INDIANA HARBOR AND CANAL

2022 AIR MONITORING DATA ANALYSIS

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

March 2024

This Page Left Intentionally Blank

INDIANA HARBOR AND CANAL – AIR MONITORING DATA ANALYSIS

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 2020) air monitoring results are presented in the following reports (USACE 2014, 2018, 2020, 2021, 2022, 2023). Table A presents a summary of the air monitoring program at the IHC CDF through July 2022.

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) DONEconstruction 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 Oct – Nov 2017 Jun – Sep 2018 Late Jun 2019 – Oct 2019 Oct – Dec 2020	Dredging and discharge of dredged material to CDF	HS and 4 CDF on-site points	6 day monitoring frequency
No Dredging/ Material in CDF	Jan – Mar 2013 Sep 2013 – April 2014 Aug 2014 – April 2015 Sep 2015 – Aug 2016 Mid Nov – Sep 2017 Dec 2017 – May 2018 Oct 2018 – Jun 2019 Late Oct 2019 – Dec 2019 Late Dec 2020 – July 2022	Idle periods between dredging events; CDF is a quiescent pond	HS and 4 CDF on-site points During dike expansion and starting June 2021 to the present time: HS and 1 CDF on-site monitor	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 report is to follow up the last 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 July 2022. This report covers all dredging events through the last IHC dredging (2020), and the CDF dike expansion/construction period (initiated June 2021) when the CDF on-site air monitoring locations were moved off the dikes. 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 – 2020 Dredging and Dredged Material Disposal

Post-dredging air monitoring data presented in this report span nine 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, summer 2019, and fall 2020.

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.

A total volume of 125,689 CY of dredged material was excavated from the canal and discharged to the CDF during the 2020 dredging season. Dredging/sediment disposal to the CDF began on October 5, 2020, and ended on December 14, 2020. All of the 2020 dredged material was placed in the CDF west cell.

No dredging was performed by USACE in 2021, 2022, and 2023. IHC CDF dike expansion started in late June 2021 and is expected to be completed in 2024. Dredging may occur in 2024 pending accumulation of sediments and the requirement to dredge.

In summary, approximately 1,697,000 cubic yards of dredged material was placed into the CDF from 2012 through 2020. Approximately 855,000 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 2020 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.

The vertical extension of the exterior dikes of the CDF began in June 2021. At that time the four CDF site air monitoring stations were removed from the top of the dike and replaced with one set of ambient air monitoring equipment at a temporary pad in the southwest corner of the site to accommodate the dike expansion work. This air monitoring is consistent with the single ambient air monitoring location on the site during CDF construction in the past. CDF onsite air monitoring will continue at this onsite temporary station until dike construction is complete (estimated 2024 based on the current schedule). Air monitoring continues at the high school station during this period. Air samples are collected on a 12-day schedule during CDF dike expansion.

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 Report

PCBs (2021/22 Analysis included in USACE 2023) Congener 8 (PCB 8) Congener 15 (PCB 15) Congener 18 (PCB 18) Congener 28 (PCB 28) Congener 31 (PCB 31)	**PAHs** 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 for this evaluation except for selected trend analyses.

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). (Note that during dike expansion which started in 2021, one set of ambient air monitoring equipment was set up at a temporary pad in the southwest corner of the site to accommodate the dike expansion work. This air monitoring is consistent with the single ambient air monitoring location on the site during CDF construction in the past. CDF onsite air monitoring will continue at this onsite temporary station until dike construction is complete.)

Post-dredging data

Post-dredging data collected after sediment disposal to the CDF started in November 2012 to July 2022 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 2012 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 and 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 21 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 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 as described in Appendix A.

Additional data groups

Data from the four onsite sampling locations were analyzed as one data set to assess potential effect of CDF activities on the on-site air compared to the high school location. Analyses were performed to evaluate whether data collected at the high school and the combined four CDF stations are statistically similar or whether localized work activities at the site may affect samples collected offsite.

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.

Statistical Analysis

All statistical analyses presented in this report were performed with Microsoft Excel and the statistical package ProUCL 5.2 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 October 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.

It is important to recognize that except for dredging in the Lake George Branch (which occurred in October and November 2012, and briefly in 2019), 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 2022 PCB analysis was presented in a separate report (USACE 2023).

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 2012-2022 or post-dredging onsite median concentration of 49.7 to 54.6 ng/m^3) followed in decreasing order by phenanthrene (Phe – 12.6 to 18.7 ng/m^3), acenaphthene (Ace – 7.75 to 12.1 ng/m^3), fluorene (Flo – 6.75 to 10.3 ng/m^3), fluoranthene (Fla – 3.1 to 3.3 ng/m^3), pyrene (Pyr – 2.1 to 2.8 ng/m^3), and acenaphthylene (Acy – 1.44 to 1.47 ng/m^3). High school median concentrations of Ace, Fla, Flo, Phe and Pyr are lower than onsite monitors median concentrations. The high school median concentrations of Acy and Nap are 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 0.736 to 0.922) while Acy and Nap do not correlate highly with any PAHs (Spearman correlation coefficients between Acy and other PAHs range from 0.274 to 0.357, and between Nap and other PAHs range from 0.295 to 0.540). These results suggest Acy and Nap are emitted from different sources (and do not have 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 (2001-2022), using the original PAH data (no temperature correction). More recent temperature-corrected data (2012-22 for the high school and CDF sites) were also examined for trends, except for Acy, where the original data were analyzed.

Over the entire sampling period (2001 through 2022), at the high school, Ace increases with time, Pyr, Nap, and Acy decrease with time, while Fla, Flo, and Phe exhibit no significant trend. Over the same 2001-2022 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/plots for PAHs at the high school and south stations from 2001 through 2022.

Over the recent monitoring period since IHC dredging and sediment placement to the CDF began (2012-2022), Acy and Fla decrease, and all other PAHs have no observable trends at the high school. Over the same period at the CDF stations (combined north, south, east, west stations), Acy, Fla, Phe decrease, Ace, Flo, and Pyr have no observable trends, and Nap increases.

In summary, five of the seven PAHs included in the analysis had similar trends between the HS and the CDF over the period after dredging and sediment placement to the CDF began, and two had dissimilar trends. More PAHs had decreasing trends over this period at the CDF (three PAHs with decreasing trends) than at the HS (two with decreasing trends). It is not possible to assess the effect of dredging and sediment placement to the CDF based on these trends.

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, Phe and Pyr) exhibit statistically higher concentrations during summer than winter and/or spring/fall at the site. Acy levels are higher in winter than summer, and higher in spring/fall than summer at the CDF. The trends are generally similar between the site monitors and the high school data, with a few exceptions. Temperature-corrected Nap data generally show no seasonal differences at the high school or at the CDF site.

Monitoring stations

Table 5 compares PAH concentrations between monitoring stations at the site and at the HS. Monitoring data from the four stations at the CDF site are aggregated and treated as one set of data for comparing conditions at the CDF to conditions at the HS. During the period after dredging started, Ace, Fla, Flo, and Phe show no statistical difference between the high school and the combined CDF stations. During this period, Nap is statistically higher at the high school than at the combined CDF stations; conversely, Pyr and Acy are statistically higher at the CDF stations than at the high school.

The lack of statistical difference between a majority of the PAHs between the high school and the CDF stations, and one PAH (Nap) having higher levels at the HS than CDF site monitors indicate PAHs are impacted by multiple sources unrelated to the CDF.

Differences are explored further in Table 5 considering active dredging data (nine events between October 2012 and July 2022) and idle quiescent pond data (inactive periods between October 2012 and July 2022).

Active/Discharge

During sediment discharge into the CDF, Flo and Pyr levels are higher at the combined CDF stations than at the high school (Table 5). The other PAHs, Ace, Acy, Fla, Nap, and Phe, are not statistically different between the high school and the CDF stations. 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, Nap levels are higher at the high school than at the CDF stations (Table 5). Conversely, Acy and Pyr levels are statistically higher at the CDF than at the high school. The other PAHs, Ace, Fla, Flo, and Phe, are not statistically different between the high school and the CDF stations. These results indicate the CDF pond have little impact on atmospheric PAHs at the high school.

Dredging activity

Table 6 compares PAH levels between active discharge and idle quiescent pond data. All PAHs except Nap and Phe are greater during discharge periods than background phase at the combined CDF stations. At the high school, there is no statistical difference between any PAH levels during discharge and quiescent pond periods after dredging and sediment placement to the CDF began. These results confirm that dredging activities have a localized effect on PAH concentrations near the CDF, but not at the high school.

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 1.42 to 1.73 ug/m^3 at the five monitors) are about 50% higher than that of benzene (median concentrations ranging from 1.12 to 1.29 ug/m^3). High school median concentration of benzene is in the range of the onsite median concentrations. High school median concentration of toluene is higher than the CDF 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.

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 (2001-2022), using the original VOC data (no temperature correction). More recent temperature-corrected data (2012-2022 for the high school and CDF stations) were also examined for trends.

Over the 2001-2022 period, toluene decreases with time at the high school and at the south station, and benzene exhibits no trend at the high school and at the south station. Over the recent monitoring period (2012-2022), toluene decreases with time at the CDF and exhibits no trend at the high school. Benzene increases with time at the high school and at the CDF over the 2012-2022 period. Appendix C includes Mann-Kendall trend analyses for benzene and toluene at the high school and south stations from 2001 through 2022.

In summary, benzene exhibits no trend over the entire monitoring period (2001-2022), but has increased over the more recent monitoring period since dredging started (2012-2022). Conversely, toluene has decreased over the entire monitoring period (2001-2022), and toluene has decreased as well over the recent monitoring period since dredging started (2012-2022) at the CDF. Benzene increase trend may be partly due to increase in detection limit starting in 2018.

Season

Table 4 compares VOC concentrations between summer, winter, and spring/fall (2012-2022 data). With temperature effects removed from the dataset, benzene and toluene show no significant differences between seasons at the high school, except for higher benzene in the winter than spring/fall. At the CDF sites, benzene and toluene show the same trends, with no difference between summer and winter, statistically higher in summer and in winter than in spring/fall.

Monitoring stations

Table 5 compares VOC concentrations between the high school and the CDF during the period after dredging started (2012-2022). Benzene levels are similar between the CDF and the high school over the 2012-22 period, during sediment discharge to the CDF, and during quiescent pond periods. Conversely, toluene levels are higher at the high school than at the CDF over the 2012-22 period, during sediment discharge to the CDF, and during quiescent pond periods.

Dredging Activity

Table 6 compares VOC levels between pre-dredging background, active discharge, and idle quiescent pond data. At the high school, benzene and toluene levels are not different between the background and discharge or quiescent pond periods. At the CDF, benzene levels are higher during active sediment discharge and during quiescent periods than background. Toluene shows no significant difference between background, discharge, and quiescent pond periods at the CDF.

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 3.74E-5 to 3.96E-5 g/m^3 at the CDF monitoring stations (Table 1d), and the median TSP value at the HS is 3.32E-5 g/m^3 over the 2012 to 2022 period.

Trend Analysis

Table 3 presents results from a Mann-Kendall trend analysis of TSP concentrations over time. Over the entire sampling period (2001-2022), TSP decreases statistically with time at the high school as well as at the CDF site (as represented by the south station). Over the recent sampling period since dredging and sediment placement to the CDF began (2012-2022), TSP exhibits no trend at the high school, but decreases statistically with time at the CDF site. Dissimilar trends at the high school and CDF site may be indicative of different sources at the two locations.

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 the high school and CDF. TSP concentrations are higher at the CDF than at the high school over the 2012-2022 monitoring period.

Active/Discharge

During sediment offloading and placement into the CDF, TSP concentrations are higher at the CDF than at the high school.

Idle/Quiescent pond

During sediment storage quiescent pond periods, TSP concentrations are higher at the CDF than at the high school.

Dredging activity

Table 6 compares TSP concentrations between pre-dredging background, active discharge, and idle quiescent pond periods. At the high school, TSP levels are higher during the pre-dredging (background) period than the active discharge and quiescent pond conditions. There is no statistical difference between TSP levels during active discharge and quiescent pond conditions at the high school. At the CDF, TSP levels are lower under quiescent pond conditions than pre-dredging and active discharge conditions. There is no statistical difference between TSP levels during active discharge and pre-dredging at the CDF. Because levels are statistically no different between the discharge and pre-dredging period (CDF) and statistically less during active discharge and quiescent pond 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.

CDF

At the CDF, 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 CDF.

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 2012 to 2022 period, Iron (onsite monitors median concentrations ranging from 0.61 to 0.68 mg/m^3), Aluminum (0.23 to 0.25 mg/m^3), Copper (0.040 to 0.046 mg/m^3), Manganese (0.046 to 0.053 mg/m^3), and Zinc (0.048 to 0.050 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 65% of the time; Cobalt is not detected over 90% of the time and is not discussed further in this report.

The median concentration of most metals at the high school are within the range of or lower than the median concentrations at the CDF site stations. The one exception is Copper, with a median concentration at the high school (0.093 mg/m^3) that is greater than the median concentrations at the CDF stations (0.040 to 0.046 mg/m^3).

Table 2 shows the Spearman correlation coefficients for TSP and metals. Unlike PCBs, PAHs, and VOCs, TSP and metals are not highly correlated (only 11 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 0.125 (with Cu) to 0.726 (with Al). Spearman correlation coefficients are lowest between Cu and other metals and range from 0.061 (with Al) to 0.384 (with Ba). As and Se also have low correlation with other metals. Iron and Manganese have the highest Spearman correlations with other metals. 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 (2001-2022). More recent data (2012-22 for the high school and CDF stations) were also examined for trends.

Over the 2001-2022 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 2001-2022 period, at the south site, similar to TSP, all metals except Al, As, and Se, decrease statistically with time, while Al exhibits no significant trend, and As and Se increase over this period. The increasing trends for As and Se may be due to increased detection limits for these two metals in 2018, as the detection limits and the median values of As and Se are close in values. Appendix D includes Mann-Kendall trend analyses for TSP and metals at the high school and south stations from 2001 through 2022.

Over the recent monitoring period (2012-2022), the trends were different when compared to the 2001-2022 trends for TSP and three metals at the high school: TSP, Al and Cr decrease statistically with time over the 2001-22 period and exhibit no trend for 2012-2022. Cu exhibits no significant trend at the HS over 2001-2022, and decreases over the 2012-2022 period. At the south station, TSP and all metals exhibit the same trend over the two monitoring periods.

In summary, most metals along with TSP exhibit decreasing trend at the high school and at the CDF onsite stations over the entire monitoring period (2001-2022), and over the recent monitoring period since dredging began (2012-2022). The exceptions are Al (no trend), As (increasing), and Se (increasing). 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. (It should also be noted that the detection limits and the median values of As and Se are close in values.) With a few exceptions trends are similar between the high school and CDF stations for most metals over both monitoring periods.

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, Cr, Cu, Ni and Zn exhibit fewer notable seasonal trends than other metals. At the CDF site, all metals except Cu and Ni exhibit notable seasonal trends.

Monitoring stations

Table 5 compares metals concentrations between the high school and the CDF monitoring stations. Before dredging began (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 began (2012-2022), four metals (Al, Fe, Mn, and Se) are statistically less at the high school than at the combined 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 the combined CDF stations during the period after dredging started (2012-2022).

Differences are explored further considering active dredging data, idle quiescent pond data, and pre-dredging background data (January 2010 through October 2012).

Active/Discharge

During sediment offloading and placement into the CDF, comparison of the high school to the combined CDF stations indicates that there is no statistical difference between six metals (As, Ba, Cr, Pb, Se, Zn) at the two sites (HS vs CDF). Four metals (Al, Fe, Mn, and Ni) are statistically higher at CDF combined stations than at the high school. Conversely, Copper is statistically less at the CDF combined stations than at the high school during sediment offloading and placement into the CDF.

Idle/Quiescent pond

During sediment storage quiescent pond periods, comparison of the high school to the combined CDF stations shows similar trends to the period when active sediment discharge is occurring for most metals. There is no statistical difference between six metals (As, Ba, Cr, Pb, Ni) at the two sites (HS vs CDF) during CDF idle/quiescent pond periods. Five metals (Al, Fe, Mn, Se, Zn) are statistically higher at CDF combined stations than at the high school. Conversely, Copper is statistically less at the CDF combined stations than at the high school during the idle/quiescent pond periods.

The higher Cu level at the high school than the CDF stations during all periods 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, Mn, and Se are lower at the high school than at the CDF 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 6 compares metals concentrations between pre-dredging background, active discharge, and idle quiescent pond periods. Several metals are statistically greater during the background/pre-dredging period than the post-dredging period. At both the high school and south station/CDF, Al, Ba, Cr, 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 post-dredging periods at the high school. As, Se, and Zn are not statistically different between the background and post-dredging periods at the south station/CDF. Cu conversely has opposing trends at the high school: Cu is statistically greater during the post-dredging phase than during the background phase at the high school. Ni is the only metal that is statistically greater during the post-dredging phase than during the background phase at the south station/CDF.

Al Ba Pb, and Mn are statistically greater during active discharge than during quiescent pond periods for the high school station. There is no statistical difference between the active discharge and the quiescent pond periods for any other metal at the high school. Al, Ba, Cr, Fe, Pb, Mn, and Ni are greater during active discharge than during the quiescent pond periods for the combined CDF onsite stations. There is no statistical difference between the active discharge and the quiescent pond periods for As, Se, and Zn for the CDF 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.

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 (PCBs analysis presented in USACE 2023)

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.
- The lack of statistical difference between a majority of the PAHs between the high school and the CDF stations, and one PAH (Nap) having higher levels at the HS than CDF site monitors indicate PAHs are impacted by multiple sources unrelated to the CDF.
- All PAHs except Nap and Phe are greater during discharge periods than background phase at the combined CDF stations. Several PAHs are also statistically higher during active discharge than quiescent pond periods at the CDF stations.
- At the high school, there is no statistical difference between any PAH levels during discharge and quiescent pond periods after dredging and sediment placement to the CDF began. 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 of PAHs since IHC dredging began shows five of the seven PAHs included in the analysis had similar trends between the HS and the CDF over the period, and two had dissimilar trends. More PAHs had decreasing trends over this period at the CDF (three PAHs with decreasing trends) than at the HS (two with decreasing trends).
- These findings suggest that dredged material disposal activities and the presence of dredged material at the CDF likely do not impact the atmospheric PAH conditions at the high school. The data also 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.
- At the high school, there are no significant differences in benzene levels and toluene levels between background, discharge, and quiescent pond periods. At the CDF, benzene levels are higher during active sediment discharge and during quiescent periods than background. Toluene shows no significant difference between background, discharge, and quiescent pond periods at the CDF.
- Over the period after IHC dredging began (2012-2022), toluene decreases with time at the CDF and exhibits no trend at the high school. Benzene increases with time at the high school and at the CDF over this period. However, benzene increase trend may be partly due to increase in detection limit starting in 2018.
- Over the 2001-2022 period, toluene decreases with time at the high school and at the south station, and benzene exhibits no trend at the high school and at the south station. 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 (2001-2022), TSP decreases statistically with time at the high school as well as at the CDF site (as represented by the south station). Over the recent sampling period since dredging and sediment placement to the CDF began (2012-2022), TSP exhibits no trend at the high school, but decreases statistically with time at the CDF site. Dissimilar trends at the high school and CDF site may be indicative of different sources at the two locations.

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.
- The median concentration of most metals at the high school are within the range of or lower than the median concentrations at the CDF site stations. The one exception is Copper, with a median concentration at the high school (0.093 mg/m^3) that is greater than the median concentrations at the CDF stations (0.040 to 0.046 mg/m^3).
- Spearman correlation coefficients for TSP and metals show TSP and metals are not highly correlated and like come from different sources.
- 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.
- Most metals along with TSP exhibit decreasing trend at the high school and at the CDF onsite stations over the entire monitoring period (2001-2022), and over the recent monitoring period since dredging began (2012-2022). The exceptions are Al (no trend), As (increasing), and Se (increasing). However, these increasing trends may be due to the new higher detection limits starting in 2018.
- 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.

References

Hu, D. and K. Hornbuckle 2010. Inadvertent Polychlorinated Biphenyls in Commercial Paint Pigments. Environmental Science & Technology. April 15, 2010; 44(8): 2822-2827.

Jacobs Engineering 2015. Draft Final Ambient Air Monitoring Plan for Remediation Activities – New Bedford Harbor Superfund Site. ACE-J23-35BG1001-M17-0009. July 23, 2015.

NIOSH 2016. *NIOSH Pocket Guide to Chemical Hazards*. The National Institute for Occupational Safety and Health, 2016. Chlorodiphenyl (42% chlorine). Web 31 Aug 2016. <https://www.cdc.gov/niosh/npg/npgd0125.html>

NIOSH 2016. *NIOSH Pocket Guide to Chemical Hazards*. The National Institute for Occupational Safety and Health, 2016. Chlorodiphenyl (54% chlorine). Web 31 Aug 2016. <https://www.cdc.gov/niosh/npg/npgd0126.html>

USACE 2003a. Indiana Harbor and Canal Dredging and Disposal Project. Ambient Air Monitoring Plan, Volume 1. USACE Chicago District, October 2003.

USACE 2003b. Indiana Harbor and Canal Air Monitoring: Background Phase Ambient Summary & Construction Phase Ambient Air Monitoring Program, USACE Chicago District, November 2003.

USACE 2005. Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2004, USACE Chicago District, June 2005.

USACE 2006. Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2005, USACE Chicago District, June 2006.

USACE 2007. Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2006, USACE Chicago District, July 2007.

USACE 2008. Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2007, USACE Chicago District, July 2008.

USACE 2009. Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2008, USACE Chicago District, September 2009.

USACE 2010. Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2009, USACE Chicago District, June 2010.

USACE 2011. Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2010, USACE Chicago District, July 2011.

USACE 2012. Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2011, USACE Chicago District, July 2012.

USACE 2013. Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2012, USACE Chicago District, April 2013.

USACE 2014. Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2013, USACE Chicago District, July 2014.

USACE 2018. Indiana Harbor and Canal Confined Disposal Facility 2016 Air Monitoring Data Analysis, USACE Chicago District, October 2018.

USACE 2020. Indiana Harbor and Canal Confined Disposal Facility - 2019 PCB Air Monitoring Data Analysis, USACE Chicago District, July 2020.

USACE 2022. Indiana Harbor and Canal Confined Disposal Facility - 2021 PCB Air Monitoring Data Analysis, USACE Chicago District, July 2022.

USACE 2023. Indiana Harbor and Canal Confined Disposal Facility - 2022 PCB Air Monitoring Data Analysis, USACE Chicago District, July 2023.

USEPA, 2004. Hudson River PCBs Superfund Site Quality of Life Performance Standards. May 2004. <https://www3.epa.gov/hudson/quality_of_life_06_04/full_report.pdf>

INDIANA HARBOR AND CANAL

2022 AIR MONITORING DATA ANALYSIS

FIGURES AND TABLES

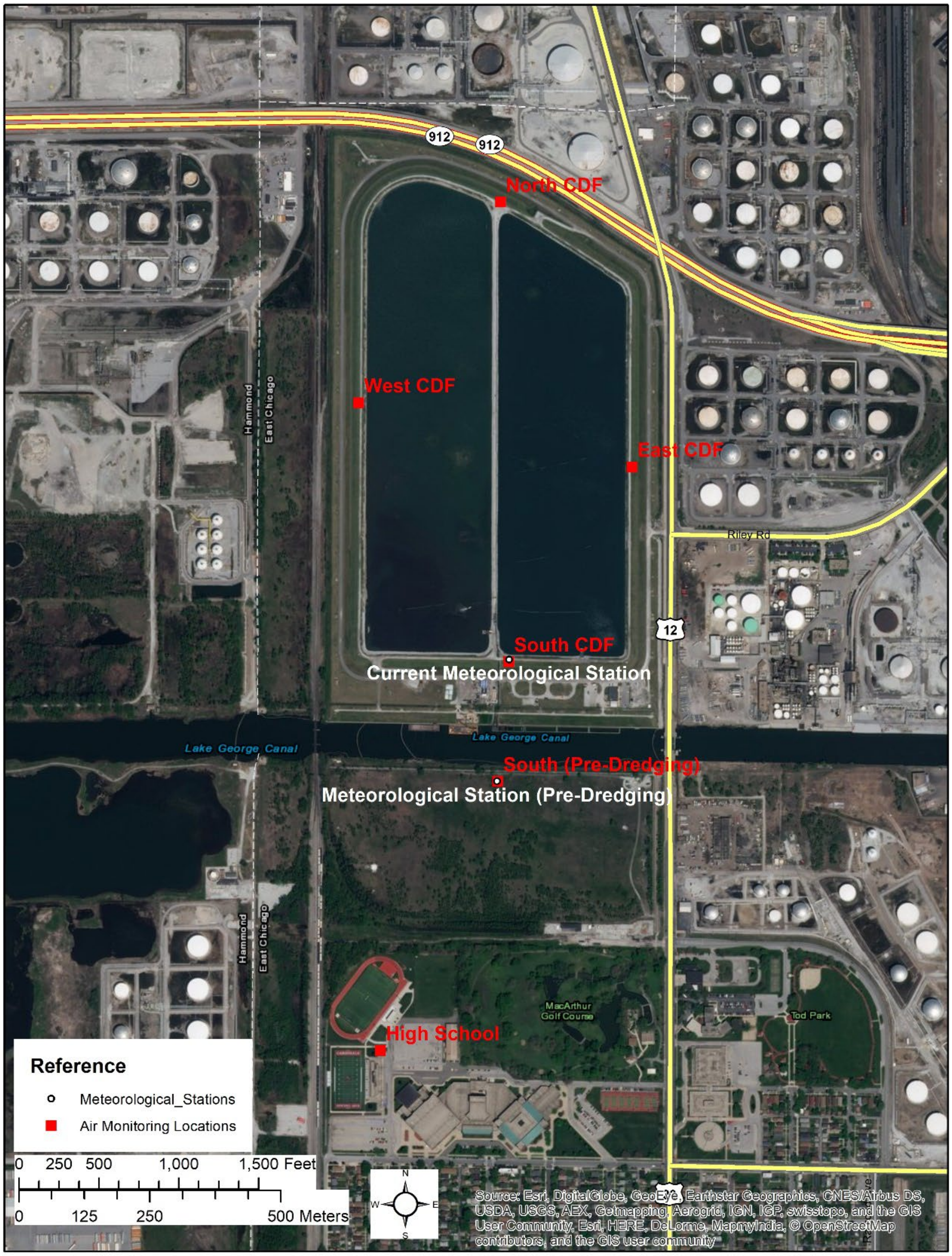
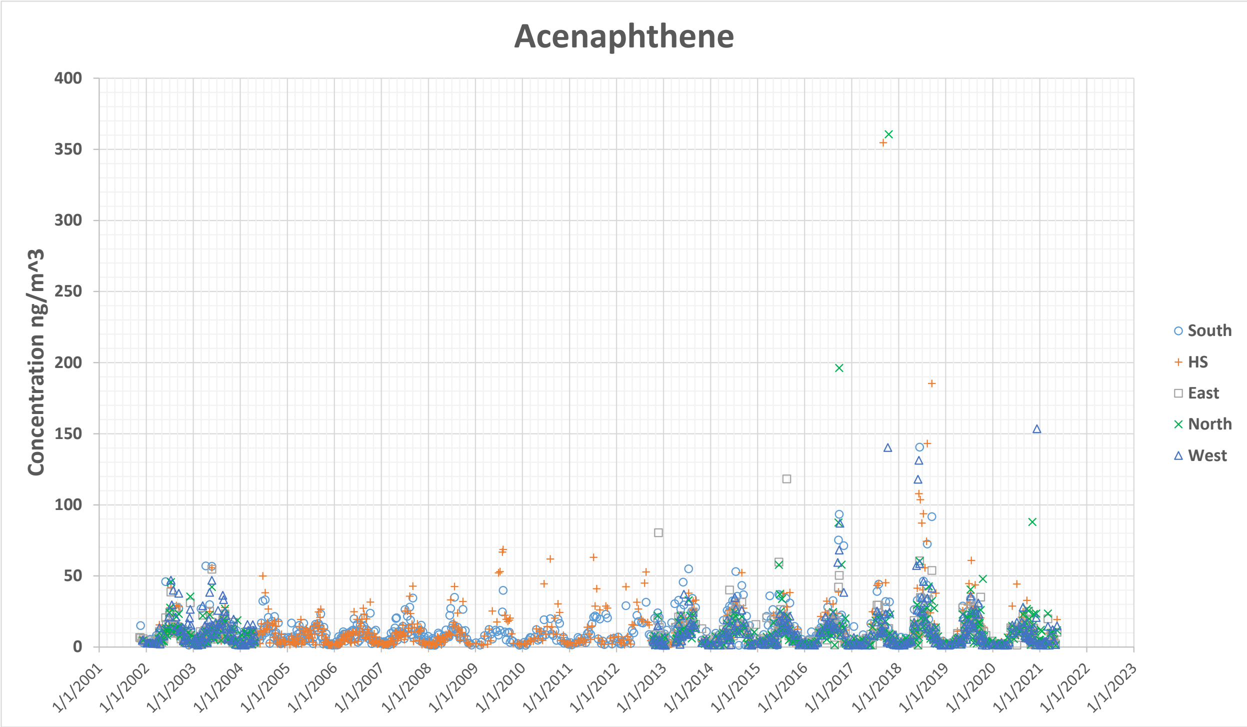


