NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

PHASE 2: THE PEACE BRIDGE COMMUNITY AIR QUALITY STUDY

Final Report

September 2016

DIVISION OF AIR RESOURCES

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Executive Summary

The NYS Department of Environmental Conservation (NYSDEC) responded to community concerns regarding air quality around the Peace Bridge and undertook a six month air quality study beginning in late August 2012. The study showed that concentrations of fine particulate matter ($PM_{2.5}$) were below the National Ambient Air Quality Standards (NAAQS) and black carbon (BC), an indicator of diesel exhaust, increased in the afternoon on weekdays. Shortly after the release of the Phase 1 study report, residents in the area and members of the Clean Air Coalition of Western New York voiced concern to NYSDEC that the study should have monitored a full year and included other air contaminants. The NYSDEC held meetings with the community and other stakeholders and designed this Phase 2 study to address those concerns. This follow-up study took place from late summer 2014 until the end of September 2015.

The Phase 2 study included a full year of air monitoring at two locations. A background location within the neighborhood was added and monitoring was expanded to include ultrafine particles (UFP). Close residential proximity to large sources of motor vehicle emissions has been linked to asthma prevalence by researchers including Dr. Lwebuga-Mukasa and others. The community members who were interested in UFP were aware that there are no air quality standards or guidelines for UFP and that these data were being collected to further the scientific understanding of the impact of motor vehicle emissions on public health. The UFP and other study data collected have been provided to the U.S. Environmental Protection Agency's (USEPA) Air Quality System (AQS) database to provide access for scientists working in this field.

Two air monitoring sites were established for this study in urban residential areas. One site was located close to and downwind of the Peace Bridge Complex (PBC) on Busti Avenue and represented higher exposures to vehicle emissions from the PBC. A second monitor was established at Public School 198 (PS198) and far enough away that vehicle emissions from the Peace Bridge and Interstate-190 (I-190) were considered negligible. Meteorological factors including wind speed, wind direction, temperature, relative humidity and barometric pressure were collected at the monitoring site closest to the Peace Bridge. The specific parameters and length of collection time for each monitor are shown in Table 1. Most parameters began in August 2014 and ended September 2015. UFP collection spanned September 2014 to September 2015 at Busti Avenue and June 2015 to September 2015 at PS198. Traffic data were obtained for the Peace Bridge from the Buffalo and Fort Erie Bridge Authority and for I-190 from the New York State Department of Transportation. The Peace Bridge vehicle data included separate data for automobiles and commercial trucks. The vehicle data for I-190 included vehicle count and vehicle length.[1]

[1] The New York State Department of Transportation and other highway agencies use 12 classes to describe vehicle type. For this Study, on I-190, any vehicle longer than 20 feet was considered a truck.

Table 1. Parameters and Monitoring Period by Site

Parameter	Busti Ave (days)	PS198 (days)
Black Carbon	415	405
Carbonyls	411	not monitored
Meteorological Conditions	415	not monitored
Fine Particulate Matter ($PM_{2.5}$)	415	400
Ultrafine Particles (UFP)	371	111
Volatile Organic Compounds	411	not monitored

In the analysis portion of this study, the air monitoring results were compared between the two sites and with traffic information to assess impacts of $PM_{2.5}$ concentrations in the neighborhood from automobiles and trucks on the PB and I-190. Other analysis techniques evaluated community impacts for BC concentrations and UFP counts as indicators of diesel emissions.

The analysis found that $PM_{2.5}$ concentrations were below the daily and annual NAAQS for both monitoring sites. $PM_{2.5}$ concentrations were highest for the winter season at both sites and the Busti Avenue monitor seasonal concentrations were nearly 20% higher than PS198. The local contribution of $PM_{2.5}$ at the Busti Avenue monitor was small and was more pronounced on weekdays. The maximum increase was 2.5 $\mu g/m^3$ at 10:00 am and remained higher through the late morning and into afternoon which tracks commuting patterns. Although $PM_{2.5}$ concentrations in this area are primarily from distant upwind sources that impact the area through transport, the local contribution of $PM_{2.5}$ at the Busti Avenue monitor is probably emissions from motor vehicles.

BC analysis found that the concentration was less than 10% of the concentration of $PM_{2.5}$. BC concentration at Busti Avenue was 40% higher than corresponding BC at PS198, suggesting diesel emissions are higher near Busti Avenue than PS198. Early morning BC concentrations are low and peak shortly after the morning commute with a similar profile for both the winter and summer commutes. BC concentrations are higher in the summer than the winter and correspond better with Peace Bridge truck traffic volume on the weekdays and to a lesser degree on Sunday. The relationship with automobiles was not readily apparent.

For the period of time (June to September 2015) when both Busti Avenue and PS198 monitors were measuring UFP, the particle counts at Busti Avenue were 40% higher than at PS198. In comparison, for the summer period, Busti Avenue and PS198 measured lower particle counts than other monitors in NYSDEC's network including the Buffalo near-road monitor along I-90 and the Queens, New York City (NYC) monitor near I-495. UFP data exhibit a strong seasonal dependence and at Busti Avenue, the summertime particle counts were about one half of the wintertime particle counts. Both automobiles and trucks contribute to UFP but the data from the Busti Avenue monitor indicated that truck emissions are responsible for a higher proportion of the UFP than automobiles.

Motor vehicles are large contributors of Volatile Organic Compounds (VOCs) in the ambient air. The USEPA has identified specific VOCs as mobile source air toxics (MSATs) and has developed regulations to reduce ambient concentrations.[2] The analysis of the 1-year monitoring data included four MSATs: acetaldehyde, 1,3-butadiene, benzene and formaldehyde. All of these air toxics were found to be greater than their respective health-based annual air guideline concentrations (AGCs), however, these four air toxics are consistently found above the AGCs in all locations of the State – even rural State park locations. The findings in this study are not unusual, nor higher than other similarly sized metropolitan areas. Additionally, the results for these four air toxics are within NYSDEC's risk management guidelines.

Four 1-hour air samples were collected by community members and analyzed for VOCs. The results were compared to their respective health-based short-term air guideline concentrations (SGCs) and all were found to be below the guideline concentrations. The results were also compared to the data collected at Busti Avenue and were found to be similar. Staff concluded that the measured results for the air toxics from this short-term assessment would not be considered an immediate public health concern.

Analysis of traffic on both the Peace Bridge and I-190 found that the number of trucks on the Peace Bridge was consistent from season-to-season but there were considerably more automobiles in the summer months. Automobile bridge crossings were higher on the weekend whereas truck crossings on the weekend were much lower than weekdays. Traffic volume on I-190 was five times higher than the traffic volume on the Peace Bridge. The percent of trucks on I-190 was about 10% of the total volume of traffic while trucks on the Peace Bridge were about 23% of the total traffic. Summertime traffic volume on I-190 was higher than other seasons. Traffic volume for automobiles and trucks on I-190 tended to be higher on weekdays than weekends.

The USEPA in recent years has begun studying near-road community exposures with greater intensity. USEPA requires near-road monitoring for nitrogen dioxide, carbon monoxide and $PM_{2.5}$ in cities with populations over one million. The USEPA also recommends that states collect UFP data at near-road monitoring sites and encourages states to submit these data to the USEPA so it can be used by health researchers. This is important because the USEPA uses data such as these to set air quality standards, approve the locations for air monitors and set motor vehicle emission limits. Data from the NYSDEC and the other monitoring networks across the country are used by the USEPA to further their understanding of the impact of mobile source emissions and the adequacy of national ambient air quality standards. The Phase 2 study results have already increased the USEPA's understanding of the wintertime behavior of UFP in cold climates. The NYSDEC will continue to collect data focused on mobile source emissions at the near-road monitors established in Buffalo, Rochester and in Queens. These results along with the findings from the Phase 2 study will provide health researchers with the information needed to investigate linkages between near-road vehicle emissions and human health outcomes.

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[2] United States Environmental Protection Agency (2007). Control of Hazardous Air Pollutants from Mobile Sources: Final Rule. Federal Register 72:37 February 26, 2007.

Introduction

Background

The NYS Department of Environmental Conservation (NYSDEC) responded to public concerns regarding air quality in the vicinity of the Peace Bridge complex (PBC) and proposed a study evaluating the air quality before and after the planned expansion of the plaza. The first phase of the study, beginning in the fall of 2012 through spring of 2013, was selected to coincide with the initial plaza construction scheduled for late spring 2013. The study focused primarily on particulate matter smaller than 2.5 microns ($PM_{2.5}$) and black carbon (BC), an indicator of diesel exhaust. The results showed that $PM_{2.5}$ concentrations were below National Ambient Air Quality Standards (NAAQS) and similar to measurements from other NYSDEC sites in the region. Additionally, the study showed that BC was higher at the Busti Avenue site in the afternoon when traffic on the bridge was highest.[3]

Shortly after the release of the Phase 1 study report, residents in the area and the Clean Air Coalition of Western New York voiced concern to NYSDEC that the study should have included one year of air monitoring and should have included other air contaminants. Although the first study demonstrated that the air in the neighborhood in the vicinity of the PBC met current $PM_{2.5}$ air quality standards, many stakeholders wanted more information about pollutants specifically coming from mobile source emissions even if some of these pollutants do not have a health-based standard or guideline concentration. They expressed concern that some of these pollutants were related to asthma and other health impairments as documented in published Peace Bridge studies by Dr. Lwebuga-Mukasa and other studies evaluating impacts of mobile source air pollution and health outcomes.[4,5,6,7,8] NYSDEC held meetings with the community and other stakeholders and found that their concerns focused on the following issues;

- The data collection period should include the summer months when bridge traffic is highest.

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[3] The results of this study are available online: http://www.dec.ny.gov/chemical/83984.html

[4] Lwebuga-Mukasa, J. S., Oyana, T. J., & Johnson, C. (2005). Local ecological factors, ultrafine particulate concentrations, and asthma prevalence rates in Buffalo, New York, neighborhoods. Journal of Asthma, 42(5), 337-348.

[5] Delfino, R. J., Kleeman, M. J., Gillen, D., Wu, J., & Nickerson, B. Risk of pediatric asthma morbidity from multipollutant exposures. Final Report for California Air Resources Board. CONTRACT NO. 10-319, 2015

[6] Oyana, T. J., & Lwebuga-Mukasa, J. S. (2004). Spatial relationships among asthma prevalence, health care utilization, and pollution sources in neighborhoods of Buffalo, New York. Journal of Environmental Health, 66(8), 25.

[7] Oyana, T. J., Rogerson, P., & Lwebuga-Mukasa, J. S. (2004). Geographic clustering of adult asthma hospitalization and residential exposure to pollution at a United States-Canada border crossing. American journal of public health, 94(7), 1250-1257.

[8] Brown, M. S., Sarnat, S. E., DeMuth, K. A., Brown, L. A. S., Whitlock, D. R., Brown, S. W., & Fitzpatrick, A. M. (2012). Residential proximity to a major roadway is associated with features of asthma control in children. PLoS One, 7(5), e37044.

- The data collection should extend for a year so results can be compared to NAAQS and State-derived Annual Guideline Concentrations (AGCs).
- The air monitoring should include collection of ultrafine particles (UFP).
- The maximum impact site should be compared to a background site within the local neighborhood and not to another NYSDEC monitor location impacted by other sources.

Study Objectives

The Phase 2 study was designed to address community concerns. It began late summer 2014 and ended September 2015 and included periods when construction was taking place at the PBC. The Phase 2 study replaces the second component of the Phase 1 study planned following the completion of the Peace Bridge Plaza construction.

The Phase 2 study provided an opportunity for the NYSDEC to work with the community and to learn more about mobile source emissions and how they impact communities near busy roadways. The study has four objectives, developed to meet the community's concerns.

The first objective was to monitor mobile source emissions over the course of a year. This length of time was selected because it encompasses all four seasons and allows for comparisons to health-based annual standards and AGCs. The volume of automobile traffic on the Peace Bridge is highest during the summer months when tourist activity is at a peak. Monitoring for a year also ensured that seasonal and routine events affecting traffic patterns are captured. The impact of many non-routine events such as American and Canadian Holidays, football and hockey games, local road construction and backups due to delays in customs clearance will also be captured by a full year of monitoring.

The second objective was to collect data from two urban residential areas. One site is close to the Peace Bridge and represents the maximum concentration from vehicle emissions. The second site is removed from the impact of vehicle emissions from the PBC and I-190 and represents air quality within the neighborhood. The difference in pollutant concentrations between the maximum concentration site and the neighborhood site can provide an indication of the significance of Peace Bridge and I-190 mobile source emissions on the nearby community.

The third objective was to evaluate whether the concentrations of mobile source air toxics in the Peace Bridge community are of public health concern.

The fourth study objective was to include the community in the data collection process. During stakeholder meetings, residents expressed concern about air quality during traffic backups and times when they detected the odor of vehicle exhaust. These concerns will be evaluated by assisting community members with their effort to collect their own data and by providing the community with sampling canisters for the collection of 1-hr air samples during periods when and where they think air quality is of concern. NYSDEC encouraged community members to collect air samples using portable monitors between the two fixed monitoring sites as well as transverse to the expected concentration gradient between the sources and the neighborhood. The results from the VOC sampling are included in this report but other sampling conducted by the community with their own instruments has not been discussed in this report. The results from their assessment may provide additional understanding of the spatial extent of mobile source emissions in the neighborhood.

The pollutants selected for the monitoring campaign included pollutants that have a health-based standard, pollutants that are classified as MSATs, and pollutants that are potential indicators of a specific source of air pollution (i.e., motor vehicles).

$PM_{2.5}$ was included in the study because it includes components that originate from vehicle emissions, has proven associations with health effects and has a health-based NAAQS. $PM_{2.5}$ is a mass-based measurement that includes particles and gaseous droplets that can travel for weeks in the atmosphere and includes direct emissions from sources as well as mass from particles that are formed from reactions in the atmosphere. The impact of $PM_{2.5}$ on health is well documented but the impact of specific components of $PM_{2.5}$ is not well understood.

BC was included in the study because it is a component of vehicle emissions. Diesel-powered vehicles emit BC at much higher rates than gasoline-powered vehicles[9] and diesel vehicles are responsible for 93% of mobile source BC emissions.[10] BC also is released from combustion of fuel oil for home and business heating, wood burning, and other industrial processes including electricity generation. BC concentrations are often used to apportion the source of diesel-powered vehicle emissions in the absence of other sources of BC. Because the dominant fuel type for building heat in the Peace Bridge neighborhood is natural gas,[11] BC was used as an indicator of diesel-powered vehicle emissions in this study when the contributions from other sources are minimal. The BC concentrations rapidly decline as distance increases away from a source and this concentration gradient can be used to identify the strength and upwind direction of a source.

UFP were included in the study because research has demonstrated health effects attributable to exposures from UFP and these small particles are released from motor vehicles and other combustion sources. UFP range in size from 0.001 to 0.1 microns and are too small to measure by weight. Instead, these particles are counted and the results are in the units of number of particles per cubic centimeter of air. The particle count of these very small particles is reduced rapidly after release due to a variety of environmental factors including diffusion and evaporation which increase in warmer

[9] US Environmental Protection Agency, Black Carbon – Basic Information. Accessed 3/10/16 http://www3.epa.gov/blackcarbon/basic.html
[10] US Environmental Protection Agency, Black Carbon – Mitigating Black Carbon. Accessed 4/19/16. https://www3.epa.gov/blackcarbon/mitigation.html
[11] Bureau of the Census, Statistical Brief, Housing in Metropolitan Areas – Home Heating Fuel. May 1995.

temperatures. BC is not affected to the same degree by environmental conditions.[12] The steep concentration gradient of UFP away from combustion sources can help determine the strength and upwind direction of the source of the UFP.

VOCs and carbonyls were included in the study because many of these air toxics (e.g., 1,3-butadiene and benzene) are emitted from motor vehicles and are a large source of emissions in urban areas. Additionally, NYSDEC has health-based guideline concentration values that were used to assess the public health impacts of these air toxics on the neighborhood.

The data collection also included information that will aid in the interpretation of the pollutant results. Meteorological data including wind speed, wind direction, temperature, relative humidity and barometric pressure were collected at the monitoring site closest to the Peace Bridge. Traffic data, including vehicle count and classification, were obtained from the Buffalo and Fort Erie Public Bridge Authority and from the New York State Thruway Authority. A comparison of pollutant results with traffic information from both the Peace Bridge and I-190 was conducted to evaluate the influence of traffic and commuting factors (e.g., volume of automobiles versus trucks, time of day or day of week).

This study is not designed to be a full assessment of all factors potentially influencing the pollutant results obtained. Rather it will provide the results of general comparisons made between pollutant concentrations and ultrafine particle counts with traffic information. Additionally, the data collected in this study cannot be used to determine which specific pollutant is responsible for health impairments or asthma in the area but it can help determine whether and to what degree mobile source emissions impact the neighborhood. Data collected in this study has been provided to public health researchers to further their understanding of how specific mobile source air pollutants affect public health.

Measurement of Mobile Source Emissions

Emissions from mobile sources (motor vehicles) have been a concern of the NYSDEC since the Agency was founded in 1970. Research performed in New York helped demonstrate the need to remove lead from gasoline, the need for catalytic convertors for motor vehicles and more recently, the need for more stringent emission control systems for heavy-duty diesel engines. The NYSDEC manages the vehicle inspection and maintenance program for motor vehicles and roadside inspections for heavy-duty diesel vehicles to ensure that motor vehicles are meeting standards applicable to their model year. Agency staff also enforce heavy-duty diesel anti-idling laws that are designed to reduce emissions in populated areas where trucks are operated.

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[12] Zhu, Y., Hinds, W. C., Shen, S., & Sioutas, C. (2004). Seasonal trends of concentration and size distribution of ultrafine particles near major highways in Los Angeles Special Issue of Aerosol Science and Technology on Findings from the Fine Particulate Matter Supersites program. Aerosol Science and Technology, 38(S1), 5-13.

Mobile source emissions on a per vehicle basis have been declining as more advanced emission control systems and cleaner fuels have been required and used in the on-road fleet. These emissions still are a major source of air pollutants in many areas of the State especially in urban areas and near roadways. Heavy-duty diesel trucks have greater emissions than automobiles and are responsible for much of the nitrogen oxides and particulate matter measured near busy highways.

It is impossible to precisely measure one specific pollutant representative of heavy-duty diesel emissions in ambient air. Diesel exhaust contains many toxic air contaminants that contribute to a range of health problems.[13] Diesel exhaust is a mixture of volatile, semi-volatile and particulate matter and many of these pollutants are also released from other urban sources. Additionally, specific components of diesel exhaust undergo transformation processes including evaporation and coagulation as they move away from the point of emission. The relatively stable components such as BC travel away from the point of origin and its concentration diminishes due to dispersion. Other compounds such as UFP are very sensitive to environmental factors such as temperature and humidity. The concentration of UFP can quickly diminish due to diffusion and evaporation. In either case the UFP number is decreased but the emissions constituents are still present – liquid particles evaporate and form gases and small solid particles may coagulate and form larger particles that are no longer considered UFP.

Some of the pollutants emitted from diesel engines such as BC and UFP can be identified and measured. When a measureable pollutant can be associated with a source, the pollutant is designated as a potential indicator pollutant. The presence of indicator pollutants can only be used to identify a specific source of emissions when the other sources that emit the same pollutants are not present or are likely to be negligible. This makes it difficult to identify or apportion sources in urban areas where there are many sources such as vehicles, building heating systems, residential wood combustion and food preparation. The process of source apportionment uses patterns of pollutant concentrations as well as knowledge of local sources of emissions to estimate the impact of individual source categories. Because the dominant fuel type for building heat in the Peace Bridge neighborhood is natural gas,[14] in this study, BC and UFP were used as indicators of diesel-powered vehicle emissions on weekdays.

Health Effects of Mobile Source Emissions

Motor vehicles are a significant source of air pollution directly releasing gases such as carbon dioxide, carbon monoxide, nitrogen oxides, benzene, formaldehyde, 1,3-butadiene, acetaldehyde and formaldehyde. Benzene, 1,3-butadiene and aldehydes combine with nitrogen oxides contributing to the formation of ozone. Additionally, the combustion of vehicle fuels contributes to the formation of particulate matter (PM).

[13] US. Environmental Protection Agency. Health Assessment Document for Diesel Engine Exhaust. May 2002.
[14] Bureau of the Census, Statistical Brief, Housing in Metropolitan Areas – Home Heating Fuel. May 1995.

Exposure to PM is associated with a variety of health effects. The range of PM size fractions that are considered by researchers looking at human health impacts include dust or total suspended particulates (TSP), coarse particulates (PM_{10}, particles that are 10 microns or less in size), fine particulates ($PM_{2.5}$, particles that are 2.5 microns or less in size) and ultrafine particulates (UFP, particles less than 0.1 microns in size). Exposure to windblown dust and larger coarse particulates (TSP) can be associated with eye, nose and throat irritation, smaller coarse PM can be inhaled and can aggravate respiratory symptoms.

Inhaling fine particulates has been consistently associated with symptoms and changes in the cardiovascular system (the heart and circulatory system), and also believed to cause adverse effects in the respiratory and nervous systems. Research looking at the health effects from exposure to UFP pollution is relatively recent and there are no air quality standards that apply to these very small particles. Unlike most of the larger PM fractions, UFP readily change their size and composition once they are in the air. This makes it harder to understand when and where they might pose a health risk. From what is known about particles and health, and because of what we do not yet fully understand, it is important to consider the range of particle sizes we encounter in the environment.

Although the bulk of $PM_{2.5}$ is due to regional transport and $PM_{2.5}$ concentrations are not a good indicator of mobile source emissions, it is important to include $PM_{2.5}$ in the Phase 2 Study because it has a health-based annual NAAQS of 12 $\mu g/m^3$ and a daily NAAQS of 35 $\mu g/m^3$. USEPA is required to set air quality standards for specific pollutants considered harmful to public health and the environment. These standards are reviewed every five years. USEPA has begun a review of the particulate matter NAAQS. The peer reviewed studies that have been published since the last review will be analyzed to determine if the $PM_{2.5}$ NAAQS should be revised and if particles of other size categories (e.g., ultrafine particles) and particle composition should be considered in a future air quality standard.

In addition to particles, motor vehicles are large contributors of VOCs in the ambient air and short-term exposure to high concentrations of mobile source related air toxics (VOCs and carbonyls) can cause allergic reactions, asthma exacerbation, headaches and irritation to the eyes, nose and throat.

Long-term exposure to air toxics has the potential to initiate cancer and non-cancer health effects such as developmental, respiratory and cardiovascular effects. Because of the ubiquitous nature of motor vehicles and diesel- and gasoline-powered equipment, air toxics related to these sources are commonly found in all locations of the State.

Study Design and Data Analysis

Study Area

The Peace Bridge is the highest volume border crossing in Western New York and the second highest border crossing between the United States and Canada. The annual average daily traffic on the bridge is approximately 15,400 vehicles. Traffic approaching or leaving the Peace Bridge Plaza generally uses I-190 which has an annual average daily traffic count of approximately 84,400 vehicles. By comparison, the traffic count for vehicles crossing the George Washington Bridge in both directions between New York City and New Jersey is 268,700 vehicles daily.[15]

Study Monitoring Locations

The study objectives included one year of data collection from two residential locations. One site was selected directly downwind and close to the PBC to capture the highest impact of vehicle emissions. The other site was removed from the impact of vehicle emissions from the Peace Bridge and represented an urban residential neighborhood.

As shown in Figure 1, the predominant wind direction is from the southwest which places the monitor (denoted by star on map) directly downwind of the area of the PBC with the greatest density of idling vehicles – the customs inspection booths. Vehicle density is highest in the lanes approaching the customs clearance area. The predominant wind direction occurs twice as often as the next most likely direction which is from the west. The monitor nearest the PBC which was located at the intersection of Busti Avenue and Rhode Island Street, was sited to collect the maximum emissions from the PBC and emissions from I-190 which is west of the complex and runs north-south. This monitor was within the residential neighborhood adjacent to the PBC but it was closer to the sources of emissions than any of the homes in the area. Therefore, the information collected from this site represent higher pollutant concentrations than what would be expected at the residences in the adjacent neighborhood.

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[15] New York State Transportation Traffic Volume Report for 2014 estimates an annual average daily traffic (AADT) of 15,400 for the Peace Bridge has an AADT volume of 84,400 vehicles on I-190 near the Busti Avenue monitor.

Figure 1. Map of Peace Bridge Complex, Predominant Wind Direction and Monitor Location

The second air quality monitor was located within the neighborhood of the PBC but far enough away from the border crossing to represent typical urban air quality. One of the main considerations in siting this monitor was determining the distance with which PBC source impacts would be negligible. Spengler et.al., (2011) demonstrated that motor vehicles at the Peace Bridge Plaza and adjacent highways resulted in elevated levels of mobile source emissions at distances of 300 to 600 meters downwind.[16] Karner et. al., (2010)[17] reviewed 41 near-road air quality studies that were undertaken between 1978 and 2008 and found that levels of mobile source pollutants, which includes VOCs and BC, diminish to background concentrations within 115 to 570 meters from the edge of the road. These results suggest that a monitor installed to measure typical urban air quality must be removed from the impact of mobile source emissions from the Peace Bridge and I-190 by at least 600 meters. The location that was selected for the second air quality monitor was at PS198 International Preparatory School (formerly Grover Cleveland High School) on the corner of York Street and Plymouth Avenue. This location is 990 meters east of the Busti Avenue monitoring location and therefore mobile source emissions from Peace Bridge Plaza and I-190 were expected to be negligible. The Busti Avenue and PS198 sites are denoted in Figure 2 with yellow stars.

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[16] Spengler, J., Lwebuga-Mukasa, J., Vallarino, J., Melly, S., Chillrud, S., Baker, J., & Minegishi, T. (2011). Air toxics exposure from vehicle emissions at a US border crossing: Buffalo Peace Bridge Study. Research report (Health Effects Institute), (158), 5-132.

[17] Alex A. Karner, Douglas S. Eisinger, and Deb A. Niemeier, Near-Roadway Air Quality: Synthesizing the Findings from Real-World Data, Environmental Science & Technology 2010 44 (14), 5334-5344.

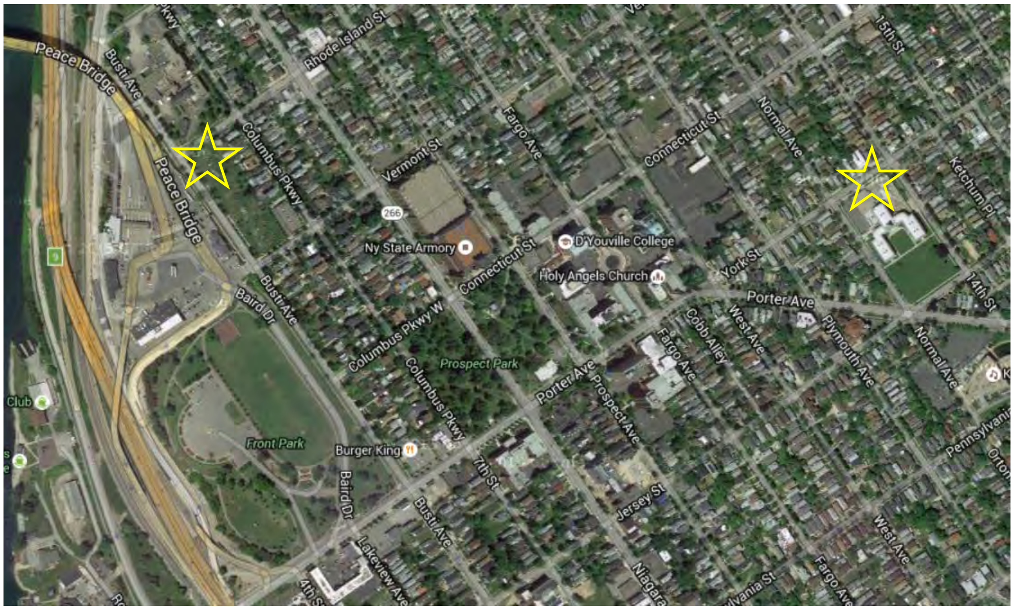

Figure 2. Busti Avenue and PS198 Monitoring Sites

It is understood that the results from the monitors do not precisely represent the ambient air quality at any one particular home within the neighborhood but that the air quality at any home will be between the concentrations measured near the source of emissions at Busti Avenue and PS198 the urban background site.

The monitoring sites began operation in August, 2014. The air monitoring was completed after one year and the sites were closed at the end of September in 2015. The monitoring equipment at the two sites is shown in Figure 3. The Busti Avenue site is larger because it accommodated more equipment as well as the meteorological sensors.

Figure 3. Study Monitoring Equipment

Federally Required Near-Road Monitoring Stations

As required by USEPA, the NYSDEC installed near-road monitoring stations alongside I-90 in Buffalo and I-490 in Rochester which monitors near-road concentrations of nitrogen dioxide, carbon monoxide and $PM_{2.5}$. The regulations require one air quality monitor in each city with a population over one million and require it to be sited to determine the maximum concentrations of near-road emissions. The location of the Buffalo monitor represented by a star in Figure 4 is between exits 51 and 52 on I-90 and the shelter is installed 20 meters from the traffic lane. The USEPA will compare the results from the near-road monitors to the results from NYSDEC's existing air monitors which are generally installed in neighborhoods away from roadways. A similar approach will be used in this Peace Bridge study where pollutant concentrations collected at the Busti Avenue site will be compared to pollutants measured at the neighborhood monitor at PS198. Data from the Busti Avenue site will also be compared to the Buffalo near-road site. The Buffalo near-road site meets the USEPA's siting criteria for a maximum impact site and it is located closer to the thruway than the Busti Avenue monitor so it is expected to reflect higher concentrations of mobile source pollutants.

Figure 4. Buffalo Near-road Monitoring Station

Study Parameters and Instrumentation

Fine Particulate Matter

Fine particulate matter ($PM_{2.5}$) was included in the study and data were collected at both sites using a TEOM 1400AB (Thermo Environmental, Franklin, MA).[18] The instruments were fitted with a $PM_{2.5}$ inlet and configured to produce 1-hour averaged concentrations. These instruments were installed and operated in an identical manner to the other TEOMs in the NYSDEC monitoring network.

[18] E. Ruppecht, M. Meyer, H. Patashnick, The tapered element oscillating microbalance as a tool for measuring ambient particulate concentrations in real time, Journal of Aerosol Science, Volume 23, Supplement 1, 1992, Pages 635-638

Ultrafine Particles

Ultrafine particles (UFP) were collected in this study using an API Model 651 condensation particle counter. The instrument is also available directly from the manufacturer under the model name TSI 3783. The instrument is the first UFP instrument to be specifically designed for long-term deployments in ambient air monitoring stations. Additionally, researchers have found that this instrument performs well in areas near busy highways.[19] The instrument does not determine the mass of particulate matter in the air but rather counts particles which are 0.007 microns to 0.1 microns. The instrument uses condensation to grow particles into a large enough size for them to obstruct a beam of light. A light detector then provides the signal which is converted to particles per cubic centimeter.

This instrument operated at the Busti Avenue site throughout the study and a second instrument operated at the PS198 site from June 11, 2015 to the end of the study. The NYSDEC operated two instruments at the Busti Avenue site in the fall 2014 and spring 2015 to evaluate the precision of the instruments. The two instruments agreed very well with coefficients of determinations (r^2) typically above 0.99.

Black Carbon

Black carbon (BC) concentrations were collected in this study using two models of the same instrument. A Magee Scientific model AE-21 Aethalometer® (Hansen et al., 1984).[20] This instrument deposits $PM_{2.5}$ particles onto a quartz fiber filter tape. The Aethalometer® calculates light attenuation (ATN) due to particle deposit on the filter relative to a clean part of the filter. By measuring the rate of change in ATN assumed to be solely due to absorption of light by BC, the mass concentration is determined. However, as the BC loading increases, the ATN to BC response becomes non-linear leading to underestimation of the BC concentration. Aethalometer® raw data were corrected for filter loading and processed into hourly intervals using software developed by the Air Quality Laboratory at Washington University.[21]

Due to instrument problems, the model AE-21 units were replaced with newer model 633 units in November 2014 and January 2015 at the PS198 and Busti Avenue monitoring sites, respectively. The model 633 employs the same method as the AE-21 but it autocorrects the data for filter loading and therefore no post-run correction of the data is required.

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[19] Lee et al, Water-based condensation particle counters comparison near a major freeway with significant heavy-duty diesel traffic, Atmospheric Environment, Volume 68, April 2013, Pages 151–161.

[20] Hansen, A.D.A., Rosen, H., Novakov, T. (1984). The Aethalometer -An instrument for the real-time measurement of optical absorption by aerosol particles. Sci. Total Environ, 36, 191-196.

[21] Turner, J.R., Hansen, A.D.A. and Allen, G.A. (2007). Methodologies to Compensate for Optical Saturation and Scattering in Aethalometer Black Carbon Measurements. In Symposium on Air Quality Measurement Methods and Technology, San Francisco, CA. AWMA, Pittsburgh PA, Paper No. 37.

Volatile Organic Compounds and Carbonyls

Sampling for VOCs and carbonyls was done on a one-in-six day schedule, over a 24-hour period. This sampling schedule is standard for air toxic monitors in the field.

For the evaluation of VOCs, air samples were collected using an evacuated 6-liter SUMMA canister with a mass flow controlled sampler. At the end of each sampling event, the canisters were returned to NYSDEC's Bureau of Air Quality Surveillance (BAQS) laboratory to be analyzed using gas chromatography/mass spectrometry GC/MS. The air samples were analyzed using USEPA's method TO-15 for 43 target compounds[22] consistent with NYSDEC's Toxics Air Monitoring Network.

The carbonyl analysis followed protocols outlined in USEPA Method TO-11a.[23] Carbonyls in air are trapped by reaction with 2, 2-dinitro-phenyl hydrazine (DNPH) coated silica gel contained within a commercially available sampling cartridge (Supelco LpDNPH S10). When the carbonyls contact the DNPH, they react and are retained within the cartridge as carbonyl-DNPH derivatives. Following sampling, the cartridges were sent to the BAQS laboratory for analysis using high performance liquid chromatography.

Meteorology

The Busti Avenue site included a Vaisala WXT520 sensor for meteorological data collection. The sensor collected wind direction, wind speed, temperature, relative humidity and barometric pressure information. Part of the sensor is a sonic anemometer that uses three transducers set equidistant to each other in a level plane to simultaneously determine the speed of an ultrasonic wave in three directions. The ambient wind speed and direction are calculated by comparing transit time for the ultrasonic waves in both directions between each transducer. The sensor was situated at a 10 meter elevation.

Traffic Data

The Buffalo and Fort Erie Public Bridge Authority collects and maintains records of vehicle crossings on the Peace Bridge by vehicle class and direction by hour. These data were obtained for the entire period of the Phase 2 study.

The NYS Thruway Authority and Canal Corporation collects and maintains records of vehicle travel by travel lane, vehicle length and direction by hour. The northbound data were obtained from stations at milepost 6.2 and 7.3. The southbound data were obtained from stations at milepost 6.4 and 8.2. In this report, the I-190 traffic data presented are from the two stations south of the entrance to the Peace Bridge. These locations are at milepost 6.2 for northbound traffic and milepost 6.4 for southbound traffic.

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[22] TO-15 suite of VOC measured can be found here: Community Air Screen program http://www.dec.ny.gov/public/81654.html

[23] The suite of carbonyls analyzed are: acetaldehyde, benzaldehyde, n-butyraldehyde, crotonaldehyde, formaldehyde, hexanal, methyl ethyl ketone, methacrolein, propionaldehyde, valeraldehyde, and m-tolualdehyde.

Community Sampling

Members of the Clean Air Coalition of Western New York were trained by NYSDEC staff on the use of VOC sampling equipment and on the procedures necessary to collect a representative air sample. Two air samples were collected by volunteers on May 24 and again on September 15, 2015. All sample locations are shown in Figure 5. For each air sample, a field log was completed that documented a chain of custody for the sampling canister and recorded sampling location, pressure gauge readings, sampling start and end times and weather conditions. Information about potential sources was assessed and recorded on the field log including nearby traffic conditions. Ambient air samples were collected over a 1-hour period using an evacuated 6-liter SUMMA canister with a calibrated orifice. After sampling, the canisters were returned to NYSDEC's BAQS laboratory for analysis.[24]

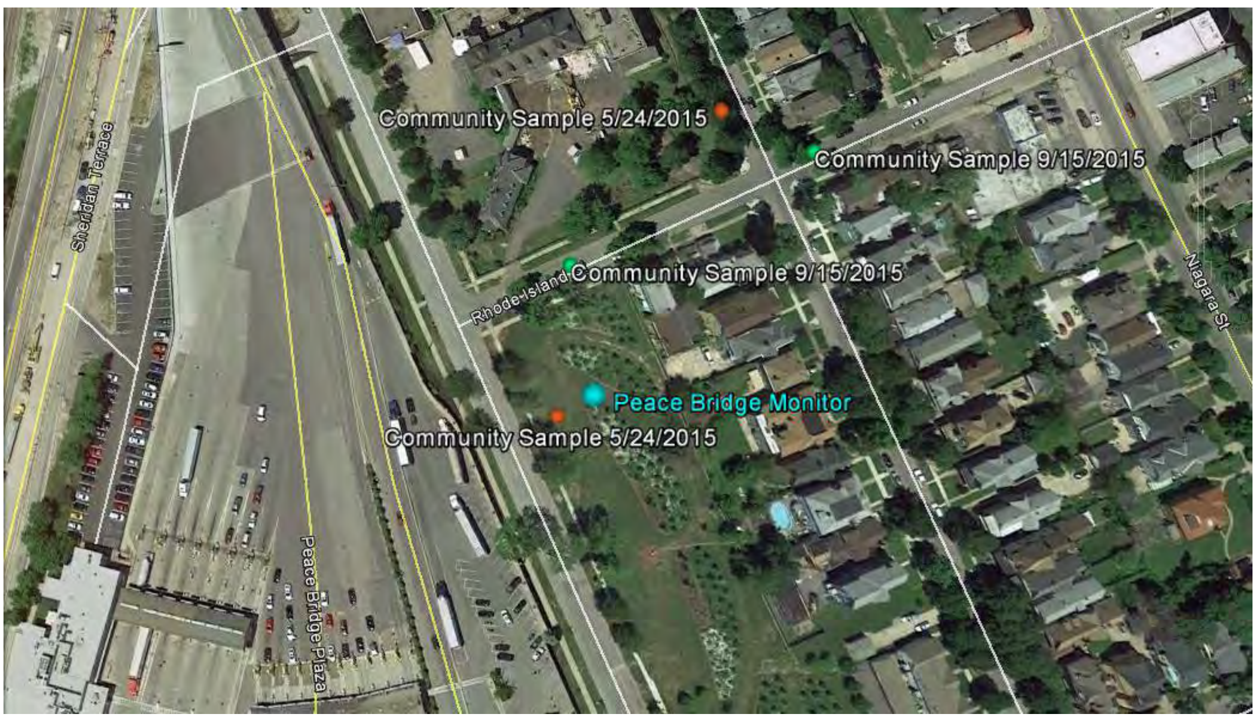

Figure 5. Location of Community VOC Samples

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[24] More details about the VOC instrumentational can be found in the section on Monitoring Network Design: Instrumentation and Data Summaries, Volatile Organic Compounds and Carbonyls.

