South Portland / Portland 24 Hour Volatile Organic Compounds Air Monitoring Results Analysis and Summary Report

Analysis and Summary for Sampling Period
November 2019 – January 2020

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Prepared by the Maine Center for Disease Control and Prevention

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Executive summary

In 2019 the Maine Department of Environmental Protection (DEP) installed five 24-hour air sample monitoring stations in South Portland and two stations in Portland and began a yearlong air monitoring program for volatile organic compounds (VOCs). The DEP is collecting 24-hour air samples every six days at each monitoring station and providing the VOC measurement data to the Maine Center for Disease Control and Prevention (Maine CDC) on a monthly basis. This report summarizes the Maine CDC analysis of VOC levels measured in 24-hour air samples from the monitoring stations in South Portland and Portland. The analysis is focused on comparing the 24-hour sample results for individual VOCs to short-term, acute, and long-term, chronic, health-based guidelines. For short-term health-based guideline comparisons, individual VOC levels from each 24-hour air sample at each station are compared to acute Minimal Risk Levels (acute MRLs) maintained by the federal Agency for Toxic Substances and Disease Registry. For long-term health-based guideline comparisons, the time-weighted cumulative average of all 24-hour samples for individual VOCs at each station is calculated and compared to the Maine Ambient Air Guidelines (AAG) which are derived to be protective of human population (including sensitive subpopulations) exposures over a lifetime.

Regarding short-term exposure levels, to date no 24-hour sample result at any sample location for the measured VOCs exceeded an acute MRL. For long-term exposures, the time-weighted cumulative average for most VOCs is well below the corresponding AAG. Currently, the cumulative averages for two chemicals exceed their corresponding AAG - acrolein at all locations, and naphthalene at some locations. The cumulative average for acrolein at all sample stations is approximately 20 times higher than the AAG. However, cumulative average acrolein levels at the South Portland/Portland stations are comparable to averages from other air monitoring stations across the state. At two sample stations in South Portland and two stations in Portland the cumulative average for naphthalene is currently above the long-term, health-based AAG, but no more than 2.5 times higher. Measured levels of naphthalene, benzene, and 1,3-butadiene are all showing pronounced seasonal trends, with higher levels being observed in winter months. At least a year of data will be needed to fully capture seasonal variations and assess whether these time-weighted cumulative averages are reasonably reflective of long-term exposures.

Background

In response to concerns regarding emissions of VOCs from petroleum and asphalt tanks in South Portland, the DEP set-up multiple fixed-location 24-hour air sampling stations in South Portland and Portland to monitor air quality. Five monitoring stations were installed in the South Portland area and two monitoring stations, in addition to the station present at Deering Oaks, in Portland[1]. The DEP installed the stations from June through November 2019 with each station, once operational, collecting a 24-hour air sample every six days. The DEP will run the air sample stations through November 2020, completing a year of monitoring with all stations operational. The air samples are analyzed for a suite of VOCs at the DEP's Air Quality laboratory. The DEP provides the VOC measurement data from the eight stations once a month to Maine CDC. This report describes how the Maine CDC intends to analyze the 24-hour VOC air sampling data it receives and prepare summary figures for the 24-hour

[1] South Portland and Portland 24-hour sample station locations: https://www.maine.gov/dep/air/monitoring/spo-voc-monitor.html

VOC data to facilitate inspection of measured levels relative to both short-term and long-term health guidelines. This document provides a set of figures that represent a compilation of data collected through January 2020. These analyses and figures will be updated approximately every three months (i.e. quarterly).

Quarterly analysis plan for 24-hour VOC sample results

The objective of the analysis plan for 24-hour VOC sample results is to compare the measured VOC levels to appropriate health-based guideline values to assess potential health risks. The analysis plan evaluates health risks for both short-term, acute, exposures and long-term, chronic, exposures. Short-term exposure hazards are assessed by comparing the individual 24-hour sample results to acute Minimum Risk Levels (MRLs) developed by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR acute MRLs are developed for an exposure period of 1 to 14 days and are estimates of the amount of a chemical a person can be exposed to each day without appreciable risk of non-cancer health effects[2]. This analysis will aid in identifying any potential short-term elevations in VOC levels that may warrant further investigation.

Long-term exposure hazard is assessed by first computing the time-weighted cumulative average for all 24-hour samples taken to date for each individual chemical at each sample location. The time-weighted cumulative averages by chemical and location are then compared to the Maine Ambient Air Guidelines (AAGs). AAGs are Maine-specific air level guidelines developed for lifetime exposures where there is a minimal risk of an adverse health effect even for sensitive individuals. AAGs are developed using U.S. Environmental Protection Agency (EPA) regional screening level (RSL) inhalation toxicity values[3]. For chemicals with the ability to cause cancer, the AAGs are set at an incremental lifetime cancer risk of 1-in-100,000, consistent with State policy. As AAGs are based on lifetime exposure, the longer the time period represented by the time-weighted cumulative average, the more representative it becomes of lifetime exposure. This time-weighted cumulative average analysis will aid in determining whether any VOC concentrations over a longer monitoring period exceed health-based AAGs.

I. Quarterly analysis and summary figures for short-term exposure concerns

For each chemical with a chemical-specific acute MRL, the individual VOC concentrations for each sample location and sampling day will be compared to the acute MRL. Only 15 of the 47 chemicals measured in the 24-hour air samples have corresponding acute MRLs. In the case of the VOC naphthalene, which is a chemical of interest but does not have an ATSDR acute MRL, the Maine Intermediate Intervention Action Level (IIAL) will be used to assess acute health concerns. Maine CDC derived an IIAL for naphthalene to be used in assessing exposures in indoor building air (e.g., schools, homes, businesses) where there has been a fuel oil spill. The IIAL was derived using the same risk assessment methodology as an ATSDR MRL. Specifically, the IIAL for naphthalene is based on a 4-hour exposure to rodents where there was no apparent effect even when examined using sensitive measures of damage to cells of the nasal and respiratory track. The rodent exposures were adjusted

[2] ATSDR MRLs - https://www.atsdr.cdc.gov/minimalrisklevels/index.html

[3] EPA RSLs - https://www.epa.gov/risk/regional-screening-levels-rsls

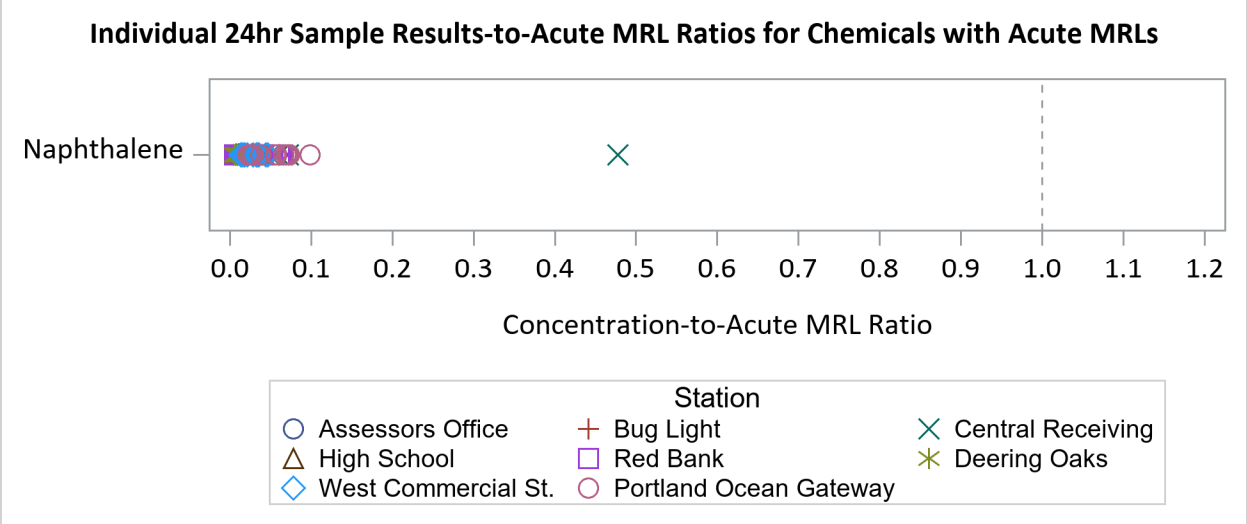
downward for an animal-to-human extrapolation and for potential sensitive human populations following standard risk assessment practices.

To summarize the comparison of 24-hour air sample results to acute MRLs, Maine CDC will calculate the ratio of the measured VOC concentration to the acute MRL and display the ratios for each chemical by station (Example Figure A)[4]. A ratio greater than 1 indicates that the VOC concentration for a 24-hour sample exceeded the chemical-specific acute MRL, or in the case of naphthalene the IIAL. A ratio lower than 1 indicates the VOC concentration did not exceed the chemical-specific acute MRL.

All chemicals with acute MRLs will be evaluated monthly as new data is received to determine if any 24-hour results are above these short-term health guidelines. Summary Figure 1 at the end of this report presents results for all of the chemicals with an acute MRL in one figure.

For the remaining chemicals with no acute MRL for comparison, the individual 24-hour sample results by sample date and sample location will be plotted as bar charts and inspected to monitor for any unusual trends or spikes in concentrations. All 24-hour sample results are available on the DEP's website[5].

Example Figure A. Individual 24-hour sample result-to-acute MRL ratio by station for naphthalene.



In Example Figure A different symbols are used for each sample location to display the ratio for naphthalene. For each sample location, there will be multiple 24-hour air sample results. This example figure shows that all the 24-hour sample results for naphthalene for all sample locations had measured air levels below the IIAL. The highest naphthalene level measured (1.2 ppb-v) was at the Central Receiving station but this level was still about 2-fold lower than the IIAL (2.5 ppb-v) with a ratio of 0.48 (i.e., 1.2 / 2.5 = 0.48).

II. Quarterly analysis and summary figures for long-term exposure concerns

[4] The ratio between the measured concentration and the toxicity value, in this case the acute MRL, is often referred to as a hazard quotient when assessing noncarcinogenic health effects.

