Annual Report of Air Quality Monitoring January 1 to December 31, 2023, at the Gregory – Portland Community Air Monitoring Stations

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Contents

Executive Summary

There are three continuous air quality monitoring stations operating in the Gregory-Portland area. The Gregory Fresnos Community Air Monitoring Station on Fresnos St. began continuous monitoring operations October 1, 2019. Two additional air-monitoring stations in Portland, TX, one near the intersection of Buddy Ganem Dr. and Wildcat Dr. on the campus of the Gregory-Portland High School and the other on Broadway Blvd. on the campus of the old East Cliff Elementary School, began operations on January 1, 2020. The U.S. Environmental Protection Agency (EPA) generally uses three years of data collection to assess attainment with the National Ambient Air Quality Standards (NAAQS). This project has now collected and validated data for more than four years at the Gregory Fresnos station and four years at the other two stations.

Since monitoring began, some measured pollutant concentrations have exceeded the concentration levels of NAAQS; however, these values have not been sustained long enough or measured frequently enough to violate a NAAQS. Furthermore, measured hydrocarbon concentrations have not exceeded the levels of concern published by the Texas Commission on Environmental Quality (TCEQ). In fact, the measured concentrations of two EPA criteria pollutants – sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) had the lowest NAAQS concentration averages in the state over the 2020 to 2022 three-year period, and average hydrocarbon concentrations are among the lowest of the Texas automated gas chromatograph monitors (auto-GCs) across the state. An assessment for the 2021 to 2023 three-year period will be conducted after all 2023 data have been validated and included in a subsequent quarterly report.

The public website developed as the community's source for information about the community air monitors continues to provide information about air quality and monitoring data from the three air monitoring stations (https://gpair.ceer.utexas.edu accessed December 2023).

UT Austin would be happy to answer any questions or conduct additional analysis at the community's or sponsors' requests. Contact Vincent Torres at vmtorres@mail.utexas.edu for information on the website or Dave Sullivan at sullivan231@mail.utexas.edu with questions about the monitoring data and analyses in this report.

1.0 Introduction

This report is jointly funded by Cheniere Energy and Gulf Coast Growth Ventures LLC (GCGV) as part of their separate Gregory-Portland community air-monitoring programs. This report includes reviews and analyses conducted by The University of Texas at Austin (UT) of the air monitoring data obtained at the three stations since their continuous monitoring operations began. UT established the Gregory Fresnos (GF) station for Cheniere Energy and has managed the station since continuous monitoring operations began on October 1, 2019. AECOM, an engineering company, established the Portland Buddy Ganem (PBG) and Portland Broadway (PBway) stations for GCGV and has managed the stations since continuous monitoring operations began on January 1, 2020. The primary emphasis in this report is the examination of data collected and validated for the period January 1 to December 31, 2023, with some comparisons to earlier data.

2.0 Summary of Activities January 1 through December 31, 2023

The data completeness acceptable minimum for regulatory monitoring of criteria air pollutants is 75 percent. These three non-regulatory air monitoring stations have generally reported quality assured data at a greater than 75% data completeness.

As was noted in recent quarterly reports, the GCGV ethane-cracking and derivatives facility has been fully operational since January 2022. Operations at the GCGV facility and the Cheniere Energy facility do not appear to have affected the level of pollutants measured at project stations.

Earlier this year the United States Environmental Protection Agency (EPA) announced a proposed decision to change their annual PM2.5 standard from its current level of 12.0 micro-grams per cubic meter (µg/m^3) to somewhere in the range of 9.0 to 10.0 µg/m^3.[1] The EPA's Air Quality Analysis Group reported on Oct. 3, 2023, that "the final rule is currently under the Office of Management and Budget (OMB) review after being received on 9/22/2023…When the final rule is signed by the EPA Administrator, it will be accompanied by a big press release and will be published in the Federal Register a few days after."[2]. Future reports and the website will provide updates once a final decision is made by the EPA. Currently, the three-year average concentrations at all three stations have been lower than the 9.0 µg/m^3 level mentioned above.

This report focuses on the data collected at the three air monitoring stations during the period January 1 through December 31, 2023, but also includes some summaries from earlier monitoring.

3.0 Air Monitoring Station Locations & Information

As noted earlier in this report, there are three air monitoring stations in the Gregory-Portland area in operation, one station operated by UT in Gregory, TX and two operated by AECOM in Portland, TX. The locations of the three stations and parameters measured are summarized in Table 1. The locations of the three stations are shown in satellite view in Figure 1[3]. Also shown in Figure 1 are the locations of the Cheniere liquefied natural gas facility and the GCGV ethane-cracking and derivatives facility.

[1] https://www.epa.gov/pm-pollution/national-ambient-air-quality-standards-naaqs-pm , accessed January 2024.

[2] Email correspondence.

[3] This image date March 2022; a more recent June 2023 image shows too many clouds blocking views of the surface.

Table 1. Gregory-Portland Community Air Monitoring Stations and Parameters Measured

Air Monitoring Station Name & Address	Volatile Organic Compounds (VOCs) compounds	Ethylene oxide (EtO) 24 hr canister every 6th day	Nitrogen Oxides (NOx, NO, & NO_2)	Sulfur Dioxide (SO_2)	Particulate Matter (PM) Mass, particles < 2.5 micron diameter	Wind Speed (WS), Wind Direction (WD), Ambient Temperature (T), Relative Humidity (RH), & Barometric Pressure (BP)
Gregory Fresnos Stephen Austin Elementary 401 Fresnos St. Gregory, TX	Yes	No	Yes	Yes	Yes	Yes
Portland Buddy Ganem 307 Buddy Ganem St. GP High School Portland, TX	Yes	Yes	No	No	Yes	Yes. + precipitation
Portland Broadway 175 Broadway Blvd. Old East Cliff Elementary School Portland, TX	Yes	Yes	No	No	Yes	Only WS, WD

Figure 1. Location of Gregory-Fresnos Community Air Monitoring Station (GF, pin G), and two Portland community stations on GPISD campuses on Buddy Ganem (PBG, pin 1) and on Broadway (PBway, pin 2) and the Cheniere Energy and GCGV industrial facilities

4.0 Summary of Measurement Data

As described in each report, the reader is reminded that pollutant concentrations are affected by several factors. One, of course, is the emission of a gas or smoke from an emission source or the availability of dust to become airborne. Another is the weather. Regarding weather, rain can reduce concentrations of several pollutants, especially particulate matter. The "mixing height" is the lower level of the atmosphere wherein gases and particles mix vertically. Temperature inversions such as those experienced at night have low mixing heights and can lead to air pollutants emitted near the surface being trapped at lower altitudes, thus allowing concentrations to increase. The converse is midday periods when the mixing height of the lower atmosphere rises, and air pollutants are diluted in a larger volume of air. The wind plays a significant role in moving air pollutants from an emission source to other locations. For this reason, a large majority of air monitoring stations operated by the TCEQ and all three Gregory-Portland stations measure wind speed and wind direction. Under high wind speeds, many gas pollutants are dispersed and diluted; however, under high-speed winds, dust on the surface can be picked up and transported, leading to higher particulate concentrations. Higher speed winds passing over the roof of a storage tank can lower the atmospheric pressure on that roof, leading to vapors being drawn out of the tank and into the air. However, in general, low speed winds often lead to higher concentrations of pollutants. Figure 2 shows how higher concentrations of NO_2 and propane at the GF station are associated with low-speed winds, with lower concentrations under higher speed winds. Winds can be thought of as being local – near the surface – and regional – at higher altitudes. The local wind direction affects pollutant concentrations in terms of whether a pollution source is in the upwind direction, or along the local upwind path of the air if wind directions are changing. Similarly, but on a larger scale, the regional wind direction affects pollutant concentrations in terms of whether or not a source such as another major city, a large power plant, a forest fire, etc., is along the regional upwind path of the air. In the graphs that follow, some short-term concentration measurements are significantly higher than the balance of the data. In some cases, this is likely the combination of emission and meteorological (Met) factors, and in other cases, normal emissions can result in unusually high concentrations owing to a source being nearby under low wind speeds or air stagnation.

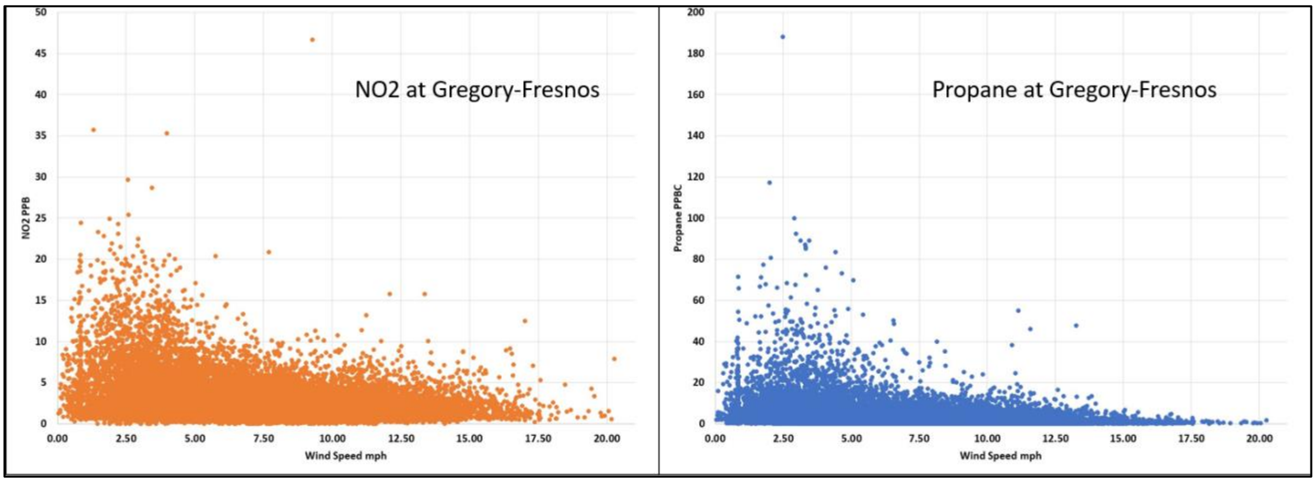

Figure 2. Effect of wind speed on primary pollutants

Please note that the measurement data in this report are quality assured station data made available at different submission frequencies:

- NOx, NO, & NO_2, SO_2, PM2.5 & Met measurements – weekly;
- Auto-GC VOC measurements – generally within 60 days of the measurement; and
- EtO canister data – generally within 60 days of the date the sample was collected.

Although all these measurements, except EtO, are made in near-real time, the nature of the complexity in quality assuring the auto-GC target hydrocarbons among the thousands of different organic compounds that exist in the air leads to a lengthy delay in releasing the quality assured target species data. Air samples for EtO data are collected at the station and then sent to a laboratory where EtO concentrations are then derived upon analysis of the air samples. Hence, the data available at the time this report was written will not all have the same date ranges. For this report, auto-GC and EtO data are available through October 31, 2023, and all other data were available through December 31, 2023.

4.1 Gregory Fresnos Station Hydrocarbon Data

Figure 3 shows the time series graph for hourly concentrations of benzene at the Gregory-Fresnos (GF) station in 2023. The graph shows benzene hourly average concentrations for each hour from January 1, 2023, through October 31, 2023 (10 months). The date and concentration of the highest value in the graph is shown in the graph. Concentrations later in the year tended to be higher owing to work being done on the nearby school building. Benzene concentrations in the air can be of health concern but to date their concentrations have been much lower than TCEQ Air Monitoring Comparison Values (AMCV) of 1,080 ppbC for a single one-hour value or 8.4 ppbC for an annual hourly average concentration. Other AMCVs for auto-GC hydrocarbons can be found at https://www.tceq.texas.gov/cgi-bin/compliance/monops/agc_amcvs.pl (accessed January 2024). Note that a straight line or a gap in a time series graph represents missing data. Data may be missing owing to equipment failure, planned equipment or site maintenance, or external factors such as power loss or severe weather.