Data Analysis

Air Quality Standards and Guidelines

$PM_{2.5}$ is the only pollutant measured in this study that has an annual and daily health-based NAAQS. Determination of attainment with the 12 µg/m^3 annual NAAQS is based on an annual mean, averaged over three years. Determination of the attainment status for the 35 µg/m^3 daily NAAQS is based on comparing the 98th percentile, averaged over three years. This study is not using the data to establish if the area is in attainment for $PM_{2.5}$ but rather to compare the difference in measured concentrations between the Busti Avenue and the PS198 monitors.

NYSDEC establishes both long-term and short-term air guideline concentrations for VOCs and carbonyls. NYSDEC will use these guideline concentrations to determine if the ambient concentrations collected in this study are potentially a public health concern.

Study Approach

The ambient air quality data were collected to determine whether emissions from traffic on the Peace Bridge and I-190 impact the neighborhood nearest the Peace Bridge. Data summaries were prepared for $PM_{2.5}$, BC and UFP. Each data summary included an average and percentile for the full year and averages by season. Summaries of differences and relative percent difference by season were prepared for matched hourly comparisons between the nearest site, Busti Avenue and the less impacted neighborhood site, PS198. These difference calculations were conducted by subtracting the concentration at PS198 from the concentration at Busti Avenue under the assumption that there are greater localized sources, specifically the Peace Bridge and I-190 motor vehicle emissions near the Busti Avenue monitor. These measured differences provide an estimate of the likelihood for additional sources impacting the Busti Avenue site.

Some pollutant concentrations vary by season because sources such as heating in the winter or automobile tourism traffic in the summer impact the amount of pollutants released in the area. Meteorological factors including temperature and wind speed also impact the rate at which emitted pollutants decay to background levels. Seasonal patterns were assessed for $PM_{2.5}$, BC and UFP. Data summaries for each of the meteorological parameters were prepared as an annual average as were percentiles for the full year and averages by season.

Diurnal plots were prepared to evaluate average concentration by each hour of the day for $PM_{2.5}$, BC and UFP. Data presented this way can be used to compare pollutant concentrations to traffic and commuting patterns. Diurnal seasonal patterns also were evaluated.

Commuting patterns vary by day of the week, so comparisons between weekday and weekend were conducted for $PM_{2.5}$, BC and UFP. Additionally, the $PM_{2.5}$ data were compared to the NAAQS directly. Because there are no standards for UFP, comparisons were made with data from other NYSDEC monitors collecting UFP counts.

No other comparisons were made for BC because it does not have a standard and USEPA does not require routine monitoring of this pollutant.

All traffic data, both the Peace Bridge and I-190, were summarized by vehicle travel direction and season and divided into two vehicle categories (automobiles and trucks). The traffic data from the Buffalo and Fort Erie Public Bridge Authority were provided by direction and by type: automobile or truck. Traffic data from the NYS Thruway Authority and Canal Corporation for the Vehicles on I-190 was provided by direction, travel lane and vehicle length. Vehicles over 20 feet in length were considered to be trucks and they were assumed to be diesel-fueled for the purpose of assessing impacts of diesel-powered emissions. Diurnal profiles by season and by weekday and weekend were prepared to facilitate comparisons with pollutant concentrations. A few sporting events were evaluated for increases in pollutant concentrations and vehicle traffic patterns.

For the 24-hr VOC and carbonyl samples, individual pollutant averages were calculated and included in the study when at least 75% of the yearly values were above the detection limit. The average concentrations were compared to the NYSDEC Annual Guideline Concentrations (AGCs). Since VOC and carbonyl monitoring was not conducted at PS198, the differential impact at the Busti Avenue monitor was not assessed. Instead, comparisons to monitoring concentrations in the NYSDEC air toxics network were conducted. NYSDEC operates air toxics monitors in a variety of communities across the State, including urban communities similar to the Peace Bridge neighborhood. Lastly, the 1-hr community VOC sample results were directly compared to NYSDEC Short-term Guideline Concentrations (SGCs), 24-hr results from the Busti Avenue site and the NYSDEC's monitoring network. Details about the interpretation of the VOC and carbonyl results, NYSDEC air toxics monitoring network and the development of NYSDEC's AGCs and SGCs can be found in Appendix A.

Mobile source emissions are mixtures of compounds both in gaseous and particulate matter which disperse and transform as they are transported away from the point of release. To assess the impact of diesel vehicle emissions on ambient $PM_{2.5}$ concentrations, this study used BC and UFP as indicator pollutants and correlations with traffic patterns to infer when and how much of the ambient $PM_{2.5}$ in this neighborhood originated from vehicles on the Peace Bridge and I-190. Because the dominant fuel type for building heat in the Peace Bridge neighborhood is natural gas, BC and UFP will be used as an indicator of diesel-powered vehicle emissions in this study when contributions from other sources are likely to be minimal.

For the neighborhood adjacent to the Peace Bridge, the impact of emissions from diesel vehicles was estimated by looking at the difference between the high concentration site at Busti Ave and the less impacted school site, the time of day and the day of week and by correlating the number of vehicles crossing the Peace Bridge and on I-190 with the concentration of the indicator pollutants BC and UFP.

Results

Data Summaries

Fine Particulate Matter

The summary in Table 2 shows the number of valid hours for the whole study and for each season, and valid matched hours for both sites. Concentrations and statistical calculations are also included.

Table 2. Summary of $PM_{2.5}$ Results

Statistic	Valid Hours	Busti Ave. µg/m³	PS198 µg/m³	Valid Paired Hours	Difference µg/m³	Percent Increase at Busti Ave
All Data: 25th percentile	9,774	5.30	4.50	9,124	1.00	18.2%
All Data: Average	9,774	8.85	8.05	9,124	1.16	12.7%
All Data: 75th percentile	9,774	11.4	10.6	9,124	1.20	10.3%
Fall Average	2,799	8.58	8.47	2,730	0.470	5.4%
Winter Average	2,119	10.4	9.29	2,092	1.11	10.7%
Spring Average	2,205	8.17	6.64	2,111	1.82	21.5%
Summer Average	2,651	8.45	7.69	2,191	1.42	15.8%

Notes: Percentiles and averages calculated with all data
Difference and Percent Increase at Busti calculated with matched datasets
Fall includes September 2014 and 2015
Summer includes August 2014 and 2015

The $PM_{2.5}$ concentrations are well below the USEPA air quality standards. The USEPA's Annual NAAQS is 12 µg/m³, and over the course of this study, the average $PM_{2.5}$ was about 74% of the standard at Busti Avenue and about 67% of the standard at PS198. The USEPA's daily NAAQS is 35 µg/m³ and the 98th percentile ranking of the 24-hour averages obtained at Busti Avenue and at PS198 were both about one half of the standard.

Table 2 includes difference and percent increase at Busti Avenue for paired hours of $PM_{2.5}$. $PM_{2.5}$ is a pollutant for which the majority of ambient concentrations are from regional transport with some local contribution. Subtracting the concentration at PS198 from the concentration at Busti Avenue is an approach to quantify the local source contribution at Busti Avenue. The results show that the $PM_{2.5}$ concentrations at Busti Avenue were typically 5-20% higher than at PS198. The only significant local sources of $PM_{2.5}$ near the Busti Avenue monitor are mobile source emissions from the Peace Bridge and I-190. Therefore, on average, 5-20% of the measured $PM_{2.5}$ from the Busti Avenue monitor could be attributed to emissions from local sources. The data analysis presented below will determine if the difference for $PM_{2.5}$ is significant enough to be attributed to local sources or regional transport.

The $PM_{2.5}$ concentrations were evaluated by hour of the day and by season for the Busti Avenue, PS198 and near-road Buffalo I-90 air monitoring sites as illustrated in the graphs in Figure 6.

Figure 6. Diurnal Plots of Seasonal $PM_{2.5}$ Concentration

In the winter, the concentrations of $PM_{2.5}$ are similar at the three sites and the wintertime concentrations are higher than the summertime concentrations. There are additional local sources in the winter including heating that may contribute to the increase in $PM_{2.5}$ concentrations at the sites. During the day, the concentrations at Busti Avenue are a little higher than at the near-road site which is most likely due to the higher percentage of heavy-duty diesel vehicles on the Peace Bridge and I-190. In the summer, the concentrations of $PM_{2.5}$ are slightly lower at PS198 which could reflect reduced activity near the school. The daytime differences are greater than during winter. Overall, because the concentrations are very similar at all sites and both seasons, the primary contributor to $PM_{2.5}$ concentrations is regional transport.

The diurnal local $PM_{2.5}$ increment, illustrated in Figure 7, is used to show the time of day when the local source contributions impact the Busti Avenue monitor. The hour-to-hour local impact was derived by subtracting the hourly diurnal average $PM_{2.5}$ concentration at PS198 (regional $PM_{2.5}$) from the hourly diurnal average at Busti Avenue. The hourly local $PM_{2.5}$ ranges from close to 0 at 3:00 am to a maximum of 2.5 $\mu g/m^3$ at 10:00 am or 0 to 24% of the total $PM_{2.5}$ impacting the neighborhood. The local increment of $PM_{2.5}$ is around 20% of the regional $PM_{2.5}$ through midday and slowly declines late in the afternoon. During the weekday commuting period, 9:00 am to 3:00 pm, the increment varies from 20-25%.

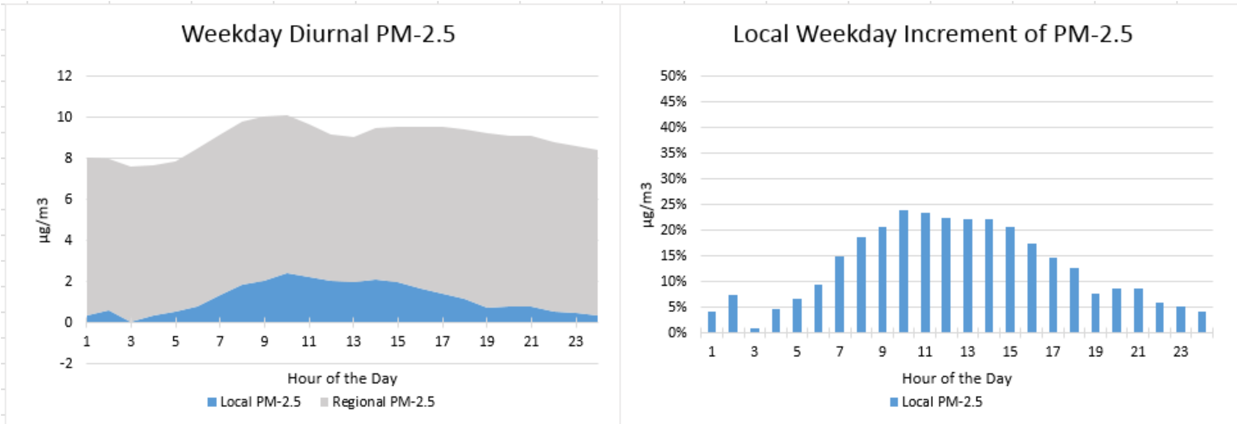

Figure 7. Local Increment of $PM_{2.5}$ by Concentration and Percent

Black Carbon

The summary in Table 3 shows the number of valid hours for the whole study and for each season, and valid matched hours for both sites. Concentrations and statistical calculations also are included.

Table 3. Summary of Black Carbon Results

Statistic	Valid Hours	Busti Ave µg/m³	PS198 µg/m³	Valid Paired Hours	Difference µg/m³	Percent Increase at Busti Ave
All Data: 25th percentile	9,756	0.37	0.24	8,024	0.16	41.2%
All Data: Average	9,756	0.79	0.49	8,024	0.34	41.3%
All Data: 75th percentile	9,756	1.06	0.63	8,024	0.49	44.9%
Fall Average	2,660	0.71	0.55	1,752	0.19	27.9%
Winter Average	2,149	0.58	0.37	1,659	0.27	42.7%
Spring Average	2,204	0.90	0.43	2,200	0.47	52.3%
Summer Average	2,743	0.94	0.59	2,413	0.37	38.2%

Notes: Percentiles and averages calculated with all data
Difference and percent increase calculated with matched datasets
Fall includes September 2014 and 2015
Summer includes August 2014 and 2015

The results in Table 3 indicate that BC typically ranges from 0.4 to a little over 1.0 µg/m³ which is less than 10% of the mass of $PM_{2.5}$ at either monitoring site. The BC percent increase also shows that the concentrations at Busti Avenue are 30% to 50% higher than at PS198. These results indicate that the Busti Avenue site was impacted by nearby sources. The only significant combustion sources in the area directly upwind of the Busti Avenue site are the vehicle emissions from the Peace Bridge Plaza and I-190.

The BC concentrations were evaluated by hour of the day and by season. In the diurnal plots in Figure 8, the hour-to-hour average BC concentrations are presented for the Busti Avenue, PS198 and near-road Buffalo I-90 air monitoring sites.

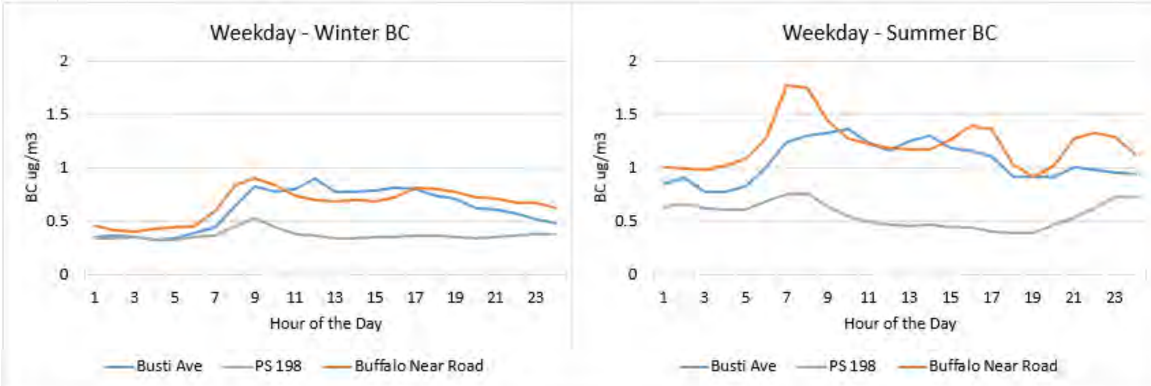

Figure 8. Diurnal Plots of Seasonal BC Concentration

The diurnal plots show the two monitoring locations most impacted by mobile source emissions, Busti Avenue and the Buffalo near-road, have higher BC concentrations than the background site at PS198. The peak concentrations in the early morning and to a smaller degree in the early evening at these sites indicate that mobile source emissions from commuting are the likely source of these higher BC concentrations. The shape of the near-road and Busti Avenue concentrations do not match exactly. The commuting peaks are sharper at the near-road site because the monitor is closer to the highway than Busti Avenue. The BC concentrations at Busti Avenue also increase midday which is not seen at either of the other sites. This is likely due to the unique traffic pattern at the Peace Bridge where traffic builds through the midday and afternoon hours.

The two BC plots and Table 3 also indicate that, in general, the BC at all of the sites are higher in the summer than winter. The diurnal plot for wind speed in Figure 9 shows that the wintertime wind speed at Busti Avenue is almost twice as high through the morning commuting hours which could considerably reduce the local BC concentration.

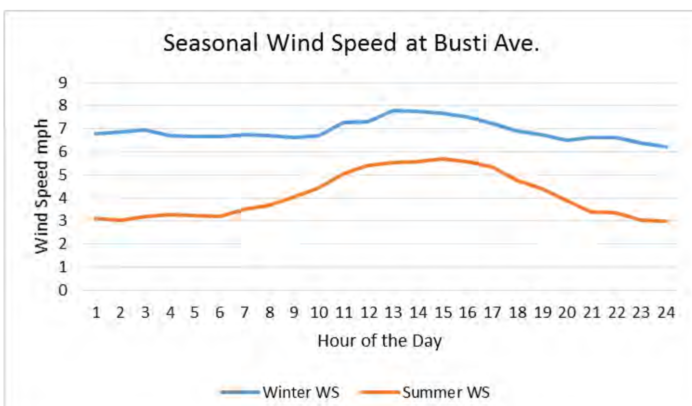

Figure 9. Diurnal Plot of Seasonal Wind Speed

Ultrafine Particles

Table 4 shows the number of valid hours for the whole study and for each season, and valid matched hours for both sites. Concentrations and statistical calculations also are included.

Table 4. Summary of Ultrafine Particle Results

Statistic	Valid Hours	Busti Ave number/ cm^3	PS198 number/ cm^3	Valid Paired Hours	Difference number/ cm^3	Percent Increase at Busti Ave
All Data: 25th percentile	8,852	7,788	4,234	2,658	3,097	42.3%
All Data: Average	8,852	11,844	7,666	2,658	4,178	35.3%
All Data: 75th percentile	8,852	19,469	9,600	2,658	5,077	34.6%
Fall Average	2,304	10,702	7,473	705	3,687	33.0%
Winter Average	2,136	23,636	NA	NA	NA	NA
Spring Average	2,208	19,549	NA	NA	NA	NA
Summer Average	2,204	12,232	7,736	1,953	4,356	36.0%

Notes: Percentiles and averages calculated with all data
Difference and percent increase calculated with matched datasets
Fall includes months in 2014 and September 2015
Summer includes August 2014 and 2015
NA: UFP instrument at PS198 from June 11, 2015 - Sept 30, 2015

The results show that UFP counts at Busti Avenue were over 30% higher than the UFP counts at PS198 over the period of time when the two sites simultaneously collected data. This is consistent with the expected UFP gradient which predicts higher particle count near the higher density of mobile source emissions and lower in areas further removed from the sources.[25] These data also show that the UFP counts in the summer are about one half of the winter values. In warm summertime weather, small volatile particles can evaporate becoming gases and small less volatile particles can impact each other due to diffusion and agglomerate into larger particles.[26] Both of these processes reduce the number of very small particles measured by the UFP instrument. In 2011, a Harvard School of Public Health research team (Spengler et al[27]), studying air pollution in the Peace Bridge neighborhood, found that the average summer UFP values were about 60% of the winter values. Some of the difference may be attributable to the types of instrumentation used in the two studies but another possibility is that the reduction in sulfur content of vehicle fuels and improvements in engines have reduced particle emissions. In the Spengler study, the researchers used a TSI Model 8525 P-Track which counts particles larger than 0.020 microns. In the NYSDEC study, the API

[25] Karner, A. A., Eisinger, D. S., & Niemeier, D. A. (2010). Near-roadway air quality: synthesizing the findings from real-world data. Environmental Science & Technology, 44(14), 5334-5344.
[26] Sioutas, C., Delfino, R. J., & Singh, M. (2005). Exposure assessment for atmospheric ultrafine particles (UFPs) and implications in epidemiologic research. Environmental health perspectives, 947-955.
[27] John Spengler, Jamson Lwebuga-Mukasa, Jose Vallarino, Steve Melly, Steve Chillrud, Joel Baker, and Taeko Minegishi, Air Toxics Exposure from Vehicle Emissions at a U.S. Border Crossing: Buffalo Peace Bridge Study, Health Effects Institute, Report 158, 2011.

Model 651 counts particles larger than 0.007 microns. Therefore processes such as diffusion and evaporation which more strongly effect the smaller size fraction will be reflected to a higher degree in overall particle collection count in the NYSDEC study. In Figure 10, the results from the Busti Avenue UFP instrument, which operated throughout the study, show that UFP concentrations are depressed in the summer and are higher in the winter. The data from the Buffalo near-road site exhibits less of a reduction in particle count in the summer. This site is only 20 meters from the edge of the road and the emissions from motor vehicles travel from tail pipes to the monitor within a few seconds. This short period of time reduces the impact of the weather related processes that reduce particle number in the summer.

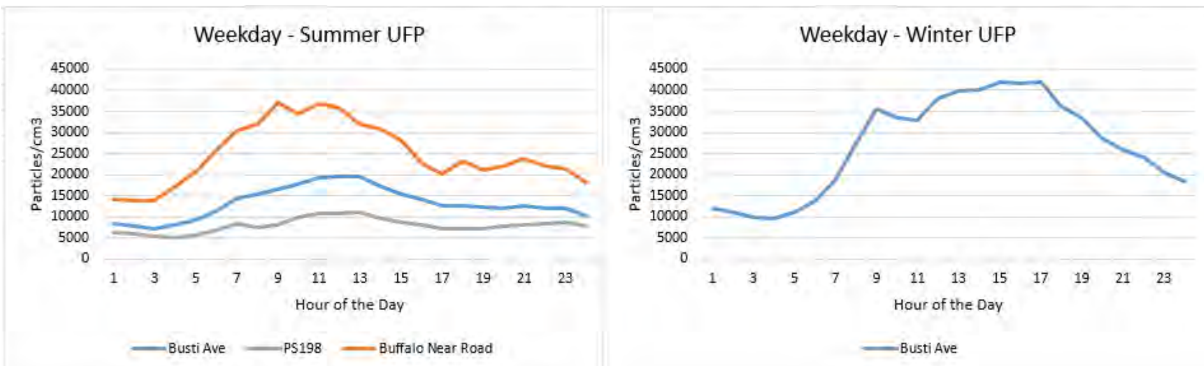

Figure 10. Diurnal Plots of Seasonal UFP

The NYSDEC also operated API Model 651 UFP instruments in other parts of the State during 2014 and 2015. In the left plot of Figure 11, the UFP percentile ranks are shown for all of the UFP instruments operating during the period when the UFP instrument was installed at PS198. This comparison shows that the data from all of the sites are more similar to one another at the 10th percentile but that there is a wider difference between the sites at the 90th percentile. This is expected for UFP which is very sensitive to the strength and distance from pollutant sources.

In the right plot in Figure 11, the results are shown from the three UFP instruments that operated throughout the study period. This time period included the winter months when UFP are higher on average. The Queens, NYC monitor is in an urban area and is 395 meters from the nearest highway (I-495). The Busti Avenue monitor is 70 and 242 meters from the traffic on the Peace Bridge and I-190, respectively. The Pinnacle monitor is in a State park with no nearby major highways and is considered a non-motor vehicle influenced background site.

This plot shows that at the 95th percentile of hourly values, the Busti Avenue UFP is similar to the UFP count at Queens but all other percentiles reflect lower UFP count. UFP is typically higher in Queens because the density of sources in this large urban area raise the average UFP above what you would find in the area around the Peace Bridge. At the 95th percentile, Busti Avenue data are similar to Queens because the data are reflecting how close the Busti Avenue monitor is to periodic high emissions from the Peace Bridge and I-190.

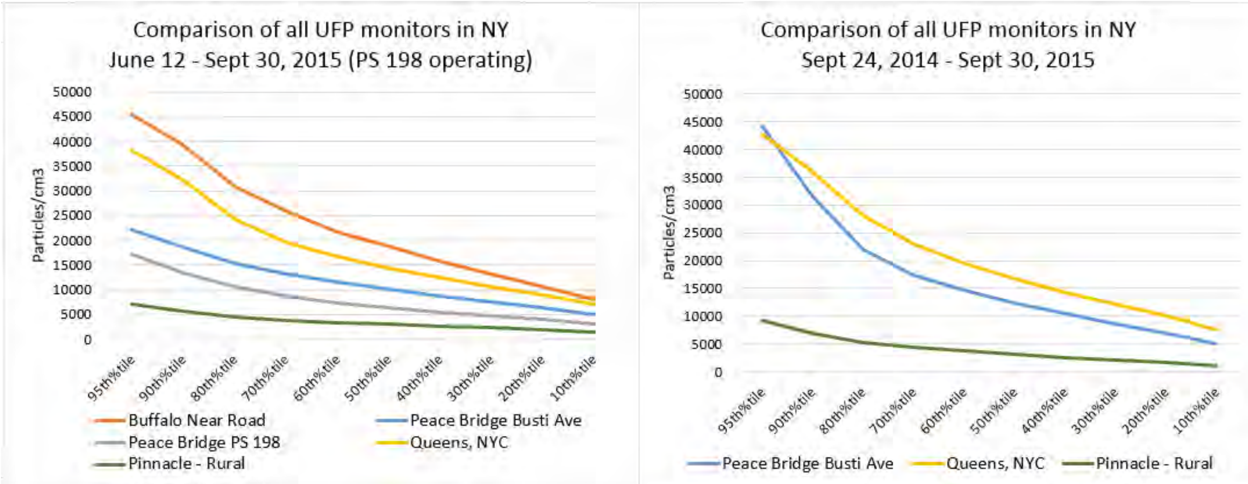

Figure 11. UFP Percentile Distribution Comparisons

Volatile Organic Compounds and Carbonyls

The air samples collected by SUMMA canister were analyzed for the presence of 43 VOCs[28] and those by cartridge were analyzed for the presence of 11 carbonyls. Twenty-five VOCs and seven carbonyls were detected with sufficient frequency (75%) to calculate a 12-month average and these averages are provided in Appendix B, Tables 1-3 along with comparisons to NYSDEC's monitoring network and health-based AGC values. For ease of visualization, comparisons to NYSDEC's network also are shown graphically in Appendices C and D. All air toxics have been included, even those with insufficient data to prepare a 12-month average. NYSDEC monitors have been grouped by land-use classification.

The results for VOCs and carbonyls typically associated with motor vehicle emissions[29] can be found in Table 5 along with a comparison to NYSDEC's air monitoring network and long-term health-based air AGC values.

As shown, the 12-month average concentration for four of the eight vehicle-related air contaminants measured at the Peace Bridge were above the long-term air AGC value. These four air toxics, all carcinogens, are 1,3-butadiene, acetaldehyde, benzene and formaldehyde. The AGC for carcinogens is set at a level that corresponds to an individual being exposed for a lifetime at the measured concentration that would add an additional cancer risk of a 1-in-a-million.[30] While above the guideline value, the concentrations found in this study were within the acceptable target risk management

[28] To learn more about uses and possible industries or other sources releasing VOCs analyzed in the study visit: Uses, Sources and Potential Exposure to Toxic Air Pollutants at: http://www.dec.ny.gov/chemical/89942.html

[29] USEPA Mobile Source Air Toxics (MSAT) accessed 12/31/2015 http://www3.epa.gov/otaq/toxics.htm. Among the eight MSAT listed in Table 5, three have been identified by USEPA as high-priority that need to be reduced due to their emissions and toxicity.

[30] This excess cancer risk is in addition to any cancer risk borne by a person not exposed to these air toxics. In general, the NYSDEC considers excess cancer risk that are below one in one million (1×10^{-6}) to be negligible and excess cancer risk that range from 1×10^{-6} to 1×10^{-5} to be acceptable.

level (1 to 10-in-a-million) used by NYSDEC. These four toxic air contaminants also were within USEPA's acceptable level of risk at a 100-in-a-million cancer risk level.

Two additional VOCs (1,2-dichloroethane and carbon tetrachloride) are above the AGC. 1,2-dichloroethane is commonly used as a chemical intermediate and as a solvent and has been detected at the same concentration in all other urban areas in New York State. Carbon tetrachloride was used historically in the production of refrigerants. Because of its long atmospheric residence time and the fact that it was phased out by the Montreal Protocol in 1996, historical uses are the primary contributors to current concentrations.

As shown in Table 5, the average concentrations for the year of monitoring found at the Peace Bridge monitor were within the range of results found at other locations in the State. This comparison is easier to see in the graphics presented in Appendix C for the VOCs and Appendix D for the carbonyls. There were a few air toxics where a single date or two of sampling provided results that are slightly higher when compared to other monitoring days or unusual in comparison to other monitoring locations in the State. For most of the air toxics where these anomalies occurred, the air toxics are generally not considered very toxic at ambient concentrations typically identified by the monitoring network.

Table 5. Average Results for VOCs Typically Associated with Motor Vehicle Emissions

Location	1,3-Butadiene (ppb)	Acetaldehyde (ppb)	Benzene (ppb)	Ethylbenzene (ppb)	Formaldehyde (ppb)	*m,p*-Xylene (ppb)	*o*-Xylene (ppb)	Toluene (ppb)
Peace Bridge	0.016	0.67	0.15	0.022	1.8	0.088	0.035	0.20
NYSDEC Network								
Adirondack State Park (rural)	na	0.34	0.077	0.0084	0.91	0.028	0.011	0.071
Brooklyn (urban)	0.042	na	0.23	0.048	na	0.20	0.071	0.38
Buffalo (near-road)	na	0.71	na	na	2.0	na	na	na
Buffalo (urban)	ns	na	0.15	0.035	na	0.15	0.056	0.31
North Bronx (urban)	0.033	0.79	0.22	0.030	2.4	0.12	0.044	0.24
Pinnacle State Park (rural)	na	na	0.10	0.0084	na	0.023	0.010	0.073
Queens (urban)	0.027	1.2	0.19	0.034	3.4	0.13	0.049	0.31
Rochester (urban)	0.016	0.56	0.14	0.039	1.3	0.11	0.067	0.20
South Bronx (urban)	0.037	0.80	0.23	0.051	2.3	0.20	0.071	0.34
Staten Island (source-sited)	0.021	0.79	0.22	0.045	1.9	0.17	0.063	0.33
Tonawanda (source-sited)	0.017	0.59	0.26	0.021	1.9	0.087	0.032	0.24
Tonawanda (suburban)	0.012	0.75	0.15	0.022	2.1	0.088	0.033	0.23
Long-Term Health-Based Air Guideline Concentrations (AGCs)	0.015	0.25	0.040	230	0.049	23	23	1300
Carcinogen	yes	yes	yes		yes			

Notes: Rochester near-road not displayed; monitor began collection on 1/6/2015.
na – Suite of chemicals not analyzed at monitoring site
ns – Insufficient number of observations for 12-month average

Community VOC Samples

Four 1-hour samples were collected by volunteers from Clean Air Coalition of Western New York. Table 6, listing the meteorological conditions during each sampling event, demonstrates that the samples were collected downwind from the Peace Bridge Complex. The results for air toxics typically associated with motor vehicle emissions[31] can be found in Table 7, along with a comparison to NYSDEC's short-term health-based air guideline concentrations (SGCs). The 1-hour sample collected on May 24, coincided with the 24-hour air sample collection at the Busti Avenue monitor. While the results are

[31] USEPA Mobile Source Air Toxics accessed 12/31/2015 http://www3.epa.gov/otaq/toxics.htm

not directly comparable because of the different sampling times, a general comparison identifies correct operability of the community sampler and whether the sample identified similar compounds within the range of results as the monitoring station. Table 7 also includes the results from the May 24th collection. The results for all VOCs detected, along with comparison to respective SGC can be found in Appendix E, Table 1.

Table 6. Meteorological conditions during sampling

Date	Start Time	Temp. (°F)	Humidity (%)	Pressure (in)	Wind Direction*	Wind Speed (mph)
5/24/2015	2:22 PM 2:27 PM	64	53	30	Southwest	6.9
9/15/2015	1:59 PM 2:08 PM	73	64	30	Southwest & west southwest	5.9

Notes: *Wind is blowing from direction provided.

Table 7. Results for VOCs Typically Associated with Motor Vehicle Emissions – Community Samples

Date/Time	Location	1,3-Butadiene (ppb)	Benzene (ppb)	Ethyl-benzene (ppb)	*m,p*-Xylene (ppb)	*o*-Xylene (ppb)	Toluene (ppb)
5/24/2015 2:22 PM	Busti Ave. at NYSDEC monitoring station	0.014	0.10	0.019	0.083	0.033	0.15
5/24/2015 2:27 PM	Columbus Parkway, North of Rhode Island St.	0.016	0.090	0.025	0.10	0.038	0.16
5/24/2015	NYSDEC – 24hr sample at Busti Ave. monitor	0.011	0.088	0.009	0.035	0.015	0.091
9/15/2015 2:08 PM	Corner Rhode Island St. and Columbus Parkway	0.025	0.14	0.063	0.25	0.077	0.22
9/15/2015 1:59 PM	Rhode Island St. 50 yards East of Busti Ave.	0.022	0.11	0.046	0.17	0.054	0.15
Short-Term Health-Based Air Guideline Concentrations (SGCs)		na	400	na	5100	5100	9800

Notes: na – A short-term health-based air concentration value has not been derived by NYSDEC at the time of this report.
The results for the NYSDEC monitor have been highlighted to differentiate it from the 1-hour community samples.

As illustrated in Table 7, all results were well below the SGCs. The 1-hour results were within a factor of four which captures the normal variability when translating a 24-hour to 1-hour modeled concentration. The results from the four community samples also are included in the figures presented in Appendix C showing comparisons between the entire year of monitoring at the Peace Bridge and NYSDEC network. As illustrated, the 1-hour samples were within the range of results for the 24-hour samples collected at the Peace Bridge monitor and NYSDEC monitoring network.

Meteorology

A summary of the meteorological parameters collected at the Busti Avenue site is presented in Table 8. The lake has a strong influence on the wind direction and the predominant wind pattern found in this study, shown in Figure 12, is very similar to the Phase 1 study. During this study, the monitor was downwind of the Peace Bridge Complex and I-190 for approximately two thirds of the time. The winds were calm (<1.0 mph) a little over 2% of the time. The average wintertime wind speed was about 66% higher than the summertime wind speed. Predominant wind direction across all seasons is from the southwest.

Table 8. Summary of Meteorological Results

Statistic	Valid Hours	Wind Direction (deg)	Wind Speed (mph)	Temp (deg F)	Relative Humidity (%)	Barometric Pressure (in Hg)
All Data: 25th percentile	9,620-9,944	163.0	3.0	33.5	60.0	29.2
All Data: Average	9,620-9,944	205.1	5.4	49.5	69.5	29.3
All Data: 75th percentile	9,620-9,944	258.0	7.0	67.3	81.0	29.4
Fall Average	2,865-2,891	203.4	5.4	55.9	68.9	29.3
Winter Average	2,146-2,154	214.7	6.8	23.0	72.4	29.4
Spring Average	1,928-2,208	208.5	5.7	43.9	67.6	29.3
Summer Average	2,681-2,691	196.7	4.1	68.3	69.2	29.2

Notes: Fall includes 2014 months and September 2015
Summer includes August 2014 and 2015 months

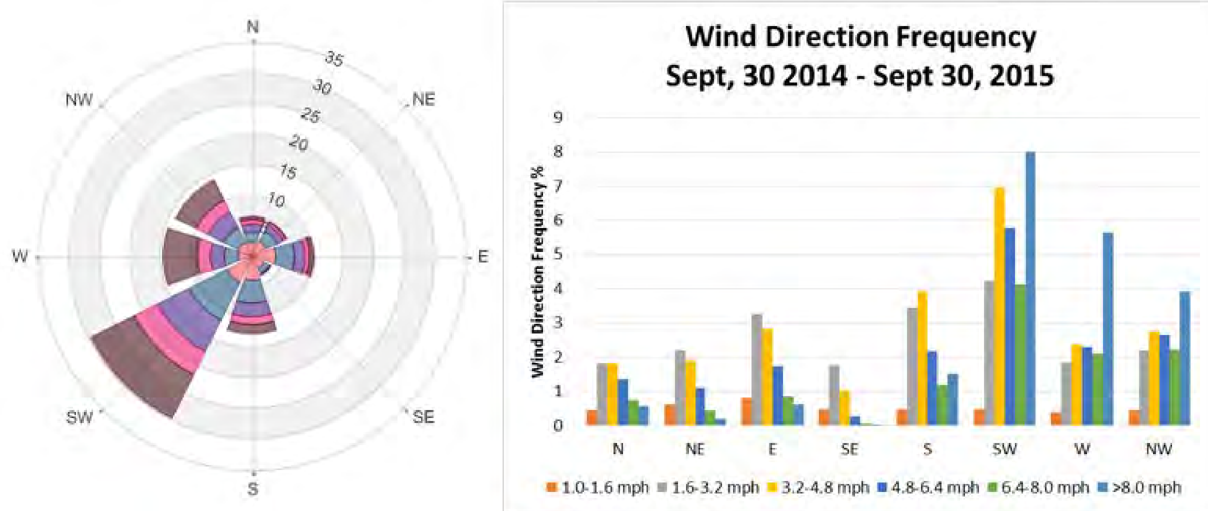

Figure 12. Wind Rose and Wind Direction Frequency Plot

A diurnal profile of the temperature by season is presented in Figure 13 and this type of data summary will be used for the interpretation of the UFP results. Since average UFP concentrations are depressed in warmer weather, the cooler temperatures in winter and spring lead to higher particle counts.