[5] DEP South Portland/Portland air monitoring data - https://www.maine.gov/dep/air/monitoring/spo-sampling-results.html

The time-weighted cumulative averages for all 24-hour samples taken to date for each individual chemical at each sample location will be calculated and compared to the Maine AAGs. Three types of figures will be generated to display results for the cumulative average AAG comparisons:

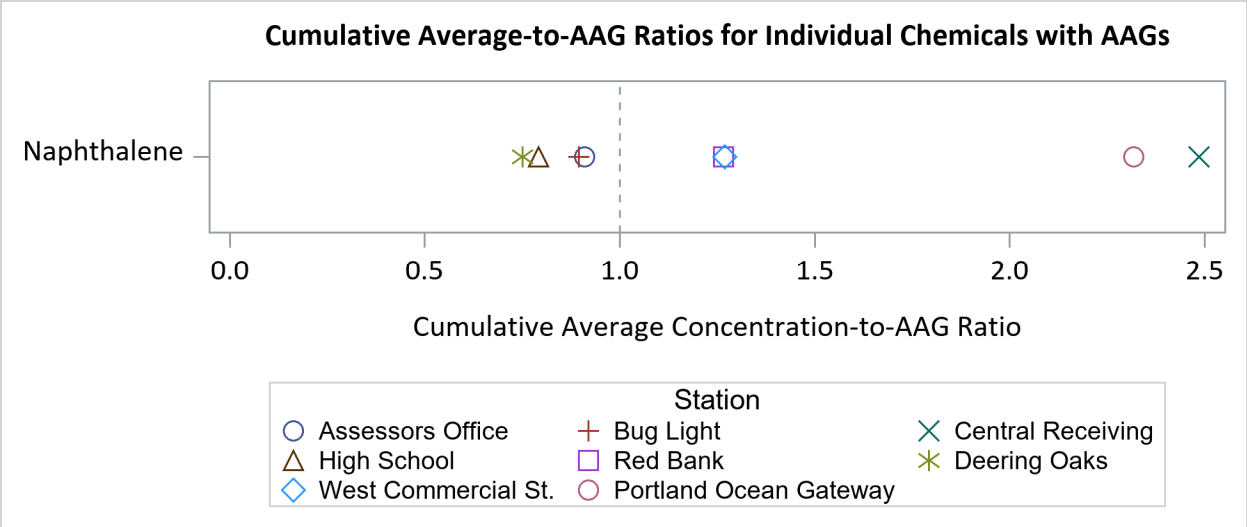
A. cumulative average to AAG ratio figure
B. cumulative average uncertainty figures and
C. cumulative average time trends figures.

All chemicals with AAGs will be evaluated quarterly to determine if the cumulative averages of any measured VOC either approaches or exceeds an AAG and to identify seasonal trends. For chemicals with no AAG for comparison, the cumulative averages will be monitored to track any pronounced trends.

A. Cumulative average to AAG ratio figures

The cumulative average to AAG ratio figure will display the calculated ratio of the time-weighted cumulative average concentration to the AAG by station and chemical (Example Figure B). As with the ratio figure described above for short-term exposures, a ratio above the value of 1 indicates a cumulative average is higher than the AAG, whereas a ratio less than 1 indicates it is below the AAG. These figures allow for quick inspection of whether the measured VOCs are trending above or below their associated AAG. There is a total of 47 VOCs in the data received from DEP, 33 of which have an AAG for comparison. The AAG comparison results for 33 chemicals can be summarized in one ratio figure. However, the cumulative average-to-AAG ratio for acrolein will be displayed as a separate ratio figure as the cumulative average for acrolein at all sample locations greatly exceeds the AAG making it difficult to inspect the results for other VOCs. For acrolein, this is also the case at all other 24-hour air monitoring stations across the state.

Example Figure B. 24-hour cumulative average-to-AAG ratio by station for naphthalene.

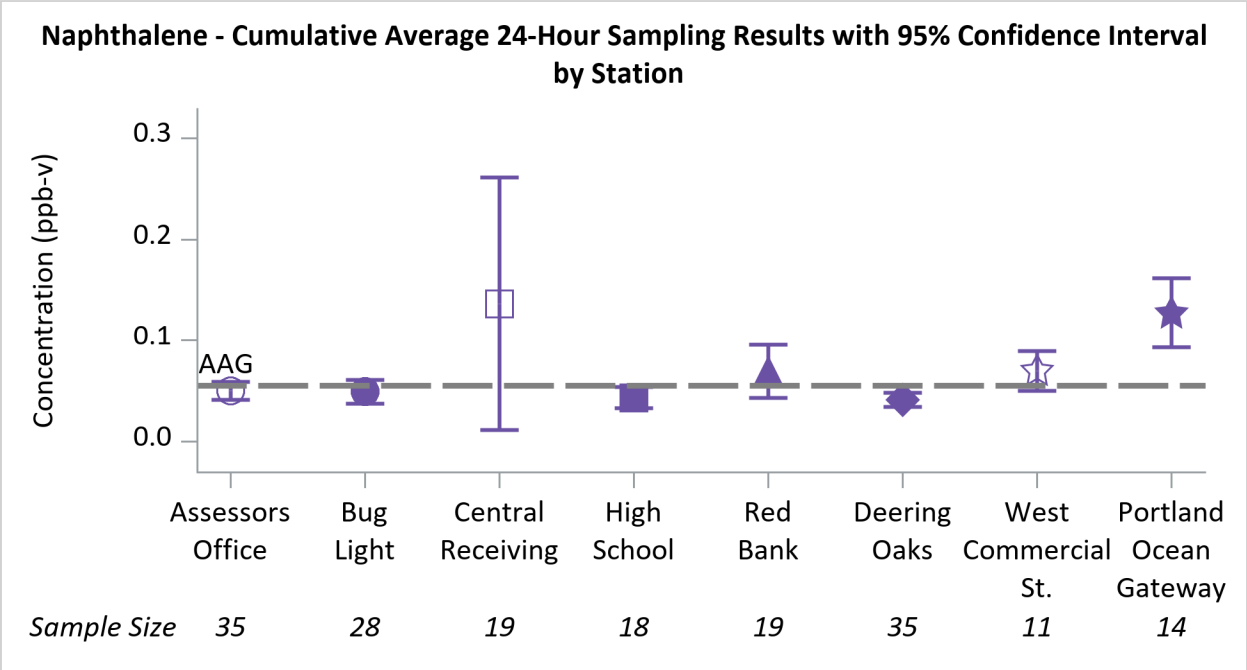


In Example Figure B different symbols are used for each sample location to display the ratio for naphthalene. For each sample location, there will be one cumulative average-to-AAG ratio for each chemical. This example figure shows the cumulative average-to-AAG ratio for naphthalene. For four stations with ratios above 1, the cumulative average naphthalene concentration is above the the AAG. For the four stations with ratios below 1, the naphthalene cumulative averages are below the AAG.

B. Cumulative average uncertainty figures

Cumulative average uncertainty figures will display the 24-hour cumulative averages with 95% confidence limits for the estimated average for each individual chemical by location with the chemical-specific AAG for comparison (dashed horizontal line). The wider the confidence limits the less confidence in the estimated time-weighted average. For the cumulative average uncertainty figures (as illustrated in Example Figure C), it takes 33 figures to present all the comparisons for all the individual VOCs with AAGs. For this reason, only those chemicals with cumulative averages that either exceed an AAG or are within a factor of three of an AAG (i.e., no less than one-third of an AAG) will be selected for display as cumulative average figures. Thus far the only chemicals that meet either of these criteria are acrolein with averages at all stations above the AAG; naphthalene with averages above the AAG at four of eight stations; and benzene, 1,3-butadiene, and carbon tetrachloride with averages that are at least one-third of the AAG.

Example Figure C. 24-hour cumulative averages with 95% confidence limits on the estimated average for naphthalene.



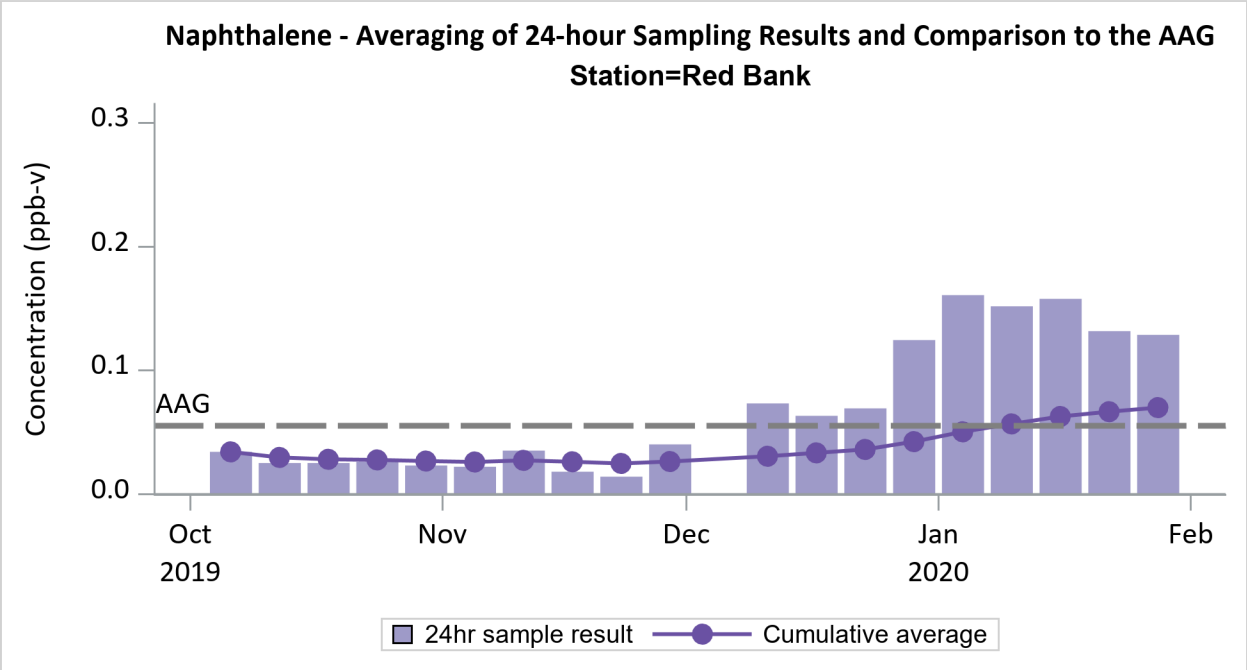
Example Figure C shows the cumulative average and 95% confidence interval for naphthalene by sample location. The length of the confidence limits reflects both the amount of variation between individual 24-hour sample results and the number of sample results. Some sample locations have more 24-hour sample results than others as the stations were brought online from June through November 2019. The more sampling results and the less variation among individual results, the shorter the confidence limits and the lower the uncertainty about the estimated cumulative average.