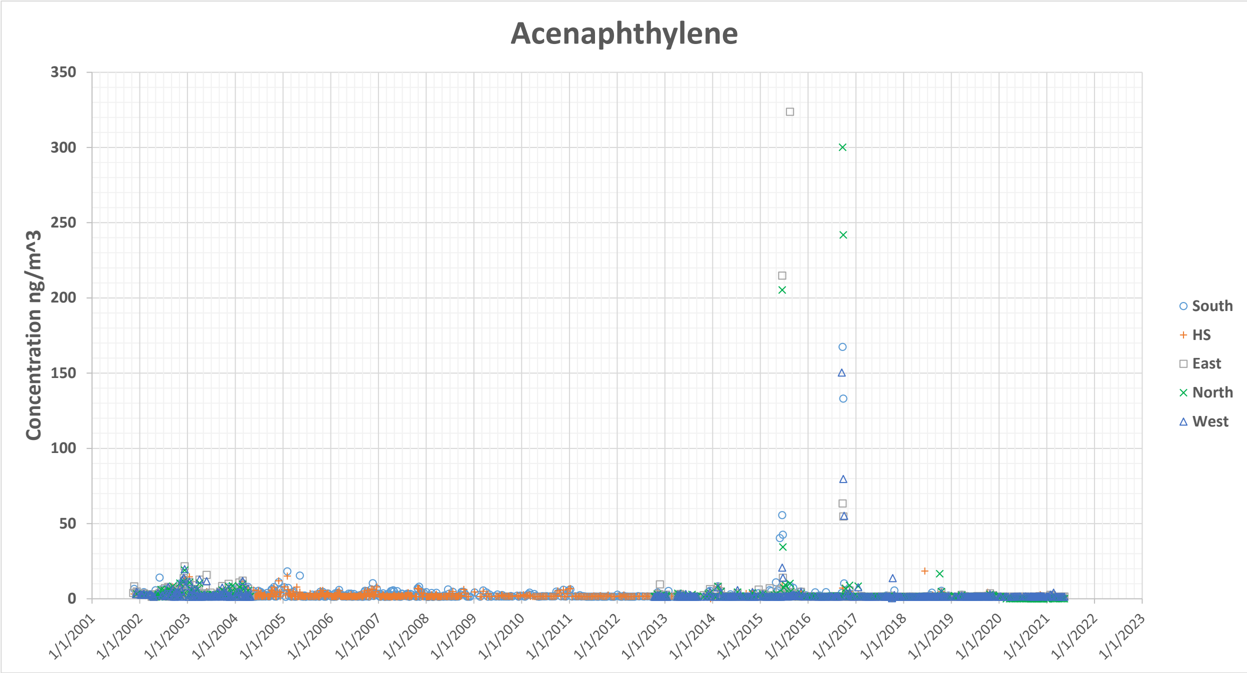
Figure 0. Location of IHC CDF Air Monitors and Meteorological Stations

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 2023.

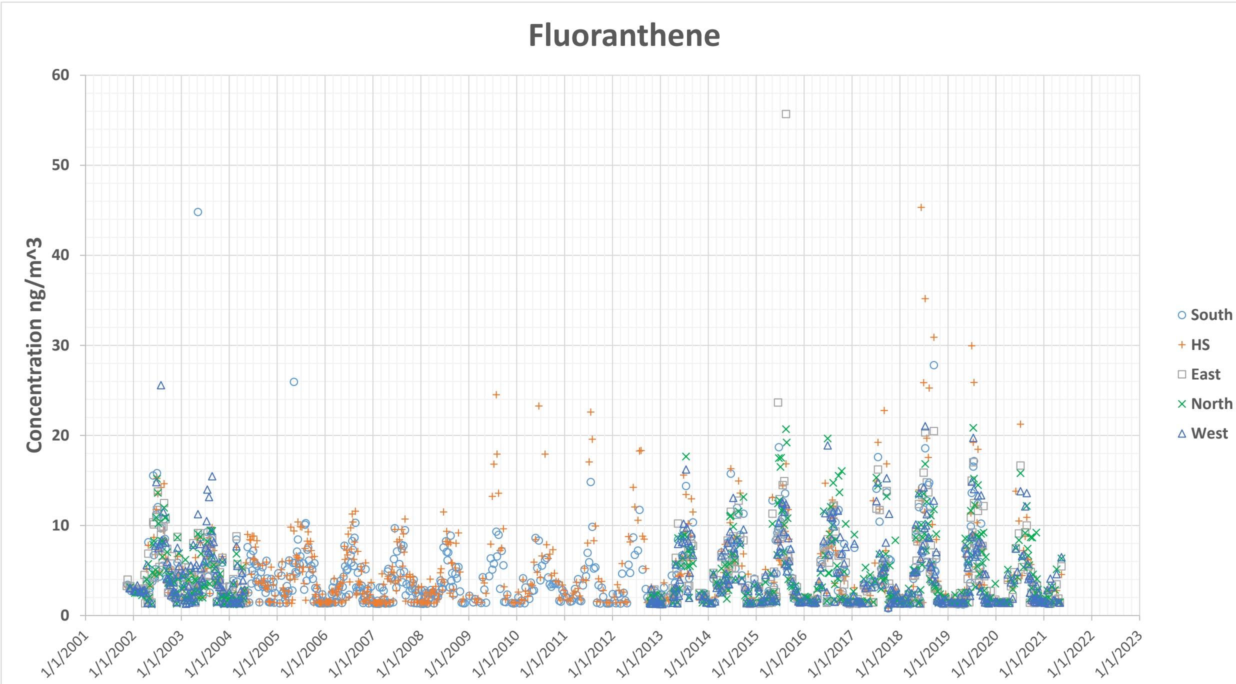
Figures 3 and 4. Atmospheric concentrations of PCB 18 and PCB 28 (pg/m^3) from all stations over the entire monitoring period. Presented in USACE 2023.

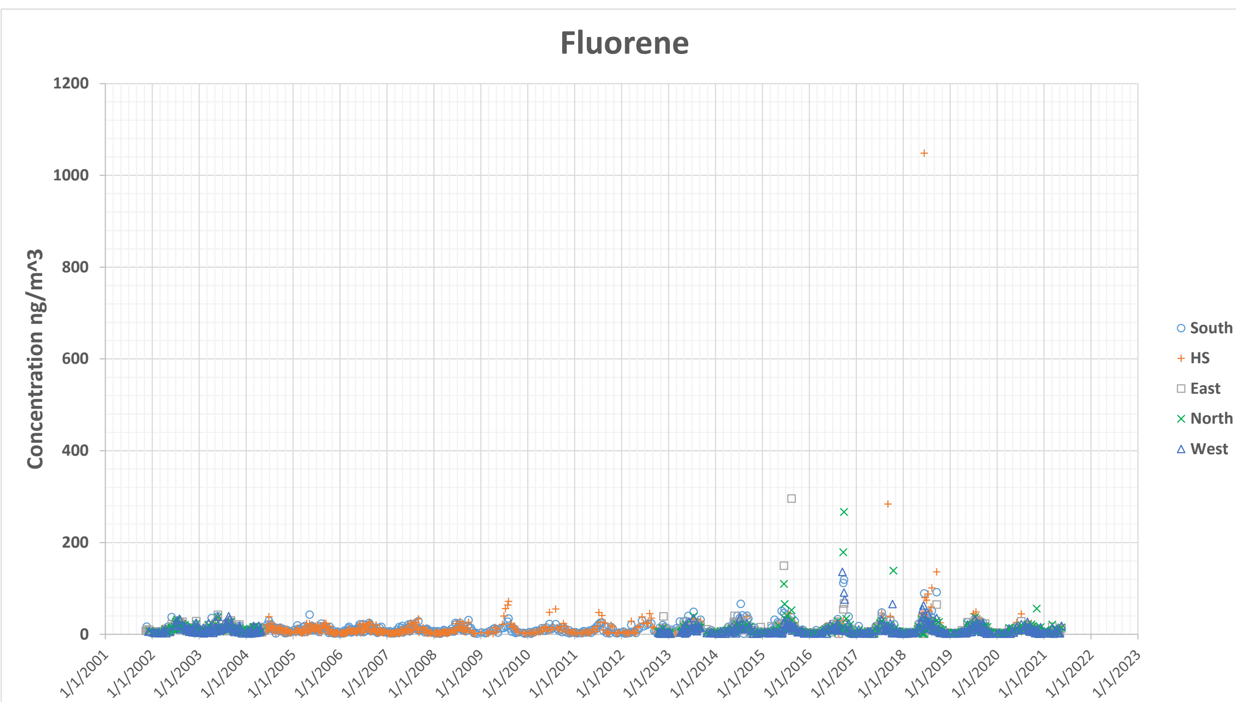
Figures 5 and 6. Atmospheric concentrations of PCB 31 and Sum 18 PCBs (pg/m^3) from all stations over the entire monitoring period. Presented in USACE 2023.



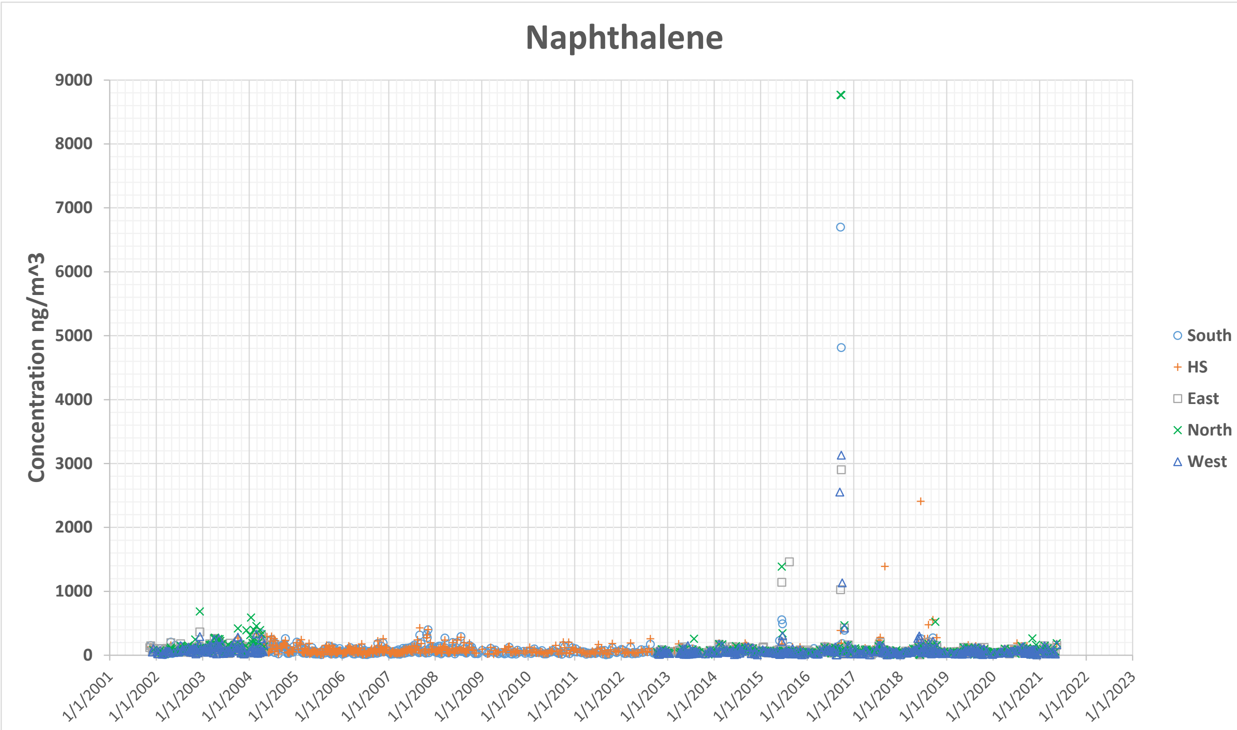


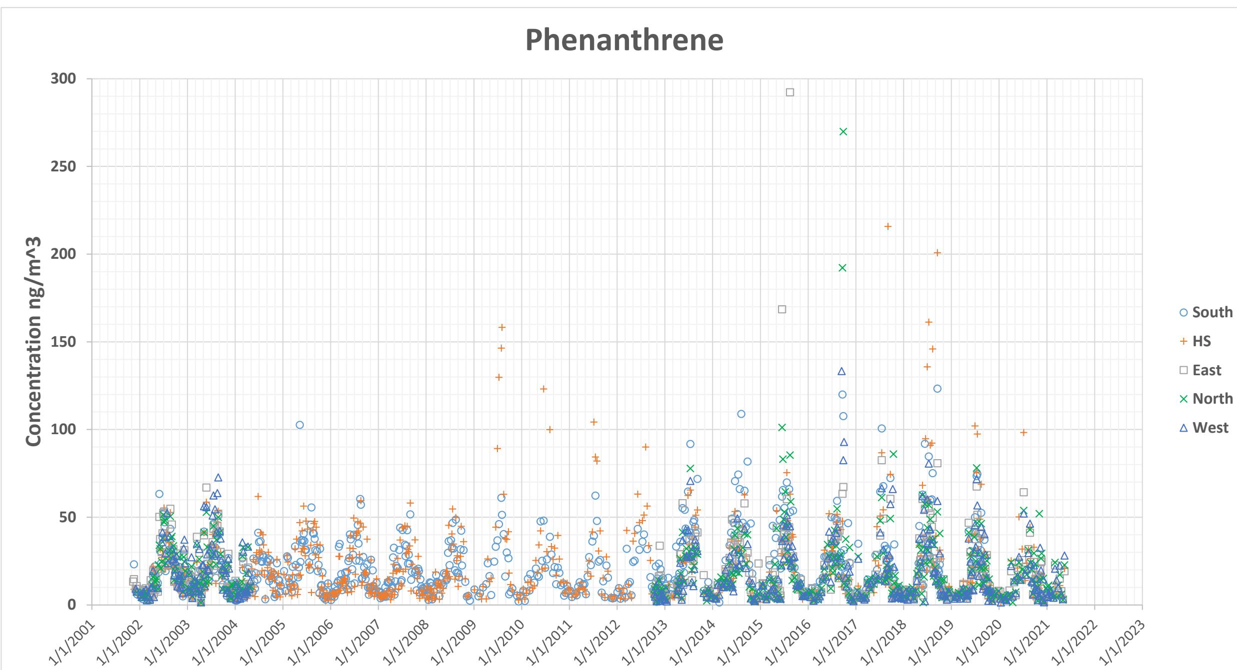
Figures 7 and 8. Atmospheric concentrations of Acenaphthene and Acenaphthylene (ng/m^3) from all stations over the entire monitoring period.





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.

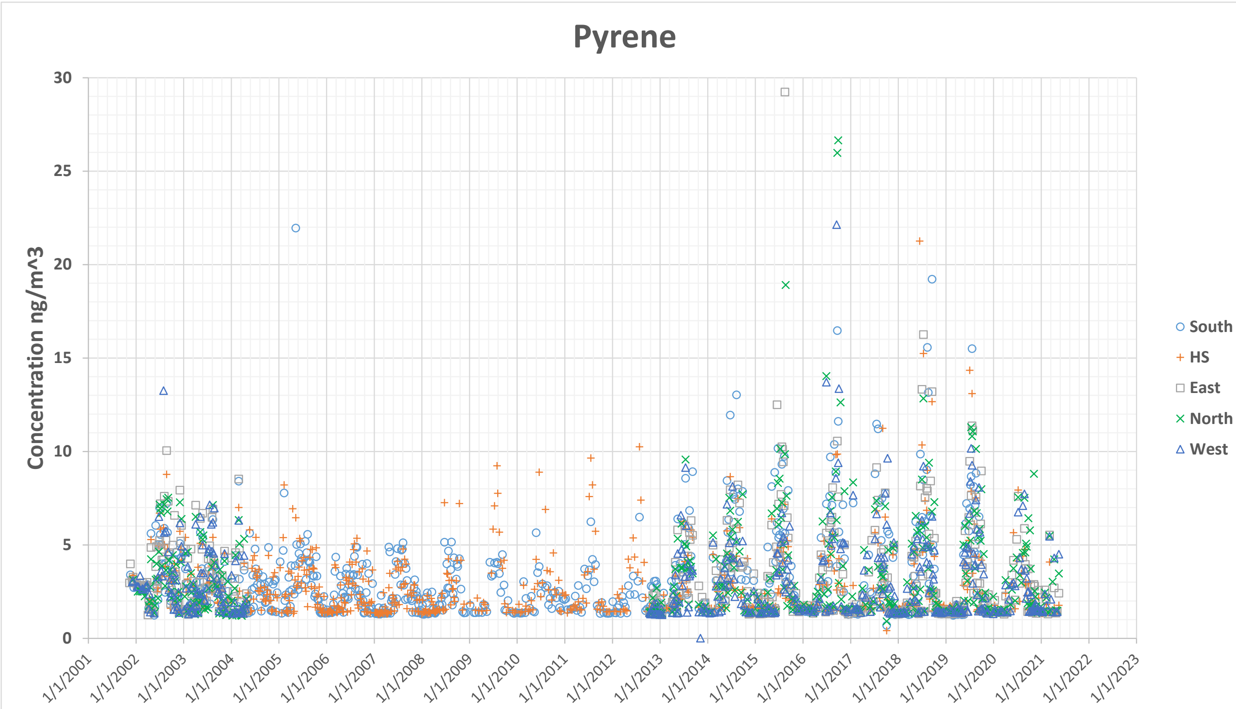
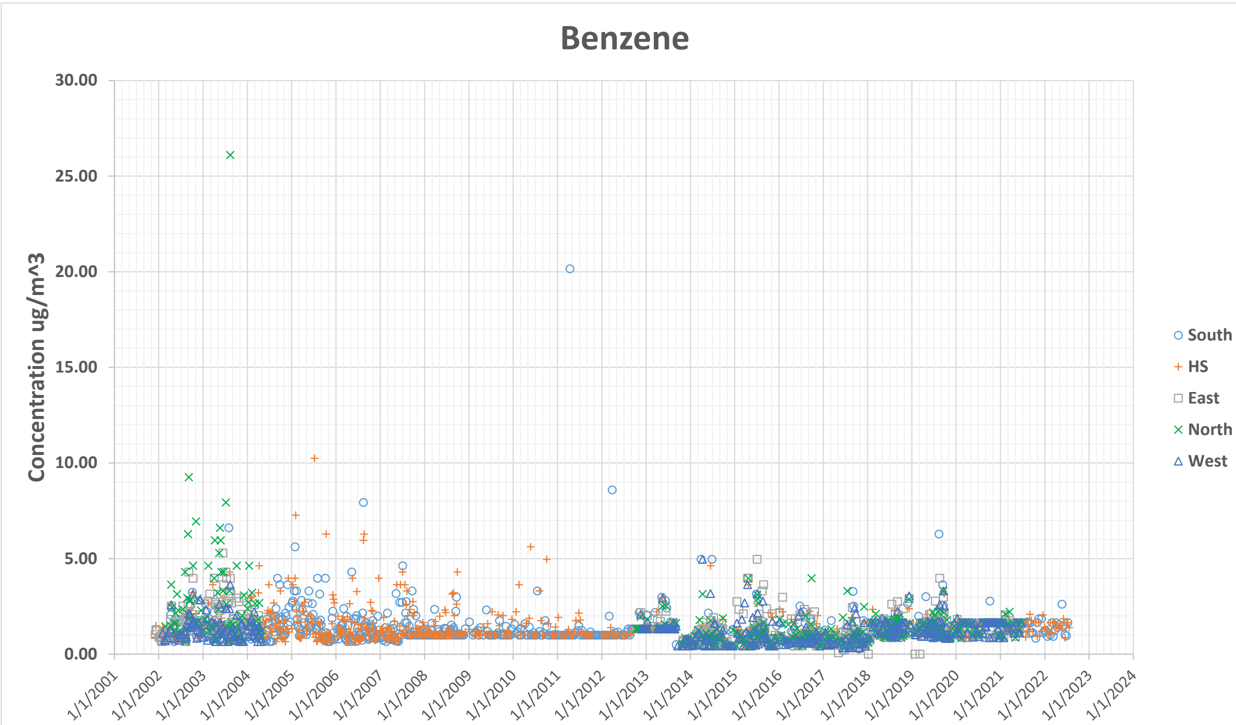
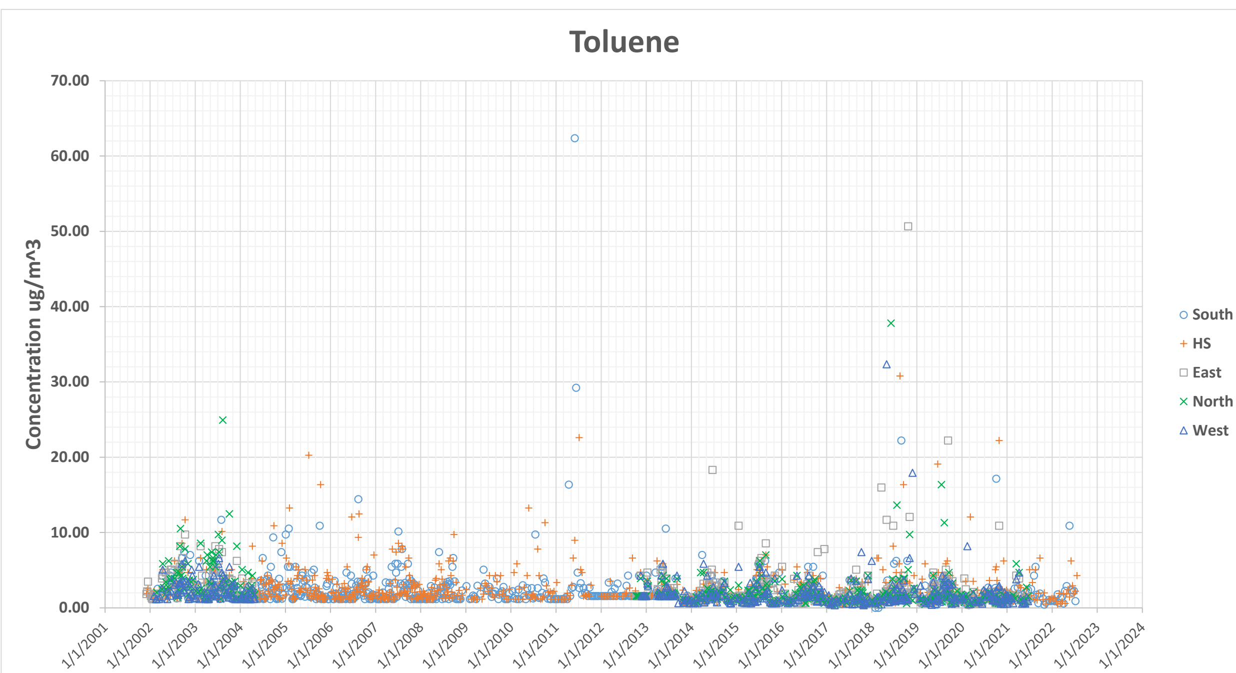
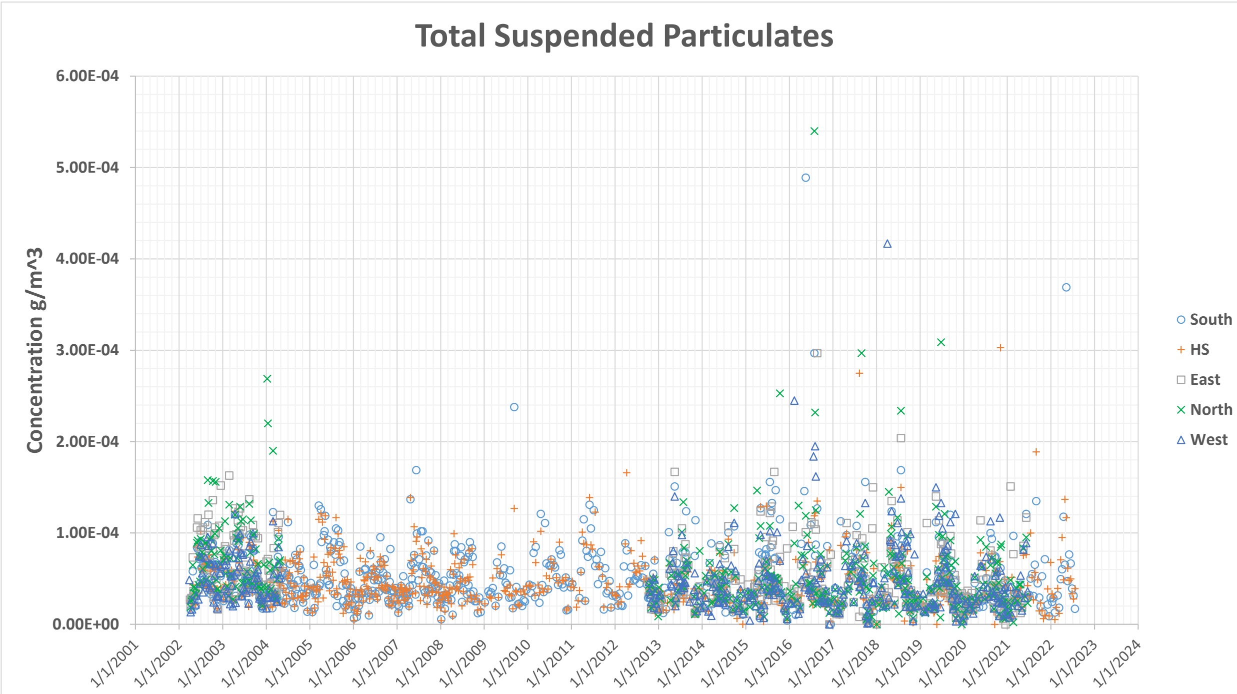