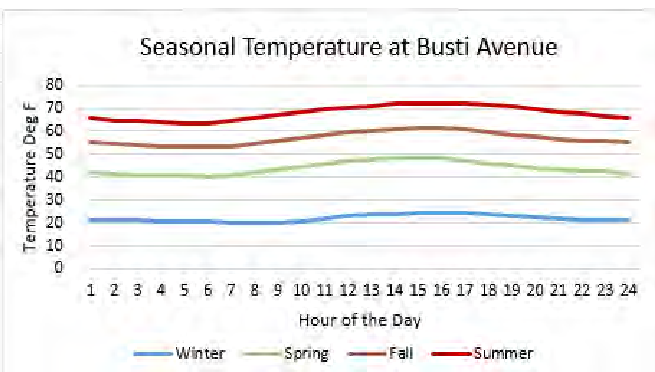

Figure 13. Diurnal temperature plot by Season

Traffic Data

Peace Bridge

As shown in Table 9, the percentage of trucks crossing in either direction ranges from 17.6 - 26.4% which was higher than the percentage of trucks on adjacent I-190 but lower than the number of trucks on I-190 (see Table 10). The number of trucks was very consistent from season-to-season while there are considerably more automobile crossings in the summer.

Table 9. Summary of Peace Bridge Traffic

Average Daily Traffic	Eastbound Autos	Eastbound Trucks	% Trucks in Eastbound Vehicles	Westbound Autos	Westbound Trucks	% Trucks in Westbound Vehicles
Fall	5,845	1,745	23.0%	5,775	1,666	22.5%
Winter	4,582	1,644	26.4%	4,445	1,599	26.3%
Spring	5,222	1,773	25.3%	5,535	1,690	23.3%
Summer	7,626	1,705	18.3%	7,796	1,653	17.6%
Annual Average	5,958	1,718	22.4%	6,026	1,654	21.5%

Notes: Annual average daily traffic (AADT) (Sept 1, 2014 - Aug 31, 2015)
Total AADT: 14,904 (automobiles, trucks and buses, east and westbound)
Fall includes 2014 months and September 2015
Summer includes August 2014 and 2015 months

The automobile diurnal plots in Figure 14, illustrate the seasonal and hourly traffic patterns for weekday and weekends. The automobile traffic was higher on the weekends with the peak period between 11:00 am to 7:00 pm. In contrast, automobile traffic on weekdays increased from 7:00 am to about 6:00 pm. Summer was higher than the other seasons for both weekdays and weekends.

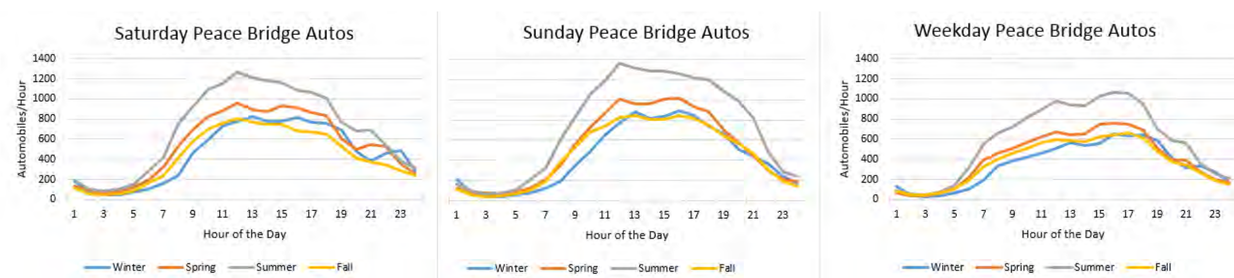

Figure 14. Diurnal Peace Bridge Automobile Traffic by Season

Diurnal profiles by season for truck crossings are shown in Figure 15 to illustrate differing traffic patterns for weekdays and weekends. Traffic volumes on weekends were lower and the number of trucks per hour was consistent throughout all four seasons, whereas the weekday truck traffic was considerably higher which reflects the commercial cross border trucking activities. The weekday truck crossing pattern increased in the morning and was steady from about 9:00 am to 7:00 pm. This pattern is very different from normal commuter automobile weekday traffic which peaks in the morning and early evening but not at midday. Automobile traffic is also higher on weekends whereas truck traffic is lower.

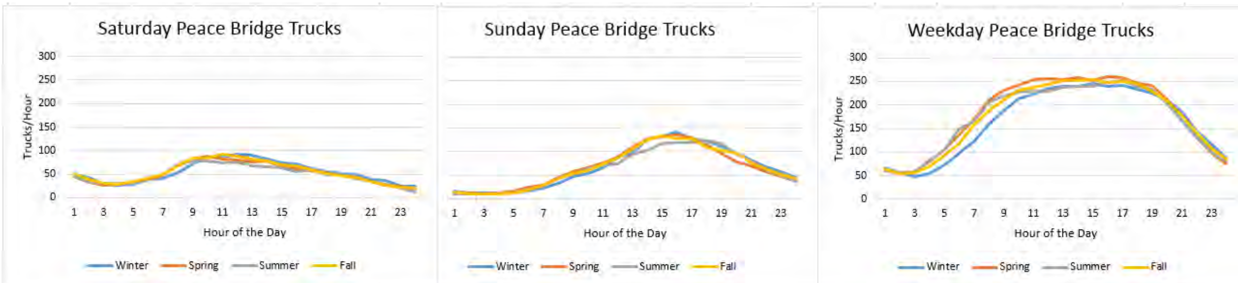

Figure 15. Diurnal Peace Bridge Truck Traffic by Season

I-190 Traffic

The overall automobile and truck traffic on I-190 was more than five times higher than the overall traffic on the Peace Bridge. The summary in Table 10 shows that the percentage of trucks on I-190 in both directions ranged from 9.7 – 10.3%. This is a lower percentage than what was determined for the Peace Bridge but the number of trucks on I-190 was a little more than twice the number of trucks on the Peace Bridge. The number of automobiles on I-190 was higher in the summer than in the other seasons though the number of trucks was fairly consistent throughout the year.

Table 10. Summary of I-190 Traffic

Annual Daily Traffic	Northbound Autos	Northbound Trucks	% Trucks in Northbound Vehicles	Southbound Autos	Southbound Trucks	% Trucks in Southbound Vehicles
Fall	35,312	3,975	10.1%	34,808	3,992	10.3%
Winter	31,621	3,506	10.0%	30,622	3,517	10.3%
Spring	35,671	3,903	9.9%	36,166	4,008	10.0%
Summer	39,201	4,203	9.7%	39,696	4,273	9.7%
Annual Average	35,349	3,888	9.9%	35,239	3,945	10.1%

Notes: Annual average daily traffic (AADT) (Sept 1, 2014 - Aug 31, 2015)
Total AADT: 78,421 automobiles and trucks, east and westbound
Fall includes 2014 months and September 2015
Summer includes August 2014 and 2015 months
Northbound data from milepost 6.2
Southbound data from milepost 6.4

The hourly automobile travel totals were averaged by day of the week to create diurnal plots to illustrate differing traffic patterns for weekdays and weekends as shown in Figure 16. Traffic volumes on weekends tend to be lower and consistent throughout the early afternoon. Whereas, automobile traffic on weekdays shows a distinct early morning and afternoon commuting pattern including a decrease in midday traffic. The automobile traffic was higher in the summer on weekdays and weekends.

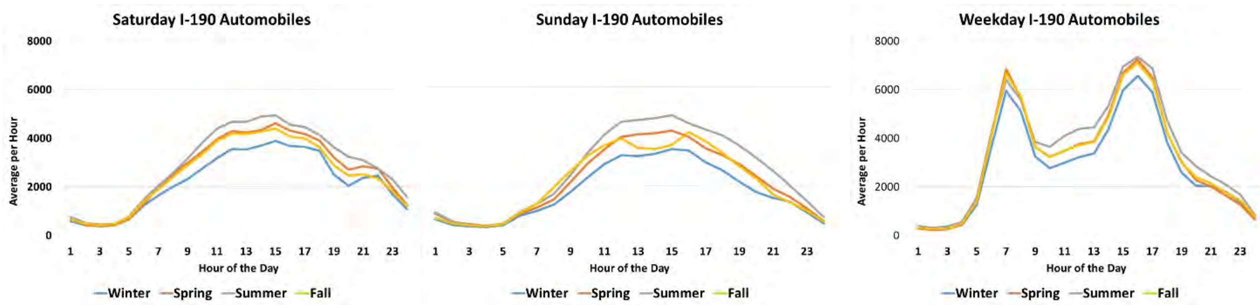

Figure 16. Diurnal I-190 Automobile Traffic by Season

The hourly truck travel totals were averaged by day of the week to create diurnal plots to illustrate differing traffic patterns for weekdays and weekends as shown in Figure 17. Traffic volumes were lower on the weekend and the number of trucks per hour was fairly consistent throughout all four seasons. The weekday truck traffic was considerably higher which is consistent with commercial trucking activities. The weekday truck travel pattern increased in the morning and is fairly steady from about 8:00 am to 4:00 pm. The number of trucks was lower in winter on weekdays.

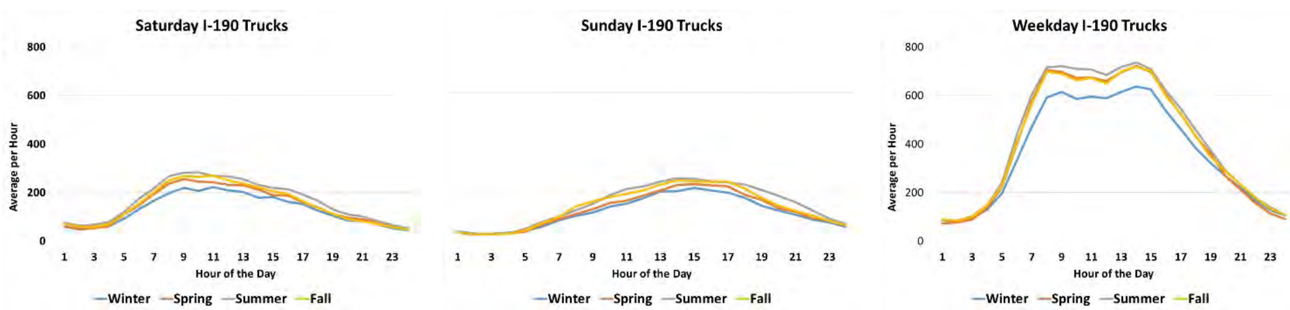

Figure 17. Diurnal I-190 Truck Traffic by Season

Sporting Event

The stakeholders asked, during the planning stages of this study, about air quality when sporting events or holidays alter traffic patterns on the Peace Bridge. Three sporting events were evaluated, two Sunday Buffalo Bills games (September 21 and November 30, 2014) and a Wednesday evening home game between the Buffalo Sabres and Toronto Maple Leafs (April 1, 2015).

Figure 18 illustrates automobile and truck traffic patterns during the Buffalo Bills home game which was played on September 21, 2014. The truck traffic was typical for both the eastbound and westbound directions for a Sunday but the automobile traffic was higher than expected for a Sunday. Eastbound automobile traffic increased sharply in the morning before the game and westbound traffic increased through the afternoon peaking after game time. Automobile traffic shows that Canadian fans cross the bridge to attend Buffalo Bills home games.

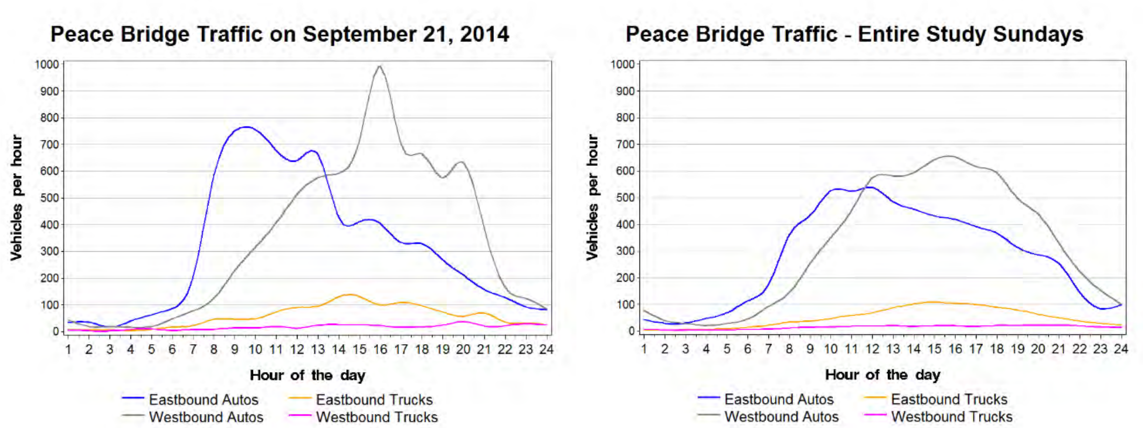

Figure 18. Diurnal Traffic Pattern during Buffalo Bills Home Game

Comparisons to $PM_{2.5}$ and BC were performed. Because this sporting event did not lead to an increase in truck traffic, no increases in concentrations of $PM_{2.5}$ and BC were found. UFP were not collected at the Busti monitor on this date.

Two other sporting events were analyzed, a Buffalo Bills home game on Sunday, November 30, 2014 and a Buffalo Sabres home game with the Toronto Maple Leafs on Wednesday, April 1, 2015. For both events, the increase in automobile traffic didn't lead to an increase in pollutant concentrations or UFP counts. The analysis for these three events can be found in Appendix F.

Integration

This section combines the individual pollutant results with traffic information to evaluate the relationship between traffic patterns, vehicle type and air pollutant data. In this study, BC and UFP were used as indicators of truck emission impacts on neighborhood air quality. While other sources release these two pollutants, the primary weekday sources in this area are vehicles. BC and UFP are both particles and rapidly decrease with increasing distance from the source, allowing them to serve as good markers for nearby emission sources. $PM_{2.5}$ is generally, not a good marker for nearby sources because the concentrations primarily originate from sources outside of this area.

Figure 19 is a diurnal plot of the regional and the local increment of $PM_{2.5}$ by weekend days and weekdays for the full year. Because a maximum impact and a background monitor have been installed for this study, the regional (background) concentrations for $PM_{2.5}$ can be removed and the local incremental impacts of $PM_{2.5}$ at Busti Avenue can be evaluated. The local increment is defined as the difference between the $PM_{2.5}$ at the local maximum site (Busti Avenue) and the background site (PS198). This amount of

$PM_{2.5}$ can be thought of as the amount that is generated by the nearby sources that impact Busti Avenue but do not also impact PS198.

The pattern of the local increment of $PM_{2.5}$ can be compared to the weekday truck traffic pattern on the Peace Bridge as shown in Figure 15. The weekday truck traffic increases in the early morning and decreases around 7:00 pm which matches the diurnal profile for the $PM_{2.5}$ increment. This comparison suggests that automobiles and trucks during the week, may be the contributors to local impacts at the Busti Avenue monitor. Because the truck volume decreases and automobile volume increases on the weekend and this is not reflected in the local $PM_{2.5}$ increment, it is likely that trucks are a greater contributor to $PM_{2.5}$ local impacts.

There are hours on the weekend days when the local increment concentrations are negative and this reflects higher $PM_{2.5}$ concentrations at PS198 than Busti Avenue. This may be due to the increased use of fireplaces, lawn mowers and outdoor grills on the weekends in the neighborhood and reduced truck traffic on the Peace Bridge and I-190. This contribution is smaller than the amount measured on weekdays, as illustrated in Figure 19.

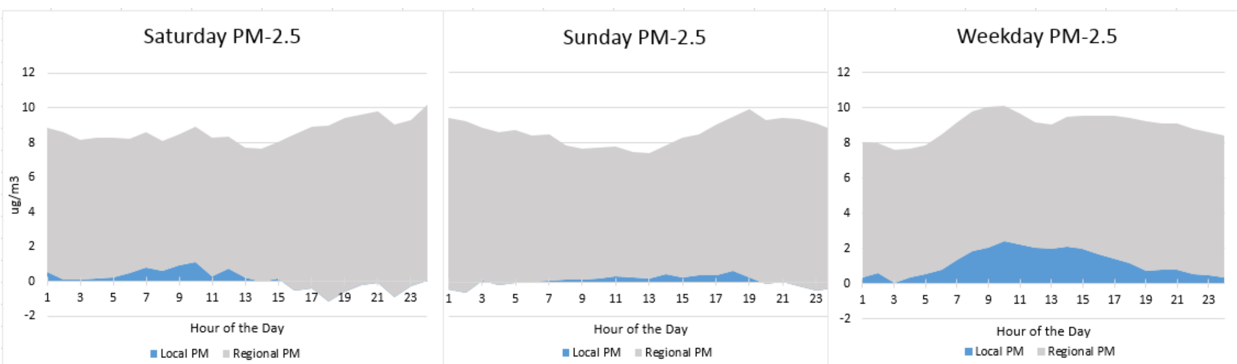

Figure 19. Diurnal $PM_{2.5}$ Increment by Day of the Week
Notes: Regional $PM_{2.5}$ data from PS198
Local $PM_{2.5}$ increment is determined by subtracting PS198 from Busti Avenue

As shown in Figure 20, the diurnal patterns for BC and UFP at the Busti Avenue site are very similar which suggests that the pollutants are coming from the same source. As discussed in the Data Summaries section, BC concentrations at Busti Avenue are 50% higher and UFP counts in the summer at Busti Avenue are approximately 40% higher as compared to PS198.

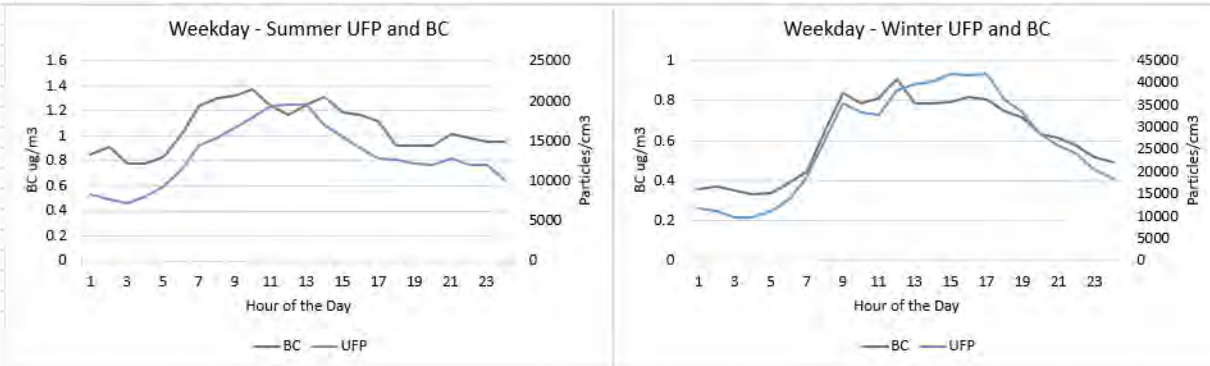

Figure 20. Weekday Diurnal Profiles for UFP and BC at Busti Avenue by Season

Using the technique of subtracting the concentration results between the two monitors allows for the localized increment of BC and UFP to be estimated. Figure 21 shows that the weekend local increment for both diesel-emissions indicator pollutants increases in the morning at the same time as the $PM_{2.5}$ increment. This suggests that during the summer, the $PM_{2.5}$ increment represents the same sources as the indicator pollutants BC and UFP. The lack of any other feasible source of BC and UFP upwind of Busti Avenue lead to the conclusion that the local increment of $PM_{2.5}$ on weekdays at Busti Avenue is due to both automobile and truck emissions.

In this study, UFP was only monitored at both sites during the summer months when UFP levels are typically lower than at other times of the year. In Figure 21, the weekday summertime UFP increment is less than 9,000 particles per cubic centimeter which is a relatively small contribution from the nearby sources. In comparison the 10th percentile category from all monitors collecting UFP counts in the State during the summer was less than 10,000 particles per cubic meter, presented in Figure 11.

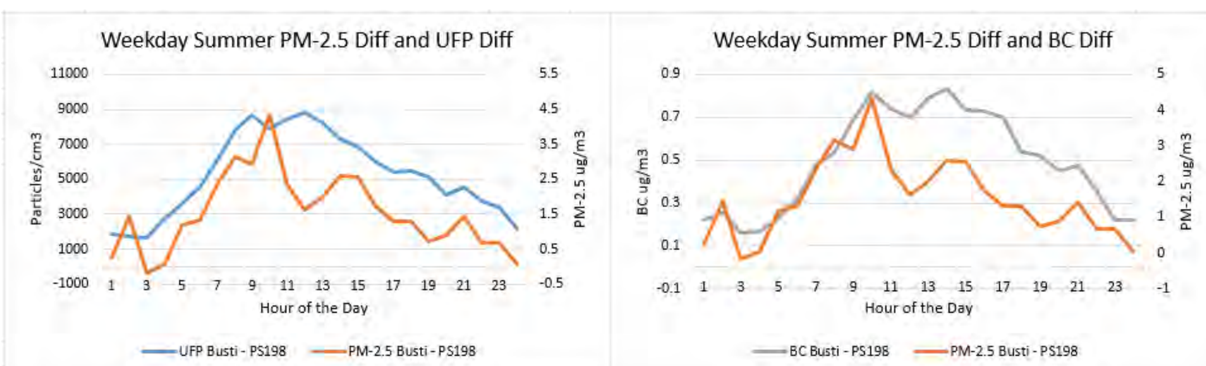

Figure 21. Diurnal Comparison of $PM_{2.5}$ Difference with Indicator Pollutants Difference for UFP and BC

Notes: Difference calculated as Busti Avenue hourly average minus PS198 hourly average

Diurnal plots can include traffic data as well. The shape or profile of the diurnal plot provides a way of comparing the volume of vehicle traffic per hour with the hourly pollutant measurements at Busti Avenue. If the vehicle diurnal patterns are similar to the pollutant pattern then this information suggests emissions from vehicles contribute to the pollutant measurements.

In Figure 22, the diurnal patterns of automobiles and trucks are compared to UFP counts. The results are presented for the weekend and weekdays in the winter when UFP are more stable which leads to higher counts. As shown, the patterns for both vehicle types were similar to the diurnal profile of UFP.

As illustrated, there were more automobiles on weekends than weekdays. If automobiles were the primary contributors, then the UFP counts should be higher on the weekends, which was not the case for the winter profile. UFP was proportional to the number of trucks on weekdays and Sundays but not on Saturdays in the winter. It is likely that there were other sources of UFP such as residential activities (e.g., wood burning and grilling) on Saturdays. UFP are released from both automobiles and trucks but UFP releases from trucks appear to be more dominant at the Busti Avenue monitor. Other research on UFP concentrations at a busy intersection (28,000 vehicles per day) support this conclusion. A recent study concluded that diesel- and gasoline-powered vehicles each contributed equally to fresh UFP mass concentrations during the winter, even though gasoline-powered vehicles made up more than 90% of the vehicles observed at the intersection.[32]

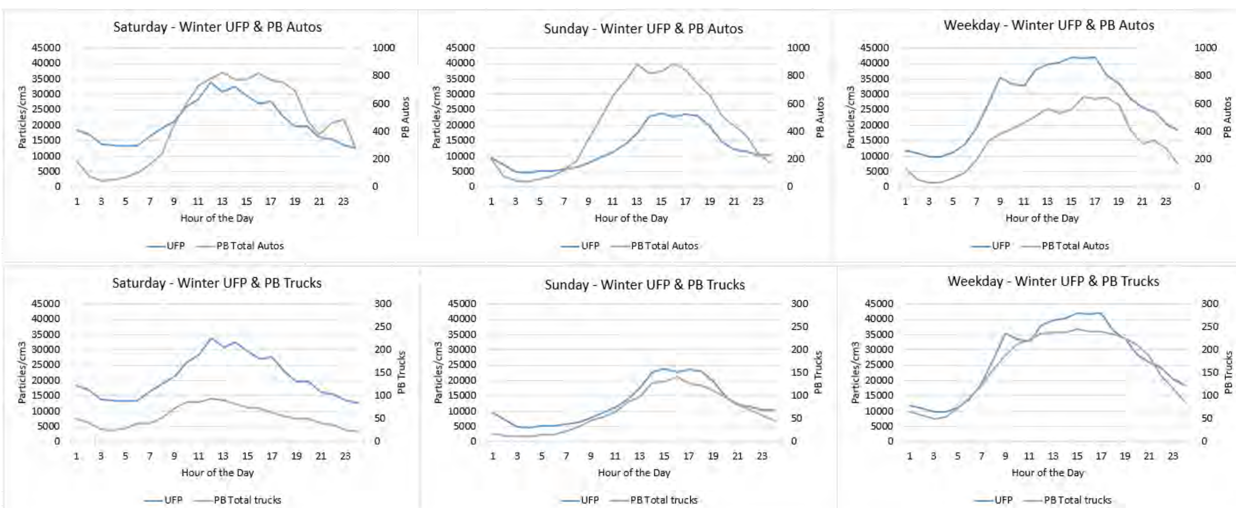

Figure 22. Winter Diurnal UFP and Automobiles and Trucks on the Peace Bridge

In Figure 23, comparisons are made between BC concentrations and the number per hour of automobiles and trucks on the Peace Bridge on the weekend and weekdays. The third series of graphs, illustrates the difference in BC concentration between the Busti Avenue and PS198 monitor which characterizes the local increment at Busti. As shown, the BC concentrations exhibited little resemblance to the automobile diurnal profile. Whereas, the concentrations of BC were higher during the weekdays which corresponds to higher truck traffic volume. Heavy-duty diesel trucks emit much more BC

[32] Johnston, M.V., Klems, J.P., Zordan, C.A., Pennington, R.M. & Smith, J.N. (2013). Selective Detection and Characterization of Nanoparticles from Motor Vehicles. Health Effects Institute Research Report Number 173. Health Effects Institute, Boston, MA.

than gasoline-powered automobiles[33] and the concentrations of BC appear to be proportional to the number of trucks on weekdays and to a lesser degree on Sunday. The BC levels at Busti are elevated on Saturday and early Sunday morning in contrast to the volume of truck traffic which is elevated during daytime. This is likely due to other sources of BC in the area including residential activities (e.g., wood burning and grilling).

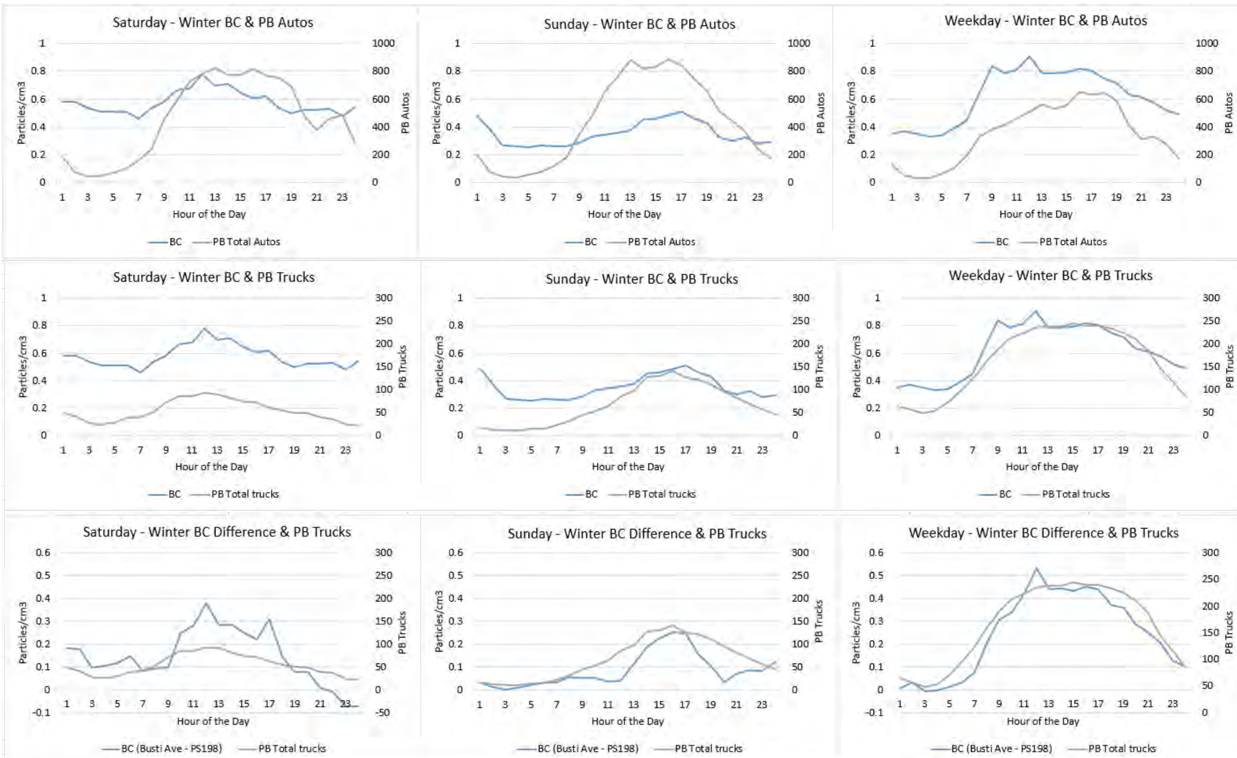

Figure 23. Winter Diurnal BC and Automobiles and Trucks on the Peace Bridge

Further analysis of $PM_{2.5}$, UFP and BC was conducted by evaluating peak concentrations represented by hourly results above the 90th percentile. The graph shows the frequency of peak concentrations separated by wind direction to differentiate contributions between sources in different upwind directions.

As illustrated in Figure 24, $PM_{2.5}$ concentrations are similar across all wind directions for weekend and weekdays at the Busti Avenue monitor. This comparison suggests that the weekday commute and higher truck volume does not contribute to localized $PM_{2.5}$ peaks in concentration. As discussed previously, regional transport is primarily the largest source for $PM_{2.5}$ concentrations in this area. The higher frequency of peaks is similar between the Busti monitor and PS198 monitor. Slightly higher number of peak concentrations occurred at PS198 on the weekends from the south southwest and southwest directions. $PM_{2.5}$ sources on the weekends from these directions are most

[33] US Environmental Protection Agency, Black Carbon – Basic Information. Accessed 3/10/16 http://www3.epa.gov/blackcarbon/basic.html

likely sources that are close to the monitor and may include lawn mowing and outdoor cooking (e.g., grills, woodfires) at parks and local residences.

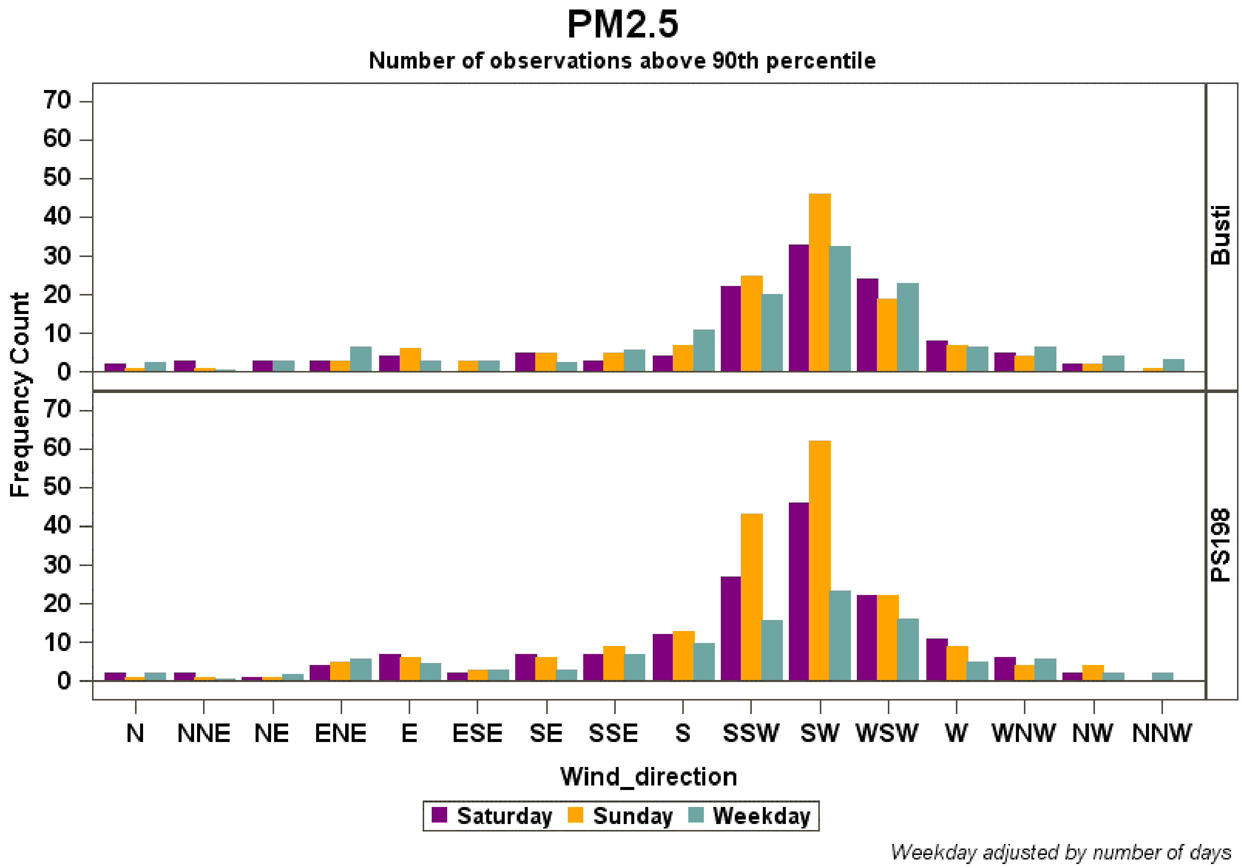

Figure 24. $PM_{2.5}$ - Wind Direction for High Concentrations

In constrast, for UFP which is source oriented to a greater extent than $PM_{2.5}$, wind direction plays a critical roll in higher particle counts as shown in Figure 25. In looking at the full year results for the Busti monitor, when winds are from the southwest and west southwest directions (the location of the PBC) the highest UFP counts are recorded. Winds from other directions, south and north of the PBC, which would include I-190 vehicle emissions, show lower but noticeable UFP counts. These comparisons suggest that I-190 is a source for UFP but not to the same degree as the PBC. Additionally, higher UFP counts are apparent for weekdays which further illustrates that emissions from trucks contribute more to particle counts than automobiles. Automobile traffic is higher on the weekend. Overall, these comparisons show that during the week, truck traffic on the Peace Bridge and to a lesser degree on I-190 contribute to hours with high particle counts.

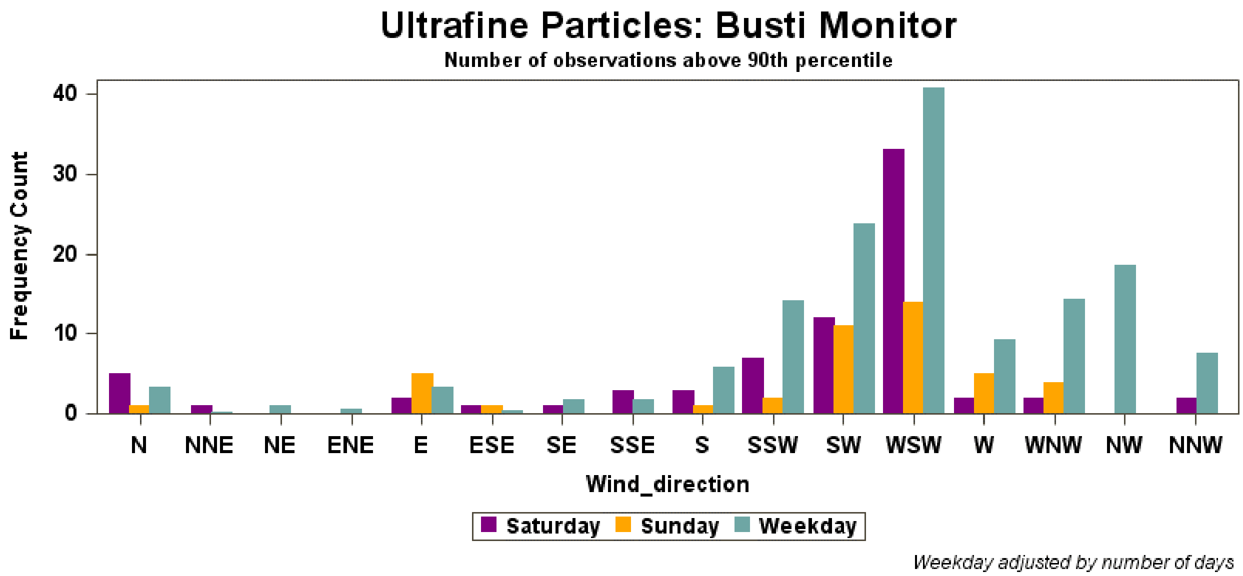

Figure 25. Ultrafine Particles Busti Monitor September 2014 - September 2015

This same analysis was conducted for the 2015 summer months when both Busti and PS198 UFP monitors were operating. As discussed previously, UFP counts are lower in the warmer periods of the year due to removal processes related to temperature and humidity. As shown in Figure 26, higher particle counts at the Busti monitor were found during the week and in the downwind direction from the PBC. Whereas, the higher particle counts at PS198 were found across the days of the week and in various wind directions which suggests that vehicle emissions from PBC and I-190 have little influence on particle counts at PS198.