C. Cumulative average time trends figures

These figures will display the individual 24-hour sampling results chronologically by sample date with separate figures for each chemical as a bar chart. The bar chart will be overlaid with a line chart showing how the cumulative average is changing as additional 24-hour sampling results are obtained and will include a reference line for the AAG (Example Figure D). These figures are useful for tracking any trends in the cumulative average (i.e., is it increasing or decreasing as more data are obtained) as well as trends in individual 24-hour results (e.g., is there evidence of seasonal patterns). The combination of the bar chart with individual 24-hour results and the line chart showing the cumulative average will also show the impact of any unusually high results on the cumulative average.

It takes more than 264 figures to display the results for all 33 VOCs measured that have an AAG for comparison with the eight different sampling locations. Due to the larger number of figures, cumulative average trend figures will only be provided in the quarterly analysis and summary updates for those chemicals exhibiting pronounced temporal changes in measured levels relative to AAGs. For now, this is limited to figures for benzene, naphthalene, and 1,3-butadiene.

Example Figure D. 24-hour individual sample bar charts with line chart displaying the trends in the time-weighted cumulative average for naphthalene.



Example Figure D displays both the individual 24-hour sample results and the cumulative average for naphthalene measurements from the South Portland Red Bank station. The height of the individual bars reflects the measured 24-hour average air concentration, collected once every six days, for a specific VOC by sample date. The line with circle markers shows the time-weighted cumulative average as of that sampling date. The dashed horizontal reference line shows the AAG. This example figure shows a pronounced increase in air levels of naphthalene during winter months and the impact of these increases on the cumulative average.

Additional analyses

Maine CDC is evaluating other analyses including, but not limited to analyses to estimate the potential cumulative impact of concurrent exposure to multiple VOCs. There are standard risk assessment methods for evaluating the cumulative hazard of concurrent exposure to multiple chemicals. These methods are relatively straight forward for cancer-causing chemicals. A cumulative cancer risk analysis involves summing the cancer risk estimates for individual chemicals under the assumption that the chemicals act in an independent and additive manner. The summing methods can be more involved with chemicals that cause health effects other than cancer (noncarcinogens), such as evaluating the cumulative impact only among chemicals that share a common target system for a health effect (e.g., reproductive, respiratory, neurological system) or a common target organ (e.g., liver, lung, blood). These additional analyses are likely only to be performed after a year of monitoring has been completed.

Maine CDC is also planning to perform analyses on the spatial pattern of emergency department (ED) visits for asthma to look for evidence of clustering of cases relative to potential exposure to VOCs. This

analysis will initially focus on ED visits that occurred between 2018 and 2019, as these are the only years for which address-level data are available to support such analyses. To access these data, Maine CDC will need to make a special request to the Maine Health Data Organization (MHDO) for access, first for just address data without any linked health information so we can perform a geocoding service necessary to enable these data to be mapped. Once this geocoding work is completed and the geocoded address data are returned to MHDO, Maine CDC will make a follow-up request to MHDO for the geocoded data linked to health outcome data, such as ED visits for asthma, that will be used to evaluate clustering of cases. Maine CDC is working to establish an agreement with MHDO to access address data for geocoding. However, the current COVID-19 response will impact progress on this work.

In the pages that follow, a set of figures are presented that summarize results to date. The current plan is to update this set of figures quarterly.

Summary Figures

I. Summary figure for short-term exposures - Acute MRL ratio figure

Acute MRL ratio figure

Figure 1. Individual 24-hour sample results-to-acute MRL ratios for chemicals with acute MRLs

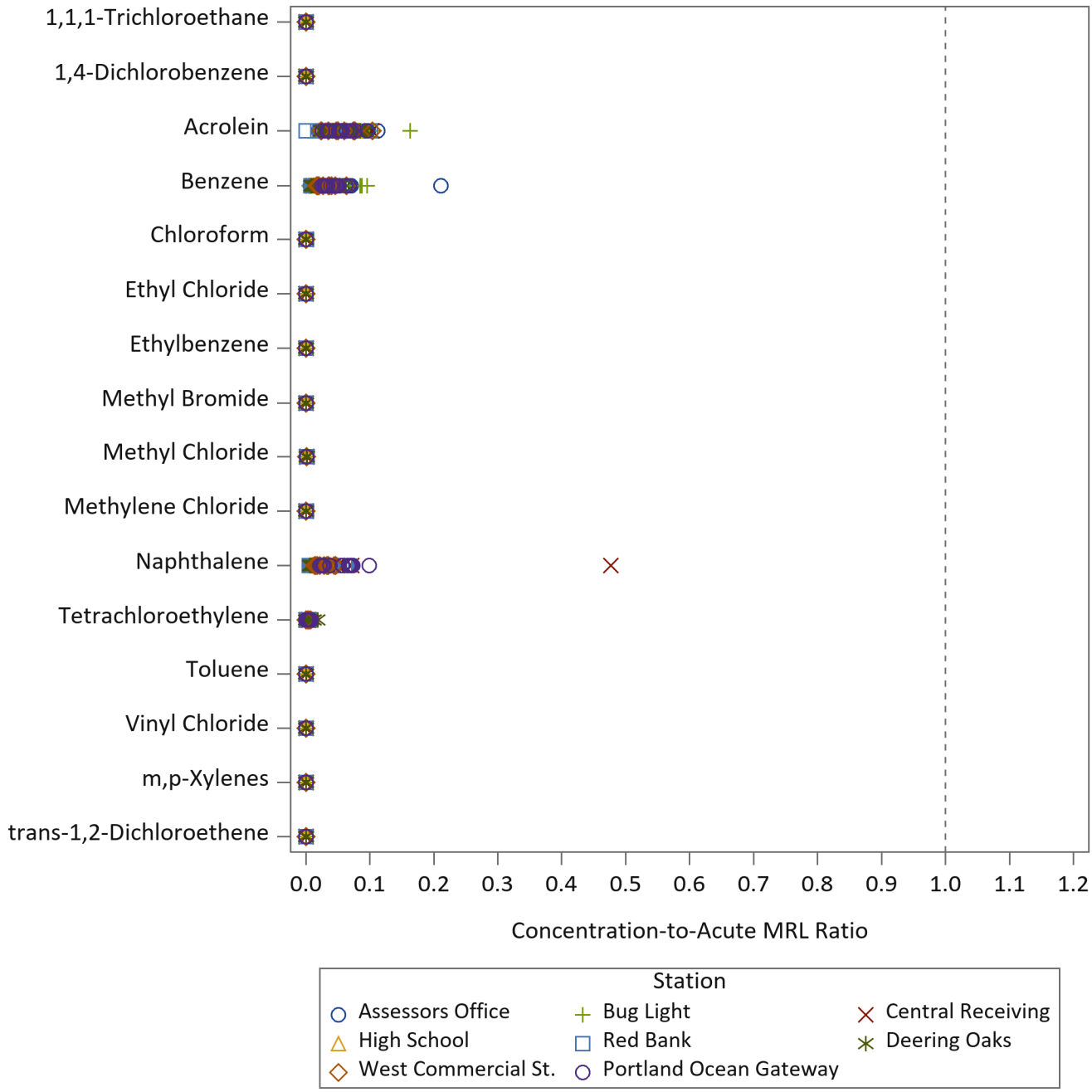


Figure 1 shows the ratio of individual 24-hour sample results collected to date at each sampling station to chemical-specific Agency for Toxic Substances and Disease Registry (ATSDR) acute Minimum Risk Levels (acute MRLs). Acute MRLs are developed for an exposure period of 1 to 14 days and are estimates of the amount of a chemical a person can be exposed to each day without a detectable risk to health. For naphthalene, the Maine Intermediate Intervention Action Level (IIAL) is used for comparison to acute exposure levels as there is no acute MRL for naphthalene currently available from ATSDR. Ratios greater than 1, the dashed grey reference line, indicate that an individual 24-hour sample result exceeded the chemical-specific acute MRL. To date, no VOC levels exceed an acute MRL. Sampling data obtained from Maine DEP current through January 2020.