Table 2 lists all target hydrocarbon species measured and reported by the GF auto-GC, with the peak one-hour concentration, maximum 24-hour day concentration, and the January through October 2023 average hourly concentration for each species. Note that the total sum of the target species (TNMTC) and the total sum of the hydrocarbons (target species plus non-target species and unknown species) (TNMHC) are included in the table. In addition, the TCEQ's Air Monitoring Comparison Values (AMCV) are shown in the table. From the TCEQ's Air Monitoring Comparison Values website[4]:

> "AMCVs are used to evaluate the potential for effects to occur as a result of exposure to concentrations of constituents in the air. AMCVs are based on data concerning health effects, odor, and vegetation effects. They are not ambient air standards. If predicted or measured airborne levels of a constituent do not exceed the comparison level, adverse health or welfare effects would not be expected to result. If ambient levels of constituents in air exceed the comparison levels, it does not necessarily indicate a problem, but rather, triggers a more in-depth review. If you have any questions about the potential for health, odor, or vegetation effects from exposure to reported concentrations of any of these compounds, please contact the Toxicology Division by telephone at (512) 239-3900 or by email at tox@tceq.texas.gov."

Data completeness for auto-GCs is based on the planned collection of 22 hours per day – as two hours per day are reserved for quality assurance activities. The GF station has collected data on the individual hydrocarbon compounds with 93 to 95 percent data completeness of the planned collection hours for the first 10 months of 2023.

Time series graphs of other hydrocarbon species are also available upon request and any graphs can be made with timescale (x-axis) or concentration-scale (y-axis) adjustments. Also, concentrations can be averaged by day, month, or other time period upon request. A user can also make graphs of data on the project website at https://gpair.ceer.utexas.edu/custom-data-request.php (accessed January 2024). To make a request, contact Dr. Dave Sullivan at sullivan231@mail.utexas.edu or 512-471-7805.

[4] https://www.tceq.texas.gov/cgi-bin/compliance/monops/agc_amcvs.pl accessed January 2024.

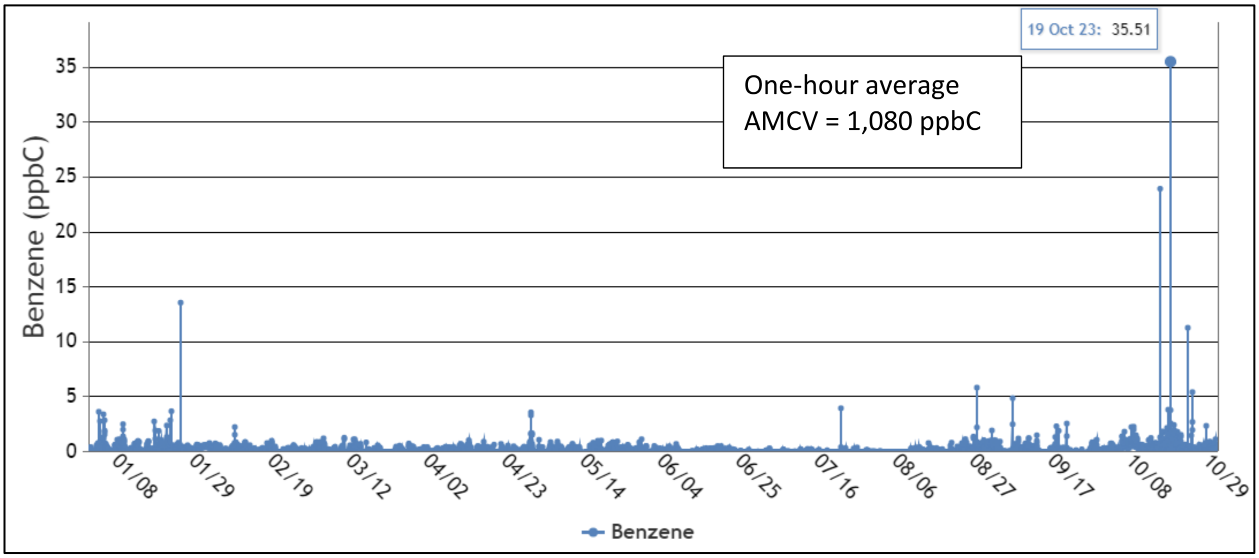

Figure 3. Hourly benzene concentrations at GF station, Jan. 1, 2023 – Oct. 31, 2023, ppbC units

Table 2. Gregory-Fresnos Auto-GC statistics for Jan. – Oct. 2023

Species	Num. Samples	Peak 1-hr ppbC	Peak 24-hr ppbC	Short-term AMCV	Mean ppbC	Long-term AMCV
TNMHC	6,344	2,213.97	197.88	N/A	37.201	N/A
TNMTC	6,344	2,079.18	188.84	N/A	34.080	N/A
Ethane	6,345	561.6	54.88	N/A	9.178	N/A
Ethylene	6,345	78.54	5.09	1,000,000	0.650	10,600
Propane	6,345	431.64	45.93	N/A	7.246	N/A
Propylene	6,345	23.77	6.50	N/A	0.619	N/A
Isobutane	6,345	151	18.05	132,000	2.370	40,000
n-Butane	6,345	228.33	24.11	368,000	4.448	40,000
Acetylene	6,253	11.62	1.31	50,000	0.358	5,000
trans-2-Butene	6,345	0.85	0.16	60,000	0.048	2,800
1-Butene	6,345	6.75	1.39	108,000	0.182	9,200
cis-2-Butene	6,345	6.35	0.60	60,000	0.026	2,800
Cyclopentane	6,345	10.2	0.77	29,500	0.128	2,950
Isopentane	6,345	151.47	13.10	340,000	2.348	40,500
n-Pentane	6,345	132.78	10.82	340,000	2.104	40,500
1,3-Butadiene	6,345	23.31	1.79	6,800	0.051	36
trans-2-Pentene	6,345	2.83	0.20	60,000	0.020	2,800
1-Pentene	6,345	1.92	0.22	60,000	0.038	2,800
cis-2-Pentene	6,345	1.39	0.14	60,000	0.010	2,800
2,2-Dimethylbutane	6,345	13.26	0.76	32,400	0.106	1,140
Isoprene	6,345	2.5	0.42	7,000	0.114	700
n-Hexane	6,345	65.59	4.25	32,400	0.590	1,140
Methylcyclopentane	6,345	28.57	1.83	4,500	0.277	450
2,4-Dimethylpentane	6,345	7.13	0.38	58,100	0.023	15,400
Benzene	6,345	35.51	2.35	1,080	0.170	8.4
Cyclohexane	6,345	48.66	2.63	6,000	0.276	600
2-Methylhexane	6,345	14.68	0.71	58,100	0.056	15,400
2,3-Dimethylpentane	6,345	7.45	0.34	58,100	0.017	15,400
3-Methylhexane	6,345	15.72	0.85	58,100	0.098	15,400
2,2,4-Trimethylpentane	6,345	15.26	1.22	32,800	0.137	3,040
n-Heptane	6,345	31.54	1.73	58,100	0.168	15,400
Methylcyclohexane	6,345	45.59	2.54	28,000	0.333	2,800
2,3,4-Trimethylpentane	6,345	3.88	0.29	32,800	0.016	3,040
Toluene	6,345	119.04	7.64	28,000	0.329	7,700
2-Methylheptane	6,345	7.08	0.51	32,800	0.045	3,040
3-Methylheptane	6,345	4.13	0.32	32,800	0.032	3,040
n-Octane	6,345	12.42	0.83	32,800	0.106	3,040
Ethyl Benzene	6,345	2.87	0.28	160,000	0.036	3,520
p-Xylene + m-Xylene	6,345	11.48	1.42	13,600	0.236	1,120
Styrene	6,345	0.74	0.58	41,600	0.016	880
o-Xylene	6,345	4.43	0.38	13,600	0.048	1,120
n-Nonane	6,345	4.57	0.35	27,000	0.046	2,520
Isopropyl Benzene -	6,345	1.28	0.25	4,590	0.004	459
n-Propylbenzene	6,345	1.00	0.19	4,590	0.013	459
1,3,5-Trimethylbenzene	6,345	1.78	0.16	27,000	0.012	333
1,2,4-Trimethylbenzene	6,344	4.25	0.56	27,000	0.200	333
n-Decane	6,345	3.16	0.49	10,000	0.091	1,900
1,2,3-Trimethylbenzene	6,345	3.89	0.58	27,000	0.042	333

4.2 Portland Buddy Ganem & Portland Broadway Stations Hydrocarbon Data

Figure 4 shows the time series graph for hourly concentrations of benzene at the Portland Buddy Ganem (PBG) station, and Figure 5 shows the time series graph for the hourly concentrations of benzene at the Portland Broadway (PBway) station. Both graphs show benzene hourly average concentrations for each hour from January 1, 2023, through October 31, 2023. The 49.3 ppbC concentration at the PBG station on April 29, 2023, is the highest benzene concentration measured at the three stations in San Patricio County to date. It was measured at 11 p.m. CST with the wind direction changing from west through south to southeast under very light and variable wind conditions.

As was the case at the Gregory Fresnos station, hydrocarbon concentrations to date are much lower than the TCEQ AMCVs. Table 3 lists the target hydrocarbon species measured and reported by the Portland Buddy Ganem (PBG) auto-GC and Table 4 lists the target hydrocarbon species measured and reported by the Portland Broadway (PBway) auto-GC with the peak one-hour concentration, maximum 24-hour day concentration, and average hourly concentration for each species for January through October 2023. Also shown in the two tables are the TCEQ's AMCVs.

Based on the 22 hours per day planned ambient measurements, the PBG station has collected data with a 90 to 94 percent data completeness based on planned collection hours for the first ten months of 2023, except for data completeness for 1,2,3-Trimethylbenzene, which had not been in the reported Portland stations' data sets until February 2023 but is 76 percent for January through October 2023. The PBway station has between 87 and 92 percent data completeness of the planned collection hours over the first ten months of 2023, except for a lower 44 percent data completeness for Acetylene, which has only been reported off and on during 2023, data completeness for 1,2,3-Trimethylbenzene, which is 81 percent for January through October 2023, and data completeness for Cis-2-pentene at 74 percent, which was not reported in the data stream at PBway from August 13 until October 11.

Time series graphs of other hydrocarbon species are also available upon request, and any graphs can be made with timescale (x-axis) or concentration-scale (y-axis) adjustments. In addition, concentrations can be averaged by day, week, or month upon request. As mentioned earlier in the report, a user can also make graphs on the project website.