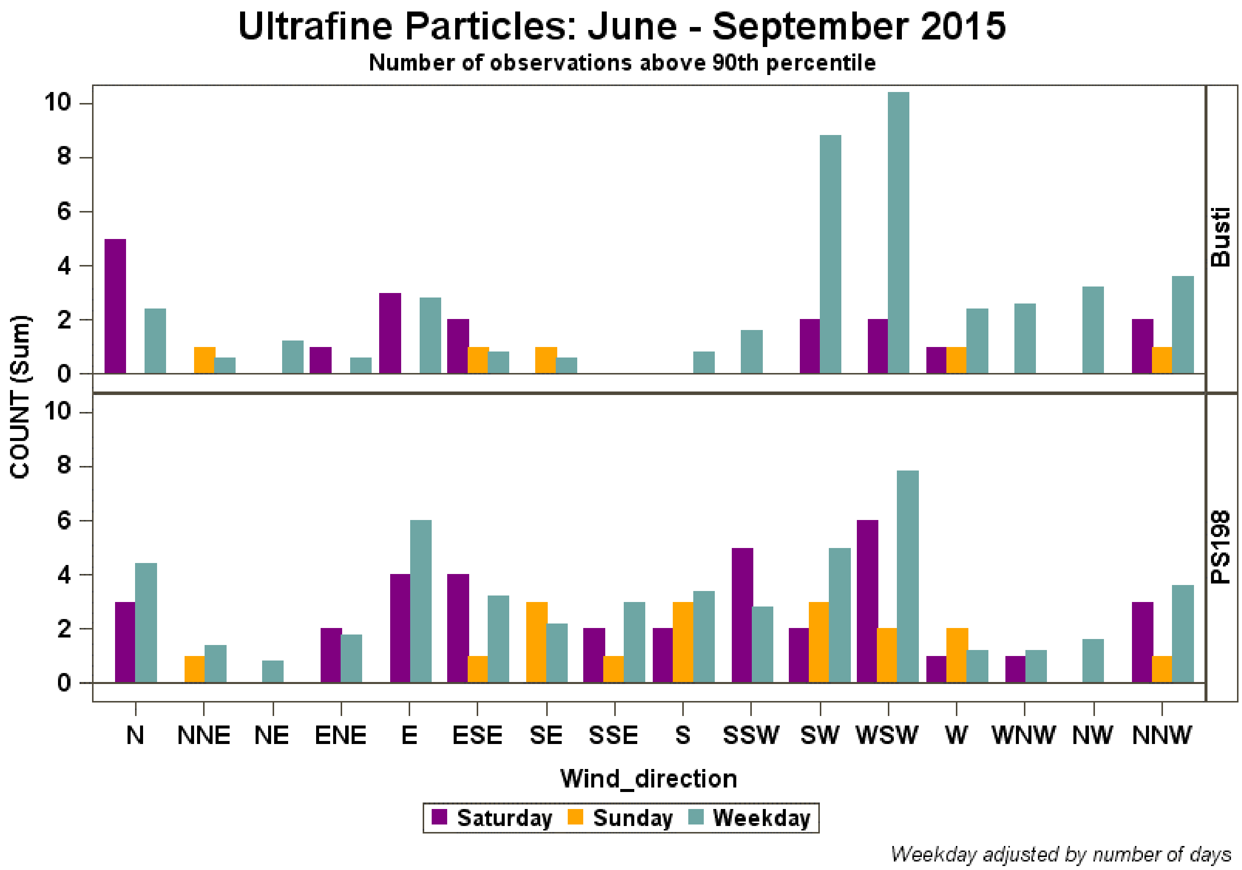

Figure 26. Ultrafine Particles - Wind Direction for High Concentrations

Further analysis looking at wind direction for peak concentrations was conducted for BC. As illustrated in Figure 27, more occurrences of concentrations above the 90th percentile were observed when the Busti monitor was downwind of the PBC during weekdays. Some contributions from the south southwest and south directions are noted which would capture emissions from I-190. Whereas BC concentrations at the PS198 monitor were from a variety of directions and the weekdays and weekend data were similar.

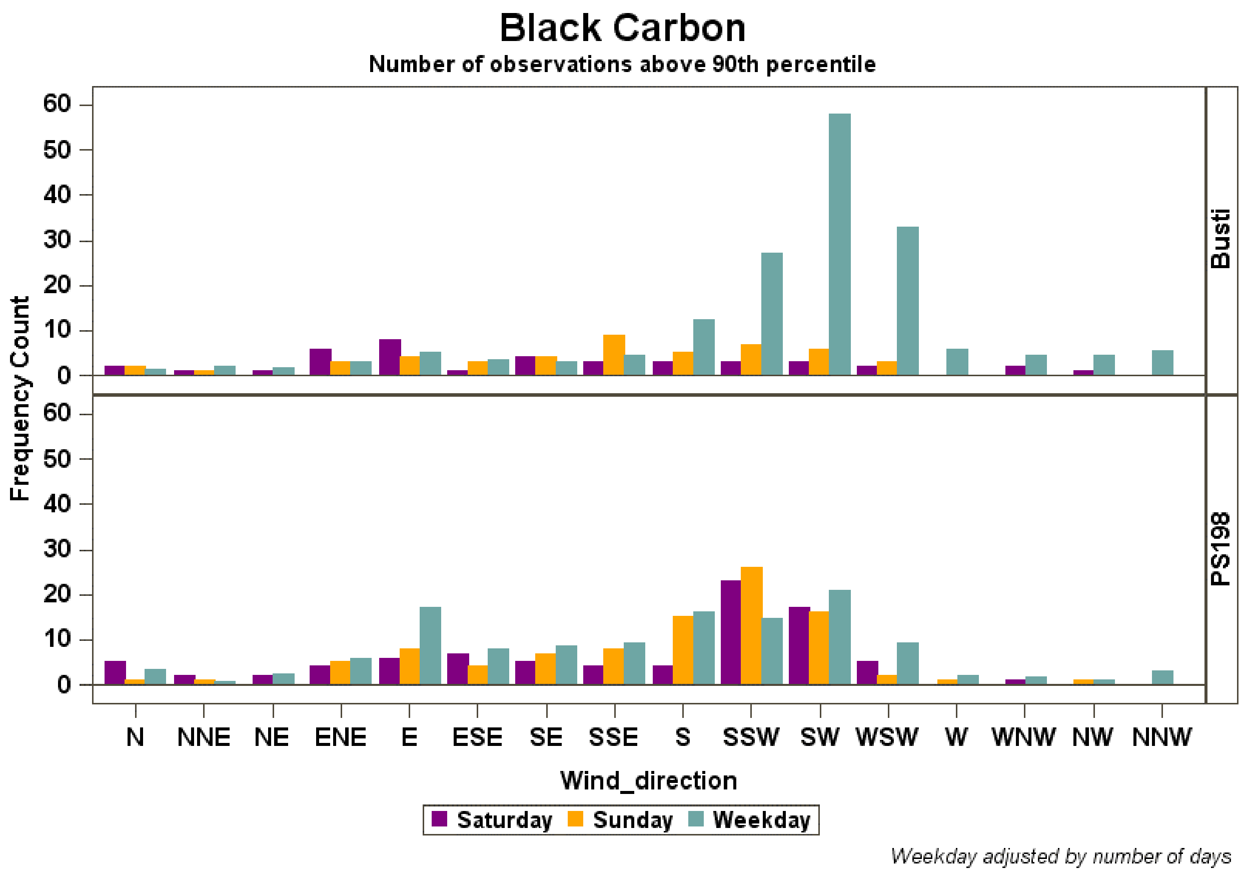

Figure 27. Black Carbon - Wind Direction for High Concentrations

In summary, truck traffic at the PBC and to a lesser degree from I-190 contribute to local UFP counts and BC concentrations. Truck traffic at the PBC contributes a small amount to local $PM_{2.5}$ concentrations during the week but does not appear to be a factor in producing high hourly $PM_{2.5}$ concentrations.

Conclusions

This study provides valuable information for the community and the USEPA on the impact of mobile source emissions on the neighborhood adjacent to the Peace Bridge. The core objectives of this study were to evaluate the traffic factors – time of day, day of week, volume of automobiles and trucks and to correlate these data with pollutant concentrations of $PM_{2.5}$, BC and UFP particle counts. Other objectives were to determine whether the annual average concentrations of VOCs and carbonyls were of public health concern and to provide the community with samplers to evaluate whether short-term concentrations of VOCs were of public health concern. A summary of the results as they apply to each study objective is provided below.

Objective 1:

The first study objective was to monitor air quality for a period of one year. Community members requested the study include the summer months when traffic on the Peace Bridge was highest and include enough data to compare results to annual air quality standards and guideline concentrations. Additionally, they requested a full year to capture the impact of unusual traffic events such as holidays and sporting events.

The monitoring portion of the study began in August 2014 and extended through September 2015. Because the initial deployment of monitoring equipment began over the course of a couple weeks, the full monitoring period extended longer than 12 months to the end of September 2015. This was done to coincide with USEPA's AQS quarterly reporting and inclusion of September completes the 3rd quarter of 2015. The Phase 2 study data, including the results for $PM_{2.5}$, BC and UFP, were permanently archived in the USEPA's AQS database which allows researchers access to evaluate the relationship between near-road emissions and community exposures.

The pollutant data collected in the Phase 2 study and traffic data obtained are described and explained in the Instrumentation and Data Summaries section. Focus is placed on each individual pollutant to separately evaluate community concentrations and relationships with traffic patterns. The evaluations included tables of summary statistics and plots of seasonal diurnal concentrations. The hourly study data were distributed to community stakeholders over the course of the study.[34]

Included in Objective 1 was a request to determine the impact of unusual traffic events due to occurrences such as sporting events and holidays. A few examples were presented in the Data Summaries, Peace Bridge Traffic section. Two Buffalo Bills football home games were played on September 21 and November 30, 2014 and a Sabres hockey home game with the Toronto Maple Leafs was played on April 1, 2015. While automobile traffic increased in response to the sporting event, truck traffic was not affected and pollutant levels did not reveal a corresponding change in concentration.

Objective 2:

The second data objective was to determine the impact of mobile source emissions on the neighborhood. In this analysis, the pollutant and traffic data were brought together in the Data Analysis and Integration section. This section focused on the impact of mobile source emissions on ambient $PM_{2.5}$ concentrations and also looked at the impact of two diesel-emissions indicator pollutants associated with mobile sources, BC and UFP.

The network design for the Phase 2 study involved installing two sites in the neighborhood. The Busti Avenue site is considered to represent the maximum impact from the mobile source emissions from the Peace Bridge and I-190 and PS198 represents the urban neighborhood with negligible impacts from Peace Bridge and I-190.

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[34] These files are available by request: dar.web@dec.ny.gov.

The analysis used $PM_{2.5}$ and the mobile source indicator pollutants BC and UFP, along with comparisons to traffic patterns to determine when and how much of these pollutants originated from vehicles on the Peace Bridge and I-190. The indicator pollutants were selected for this study because they are emitted primarily from diesel-powered vehicles, can be reliably measured, have few competing sources and the community had interest in UFP. The concentration differences between Busti Avenue and PS198 for $PM_{2.5}$, BC and UFP were used to determine the local increment at Busti Avenue. Diurnal plots were used to determine if the average hourly concentration of these pollutants were similar to the average hourly number of automobiles and trucks on the Peace Bridge.

The results of these analyses for $PM_{2.5}$ show that the primary contribution to $PM_{2.5}$ concentrations at both monitoring sites is from sources outside of the region and that concentrations measured at both monitors are well below daily and annual NAAQS. Although the $PM_{2.5}$ concentrations at Busti were approximate 10-20% higher than at PS198, the maximum hourly local increment was about 2.5 $\mu g/m^3$. This represents a relatively low contribution of $PM_{2.5}$ to the nearby community from mobile sources on Peace Bridge and I-190. Although most $PM_{2.5}$ concentrations in the State are higher in the summer, the concentrations in this location were higher in the winter. The weekday hourly concentrations were relatively consistent at both monitors with a slight increase in the summer around mid-morning at Busti. Higher concentrations for $PM_{2.5}$ were found during the day at the Busti monitor compared to the near-road monitor which is likely due to higher percentage of heavy-duty diesel vehicles on the Peace Bridge and I-190.

BC concentrations at Busti Avenue were about 10% the mass of $PM_{2.5}$ concentrations measured at the same site. BC is around 50% higher at Busti Avenue than PS198 consistent with higher diesel emissions near Busti Avenue than PS198. This is expected since the concentration gradient for BC diminishes quickly downwind from a primary source. Busti Avenue has higher BC concentrations than PS198, the background site. Early morning concentrations are low and peak shortly after the morning commute with a similar profile for both the winter and summer commutes. BC concentrations are higher in the summer than the winter. BC concentrations correspond better with Peace Bridge truck traffic volume on the weekdays and to a lesser degree on Sunday. The relationship with automobiles was not readily apparent.

Busti Avenue UFP counts are about 40% higher than PS198 for the four months of simultaneous monitoring in the summer and September of 2015. This is not unexpected since the concentration gradient for UFP diminishes quickly downwind from a primary source. The summer UFP counts are about 50% of the winter values at Busti Avenue which indicates that summertime meteorology favor UFP degradation. Comparison between UFP monitors at other locations in the State is challenging because the monitors are sited at varying distances from roadways with different volumes of daily traffic and the proximity of the monitor to the source greatly affects the particle counts. Our study found that the results at Busti and PS198 were not unusual in comparison to the results from other monitors in the State.

Evaluations of $PM_{2.5}$, BC and UFP data with wind direction showed that truck traffic at the PBC and to a lesser degree from I-190 contribute to local UFP counts and BC concentrations. Truck traffic at the PBC contributed a small amount to local $PM_{2.5}$ concentrations during the week but does not appear to be a factor in producing high hourly concentrations.

Objective 3:

The third study objective was to determine how the levels of VOCs and carbonyls in the Peace Bridge community compare with NYSDEC's guideline concentrations.

Motor vehicles are a large source of air toxics, including VOCs and carbonyls, both by primary emissions and secondary formation. The analysis of the 1-year of monitoring data found vehicle-related air toxics, acetaldehyde, 1,3-butadiene, benzene and formaldehyde to be greater than their respective health-based long-term air guideline concentrations. However, these four air toxics are consistently above long-term air guideline concentrations in all locations of the State – including most rural locations in State parks – therefore, the findings in this study are not unusual, nor higher than similarly sized metropolitan areas. Additionally, the results for these four air toxics are within NYSDEC's risk management guidelines and confirm the ubiquitous nature of these vehicle-related air toxics as they are found throughout the State.

It is not possible to directly compare the results of the Phase 2 study with previous studies of air toxics performed in this neighborhood. In the Spengler et al. study of air toxics from vehicle emissions at the Peace Bridge, the samples were collected over 12-hours for two winter monitoring sessions and one summer session and the researchers used different sampling and analysis methods for VOCs but the methods for carbonyls were similar.

Objective 4:

The fourth study objective was to include the community in data collection. The community was concerned that air quality might be worse when there was an unusual traffic event or at a time when they could detect the odor of vehicle emissions. The NYSDEC VOC and carbonyl samples were collected over a 24-hour period. Community participants wanted to determine if sampling for 1-hour intervals could potentially capture elevated concentrations of VOCs during traffic events. The results from the community sampling for VOCs are included in this report.

Because the community samples are below the short-term air guideline concentrations and the comparisons to other monitoring data reveal nothing unusual, staff concluded that the measured results for the air toxics from this short-term assessment would not be considered a potential health threat or an immediate public health concern.

Summary

The Phase 2 study is complete and the four study objectives have been met. Data were collected at two locations within the community for more than a full year. The impacts of mobile source emissions on the neighborhood next to the Peace Bridge were quantified and community members were able to collect their own VOC, UFP and $PM_{2.5}$ data. Community members may decide to release the UFP and $PM_{2.5}$ data they collected under a separate report.

The Phase 2 study showed a modestly higher increase in $PM_{2.5}$ concentrations in the neighborhood closest to the Peace Bridge. The pattern of daily automobile and truck traffic on the Peace Bridge correlated well with the time of day when $PM_{2.5}$ concentrations were elevated nearby. All monitored concentrations of $PM_{2.5}$ were below ambient air quality standards.

BC concentrations correspond better with Peace Bridge truck traffic volume on the weekdays. Analysis for UFP found that increases in automobile and truck traffic contributed to higher UFP counts at the site closest to the Peace Bridge with higher UFP counts from trucks during the week. The UFP counts and BC across the monitoring period for both sites was lower than corresponding measurements at a near-road monitor in NYSDEC's network. Results for both BC and UFP suggest they served as appropriate indicators of diesel-powered vehicle emissions on weekdays.

Analysis of the VOC and carbonyl data collected for the full year revealed concentrations of motor vehicle emissions commonly found in other similarly sized metropolitan areas. The community VOC samples were well below respective health-based guideline concentrations.

The USEPA in recent years, has begun studying near-road community exposures with greater intensity. USEPA requires near-road monitoring for nitrogen dioxide, carbon monoxide and $PM_{2.5}$ in cities over one million people. The agency also recommends states collect UFP and BC data at near-road monitoring sites and encourages states to submit these data to the USEPA so it can be used by health researchers. This is important because the USEPA sets air quality standards, approves the locations for air monitors and establishes emission limits for motor vehicles. Data from the NYSDEC and the other monitoring networks across the country are used by the USEPA to further their understanding of the impact of mobile source emissions and the adequacy of motor vehicle emission regulations. This information is used in tandem with health effect studies to evaluate the adequacy of the current national ambient air quality standards every five years. The Phase 2 study results have already increased the USEPA's understanding of the wintertime behavior of UFP in cold climates. The NYSDEC will continue to collect data focused on mobile source emissions at the near-road monitors established in Buffalo, Rochester and in Queens (New York City). These results along with the findings from the Phase 2 study will provide health researchers with the information needed to investigate linkages between near-road vehicle emissions and effects on human health.

Limitations

The purpose of this study was to respond to community concerns with a year-long monitoring study for specific pollutants related to motor vehicle emissions with emphasis on looking at the impact from diesel-powered vehicles on the Peace Bridge community. The following are the limitations of this study.

- I-190 traffic data obtained from the NYS Thruway Authority included vehicle length and not vehicle type. For this study, diesel powered trucks were assumed to be any vehicle longer than 20 feet. This classification may include some gasoline-powered vehicles in the truck category and it may omit diesel vehicles that are less than 20 feet in length.
- Analysis did not include an examination of the sensitivity of monitored concentrations to the hours of vehicle idling.
- Analysis did not isolate individual factors that simultaneously affect pollutant concentrations such as wind direction and speed and traffic patterns.
- The data collected in this study cannot determine which specific pollutant is responsible for health impairments or asthma in the area but it can help determine which vehicular profiles on Peace Bridge and I-190 correspond better with pollutant concentrations and particle counts in the neighborhood.
- The risk estimates in this study do not account for other sources of exposure such as indoor or occupational. Additionally the risk estimates assume that people reside at the monitor location and that these values are not attenuated by time spent at other locations (such as school, work). This study is not able to determine an individual's overall exposure.
- Conservative cancer risk estimates have been provided in this study for the air toxics, which assumes continuous exposure for 70 years (365 days per year, 24 hours per day) at the monitor locations and that the monitor concentrations remain constant for 70 years. In addition, all air toxics with a cancer risk associated with them are based upon the upper-bound excess lifetime cancer risk resulting from continuous exposure to an air contaminant. The use of an "upper limit" means that the true risk of developing cancer from exposure is not likely to be higher and may be lower than the estimates provided in this study.

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Appendix A - Method for Interpreting VOCs and Carbonyls

NYSDEC's Air Toxics Monitoring Network

NYSDEC has operated an air toxics monitoring network across the State since 1990 for the purpose of determining human exposure and health risks from toxic air contaminants, commonly referred to as air toxics. NYSDEC established the network to support four major objectives:

- Establish trends and evaluate the effectiveness of air toxic emissions reduction strategies.
- Characterize ambient concentrations (and deposition) in local areas. Air toxics often originate from local sources and can concentrate in relatively small geographical areas, producing the greatest risks to human health.
- Provide data to support, evaluate, and improve air quality models. Air quality models are used to develop emission control strategies, perform exposure assessments, and assess program effectiveness.
- Provide data to support scientific studies to better understand the relationship between ambient air toxics concentrations, human exposure, and health effects from these exposures.

NYSDEC's air toxics monitoring network is designed to measure an average exposure over the course of a year. Samples are collected over a 24-hour period, on a one-in-six day schedule. Over the course of this Study, the statewide network consisted of 12 VOC and 10 carbonyl monitors with 12-months of data. NYSDEC compared air toxics monitoring data from the network to results obtained in the Peace Bridge neighborhood to provide a perspective on how air quality in the neighborhood compares with other locations in the State.

It is generally known that areas with higher population densities have more sources of air toxics such as cars, trucks, gas stations and dry cleaners. NYSDEC grouped the monitors by land-use classification into the following categories: source-sited, near-road, urban, suburban and rural.

Interpretation of Results

NYSDEC compared the one-year monitoring results for both VOCs and carbonyls to health-based annual guideline concentrations (AGCs) established by NYSDEC to assess whether the results were of public health concern. NYSDEC also compared the air sample results to ambient air monitoring concentrations from NYSDEC's air toxics monitoring network, since many of the air toxics assessed are frequently detected at other locations in the State. Finally, NYSDEC compared the four community samples to health-based short-term guideline concentrations (SGCs) established by NYSDEC and the 24-hr results from the Peace Bridge Study and NYSDEC's air toxics monitoring network. NYSDEC installed a monitoring station near the PBC on Busti Avenue. The monitor has instrumentation for a variety of parameters including the analysis of volatile organic compounds (VOCs) which included carbonyls. The objective of monitoring was to determine whether the VOC and carbonyl levels found in the neighborhood near the Peace Bridge were of public health concern. Because NYSDEC operates a network of air toxic monitors in other locations of the State, including near roadways, the information from those sites served as comparison for the results obtained at the monitor near the PBC.

What follows are explanations of NYSDEC's long-term and short-term health-based air guideline concentrations and a description of the air toxics monitoring network.

NYSDEC's Health-based Air Guideline Concentrations

Many organizations and agencies derive exposure limits to protect workers or the general public from adverse health outcomes from exposures to air contaminants. Each one of these exposure limits requires extensive research and development time. As such, NYSDEC establishes both long-term and short-term air guideline concentrations by adopting the most conservative health-based air comparison values developed by NYSDEC or others, such as the USEPA or the New York State Department of Health (NYSDOH). NYSDEC uses these values as part of its strategy to determine the degree of pollutant removal required for sources releasing air contaminants or to identify significant concerns from ambient monitoring data. These health-based air guideline concentrations are being used in this study.

First, NYSDEC compared the year-long monitoring results for both the VOCs and carbonyls to Annual Guideline Concentrations (AGCs). AGCs are ambient (for outdoor air) annual-based concentrations that NYSDEC uses to protect the public from adverse health outcomes associated with long-term (e.g., continuous lifetime) exposure to an air contaminant. AGCs are compared to annual average results from a full year of monitoring or air dispersion modeling estimates.

NYSDEC then compared the 1-hour community air sample results to Short-term Guideline Concentrations (SGCs) to determine whether the results represent an immediate public health concern. NYSDEC established SGCs to protect the general public from adverse health outcomes associated with short-term (1-hour) exposures to toxic air contaminants. The general public includes infants and children, and other individuals who may be more sensitive to lower concentrations than healthy adults. Examples of health outcomes from short-term exposures may include headaches, nausea, allergic reactions, asthma exacerbation, and irritation to the eyes, nose and throat.

There are two health outcomes from long-term exposures - cancer and non-cancer endpoints such as reproductive, developmental, respiratory and cardiovascular effects. The non-cancer AGC is established for an air concentration that is not expected to cause health effects during a lifetime of continuous exposure. The AGC is often modified – to be very conservative - from an experimental value to account for uncertainties such as whether the effects in animals can be used to estimate the likelihood of effects in humans and to account for the sensitive individuals in the population. The non-cancer health endpoints generally require higher exposures to elicit a response when compared to cancer health endpoints.

The other health outcome possible from long-term exposure is cancer. Cancer AGCs are defined as chemical concentrations in air that are associated with an estimated excess lifetime human cancer risk of 1-in-a-million (1×10^{-6}). Under the 1990 Clean Air Act, the acceptable cancer risk used by the USEPA to make regulatory decisions regarding the need for further air pollution reductions from sources or to identify significant concerns from ambient monitoring data is 100-in-a-million (1×10^{-4}). The acceptable cancer risk used by NYSDEC's Division of Air Resources to make regulatory permitting decisions about the need to consider further air pollution controls for sources ranges from 1-in-a-million to 10-in-a-million (1×10^{-5}). This is more conservative than USEPA's acceptable level of concern. The selection of an acceptable level of concern is a risk management decision.[35]

These guideline values are not bright lines between air concentrations that cause health effects and those that do not. They are values that are used by NYSDEC to assess the acceptability of proposed new air pollution sources during the permitting process, and are also used to evaluate the results of ambient air monitoring studies that measure the impacts of numerous sources of air pollution in an area. The purpose of the guideline is to help guide decisions about reducing community exposure to air pollution.[36]

[35] The interpretation of the sample results involves evaluating potential risk from the measured air concentrations. This process is called risk assessment – developing estimates of potential health effects associated with the exposure of individuals or populations to the measured air concentrations. Risk Management is a distinctly different process from risk assessment. Risk managers use the results of the risk assessment to make further decisions such as the need for more sampling, facility inspections or emission reduction strategies.

[36] More information about controlling air pollution sources and the derivation of SGCs and AGCs can be found online at: http://www.dec.ny.gov/chemical/89934.html

Appendix B – Twelve Month Averages for Volatile Organic Compounds and Carbonyls

Interpretation of Results

As shown in Table 1, for the volatile organic compounds (VOCs) monitored at the Peace Bridge, all but four results are below respective long-term health-based air guideline concentrations (AGC). The 12-month average for the four VOCs (1,2-dichloroethane, 1,3-butadiene, benzene, carbon tetrachloride), although above the guideline concentration, are within the acceptable target risk level (1 to 10-in-a-million) used by NYSDEC to make decisions about the need to consider further air pollution controls for sources. The concentrations of these four VOCs are also well below USEPA's acceptable level of concern of 100-in-a-million cancer risk.

As shown in Table 3, for the carbonyls monitored at the Peace Bridge, the 12-month average for two results (acetaldehyde, formaldehyde) are above the long-term health-based air guideline concentration. Although above the guideline concentration, the results are within the acceptable target risk level (1-in-a-million to 10-in-a-million) used by NYSDEC to make decisions about the need to consider further air pollution controls for sources. The concentrations of these four carbonyls also are well below USEPA's acceptable level of concern at 100-in-a-million cancer risk.

The results for the Peace Bridge monitoring were compared graphically to NYSDEC's Air Toxics Monitoring Network (Appendices C and D). The comparisons suggest that the level of air toxics measured in the community nearest the Peace Bridge are not unlike concentrations found in other locations with similar urban development.

Table 1. Volatile Organic Compounds Twelve Month Average

Chemical	Peace Bridge (ppb)	Brookside Terrace (ppb)	Buffalo (ppb)	Fresh-kills West (ppb)	Grand Island Blvd (ppb)	IS52 (ppb)	Long-Term Health-Based Guideline Concentrations (AGC) (ppb)	Carcinogen
1,1,1-Trichloroethane	0.0048	0.0056	0.013	0.0081	0.0053	0.0066	900	
1,2,4-Trimethylbenzene	0.024	0.023	0.046	0.04	0.02	0.067	1.2	
1,2-Dichloroethane	0.015	0.016	0.016	0.018	0.016	0.018	0.01	yes
1,2-Dichloropropane	0.0042	0.0051	ns	0.0046	0.0049	0.0057	0.87	
1,3,5-Trimethylbenzene	0.0064	0.0068	0.012	0.012	0.0067	0.021	1.2	
1,3-Butadiene	0.016	0.012	ns	0.021	0.017	0.037	0.015	yes
1,4-Dichlorobenzene	0.0033	0.0041	ns	0.006	0.0036	0.028	0.015	yes
Benzene	0.15	0.15	0.15	0.22	0.26	0.23	0.04	yes
Bromomethane	0.0081	0.0089	0.0088	0.011	0.0088	0.011	1.3	
Carbon tetrachloride	0.083	0.083	0.083	0.085	0.083	0.085	0.027	yes
Chlorobenzene	0.0044	0.0051	0.0053	0.0043	0.0046	0.006	13	
Chloroform	0.021	0.026	0.022	0.025	0.02	0.034	3	yes
Chloromethane	0.51	0.52	0.52	0.54	0.51	0.53	44	
Dichlorodifluoromethane	0.53	0.52	0.52	0.53	0.52	0.53	2400	
Dichloromethane	0.075	0.095	0.083	0.11	0.082	0.26	17	yes
Dichlorotetrafluoroethane	0.015	0.016	0.016	0.016	0.016	0.017	2400	
Ethylbenzene	0.022	0.022	0.035	0.045	0.021	0.051	230	
m,p-Xylene	0.088	0.088	0.15	0.17	0.087	0.2	23	
o-Xylene	0.035	0.033	0.056	0.063	0.032	0.071	23	
Styrene	0.0092	0.012	0.1	0.0099	0.0064	0.015	230	
Tetrachloroethylene	0.015	0.013	ns	0.016	0.015	0.047	0.59	yes
Toluene	0.2	0.23	0.31	0.33	0.24	0.34	1300	
Trichloroethylene	0.0089	0.0053	ns	0.0045	0.0066	0.0069	0.037	yes
Trichlorofluoromethane	0.24	0.24	0.25	0.25	0.24	0.25	900	
Trichlorotrifluoroethane	0.074	0.074	0.074	0.075	0.074	0.077	23000	

ns – Insufficient number of observations for 12-month average

Table 2. Volatile Organic Compounds - *continued*

Chemical	PS274 (ppb)	Pfizer (ppb)	Pinnacle (ppb)	Queens College (ppb)	Rochester (ppb)	White-face (ppb)	Long-Term Health-Based Guideline Concentrations (AGC) (ppb)	Carcinogen
1,1,1-Trichloroethane	0.0054	0.0052	0.0052	0.0046	0.013	0.0045	900	
1,2,4-Trimethylbenzene	0.074	0.036	0.0065	0.043	0.02	0.0063	1.2	
1,2-Dichloroethane	0.017	0.016	0.016	0.016	0.016	0.015	0.01	yes
1,2-Dichloropropane	0.0042	0.0045	0.005	0.0041	0.0052	0.0041	0.87	
1,3,5-Trimethylbenzene	0.021	0.01	ns	0.012	0.0061	ns	1.2	
1,3-Butadiene	0.042	0.033	ns	0.027	0.016	ns	0.015	yes
1,4-Dichlorobenzene	0.03	0.017	0.0033	0.015	0.0043	0.0022	0.015	yes
Benzene	0.23	0.22	0.1	0.19	0.14	0.077	0.04	yes
Bromomethane	0.0094	0.0097	0.0088	0.0086	0.0088	0.008	1.3	
Carbon tetrachloride	0.086	0.084	0.084	0.084	0.085	0.083	0.027	yes
Chlorobenzene	0.0038	0.0044	ns	0.0043	0.0077	0.0039	13	
Chloroform	0.031	0.029	0.017	0.026	0.024	0.016	3	yes
Chloromethane	0.55	0.55	0.52	0.53	0.54	0.51	44	
Dichlorodifluoromethane	0.54	0.53	0.53	0.53	0.53	0.52	2400	
Dichloromethane	0.17	0.11	0.065	0.11	0.22	0.059	17	yes
Dichlorotetrafluoroethane	0.015	0.016	0.016	0.015	0.016	0.015	2400	
Ethylbenzene	0.048	0.03	0.0084	0.034	0.039	0.0084	230	
m,p-Xylene	0.2	0.12	0.023	0.13	0.11	0.028	23	
o-Xylene	0.071	0.044	0.01	0.049	0.067	0.011	23	
Styrene	0.013	0.0087	0.006	0.011	0.076	0.0051	230	
Tetrachloroethylene	0.057	0.027	0.0068	0.029	0.011	0.005	0.59	yes
Toluene	0.38	0.24	0.073	0.31	0.2	0.071	1300	
Trichloroethylene	0.0054	0.0046	ns	0.0046	0.0059	ns	0.037	yes
Trichlorofluoromethane	0.26	0.25	0.24	0.28	0.25	0.24	900	
Trichlorotrifluoroethane	0.075	0.074	0.074	0.074	0.074	0.073	23000	

ns – Insufficient number of observations for 12-month average

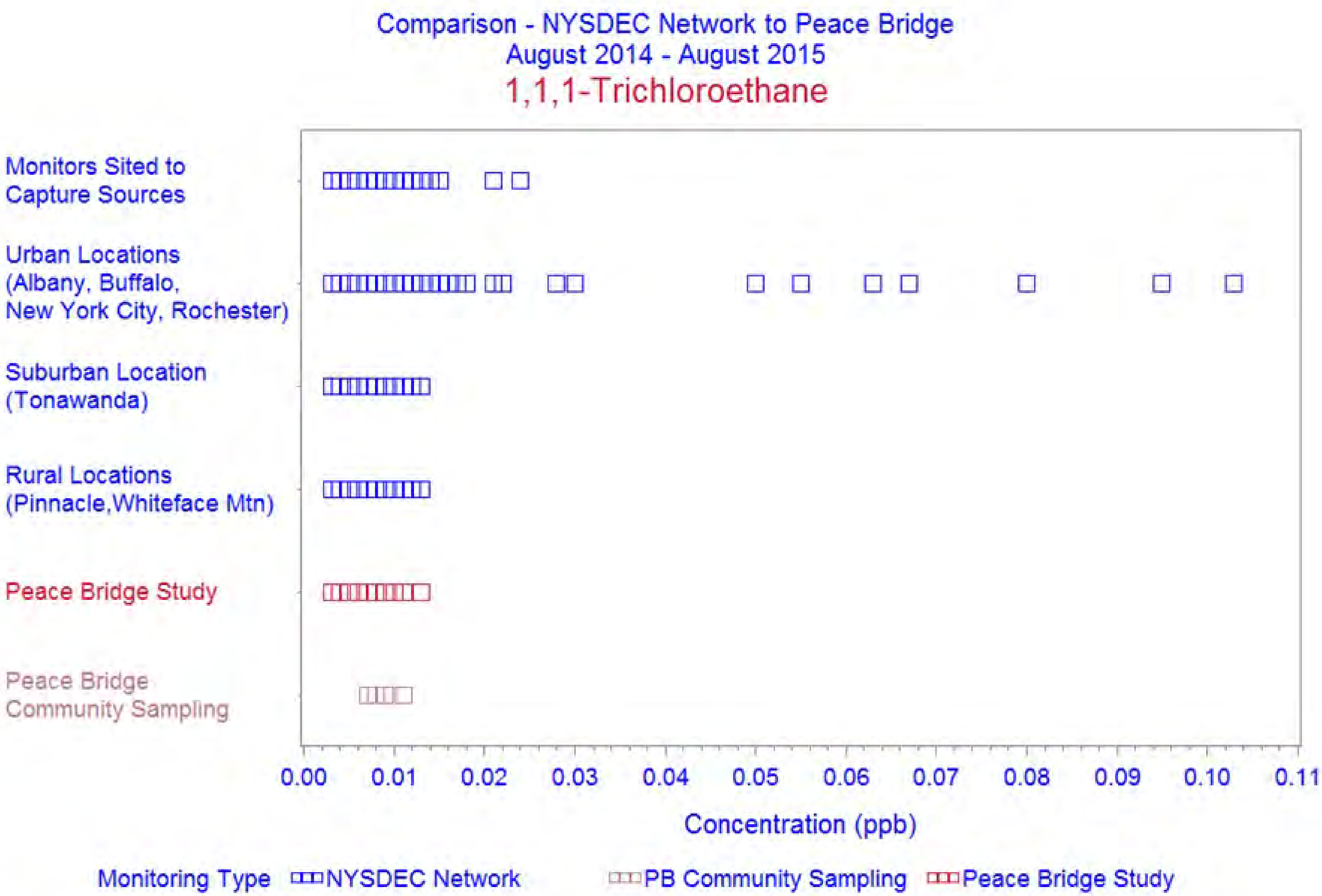
Table 3. Carbonyls Twelve Month Average

Chemical	Acetaldehyde (ppb)	Benzaldehyde (ppb)	Formaldehyde (ppb)	Hexanal (ppb)	Methyl-ethyl-ketone (ppb)	Propion-aldehyde (ppb)	Valer-aldehyde (ppb)
Peace Bridge	0.67	0.023	1.8	0.029	0.11	0.088	0.015
Brookside Terrace	0.75	0.030	2.1	0.047	0.14	0.090	0.024
Buffalo Near-Road	0.71	0.034	2.0	0.031	0.11	0.085	0.014
Freshkills West	0.79	0.030	1.9	0.043	0.13	0.11	0.019
Grand Island Blvd	0.59	0.023	1.9	0.035	0.38	0.090	0.015
IS52	0.80	0.037	2.3	0.068	0.13	0.11	0.028
Pfizer	0.79	0.054	2.4	0.036	0.098	0.084	0.017
Queens College	1.2	0.054	3.4	0.097	0.18	0.17	0.045
Rochester	0.56	0.027	1.3	0.036	0.12	0.065	0.016
Whiteface	0.34	0.018	0.91	0.025	0.077	0.044	0.010
Long-Term Health-Based Guideline Concentrations (AGC)	0.25	2	0.049	4.8	1700	3.4	120
Carcinogen	yes		yes				