Summary Figures

II. Summary figures for long-term exposures -

A. Cumulative average to AAG ratio figures

B. Cumulative average uncertainty figures

C. Cumulative average time trends figures

A. Cumulative average to AAG ratio figures

Figure 2a. Cumulative average-to-AAG ratios for individual chemicals with AAGs

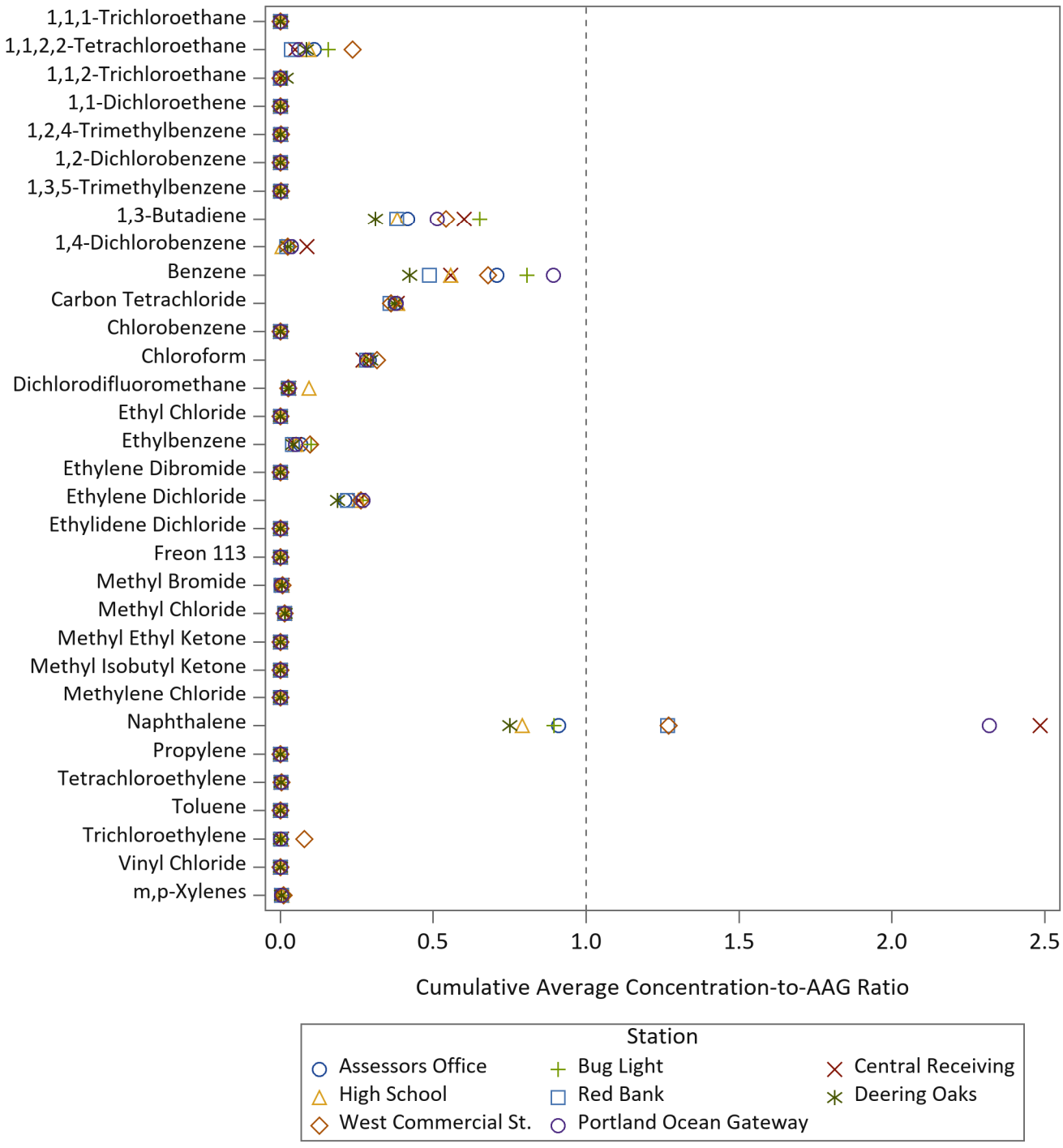


Figure 2a shows the ratio of the time-weighted cumulative average, i.e., the average of all individual 24-hour samples collected to date for an individual chemical by station, to the Maine Ambient Air Guideline (AAG) for all chemicals with an AAG. An AAG is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. Ratios that are greater than 1, the dashed grey reference line, indicate that the current 24-hour sample cumulative average exceeds the chemical-specific AAG. Currently, only the chemicals naphthalene (above) and acrolein (Figure 2b) are trending with cumulative averages above an AAG. Sampling data obtained from Maine DEP current through Jan. 2020.

Figure 2b. Cumulative average-to-AAG ratios for acrolein

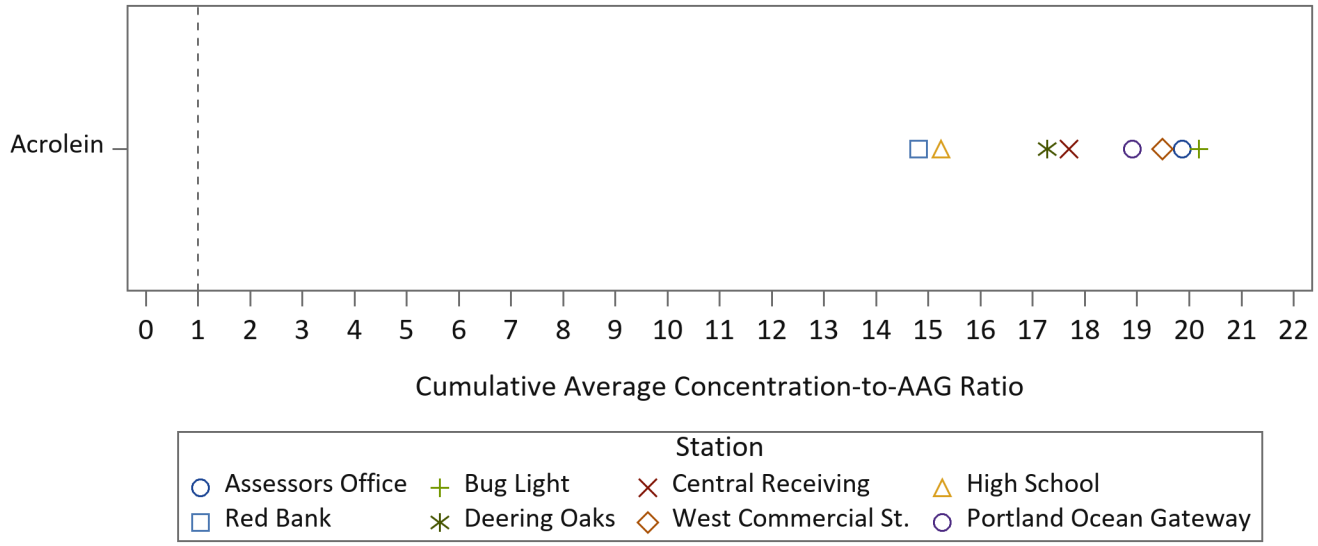


Figure 2b shows the ratio of the time-weighted cumulative average to the Maine Ambient Air Guideline (AAG) for acrolein. All cumulative averages for individual stations exceed the acrolein AAG; this is also the case for all sampling locations across the State of Maine. Sampling data obtained from Maine DEP current through Jan. 2020.

B. Cumulative average uncertainty figures

Figure 3. Average 24-hour sampling results with 95% confidence interval by station for Acrolein

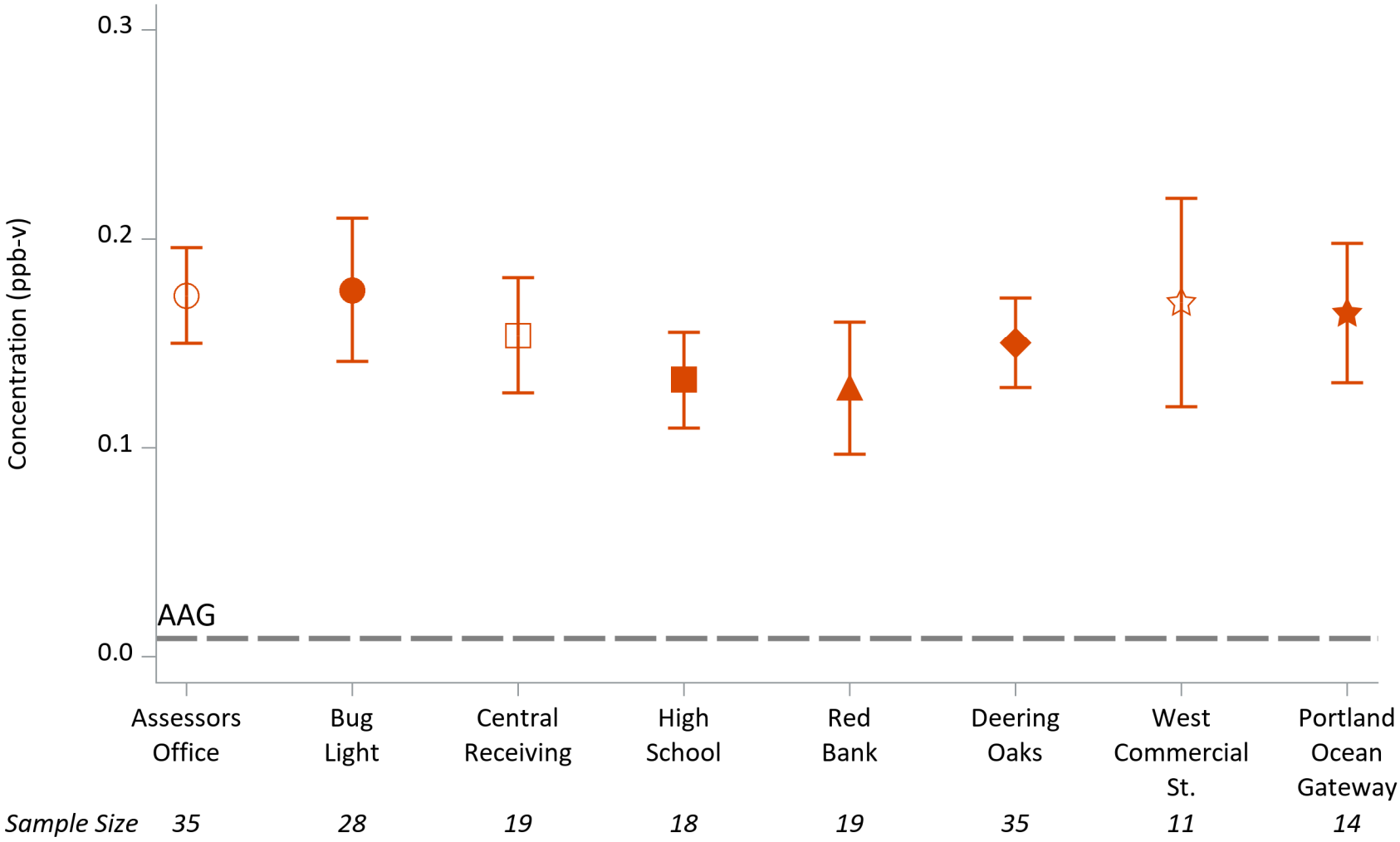


Figure 3 shows the average acrolein level as a marker (circle, square, diamond, triangle, etc.) with 95% confidence interval (vertical lines) for all individual 24-hour samples collected by station. 24-hour air samples are collected every 6 days. The number of samples collected by station is shown as the sample size. AAG = State of Maine Ambient Air Guideline, which is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. Average acrolein levels exceed the AAG at all sampling locations. Sampling data obtained from Maine DEP current through Jan. 2020.