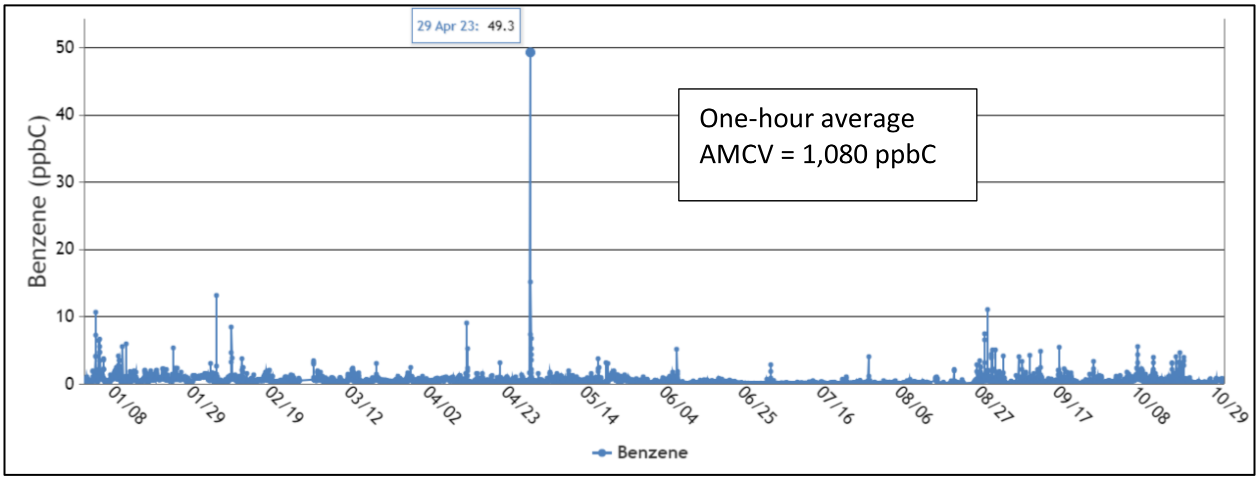

Figure 4. Hourly benzene concentrations at PBG station, Jan. 1, 2023 – Oct. 31, 2023, ppbC units

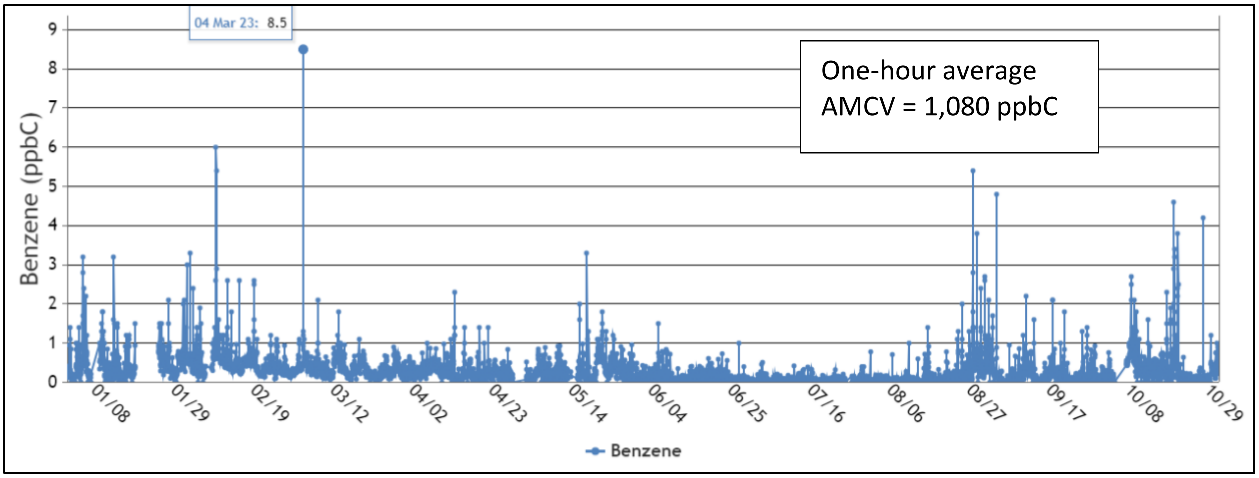

Figure 5. Hourly benzene concentrations at PBway station, Jan. 1, 2023 – Oct. 31, 2023, ppbC units

Table 3. PBG Auto-GC statistics for Jan. – Oct. 2023

Species	Num. Samples	Peak 1-hr ppbC	Peak 24-hr ppbC	Short-term AMCV	Mean ppbC	Long-term AMCV
TNMHC	6,313	5,135.2	342.39	N/A	45.550	N/A
TNMTC	6,313	4,905.5	326.77	N/A	42.146	N/A
Ethane	6,313	1,063.0	70.42	N/A	11.787	N/A
Ethylene	6,307	88.8	5.04	1,000,000	0.866	10,600
Propane	6,313	1,327.0	88.76	N/A	8.644	N/A
Propylene	6,313	50.7	3.62	N/A	0.640	N/A
Isobutane	6,313	624.0	39.86	132,000	2.928	40,000
n-Butane	6,313	740.0	48.76	368,000	5.066	40,000
Acetylene	6,021	11.1	1.84	50,000	0.324	5,000
trans-2-Butene	6,312	1.7	0.53	60,000	0.083	2,800
1-Butene	6,307	6.2	0.60	108,000	0.301	9,200
cis-2-Butene	6,313	4.3	0.26	60,000	0.049	2,800
Cyclopentane	6,313	17.7	0.99	29,500	0.149	2,950
Isopentane	6,313	410.0	26.23	340,000	2.705	40,500
n-Pentane	6,313	275.0	18.29	340,000	2.154	40,500
1,3-Butadiene	6,304	7.4	0.38	6,800	0.071	36
trans-2-Pentene	6,042	2.6	0.15	60,000	0.016	2,800
1-Pentene	6,042	1.2	0.20	60,000	0.042	2,800
cis-2-Pentene	6,035	0.9	0.06	60,000	0.005	2,800
2,2-Dimethylbutane	6,042	27.3	1.58	32,400	0.074	1,140
Isoprene	6,042	2.7	0.97	7,000	0.234	700
n-Hexane	6,313	132.0	7.07	32,400	0.599	1,140
Methylcyclopentane	6,313	56.8	2.94	4,500	0.233	450
2,4-Dimethylpentane	6,313	16.8	0.84	58,100	0.007	15,400
Benzene	6,313	49.3	2.86	1,080	0.518	8.4
Cyclohexane	6,313	106.0	5.56	6,000	0.433	600
2-Methylhexane	6,313	35.2	1.92	58,100	0.169	15,400
2,3-Dimethylpentane	6,313	17.5	0.91	58,100	0.063	15,400
3-Methylhexane	6,313	43.0	2.37	58,100	0.224	15,400
2,2,4-Trimethylpentane	6,313	19.4	1.26	32,800	0.282	3,040
n-Heptane	6,313	76.5	4.19	58,100	0.377	15,400
Methylcyclohexane	6,313	131.0	6.91	28,000	0.563	2,800
2,3,4-Trimethylpentane	6,313	3.3	0.25	32,800	0.043	3,040
Toluene	6,313	82.2	4.90	28,000	0.796	7,700
2-Methylheptane	6,313	14.3	0.80	32,800	0.096	3,040
3-Methylheptane	6,313	10.0	0.63	32,800	0.071	3,040
n-Octane	6,313	30.1	1.71	32,800	0.216	3,040
Ethyl Benzene	6,313	6.4	0.53	160,000	0.100	3,520
p-Xylene + m-Xylene	6,313	21.1	1.50	13,600	0.319	1,120
Styrene	6,270	0.7	0.37	41,600	0.061	880
o-Xylene	6,271	9.5	0.53	13,600	0.089	1,120
n-Nonane	6,271	7.8	0.65	27,000	0.101	2,520
Isopropyl Benzene -	6,271	2.9	0.33	4,590	0.016	459
n-Propylbenzene	6,269	10.9	0.59	4,590	0.029	459
1,3,5-Trimethylbenzene	6,271	23.3	1.31	27,000	0.034	333
1,2,4-Trimethylbenzene	6,313	41.9	2.36	27,000	0.169	333
n-Decane	6,313	12.9	0.97	10,000	0.302	1,900
1,2,3-Trimethylbenzene	5,080	13.5	0.75	27,000	0.070	333

Table 4. PBway Auto-GC statistics for Jan. – Oct. 2023

Species	Num. Samples	Peak 1-hr ppbC	Peak 24-hr ppbC	Short-term AMCV	Mean ppbC	Long-term AMCV
TNMHC	6,025	1,473.5	180.45	N/A	37.460	N/A
TNMTC	6,025	1,419.2	173.42	N/A	34.497	N/A
Ethane	5,926	172.0	50.00	N/A	10.454	N/A
Ethylene	5,924	16.7	3.62	1,000,000	0.755	10,600
Propane	6,173	377.0	39.68	N/A	7.086	N/A
Propylene	6,173	19.6	3.25	N/A	0.858	N/A
Isobutane	6,173	129.0	14.09	132,000	2.493	40,000
n-Butane	6,173	352.0	28.70	368,000	4.643	40,000
Acetylene	2,932	5.7	1.10	50,000	0.327	5,000
trans-2-Butene	6,161	67.3	5.10	60,000	0.235	2,800
1-Butene	6,173	3.2	0.96	108,000	0.242	9,200
cis-2-Butene	6,173	2.7	0.43	60,000	0.068	2,800
Cyclopentane	6,173	7.9	0.91	29,500	0.216	2,950
Isopentane	6,173	124.0	15.91	340,000	2.438	40,500
n-Pentane	6,173	135.0	9.02	340,000	1.908	40,500
1,3-Butadiene	6,173	8.5	0.50	6,800	0.062	36
trans-2-Pentene	6,172	3.7	0.50	60,000	0.024	2,800
1-Pentene	6,173	2.4	0.37	60,000	0.059	2,800
cis-2-Pentene	4,969	1.5	0.19	60,000	0.008	2,800
2,2-Dimethylbutane	6,093	3.5	0.58	32,400	0.088	1,140
Isoprene	6,165	5.1	1.54	7,000	0.487	700
n-Hexane	6,025	44.2	3.02	32,400	0.434	1,140
Methylcyclopentane	6,025	20.0	1.65	4,500	0.185	450
2,4-Dimethylpentane	6,025	1.9	0.34	58,100	0.004	15,400
Benzene	6,025	8.5	1.59	1,080	0.277	8.4
Cyclohexane	6,025	23.7	2.11	6,000	0.262	600
2-Methylhexane	6,025	4.0	1.08	58,100	0.056	15,400
2,3-Dimethylpentane	6,025	2.8	0.45	58,100	0.026	15,400
3-Methylhexane	6,025	4.8	1.02	58,100	0.083	15,400
2,2,4-Trimethylpentane	6,025	12.0	1.65	32,800	0.152	3,040
n-Heptane	6,025	13.3	1.29	58,100	0.136	15,400
Methylcyclohexane	6,025	23.5	2.27	28,000	0.287	2,800
2,3,4-Trimethylpentane	6,025	3.8	0.32	32,800	0.028	3,040
Toluene	6,022	15.6	2.72	28,000	0.473	7,700
2-Methylheptane	6,025	2.8	0.40	32,800	0.038	3,040
3-Methylheptane	6,025	1.9	0.26	32,800	0.023	3,040
n-Octane	6,025	5.7	0.80	32,800	0.080	3,040
Ethyl Benzene	6,025	5.7	0.43	160,000	0.024	3,520
p-Xylene + m-Xylene	6,025	20.0	1.76	13,600	0.210	1,120
Styrene	6,025	0.5	0.28	41,600	0.008	880
o-Xylene	6,025	4.0	0.53	13,600	0.029	1,120
n-Nonane	6,024	2.5	0.35	27,000	0.030	2,520
Isopropyl Benzene -	6,024	2.4	0.13	4,590	0.009	459
n-Propylbenzene	6,025	9.5	0.49	4,590	0.008	459
1,3,5-Trimethylbenzene	5,992	13.3	0.69	27,000	0.010	333
1,2,4-Trimethylbenzene	5,828	28.4	1.75	27,000	0.254	333
n-Decane	5,951	3.3	0.29	10,000	0.054	1,900
1,2,3-Trimethylbenzene	5,398	3.1	0.91	27,000	0.043	333

4.3 Ethylene Oxide Measurements

As was noted earlier in this report, the GCGV ethane-cracking and derivatives facility began operating in late 2021 through early 2022. As shown in Figure 6 through Figure 9, the levels of EtO measured at the two GCGV stations have remained low, with no discernable trends. Note that values of 0.0 ppbC were recorded from the laboratory as non-detects. The TCEQ effects screening level (ESL) and Air Monitoring Comparative Value (AMCV) for chronic exposure to EtO is 2.4 ppbV or 4.8 ppbC. The terms AMCV and ESL are defined in Appendix A.2. (https://www.tceq.texas.gov/downloads/toxicology/dsd/final/eto.pdf, accessed January 2024). It is notable that there has been no change in concentrations over the past two years while the GCGV industrial facility has been in operation. In fact, there has been an increased frequency of non-detects over time.

