy and Nap: the first is from temperature-corrected data, the second is from non-temperature corrected data dated.

Table 6. Two-sample two-tailed Gehan test for significant differences[a] in PCBs (presented in USACE 2020), PAHs, VOCs, and TSP[b] concentrations among monitoring stations for Discharge (2012-19), Quiescent Pond (2012-19), and Background (2010-12) data.

	Discharge										*Quiescent Pond*										*Background*
	H-S	*H-E*	*H-N*	*H-W*	*S-E*	*S-N*	*S-W*	*E-N*	*E-W*	*N-W*	*H-S*	*H-E*	*H-N*	*H-W*	*S-E*	*S-N*	*S-W*	*E-N*	*E-W*	*N-W*	*H-S*
PCB 8	Presented in USACE 2020																				
PCB 15																					
PCB 18																					
PCB 28																					
PCB 31																					
PCB 1																					
PCB 11																					
Sum 18 PCBs																					
Sum 209 PCBs																					
Ace	<	-	-	-	>	>	>	-	-	-	<	>	>	>	>	>	>	>	-	<	-
Acy	<	<	-	-	-	-	>	-	-	-	<	-	-	-	>	-	>	-	-	-	--
Fla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	>
Flo	<	-	-	-	>	>	>	-	-	-	<	-	>	-	>	>	>	>	-	-	-
Nap	-	-	-	-	-	-	-	-	-	-	>	-	-	>	-	-	-	-	-	-	--
Phe	<	<	-	-	>	>	>	-	>	-	<	-	-	-	>	>	>	>	>	-	-
Pyr	-	-	-	-	-	-	>	-	-	-	-	-	>	>	-	>	>	-	-	-	-
Benz	<	<	<	-	-	-	>	-	>	>	-	<	-	-	-	-	>	>	>	-	<
Tol	-	-	-	-	-	-	-	-	-	-	>	-	>	>	<	-	>	>	>	>	-
TSP	<	<	<	<	-	-	-	-	-	-	<	<	<	<	-	-	-	-	-	-	-
Al	<	<	<	<	-	-	-	-	-	-	<	<	<	<	-	-	-	-	-	-	-
As	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	-	<	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	>	>	>	>	<	-	-	-	-	-	>	>	>	>	<	-	<	-	-	-	<
Fe	<	<	-	-	-	-	-	-	-	-	-	<	<	-	-	-	-	-	-	-	-
Pb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn	<	<	<	-	-	-	-	-	-	-	<	<	<	<	-	-	-	-	-	-	-
Ni	-	<	-	<	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Se	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[a] > indicates greater than, < indicates less than, and - indicates no significant difference using a significance level of 5%. [b] All data except Acy, Nap, TSP, and metals are temperature-corrected. Two results are shown for Acy and Nap: the first is from temperature-corrected data, the second is from non-temperature corrected data dated.

Table 7. Two-sample Gehan test for significant differences[a] in PCBs (presented in USACE 2020), PAHs, VOCs, TSP, and Metals[b] concentrations between dredging activities (Background BG, Discharge D, Quiescent Pond QP) for all sites and by each monitoring station.

	High School			South			East	North	West
	D-BG	**QP-BG**	**D-QP**	**D-BG**	**QP-BG**	**D-QP**	**D-QP**	**D-QP**	**D-QP**
PCB 8	Presented in USACE 2020								
PCB 15									
PCB 18									
PCB 28									
PCB 31									
PCB 1									
PCB 11									
Sum 5 PCBs									
Sum 18 PCBs									
Sum 209 PCBs									
Ace	-	-	-	>	>	>	>	>	>
Acy	-	<	-	-	-	-	>	-	-
Fla	-	-	-	>	>	>	>	>	>
Flo	-	-	-	>	>	>	>	>	-
Nap	-	-	-	>	-	-	-	-	-
Phe	-	-	-	>	>	>	-	>	-
Pyr	-	-	>	>	>	>	>	>	>
Acy (not TC)	-	<	-	-	-	-	>	-	-
Nap (not TC)	-	-	-	>	-	-	-	-	-
Benz	-	-	-	-	<	>	-	>	-
Tol	-	-	-	-	-	-	-	-	>
TSP	<	<	-	-	<	>	>	>	>
Al	-	<	>	>	<	>	>	>	>
As	-	-	-	-	-	-	-	-	-
Ba	-	<	>	-	<	>	>	>	>
Cr	-	<	-	-	-	-	-	-	-
Co	-	-	-	-	-	-	-	>	-
Cu	>	>	-	<	<	-	-	-	-
Fe	<	<	-	-	<	>	-	-	>
Pb	<	<	-	<	<	>	-	-	-
Mn	<	<	>	-	<	>	>	>	>
Ni	-	-	-	-	-	-	>	-	-
Se	-	<	-	-	-	-	-	-	-
Zn	-	<	-	-	-	-	-	-	-

[a] > indicates greater than, < indicates less than, and - indicates no significant difference using a significance level of 5%. [b] All data except Acy, Nap, TSP, and metals are temperature-corrected. Two results are shown for Acy and Nap: the first is from temperature-corrected data, the second is from non-temperature corrected data dated.

Appendix A

Metals Filter Blank Contamination

An issue arose when there was a change of laboratories for the air data analysis in Fall 2013. The new laboratory used blank filters for air sample collection (for metals and total suspended particulates analysis) that were discovered to be have detectable concentrations of several metals.

To address the filter blank contamination issue, USGS developed a procedure to adjust the measured concentrations of selected metals in the environmental samples based on the masses measured on the method filter blanks. The data adjustment consists of subtracting metals concentrations detected on blanks from the environmental samples collected. This procedure is described in further details below.

The laboratory analyzing metals prior to October 1, 2013 was TestAmerica. TestAmerica provided a quartz fiber filter that was used to collect the samples analyzed for metals. Because of a change in the USGS contract, RTI Laboratories began analyzing samples on October 1, 2013. RTI provided a different filter for the collection of metals than TestAmerica. A glass fiber filter was provided instead of the quartz fiber filter. Analysis of glass fiber filters began on November 6, 2013. The method filter blanks for the glass fiber filters had higher concentrations of some metals when compared to the quartz filters. It was decided to adjust the measured concentrations for the samples based on the masses measured on the method filter blanks for all samples collected using the glass fiber filters.

Some contamination for selected metals was observed on quartz fiber filter blanks submitted to TestAmerica. Samples submitted to TestAmerica were not adjusted. To minimize the possibility of a negative bias resulting from over applying a method filter blank correction to the RTI metals data, it was decided to only adjust metals concentrations that had masses measured on the method filter blank greater than the average masses measured on the filters from TestAmerica. The following method was used to blank correct metals concentrations for natural samples analyzed by RTI (USGS 2016).

First the average mass was determined for all filter blanks submitted to TestAmerica.

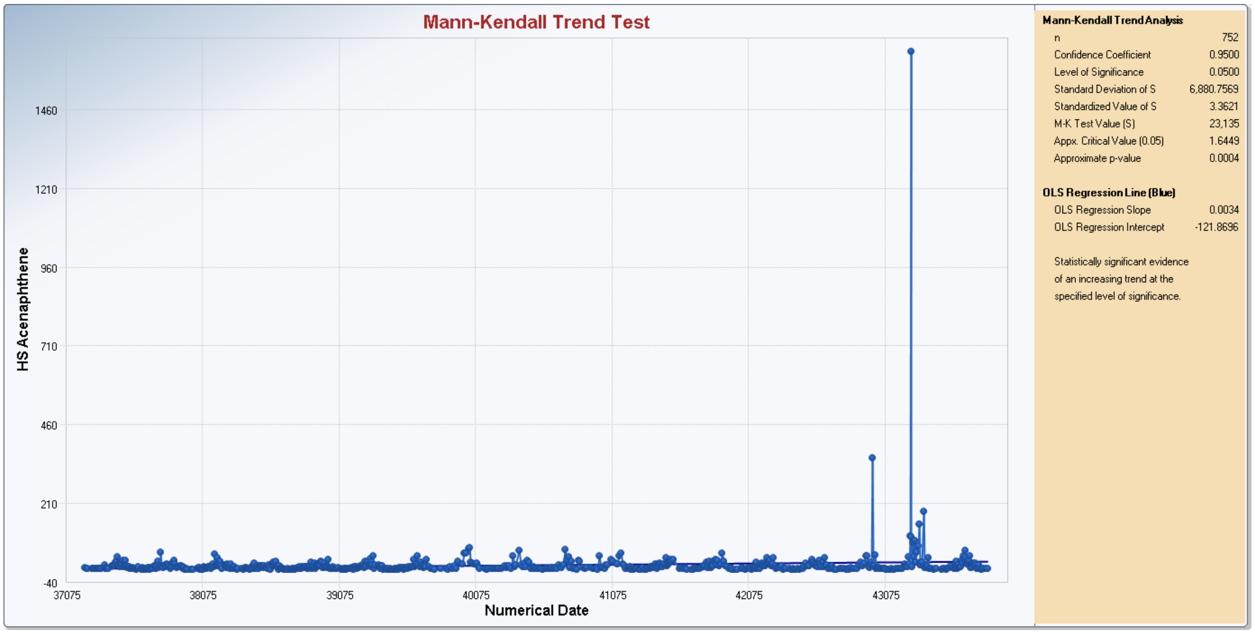
Analyte	Average Mass for Filter Blanks Submitted to TestAmerica (ug)
Barium	13.79
Chromium	4.07
Cobalt	3.38
Copper	2.88
Manganese	1.68
Nickel	2.80
Iron	68.70
Zinc	8.13

The TestAmerica average mass of each metal was compared to method filter blank results from RTI. RTI measures a method filter blank for each analytical run. Environmental samples collected from 2 or 3 sampling dates are usually batched and analyzed during the same analytical run. If the mass measured on a method filter blank analyzed by RTI was greater than the average masses listed in the table above, that mass was then subtracted from the mass determined for the environmental sample. The concentration of each metal then was calculated by dividing the remainder mass by the airflow for each sample.

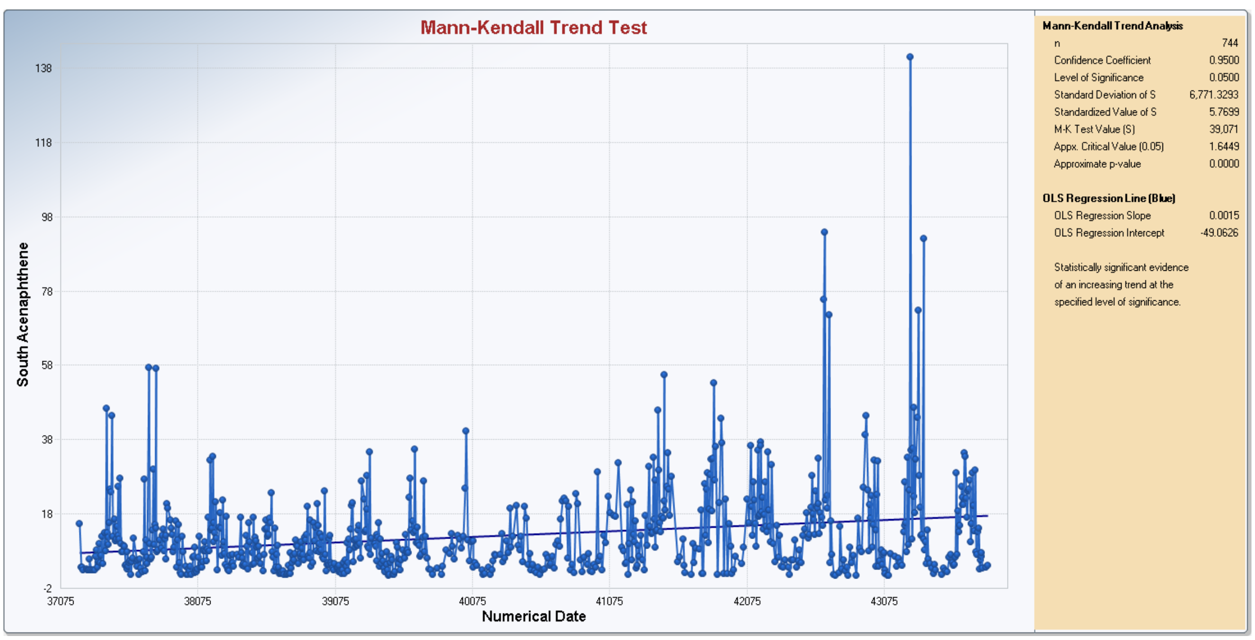
In addition to the metals listed in the table above, aluminum was also adjusted based on the large masses reported for some of the RTI method blanks. All of the blank filters submitted o TestAmerica (78 filter blanks submitted during the period when TestAmerica was analyzing air samples) had results of non-detect for aluminum.

In August 2015 RTI was notified to stop using the glass fiber filters and change to the same type of quartz filter used by TestAmerica. Method filter blank contamination decreased but not to levels consistent with what was observed with TestAmerica. As a result, the adjustments of the environmental data continues for several metals, including aluminum, chromium, copper, manganese, nickel, iron, and zinc.