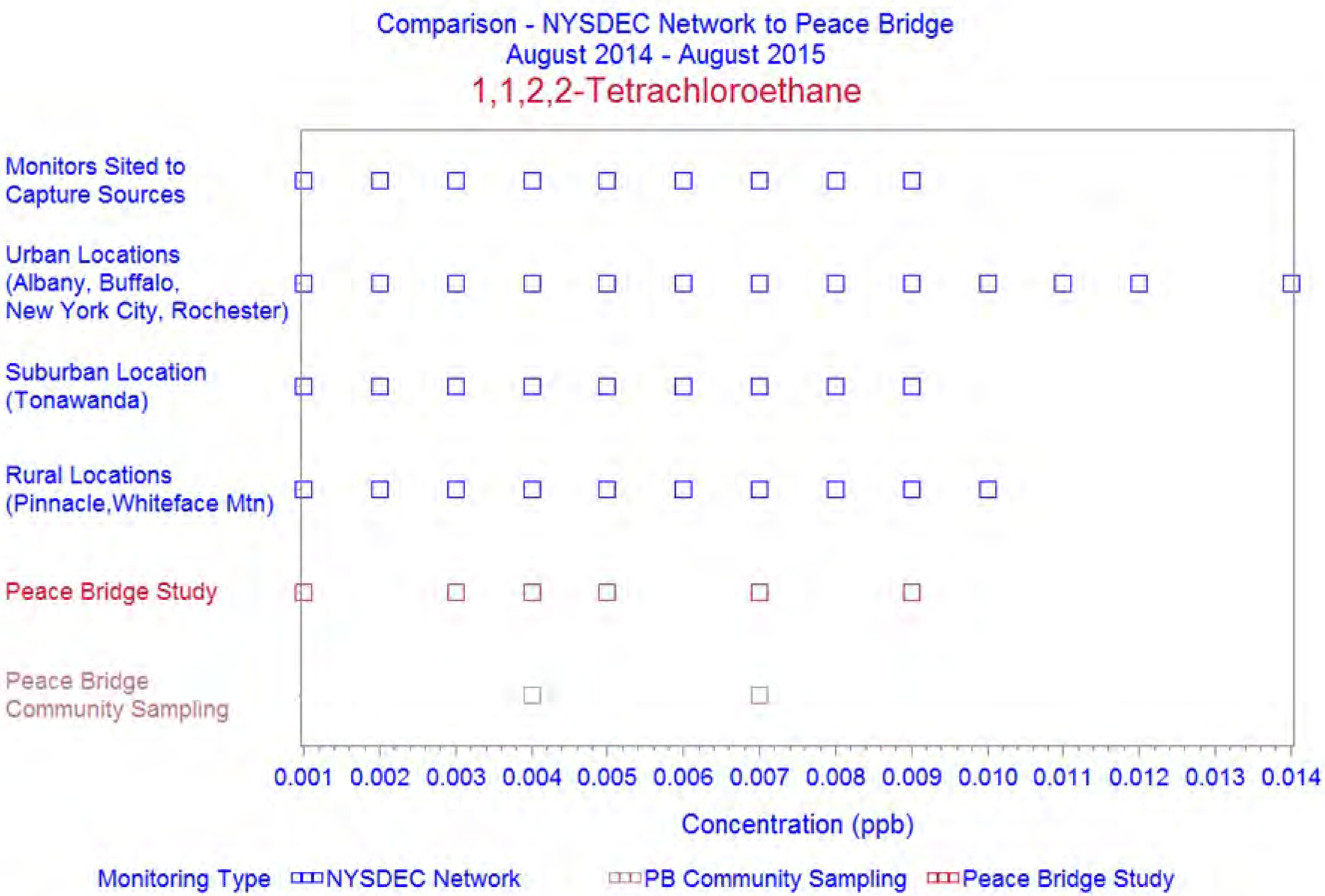
Appendix C – Graphical Comparisons

NYSDEC Monitoring Network to Peace Bridge Results for

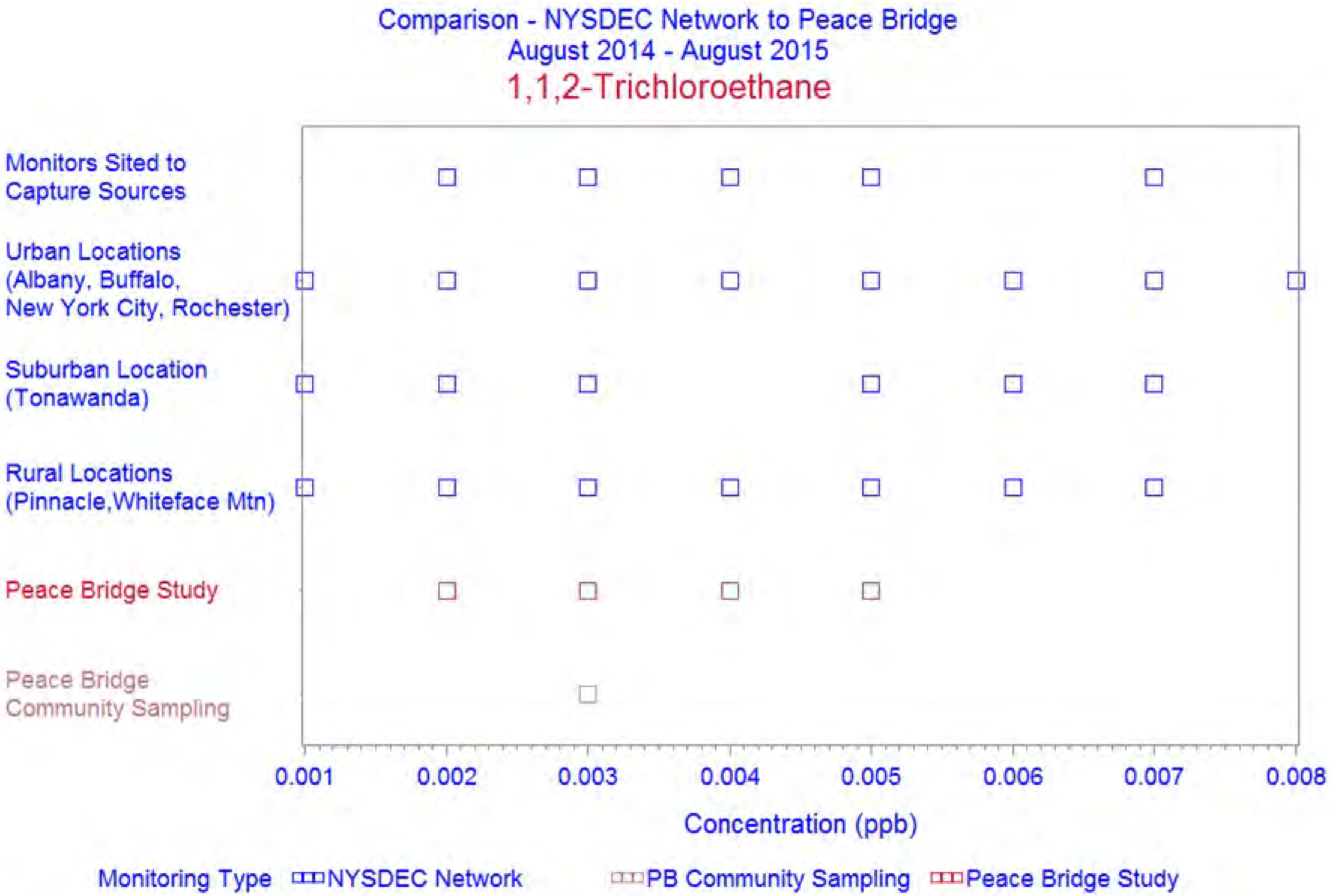
Volatile Organic Compounds



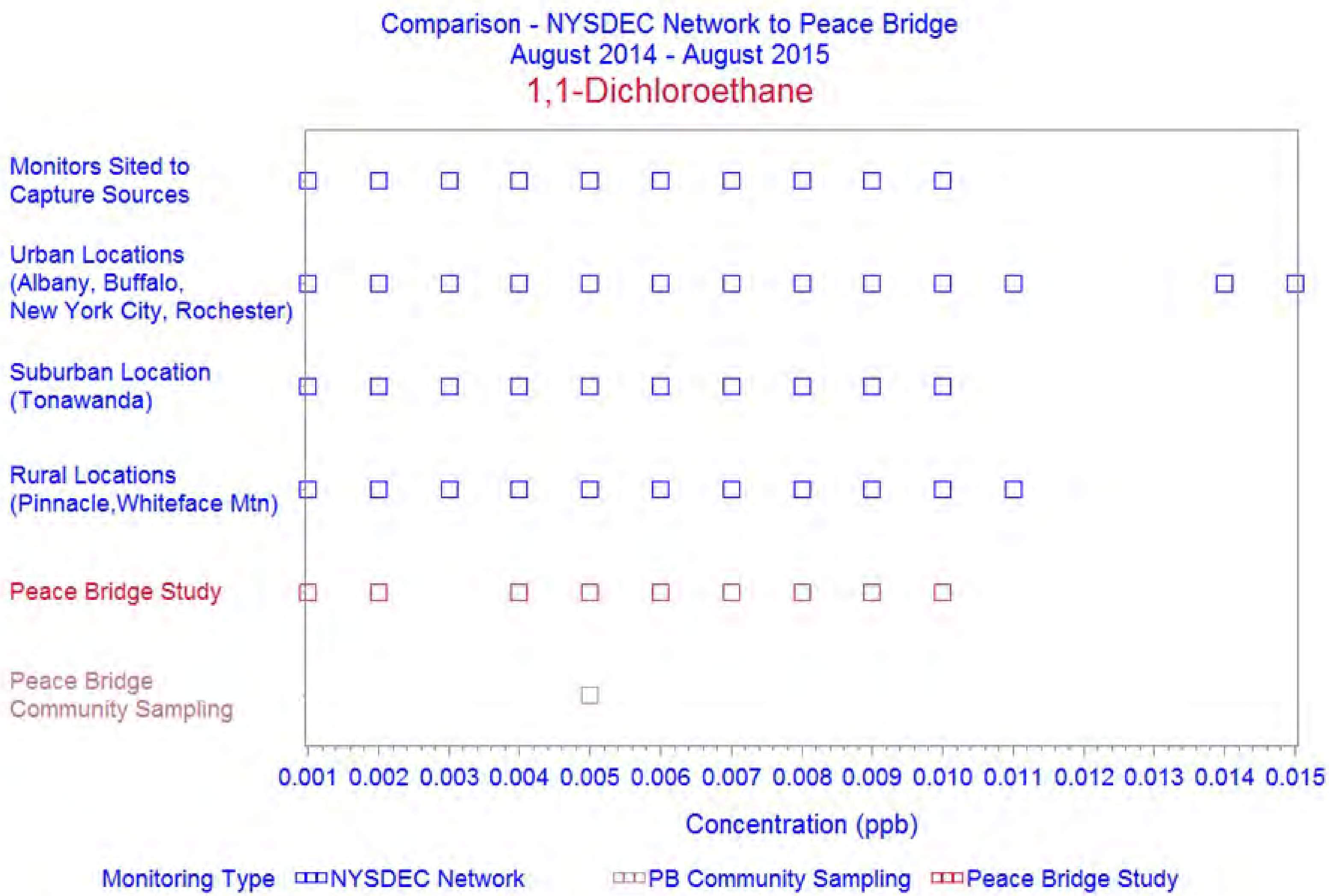
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



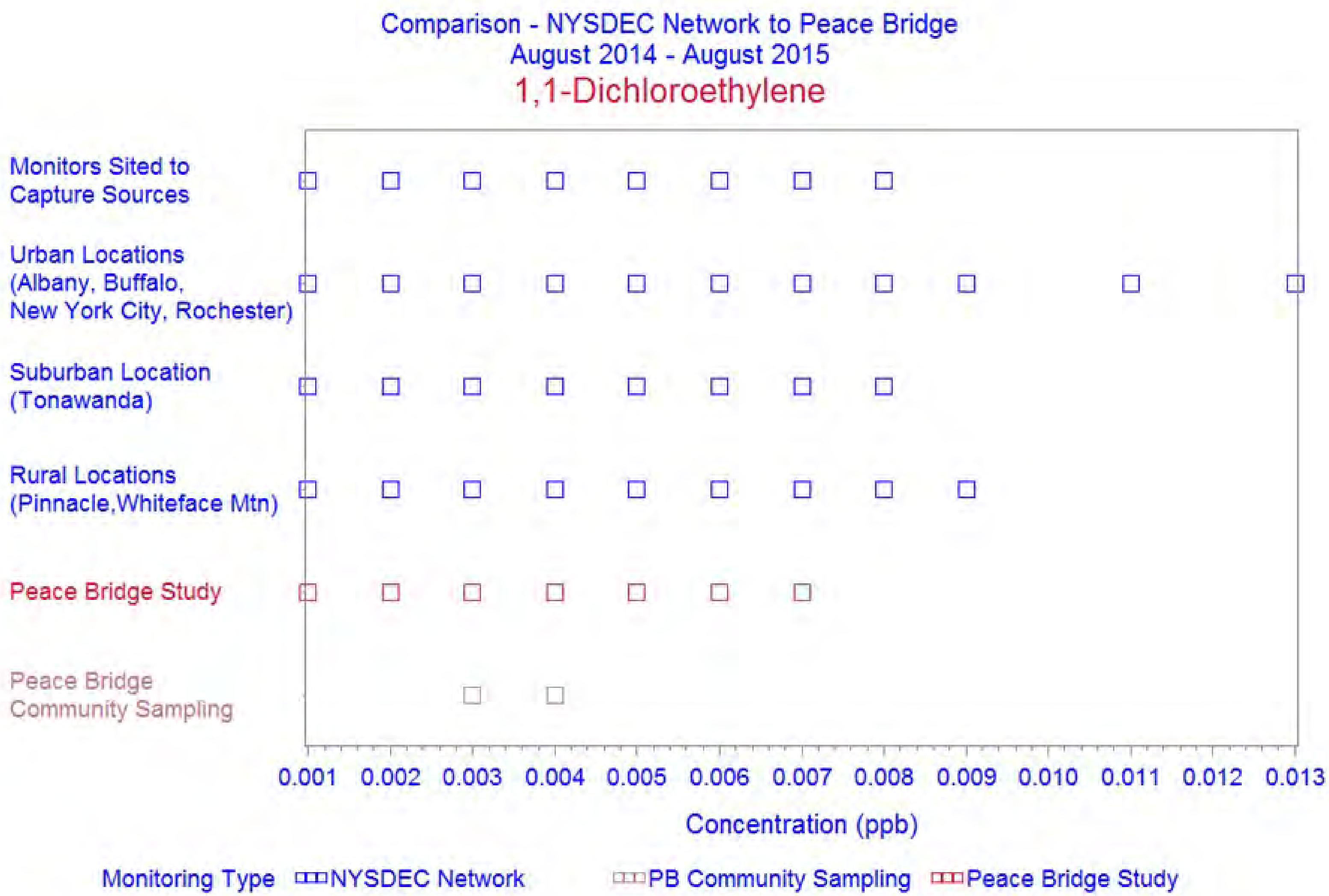
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



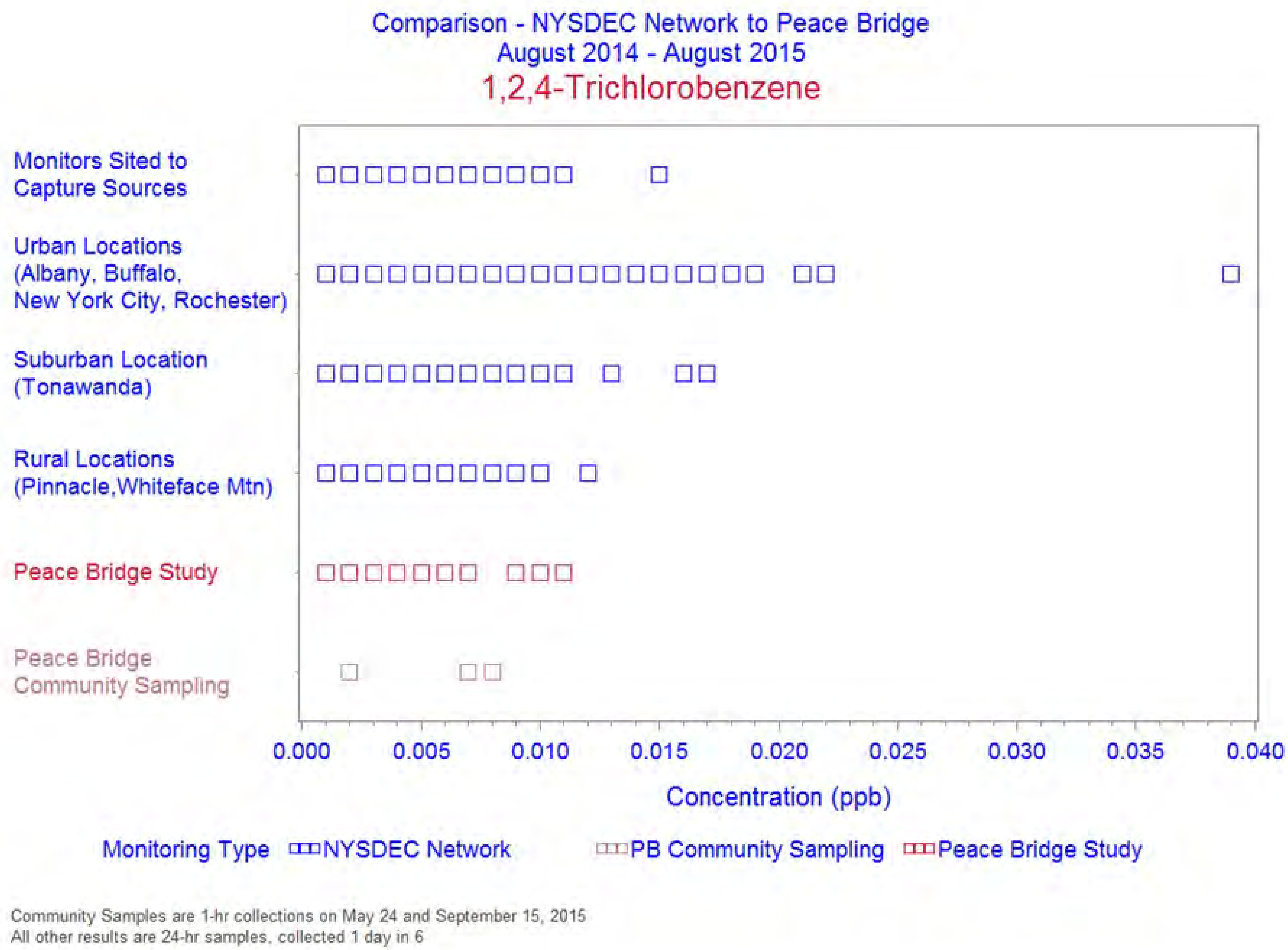
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

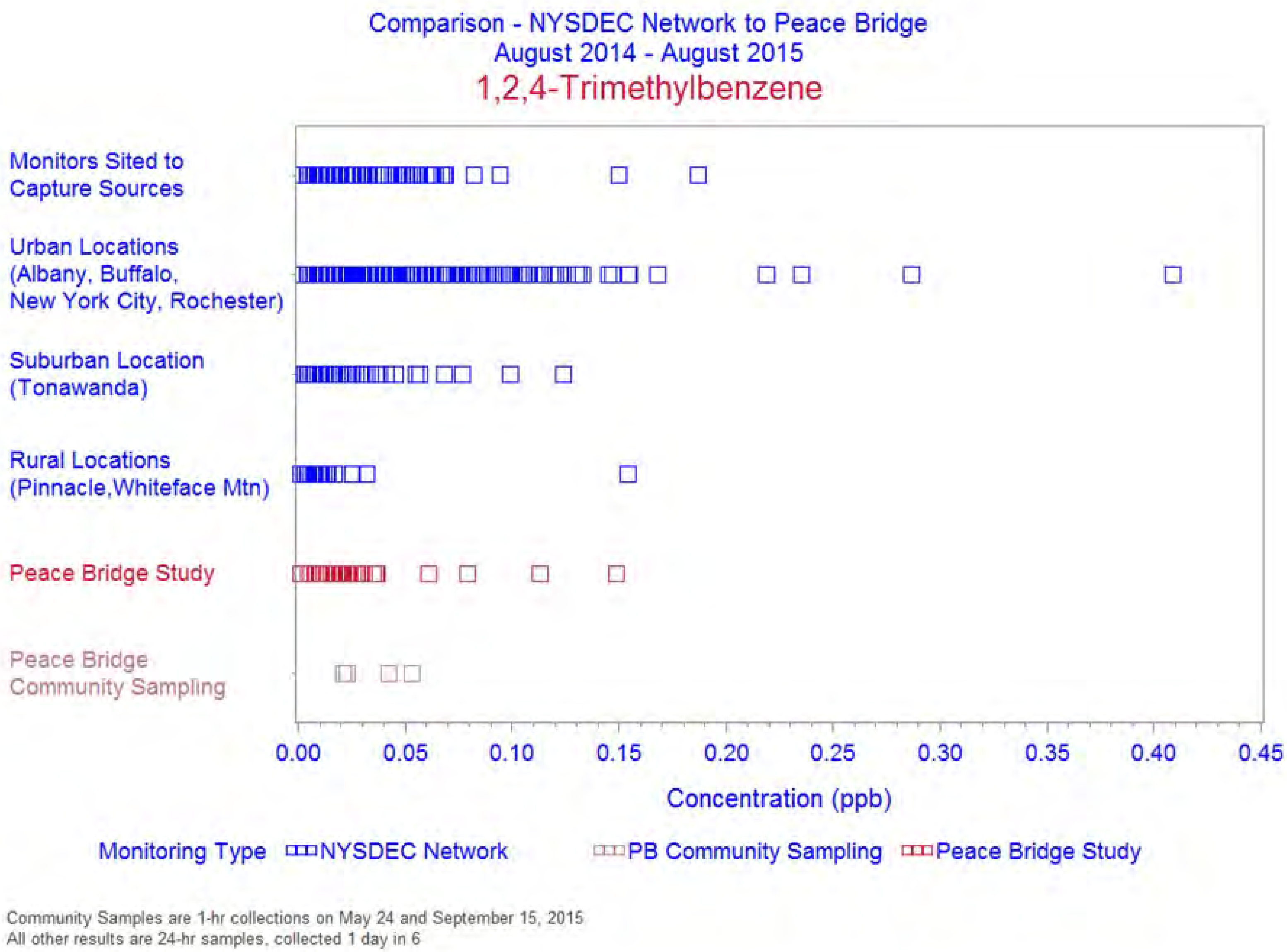


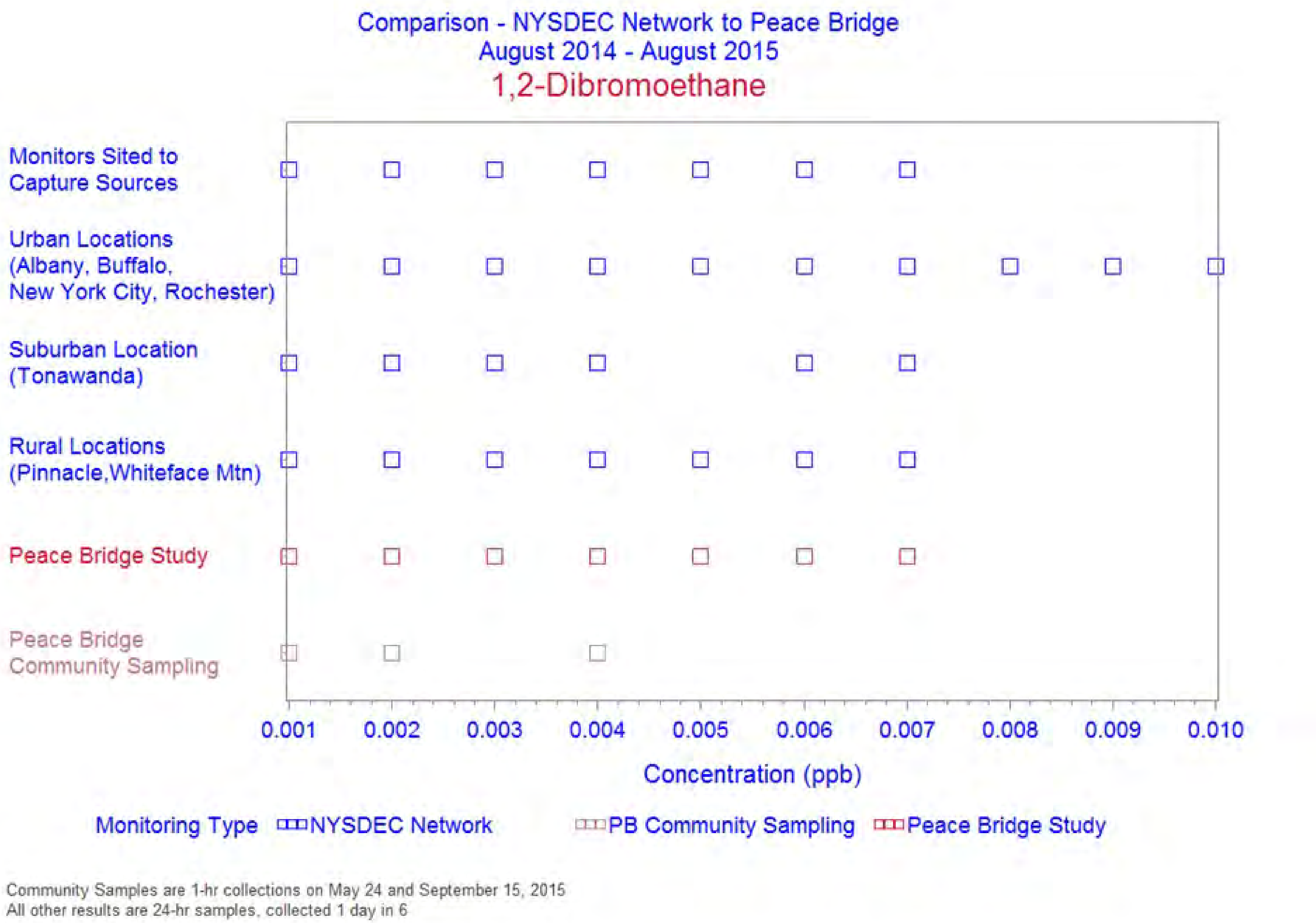
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



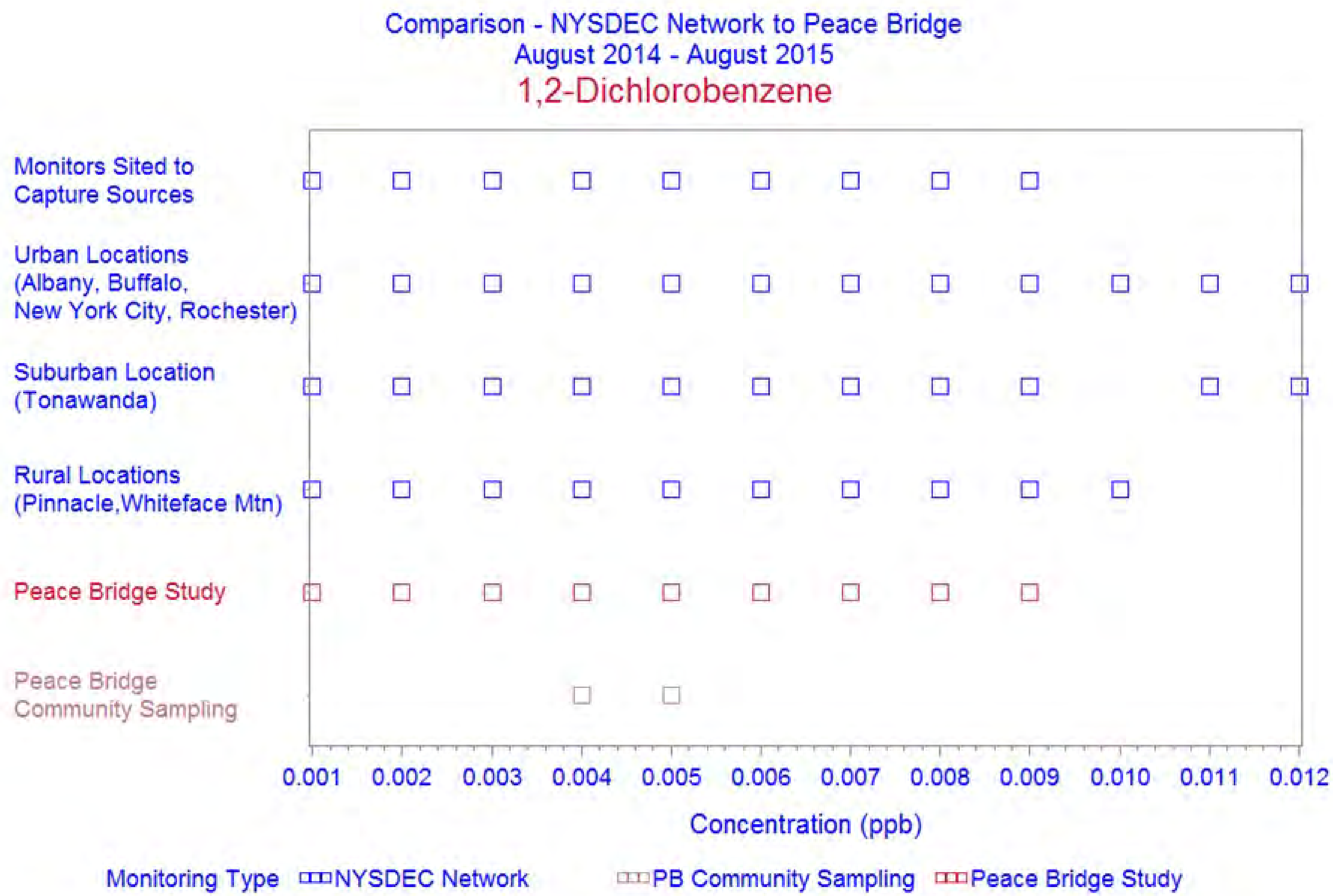
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6


Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
1,2,4-Trichlorobenzene
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
Concentration (ppb)
Monitoring Type
NYSDEC Network
PB Community Sampling
Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

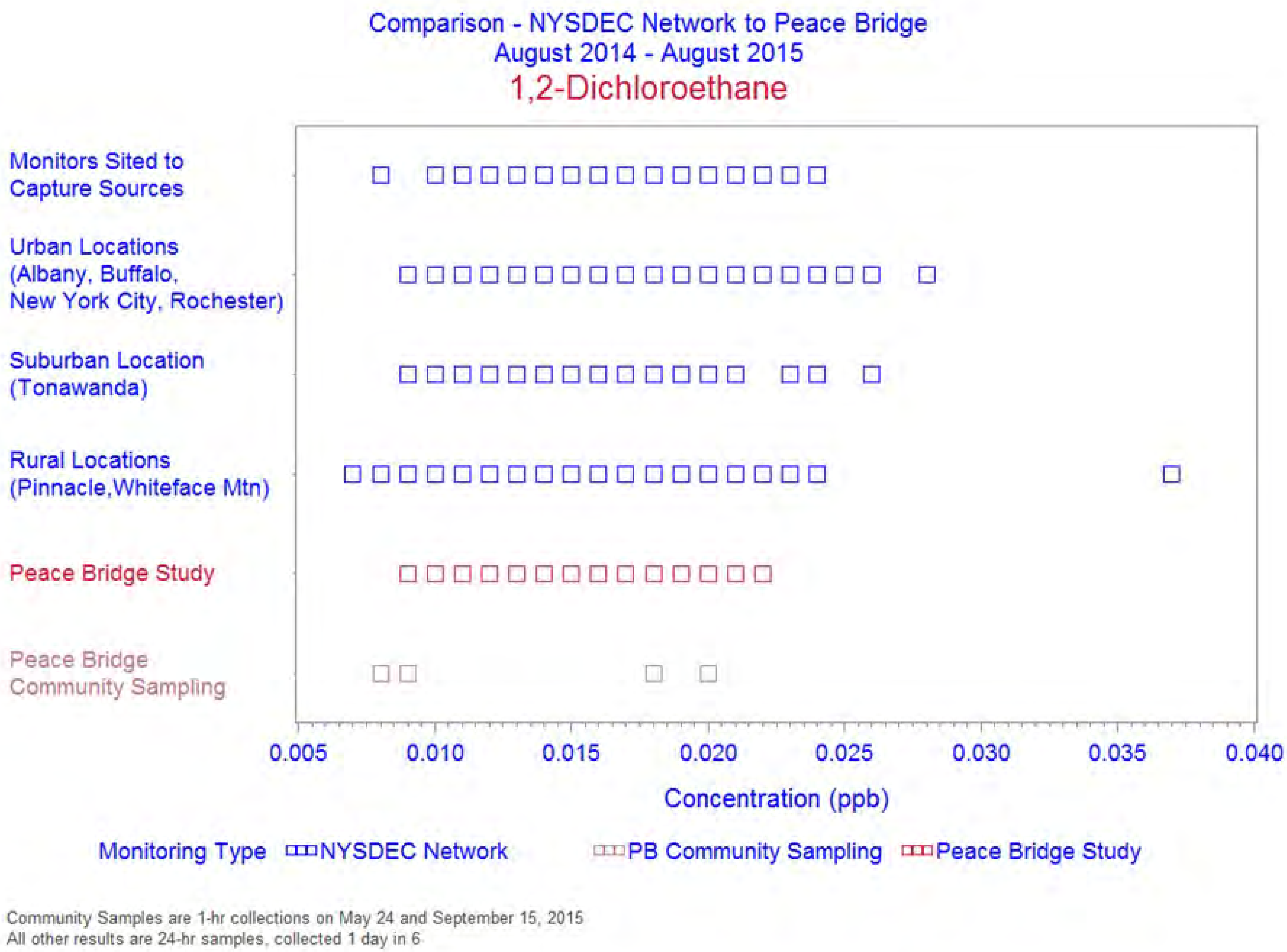

Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
1,2,4-Trimethylbenzene
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
Concentration (ppb)
Monitoring Type
NYSDEC Network
PB Community Sampling
Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

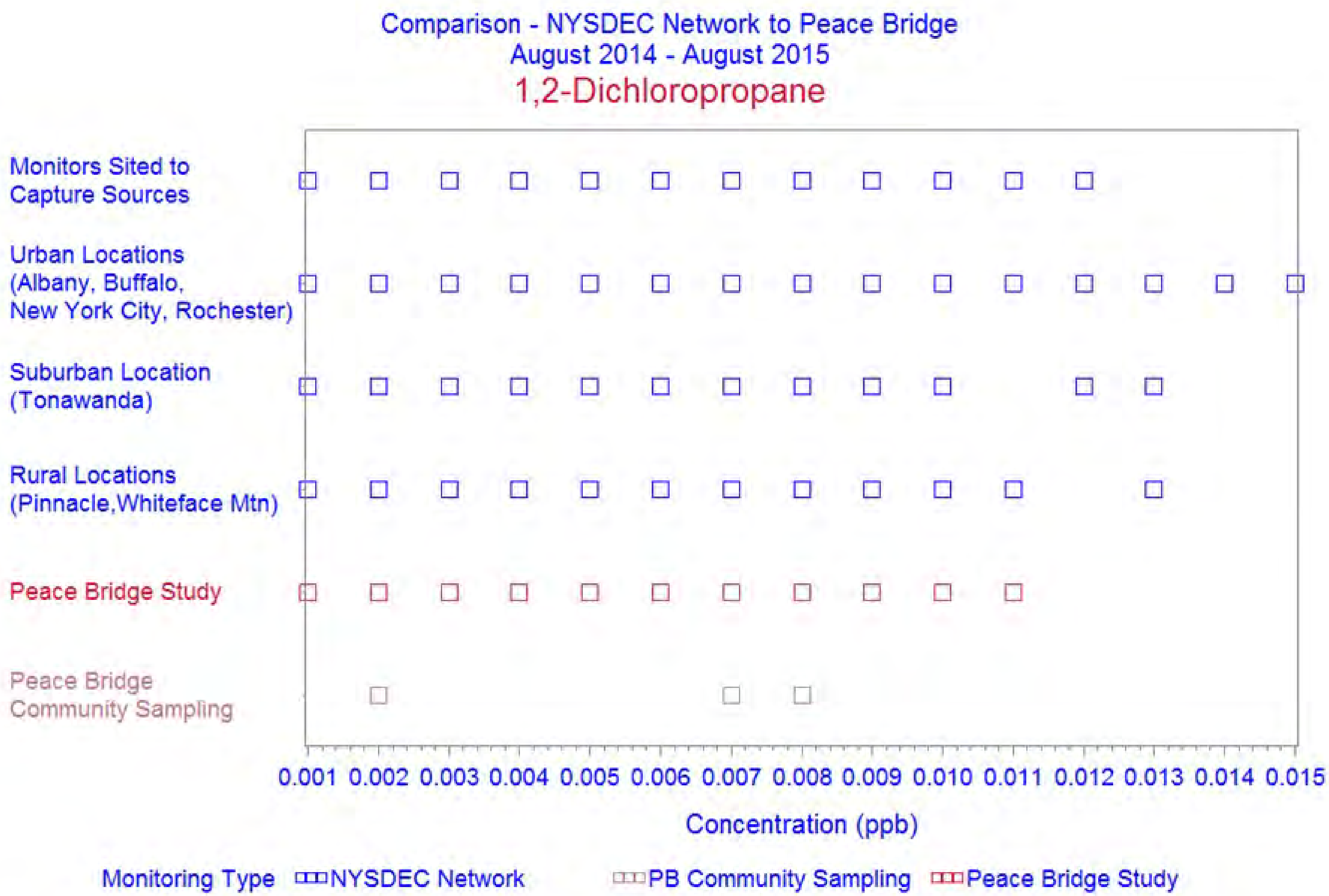


Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
1,2-Dibromoethane
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.010
Concentration (ppb)
Monitoring Type
NYSDEC Network
PB Community Sampling
Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