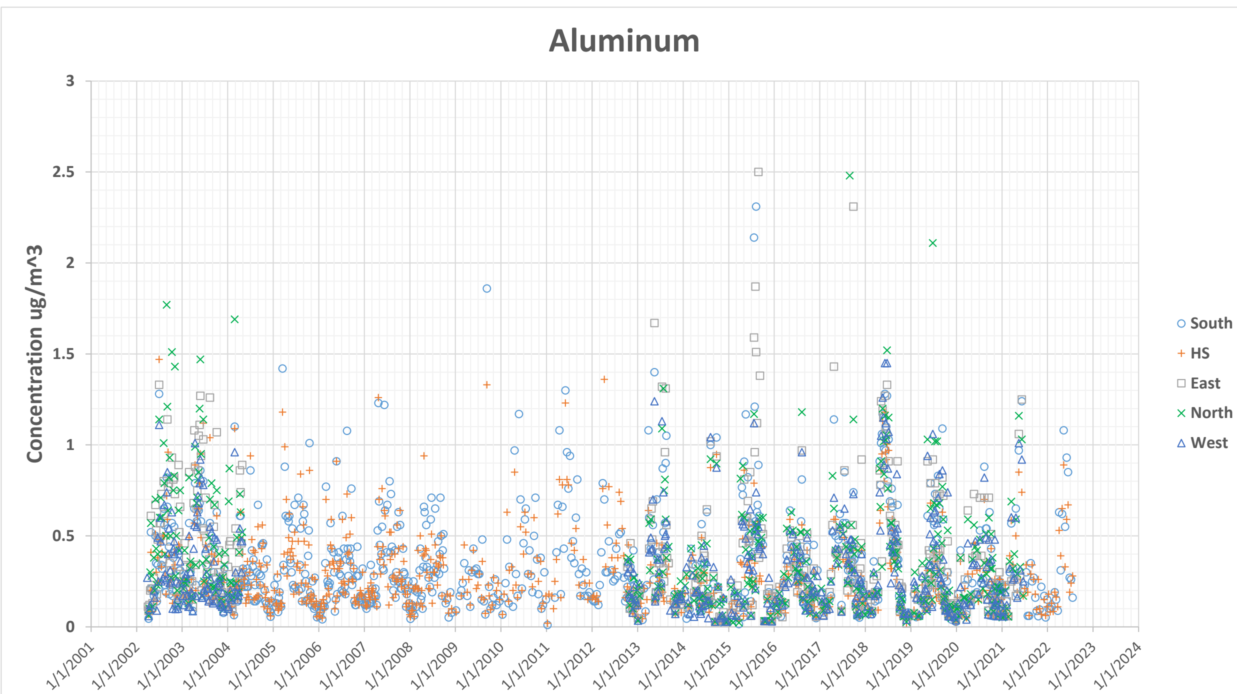
Figure 13. Atmospheric concentrations of Pyrene (ng/m^3) from all stations over the entire monitoring period.



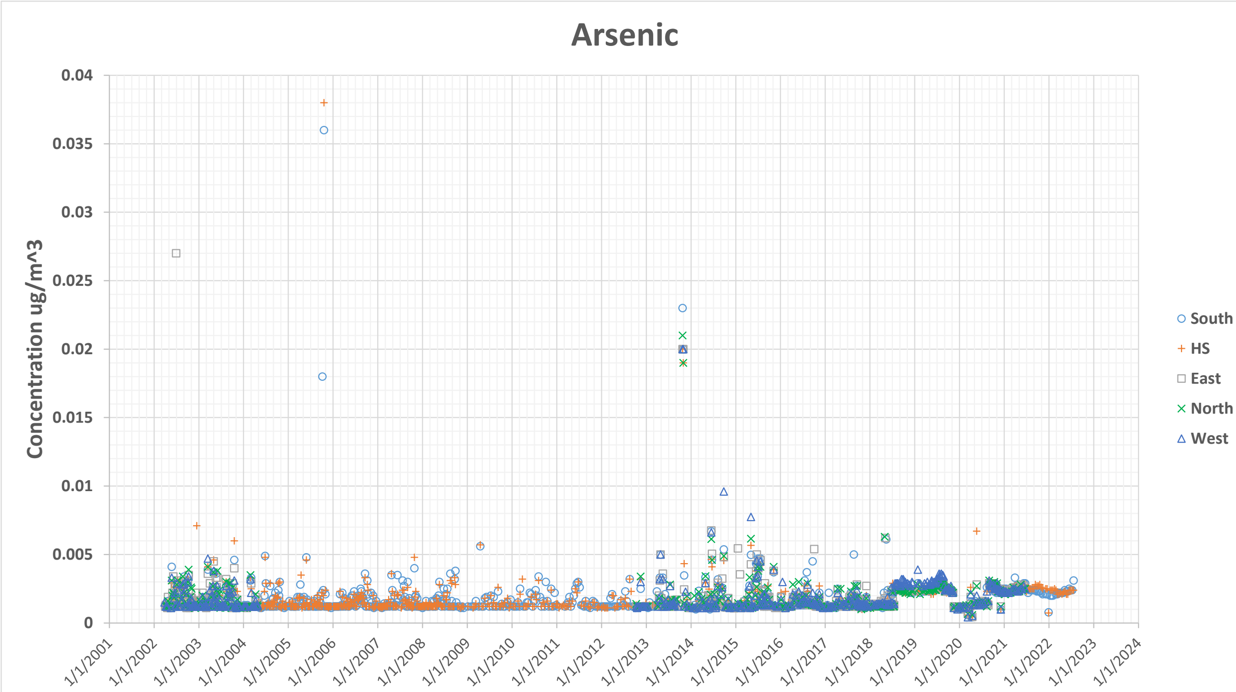


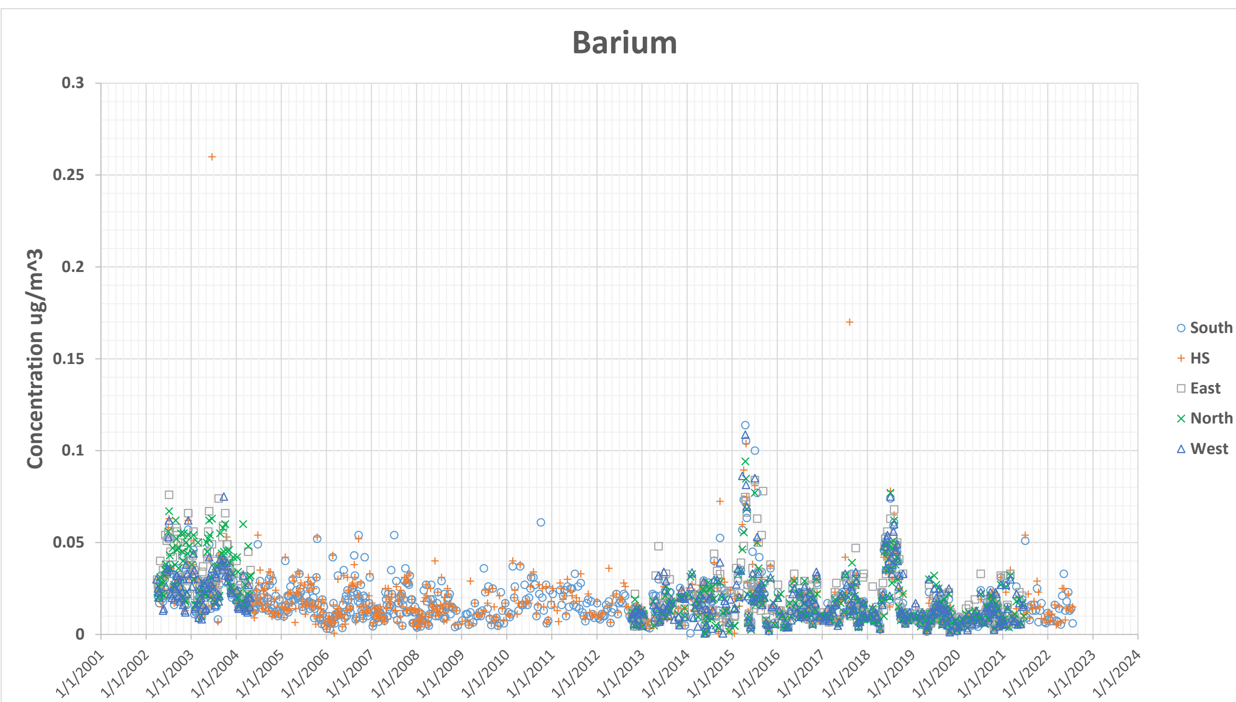
Figures 14 and 15. Atmospheric concentrations of Benzene and Toluene (ug/m^3) from all stations over the entire monitoring period.



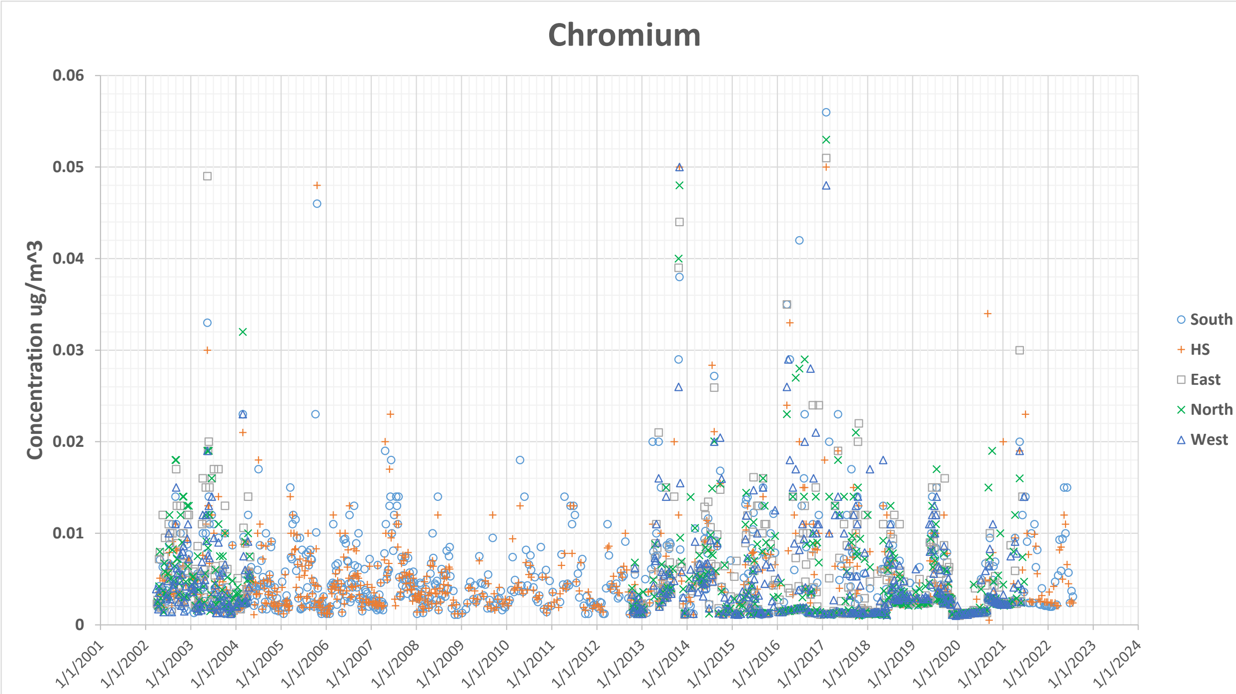


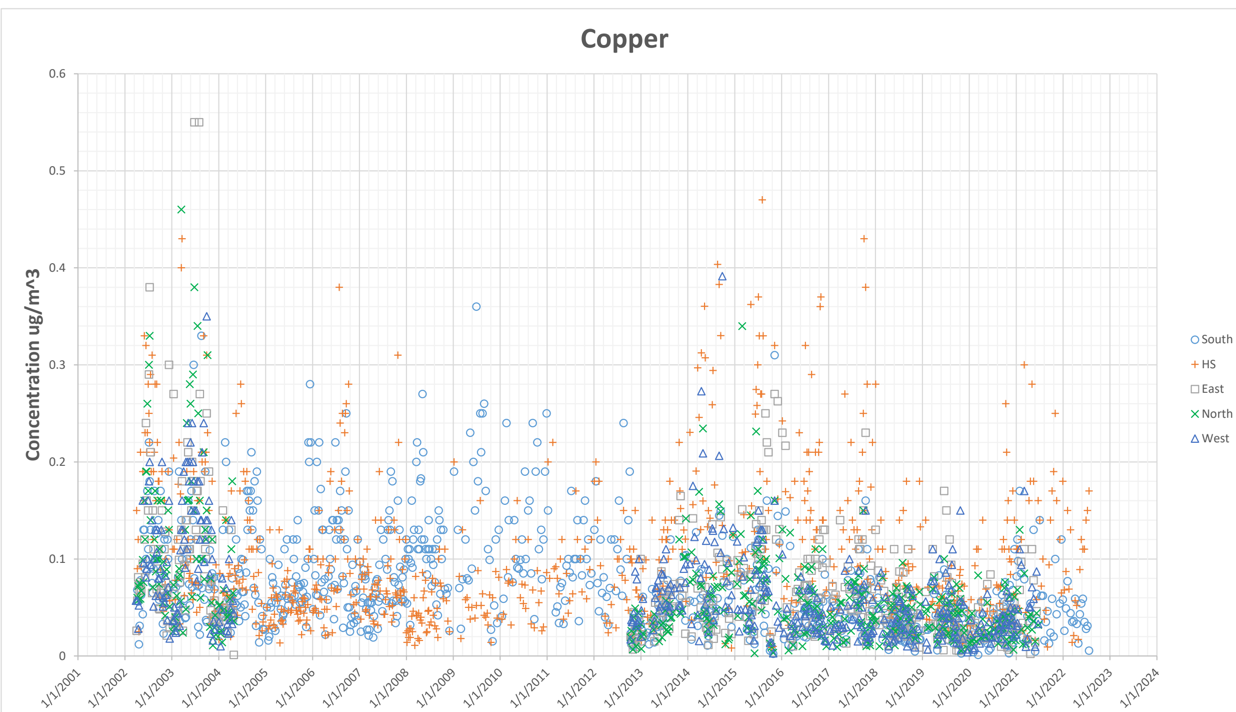
Figures 16 and 17. Atmospheric concentrations of Total Suspended Particulates (g/m^3) and Aluminum (ug/m^3) from all stations over the entire monitoring period.



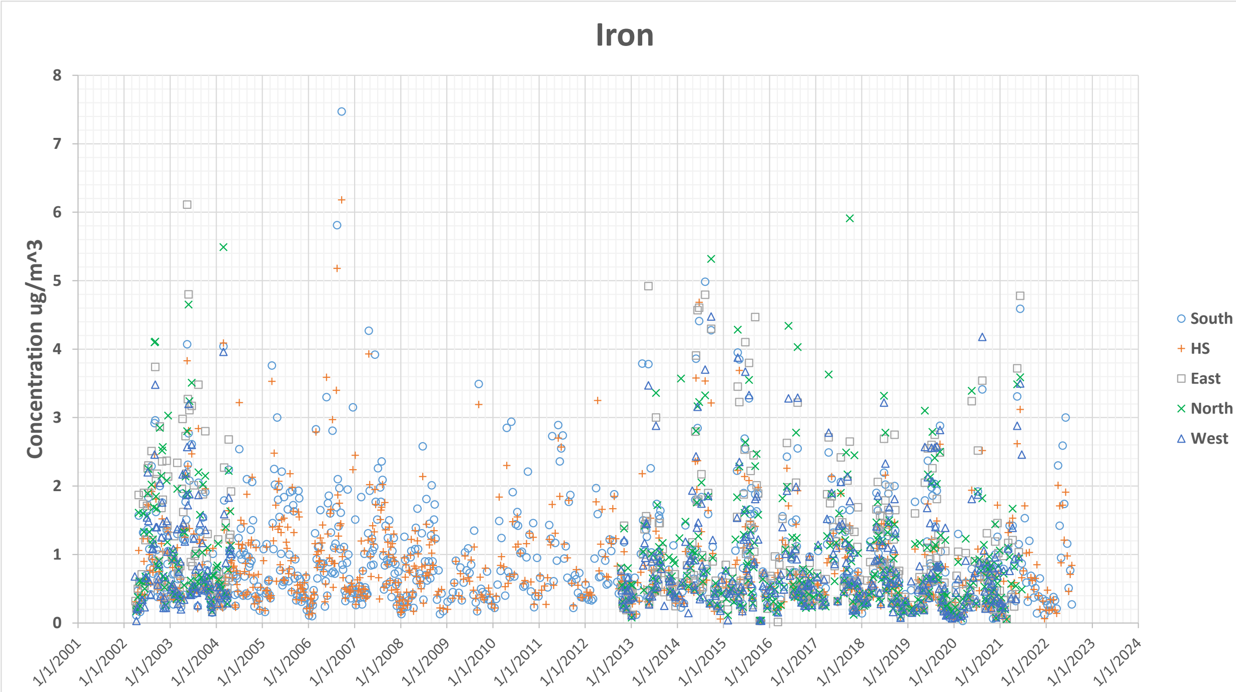


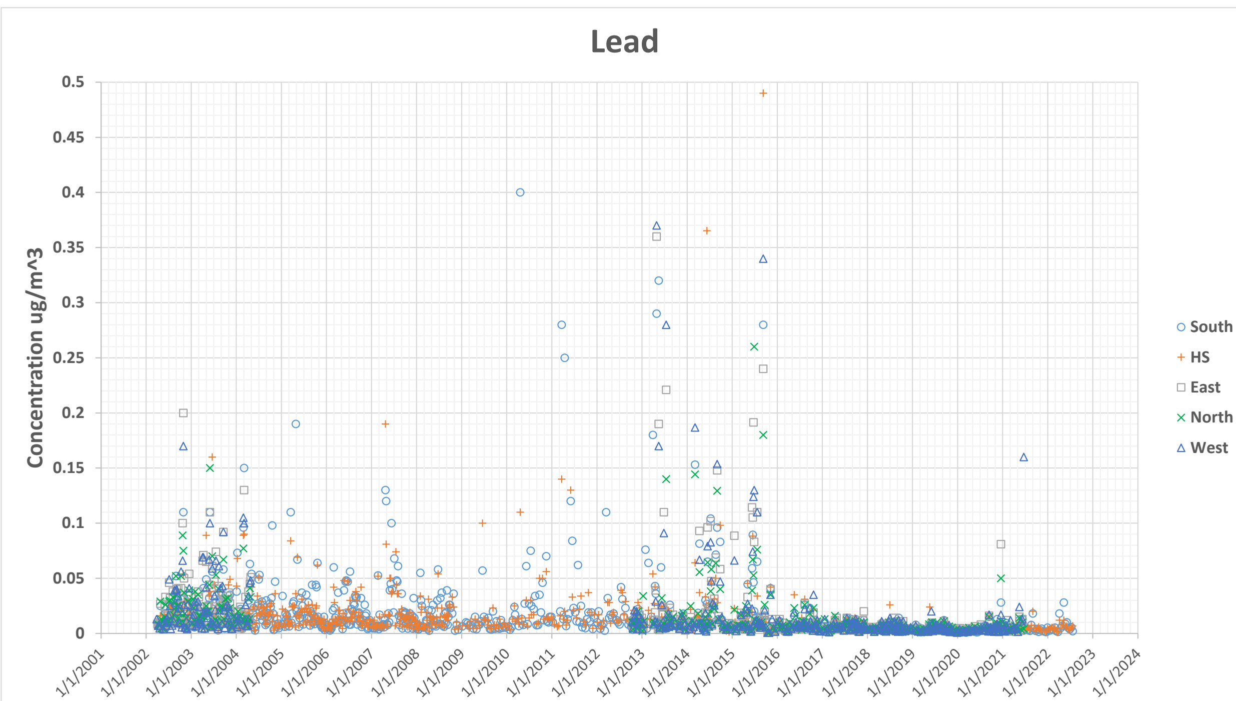
Figures 18 and 19. Atmospheric concentrations of Arsenic and Barium (ug/m^3) from all stations over the entire monitoring period.



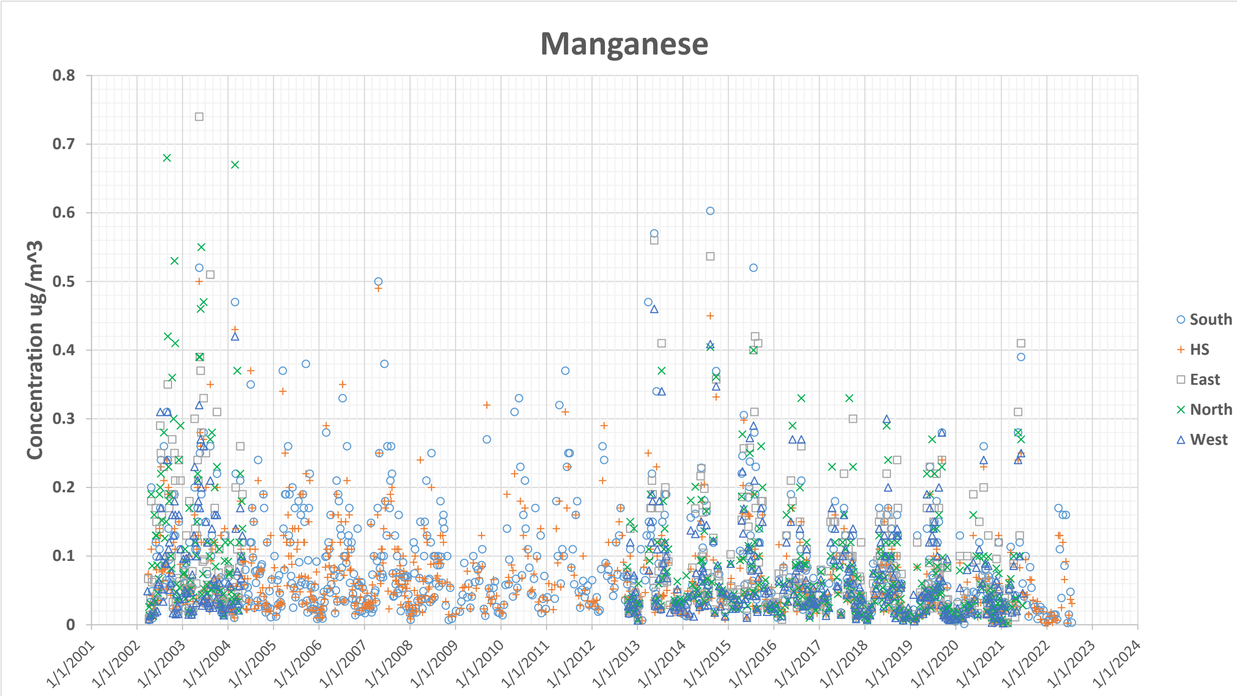


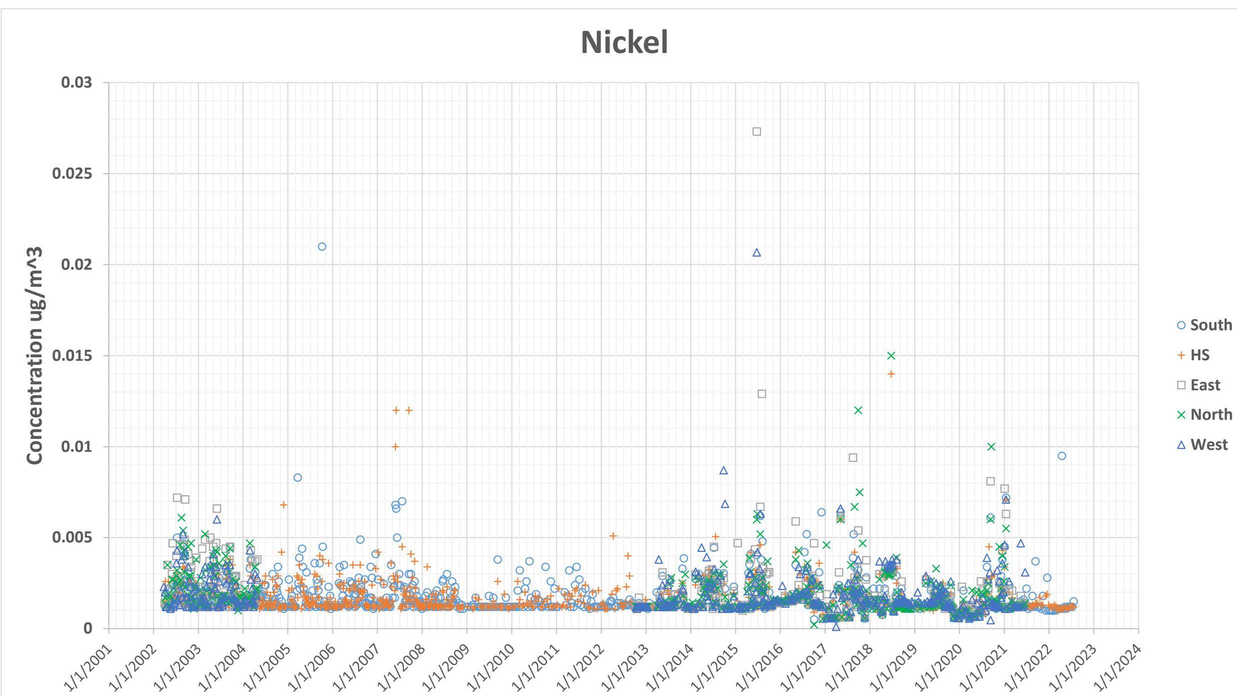
Figures 20 and 21. Atmospheric concentrations of Chromium and Copper (ug/m^3) from all stations over the entire monitoring period.