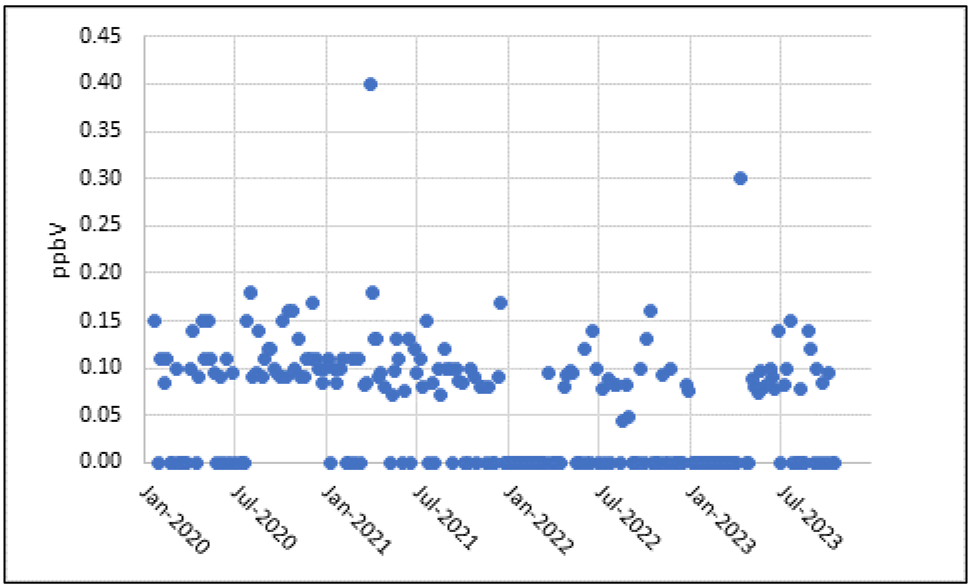

Figure 6. PBG EtO concentrations, every 6th day samples Jan. 2020 through Oct. 2023

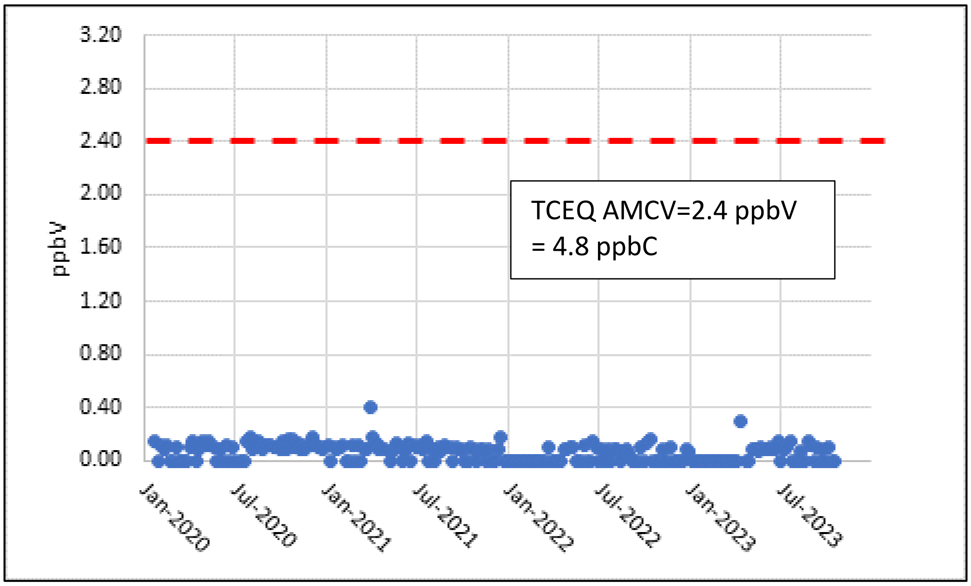

Figure 7. PBG EtO concentrations, every 6th day samples Jan. 2020 through Oct. 2023 in comparison to TCEQ Air Monitoring Comparative Value

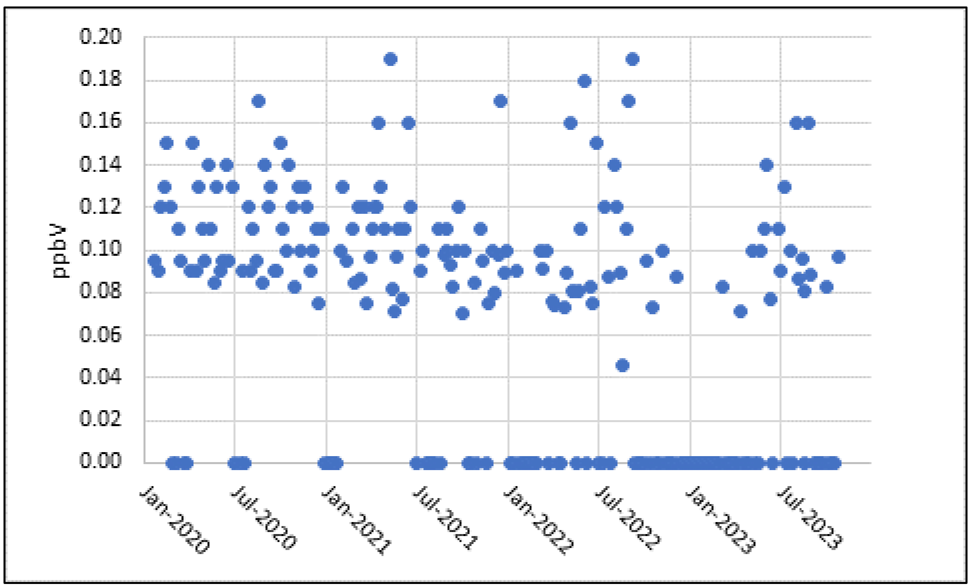

Figure 8. PBway EtO concentrations, every 6th day samples Jan. 2020 through Oct. 2023

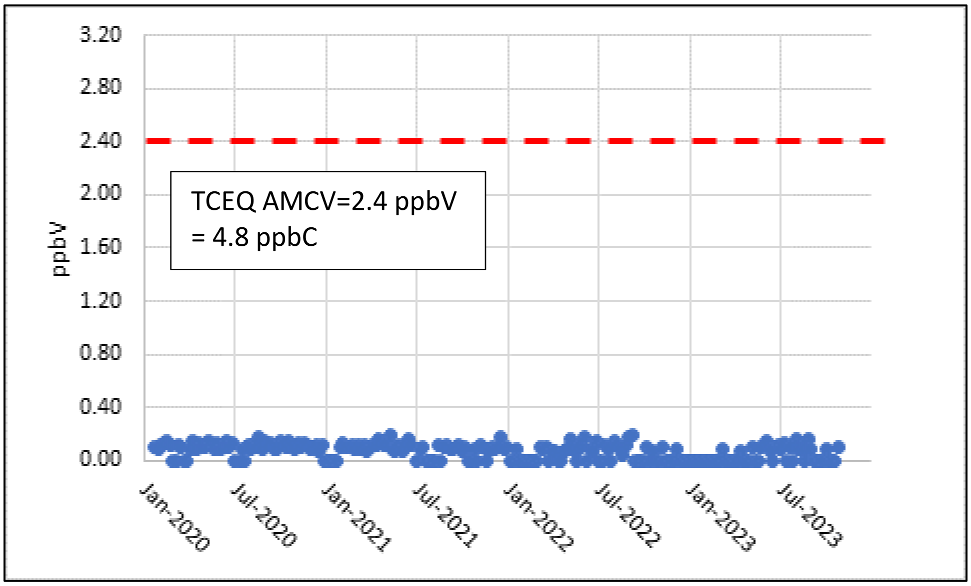

Figure 9. PBway EtO concentrations, every 6th day samples Jan. 2020 through Oct. 2023 in comparison to TCEQ Air Monitoring Comparative Value

4.4 Comparing Hydrocarbon Data between Stations

Figure 10 shows a bar graph comparison between the average concentrations for the first ten months of 2023 of the hydrocarbons measured by auto-GC, including TNMTC and TNMHC, at the three stations. The graph shows relatively close correlation among the three stations, although the Portland Buddy Ganem (PBG) is trending higher than the other two stations. A close examination of PBG benzene concentrations compared to the other two stations was presented in the October 2023 Quarterly Report, and it was shown that wind speed had a big effect on the concentrations, and adjusting for it made the difference between PBG and the other stations smaller.

Figure 11 is a similar graph excluding TNMTC and TNMHC. This second graph allows for a better comparison of the similarity among the stations. The most common nonmethane hydrocarbons in the atmosphere in urban areas are ethane and propane, followed by other alkane species such as butanes and pentanes. These species have low chemical reactivities and thus can persist in the air longer than more reactive species. Some ethane and propane are likely transported into the region from nearby oil and gas extraction fields.

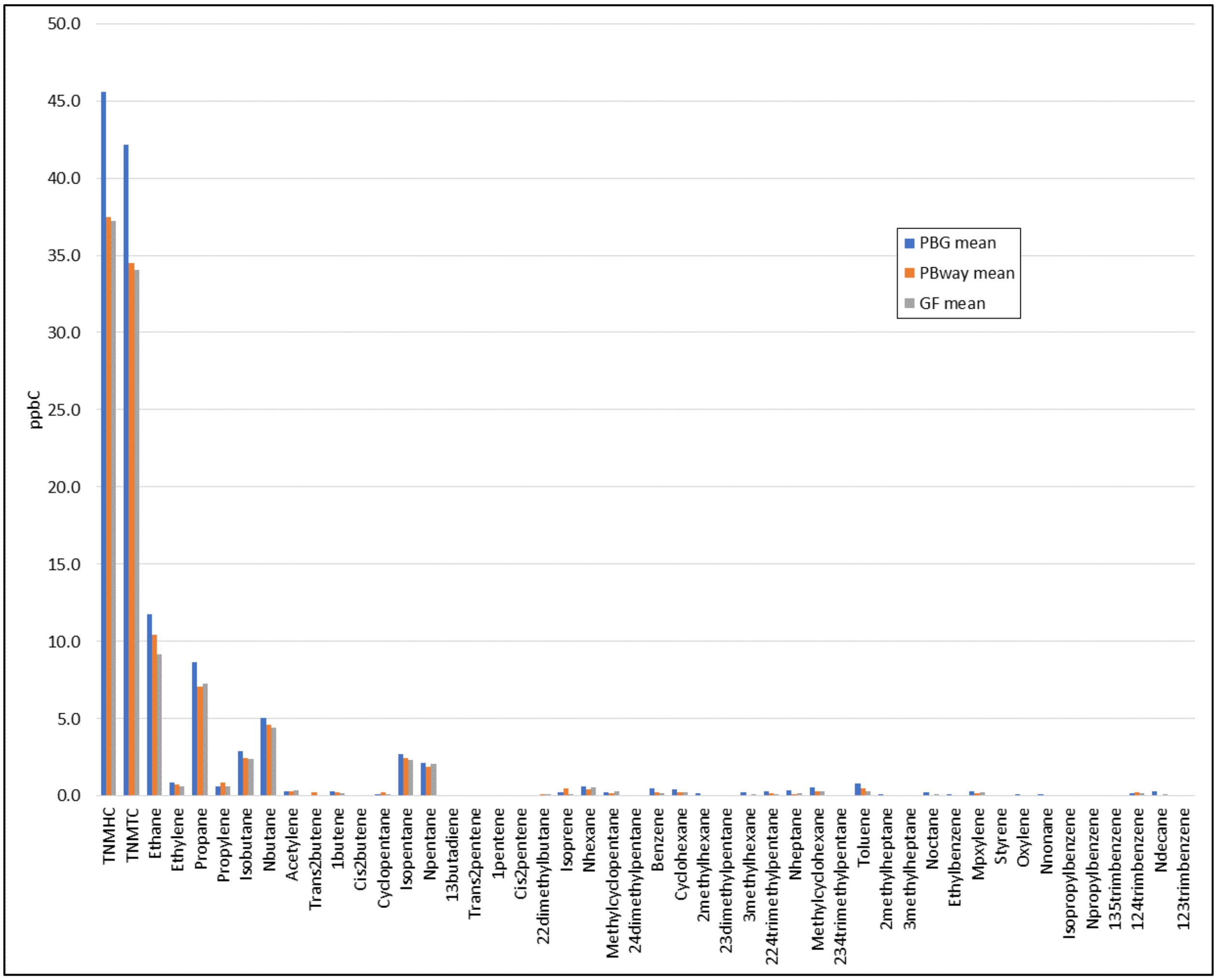

Figure 10. January through October 2023 mean concentrations of TNMTC, TNMHC, and hydrocarbon species at three stations.