Figure 4. Average 24-hour sampling results with 95% confidence interval by station for Benzene

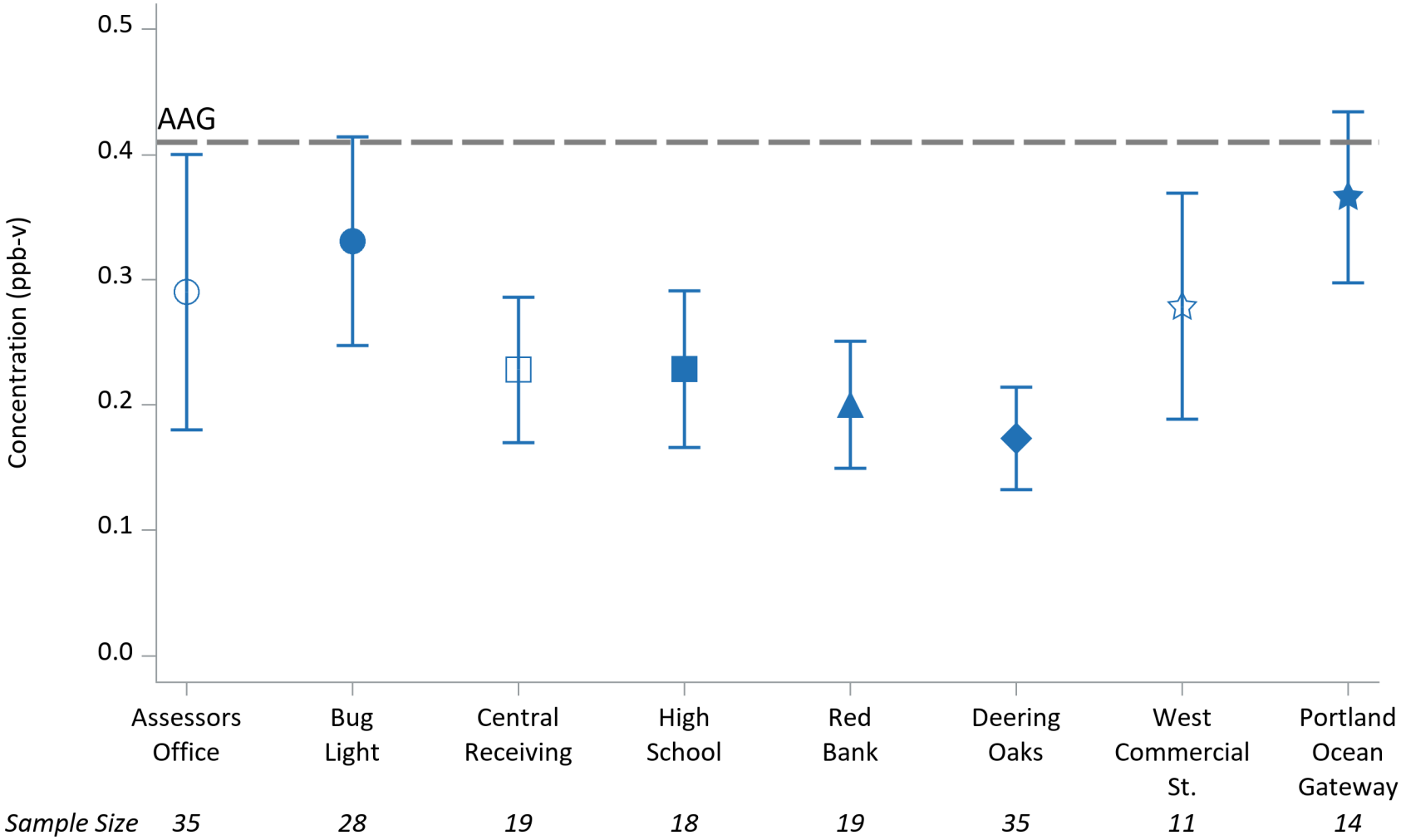


Figure 4 shows the average benzene level as a marker (circle, square, diamond, triangle, etc.) with 95% confidence interval (vertical lines) for all individual 24-hour samples collected by station. 24-hour air samples are collected every 6 days. The number of samples collected by station is shown as the sample size. AAG = State of Maine Ambient Air Guideline, which is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. While average levels of benzene are below the AAG at all sampling locations, for two locations the 95% confidence interval does extend above the AAG reference line. Sampling data obtained from Maine DEP current through Jan. 2020.

Figure 5. Average 24-hour sampling results with 95% confidence interval by station for Naphthalene

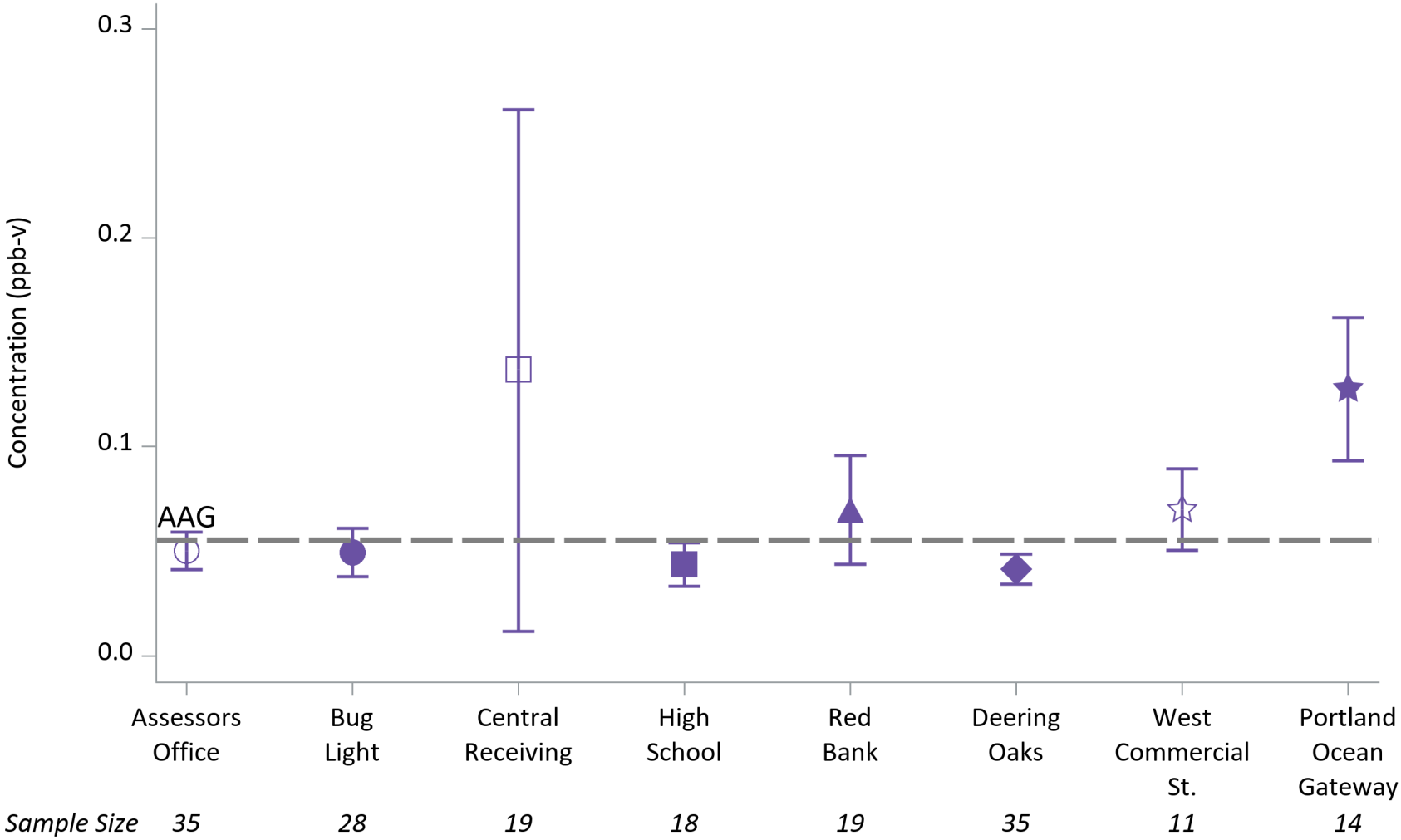


Figure 5 shows the average naphthalene level as a marker (circle, square, diamond, triangle, etc.) with 95% confidence interval (vertical lines) for all individual 24-hour samples collected by station. 24-hour air samples are collected every 6 days. The number of samples collected by station is shown as the sample size. AAG = State of Maine Ambient Air Guideline, which is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. Four stations have average naphthalene levels that are above the AAG, and another two have 95 % confidence limits that extend above the AAG. Sampling data obtained from Maine DEP current through Jan. 2020.

Figure 6. Average 24-hour sampling results with 95% confidence interval by station for 1,3-Butadiene