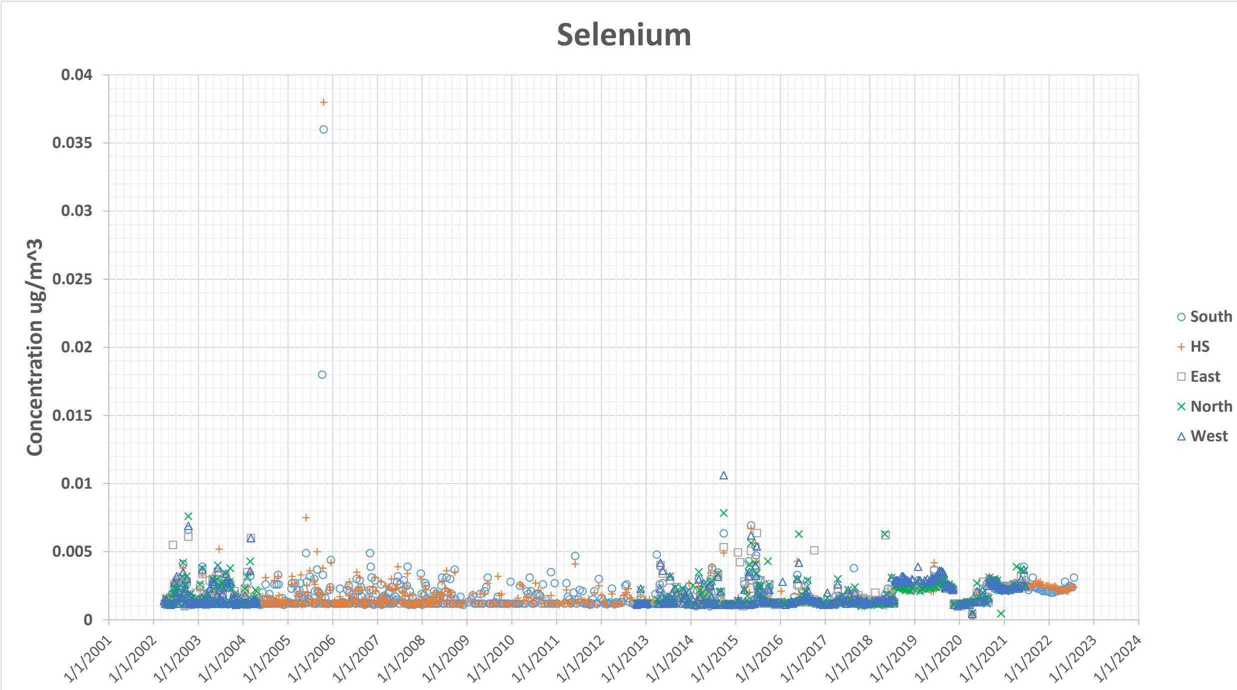


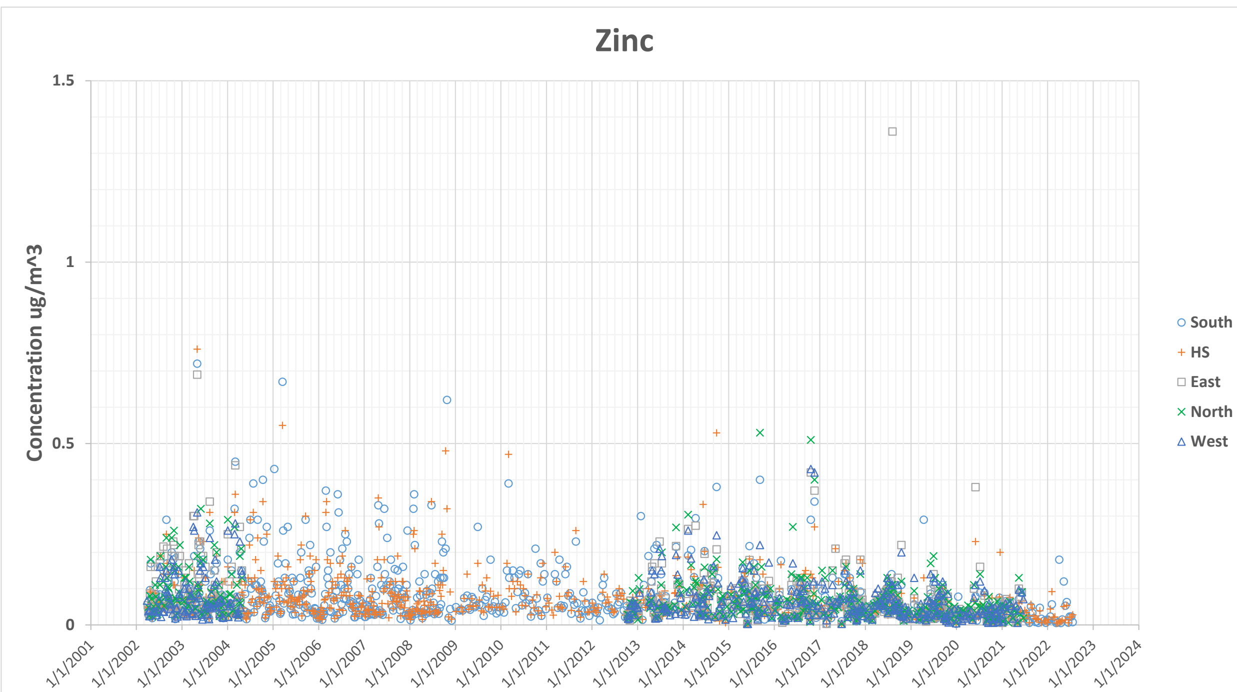
Figures 22 and 23. Atmospheric concentrations of Iron and Lead (ug/m^3) from all stations over the entire monitoring period.





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 2023.

Table 1b. Statistical description of measured PAH (ng/m^3) concentrations from 2012-2022.

	Number of Observations	% NDs	Minimum Detected Data	Maximum Detected Data	KM Mean	KM SD	50%ile
North Ace	335	10.45%	1.4	360.6	11.99	24.25	7.75
East Ace	316	7.28%	1.3	118.3	11.13	12.06	8.59
West Ace	319	7.84%	1.3	153.6	12.23	17.8	8.06
South Ace	362	6.91%	1.36	140.6	15.87	15.8	12.08
HS Ace	373	7.51%	1.39	1643	18.81	88.06	7.5
North Acy	335	79.10%	0.6	300.1	3.453	23.76	1.47
East Acy	316	77.85%	1.3	323.6	2.836	22.24	1.44
West Acy	319	83.39%	0.32	150.4	1.717	10.08	1.45
South Acy	362	74.86%	0.46	167.4	2.206	11.99	1.44
HS Acy	373	85.25%	0.24	18.41	0.601	1.495	1.57
North Fla	335	20.60%	1.17	20.84	4.865	4.29	3.09
East Fla	316	18.67%	1.299	55.68	4.84	4.925	3.16
West Fla	319	21.32%	0.9	21.01	4.554	3.936	3.08
South Fla	362	18.51%	0.79	27.81	4.851	4.417	3.28
HS Fla	373	23.86%	0.82	45.32	5.057	5.741	2.8
North Flo	335	7.76%	1.38	266.4	11.41	20.88	7.07
East Flo	316	5.70%	1.44	295.8	11.7	20.17	8.1
West Flo	319	5.64%	1.28	136.2	10.61	13.19	6.75
South Flo	362	5.25%	1.66	118.9	15.08	15.74	10.3
HS Flo	373	6.70%	1.43	1048	15.13	57.33	6.46
North Nap	335	1.79%	8.89	8768	119.5	675.9	52.64
East Nap	316	1.58%	14.46	2901	81.72	198.9	54.64
West Nap	318	2.20%	7.4	3130	81.23	233.8	49.65
South Nap	361	1.11%	8.26	6698	96.07	431.7	52.11
HS Nap	373	1.88%	6.51	2408	79.27	150.6	52.77
North Phe	335	0.90%	1.76	269.9	19.51	23.3	13.05
East Phe	316	0.32%	1.94	292.3	20.59	23.36	14.44
West Phe	319	0.94%	2.02	133.3	18.31	17.3	12.55
South Phe	362	0.83%	1.75	149.6	26.6	24.42	18.71
HS Phe	373	1.07%	1.51	934.8	24.18	54.44	11.64
North Pyr	335	28.66%	0.91	26.64	3.361	3.199	2.27
East Pyr	316	24.37%	1.37	29.23	3.439	2.897	2.41
West Pyr	319	36.99%	0.61	22.13	2.658	2.685	2.08
South Pyr	362	25.14%	0.69	19.21	3.65	3.249	2.8
HS Pyr	373	45.84%	0.41	21.25	2.294	2.753	1.76

Data are original (not temperature-corrected).

Table 1c. Statistical description of measured VOC (ug/m^3) concentrations from 2012-2022.

	Number of Observations	% NDs	Minimum Detected Data	Maximum Detected Data	KM Mean	KM SD	50%ile
North Benzene	333	24.92%	0.33	3.965	1.092	0.58	1.156
East Benzene	318	24.21%	0.0661	4.956	1.182	0.696	1.288
West Benzene	320	30.31%	0.33	4.956	1.03	0.592	1.123
South Benzene	353	27.48%	0.172	6.277	1.113	0.697	1.222
HS Benzene	373	26.27%	0.396	4.625	1.084	0.536	1.255
North Toluene	333	8.41%	0.468	109.1	2.219	6.402	1.442
East Toluene	316	6.96%	0.335	155.9	2.886	9.352	1.656
West Toluene	320	10.31%	0.359	32.35	1.829	2.295	1.422
South Toluene	357	11.20%	0.351	779.4	5.46	48.97	1.559
HS Toluene	374	8.02%	0.386	105.2	2.638	5.923	1.734

Data are original (not temperature-corrected).

Table 1d. Statistical description of measured TSP (g/m^3) and Metals (ug/m^3) concentrations from 2012-2022.

	Number of Observations	% NDs	Minimum Detected Data	Maximum Detected Data	KM Mean	KM SD	50%ile
North TSP	332	0.60%	2.35E-06	0.067	3.20E-04	0.00388	3.96E-05
East TSP	328	0.61%	9.80E-08	0.0568	3.18E-04	0.00359	3.91E-05
West TSP	326	0.00%	1.04E-07	0.065	3.13E-04	0.00379	3.74E-05
South TSP	363	0.28%	9.48E-08	0.0744	4.82E-04	0.00464	3.88E-05
HS TSP	378	1.06%	3.81E-07	0.0529	3.17E-04	0.0033	3.32E-05
North Al	330	3.94%	0.0227	2.48	0.343	0.313	0.251
East Al	328	3.35%	0.019	2.5	0.374	0.361	0.25
West Al	325	4.62%	0.0298	1.45	0.322	0.269	0.24
South Al	365	6.58%	0.015	2.31	0.345	0.322	0.23
HS Al	377	6.37%	0.019	1.18	0.255	0.209	0.19
North As	333	69.67%	5.80E-04	0.021	0.0013	0.0017	0.0015
East As	330	69.09%	4.40E-04	0.02	0.00137	0.00175	0.0016
West As	328	71.04%	4.20E-04	0.02	0.00134	0.00179	0.0016
South As	365	72.33%	4.20E-04	0.023	0.00135	0.00179	0.0018
HS As	378	73.54%	4.50E-04	0.02	0.00122	0.00157	0.0016
North Ba	334	0.90%	0.0014	0.0942	0.0164	0.0131	0.0129
East Ba	331	0.30%	0.0018	0.084	0.0185	0.0138	0.014
West Ba	328	1.22%	0.0021	0.109	0.0173	0.0142	0.0135
South Ba	367	1.36%	0.0014	0.114	0.0172	0.0149	0.013
HS Ba	380	1.32%	0.0014	0.17	0.0168	0.0158	0.013
North Cr	334	38.62%	0.001	0.053	0.00486	0.0063	0.0029
East Cr	331	35.35%	0.0011	0.051	0.00518	0.00634	0.0032
West Cr	327	38.53%	0.0011	0.05	0.00503	0.00615	0.003
South Cr	367	41.69%	0.0013	0.056	0.00505	0.00633	0.0029
HS Cr	380	42.11%	5.10E-04	0.05	0.00435	0.00597	0.0027
North Cu	334	0.00%	0.00278	0.34	0.0504	0.0382	0.042
East Cu	331	0.30%	0.0054	0.27	0.0581	0.0451	0.0455
West Cu	328	0.00%	0.0028	0.391	0.0533	0.0411	0.044
South Cu	367	0.27%	0.0023	0.31	0.0475	0.0346	0.0398
HS Cu	379	0.26%	0.00827	0.47	0.114	0.0834	0.093
North Fe	333	0.30%	0.033	5.91	0.935	0.892	0.64
East Fe	330	0.61%	0.0154	4.92	1	0.93	0.679
West Fe	327	0.31%	0.037	4.477	0.872	0.788	0.617
South Fe	366	1.37%	0.076	4.986	0.9	0.826	0.61
HS Fe	379	0.79%	0.031	4.685	0.732	0.625	0.55

	Number of Observations	% NDs	Minimum Detected Data	Maximum Detected Data	KM Mean	KM SD	50%ile
North Pb	334	2.99%	8.80E-04	0.26	0.0107	0.023	0.0053
East Pb	331	3.02%	0.0013	0.36	0.0142	0.0347	0.00583
West Pb	328	3.66%	0.001	0.37	0.0146	0.0384	0.0059
South Pb	367	4.09%	0.0011	0.32	0.0127	0.0317	0.0053
HS Pb	380	3.16%	0.0012	0.49	0.0109	0.0325	0.00535
North Mn	334	0.60%	0.0059	0.404	0.0722	0.0708	0.0466
East Mn	331	0.30%	0.0034	0.56	0.083	0.0837	0.0534
West Mn	328	0.30%	0.0032	0.46	0.0683	0.0669	0.0458
South Mn	367	1.63%	0.0035	0.603	0.0753	0.081	0.047
HS Mn	380	1.58%	0.0026	0.45	0.0557	0.0545	0.0398
North Ni	332	47.29%	2.20E-04	0.012	1.49E-03	0.00134	0.0014
East Ni	330	47.58%	6.40E-04	0.0273	1.62E-03	0.00186	0.0014
West Ni	327	49.54%	1.10E-04	0.0207	1.50E-03	0.00157	0.0015
South Ni	365	53.70%	5.10E-04	0.0095	1.42E-03	0.00117	0.0013
HS Ni	378	52.91%	6.70E-04	0.0071	1.35E-03	8.84E-04	0.0013
North Se	334	73.35%	4.60E-04	0.00784	0.00107	9.97E-04	0.00141
East Se	329	74.47%	4.00E-04	0.00638	9.74E-04	9.91E-04	0.0014
West Se	328	75.30%	4.50E-04	0.0106	0.00104	0.00106	0.0015
South Se	366	76.78%	3.20E-04	0.00694	9.10E-04	0.00103	0.00165
HS Se	379	79.42%	3.20E-04	0.0067	9.09E-04	8.43E-04	0.0015
North Zn	334	1.50%	0.0058	0.53	0.0635	0.0593	0.049
East Zn	331	2.72%	0.0043	3.29	0.0774	0.198	0.05
West Zn	328	1.83%	0.0047	0.43	0.062	0.0517	0.049
South Zn	367	3.54%	0.0029	0.4	0.0599	0.0563	0.048
HS Zn	380	3.16%	0.00518	0.529	0.0565	0.0509	0.0421

Table 2. Spearman correlation coefficients between PAH, VOC, TSP, and Metals concentrations at all sites from 2012-2022.

Ace							
Acy	0.279						
Fla	0.793	0.319					
Flo	0.921	0.277	0.834				
Nap	0.543	0.295	0.496	0.540			
Phe	0.883	0.274	0.902	0.922	0.537		
Pyr	0.736	0.357	0.878	0.780	0.491	0.841	
	Ace	**Acy**	**Fla**	**Flo**	**Nap**	**Phe**	**Pyr**

Benzene	
0.669	**Toluene**

TSP												
Al	0.726											
As	0.279	0.303										
Ba	0.508	.0574	0.215									
Cr	0.293	0.320	0.366	0.291								
Cu	0.125	0.061	0.083	0.384	0.167							
Fe	0.709	0.787	0.330	0.551	0.493	0.216						
Pb	0.429	0.419	0.125	0.537	0.335	0.357	0.603					
Mn	0.678	0.752	0.226	0.478	0.416	0.136	0.901	0.568				
Ni	0.393	0.448	0.277	0.393	0.365	0.238	0.509	0.357	0.449			
Se	0.284	0.306	0.829	0.181	0.331	0.016	0.297	0.044	0.214	0.249		
Zn	0.444	0.442	0.100	0.556	0.284	0.277	0.601	0.632	0.617	0.367	0.063	
	TSP	**Al**	**As**	**Ba**	**Cr**	**Cy**	**Fe**	**Pb**	**Mn**	**Ni**	**Se**	**Zn**

Table 3. Statistically significant trends[a] of atmospheric PCB (presented in USACE 2023), 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 2001-2022	S 2001-2022	H 2012-2022	IHC CDF 2012-2022
PCB 8				
PCB 15	PCB Trends			
PCB 18	Presented in			
PCB 28	USACE 2023			
PCB 31				
Sum 18 PCBs				
Ace	I	I	-	-
Acy	D	D	D	D
Fla	-	-	D	D
Flo	-	I	-	-
Nap	D	D	-	I
Phe	-	I	-	D
Pyr	D	-	-	-
Benz	-	-	I	I
Tol	D	D	-	D
TSP	D	D	-	D
Al	D	-	-	-
As	I	I	I	I
Ba	D	D	D	D
Cr	D	D	-	D
Cu	-	D	D	D
Fe	D	D	D	D
Pb	D	D	D	D
Mn	D	D	D	D
Ni	D	D	D	D
Se	I	I	I	I
Zn	D	D	D	D

Statistically significant trends over time using Mann-Kendall trend analysis at the 5% significance level. [b]All 2012-2022 data except Acy, the metals and TSP are temperature-corrected. The 2001-2022 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 2023), PAHs, VOCs, TSP, and Metals concentrations between seasons from 2012-2022.

	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	>	-	>	>	>	>
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, TSP, and metals are temperature-corrected.

Table 5. Two-sample two-tailed Gehan test for significant differences[a] in PCBs (presented in USACE 2023), PAHs, VOCs, and TSP[b] concentrations between monitoring stations from 2012-2022.

	H-CDF All Data	*H-CDF During Discharge*	*H-CDF Quiescent Pond*
PCB 8	Presented in USACE 2023		
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, TSP, and metals are temperature-corrected.

Table 6. Two-sample Gehan test for significant differences[a] in PCBs (presented in USACE 2023), PAHs, VOCs, TSP, and Metals[b] concentrations between dredging activities (Background BG, Discharge D, Quiescent Pond QP)

	High School			CDF		
	D-BG	QP-BG	D-QP	D-BG	QP-BG	D-QP
PCB 8	Presented in USACE 2023					
PCB 15						
PCB 18						
PCB 28						
PCB 31						
PCB 1						
PCB 11						
Sum 5 PCBs						
Sum 18 PCBs						
Sum 209 PCBs						
Ace	-	-	-	>	>	>
Fla	-	-	-	>	>	>
Flo	-	-	-	>	>	>
Nap	-	-	-	>	-	-
Phe	-	-	-	>	>	-
Pyr	-	-	-	>	>	>
Acy (not TC)	-	-	-	>	-	>
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.

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.

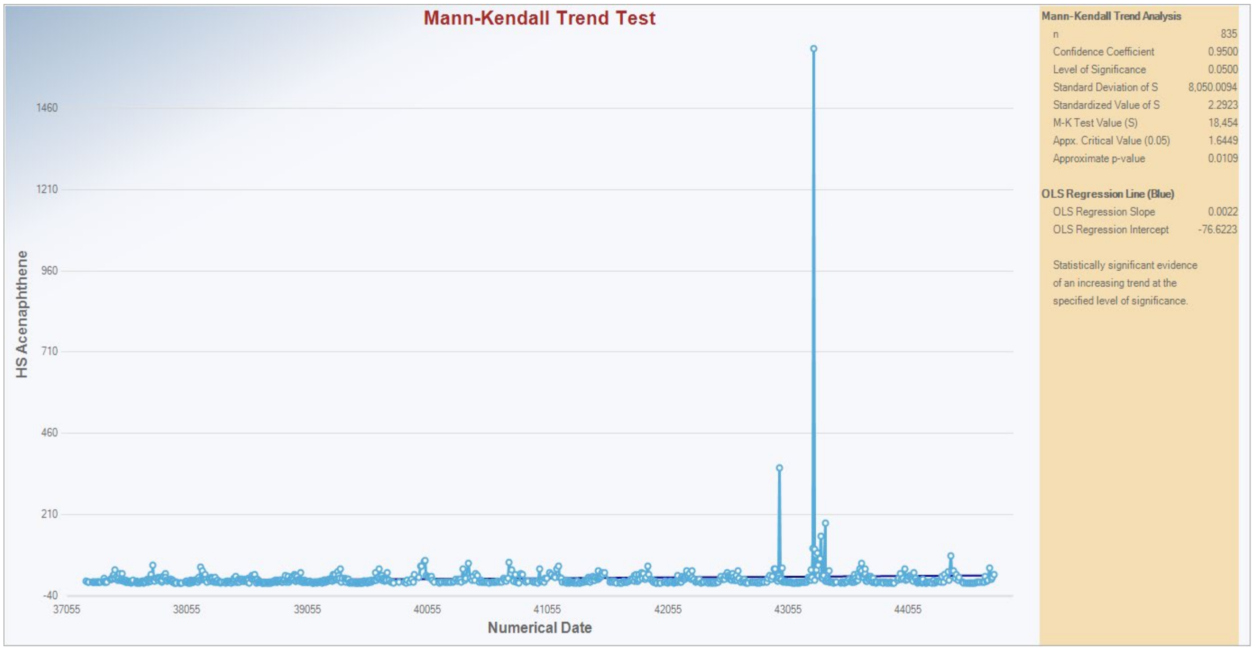
Analyte	Average Mass for Filter Blanks Submitted to TestAmerica (ug)
Barium	13.79
Chromium	4.07
Cobalt	3.38
Copper	2.88
Manganese	1.68
Nickel	2.80
Iron	68.70
Zinc	8.13

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.

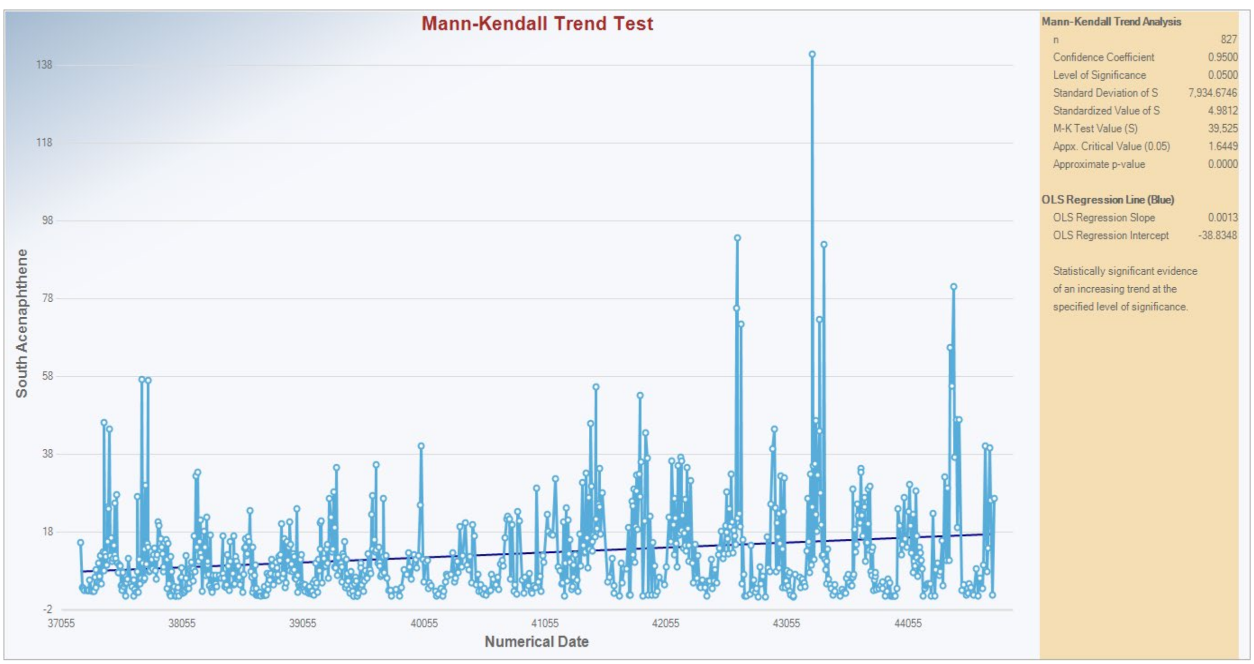
In addition to the metals listed in the table above, aluminum was also adjusted based on the large masses reported for some of the RTI method blanks. All of the blank filters submitted o TestAmerica (78 filter blanks submitted during the period when TestAmerica was analyzing air samples) had results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

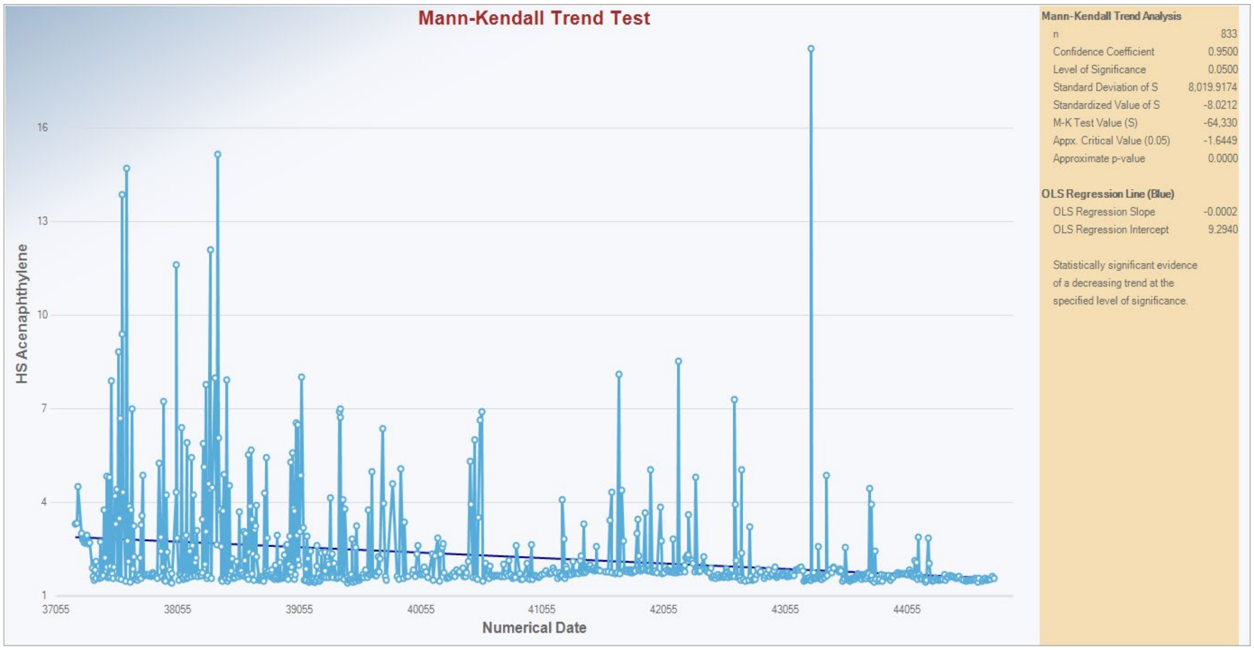
Appendix B
PAH Trends at High School and South Stations
2001-2022 Data



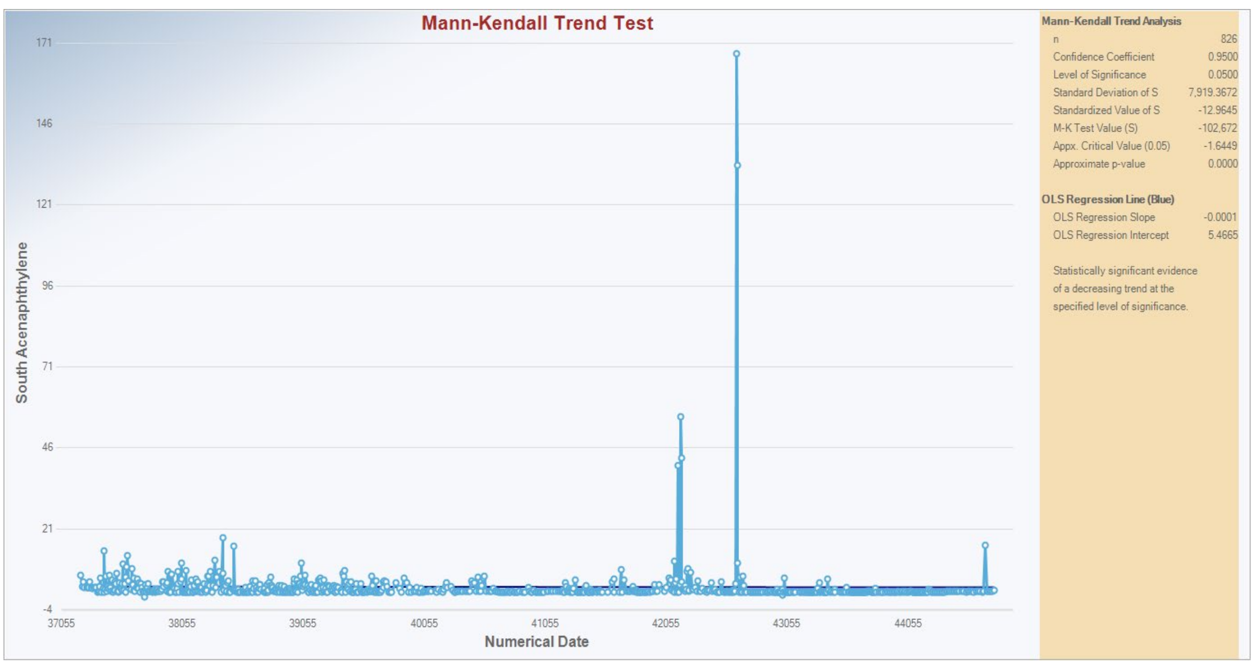
Appendix Figure B1. Mann-Kendall trend for **Acenaphthene** at the **high school station** from 2001 through 2022 with statistically significant evidence of **increasing trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 12/29/2022 [numerical date 43828] for all trend analyses).