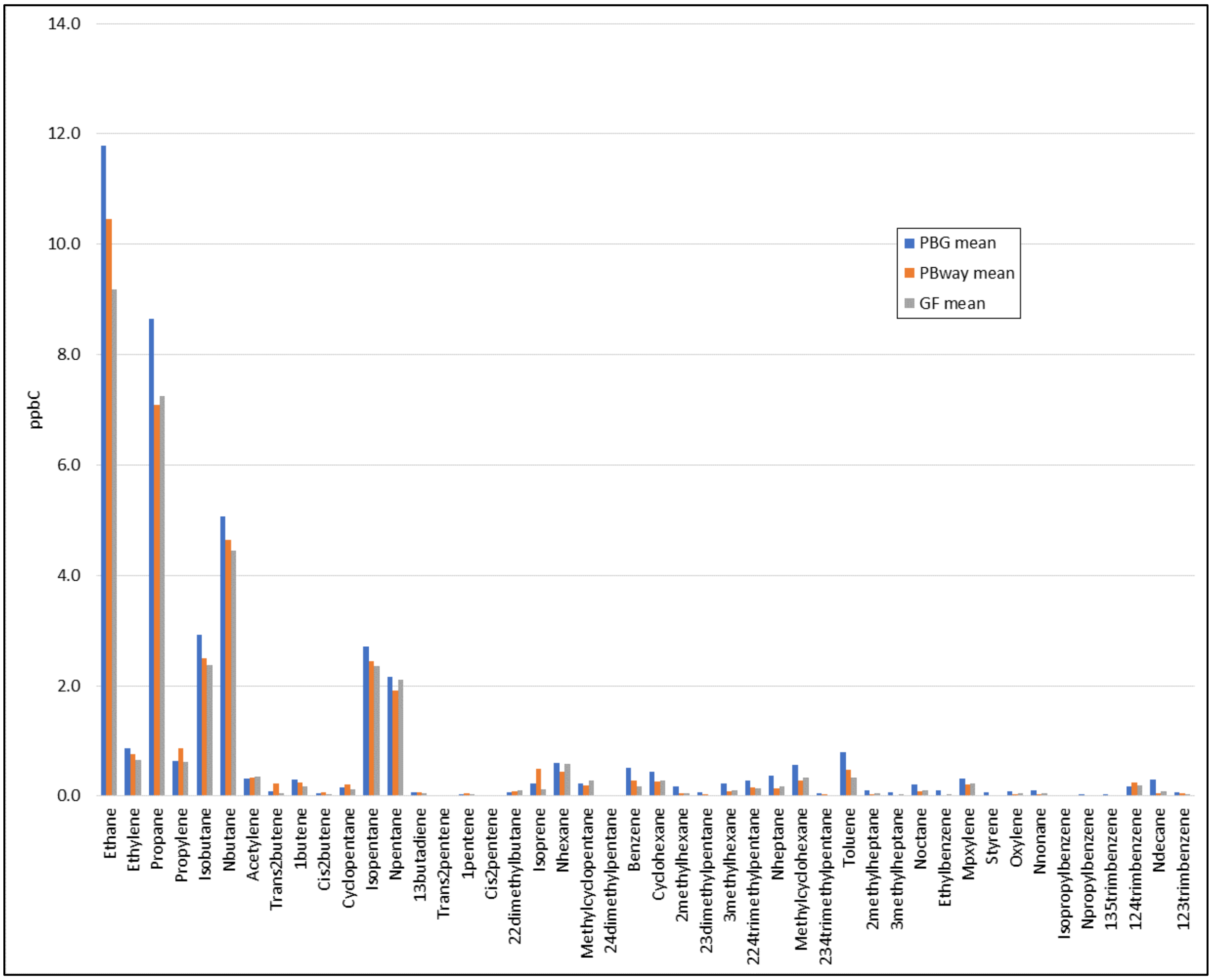

Figure 11. January through October 2023 mean concentrations of hydrocarbon species at three air monitoring stations.

4.5 Gregory Fresnos Station Criteria Pollutant Data

Sulfur dioxide (SO_2), fine particulate matter (PM2.5), and nitrogen dioxide (NO_2) are three pollutants measured at the GF site that are regulated by the U.S. Environmental Protection Agency (EPA). These pollutants, along with ozone, lead, combined coarse and fine particulate matter (PM10), and carbon monoxide are referred to as "criteria pollutants" and are governed by National Ambient Air Quality Standards (NAAQS). Some NAAQS are based on annual average concentrations, and some are based on the frequency with which very high concentrations are measured. The rationale is that different pollutants affect human health in different ways.

- PM2.5 has both an annual average NAAQS and 24-hour NAAQS. For the PM2.5 24-hour NAAQS, the three-year average of the 98th percentile 24-hour (midnight to midnight, using standard time) concentration each year must be less than 35 micrograms per cubic meter ($\mu g/m^3$). The annual average, averaged over three years, is calculated by first averaging 24-hour averages by quarter and then averaging the four quarters, must be less than 12 $\mu g/m^3$.
- The NAAQS for NO_2 is for the one-hour values to average less than 53 ppb in a calendar year averaged over three years and for the three-year average of the 98th percentile daily maximum values to be less than 100 ppb.

- SO_2 has a 1-hour NAAQS, based on ranking the daily maximum one-hour values for each day in a year, selecting the 99th percentile daily maximum values, and then calculating a three-year average, which must be less than 75 ppb.

No concentrations at levels that violate the NAAQS have been seen at the GF station. Several recorded PM2.5 one-hour values exceeded the level of the 24-hour NAAQS, 35 μg/m^3, but as noted above, the NAAQS is not violated unless the 98th percentile of 24-hour averaged concentrations in a year, averaged over three years violates the 24-hour NAAQS, or unless the overall annual average, averaged over three years, exceeds the level of the annual NAAQS (12 μg/m^3).

Figure 12 shows the 24-hour averaged daily PM2.5 concentrations since the start of monitoring in October 2019. This graph is provided to illustrate the roughly seasonal pattern of PM2.5, with higher concentrations in the summers associated with transported dust from Northern Africa. The average concentration for 2023 was 8.4 μg/m^3. Table 5 lists the annual mean PM2.5 concentration from each of the past four years and the most recent three-year average for the GF station. No 24-hour averages in 2023 at Gregory Fresnos have exceeded the level of the 24-hour NAAQS.

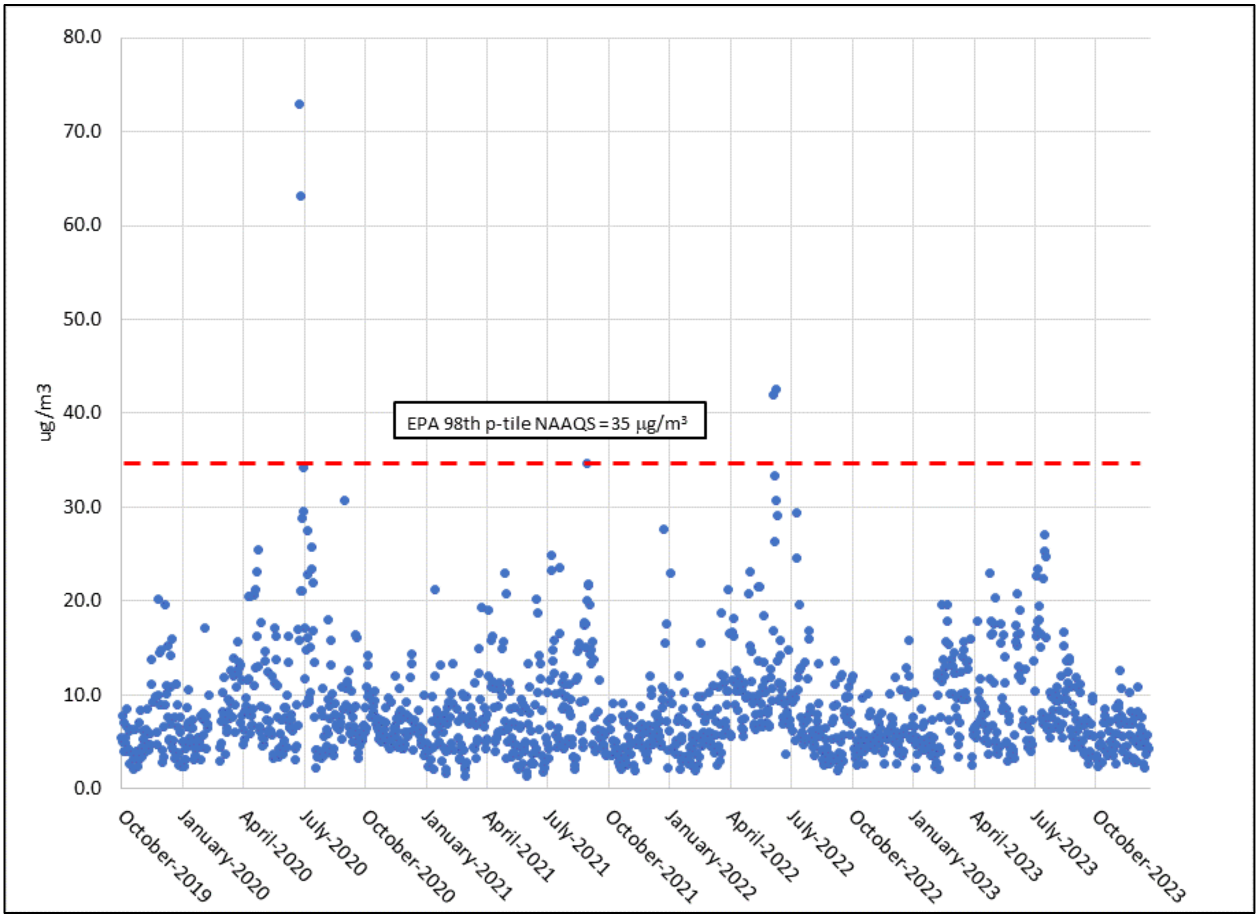

Figure 12. Averaged 24-Hour PM2.5 at GF, Oct. 1, 2019 – Dec. 31, 2023, with NAAQS

Table 5. GF PM2.5 annual means and three-year averages showing NAAQS compliance.

Year	Annual Mean μg/m^3	NAAQS 3-Year Annual Average Value, μg/m^3	Annual 98th Percentile Value μg/m^3	NAAQS 3-Year 98th Percentile Average Value, μg/m^3
2020	8.9		27.4	
2021	7.6		21.7	
2022	8.1		24.3	
2023	8.4		20.9	
2021-2023 3-year average	8.0	12.0	22.3	35.0

Figure 13 shows the hourly average time series graph for daily maximum NO_2 at the Gregory Fresnos station from October 1, 2019, through September 30, 2023. The figure also shows the 24-hour 100 ppb NAAQS level. The figure shows measured concentrations have been well below the level of the NAAQS. Table 6 lists for the past four years the NO_2 annual 98th percentile and the annual averages showing NAAQS compliance of these standards by large margins.