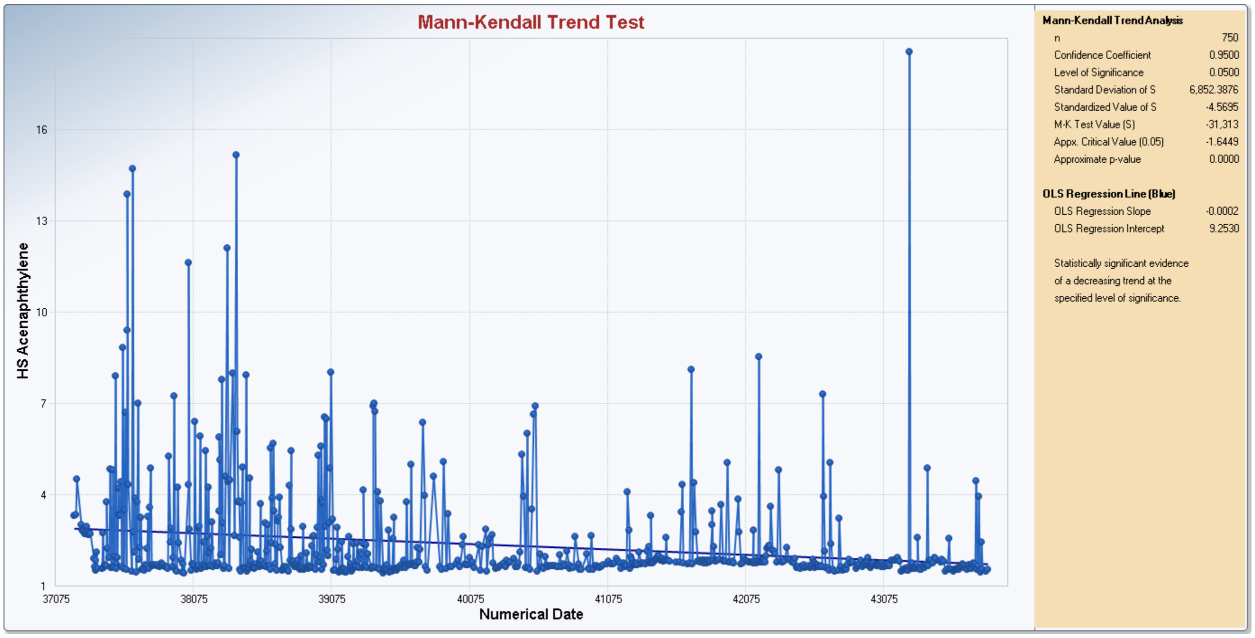
Appendix B
PAH Trends at High School and South Stations
2001-2019 Data



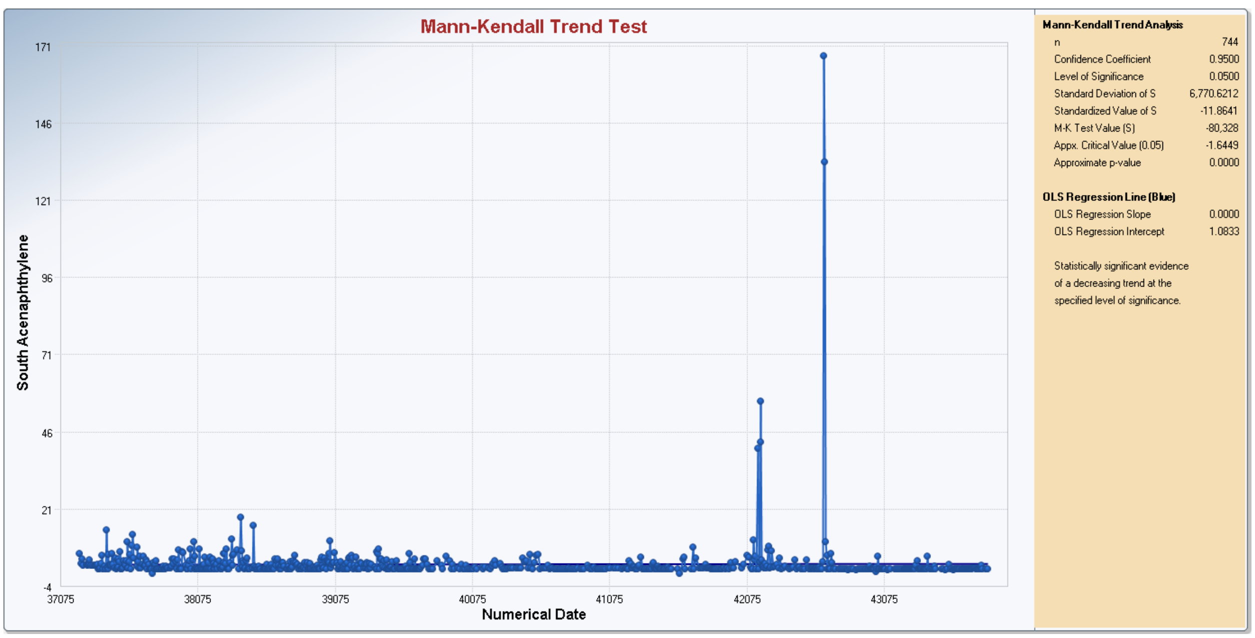
Appendix Figure B1. Mann-Kendall trend for **Acenaphthene** at the **high school station** from 2001 through 2019 with statistically significant evidence of **increasing trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 12/29/2019 [numerical date 43828] for all trend analyses).



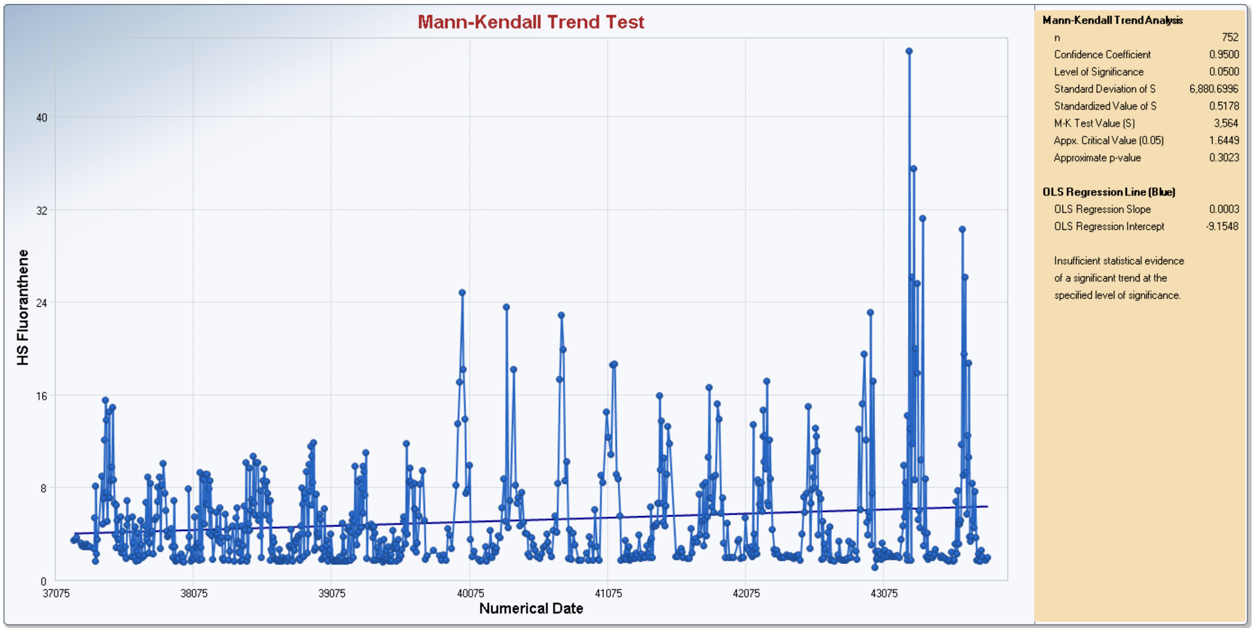
Appendix Figure B2. Mann-Kendall trend for **Acenaphthene** at the **south station** from 2001 through 2019 statistically significant evidence of **increasing trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 12/29/2019 [numerical date 43828] for all trend analyses).



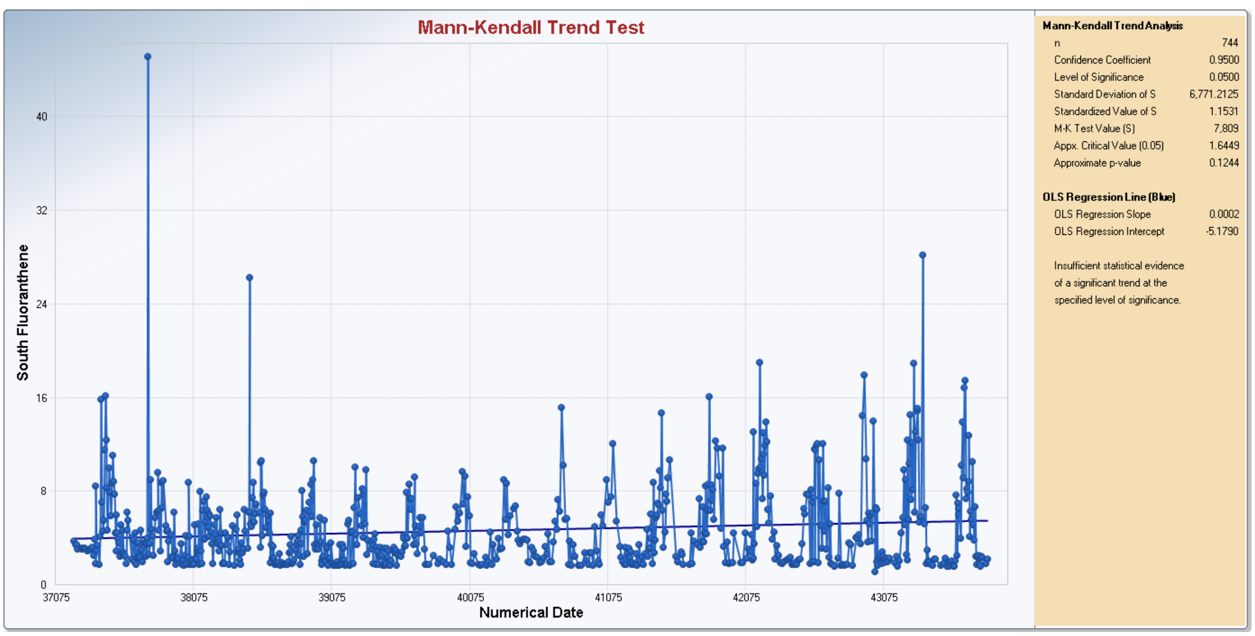
Appendix Figure B3. Mann-Kendall trend for **Acenaphthylene** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



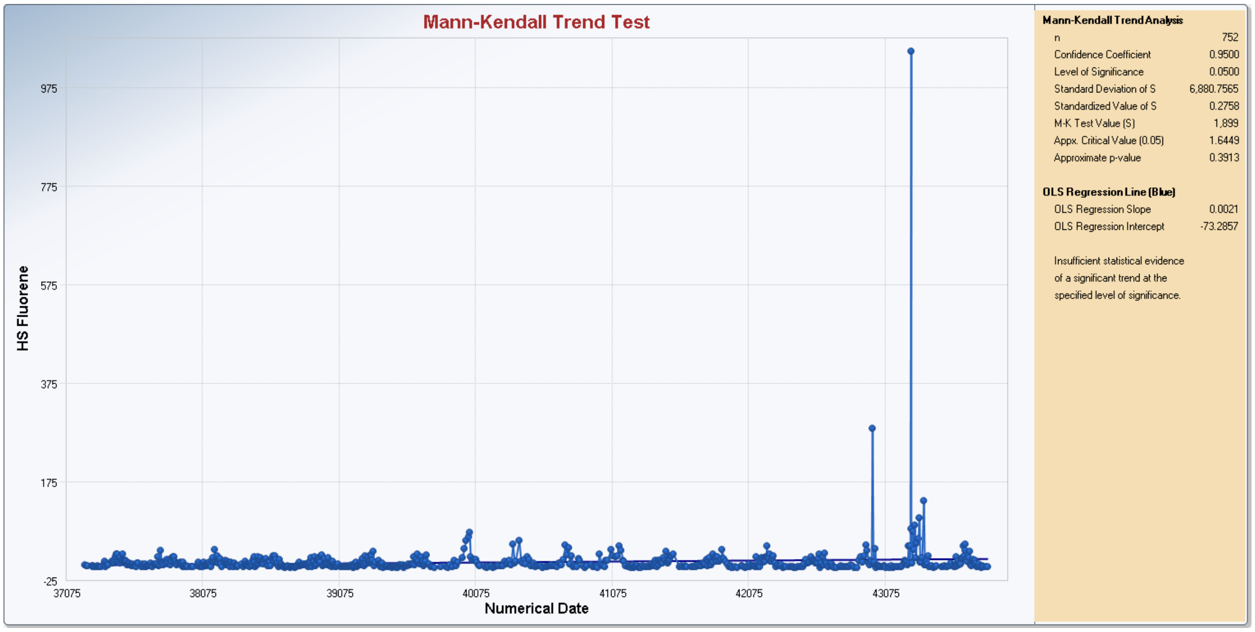
Appendix Figure B4. Mann-Kendall trend for **Acenaphthylene** at the **south station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



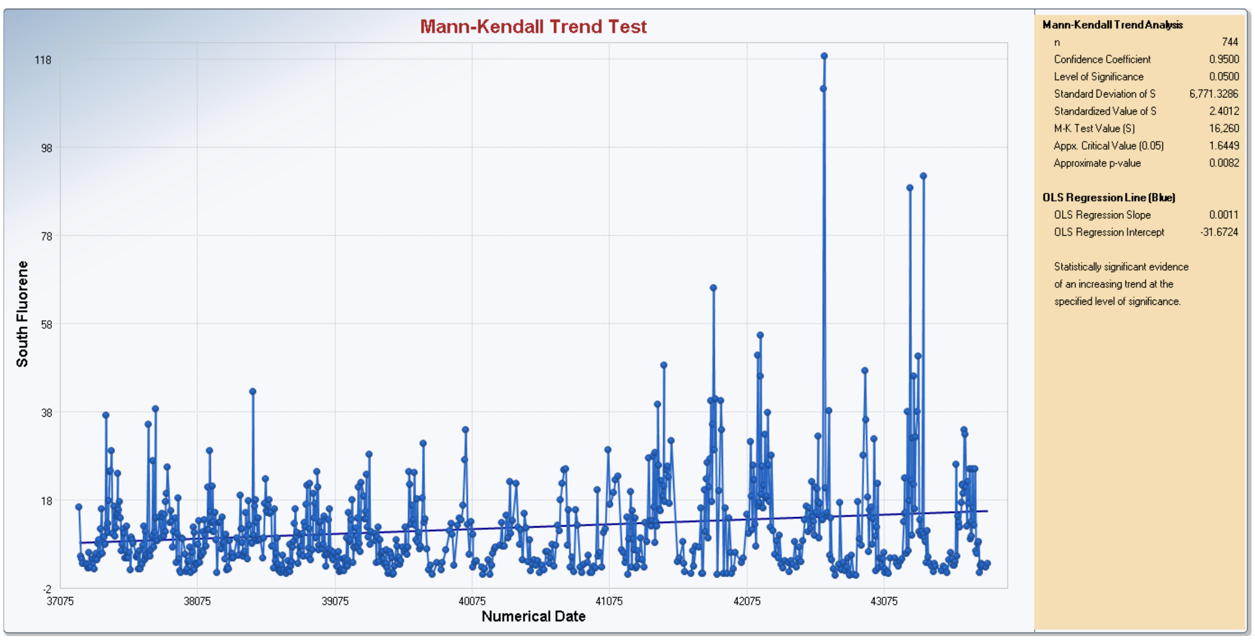
Appendix Figure B5. Mann-Kendall trend for **Fluoranthene** at the **high school station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period.