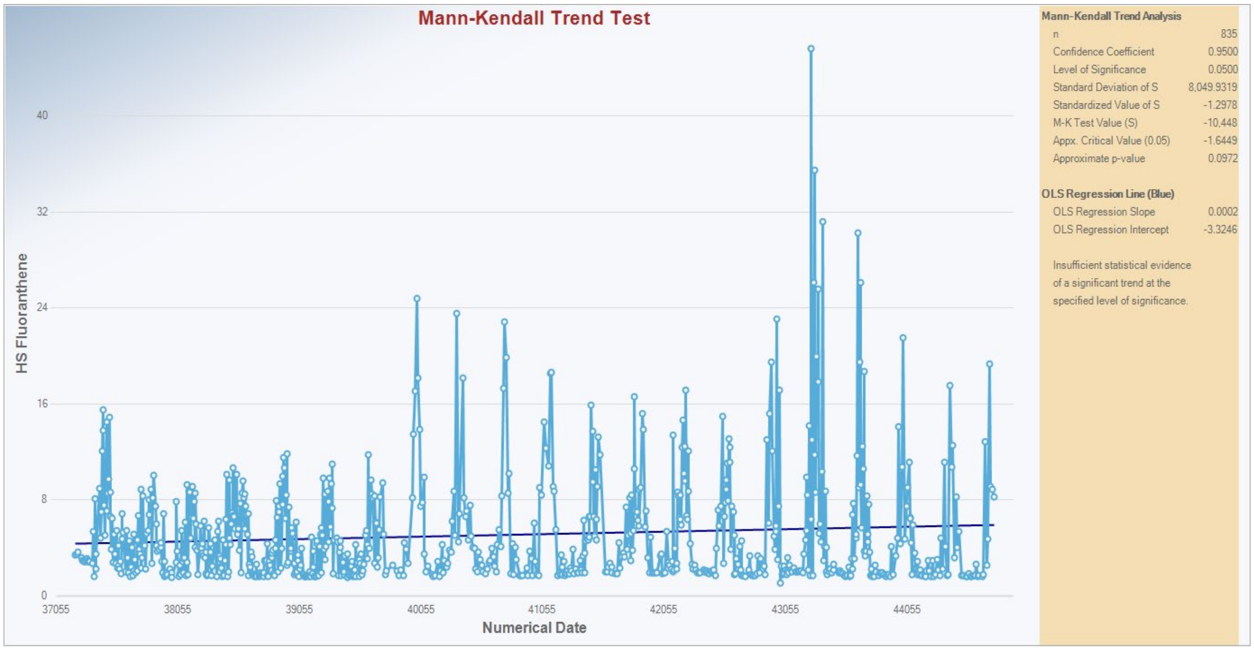
Appendix Figure B2. Mann-Kendall trend for **Acenaphthene** at the **south station** from 2001 through 2022 statistically significant evidence of **increasing trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 12/29/2022 [numerical date 43828] for all trend analyses).



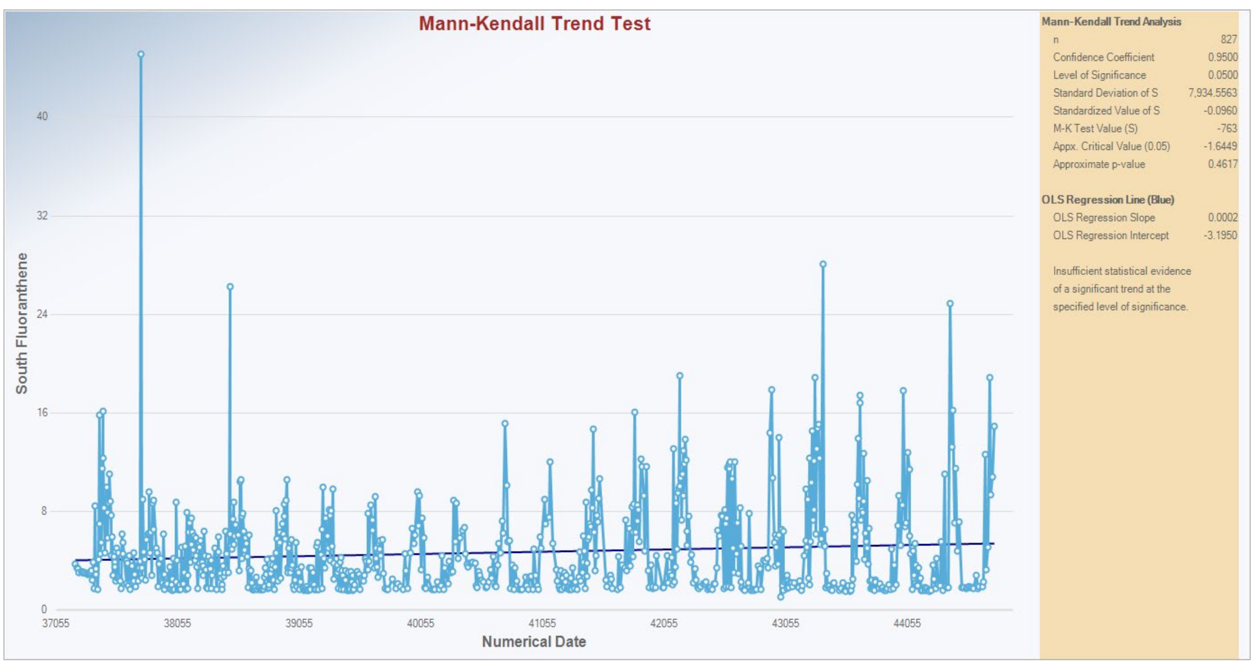
Appendix Figure B3. Mann-Kendall trend for **Acenaphthylene** at the **high school station** from 2001 through 2022 with statistically significant evidence of **decreasing trend** over sampling period.



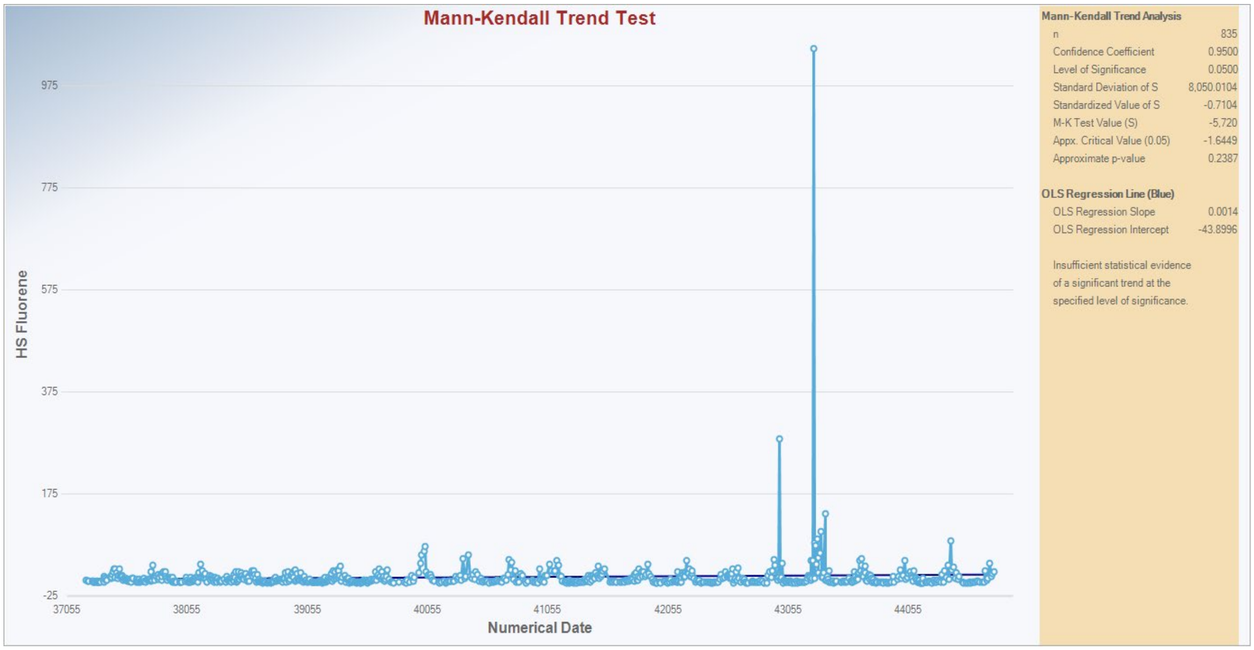
Appendix Figure B4. Mann-Kendall trend for **Acenaphthylene** at the **south station** from 2001 through 2022 with statistically significant evidence of **decreasing trend** over sampling period.



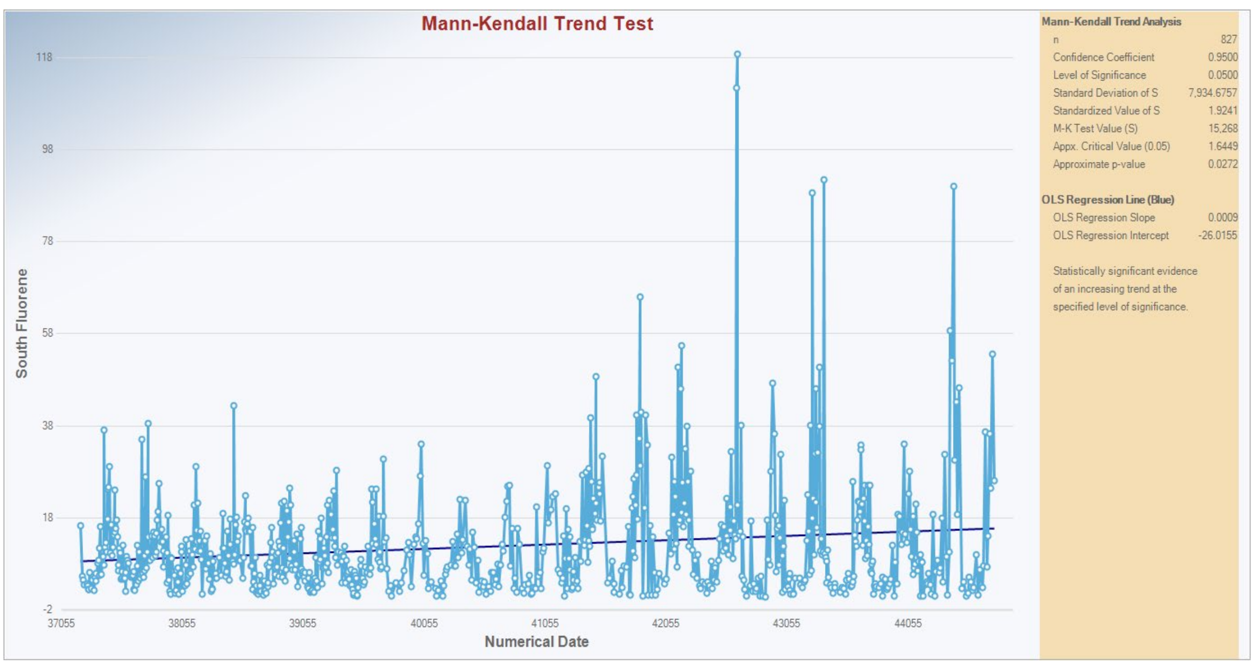
Appendix Figure B5. Mann-Kendall trend for **Fluoranthene** at the **high school station** from 2001 through 2022 with **insufficient statistical evidence of a significant trend** over sampling period.



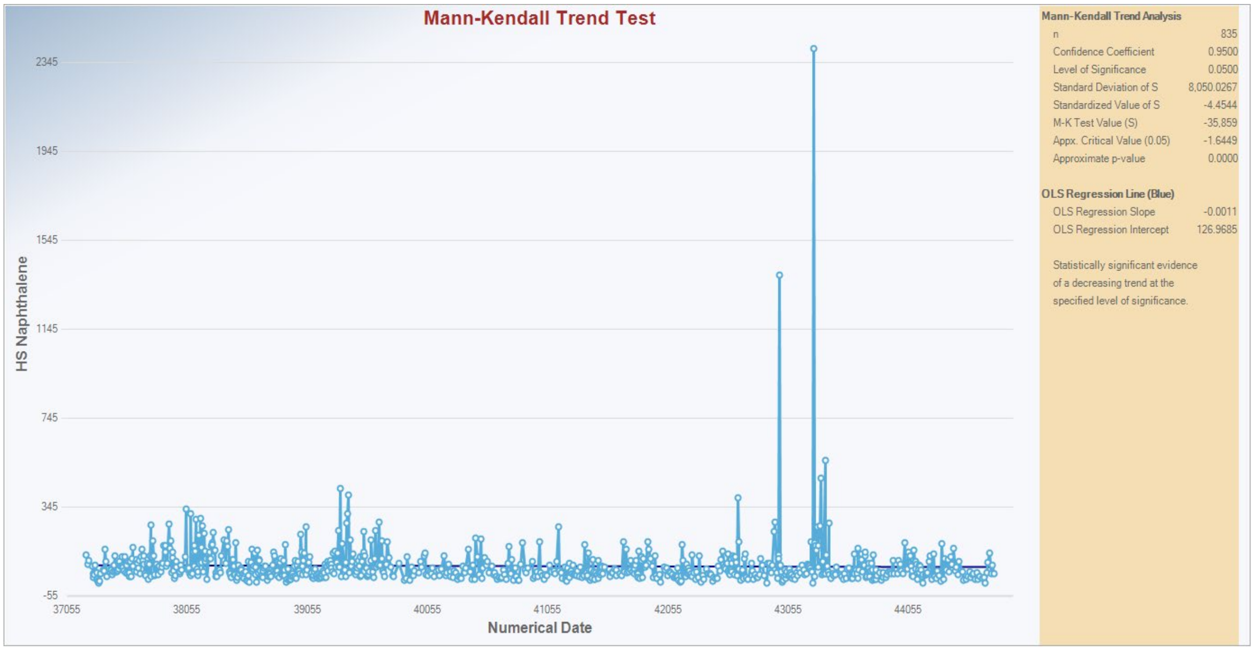
Appendix Figure B6. Mann-Kendall trend for **Fluoranthene** at the **south station** from 2001 through 2022 with **insufficient statistical evidence of a significant trend** over sampling period.



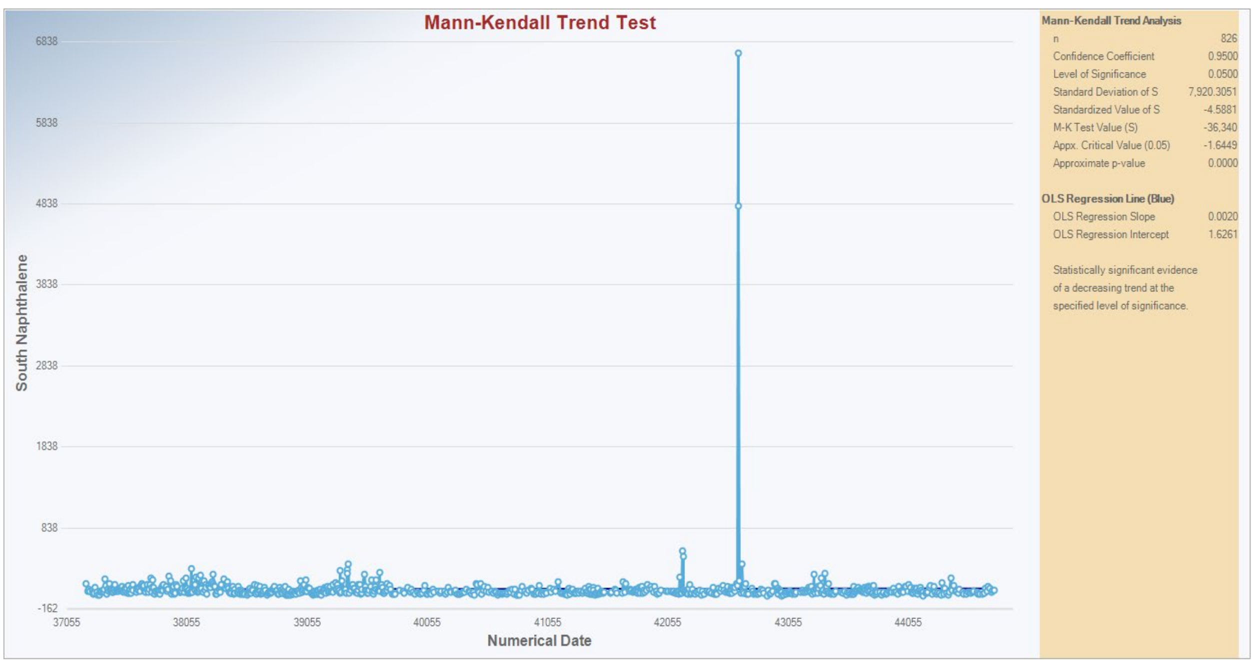
Appendix Figure B7. Mann-Kendall trend for **Fluorene** at the **high school station** from 2001 through 2022 with **insufficient statistical evidence of a significant trend** over sampling period.



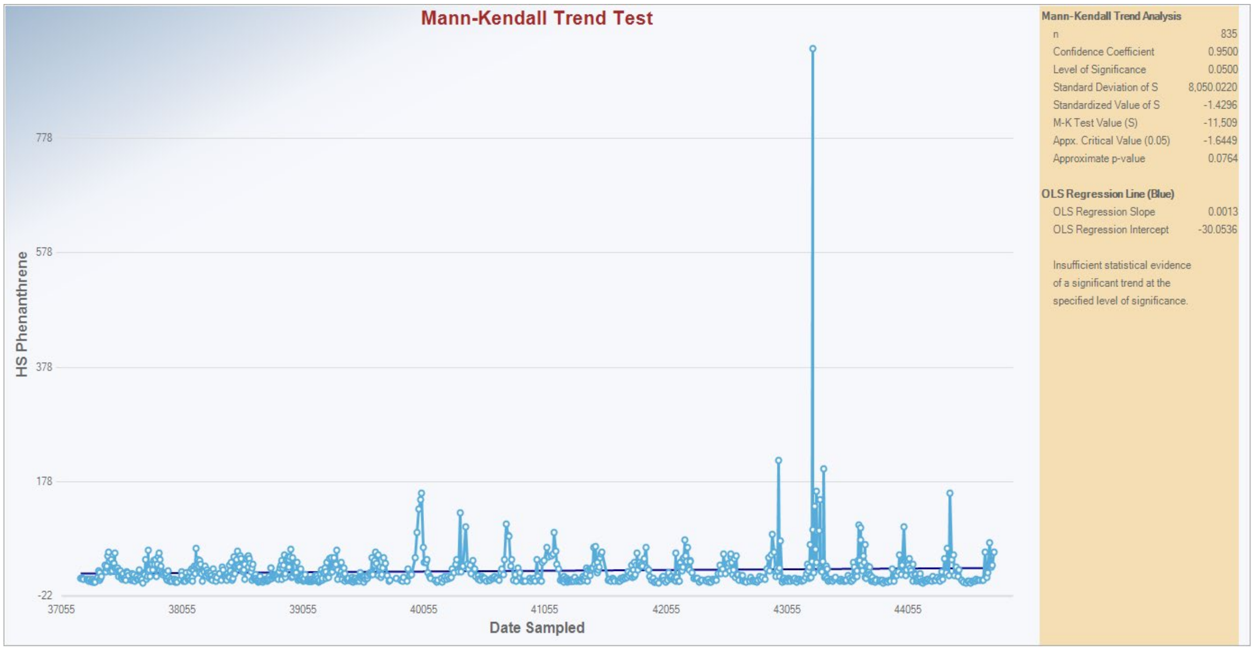
Appendix Figure B8. Mann-Kendall trend for **Fluorene** at the **south station** from 2001 through 2022 with statistically significant evidence of **increasing trend** over sampling period.



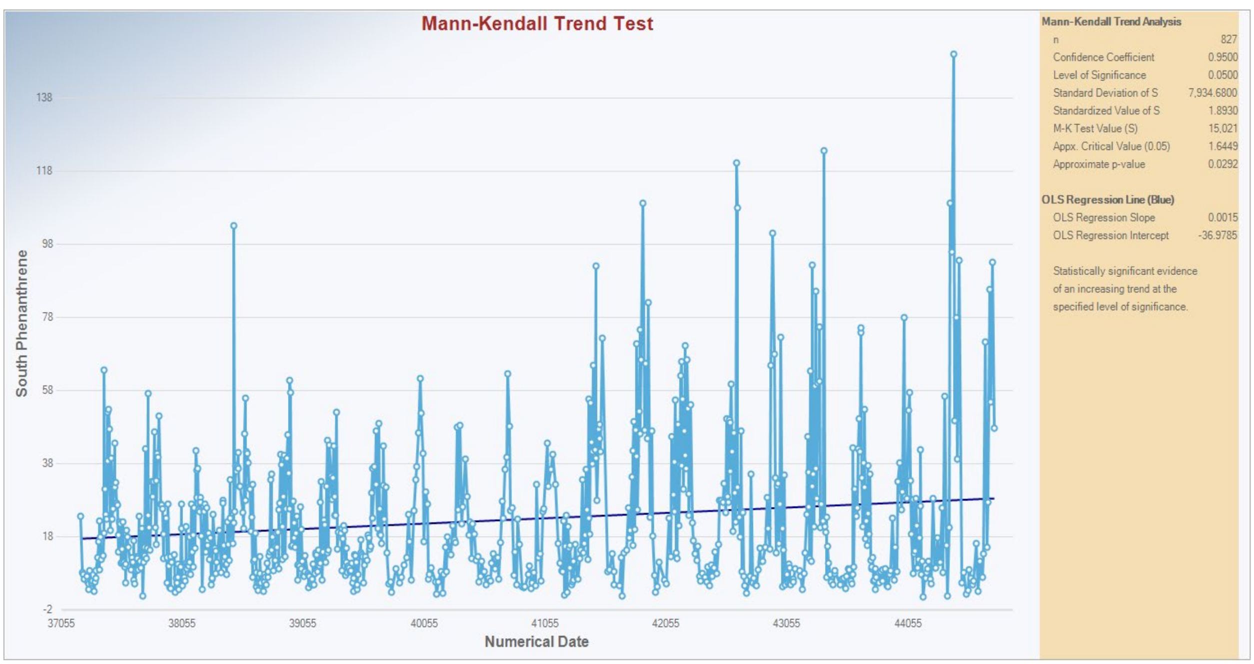
Appendix Figure B9. Mann-Kendall trend for **Naphthalene** at the **high school station** from 2001 through 2022 with statistically significant evidence of **decreasing trend** over sampling period.