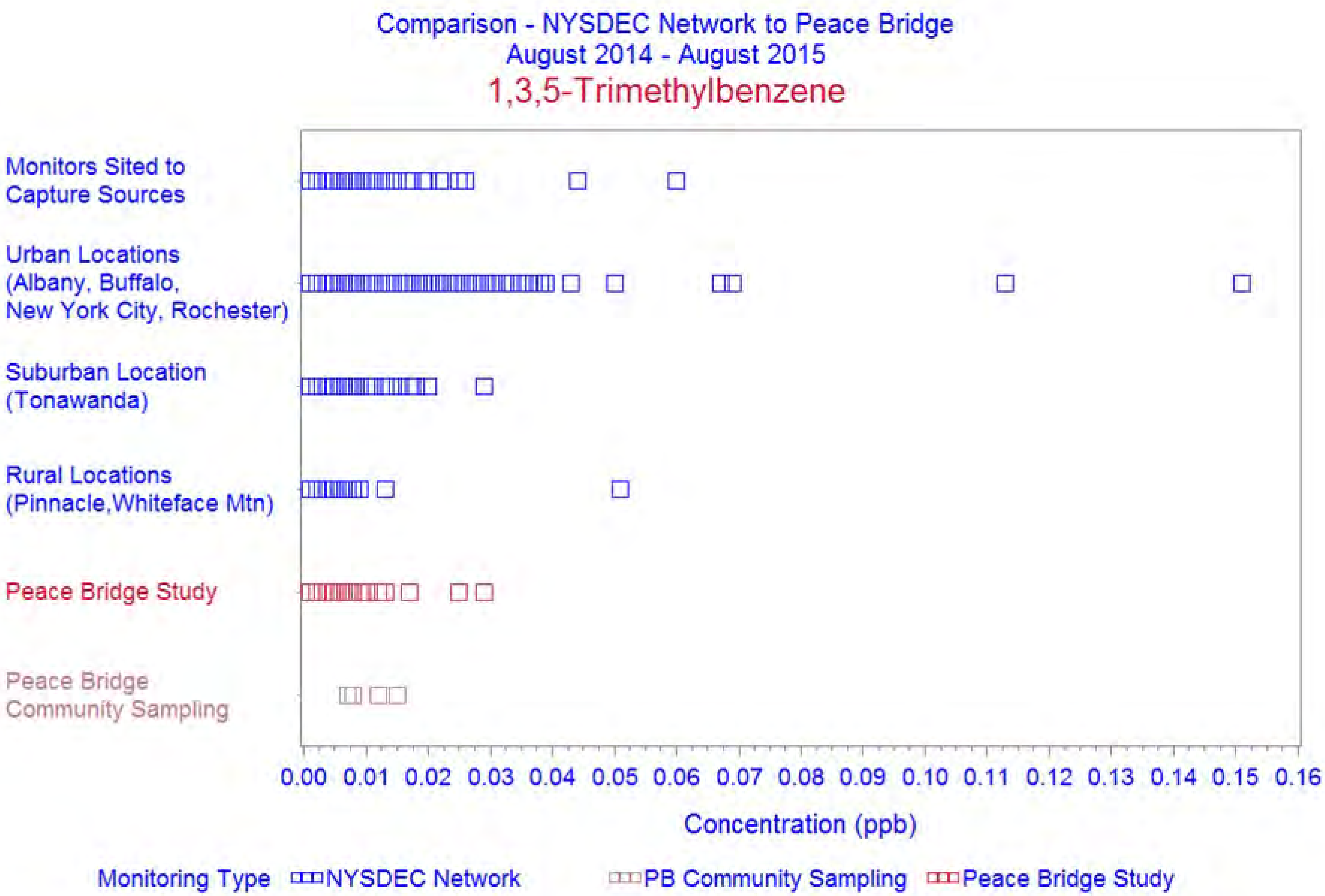


Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

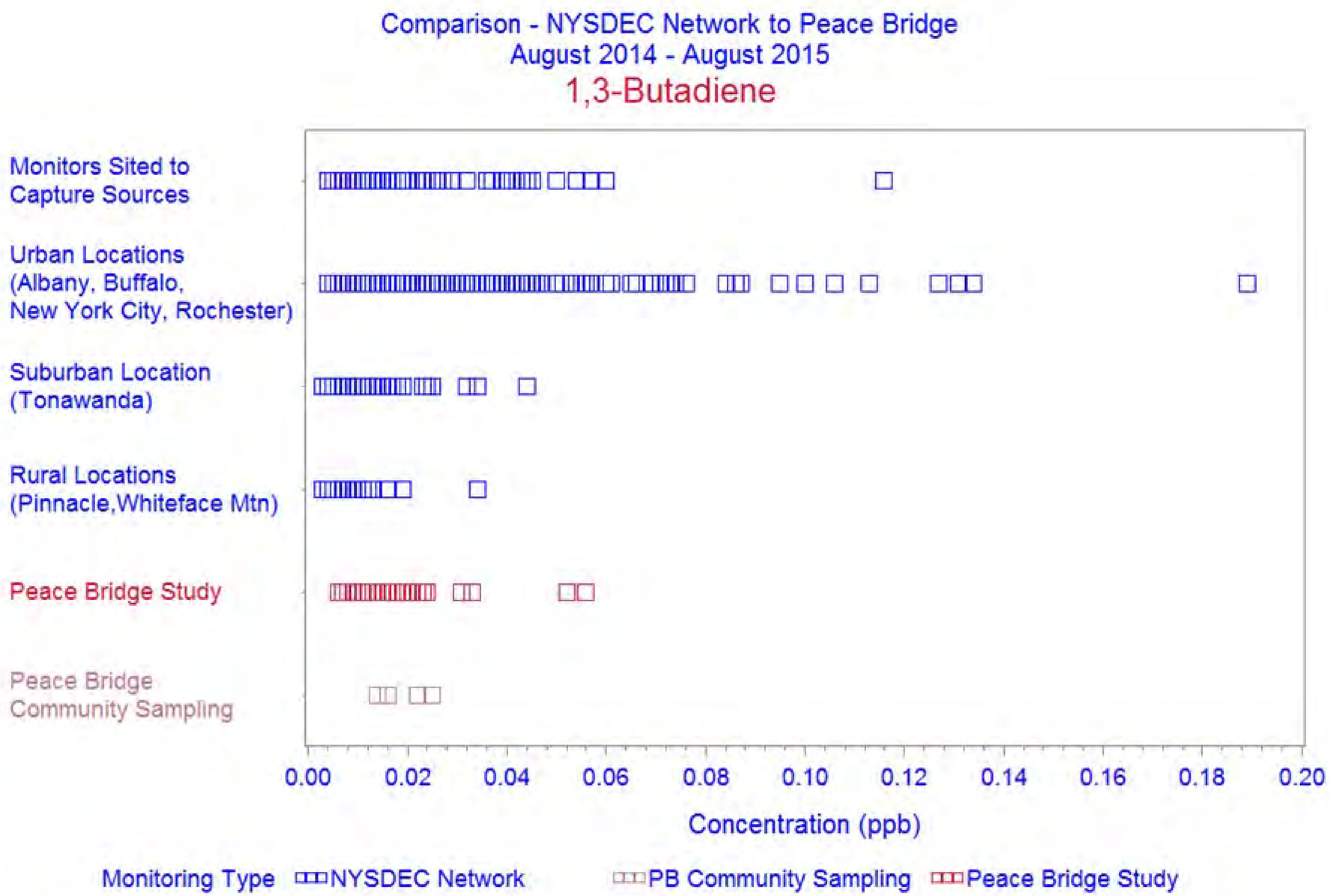

Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
1,2-Dichloroethane
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
Concentration (ppb)
Monitoring Type
NYSDEC Network
PB Community Sampling
Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



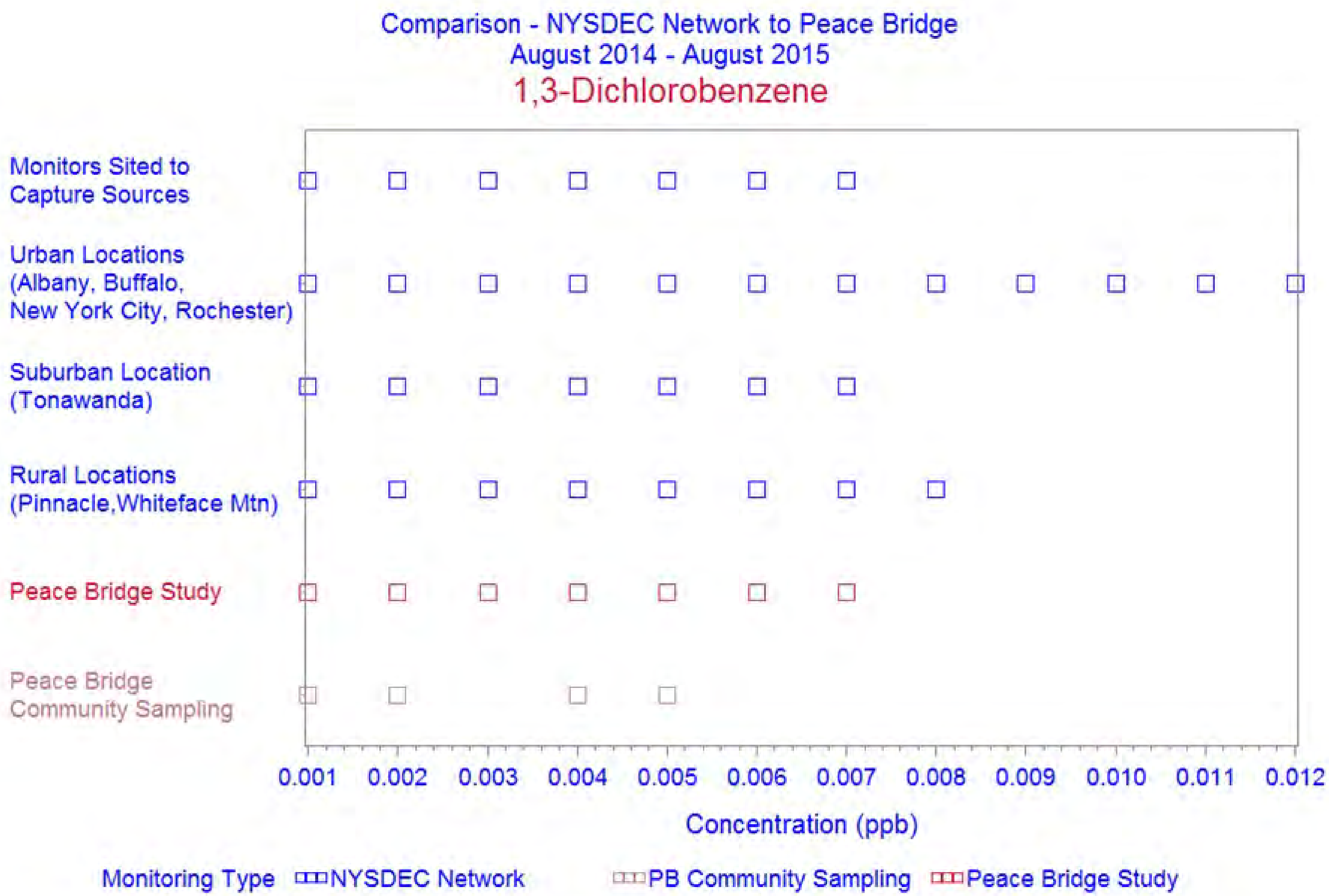
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



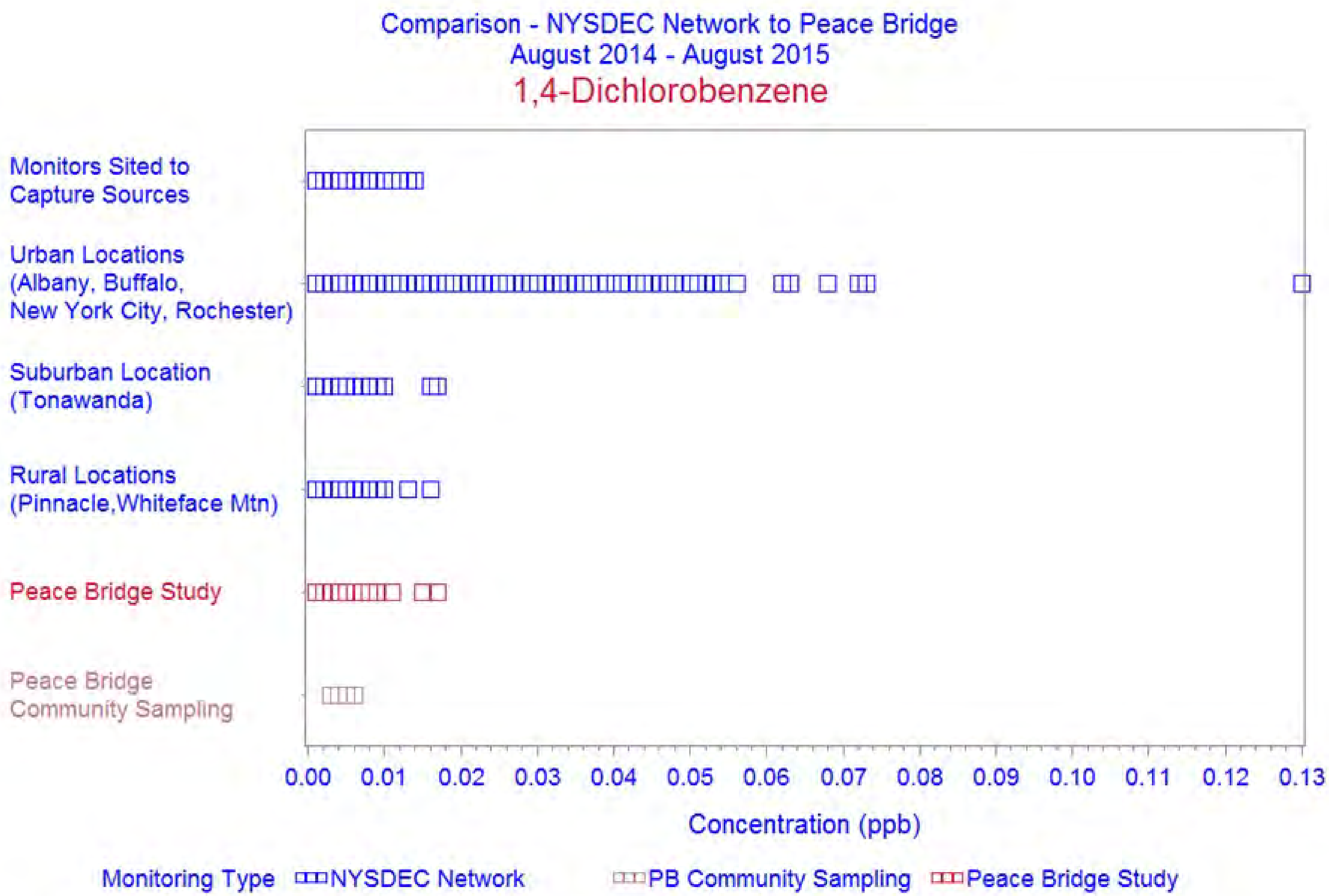
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



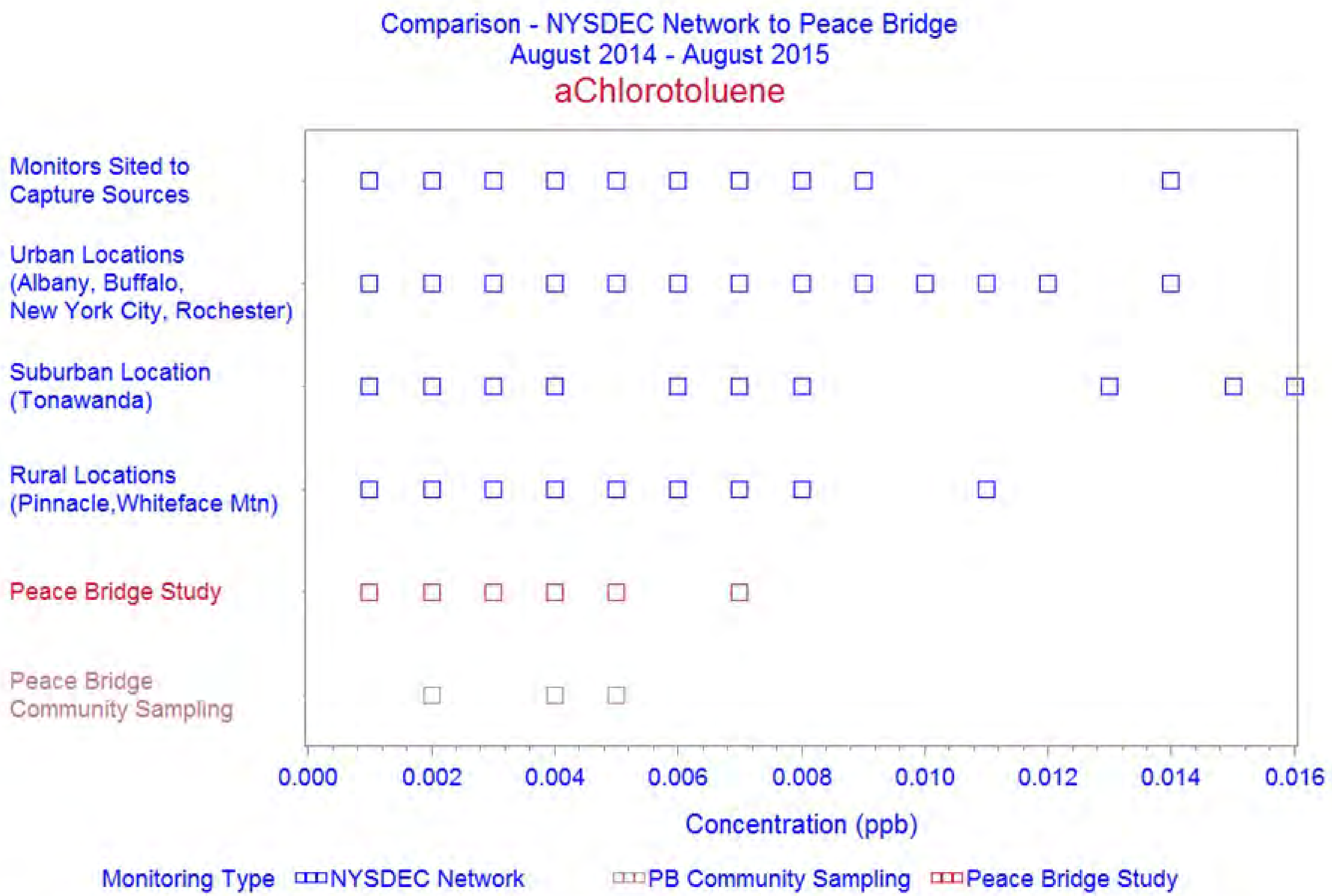
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



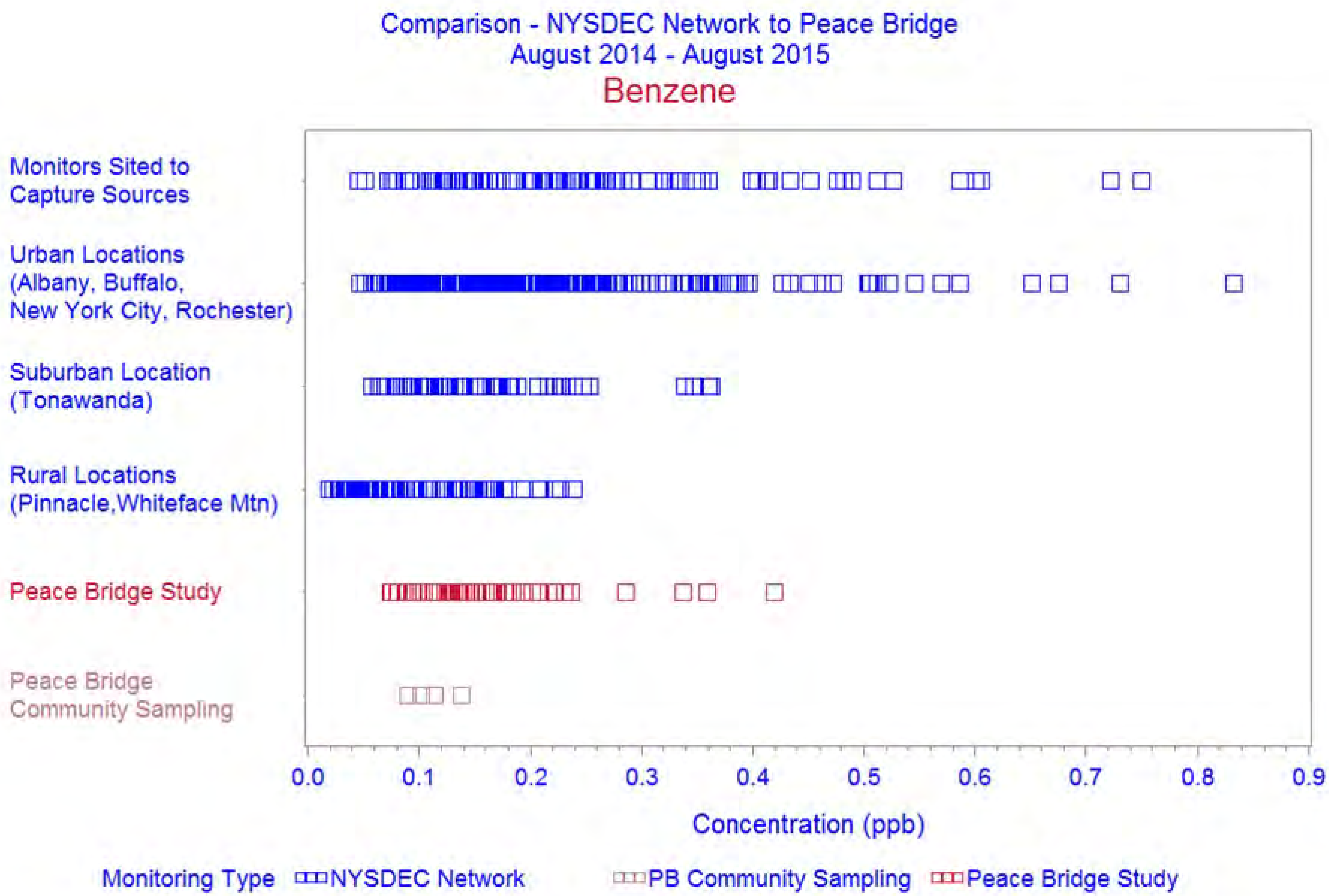
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



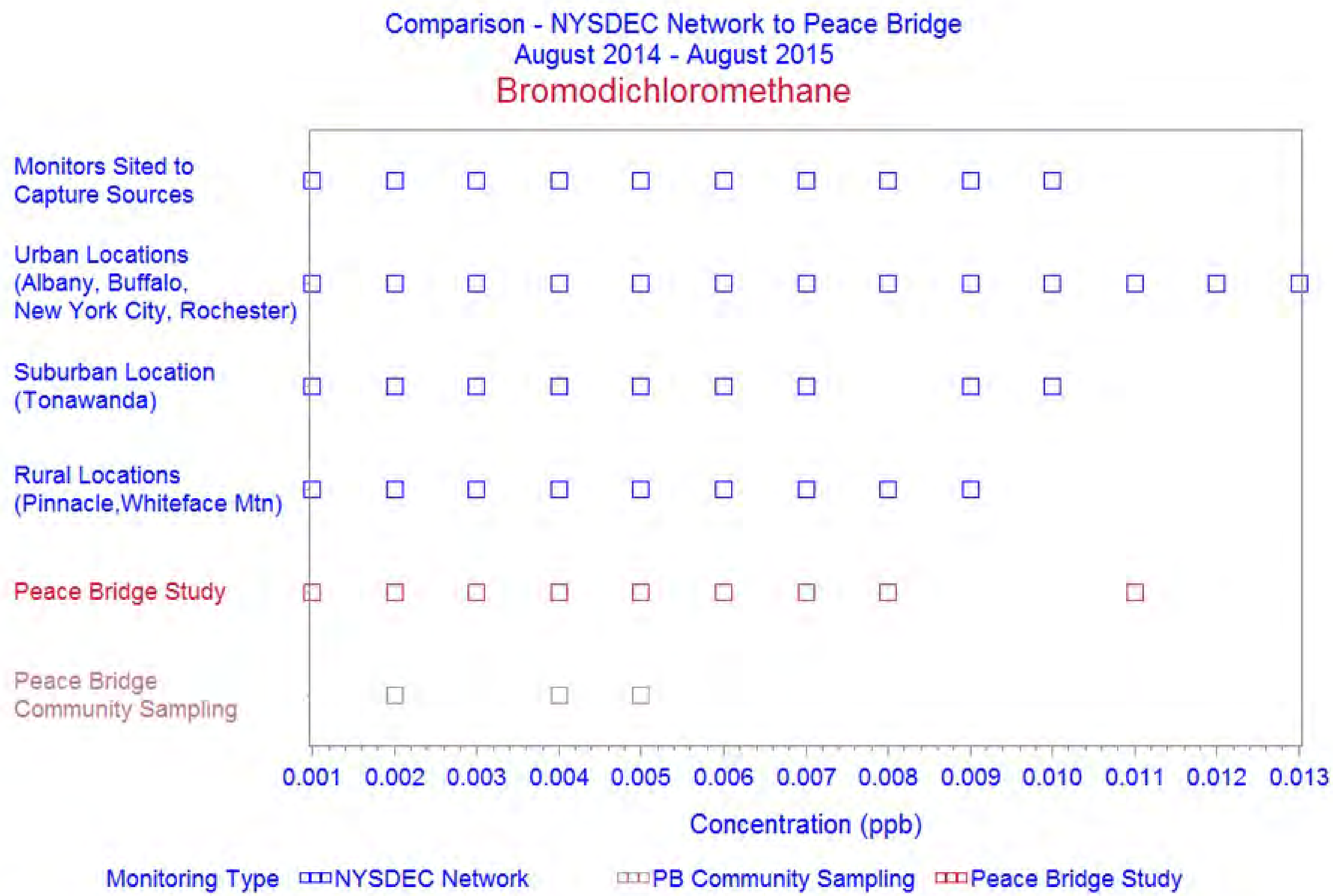
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



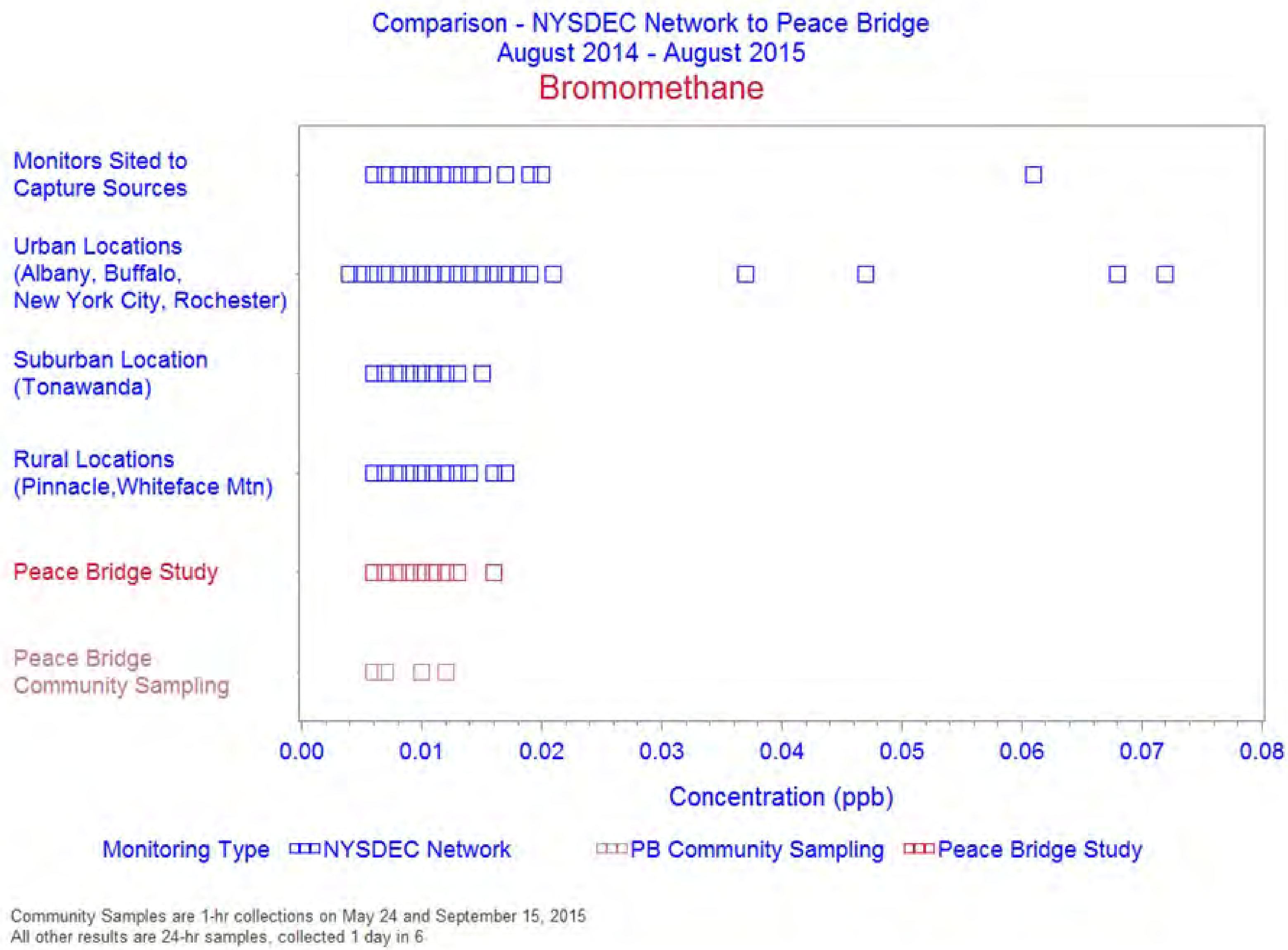
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

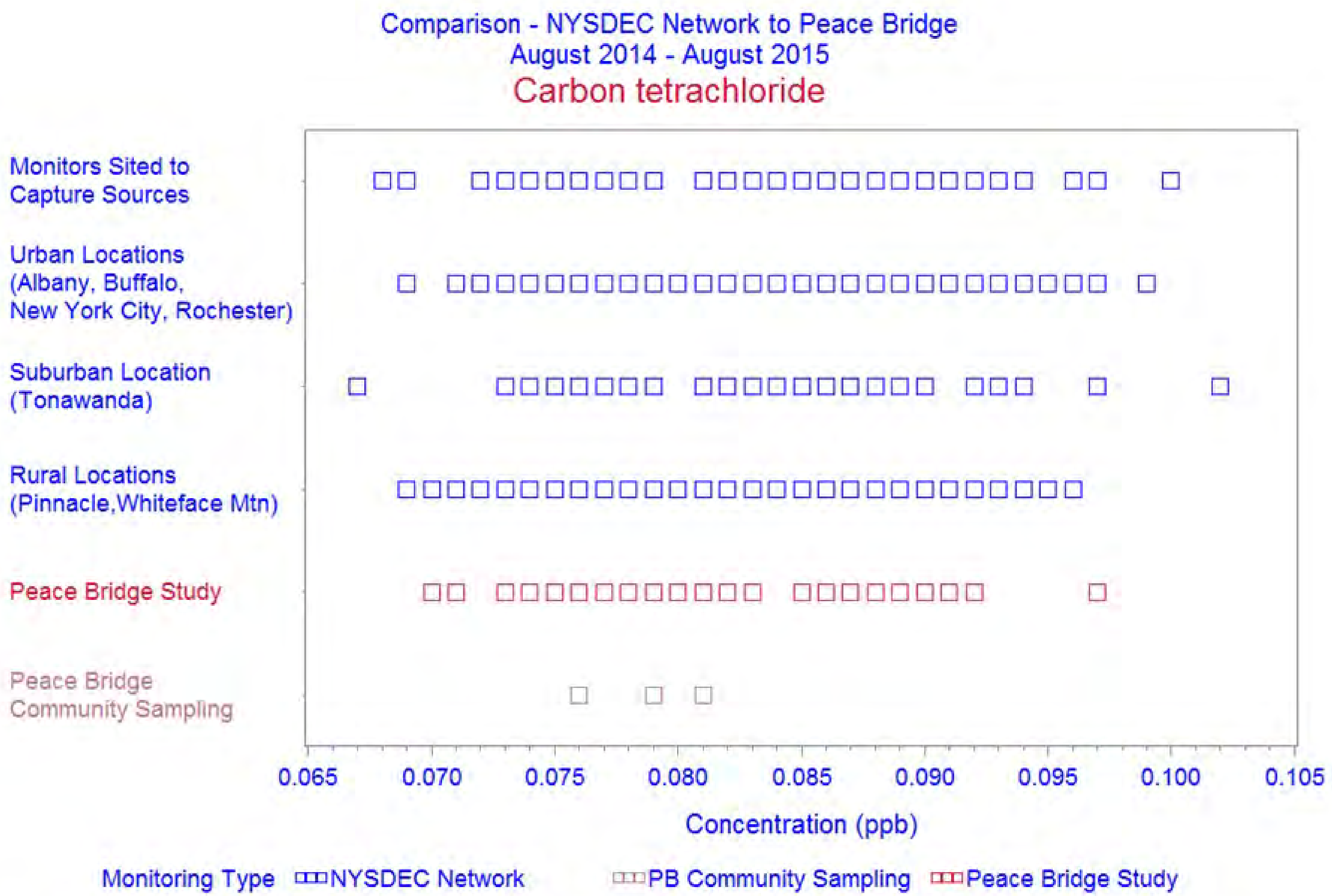


Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

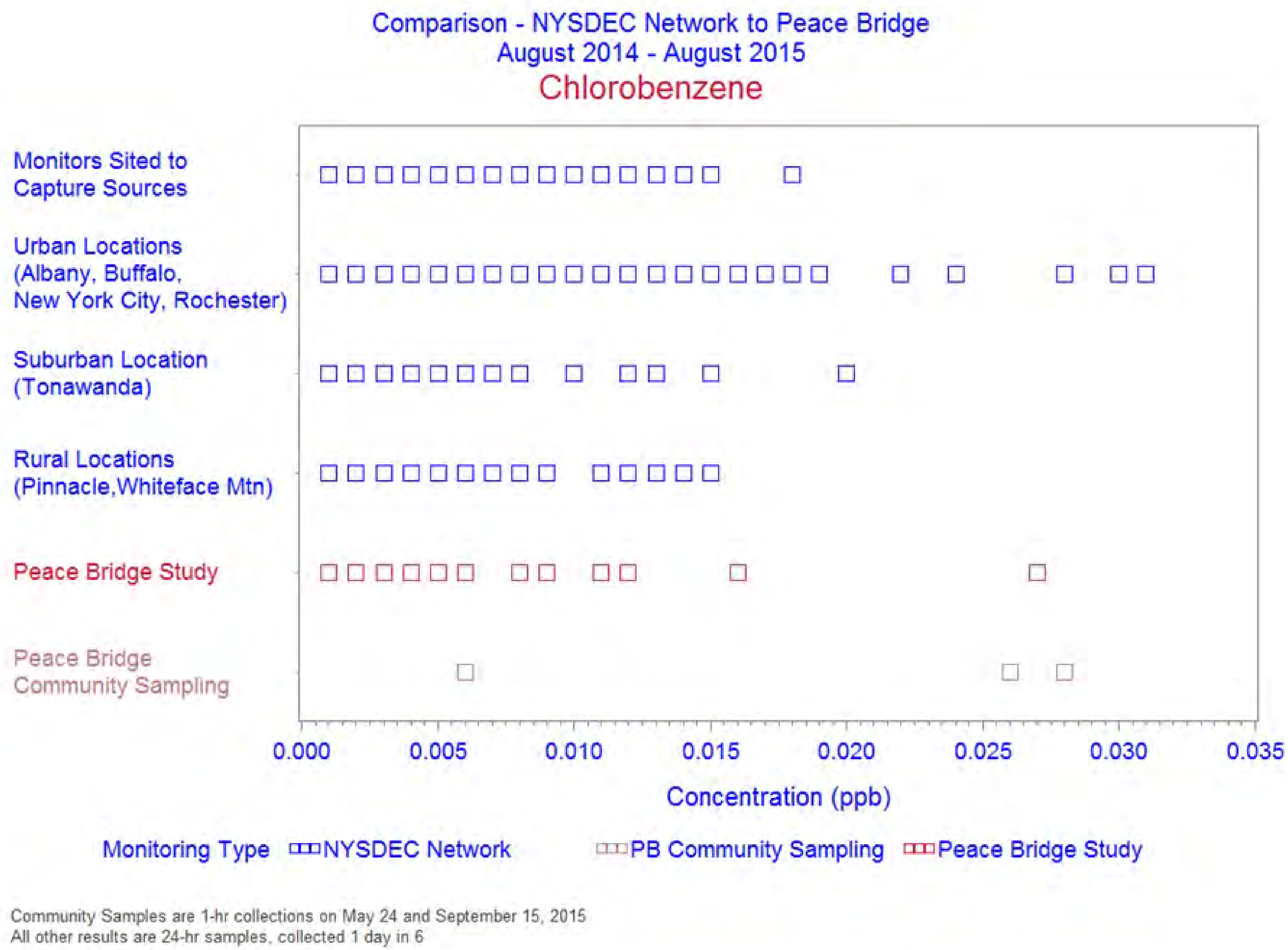


Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

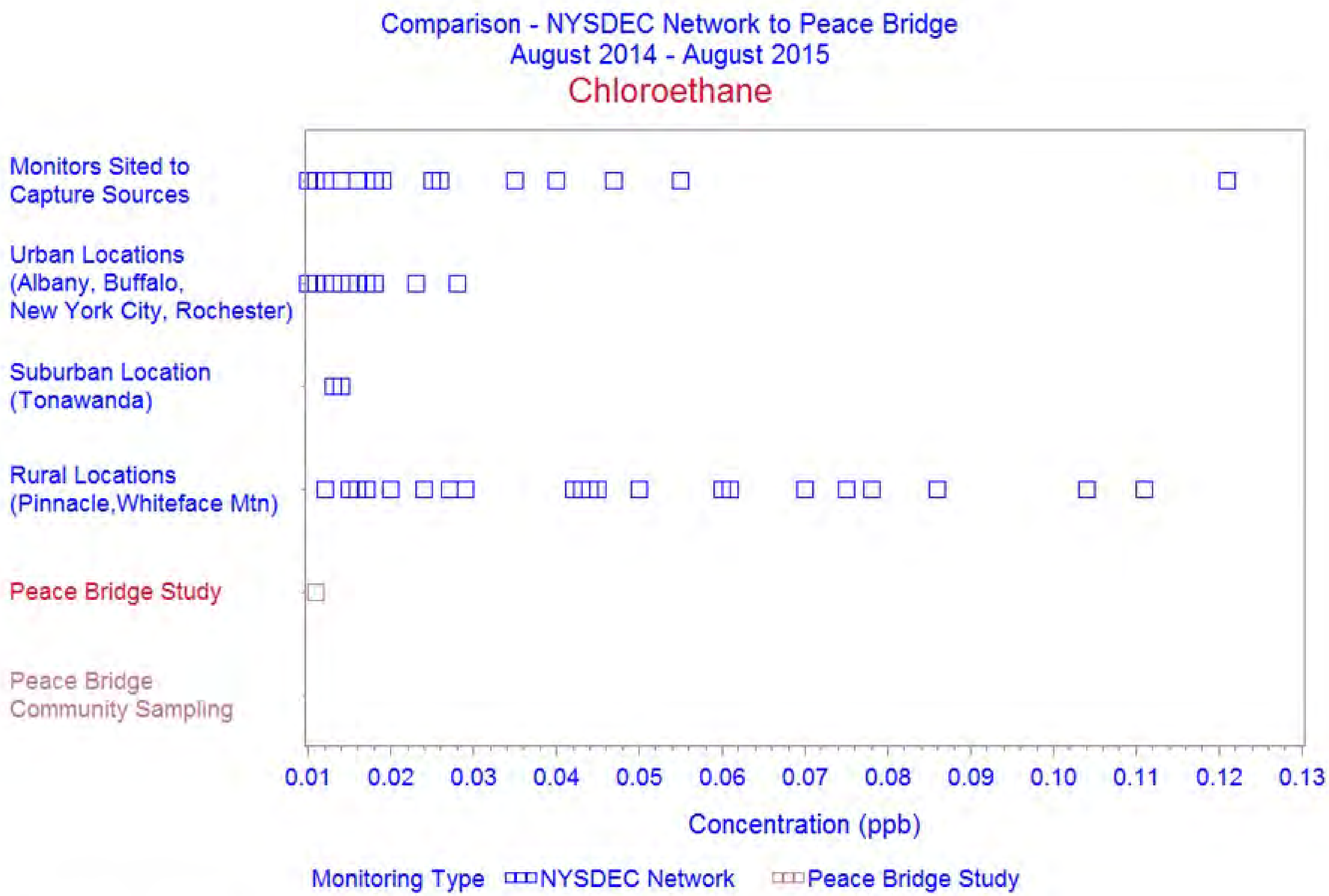

Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
Bromomethane
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
Concentration (ppb)
Monitoring Type
NYSDEC Network
PB Community Sampling
Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