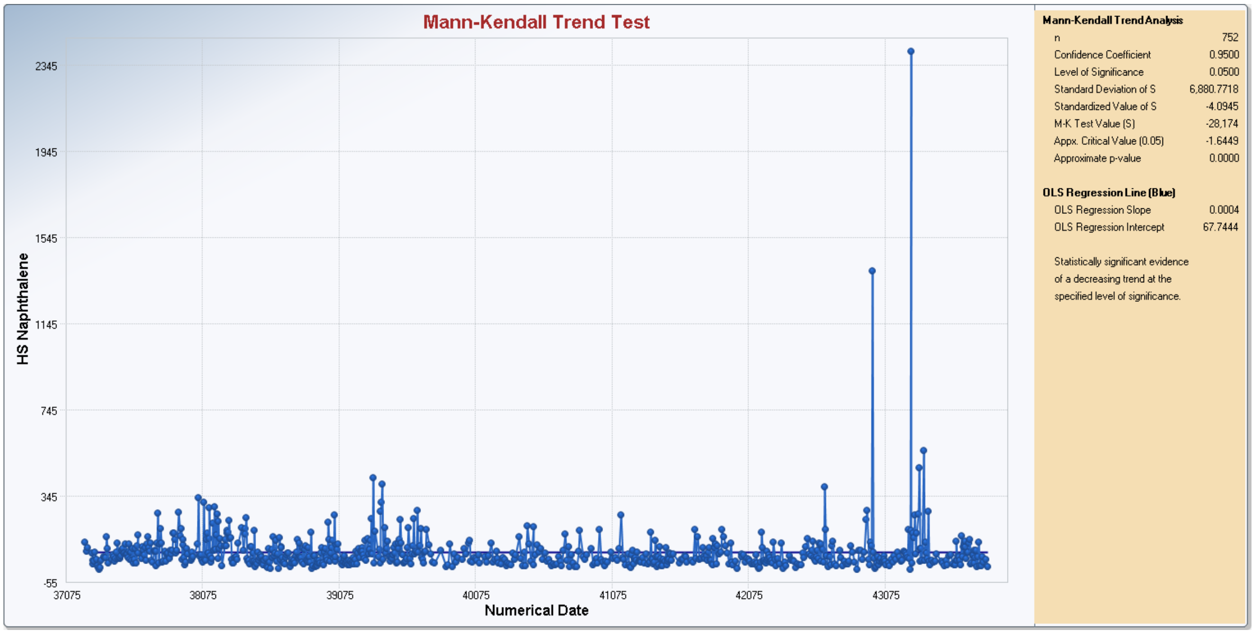
Appendix Figure B6. Mann-Kendall trend for **Fluoranthene** at the **south station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period.



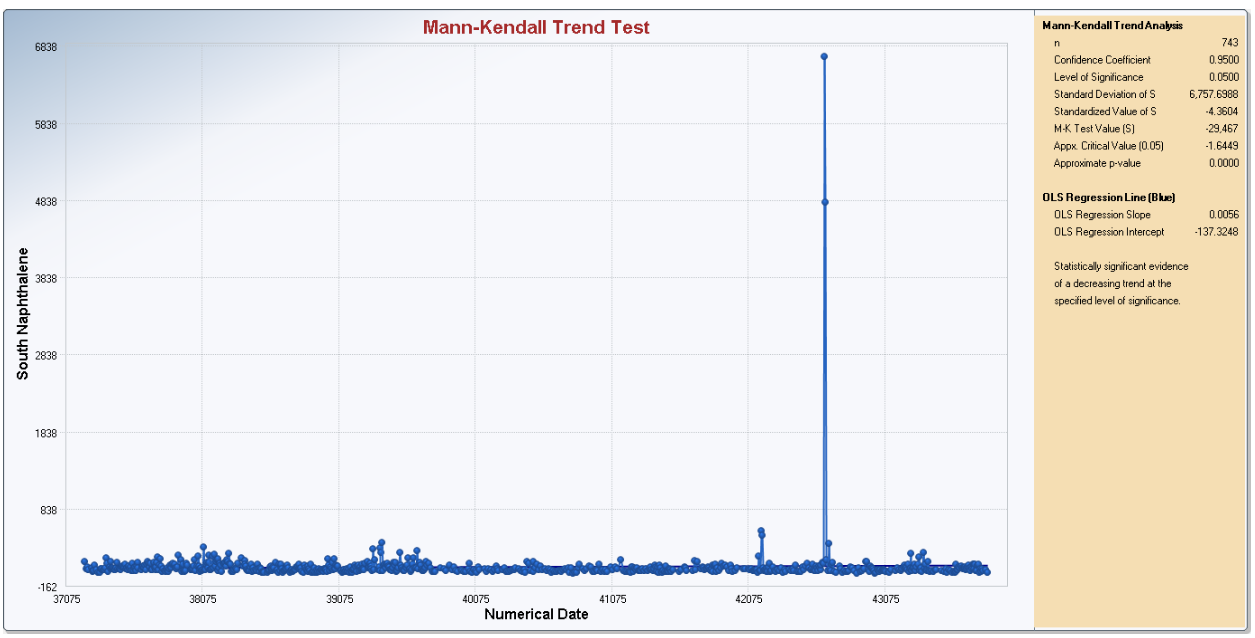
Appendix Figure B7. Mann-Kendall trend for **Fluorene** at the **high school station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period.



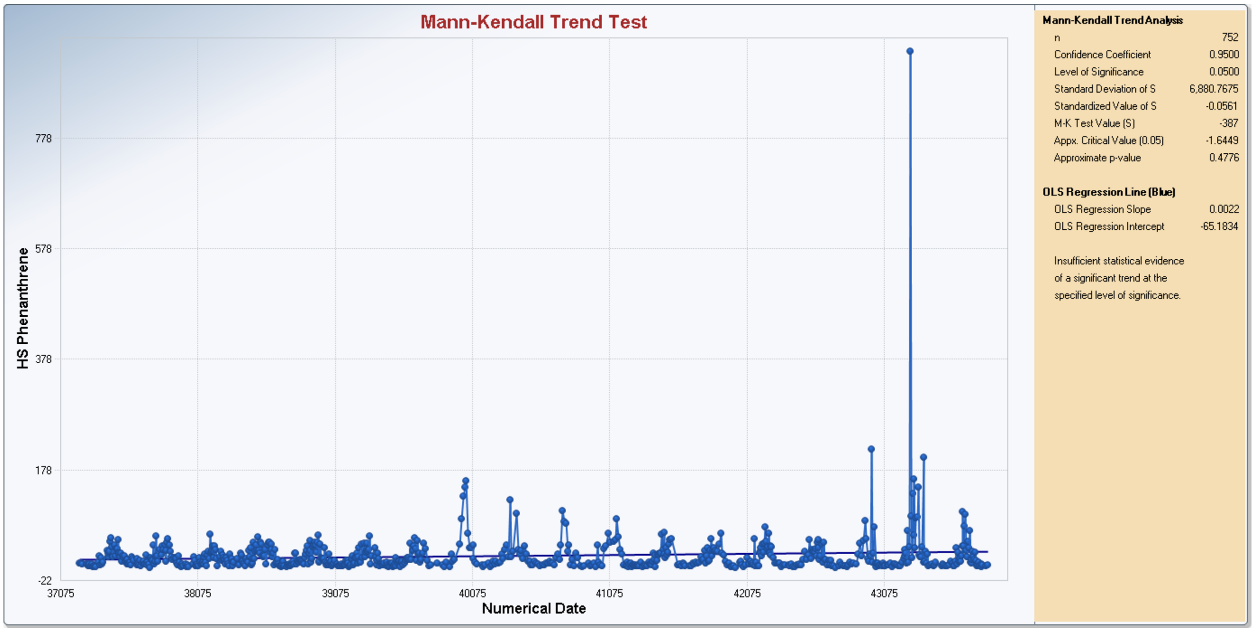
Appendix Figure B8. Mann-Kendall trend for **Fluorene** at the **south station** from 2001 through 2019 with statistically significant evidence of **increasing trend** over sampling period.



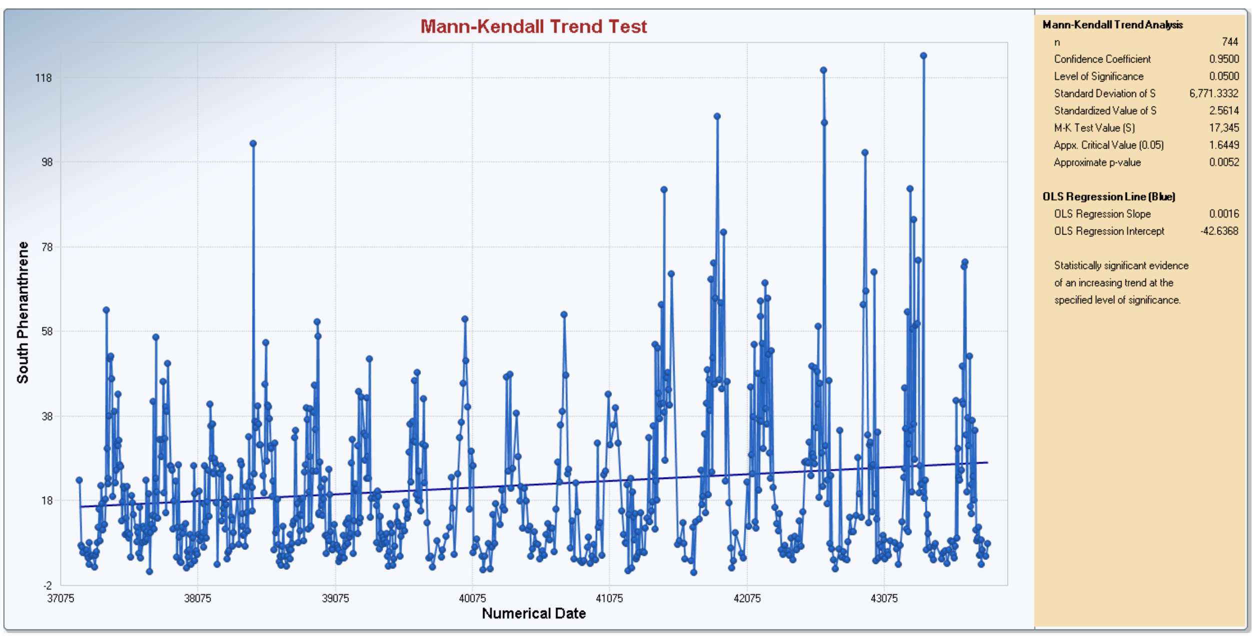
Appendix Figure B9. Mann-Kendall trend for **Naphthalene** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



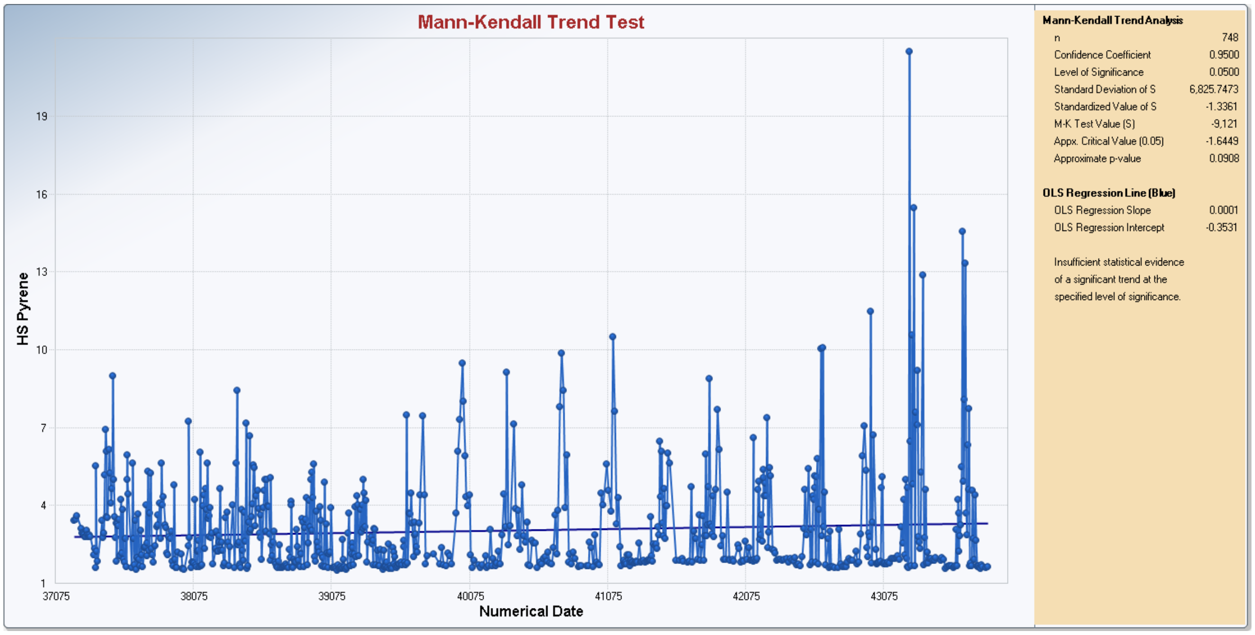
Appendix Figure B10. Mann-Kendall trend for **Naphthalene** at the **south station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



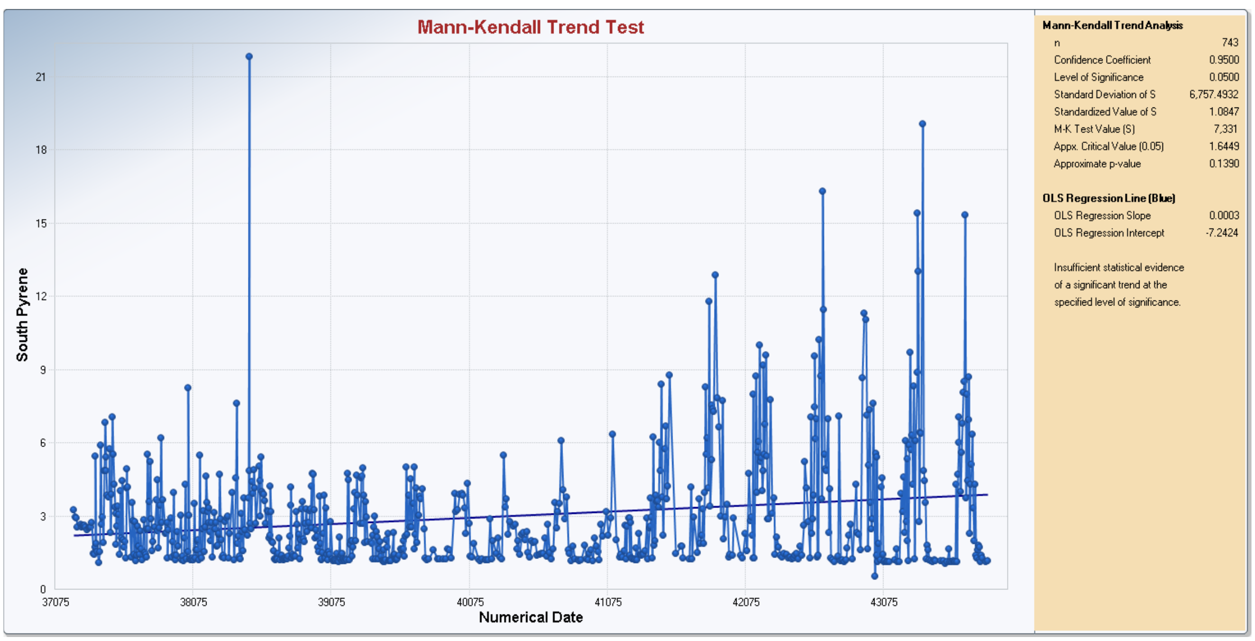
Appendix Figure B11. Mann-Kendall trend for **Phenanthrene** at the **high school station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period.