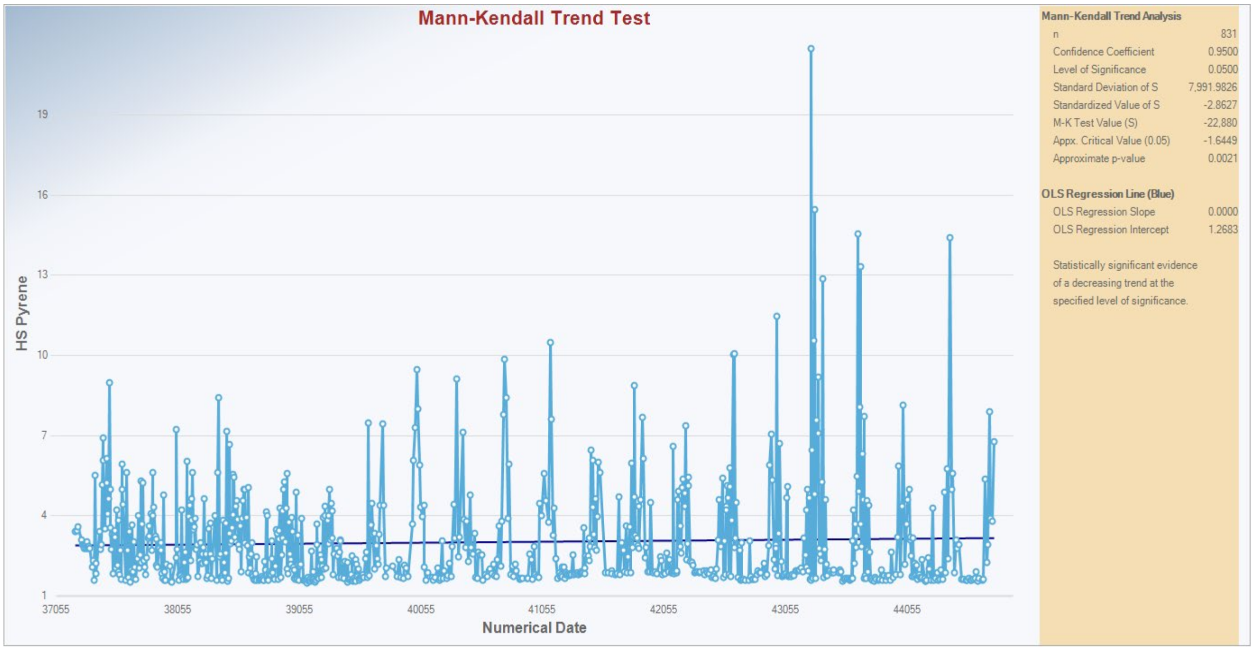
Appendix Figure B10. Mann-Kendall trend for **Naphthalene** at the **south station** from 2001 through 2022 with statistically significant evidence of **decreasing trend** over sampling period.



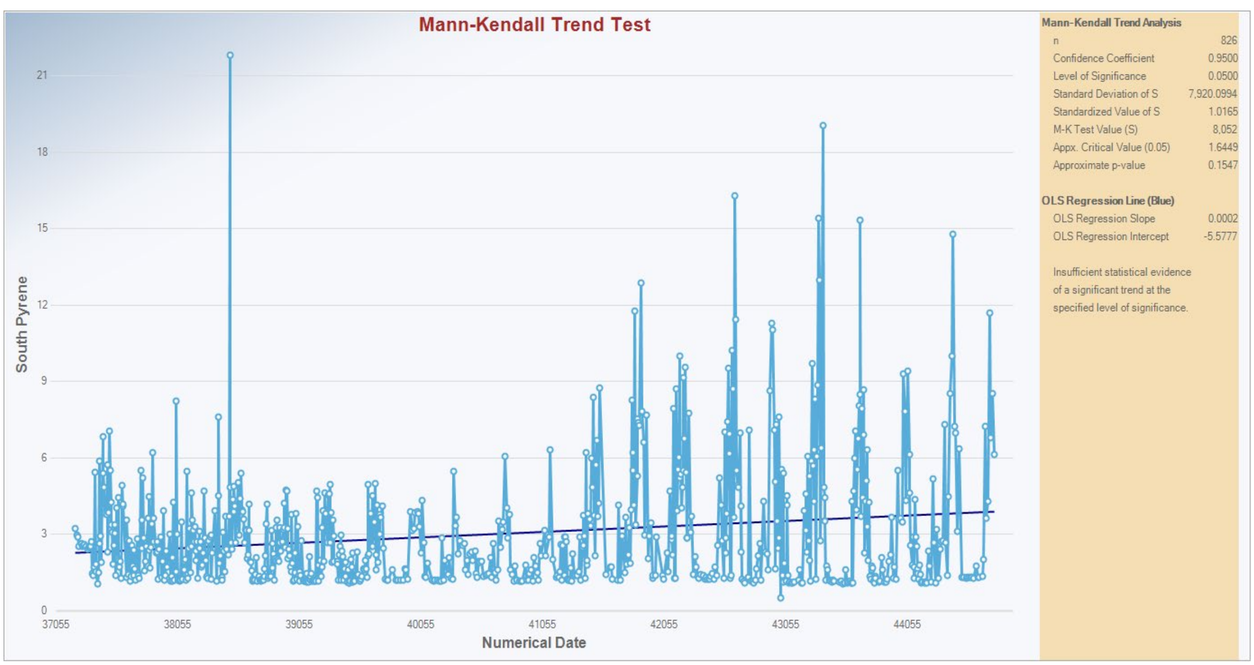
Appendix Figure B11. Mann-Kendall trend for **Phenanthrene** at the **high school station** from 2001 through 2022 with **insufficient statistical evidence of a significant trend** over sampling period.



Appendix Figure B12. Mann-Kendall trend for **Phenanthrene** at the **south station** from 2001 through 2022 with statistically significant evidence of **increasing trend** over sampling period.

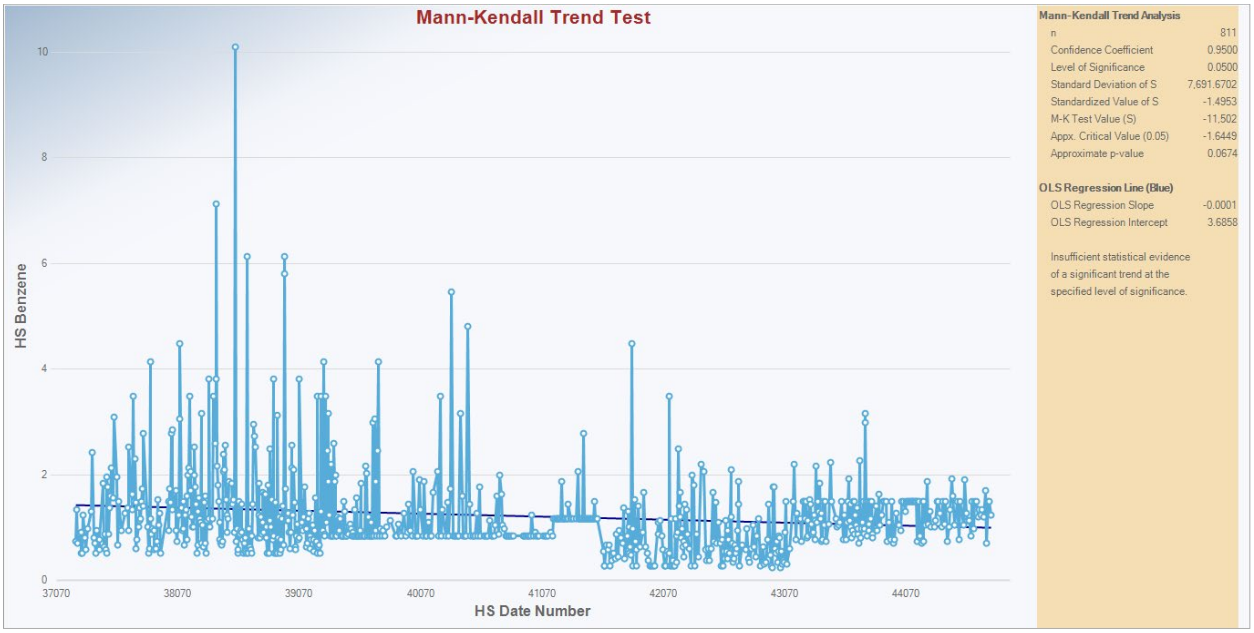


Appendix Figure B12. Mann-Kendall trend for **Pyrene** at the **high school station** from 2001 through 2022 with statistically significant evidence of **decreasing trend** over sampling period.

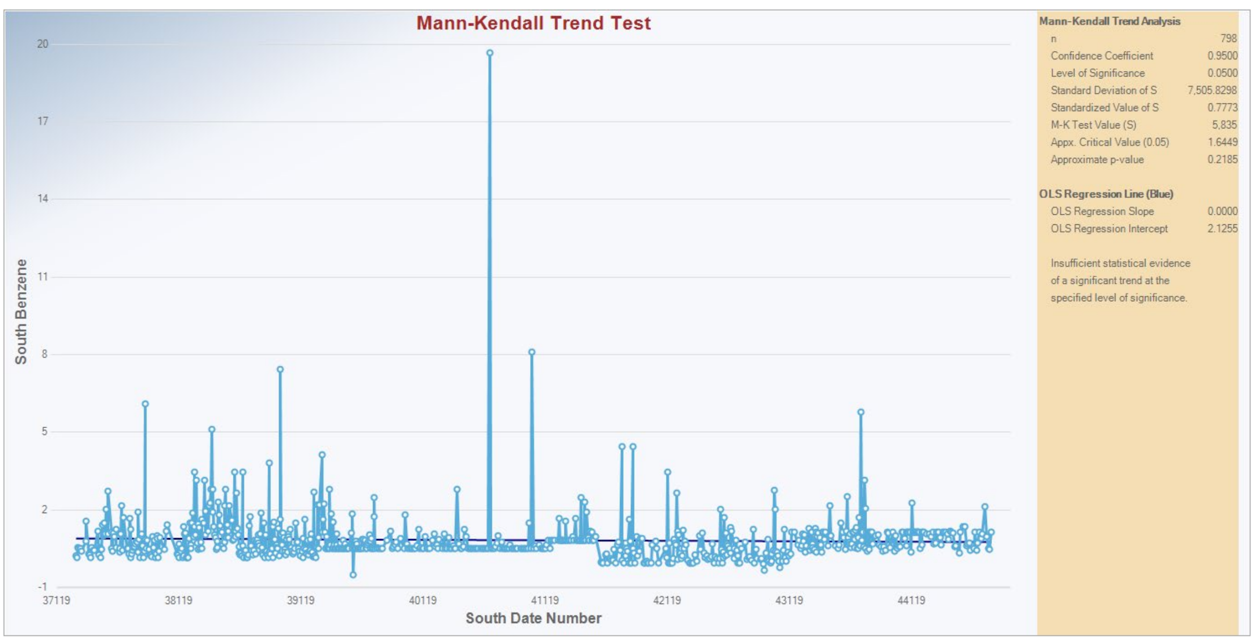


Appendix Figure B12. Mann-Kendall trend for **Pyrene** at the **south station** from 2001 through 2022 with **insufficient statistical evidence of a significant trend** over sampling period.

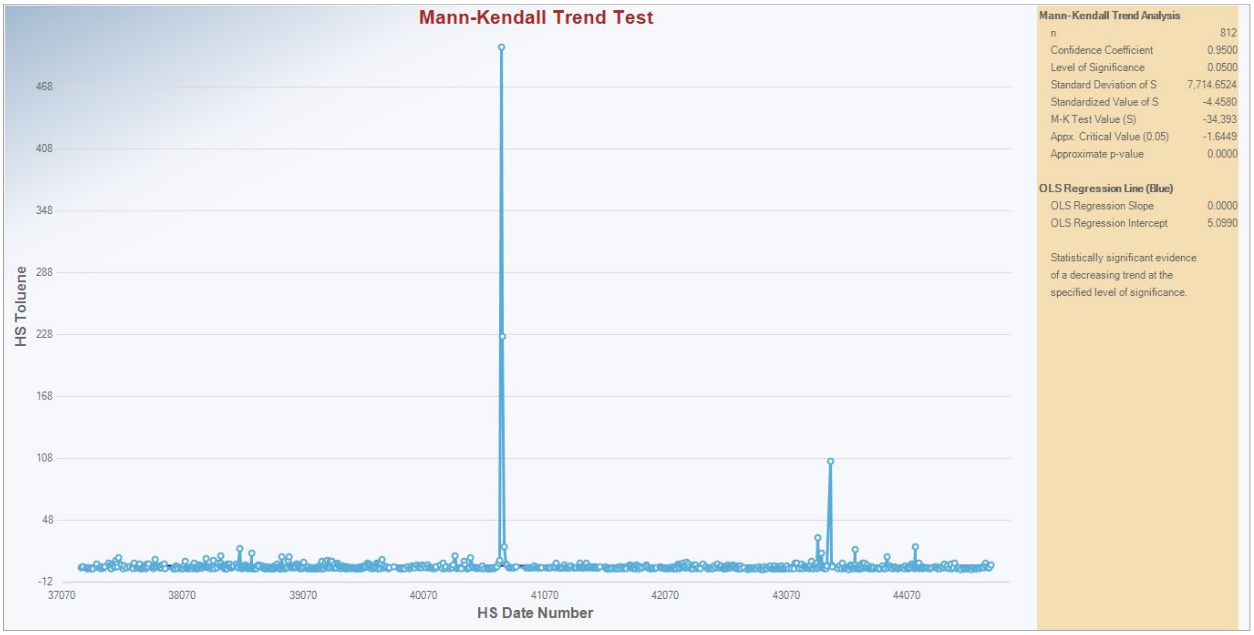
Appendix C
VOC Trends at High School and South Stations
2001-2022 Data



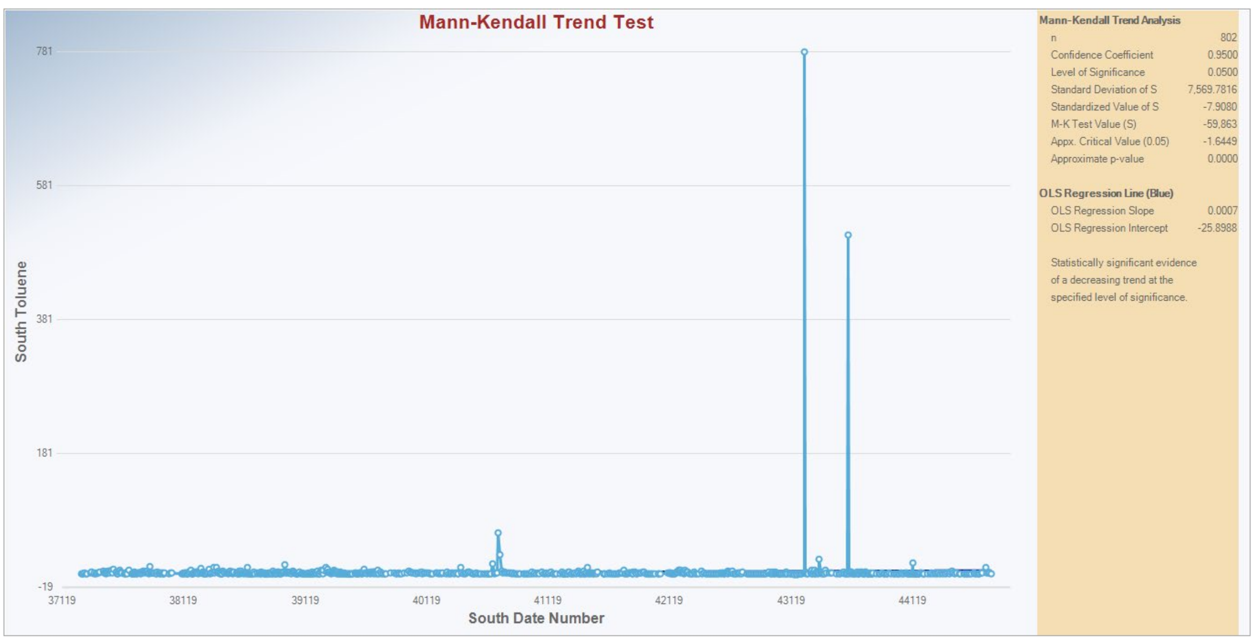
Appendix Figure C1. Mann-Kendall trend for **Benzene** at the **high school station** from 2001 to 2022 with **insufficient statistical evidence of a significant trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 7/22/2022 [numerical date 44764] for all trend analyses).



Appendix Figure C2. Mann-Kendall trend for **Benzene** at the **south station** from 2001 to 2022 with **insufficient statistical evidence of a significant trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 7/22/2022 [numerical date 44764] for all trend analyses).

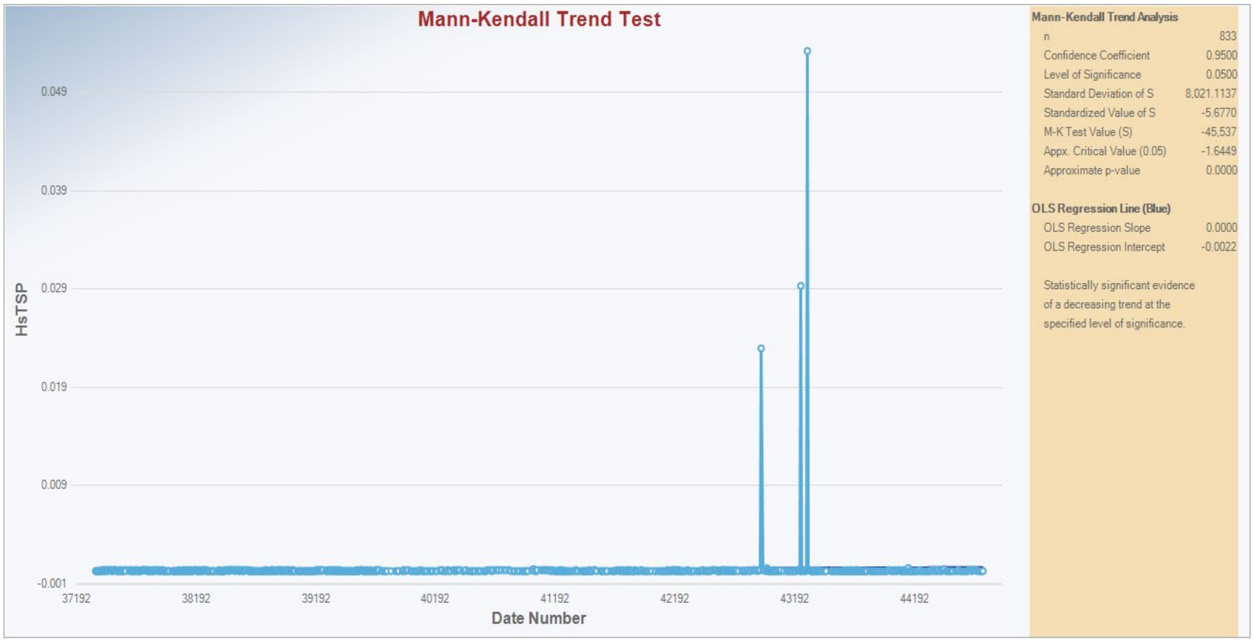


Appendix Figure C3. Mann-Kendall trend for **Toluene** at the **high school station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.

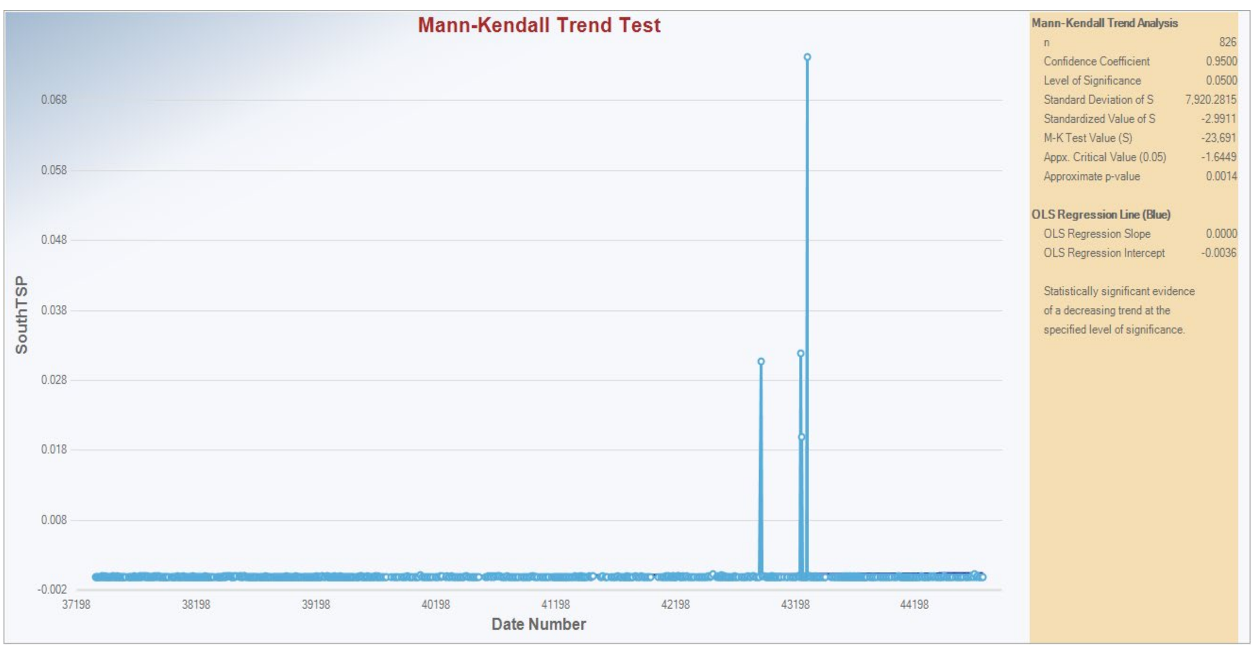


Appendix Figure C4. Mann-Kendall trend for **Toluene** at the **south station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.

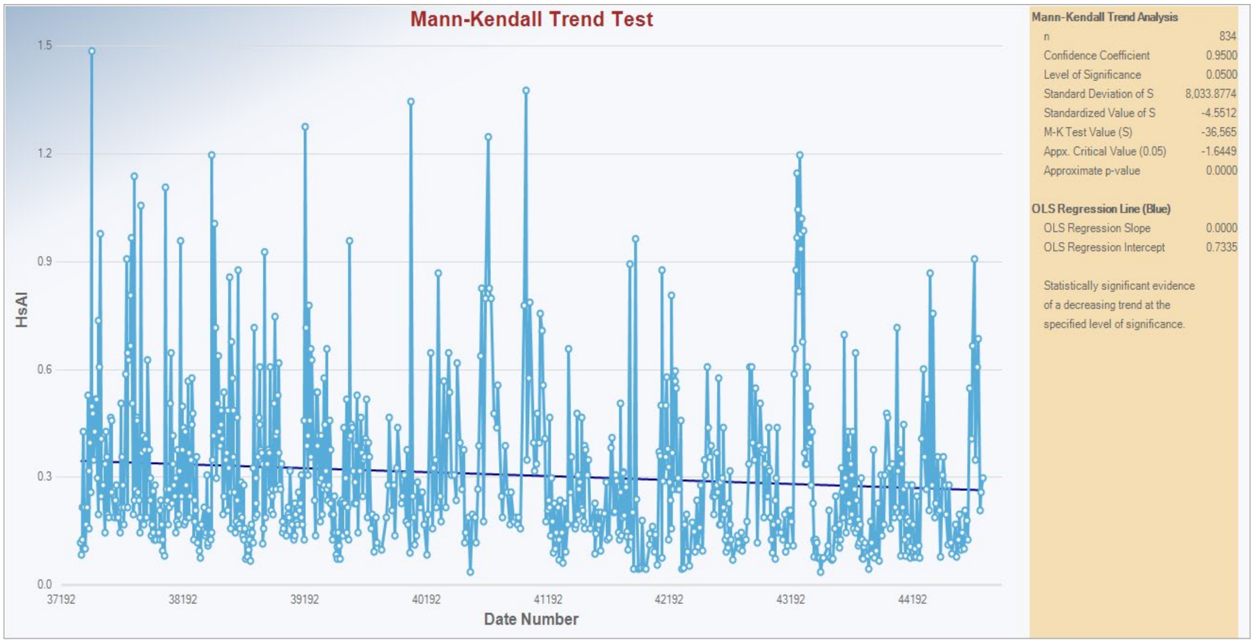
Appendix D
TSP and Metal Trends at High School and South Stations
2001-2022 Data



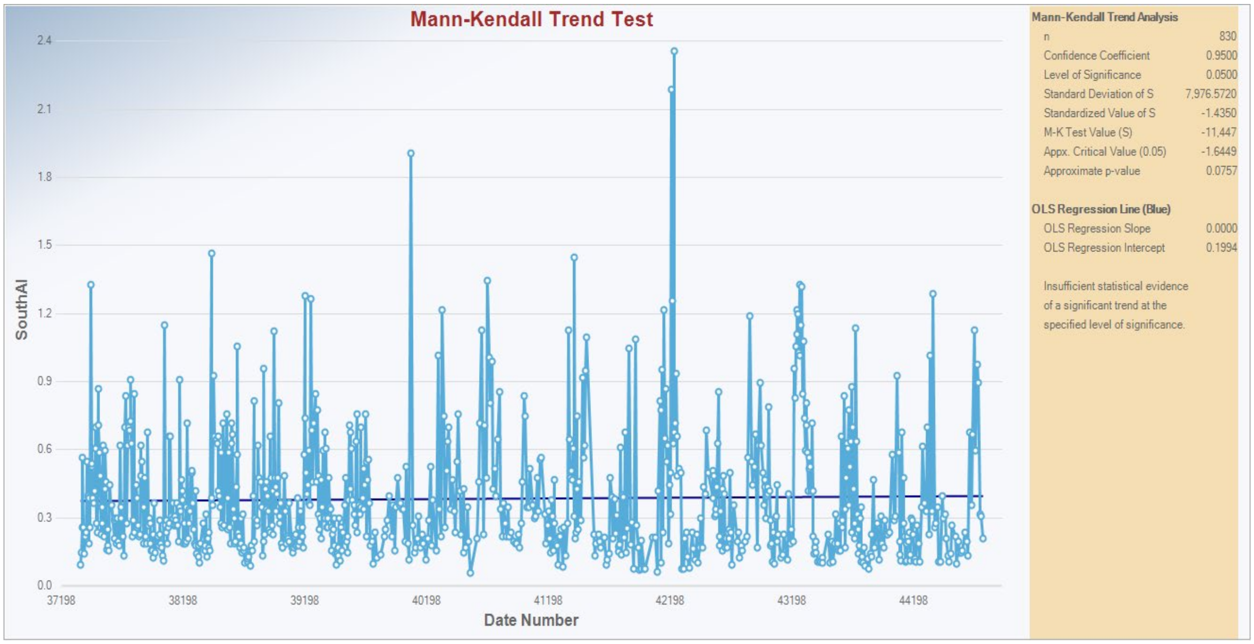
Appendix Figure D1. Mann-Kendall trend for **TSP** at the **high school station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 7/22/2022 [numerical date 44764] for all trend analyses).