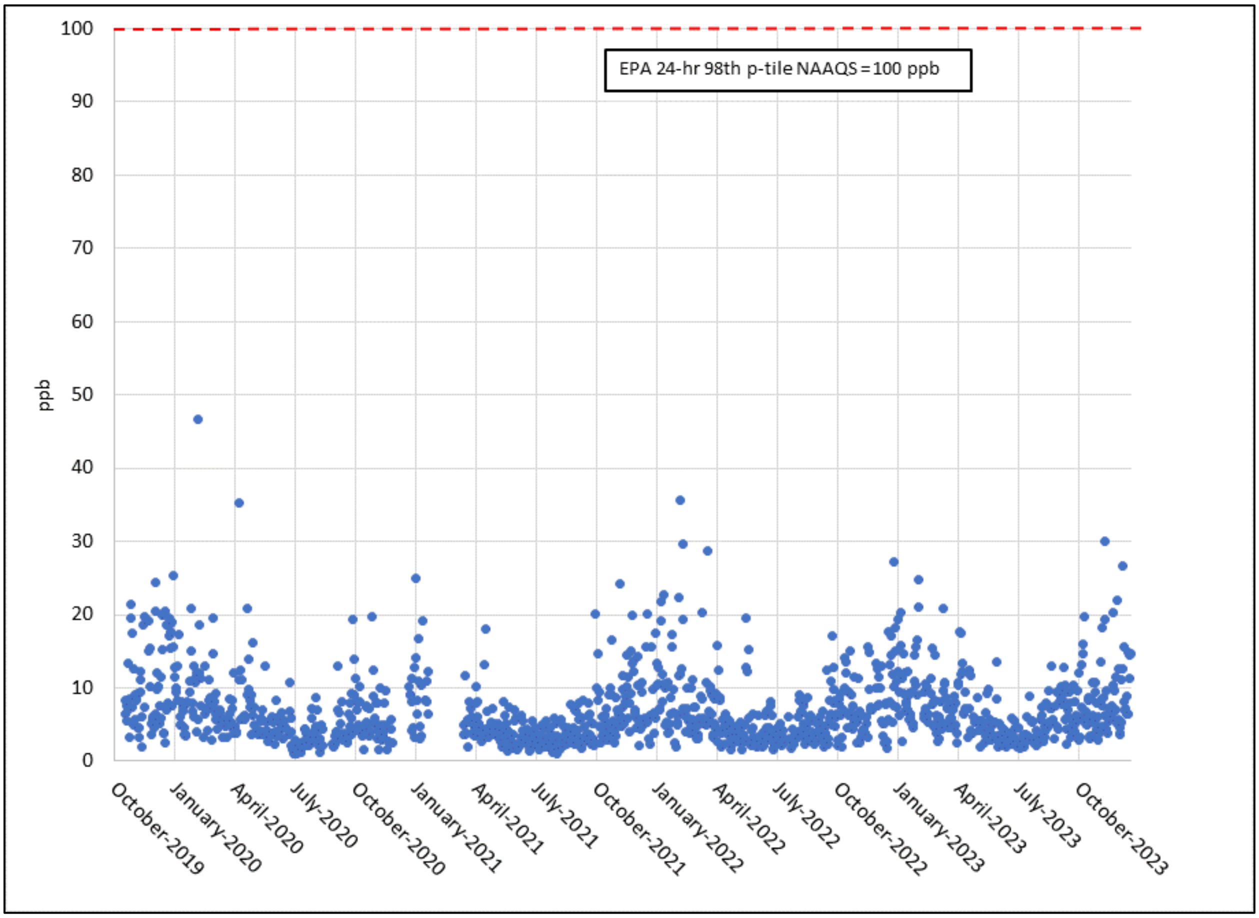

Figure 13. Daily maximum NO_2 at GF, ppb units, Oct. 1, 2019 – Dec. 31, 2023, with NAAQS

Table 6. GF NO_2 annual 98th p-tile values, three-year mean showing NAAQS compliance.

Year	Annual Average Values, ppb	NAAQS Annual Average Value, ppb	Annual 98th percentile ppb	NAAQS 3-Year 98th Percentile Average Value, ppb
2020	6.4		19.4	
2021	5.7		18.5	
2022	6.5		19.7	
2023	7.3		20.6	
3-year Avg 2021-2023	6.5	53	19.6	100

SO_2 is rarely found in ambient air, and the SO_2 instruments are calibrated to accurately measure high concentrations that are a risk to public health. As a result, the large majority of SO_2 concentrations measurements are close to 0.0. Many instruments measuring low concentrations will produce time series with much scatter near 0.0 owing to the nature of carrying out the chemical or electrical reaction that is associated with the measurement and converting that to a number representing the concentration. When an instrument has been calibrated to accurately measure high concentrations to safeguard public health, generally at low concentrations near zero there can be high relative error. The time series graph for SO_2 since Oct. 2019 at the GF station is shown in Figure 14. The graph is scaled to illustrate how low the concentrations have been compared to the 75-ppb level of the NAAQS. Table 7 lists the annual 99th percentile values of daily maximum SO_2 for the past three complete years, again showing compliance between the level of the NAAQS and measured concentrations by more than 70 ppb.

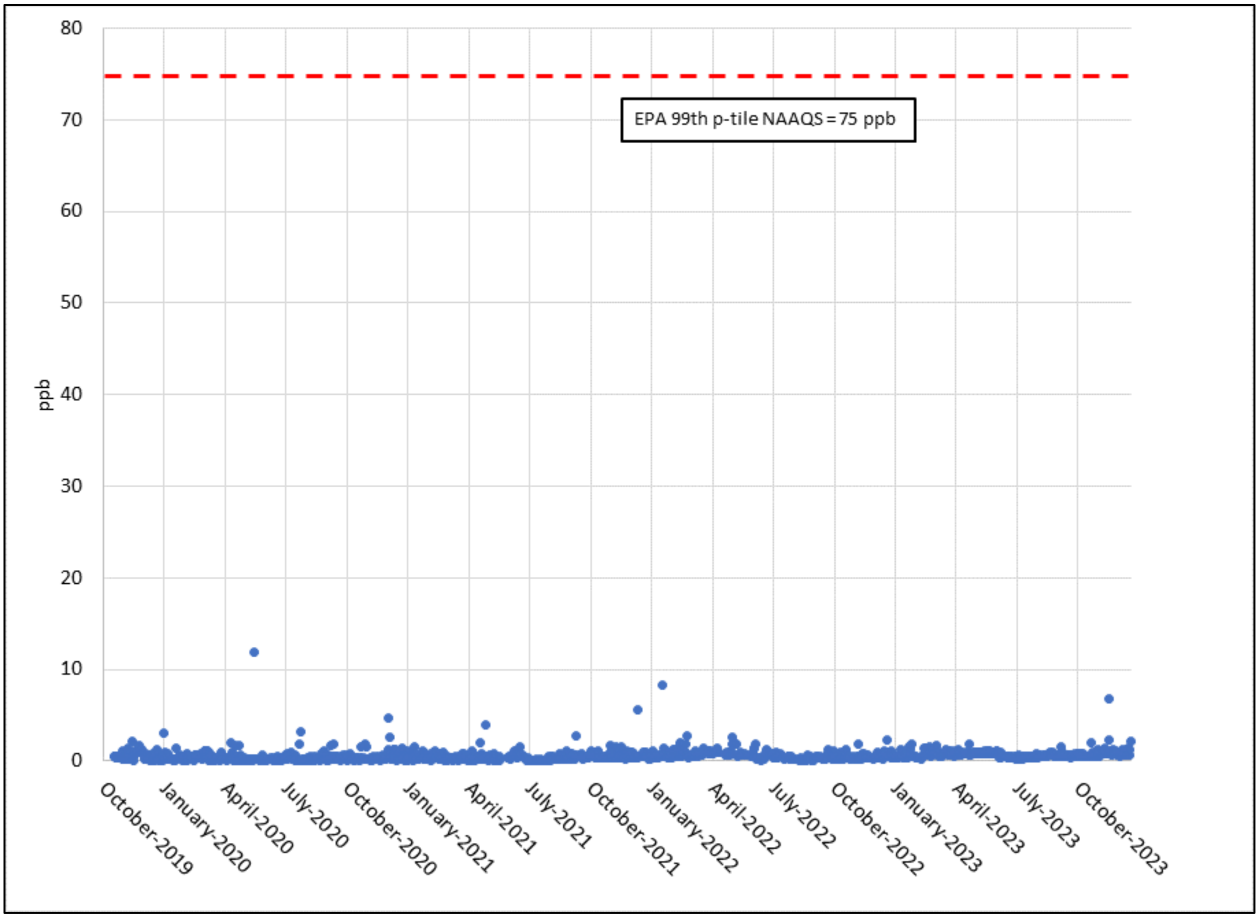

Figure 14. Daily maximum SO_2 at GF, Oct. 1, 2019 – Dec. 31, 2023, with NAAQS at 75 ppb

Table 7. GF SO_2 annual 99th percentile values of daily maximums three-year average showing NAAQS compliance.

Year	Annual 99th percentile ppb	NAAQS 99th Percentile Average Value, ppb
2020	2.5	
2021	2.0	
2022	2.3	
2023	1.9	
3-year Avg. 2021 - 2023	2.1	75

4.6 Portland Buddy Ganem & Portland Broadway Stations Criteria Pollutant Data

Fine particulate matter (PM2.5) is the only NAAQS-regulated pollutant measured at the PBG and PBway stations. Figure 15 shows the 24-hour average concentrations at the PBG site from Jan. 2020 through December 2023, and Figure 16 shows the same time series for the PBway site. The 3-year average concentration PBG is 7.1 µg/m^3 and is 8.2 µg/m^3 at PBway. Table 8 and Table 9 summarize the average annual PM2.5 concentrations for the PBG and PBway stations and the three-year average annual concentrations. The average PM2.5 concentration for the first three quarters of 2023 was 8.9 µg/m^3 at PBway and was 7.9 µg/m^3 at PBG.

To a large extent, PM2.5 concentrations are of a regional nature, in that transported dust or smoke, or locally formed aerosols generally affect a multi-county or larger area. As was the case with the GF station, there have been periods of elevated PM2.5 in summer months associated with transported dust from Northern Africa. As an example of the regional nature of PM2.5, all three stations exceeded the 35 µg/m^3 24-hour NAAQS on the same two dates, June 12, 2022, and June 16, 2022, owing to the transported North African dust. Across the State of Texas, with 66 regulatory PM2.5 monitors, 22 stations had elevated PM2.5 on June 12, 2022, and 48 stations had elevated PM2.5 on June 16, 2022. Among TCEQ regions, all parts of the state had some elevated concentrations between June 12 and June 16, 2022. No 24-hour averages in 2023 at Portland stations have exceeded the level of the NAAQS.

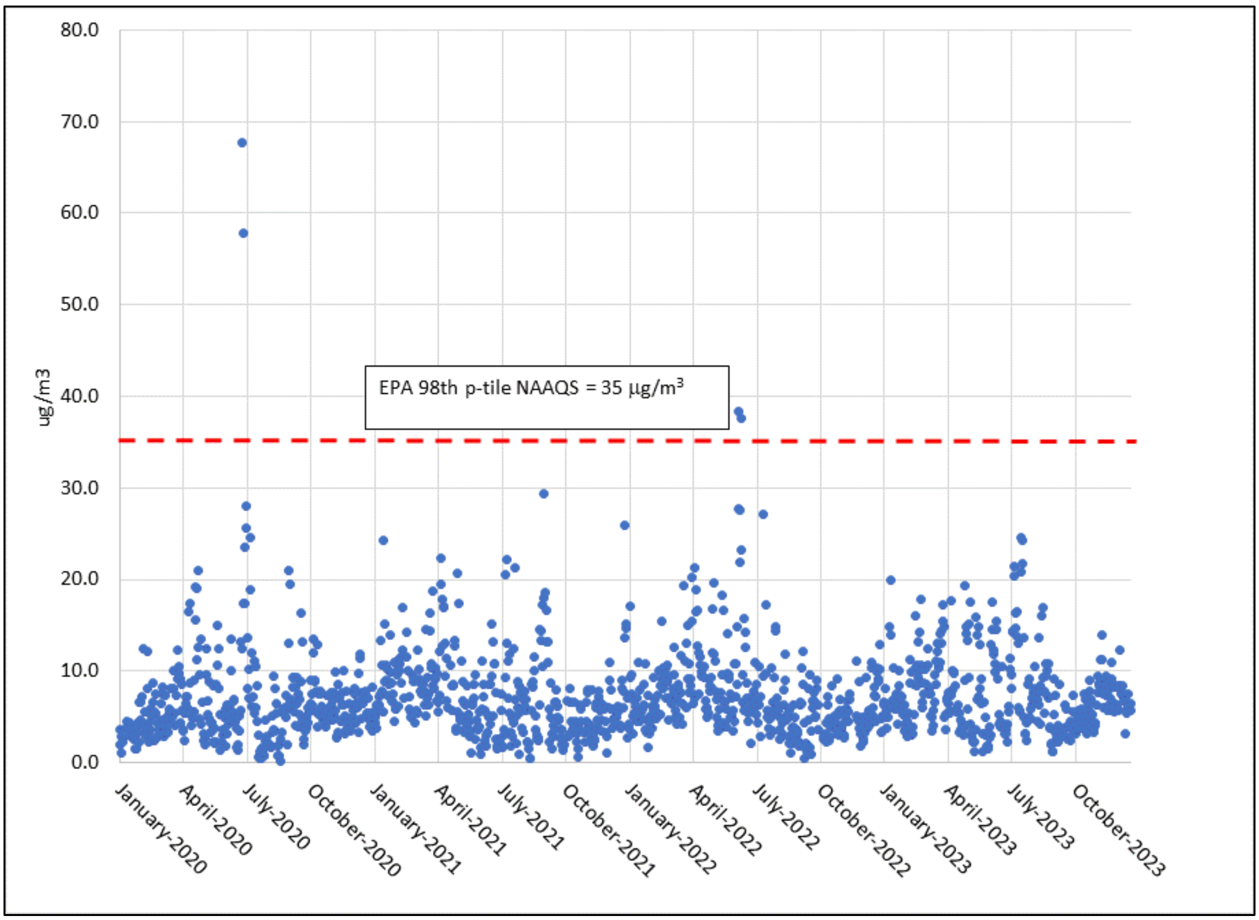

Figure 15. Mean 24-Hour PM2.5 at PBG, Jan. 1, 2020 – Dec. 31, 2023, NAAQS scale.