Appendix Figure B12. Mann-Kendall trend for **Phenanthrene** at the **south station** from 2001 through 2019 with statistically significant evidence of **increasing trend** over sampling period.

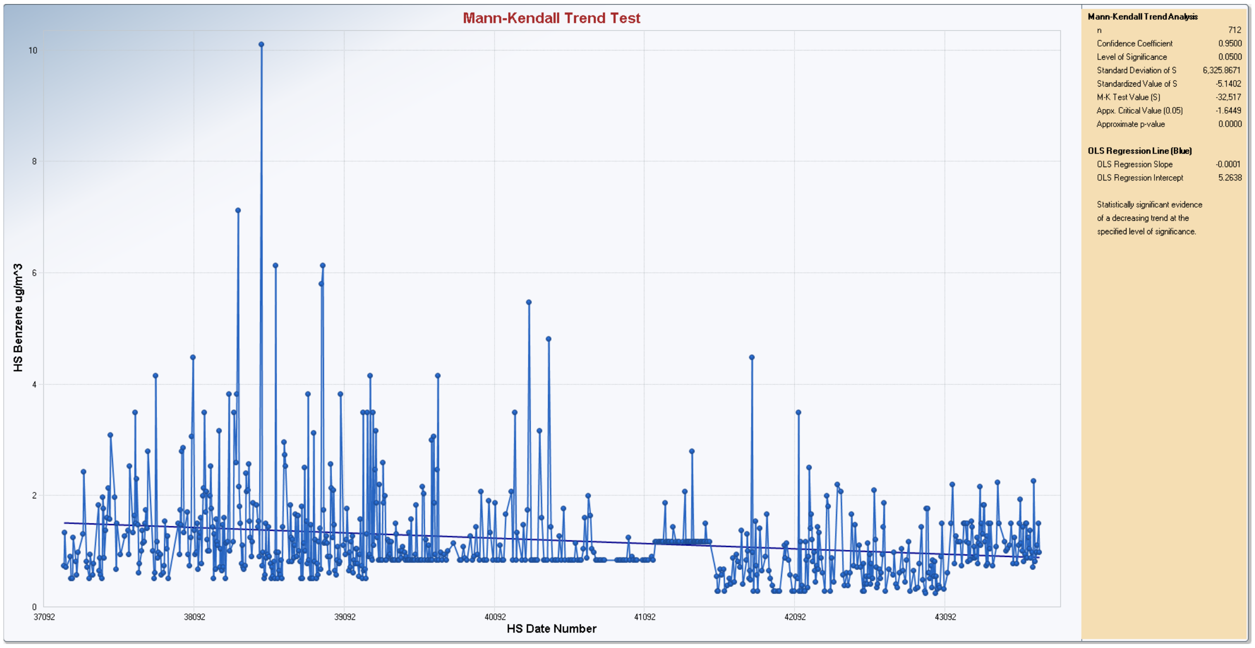


Appendix Figure B12. Mann-Kendall trend for **Pyrene** at the **high school station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period.

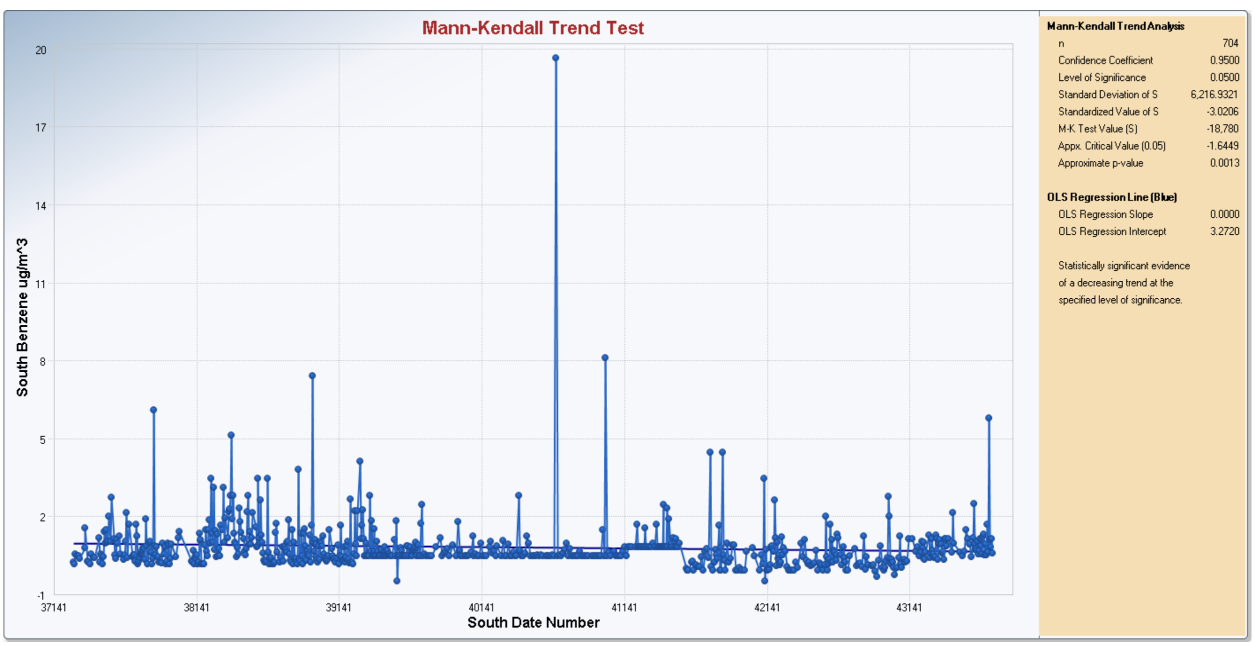


Appendix Figure B12. Mann-Kendall trend for **Pyrene** at the **south station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period.

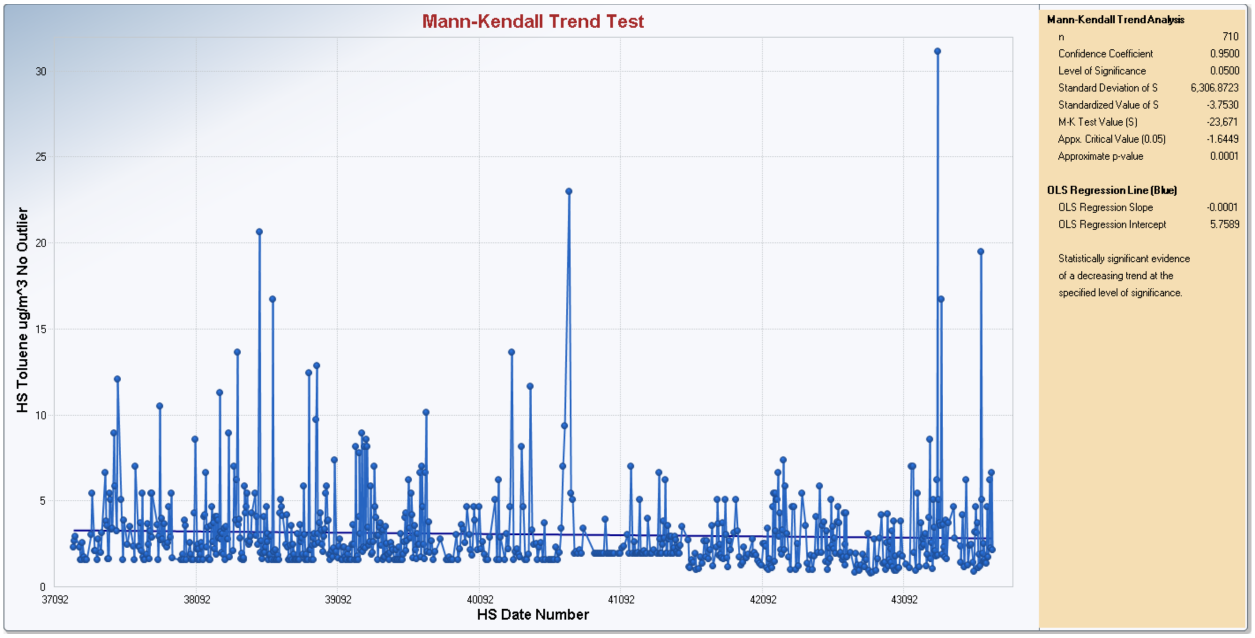
Appendix C
VOC Trends at High School and South Stations
2001-2019 Data



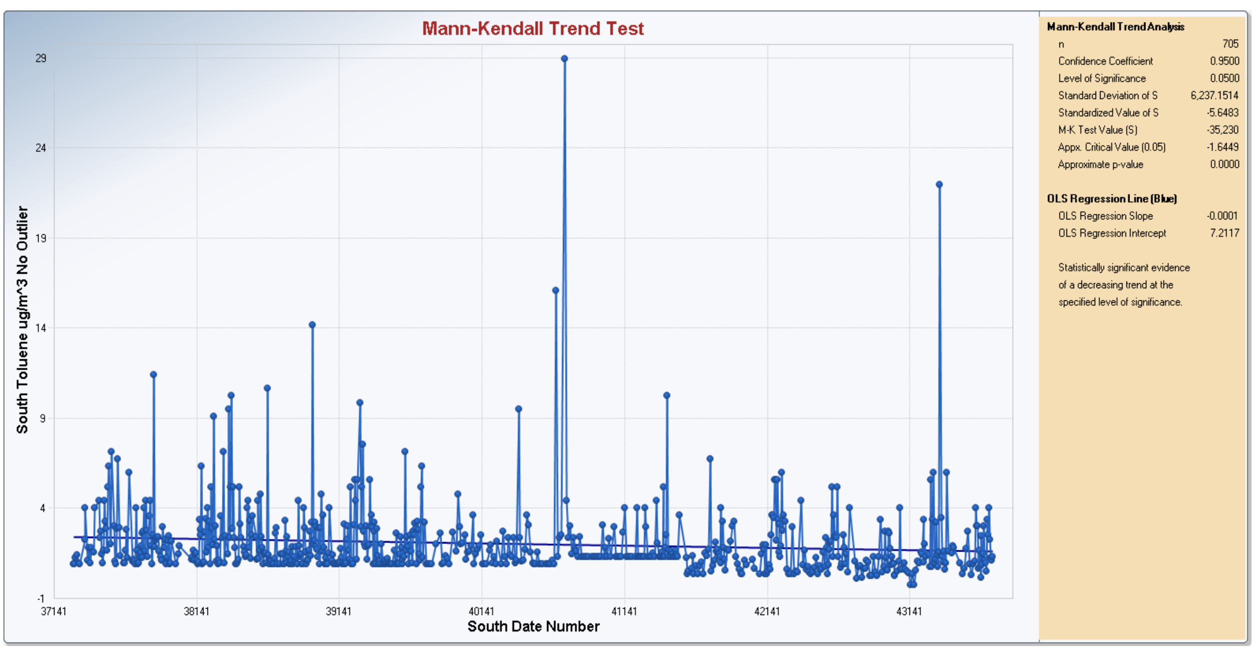
Appendix Figure C1. Mann-Kendall trend for **Benzene** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 9/12/2019 [numerical date 43720] for all trend analyses).



Appendix Figure C2. Mann-Kendall trend for **Benzene** at the **south station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 9/12/2019 [numerical date 43720] for all trend analyses).

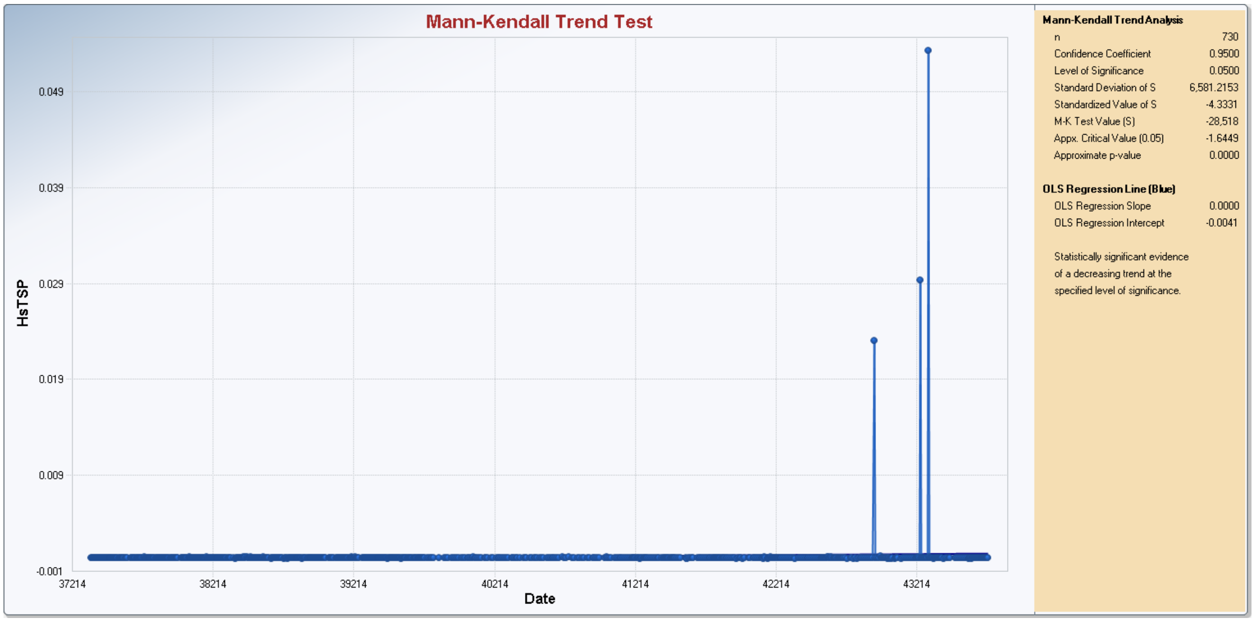


Appendix Figure C3. Mann-Kendall trend for **Toluene** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.