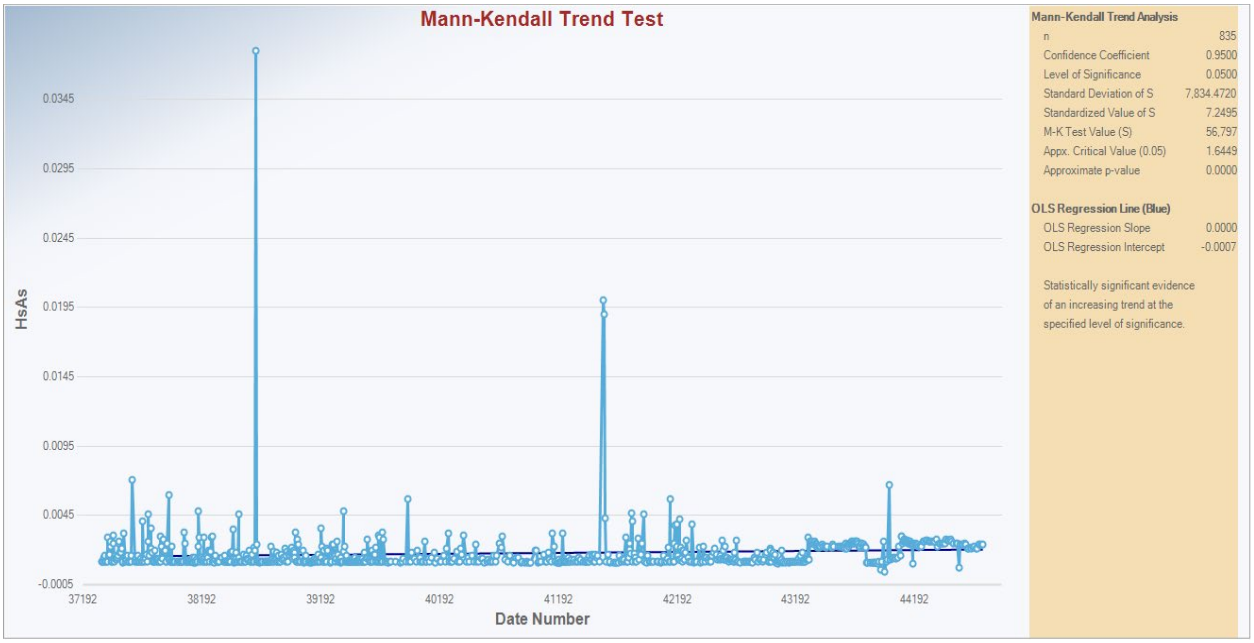
Appendix Figure D2. Mann-Kendall trend for **TSP** at the **south station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period. (Data from 11/19/2001 [numerical date 37214] to 7/22/2022 [numerical date 44764] for all trend analyses).



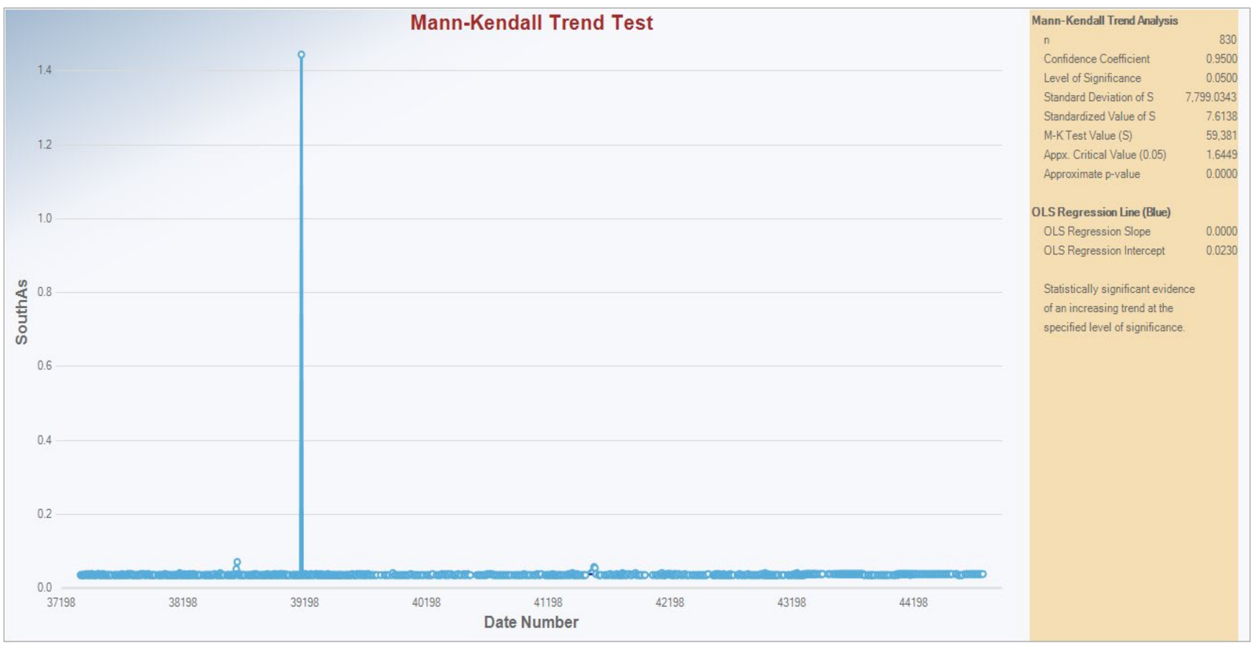
Appendix Figure D3. Mann-Kendall trend for **Aluminum** at the **high school station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



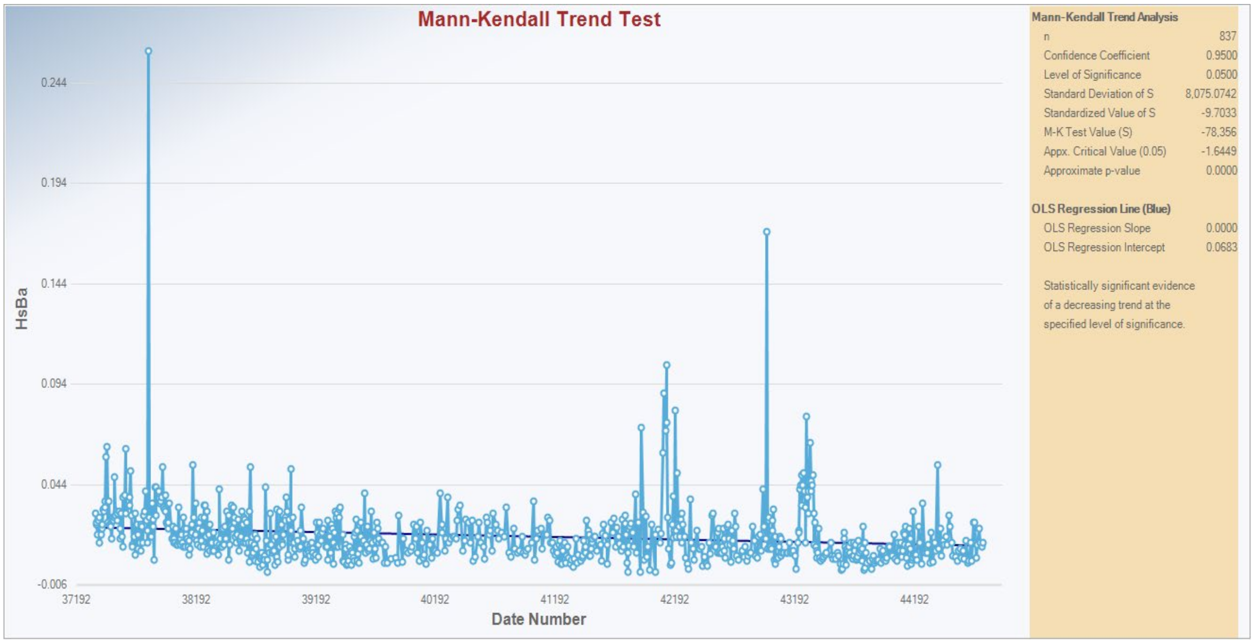
Appendix Figure D4. Mann-Kendall trend for **Aluminum** at the **south station** from 2001 to 2022 **insufficient statistical evidence of a significant trend** over sampling period.



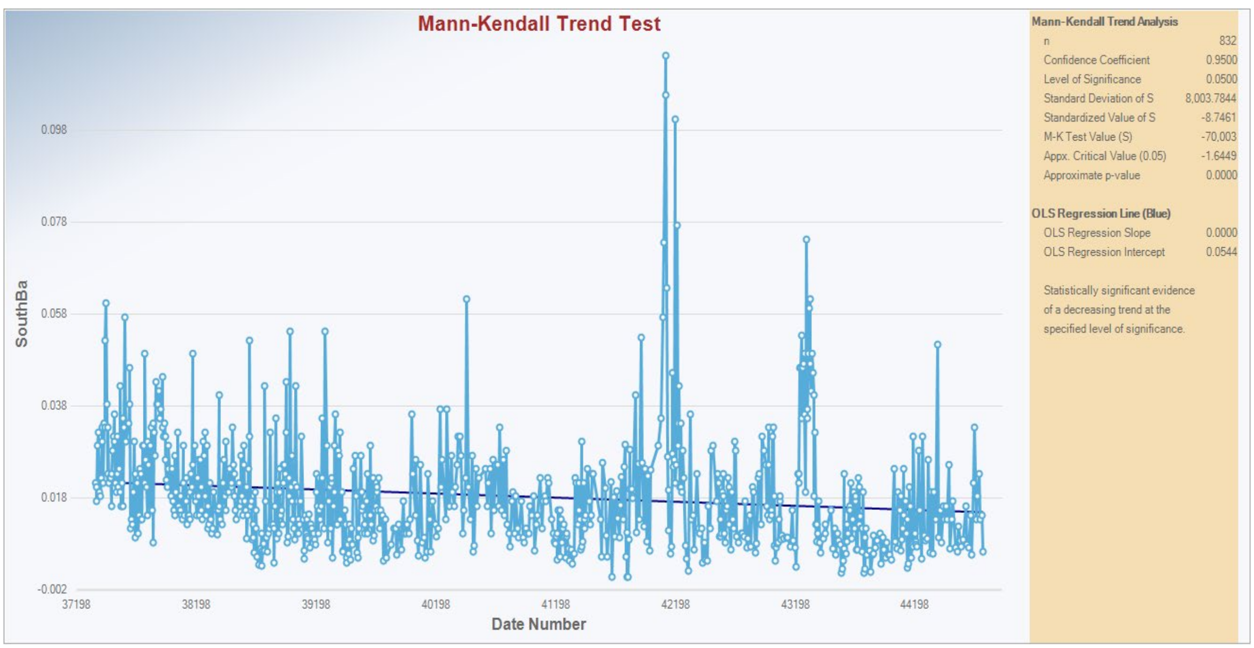
Appendix Figure D5. Mann-Kendall trend for **Arsenic** at the **high school station** from 2001 to 2022 with statistically significant evidence of **increasing trend** over sampling period.



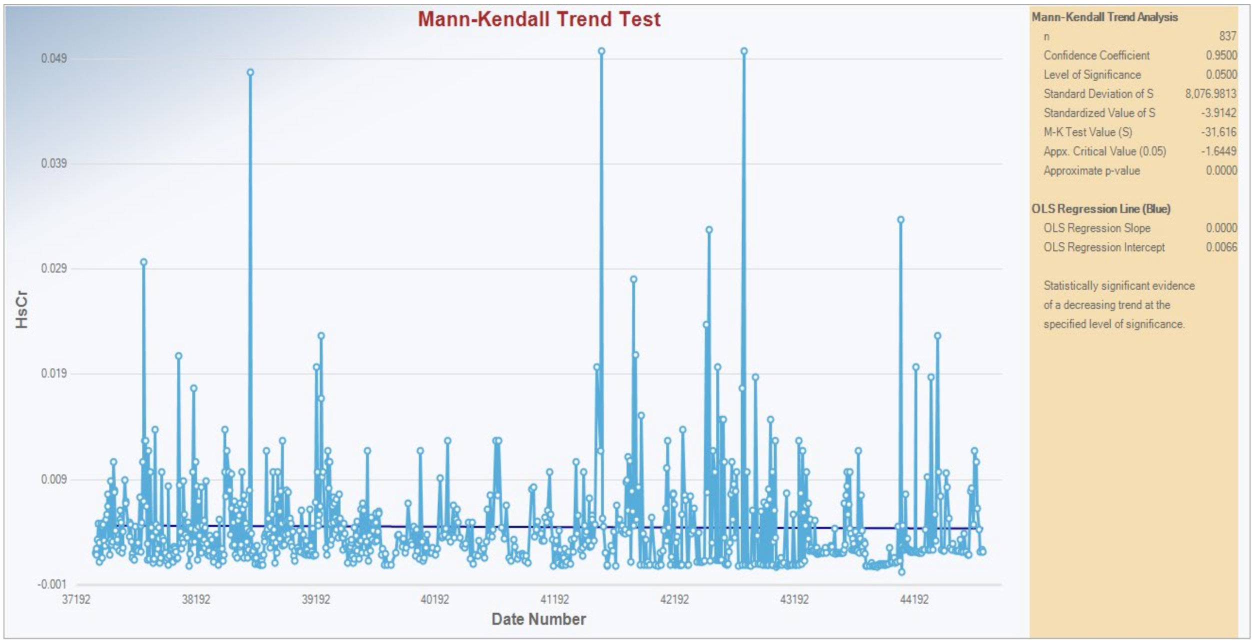
Appendix Figure D6. Mann-Kendall trend for **Arsenic** at the **south station** from 2001 to 2022 with statistically significant evidence of **increasing trend** over sampling period.



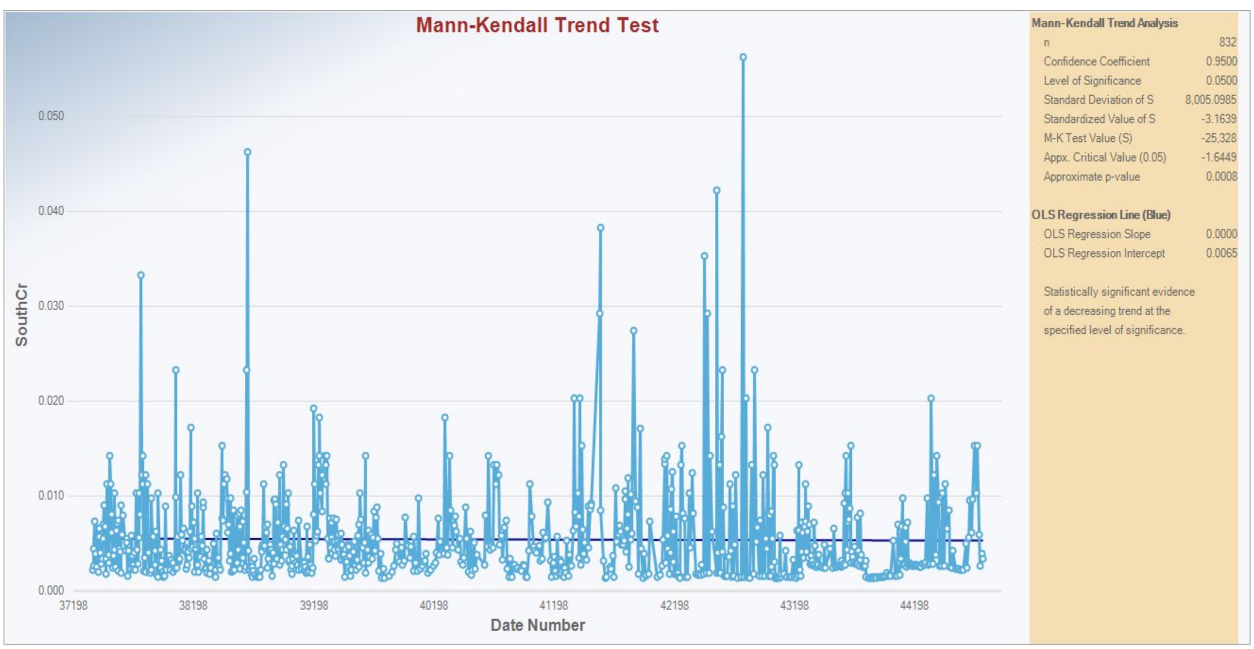
Appendix Figure D7. Mann-Kendall trend for **Barium** at the **high school station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



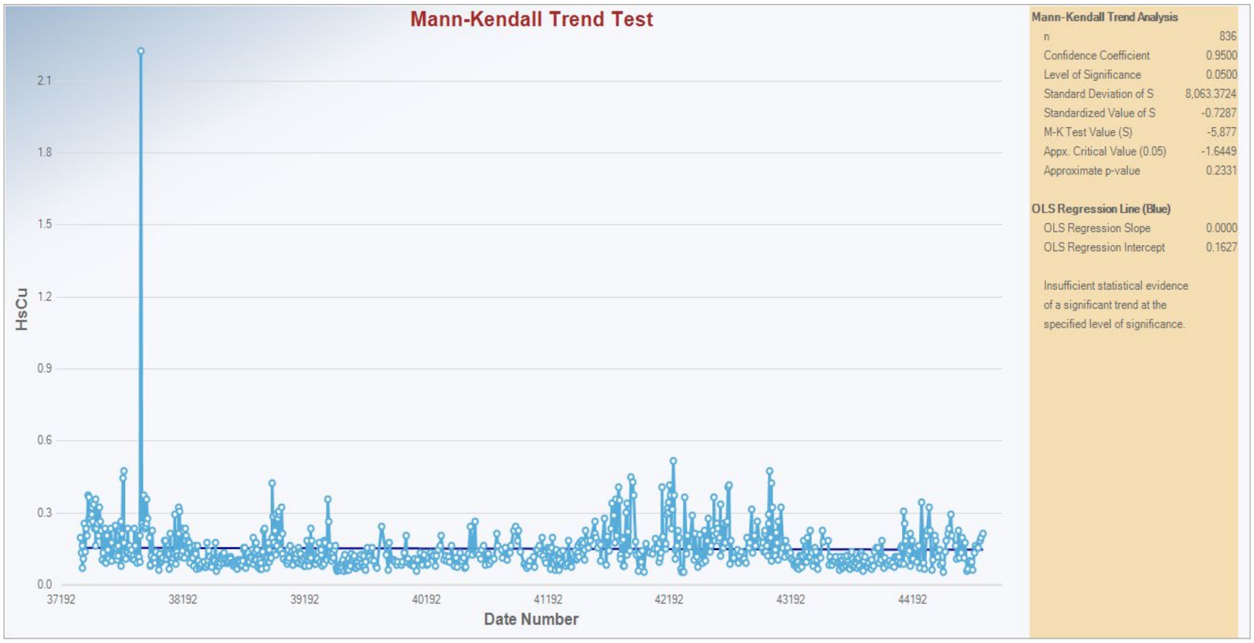
Appendix Figure D8. Mann-Kendall trend for **Barium** at the **south station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



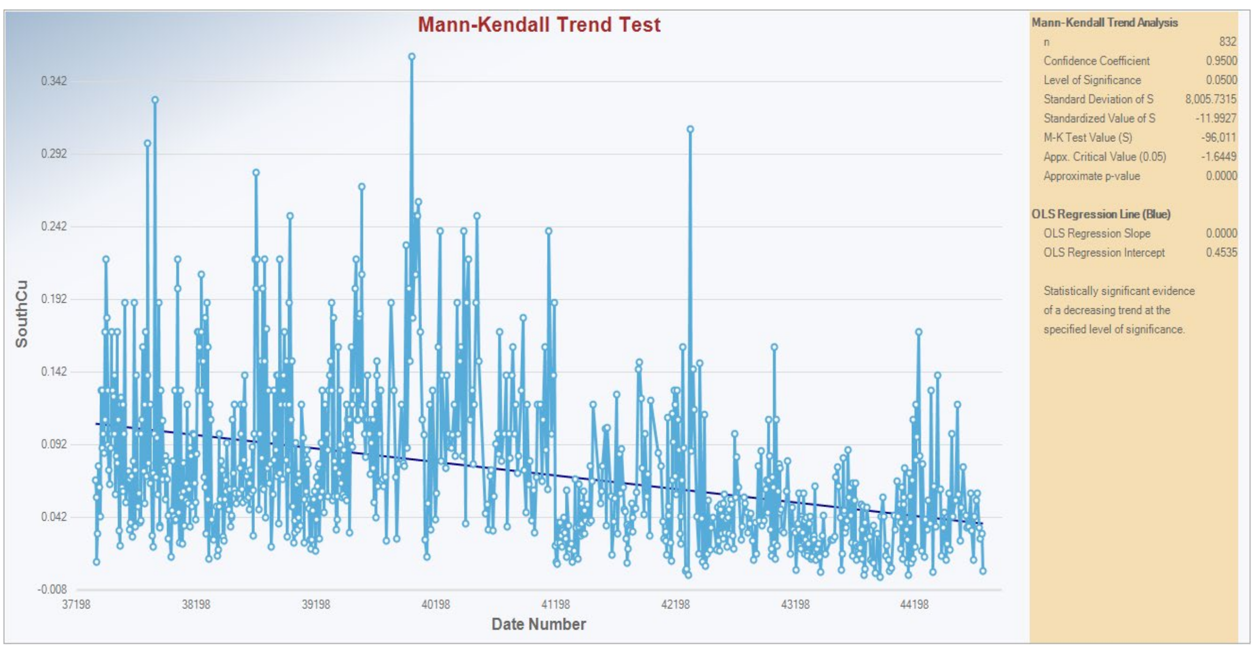
Appendix Figure D9. Mann-Kendall trend for **Chromium** at the **high school station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



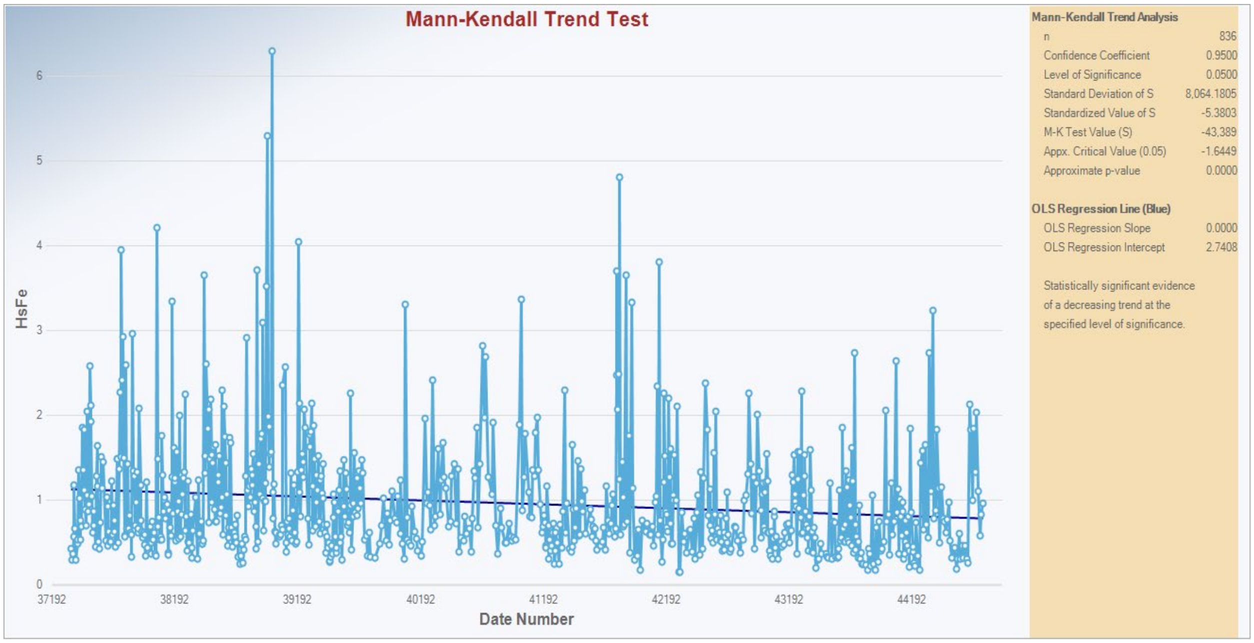
Appendix Figure D10. Mann-Kendall trend for **Chromium** at the **south station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



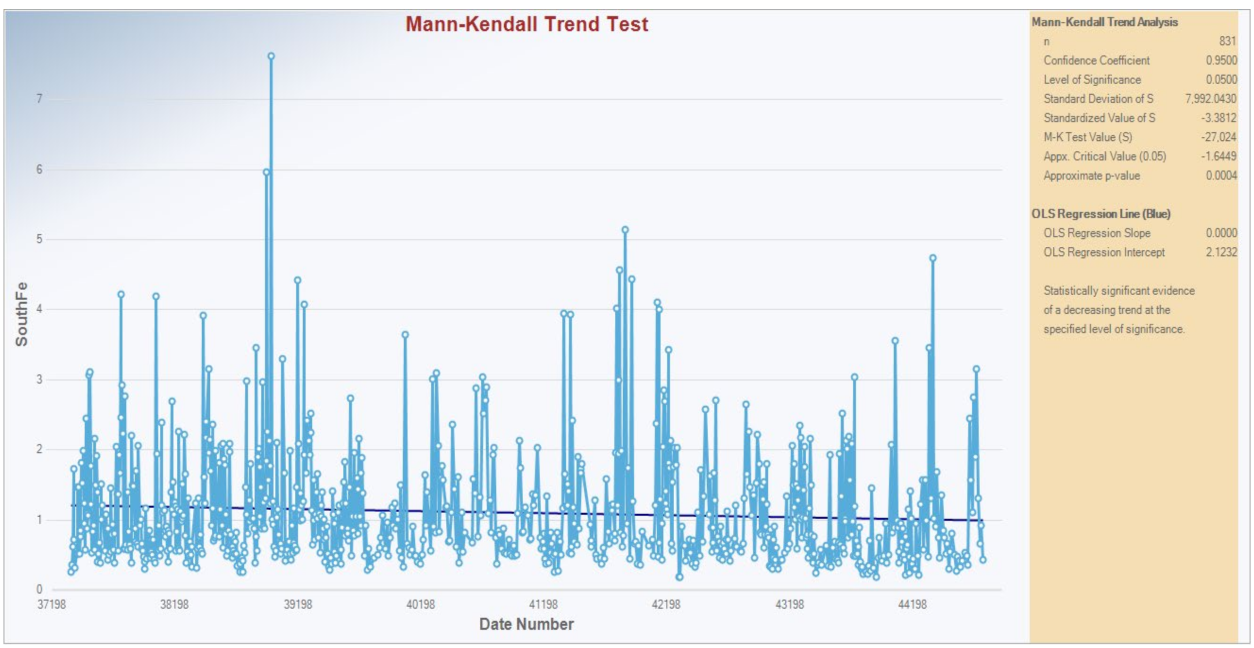
Appendix Figure D11. Mann-Kendall trend for **Copper** at the **high school station** from 2001 to 2022 with **insufficient statistical evidence of a significant trend** over sampling period.