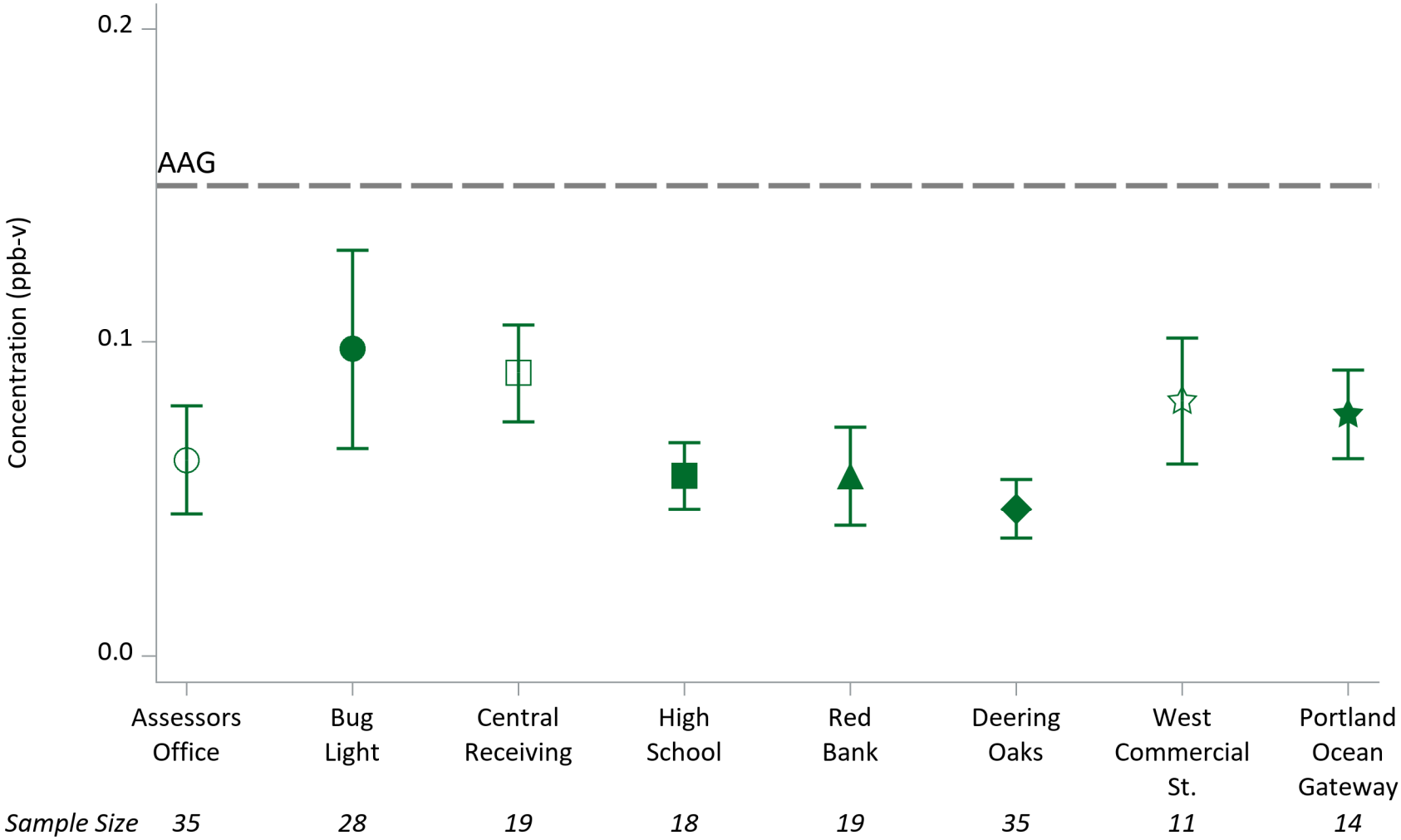


Figure 6 shows the average 1,3-butadiene level as a marker (circle, square, diamond, triangle, etc.) with 95% confidence interval (vertical lines) for all individual 24-hour samples collected by station. 24-hour air samples are collected every 6 days. The number of samples collected by station is shown as the sample size. AAG = State of Maine Ambient Air Guideline, which is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. All averages and confidence limits are below the AAG. Sampling data obtained from Maine DEP current through Jan. 2020.

Figure 7. Average 24-hour sampling results with 95% confidence interval by station for Carbon Tetrachloride

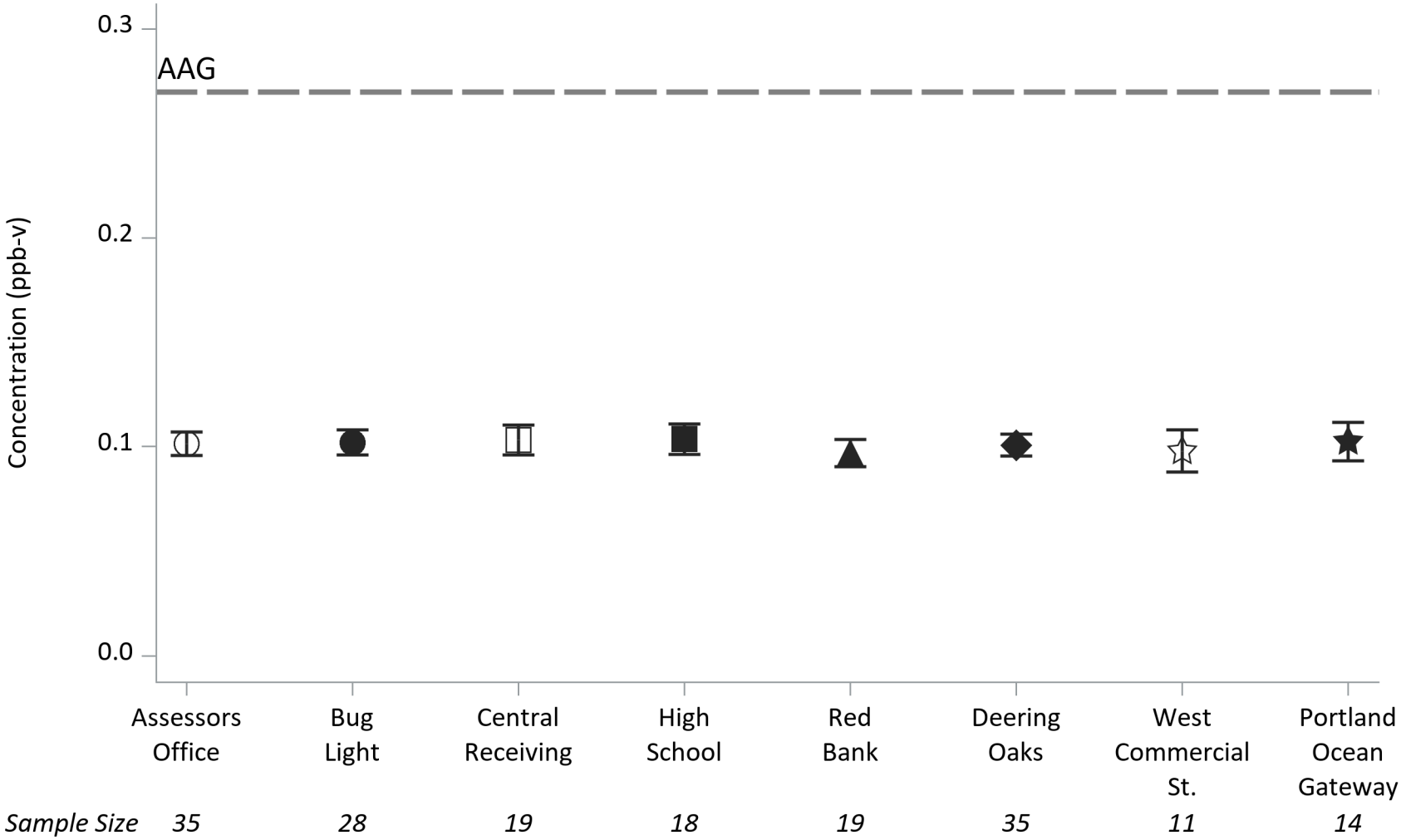


Figure 7 shows the average carbon tetrachloride level as a marker (circle, square, diamond, triangle, etc.) with 95% confidence interval (vertical lines) for all individual 24-hour samples collected by station. 24-hour air samples are collected every 6 days. The number of samples collected by station is shown as the sample size. AAG = State of Maine Ambient Air Guideline, which is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. All averages and 95% confidence limits are below the AAG. Sampling data obtained from Maine DEP current through Jan. 2020.

C. Cumulative average time trends figures

Figure 8. Individual 24-hour sampling results with the cumulative average time trends for Naphthalene

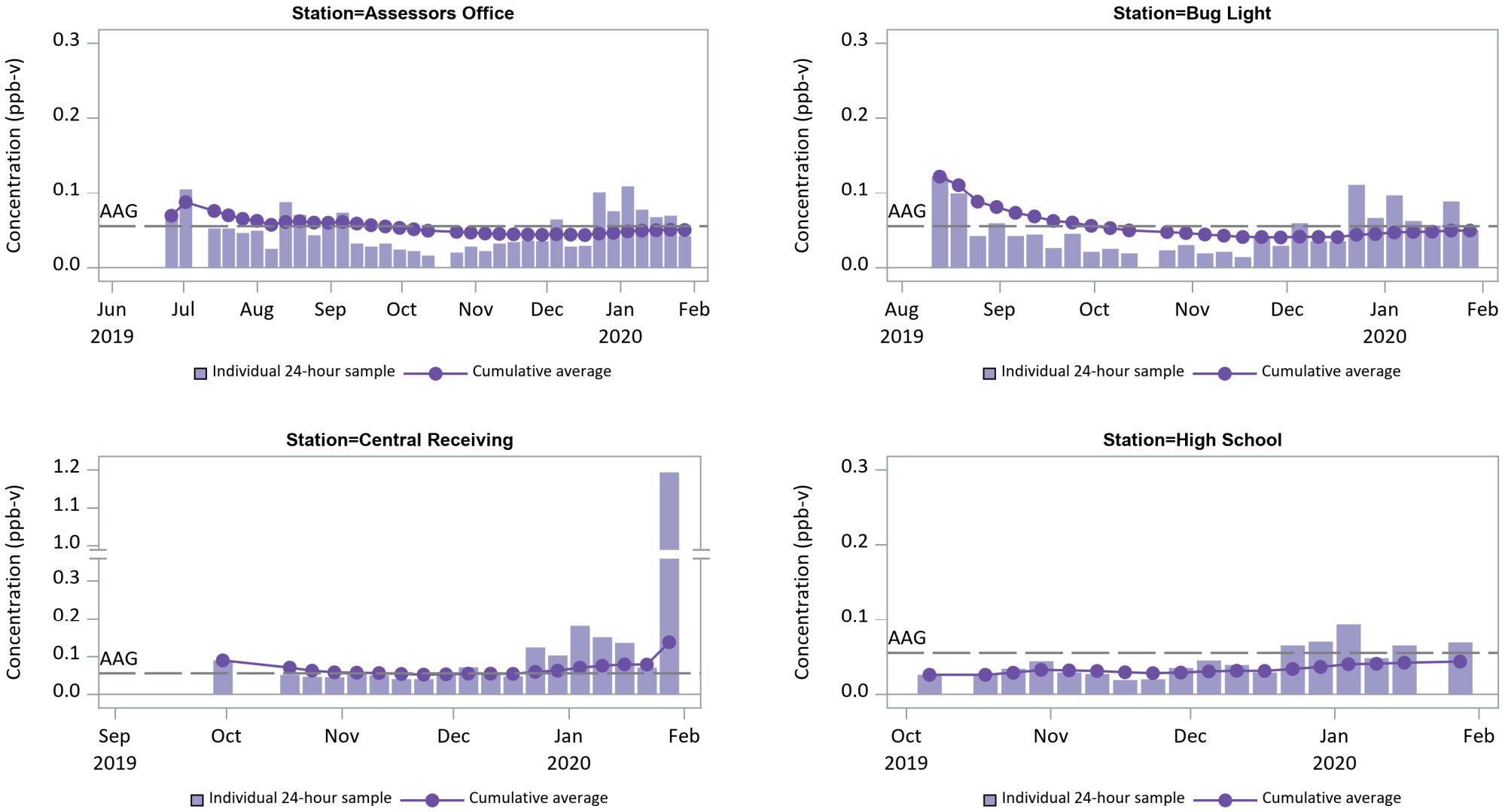


Figure 8 shows the individual 24-hour sample results by date for naphthalene displayed as bars with the cumulative average displayed as a line with markers showing the average trend over time. 24-hour air samples are collected every 6 days. AAG = State of Maine Ambient Air Guideline, which is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. Sampling data obtained from Maine DEP current through Jan. 2020.