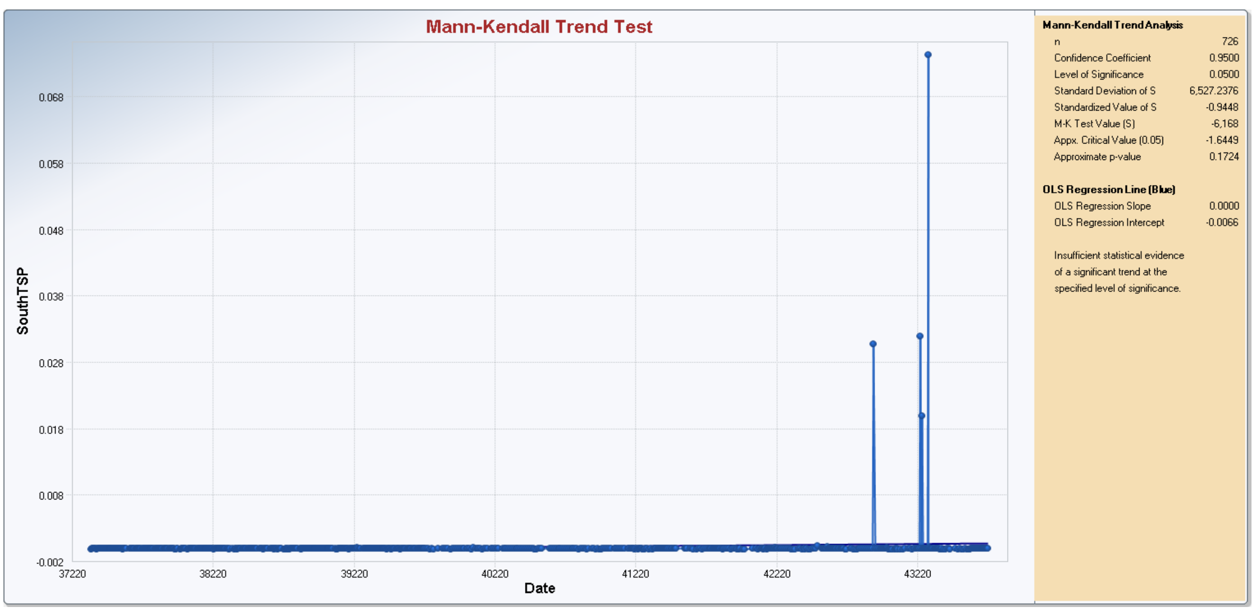


Appendix Figure C4. Mann-Kendall trend for **Toluene** at the **south station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.

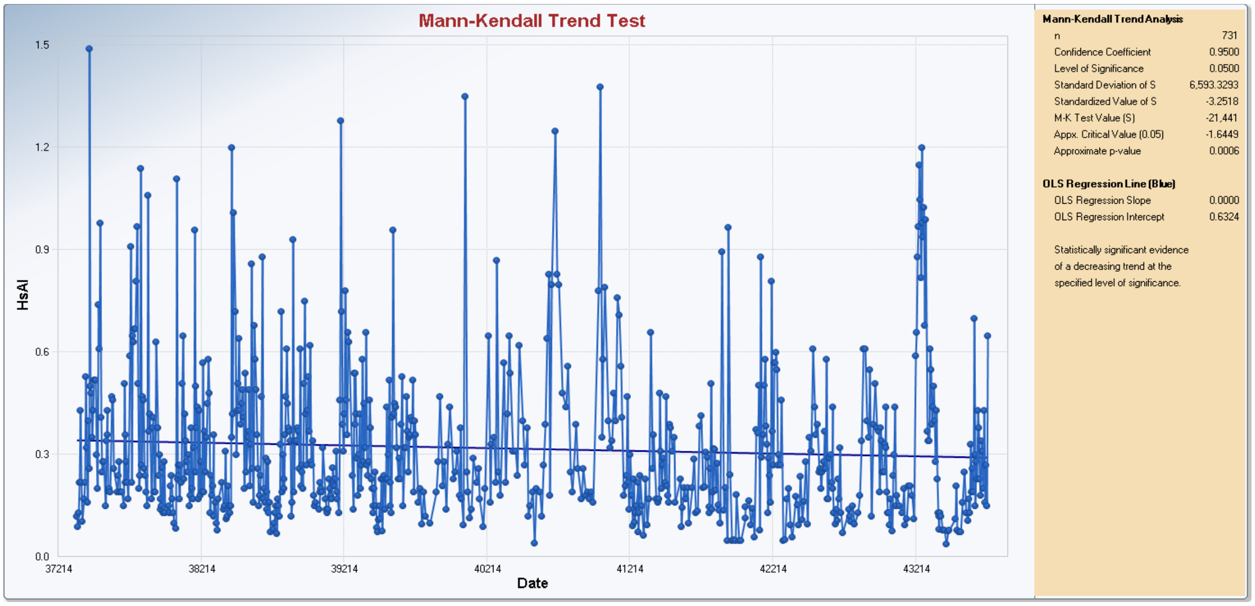
Appendix D
TSP and Metal Trends at High School and South Stations
2001-2019 Data



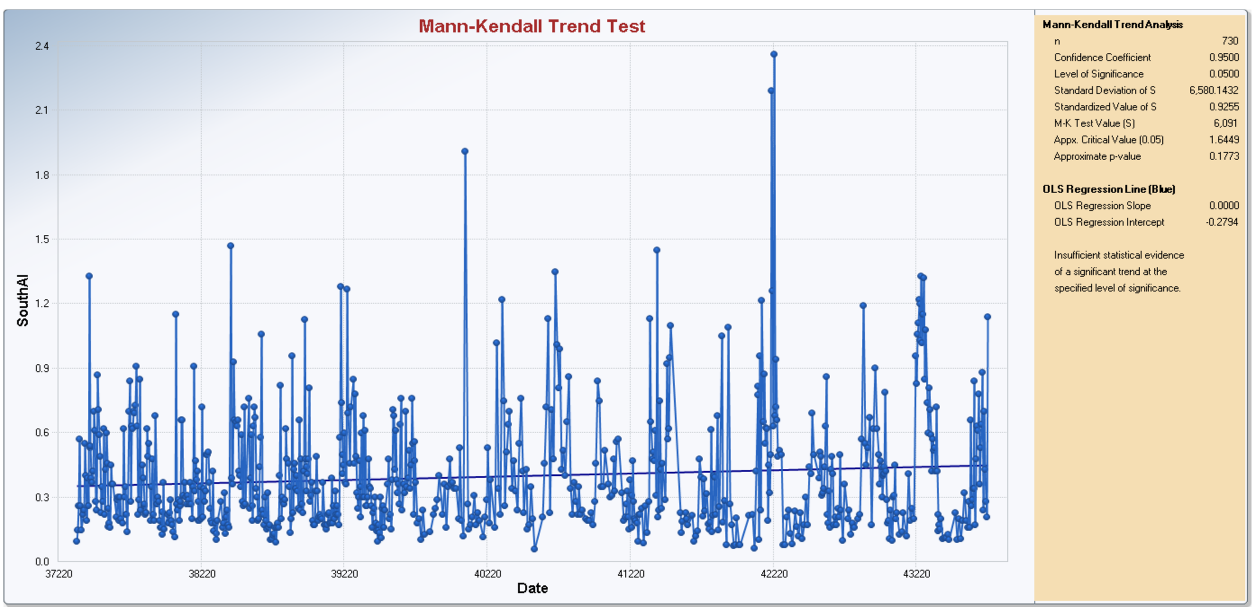
Appendix Figure D1. Mann-Kendall trend for **TSP** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 9/12/2021 [numerical date 43720] for all trend analyses).



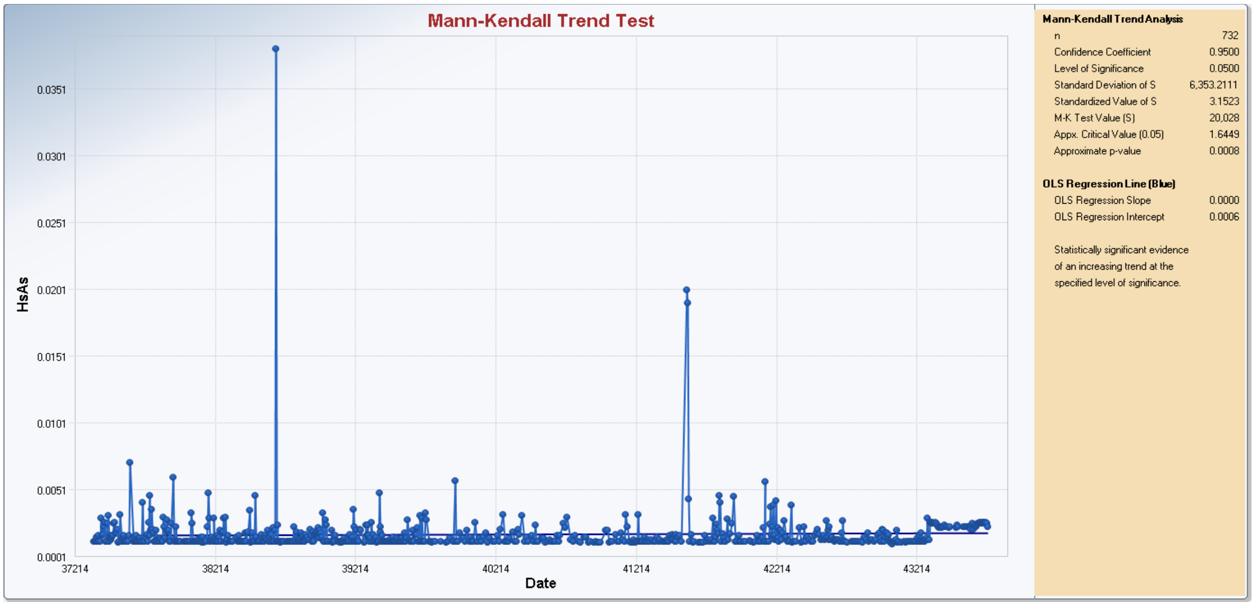
Appendix Figure D2. Mann-Kendall trend for **TSP** at the **south station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 9/12/2021 [numerical date 43720] for all trend analyses).



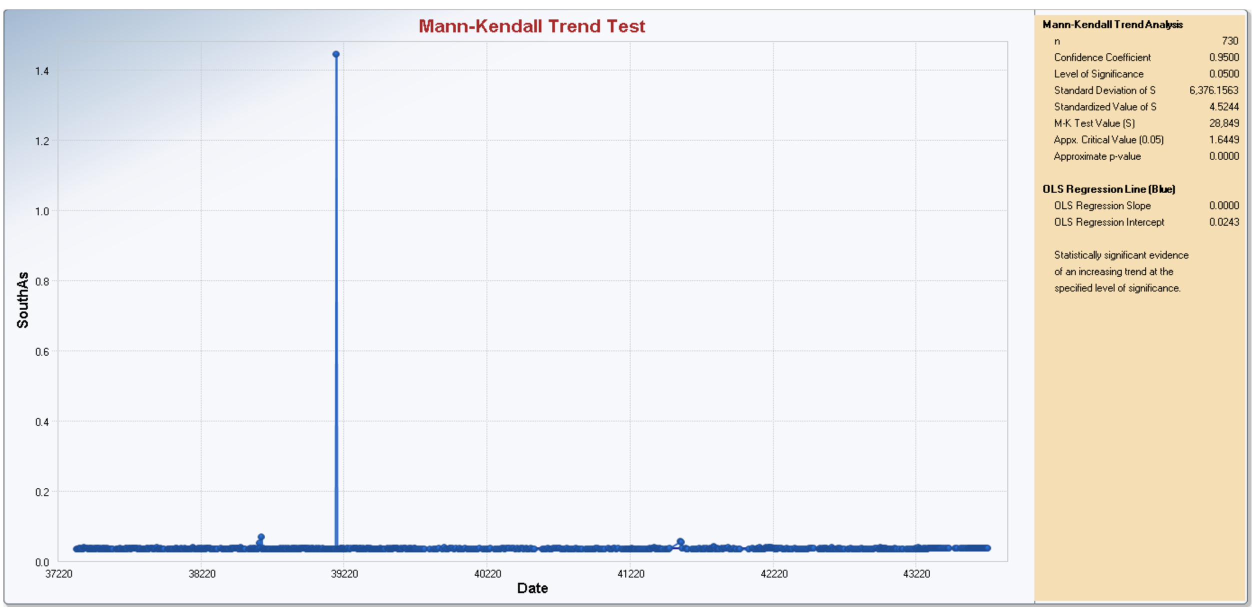
Appendix Figure D3. Mann-Kendall trend for **Aluminum** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



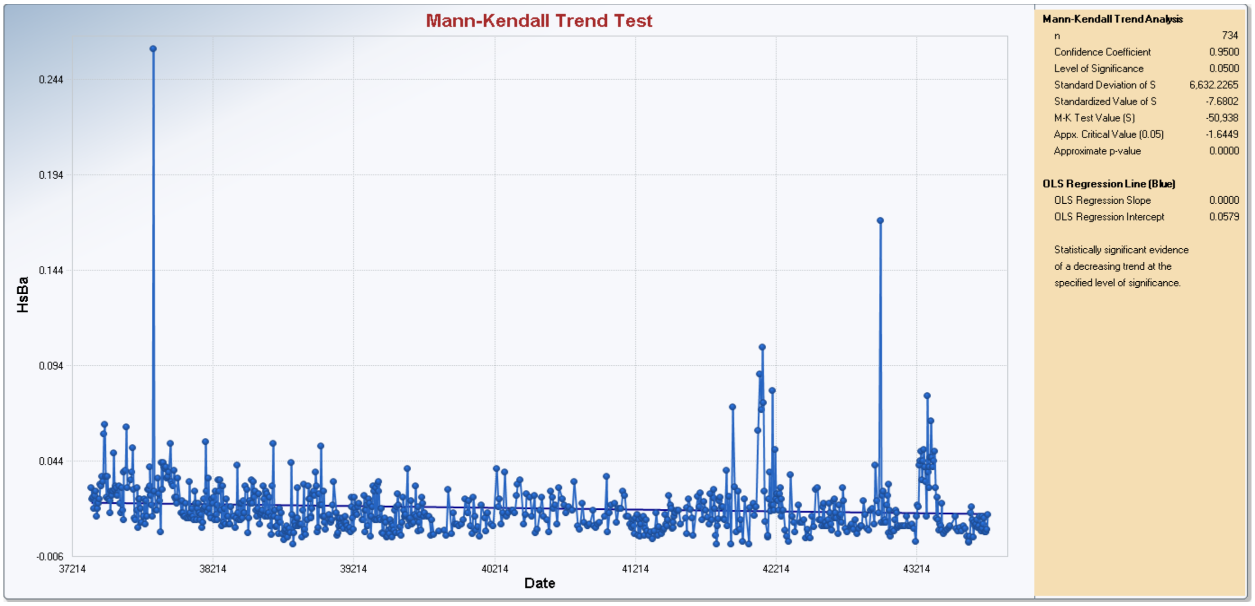
Appendix Figure D4. Mann-Kendall trend for **Aluminum** at the **south station** from 2001 through 2019 **insufficient statistical evidence of a significant trend** over sampling period.