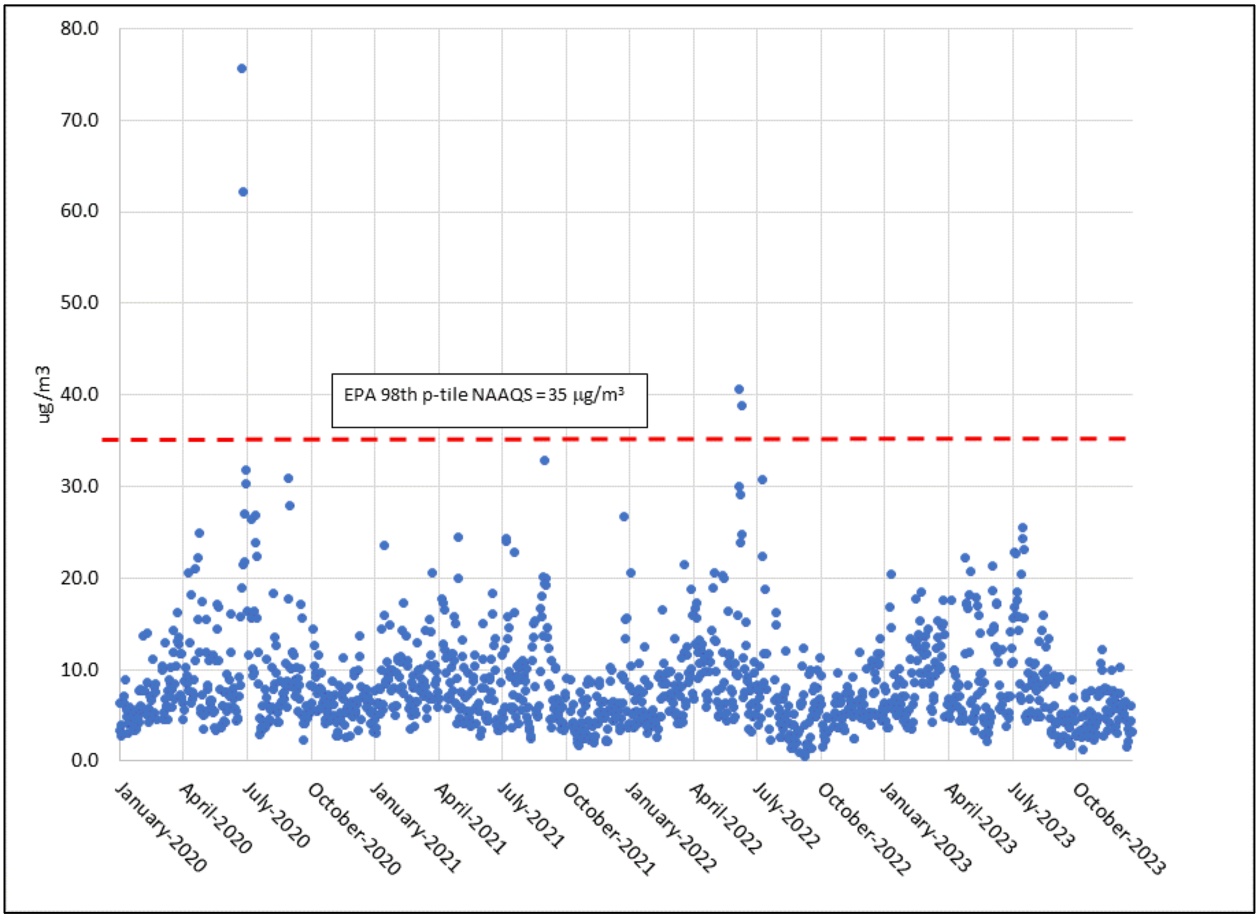

Figure 16. Mean 24-Hr PM2.5 at PBway, Jan. 1, 2020 – Dec. 31, 2023, with NAAQS value.

Table 8. PBG PM2.5 annual means and 3-year averages showing NAAQS compliance.

Year	Annual Mean $\mu g/m^3$	NAAQS 3-Year Annual Average Value, $\mu g/m^3$	Annual 98th Percentile Value $\mu g/m^3$	NAAQS 3-Year 98th Percentile Average Value, $\mu g/m^3$
2020	6.6		20.8	
2021	7.2		20.5	
2022	7.4		21.3	
2023	7.6		19.3	
3-year Avg. 2021-2023	7.4	12.0	20.4	35.0

Table 9. PBway PM2.5 annual means and 3-year averages showing NAAQS compliance.

Year	Annual Mean $\mu g/m^3$	NAAQS 3-Year Annual Average Value, $\mu g/m^3$	Annual 98th Percentile Value $\mu g/m^3$	NAAQS 3-Year 98th Percentile Average Value, $\mu g/m^3$
2020	8.7		26.9	
2021	8.2		20.5	
2022	7.8		22.5	
2023	8.1		20.7	
3-year Avg. 2021-2023	8.0	12.0	21.2	35.0

5.0 Data Analysis

5.1 Multivariate Analysis of Hydrocarbon Data

The hourly auto-GC data were studied to infer the types of emission sources contributing to the measured concentrations. One approach to doing this is to select all the complete data records – that is to say, the observations with all 46 compounds present – and then look at the relationships among the compounds to see which ones are best correlated together. The simplest approach of this type is called principal component analysis (PCA). PCA is a relatively simple method that – given N variables -- looks for a vector in the N-dimensional space of the data that captures the maximum variance amount within the data to be the 1st principal component, then looks for the vector orthogonal (at a 90-degree angle) to the first that captures the remaining maximum variance to be the 2nd principal component, and so on. The result is a table with a weighting for how well a compound is related to each principal component. PCA provides guides for how many principal components are useful in explaining the total data set. Generally, the 46-hydrocarbon data set can be reduced to somewhere between 4 to 10 "factors". A complementary method to PCA is factor analysis, in which one can specify in advance how many factors exist, and the method produces the best reduction of the 46-compound data set to that exact number of specified factors, say M-factors. This set of M-factors can be rotated in M-space to produce a clearer picture of the factors that produced the reported concentrations. PCA and factor analysis can identify the sources, but not how much each source contributes to the total hydrocarbon concentration. Beyond PCA and factor analysis, there are more complicated methods that do assign a portion of the total hydrocarbon mass to each factor. If we have the actual hydrocarbon composition for each emission source, then chemical mass balance (CMB) analysis can assign a portion of the total hydrocarbon amount to each factor. In most cases, however, we do not know the actual source composition. An alternative is positive matrix factorization (PMF). PMF requires an estimate of the uncertainty in each measurement – both a minimum detection level (MDL) and a percent uncertainty for detectable concentration measurements. Given the concentrations and uncertainty estimates and a user's guess at the number of factors "M", PMF solves a nonlinear optimization program to estimate the composition of the M-factors and how much each factor contributes to the total hydrocarbon mass.

One caution, however, is that in using hydrocarbon data one must recognize that chemical reactions can happen in the air, especially during sunlight hours, and so the gases in the emissions from a distant source may change in composition over time. Because there are several industrial facilities, major roadways, and other possible sources within the Portland-Gregory area, it may be the case that fresh emissions are more likely to be measured than aged emissions.

The initial PCA calculations using data form the first 10 months of 2023 suggested seven factors within the 46 auto-GC species at the three stations, with some differences found among the stations. Natural gas, which is rich in Ethane, Propane, Butane and Pentane isomers appears to be the major source of total hydrocarbon make-up, with motor vehicles – both light-duty cars and heavy-duty vehicles – appear as likely factors. The initial PMF runs suggested that at all three sites, the natural gas factor represented 40 to 50 percent of the total hydrocarbon mass. This is similar to the results found in other auto-GC PMF analyses conducted in other Texas urban areas. This work is ongoing and future reports will expand on this research.

5.2 Sulfur Dioxide at Gregory Fresnos

Among the three stations, only the Gregory Fresnos station measures SO_2. As noted earlier, when an air pollution monitoring instrument is calibrated to accurately measure higher concentrations that are threats to human health, concentrations close to zero are often very "noisy", in that the conversions in the instrument from a measured voltage or chemical reaction, or both are mapped through a mathematical formula to a concentration, and the very low signals can appear to bounce around randomly near zero. In general, the concentration of SO_2 in normal air is very close to 0.0 ppb, and that has been the case at the Gregory Fresnos station. However, for what seems to have been only the fifth occasion since the start of monitoring, on November 28, 2023, the monitor recorded noticeably higher than 0.0 hourly concentrations of 4.7 and 6.8 ppb under relatively strong 8 mile per hour winds from the northeast at 8 a.m. and 9 a.m. The station operators reported that the most likely source was re-roofing of the school roof, where heated tar was applied as a sealant. Tar generally contains sulfur, and when heated can release SO_2. A graph showing the SO_2 on November 28, 2023, appears in Figure 17.

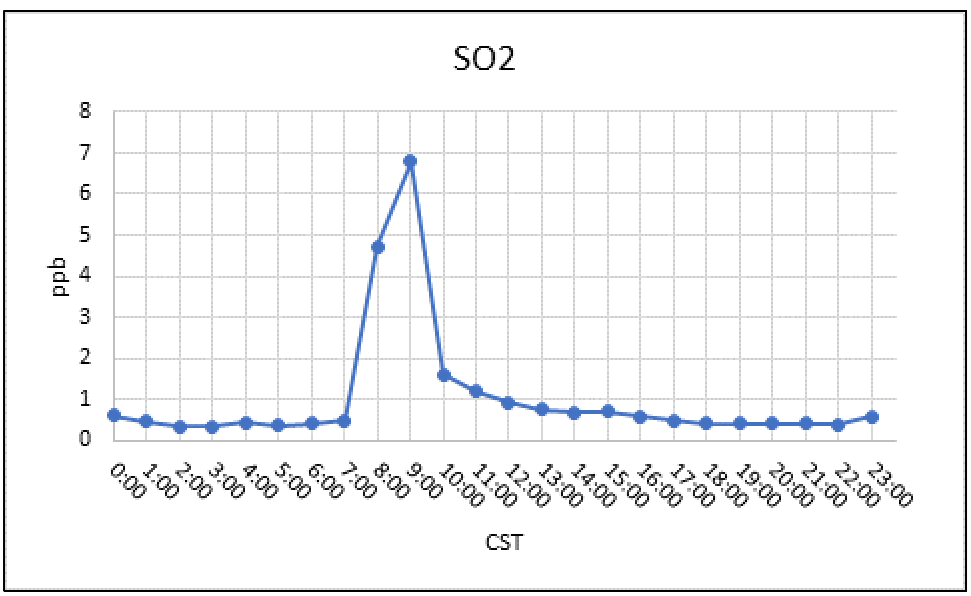

Figure 17. SO_2 hourly concentrations on Nov. 28, 2023, at Gregory Fresnos

On the other occasions that SO_2 was elevated at Gregory Fresnos, the conditions varied. The instances of elevated SO_2 along with the wind speed and direction are listed in Table 10. The reader is reminded that the NAAQS level for SO_2 is 75 ppb and the highest concentration measured to date has been 11.9 ppb on May 16, 2020.