Figure 8. Individual 24-hour sampling results with the cumulative average time trends for Naphthalene

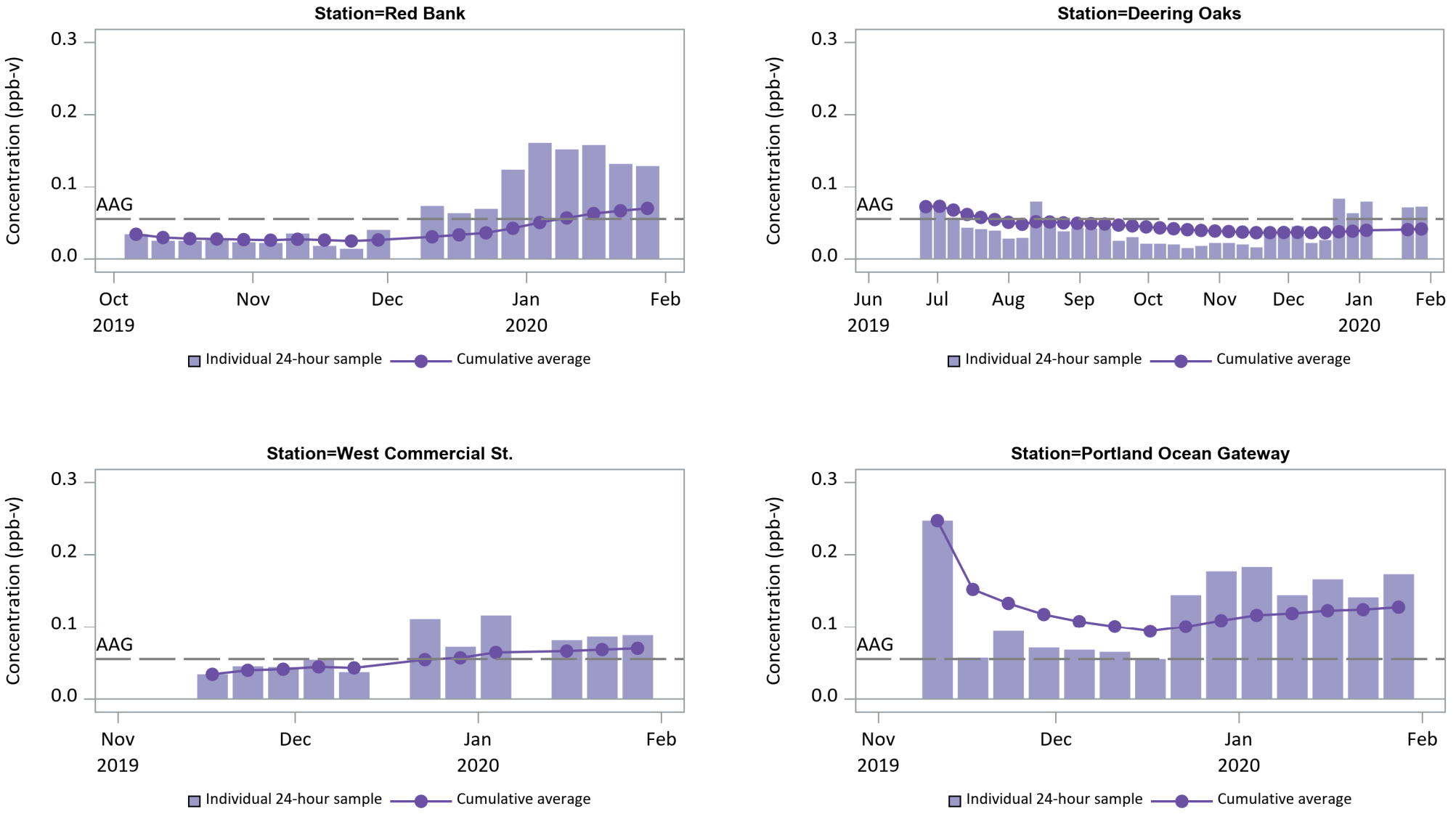


Figure 8 shows the individual 24-hour sample results by date for naphthalene displayed as bars with the cumulative average displayed as a line with markers showing the average trend over time. 24-hour air samples are collected every 6 days. AAG = State of Maine Ambient Air Guideline, which is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. Sampling data obtained from Maine DEP current through Jan. 2020.

Figure 9. Individual 24-hour sampling results with the cumulative average time trends for Benzene

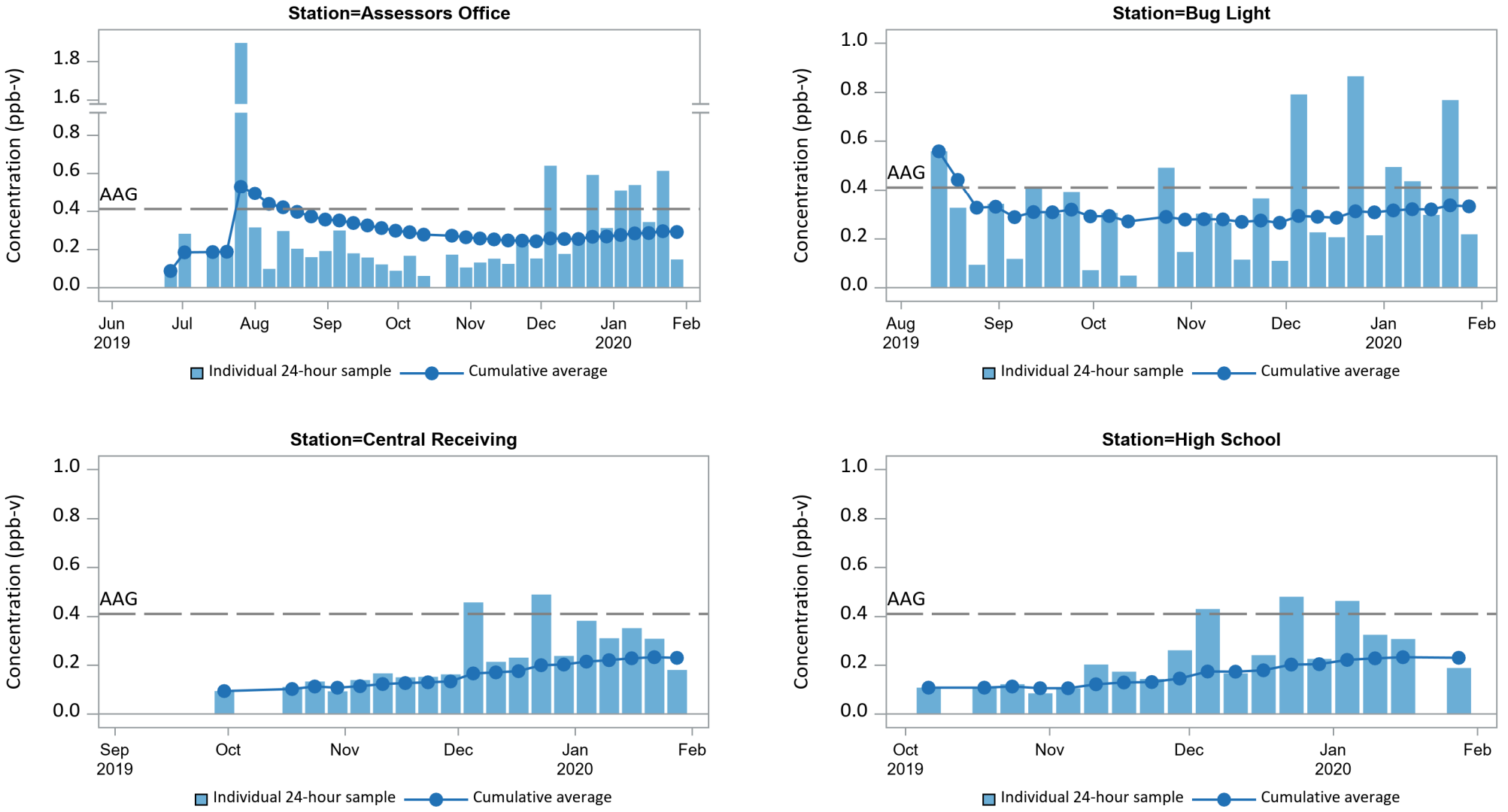


Figure 9 shows the individual 24-hour sample results by date for benzene displayed as bars with the cumulative average displayed as a line with markers showing the average trend over time. 24-hour air samples are collected every 6 days. AAG = State of Maine Ambient Air Guideline, which is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. Sampling data obtained from Maine DEP current through Jan. 2020.

Figure 9. Individual 24-hour sampling results with the cumulative average time trends for Benzene