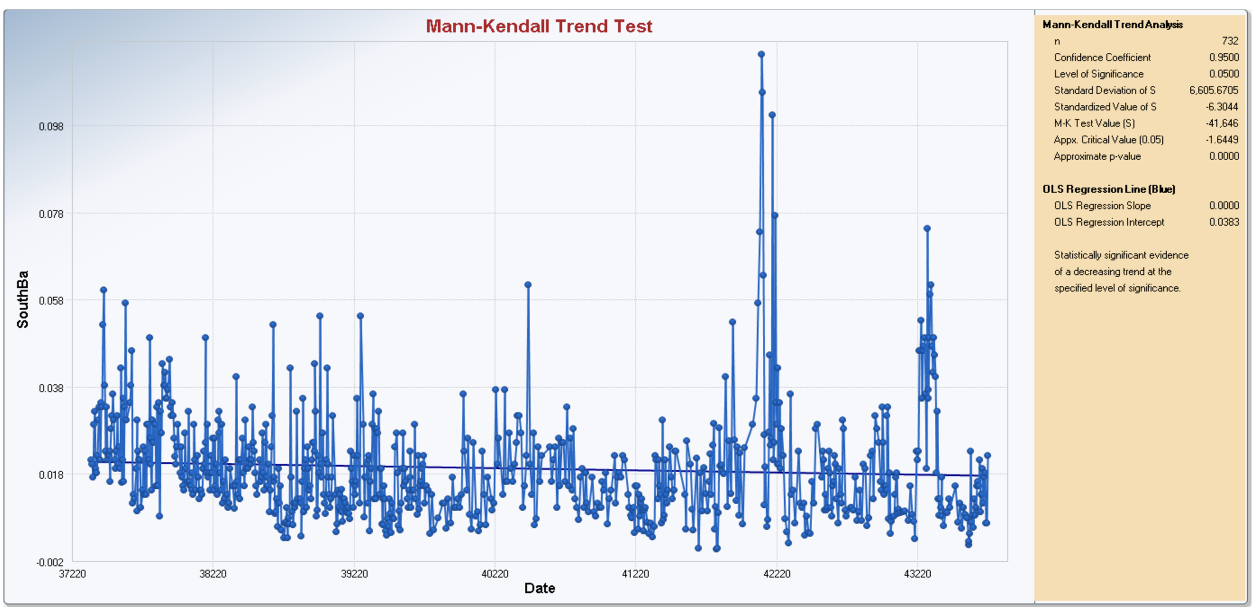
Appendix Figure D5. Mann-Kendall trend for **Arsenic** at the **high school station** from 2001 through 2019 with statistically significant evidence of in**creasing trend** over sampling period.



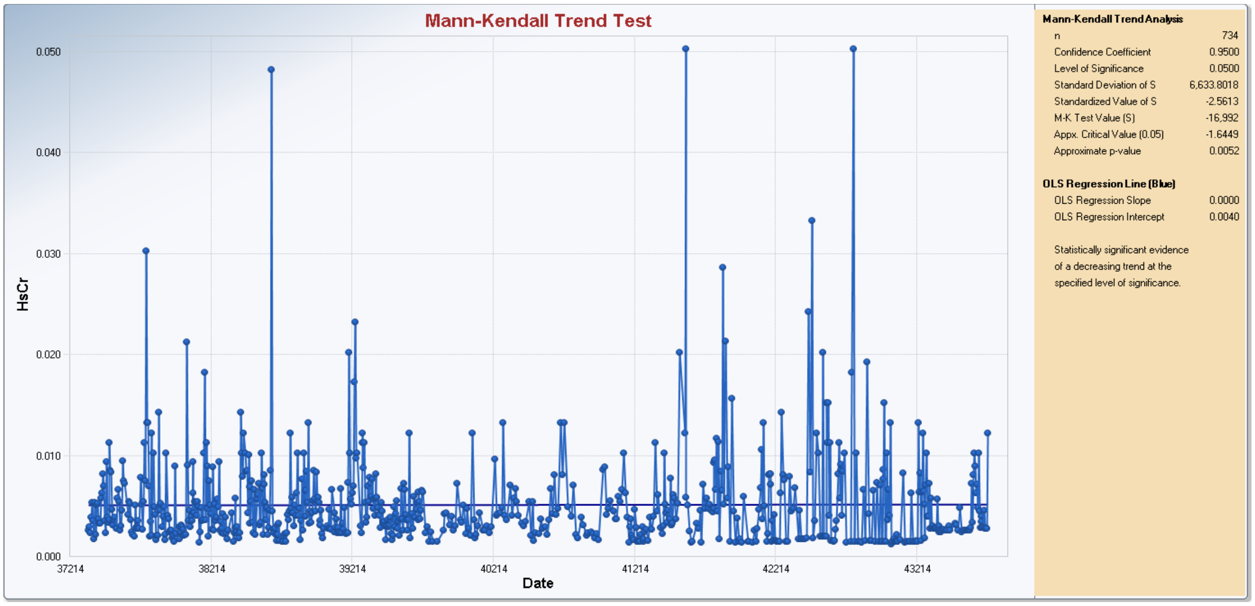
Appendix Figure D6. Mann-Kendall trend for **Arsenic** at the **south station** from 2001 through 2019 with statistically significant evidence of **increasing trend** over sampling period.



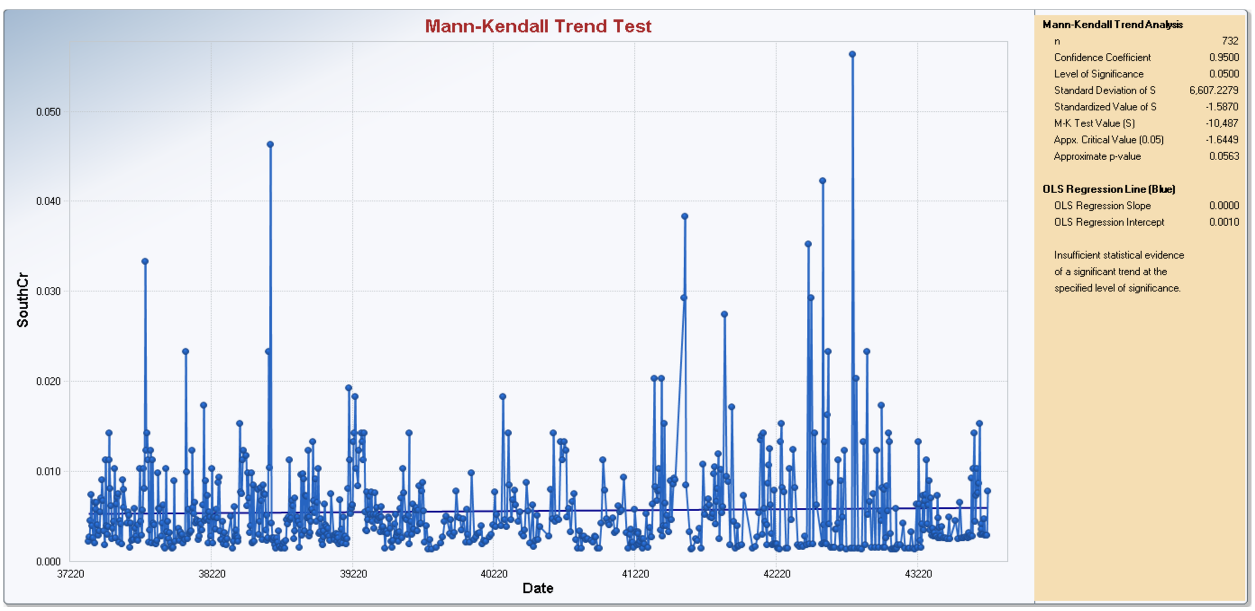
Appendix Figure D7. Mann-Kendall trend for **Barium** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



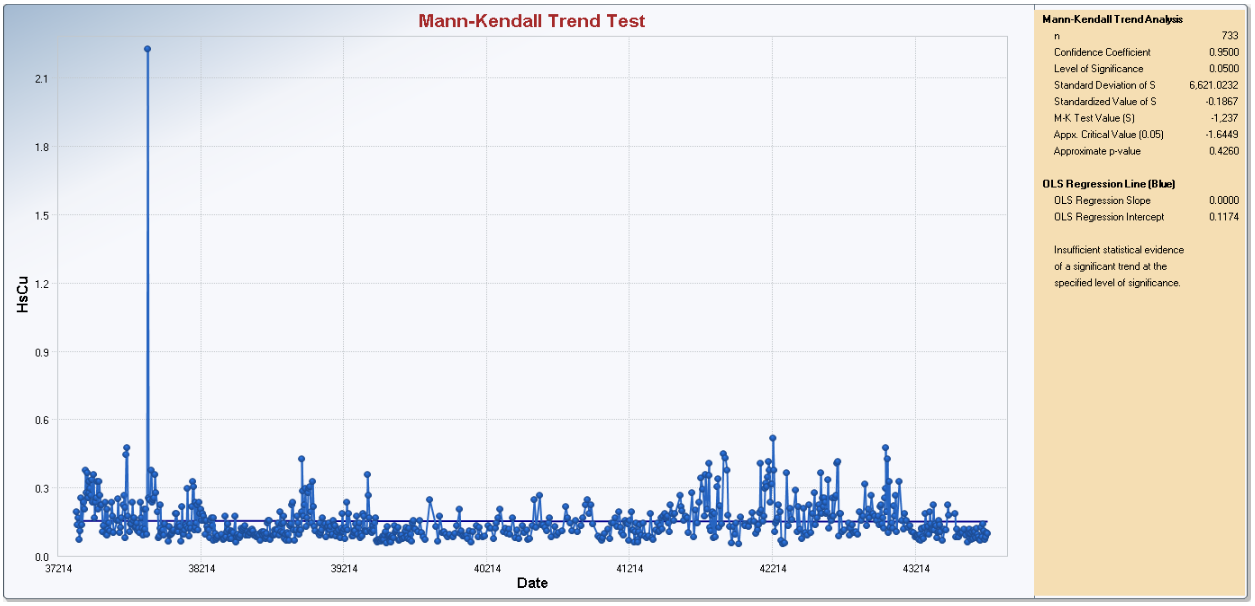
Appendix Figure D8. Mann-Kendall trend for **Barium** at the **south station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



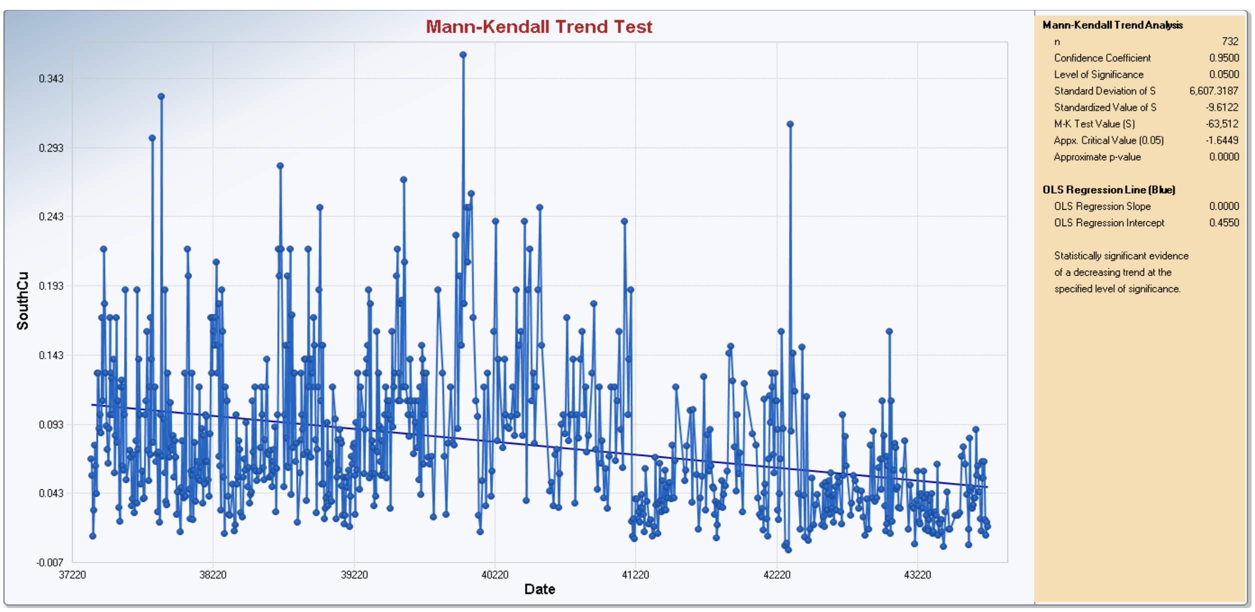
Appendix Figure D9. Mann-Kendall trend for **Chromium** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



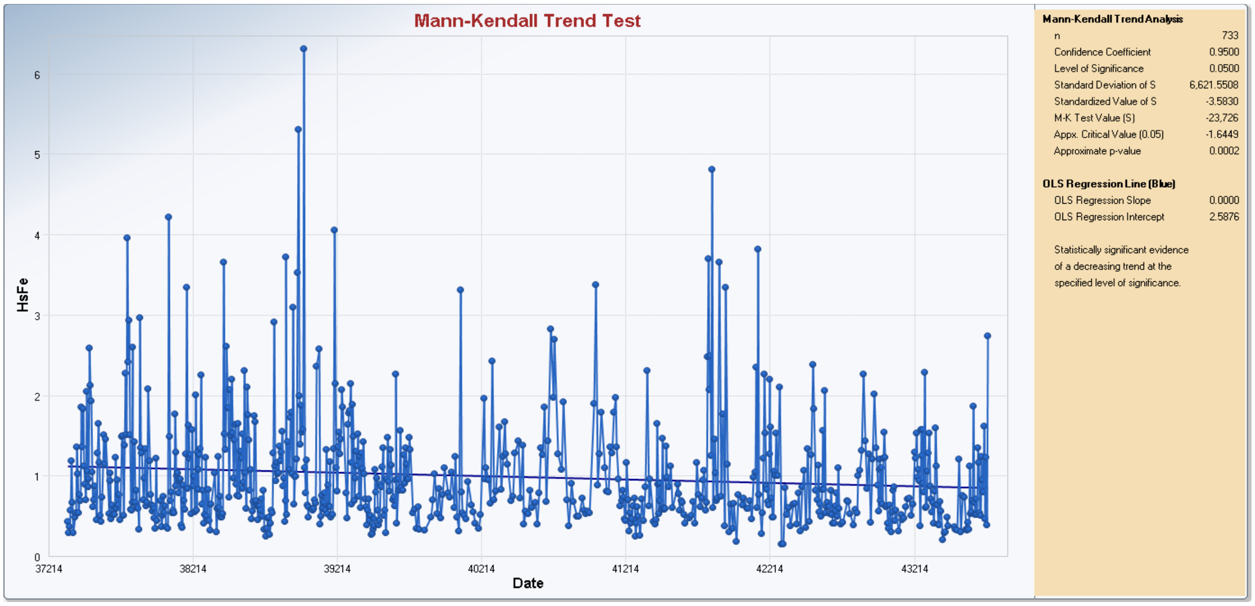
Appendix Figure D10. Mann-Kendall trend for **Chromium** at the **south station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period.