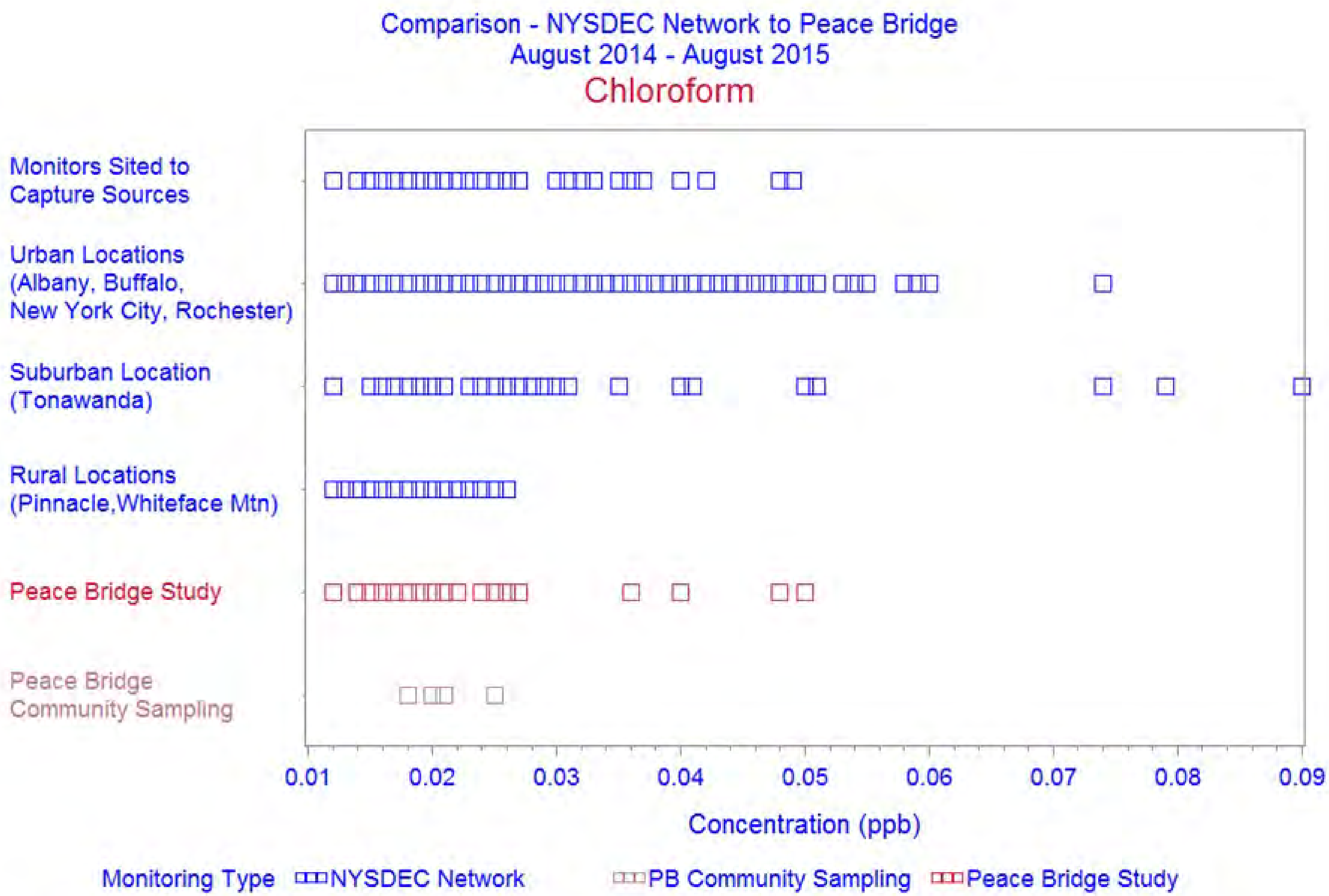
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



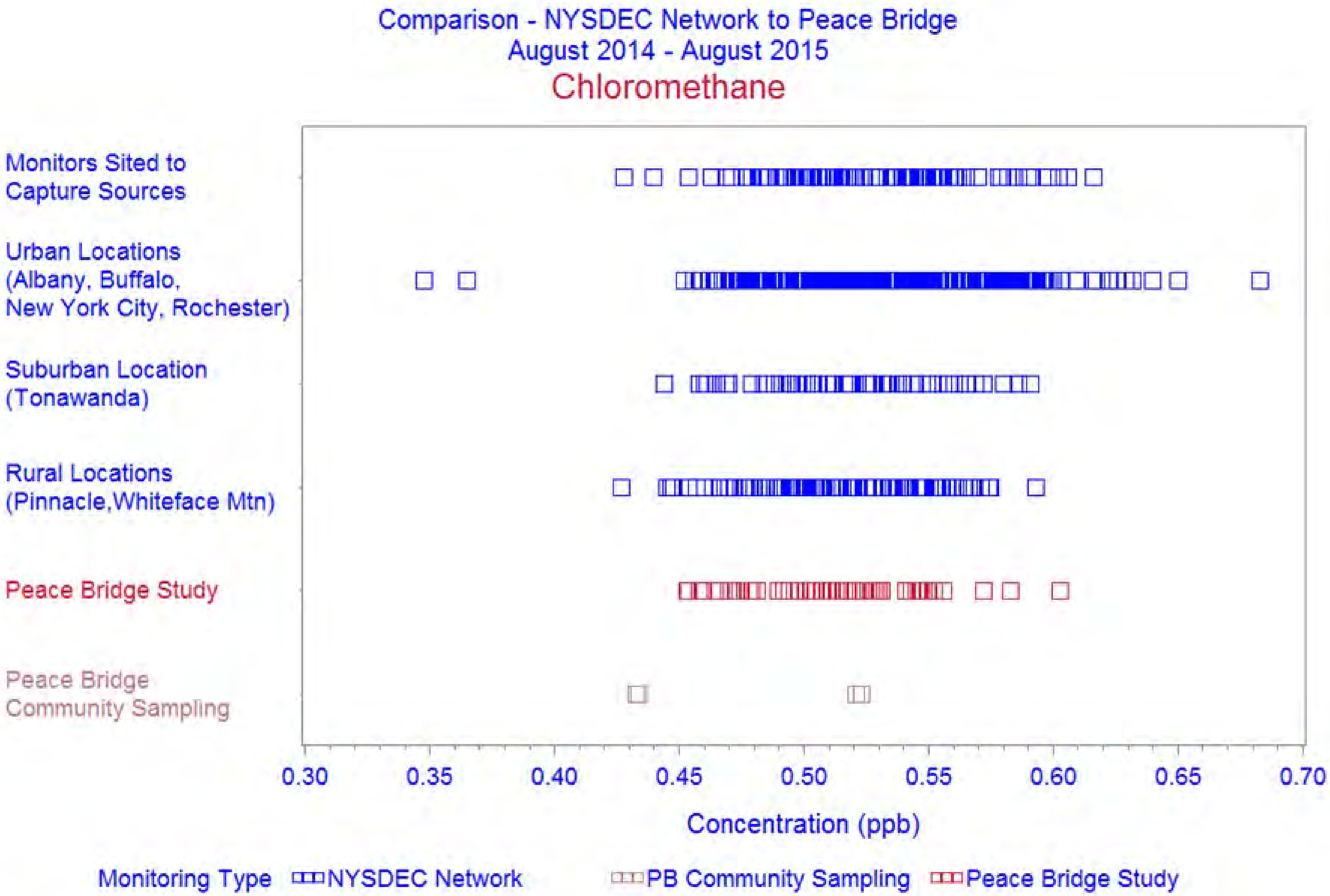
Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
Chlorobenzene
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
Concentration (ppb)
Monitoring Type
NYSDEC Network
PB Community Sampling
Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



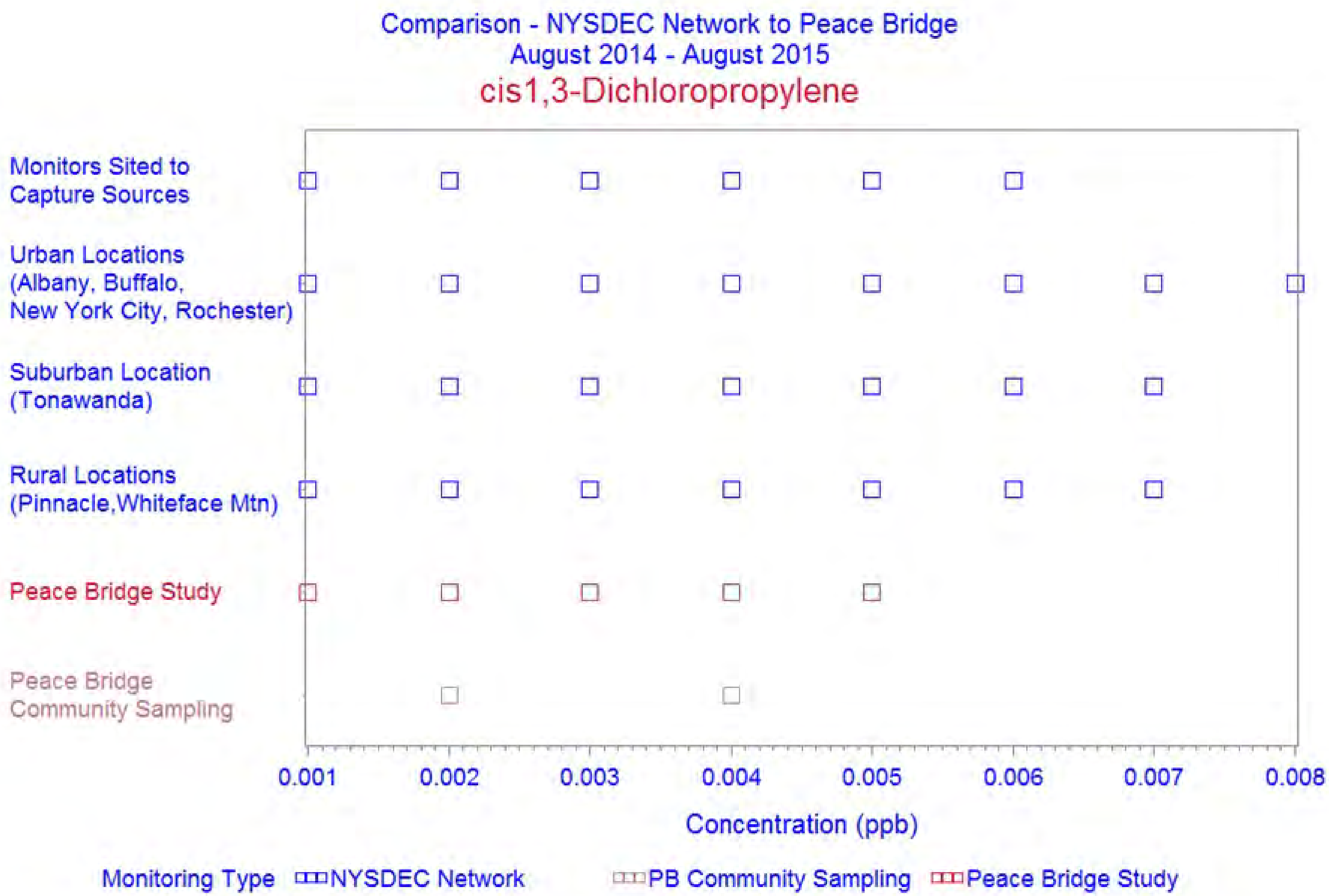
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



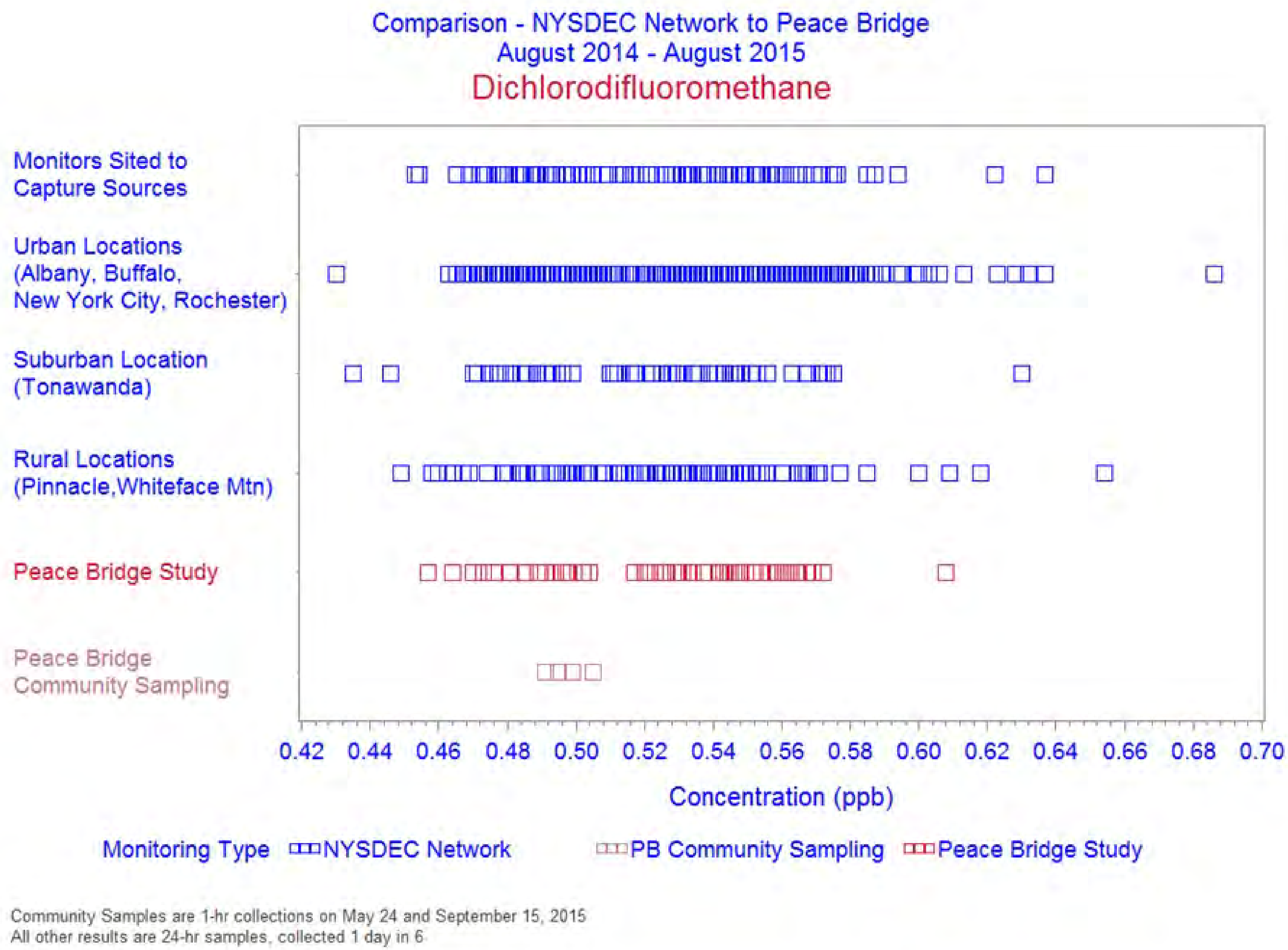
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

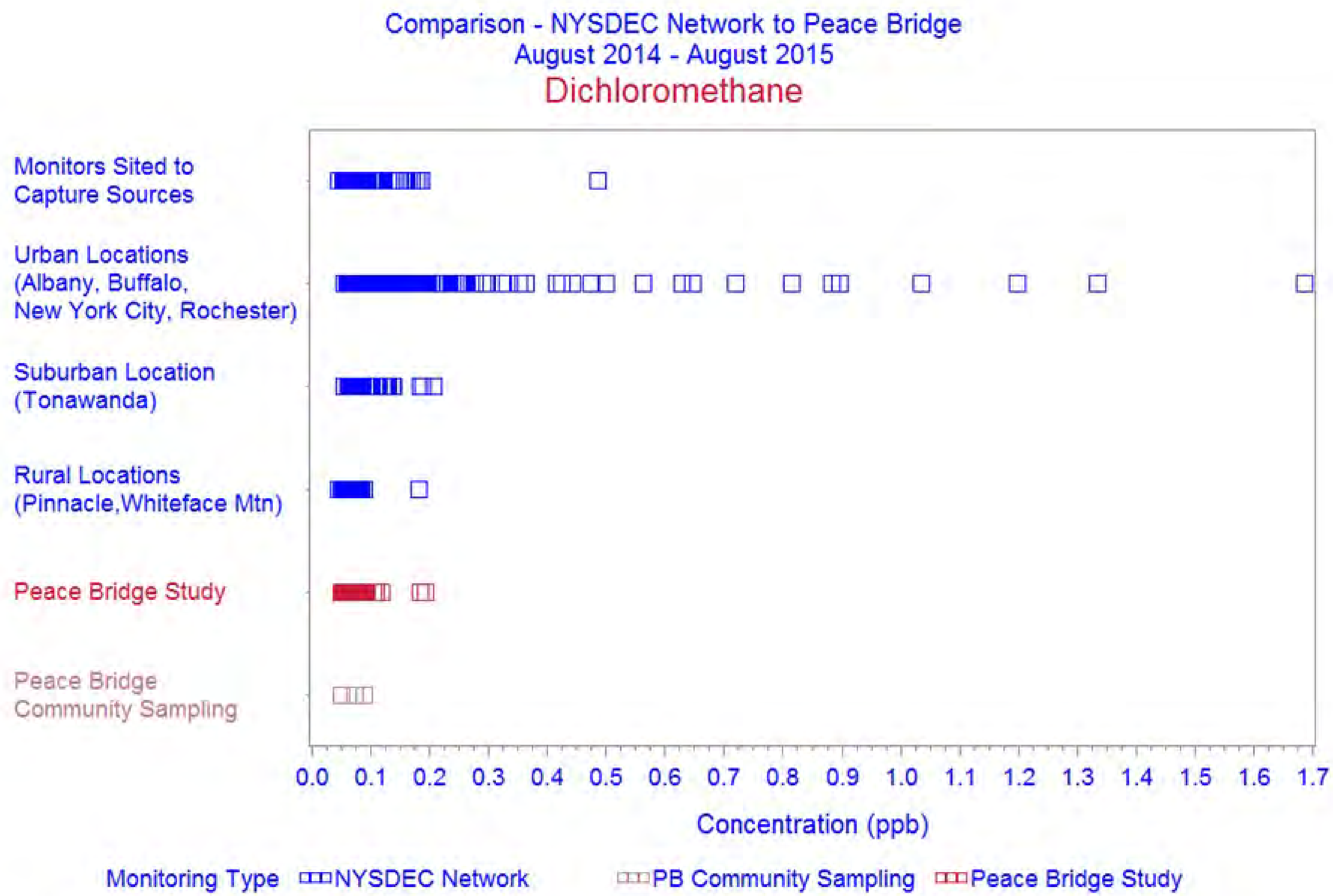


Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

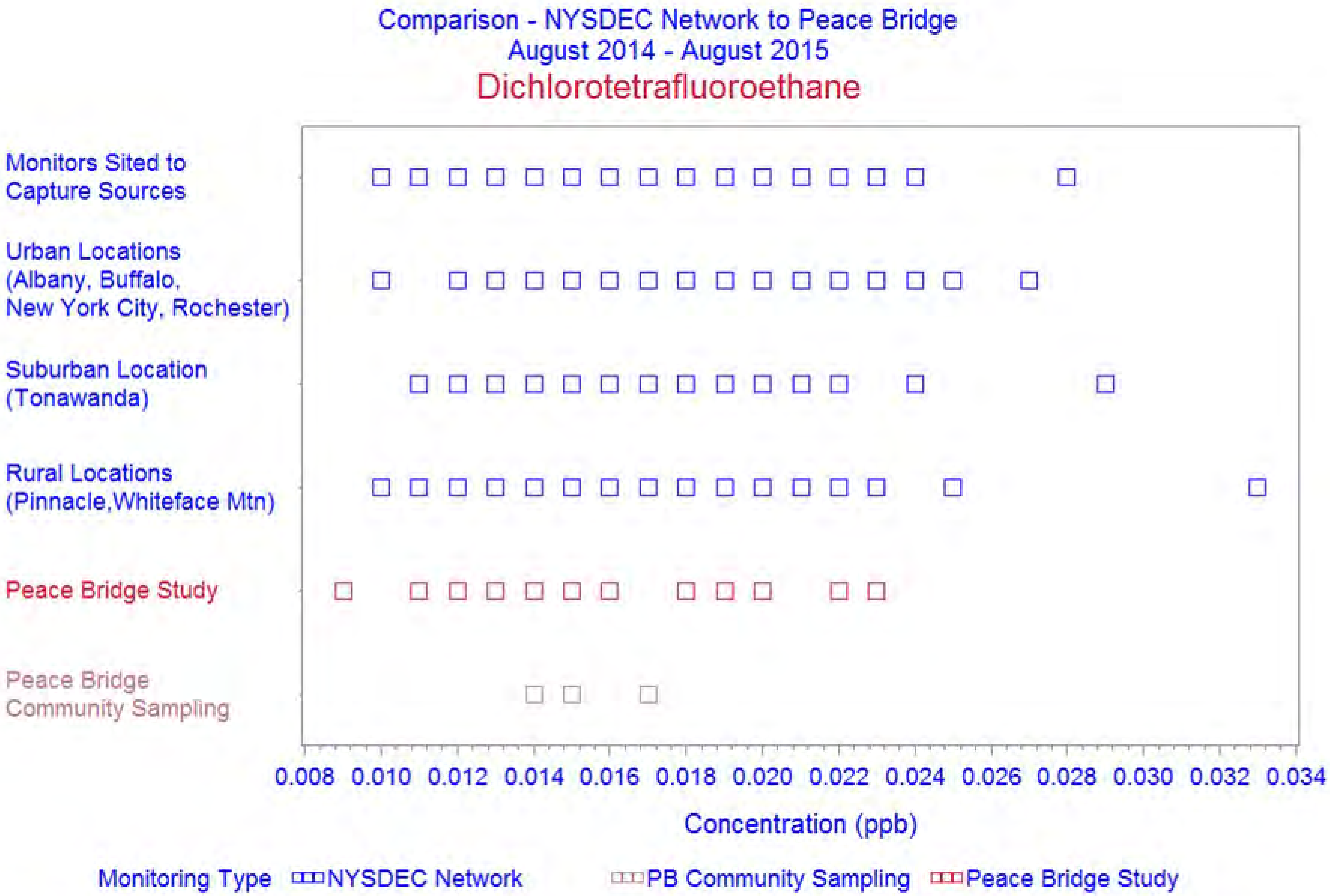


Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

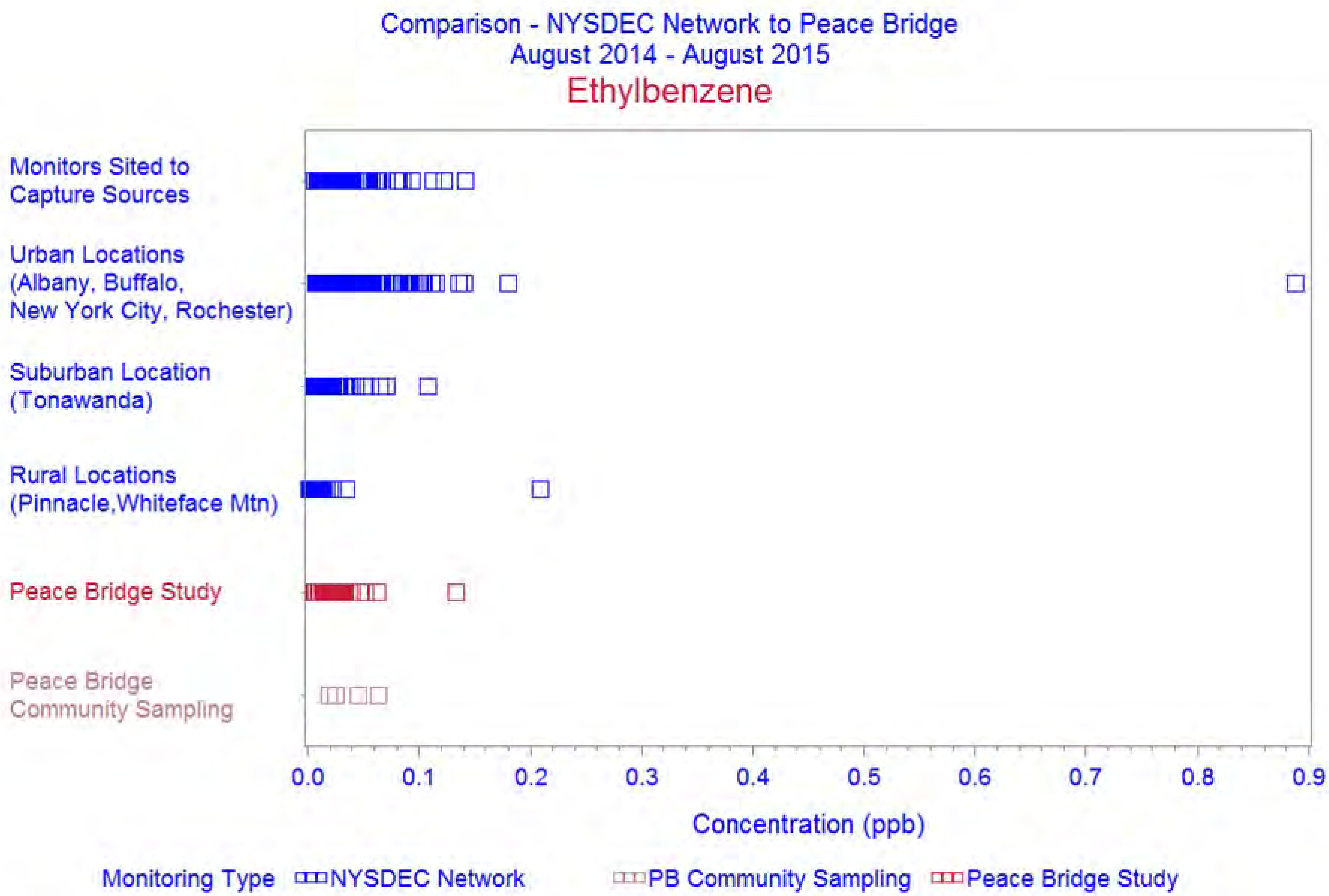

Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
Dichlorodifluoromethane
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.42 0.44 0.46 0.48 0.50 0.52 0.54 0.56 0.58 0.60 0.62 0.64 0.66 0.68 0.70
Concentration (ppb)
Monitoring Type
NYSDEC Network
PB Community Sampling
Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



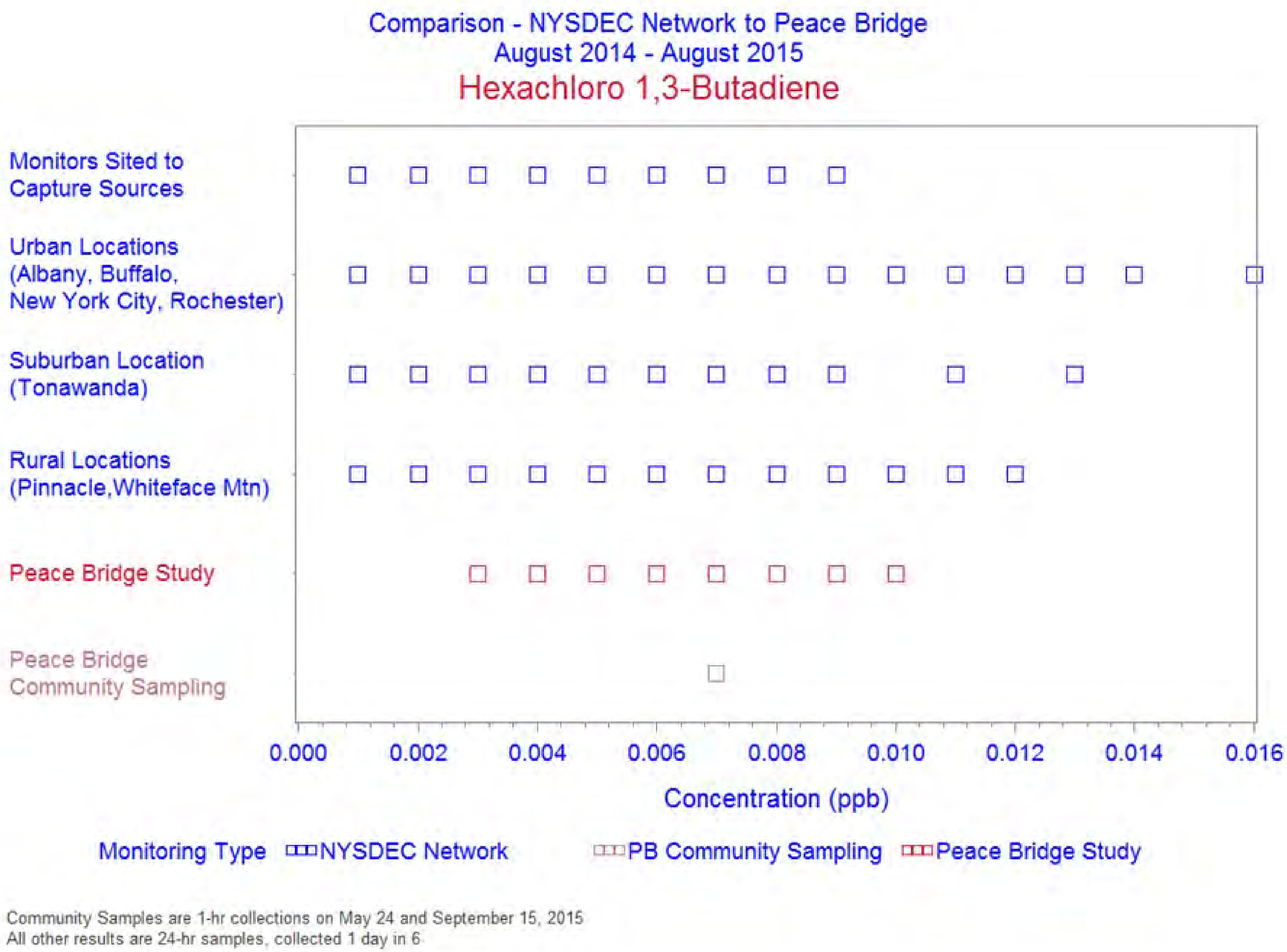
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



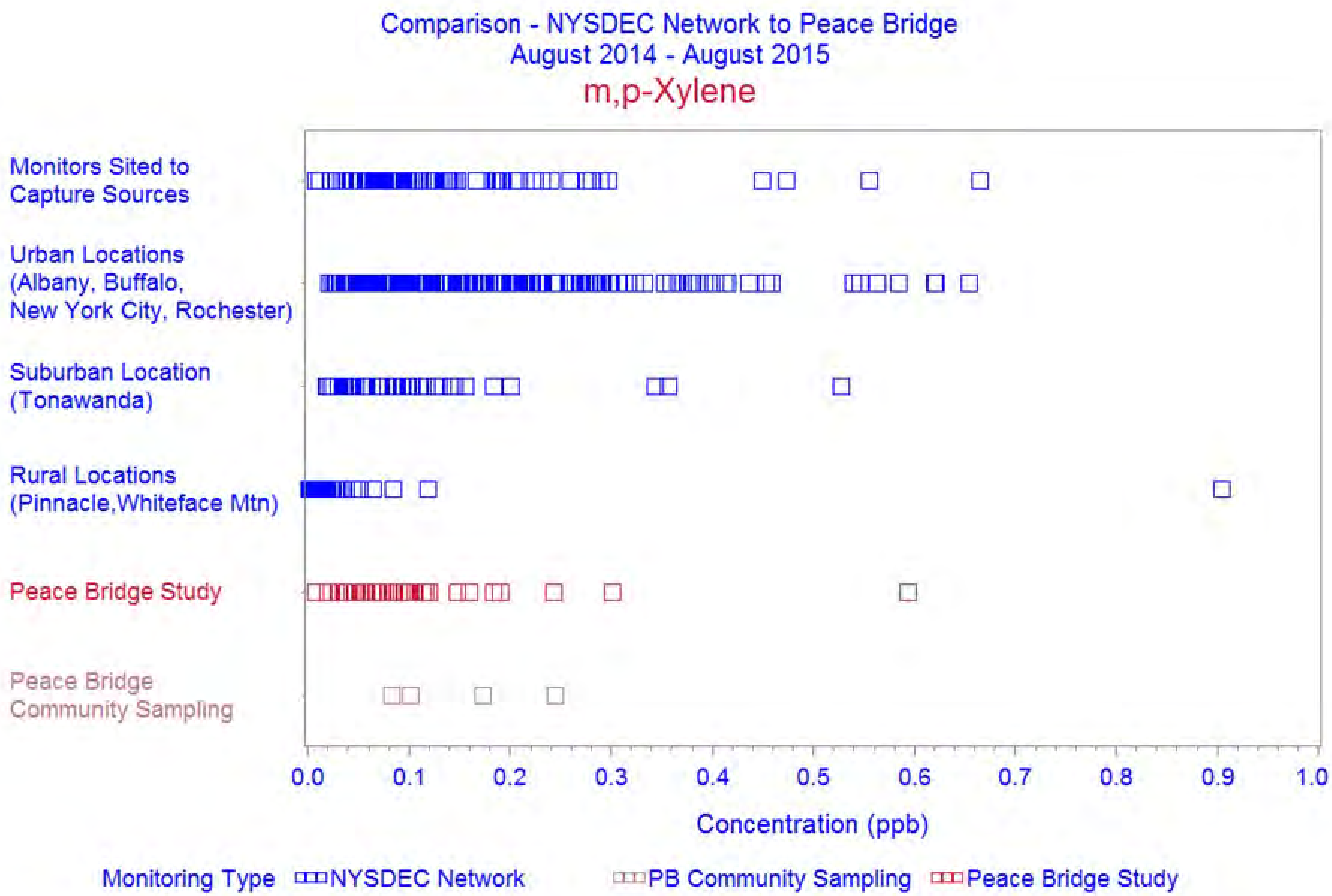
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