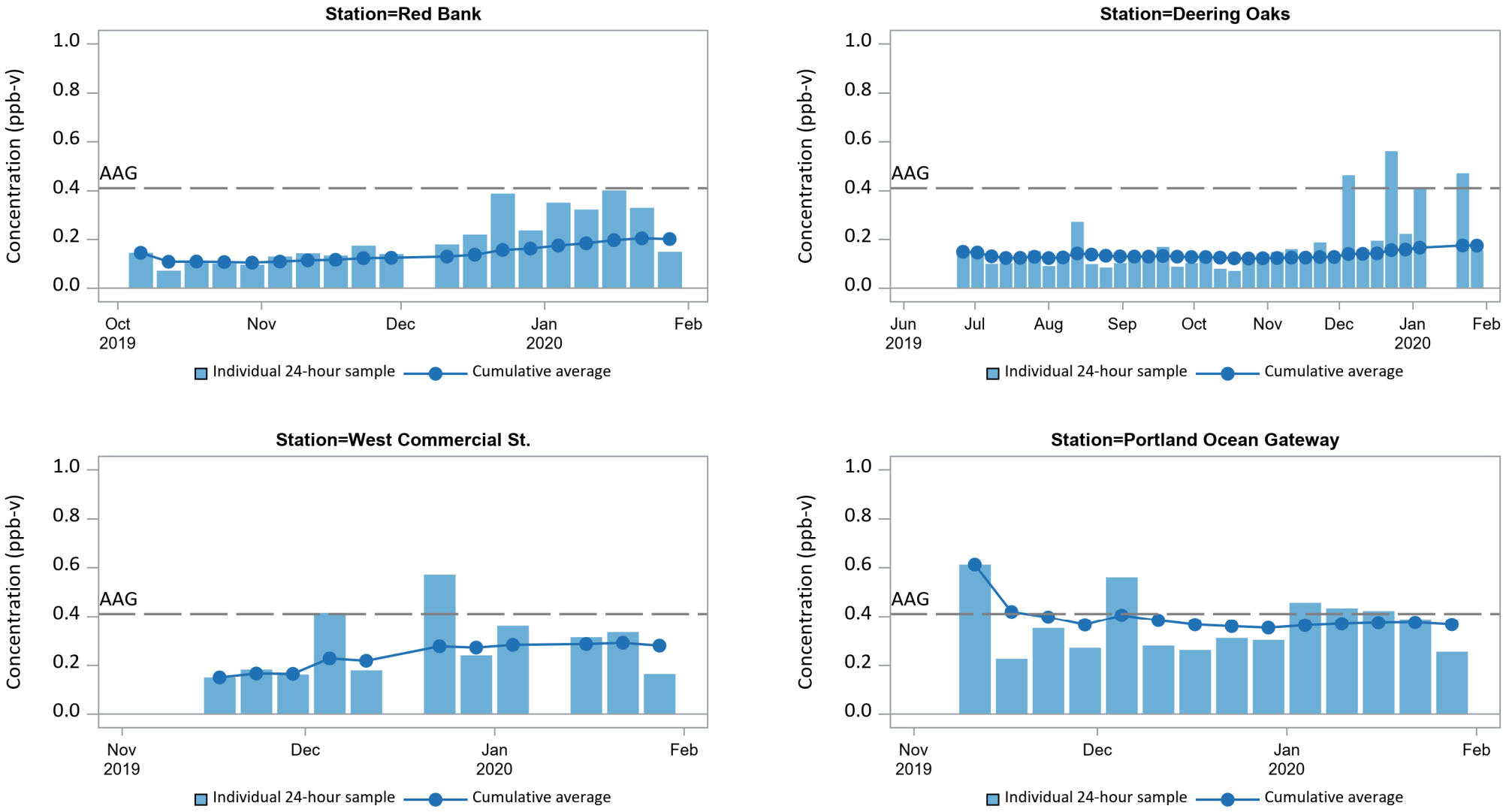


Figure 9 shows the individual 24-hour sample results by date for benzene displayed as bars with the cumulative average displayed as a line with markers showing the average trend over time. 24-hour air samples are collected every 6 days. AAG = State of Maine Ambient Air Guideline, which is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. Sampling data obtained from Maine DEP current through Jan. 2020.

Figure 10. Individual 24-hour sampling results with the cumulative average time trends for 1,3-Butadiene

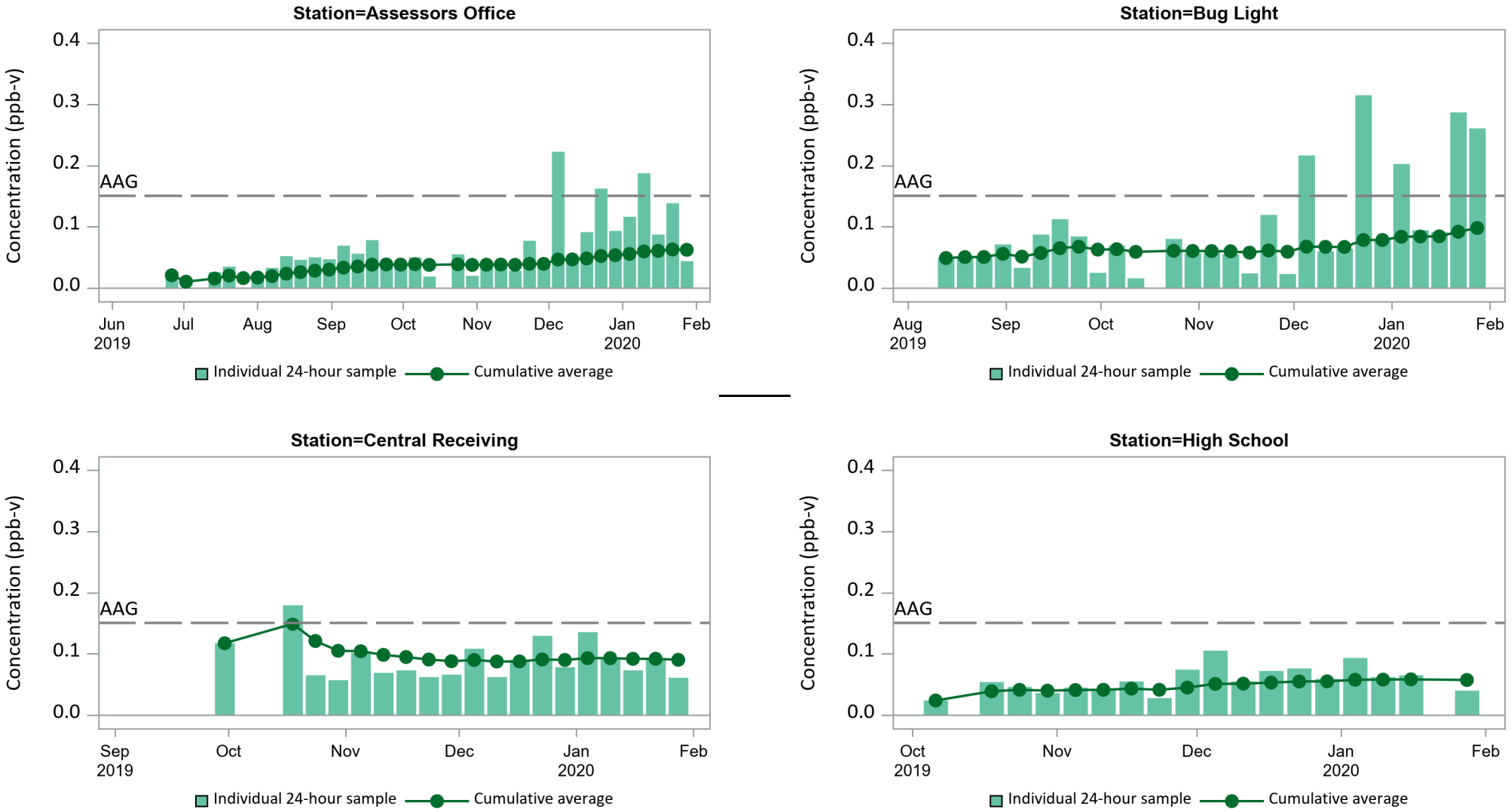


Figure 10 shows the individual 24-hour sample results by date for 1,3-butadiene displayed as bars with the cumulative average displayed as a line with markers showing the average trend over time. 24-hour air samples are collected every 6 days. AAG = State of Maine Ambient Air Guideline, which is an exposure level believed to be associated with a minimal risk of an adverse health effect from life-time exposure, even for sensitive members of the population. Sampling data obtained from Maine DEP current through Jan. 2020.

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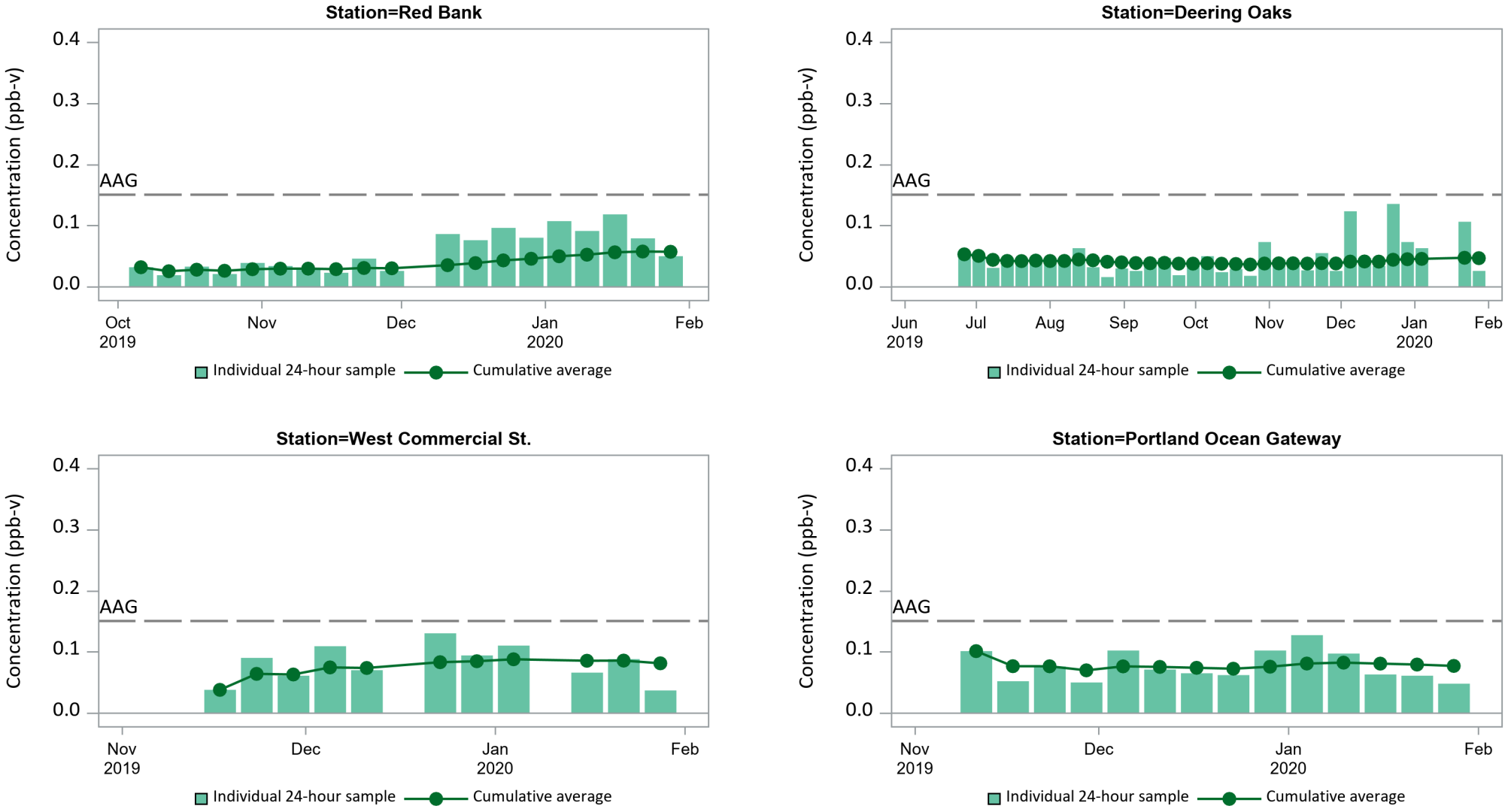

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