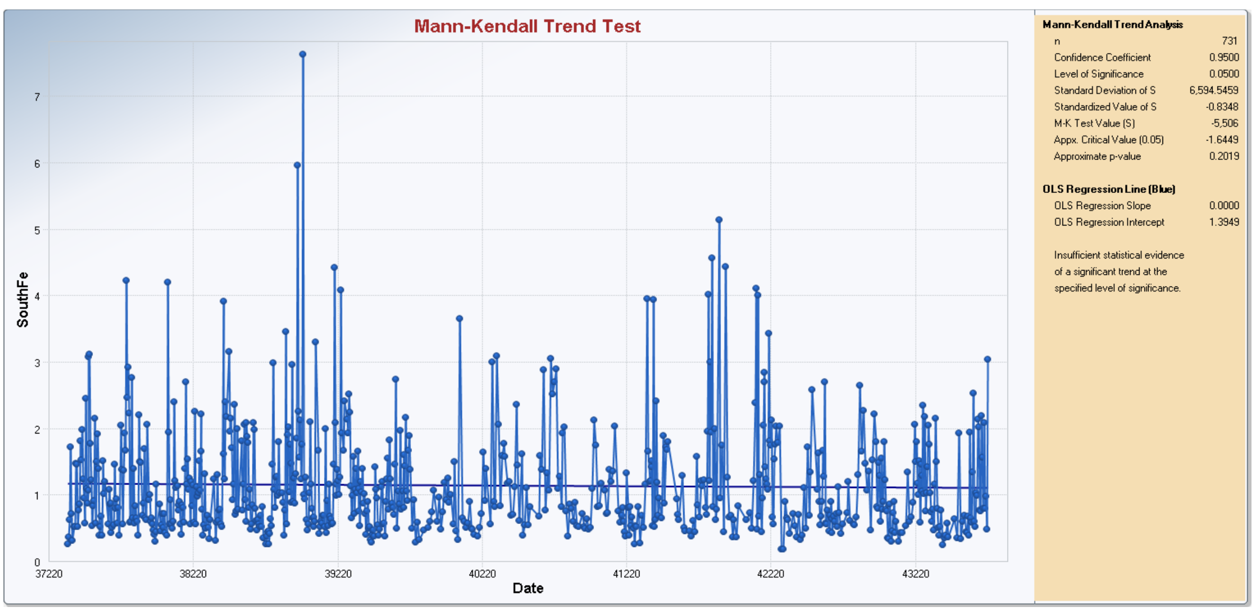
Appendix Figure D11. Mann-Kendall trend for **Copper** at the **high school station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period.



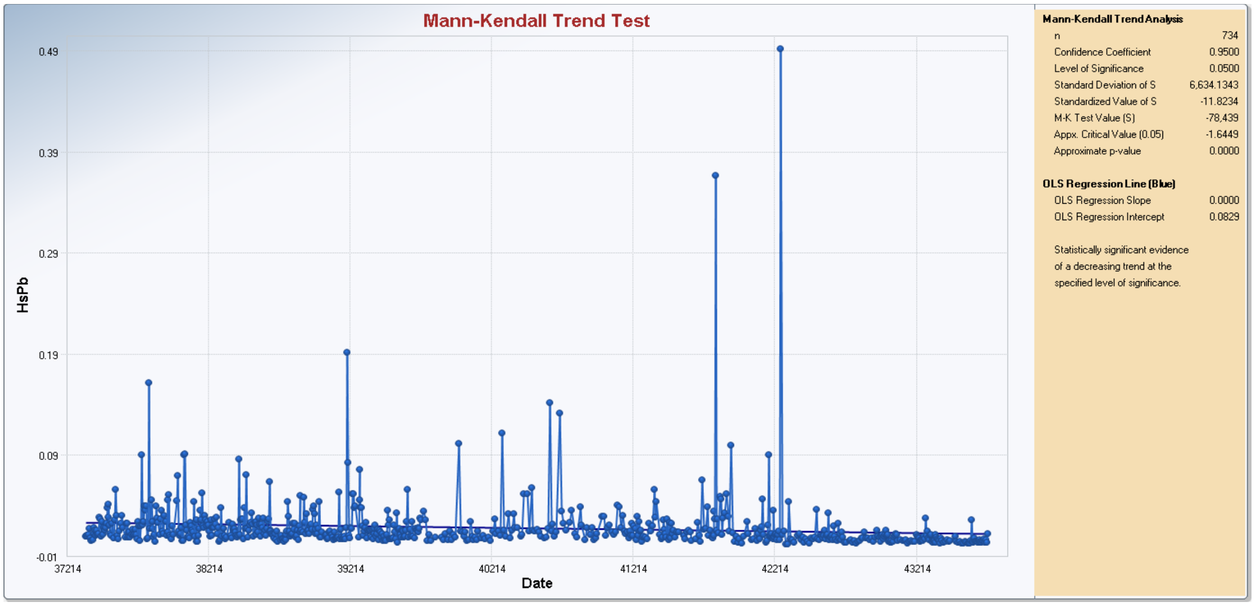
Appendix Figure D12. Mann-Kendall trend for **Copper** at the **south station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



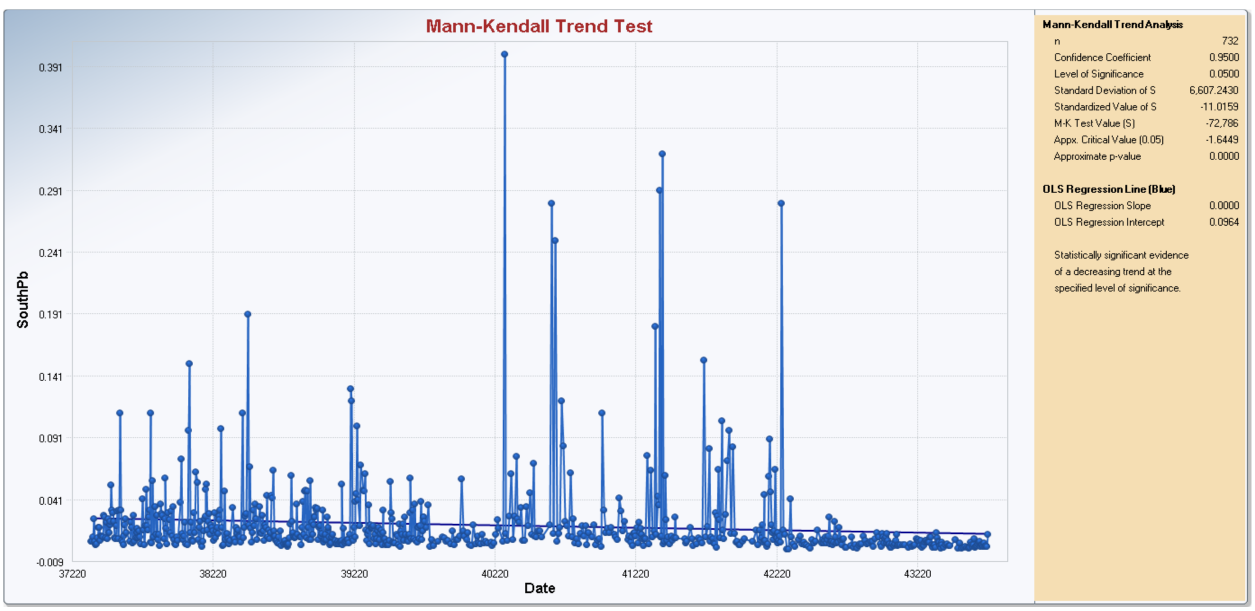
Appendix Figure D12. Mann-Kendall trend for **Iron** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



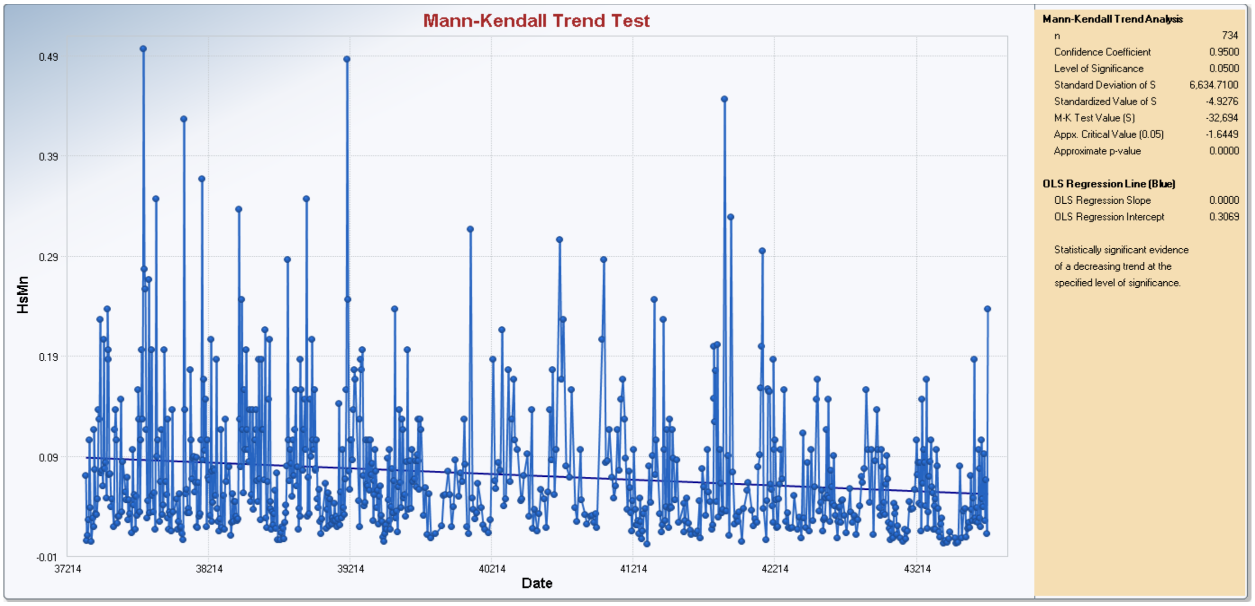
Appendix Figure D12. Mann-Kendall trend for **Iron** at the **south station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period.



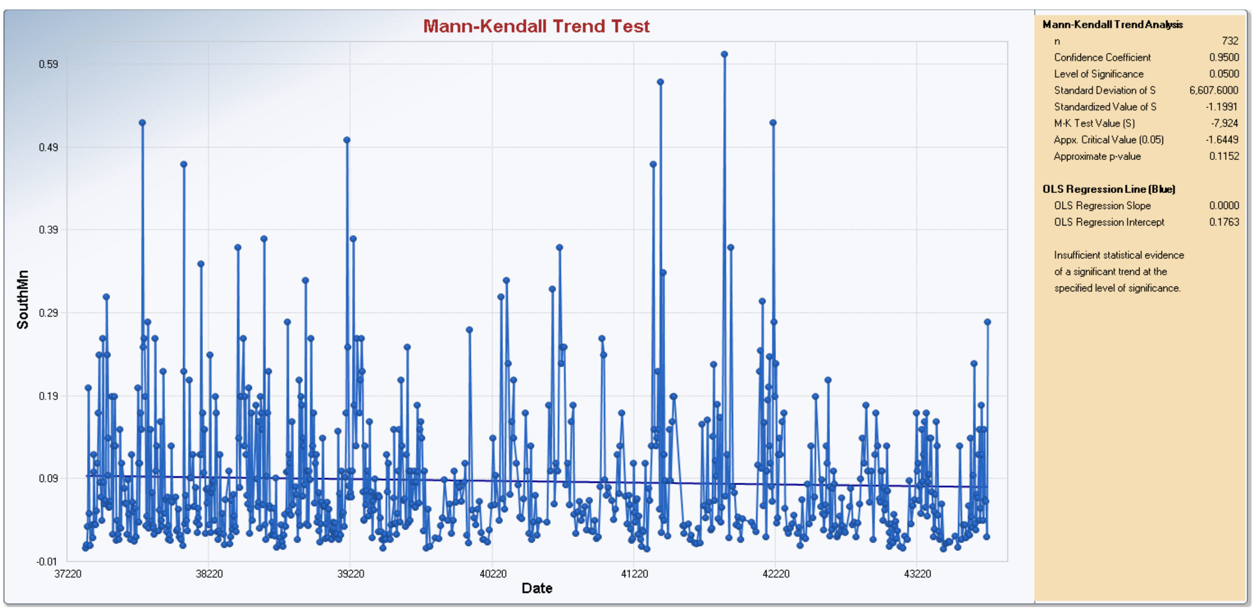
Appendix Figure D13. Mann-Kendall trend for **Lead** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