Table 10. Elevated SO2 at Gregory Fresnos, 2020 - 2023

Date	Time CST	SO2 ppb	Wind Speed mph	Wind direction deg.	Likely source
5/16/2020	2:00	11.9	4.4	31.8	Light, variable winds, late at night, too hard to tell
5/16/2020	3:00	6.7	1.4	149.6	
12/5/2020	18:00	4.7	4.0	5.6	
12/17/2021	13:00	1.1	10.0	157.0	Source to the southeast
12/17/2021	14:00	3.9	10.5	155.6	
12/17/2021	15:00	3.1	10.0	156.5	
12/17/2021	16:00	2.1	9.1	153.8	
12/17/2021	17:00	2.1	8.8	151.3	
12/17/2021	18:00	5.7	8.1	154.1	
1/23/2022	9:00	4.8	5.0	65.8	Unknown, but lasted all day
1/23/2022	10:00	6.6	4.9	65.7	
1/23/2022	11:00	8.3	4.9	52.4	
1/23/2022	12:00	3.7	4.2	51.0	
1/23/2022	13:00	2.8	3.6	53.7	
1/23/2022	14:00	2.0	4.2	74.7	
1/23/2022	15:00	2.4	4.4	61.2	
1/23/2022	16:00	1.7	4.2	69.7	
11/28/2023	8:00	4.7	8.6	61.1	Nearby roofing work
11/28/2023	9:00	6.8	8.9	56.7	
11/28/2023	10:00	1.6	7.6	52.0	

6.0 Conclusions

The air monitoring to date has been very successful. Although some concentrations have occasionally exceeded the concentration levels of the NAAQS, to date, the NAAQS have not been violated. Furthermore, measured hydrocarbon concentrations have not exceeded TCEQ long- term or short-term AMCVs. To date, operations at the GCGV facility and the Cheniere Energy facility do not appear to have affected the level of pollutants measured at project stations. UT Austin would be happy to answer any questions or conduct additional analysis at the community's or sponsors' requests.

Appendices

A.1 Air Monitoring Station Locations & Information

Table A-1. Gregory-Portland Community Air Monitoring Stations and Parameters Measured

Air Monitoring Station Name & Address	Volatile Organic Compounds (VOCs) 46 compounds	Ethylene oxide (EtO) 24 hr canister every sixth day	Nitrogen Oxides (NOx, NO, & NO_2)	Sulfur Dioxide (SO_2)	Particulate Matter (PM) Mass, particles < 2.5 micron diameter	Wind Speed (WS), Wind Direction (WD), Ambient Temperature (T), Relative Humidity (RH), & Barometric Pressure (BP)
Gregory Fresnos Stephen Austin Elementary 401 Fresnos St. Gregory, TX	Yes	No	Yes	Yes	Yes	Yes
Portland Buddy Ganem 307 Buddy Ganem St. GP High School Portland, TX	Yes	Yes	No	No	Yes	Yes. + precipitation
Portland Broadway 175 Broadway Blvd. Old East Cliff Elementary School Portland, TX	Yes	Yes	No	No	Yes	Only WS, WD

Figure 18. Location of Gregory-Fresnos Community Air Monitoring Station (GF, pin G), and two Portland community stations on GPISD campuses on Buddy Ganem (PBG, pin 1) and on Broadway (PBway, pin 2) and the Cheniere Energy and GCGV industrial facilities

A.2 Glossary of Terms and Terminology

Pollutant concentrations – Concentrations of most gaseous pollutants are expressed in units denoting their "mixing ratio" in air, i.e., the ratio of the number molecules of the pollutant to the total number of molecules per unit volume of air. Because concentrations for all gases other than molecular oxygen, nitrogen, and argon are very low, the mixing ratios are usually scaled to express a concentration in terms of "parts per million" (ppm) or "parts per billion" (ppb).

Sometimes the units are explicitly expressed as ppm-volume (ppmV) or ppb-volume (ppbV) where 1 ppmV indicates that one molecule in one million molecules of ambient air is the compound of interest and 1 ppbV indicates that one molecule in one billion molecules of ambient air is the compound of interest. In general, air pollution standards and health effects screening levels are expressed in ppmV or ppbV units. Because hydrocarbon species may have a chemical reactivity related to the number of carbon atoms in the molecule, mixing ratios for these species are often expressed in ppb-carbon (ppbV times the number of carbon atoms in the molecule), to reflect the ratio of carbon atoms in that species to the total number of molecules in the volume. This is relevant to our measurement of auto-GC species and TNMHC, which are reported in ppbC units. For the purpose of relating hydrocarbons to health effects, this report notes hydrocarbon concentrations in converted ppbV units. However, because TNMHC is a composite of all species with different numbers of carbons, it cannot be converted to ppbV. Pollutant concentration measurements are time-stamped based on the start time of the sample, in Central Standard Time (CST), with sample duration noted.

Auto-GC – The automated gas chromatograph collects a sample for 40 minutes, and then automatically analyzes the sample for a target list of 46 hydrocarbon species. These include benzene and 1,3-butadiene, which are air toxics, various species that have relatively low odor thresholds, and a range of gasoline and vehicle exhaust components.

Total non-methane hydrocarbons (TNMHC) – TNMHC represent a large fraction of the total volatile organic compounds released into the air by human and natural processes. TNMHC is an unspeciated total of all hydrocarbons, and individual species must be resolved by other means, such as with canisters or auto-GCs.

Canister – Electro-polished stainless-steel canisters are filled with 24-hour air samples on a regular every sixth-day schedule, or when an independent sensor detects that *elevated* (see below) levels of hydrocarbons (TNMHC or a specific chemical species) are present. Event-triggered samples are taken for a set time period to capture the chemical make-up of the air.

Air Monitoring Comparison Values (AMCV) – The TCEQ uses AMCVs in assessing ambient data. Two valuable online documents ("Fact Sheet" and "Uses of ESLs and AMCVs Document") that explain AMCVs are at https://www.tceq.texas.gov/toxicology/amcv/about (accessed January 2023). The following text is an excerpt from the TCEQ "Fact Sheet" document:

> Effects Screening Levels are chemical-specific air concentrations set to protect human health and welfare. Short-term ESLs are based on data concerning acute health effects, the potential for odors to be a nuisance, and effects on vegetation, while long-term ESLs are based on data concerning chronic health and vegetation effects. Health-based ESLs are set below levels where health effects would occur whereas welfare-based ESLs (odor and

vegetation) are set based on effect threshold concentrations. The ESLs are screening levels, **not ambient air standards.** Originally, the same long- and short-term ESLs were used for both air permitting and air monitoring.

There are significant differences between performing health effect reviews of air permits using ESLs, and the various forms of ambient air monitoring data. The Toxicology Division is using the term "air monitoring comparison values" (AMCVs) in evaluations of air monitoring data in order to make more meaningful comparisons. "AMCVs" is a collective term and refers to all odor-, vegetative-, and health-based values used in reviewing air monitoring data. Similar to ESLs, AMCVs are chemical-specific air concentrations set to protect human health and welfare. Different terminology is appropriate because air *permitting* and air *monitoring* programs are different.

On October 10, 2023, the TCEQ announced:

The National Academies is seeking suggestions for experts to conduct a scientific review of the Texas Commission on Environmental Quality's carcinogenic dose-response assessment for ethylene oxide, a carcinogenic air pollutant. The study will review the methods, results, and conclusions of the assessment document developed for ethylene oxide by the Texas Commission on Environmental Quality.

Rationale for Differences between ESLs and AMCVs – A very specific difference between the permitting program and monitoring program is that permits are applied to one company or facility at a time, whereas monitors may collect data on emissions from several companies or facilities or other source types (e.g., motor vehicles). Thus, the protective ESL for permitting is set lower than the AMCV in anticipation that more than one permitted emission source may contribute to monitored concentrations.

National Ambient Air Quality Standards (NAAQS) – U.S. Environmental Protection Agency (EPA) has established a set of standards for several air pollutions described in the Federal Clean Air Act. NAAQS are defined in terms of *levels* of concentrations and particular *forms*. For example, the NAAQS for particulate matter with size at or less than microns (PM2.5) has a *level* of 12 micrograms per cubic meter averaged over 24- hours, and a *form* of the annual average based on four quarterly averages, averaged over three years. Individual concentrations measured above the level of the NAAQS are called *exceedances*. The number calculated from a monitoring site's data to compare to the level of the standard is called the site's *design value,* and the highest design value in the area for a year is the regional design value used to assess overall NAAQS compliance. A monitor or a region that does not comply with a NAAQS is said to be *noncompliant*. At some point after a monitor or region has been in noncompliance, the U.S. EPA may choose to label the region as *nonattainment*. A nonattainment designation triggers requirements under the Federal Clean Air Act for the development of a plan to bring the region back into compliance. A more detailed description of NAAQS can be found on the EPA's Website at https://www.epa.gov/criteria-air-pollutants#self (accessed January 2023)

One species measured by this project and regulated by a NAAQS is sulfur dioxide (SO_2). EPA set the SO_2 NAAQS to include a level of 75 ppb averaged over one hour, with a form of the three-year average of the annual 99th percentiles of the daily maximum one- hour averages. If measurements are taken for a full year at a monitor, then the 99th percentile would be the fourth highest daily one hour maximum. There is also a secondary SO_2 standard of 500 ppb over three hours, not to be exceeded more than once in any one year.

Elevated Concentrations – In the event that measured pollutant concentrations are above a set threshold they are referred to as "elevated concentrations." The values for these thresholds are summarized by pollutant below. As a precursor to reviewing the data, the reader should understand the term "*statistical significance*." In the event that a concentration is higher than one would typically measure over, say, the course of a week, then one might conclude that a specific transient assignable cause may have been a single upwind pollution source, because experience shows the probability of such a measurement occurring under normal operating conditions is small. Such an event may be labeled "statistically significant" at level 0.01, meaning the observed event is rare enough that it is not expected to happen more often than once in 100 trials. This does not necessarily imply the failure to meet a health-based standard. A discussion of "elevated concentrations" and "statistical significance" by pollutant type follows:

- For SO_2, any measured concentration greater than the level of the NAAQS, which is 75 ppb over one hour, is considered "elevated." Note that the concentrations of SO2 need not persist long enough to constitute an exceedance of the standard to be regarded as elevated. In addition, any closely spaced values that are statistically significantly (at 0.01 level) greater than the long-run average concentration for a period of one hour or more will be considered "elevated" because of their unusual appearance, as opposed to possible health consequence. The rationale for doing so is that unusually high concentrations at a monitor may suggest the existence of unmonitored concentrations closer to the source area that are potentially above the state's standards.
- For TNMHC, any measured concentration greater than the threshold of 2000 ppbC is considered "elevated."
- For benzene and other air toxics in canister samples or auto-GC measurements, any concentration above the AMCV is considered "elevated." Note that 40-minute auto-GC measurements are compared with the short-term AMCV.
- Some hydrocarbon species measured by the auto-GC generally appear in the air in very low concentrations close to the method detection level. Similar to the case above with SO_2, any values that are statistically significant (at 0.01 level) greater than the long-run average concentration at a given time or annual quarter will be considered "elevated" because of their unusual appearance, as opposed to possible health consequence. The rationale for doing so is that unusually high concentrations at a monitor may suggest an unusual emission event in the area upwind of the monitoring site.