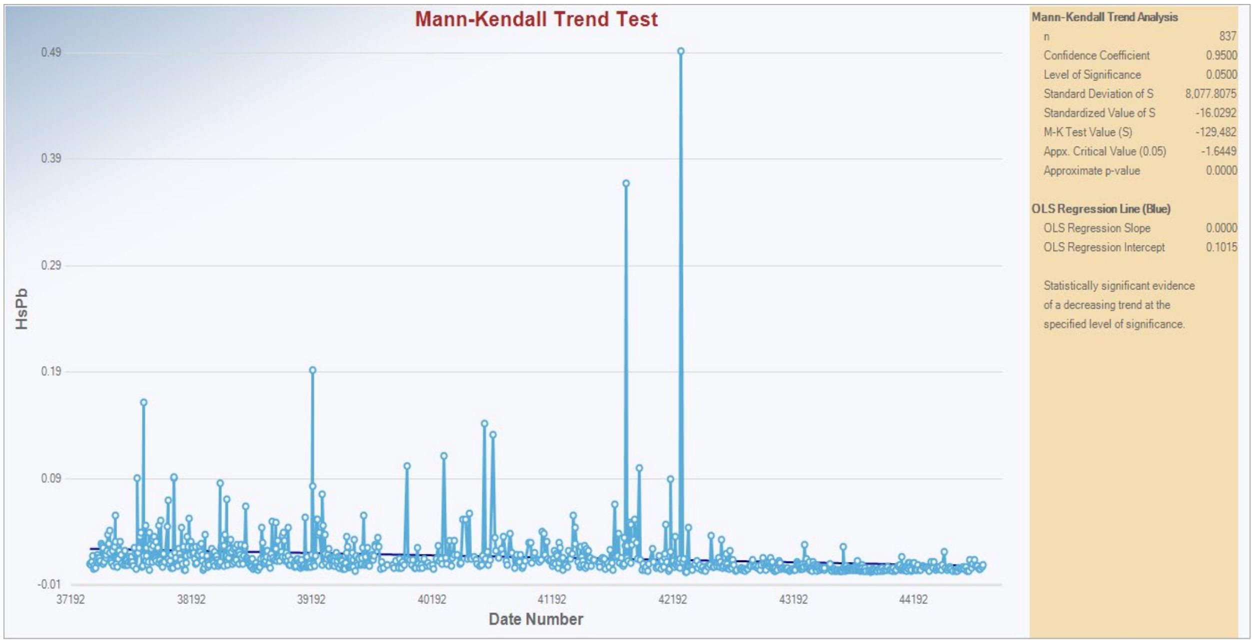
Appendix Figure D12. Mann-Kendall trend for **Copper** at the **south station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



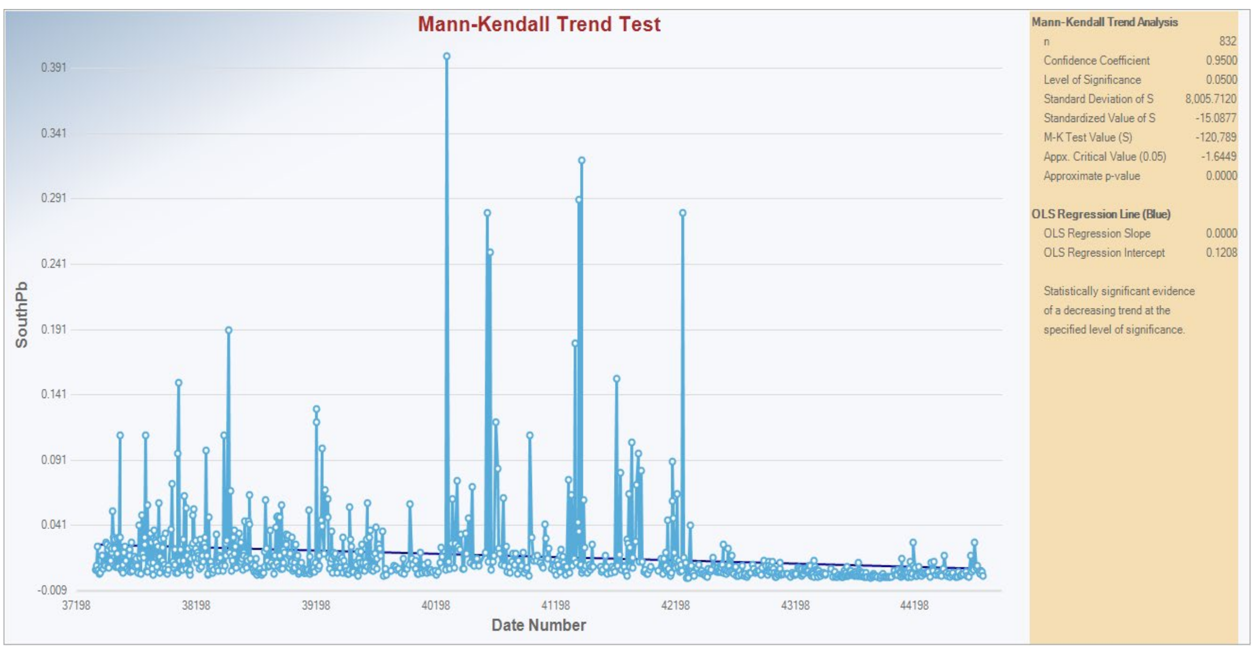
Appendix Figure D12. Mann-Kendall trend for **Iron** at the **high school station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



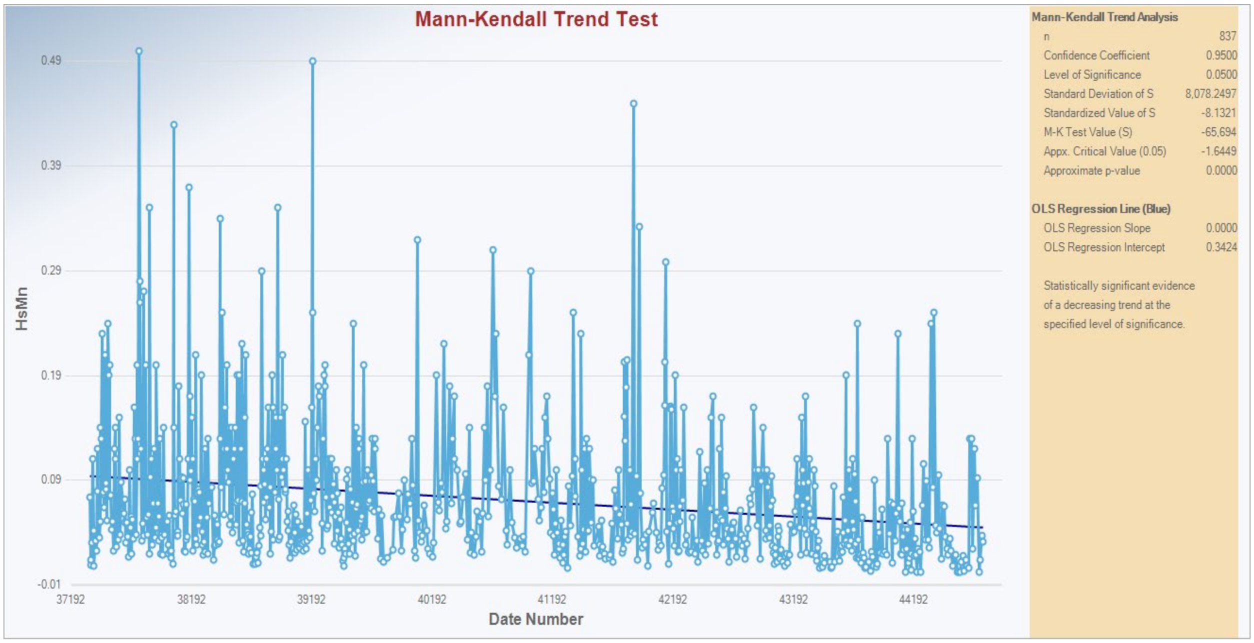
Appendix Figure D12. Mann-Kendall trend for **Iron** at the **south station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



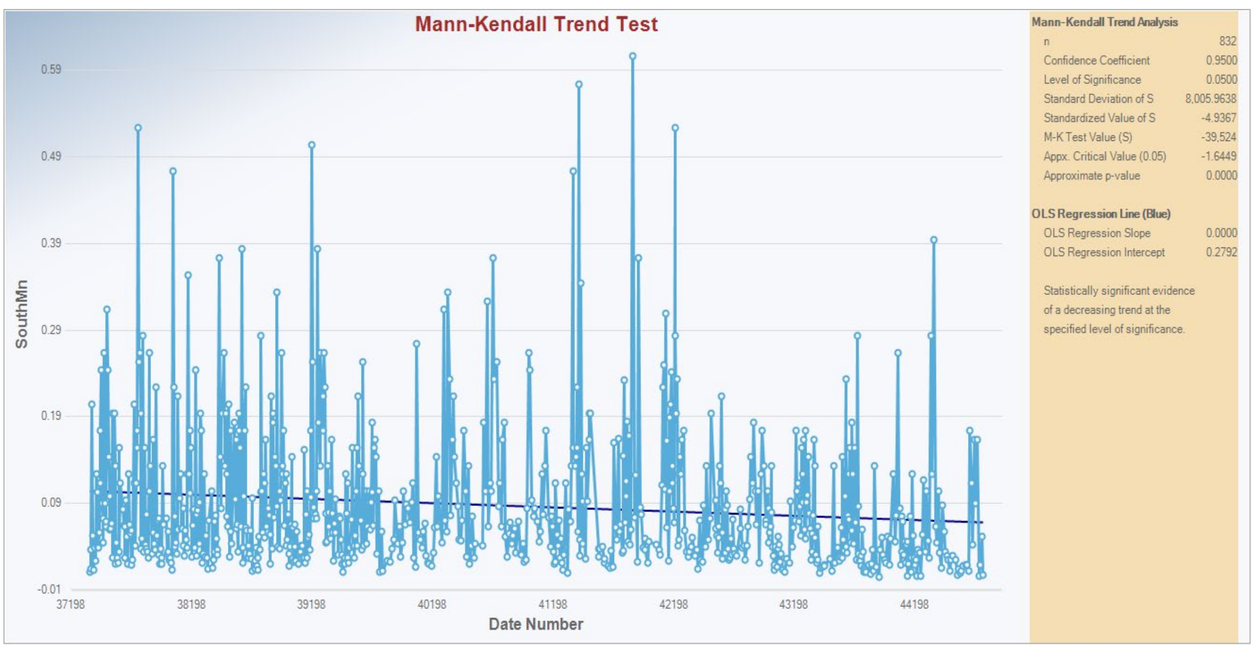
Appendix Figure D13. Mann-Kendall trend for **Lead** at the **high school station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



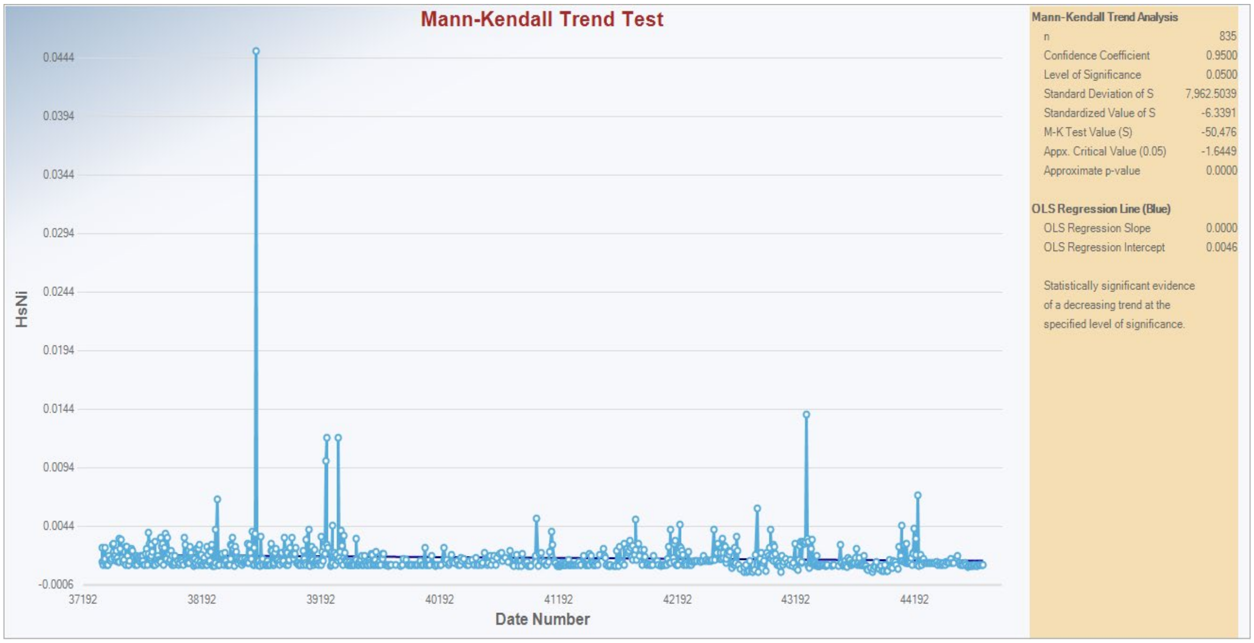
Appendix Figure D14. Mann-Kendall trend for **Lead** at the **south station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



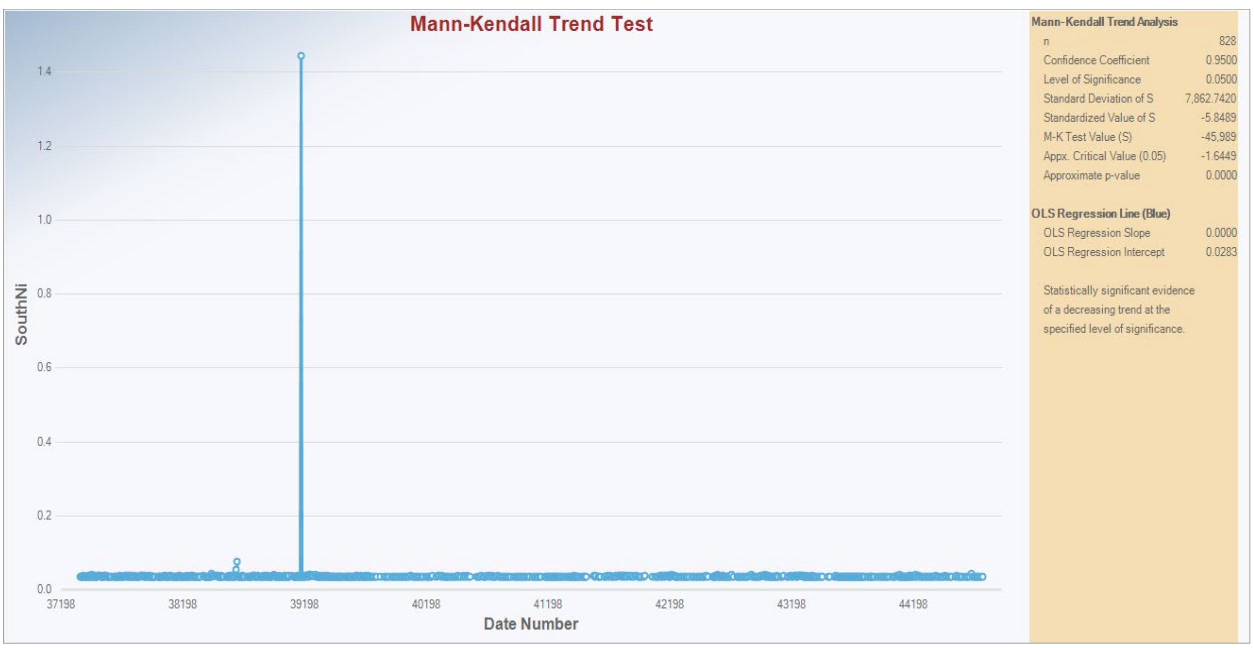
Appendix Figure D15. Mann-Kendall trend for **Manganese** at the **high school station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



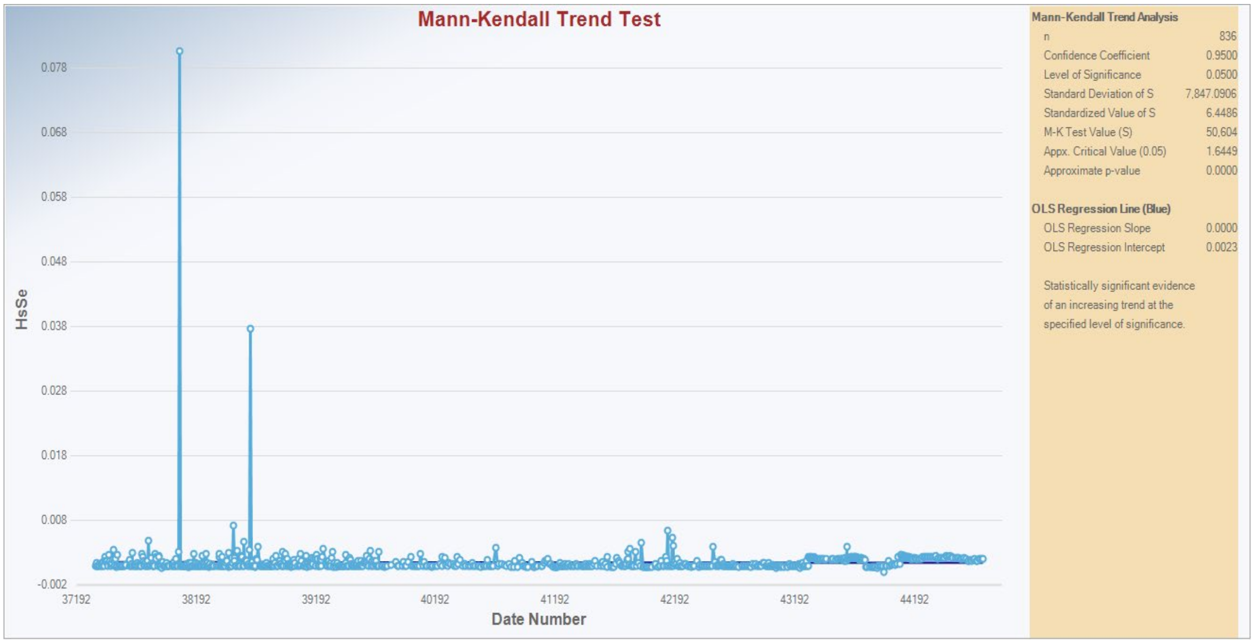
Appendix Figure D16. Mann-Kendall trend for **Manganese** at the **south station** from 2001 to 2022 with with statistically significant evidence of **decreasing trend** over sampling period.



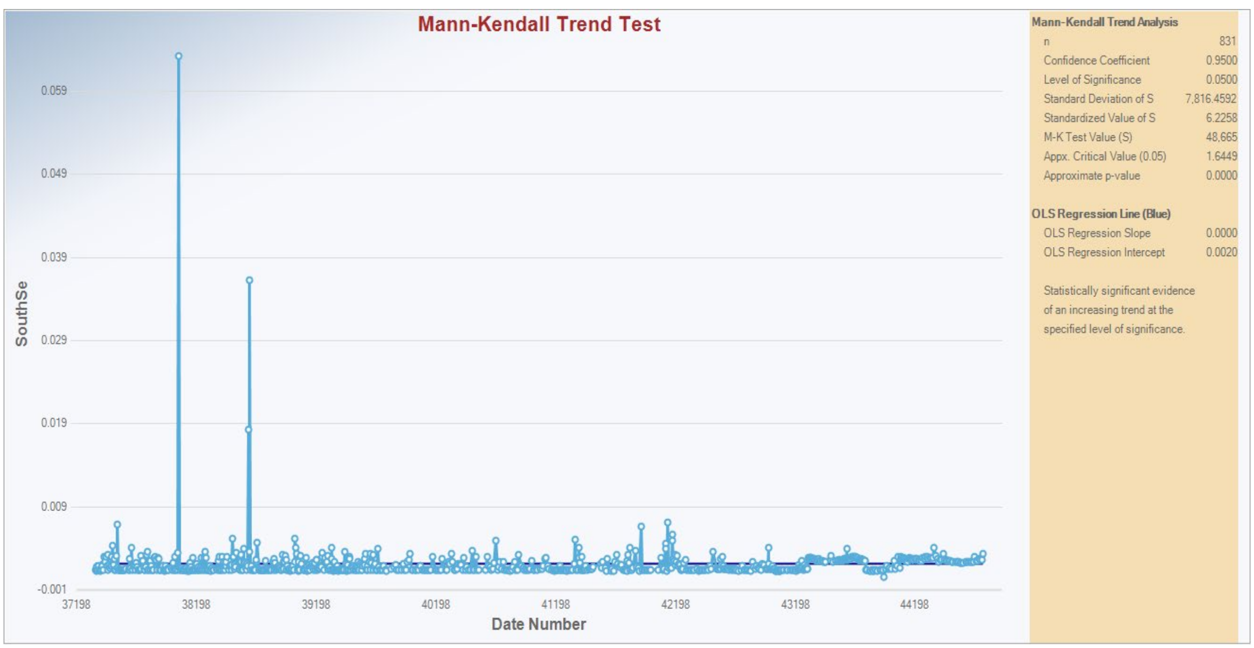
Appendix Figure D17. Mann-Kendall trend for **Nickel** at the **high school station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



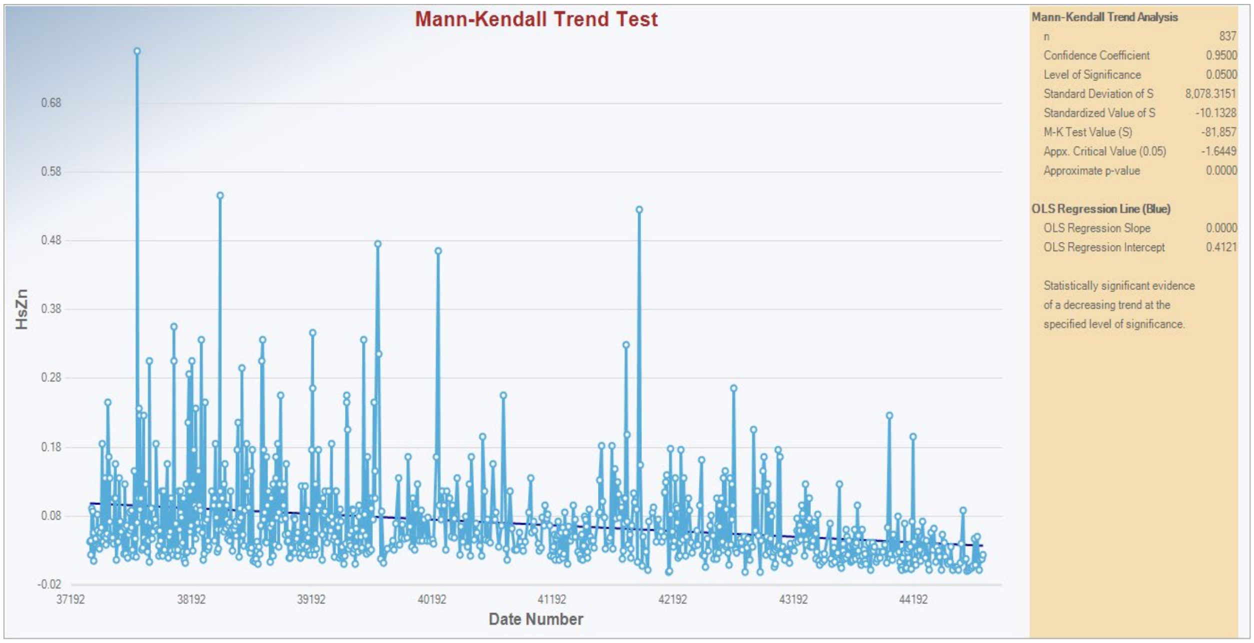
Appendix Figure D18. Mann-Kendall trend for **Nickel** at the **south station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



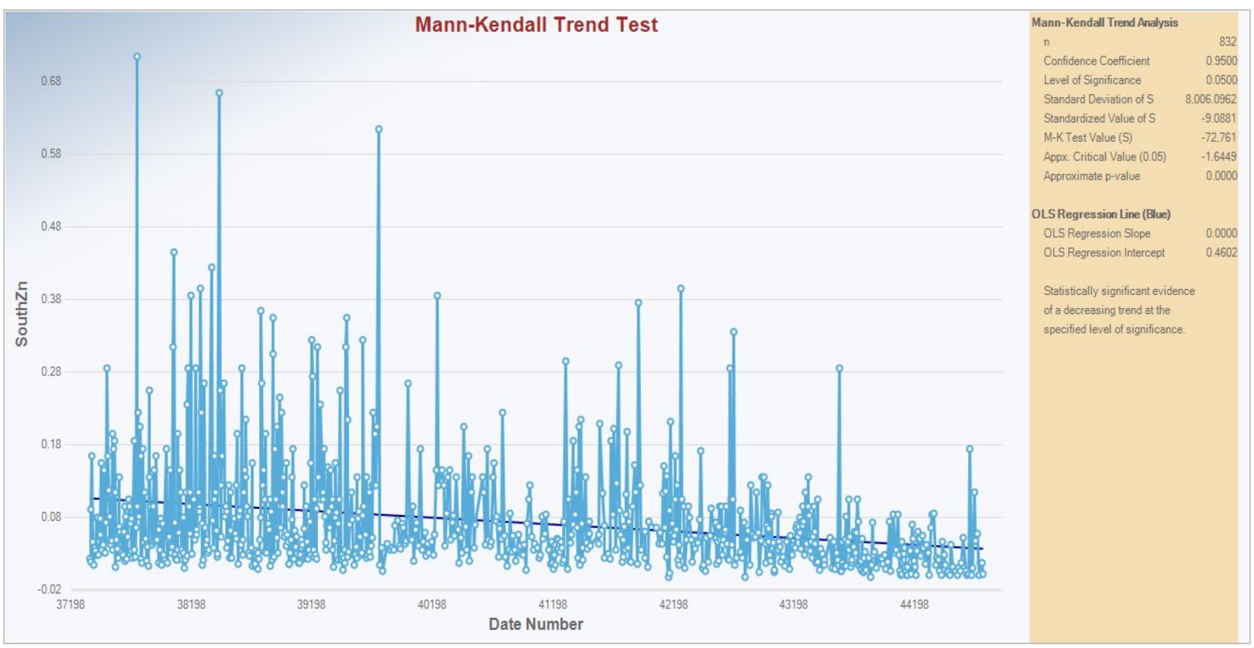
Appendix Figure D19. Mann-Kendall trend for **Selenium** at the **high school station** from 2001 to 2022 with statistically significant evidence of **increasing trend** over sampling period.



Appendix Figure D20. Mann-Kendall trend for **Selenium** at the **south station** from 2001 to 2022 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 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.



Appendix Figure D22. Mann-Kendall trend for **Zinc** at the **south station** from 2001 to 2022 with statistically significant evidence of **decreasing trend** over sampling period.