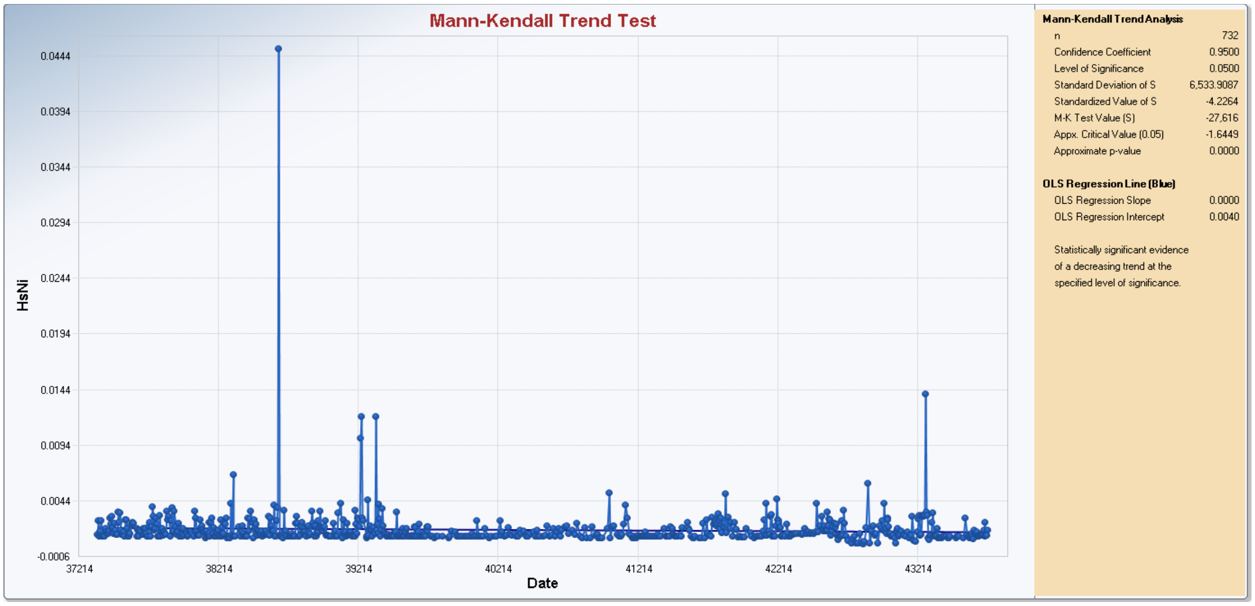
Appendix Figure D14. Mann-Kendall trend for **Lead** at the **south station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



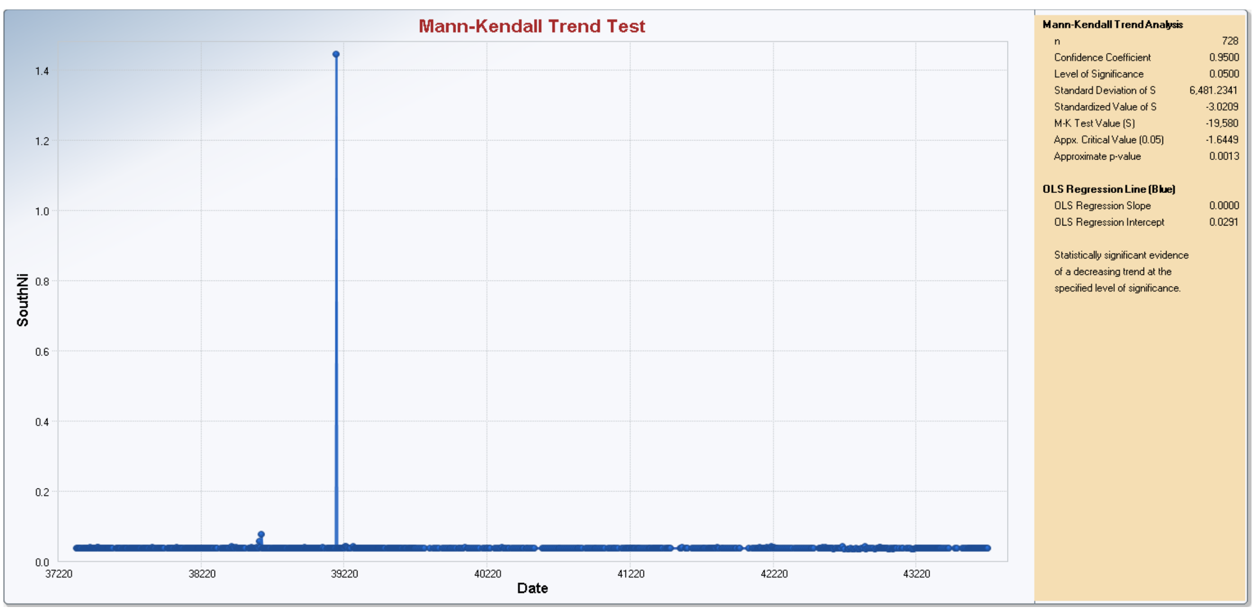
Appendix Figure D15. Mann-Kendall trend for **Manganese** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



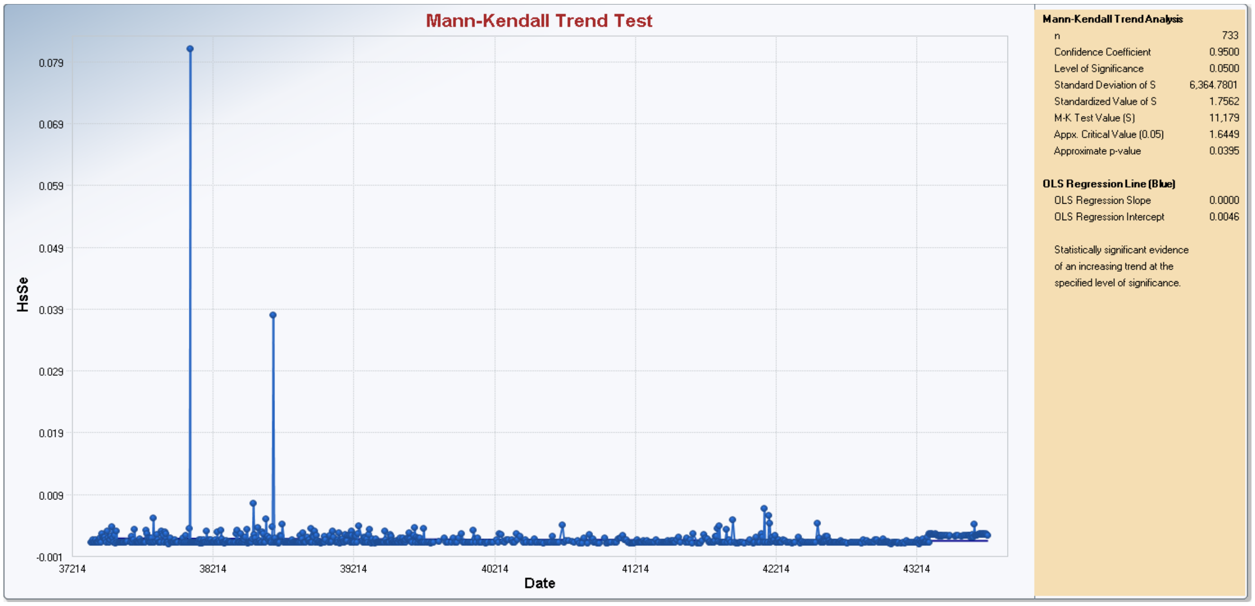
Appendix Figure D16. Mann-Kendall trend for **Manganese** at the **south station** from 2001 through 2019 with **insufficient statistical evidence of a significant trend** over sampling period.



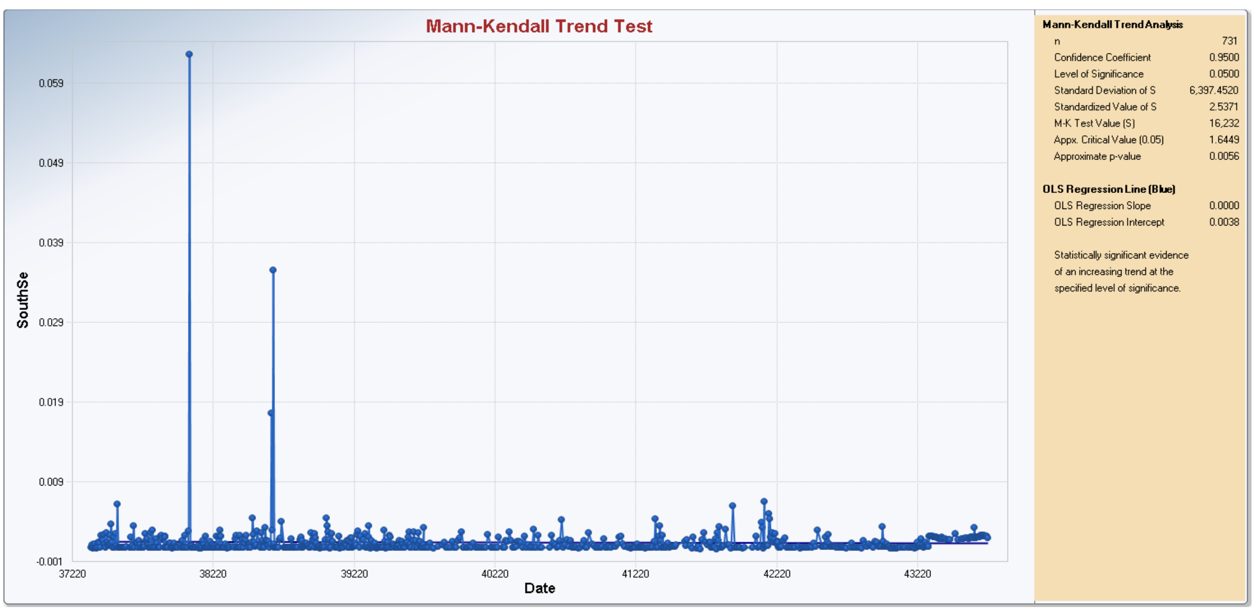
Appendix Figure D17. Mann-Kendall trend for **Nickel** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



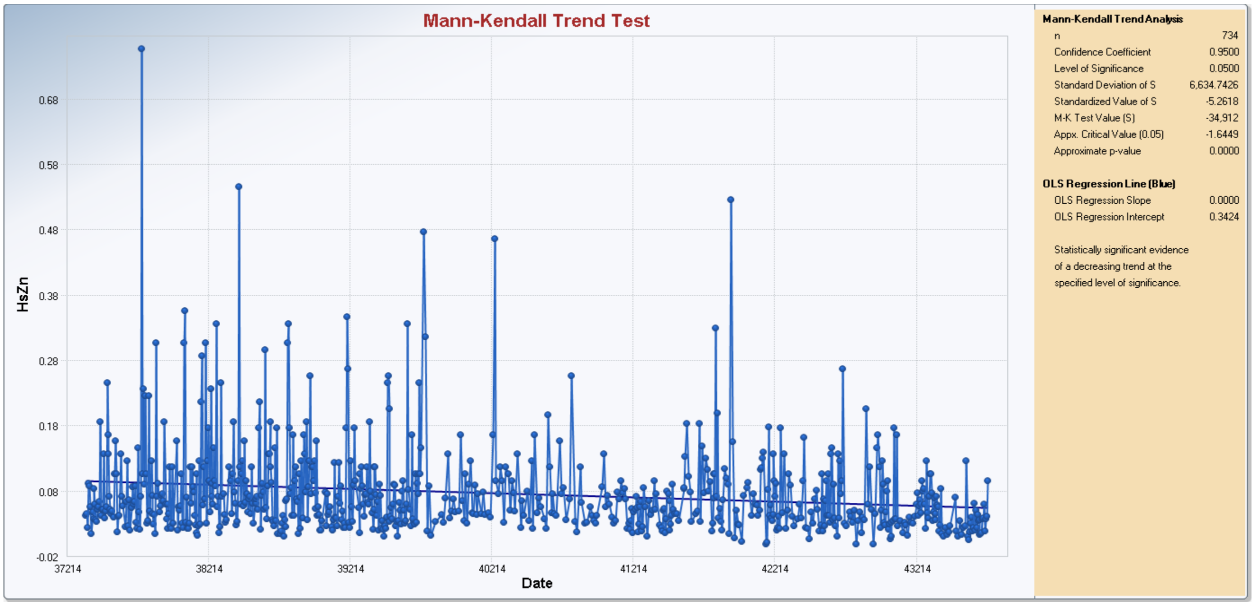
Appendix Figure D18. Mann-Kendall trend for **Nickel** at the **south station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



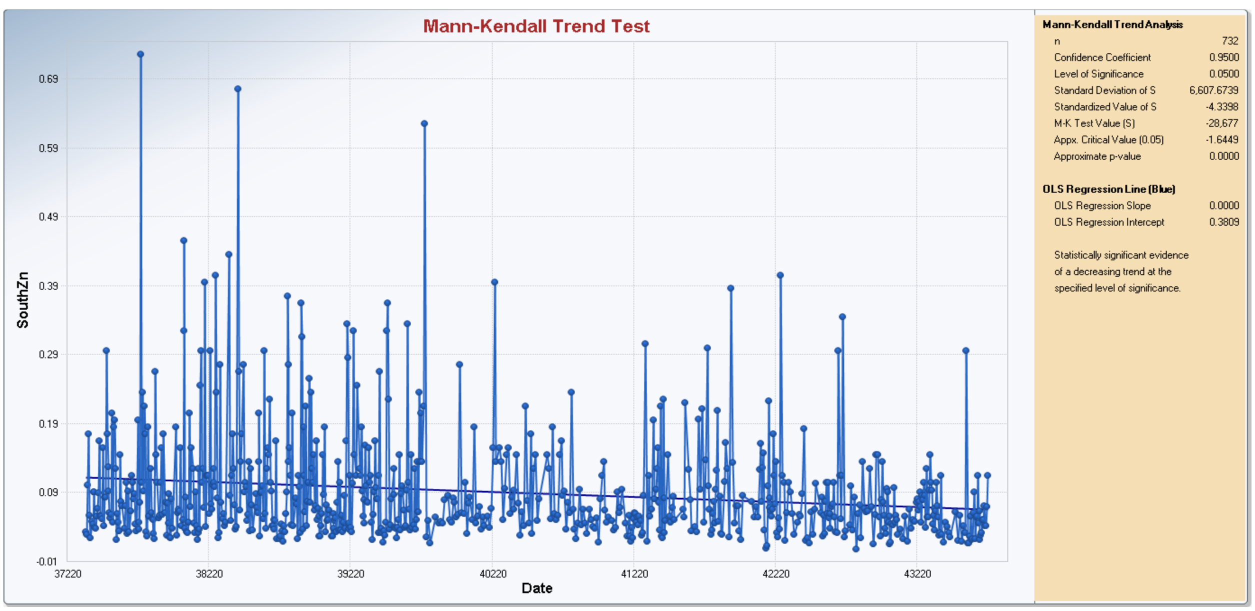
Appendix Figure D19. Mann-Kendall trend for **Selenium** at the **high school station** from 2001 through 2019 with statistically significant evidence of **increasing trend** over sampling period.



Appendix Figure D20. Mann-Kendall trend for **Selenium** at the **south station** from 2001 through 2019 with statistically significant evidence of **increasing trend** over sampling period.



Appendix Figure D21. Mann-Kendall trend for **Zinc** at the **high school station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.



Appendix Figure D22. Mann-Kendall trend for **Zinc** at the **south station** from 2001 through 2019 with statistically significant evidence of **decreasing trend** over sampling period.