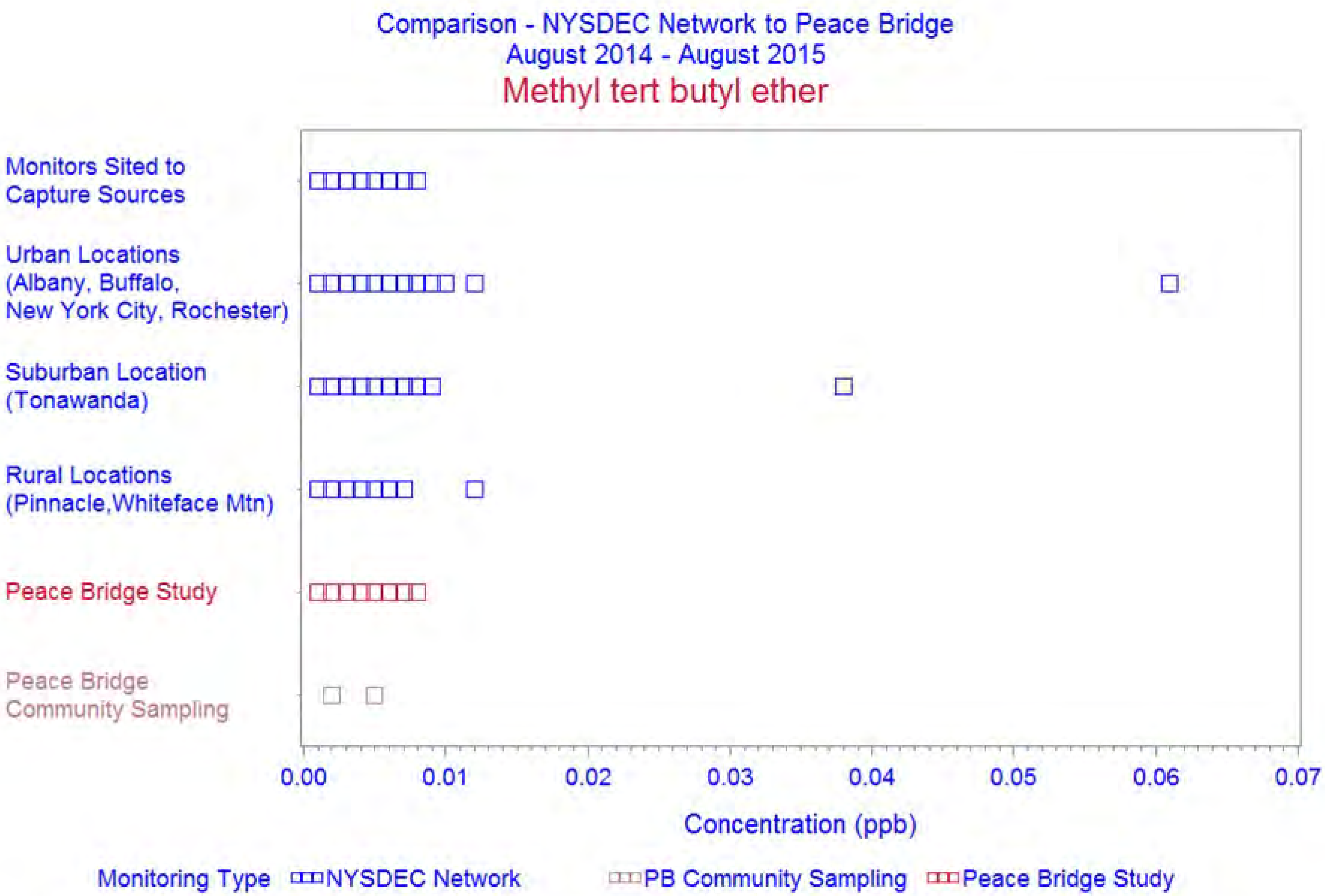
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



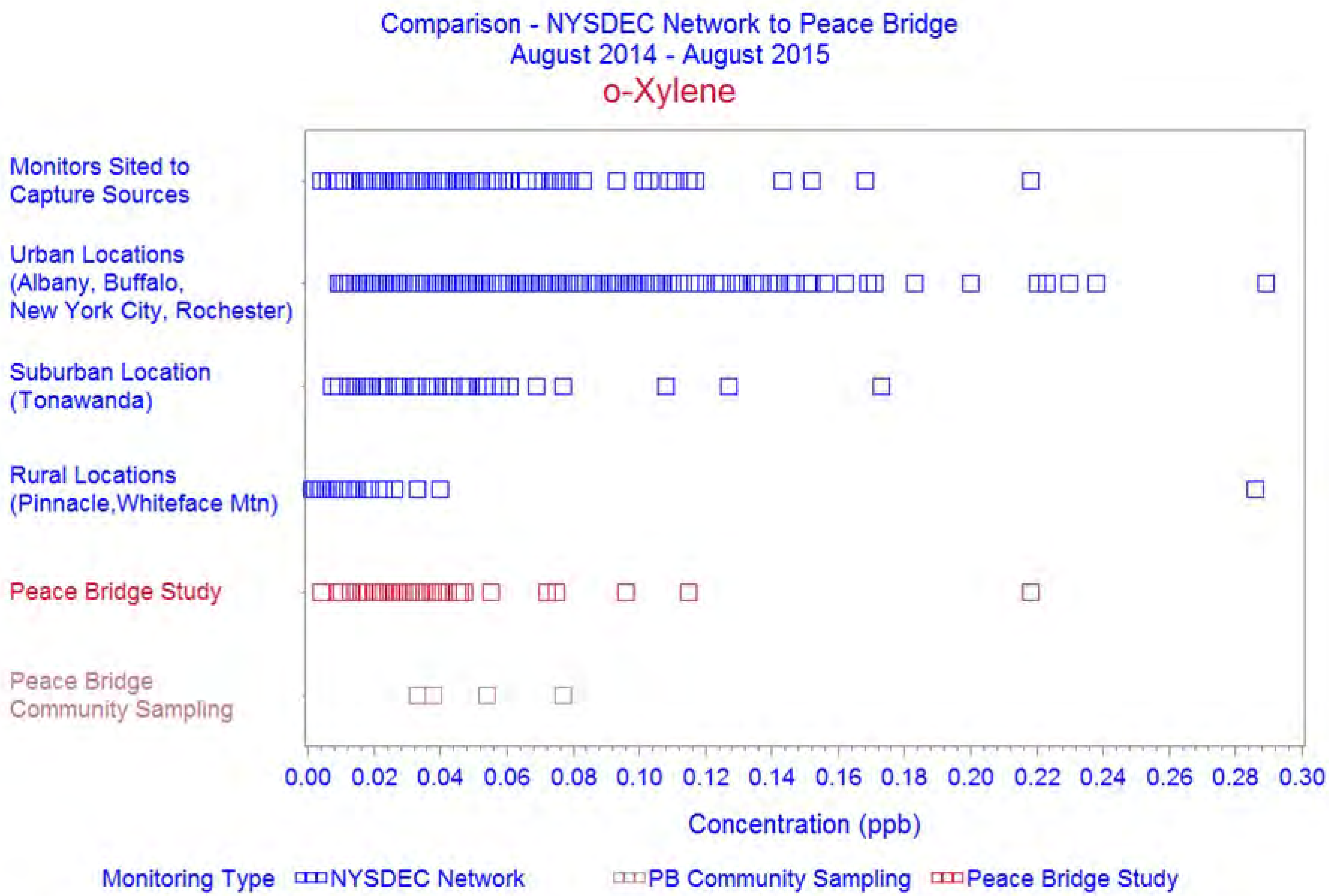
Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
Hexachloro 1,3-Butadiene
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
0.016
Concentration (ppb)
Monitoring Type
NYSDEC Network
PB Community Sampling
Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



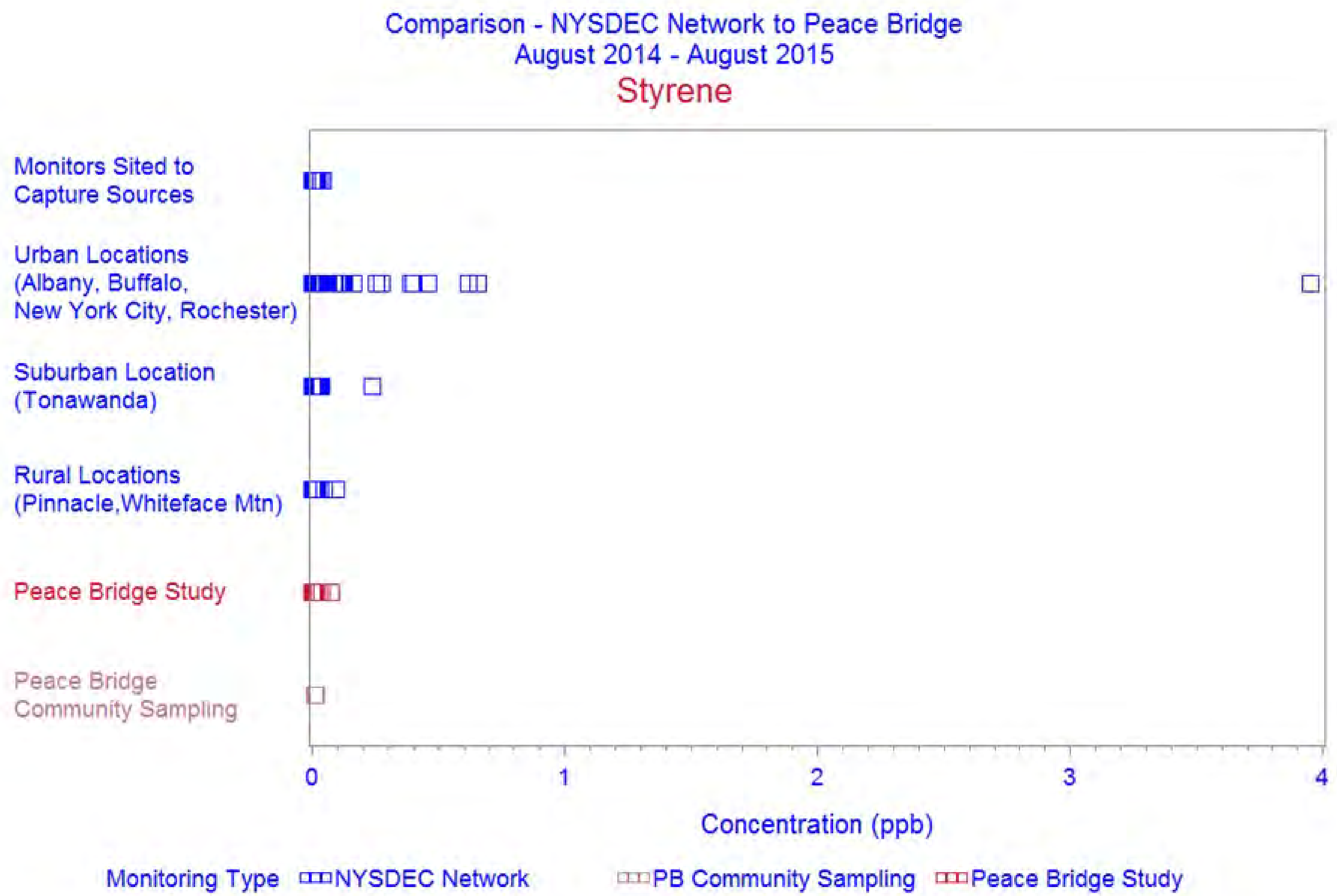
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



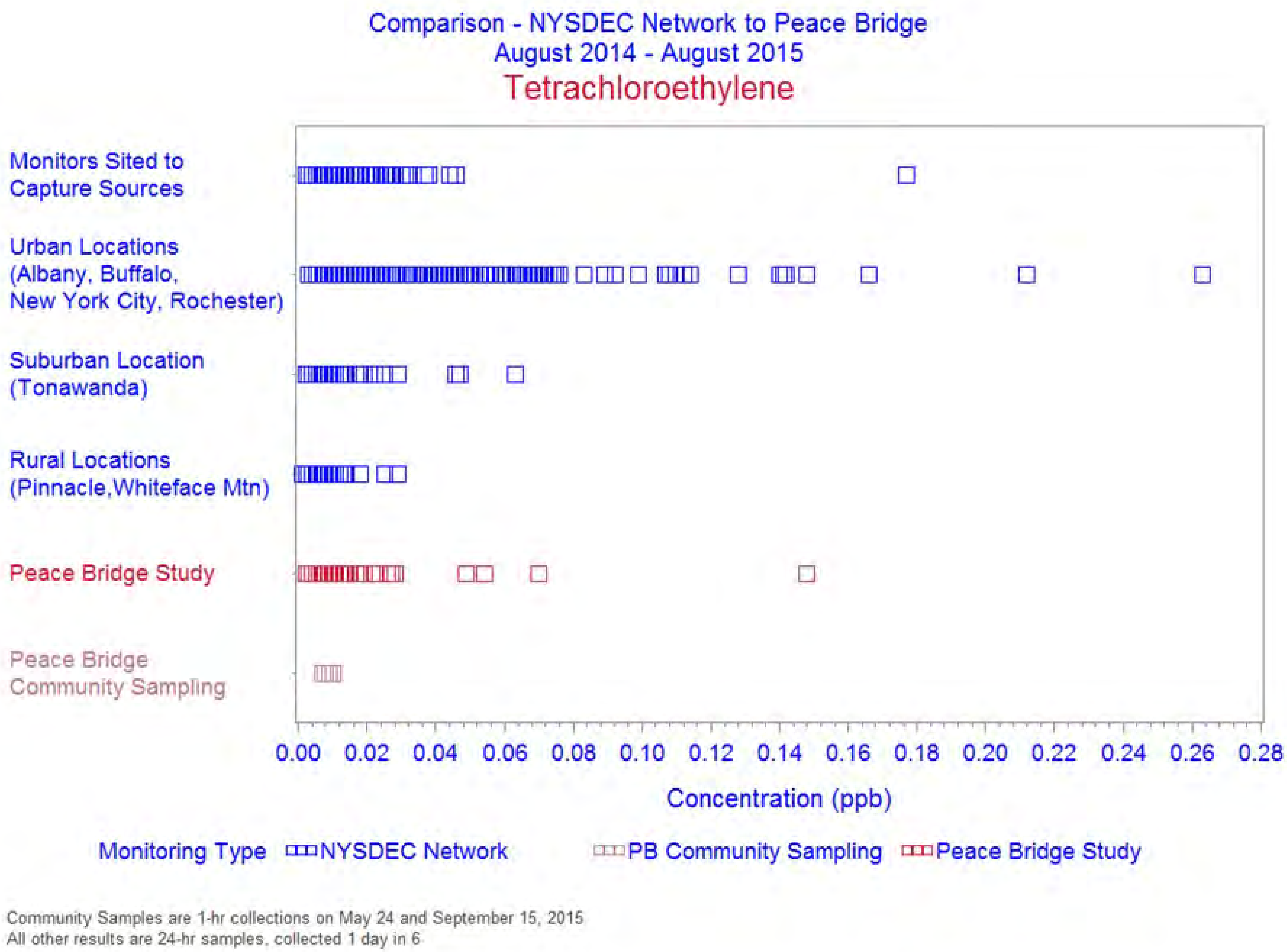
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

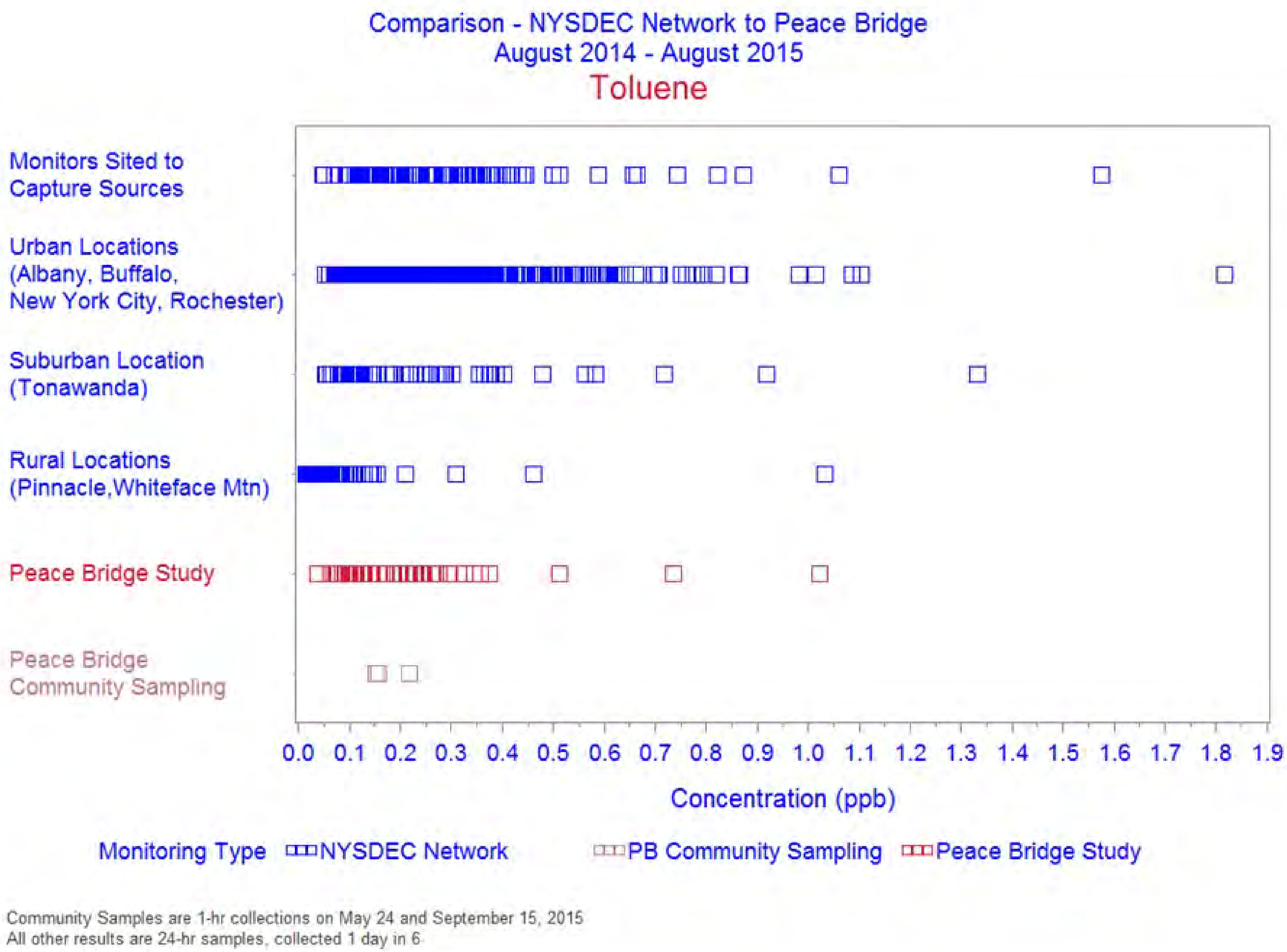


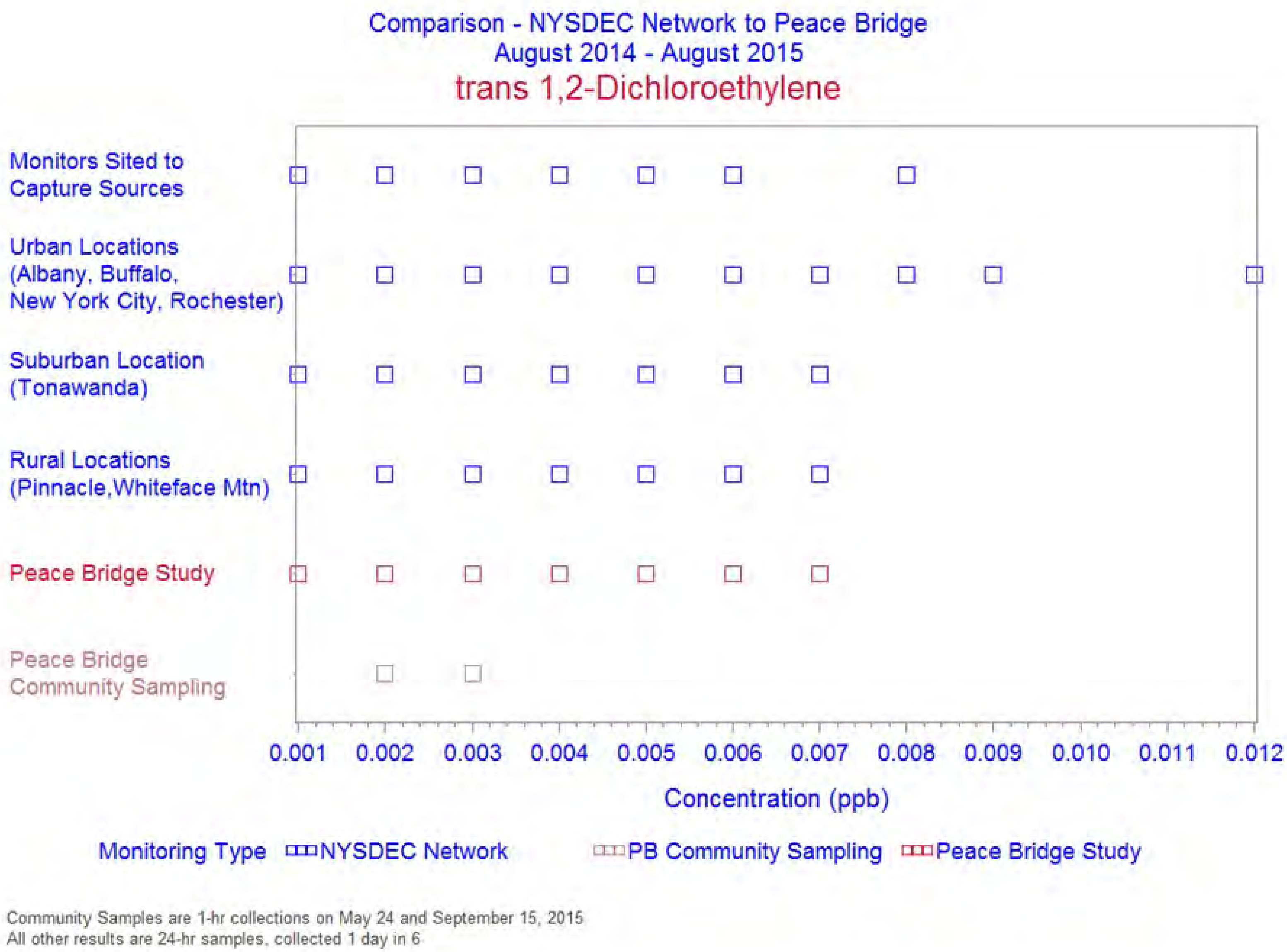
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



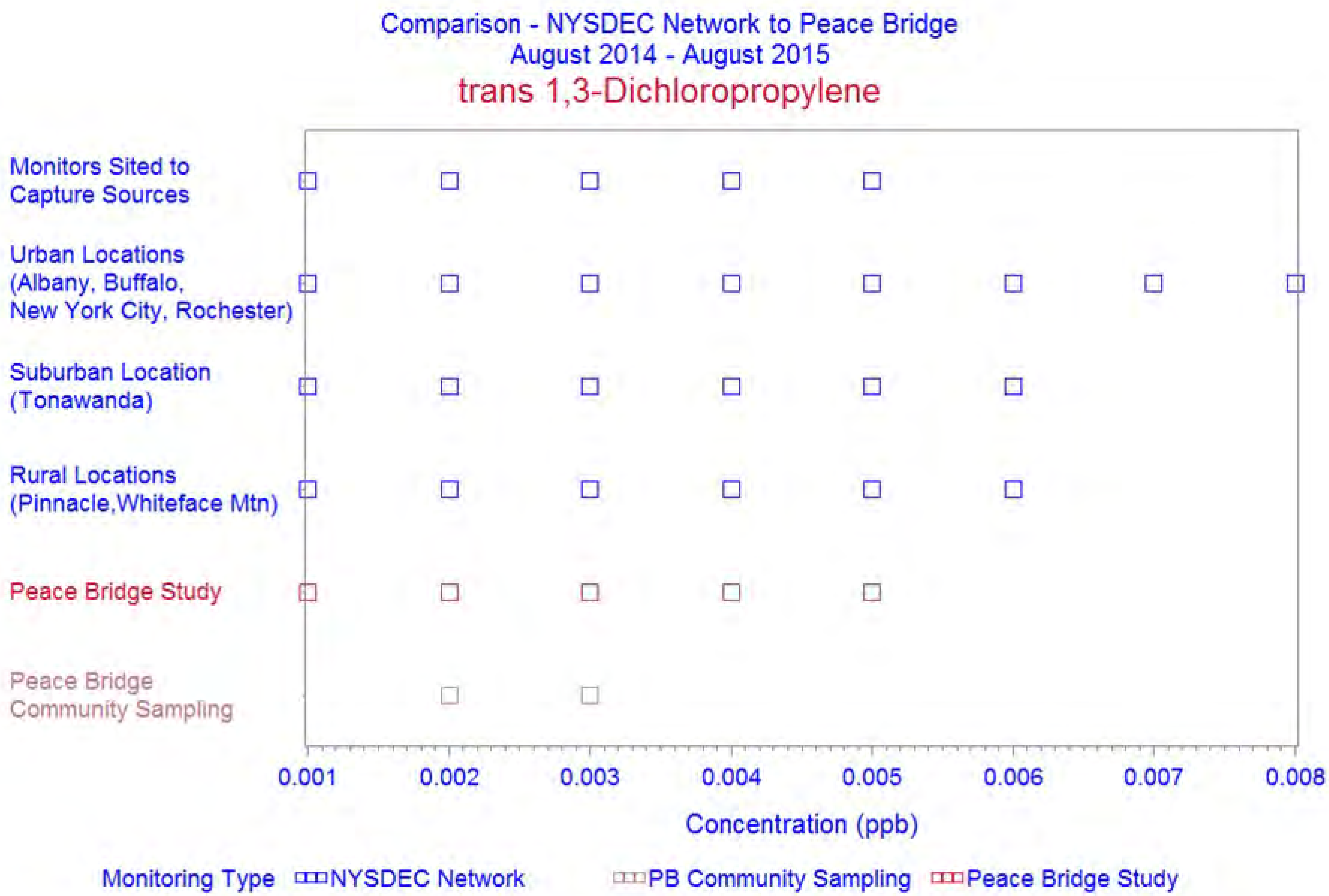
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6


Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
Tetrachloroethylene
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28
Concentration (ppb)
Monitoring Type NYSDEC Network PB Community Sampling Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

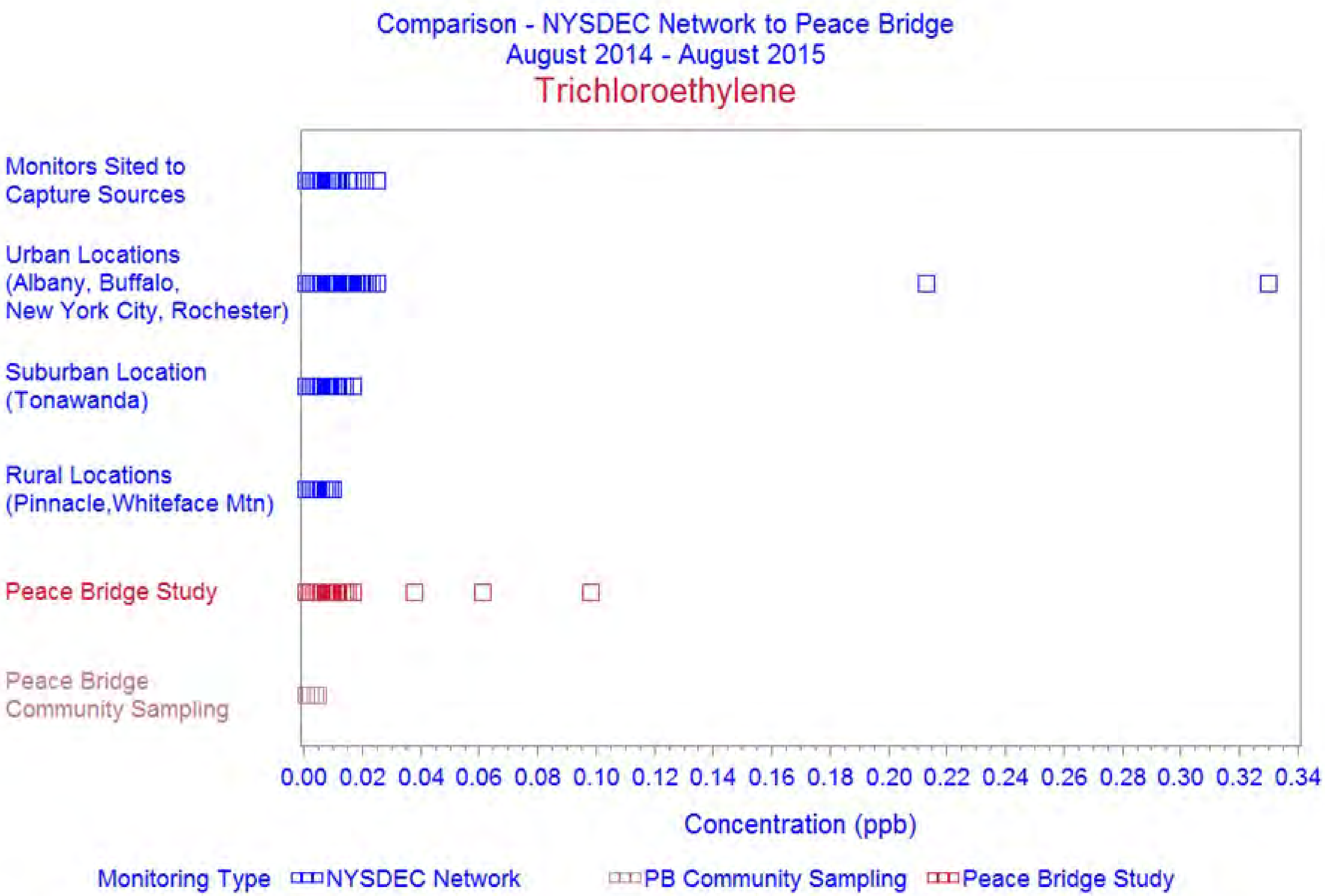

Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
Toluene
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9
Concentration (ppb)
Monitoring Type
NYSDEC Network
PB Community Sampling
Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



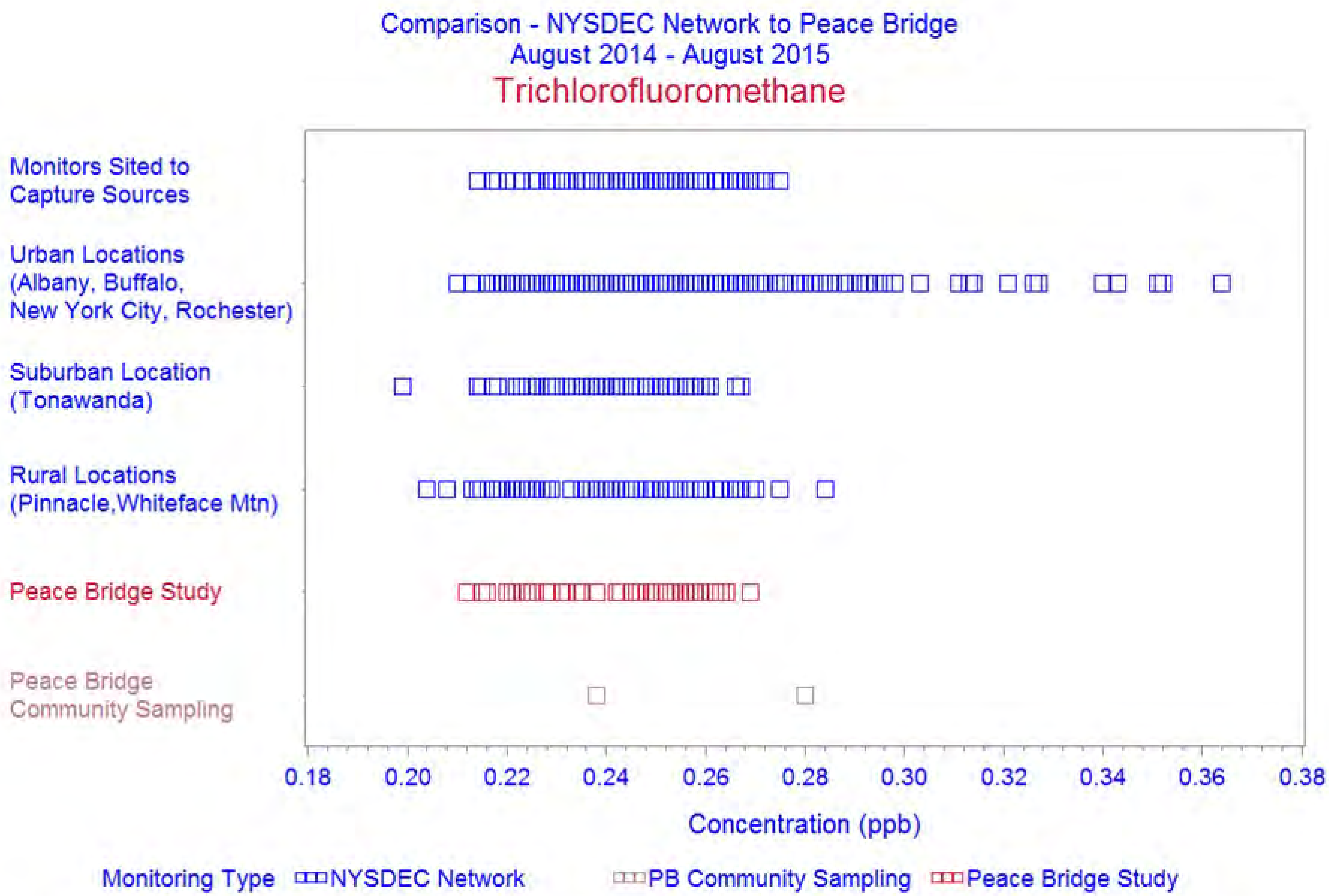
Comparison - NYSDEC Network to Peace Bridge
August 2014 - August 2015
trans 1,2-Dichloroethylene
Monitors Sited to Capture Sources
Urban Locations (Albany, Buffalo, New York City, Rochester)
Suburban Location (Tonawanda)
Rural Locations (Pinnacle,Whiteface Mtn)
Peace Bridge Study
Peace Bridge Community Sampling
0.001 0.002 0.003 0.004 0.005 0.006 0.007 0.008 0.009 0.010 0.011 0.012
Concentration (ppb)
Monitoring Type NYSDEC Network PB Community Sampling Peace Bridge Study
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



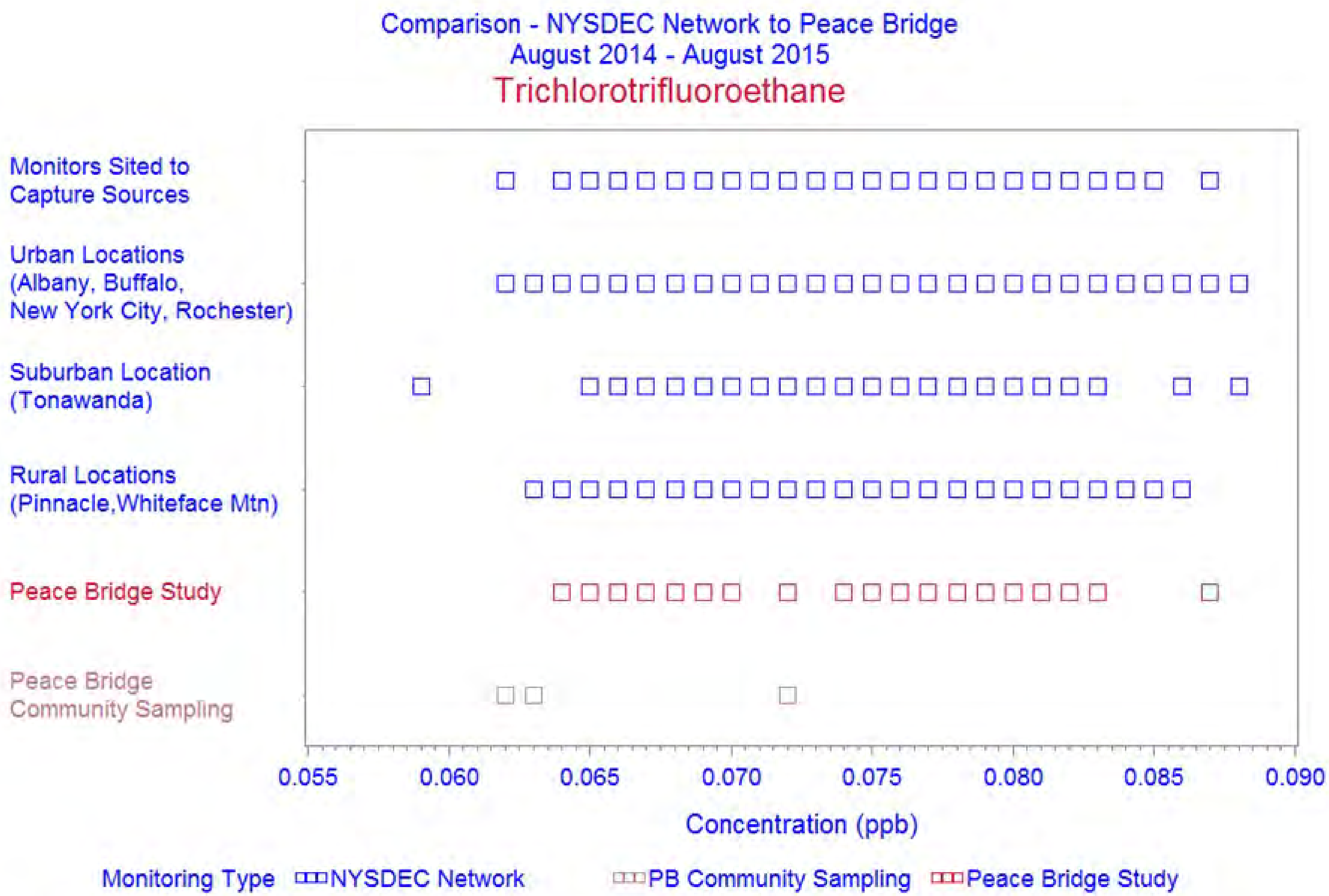
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



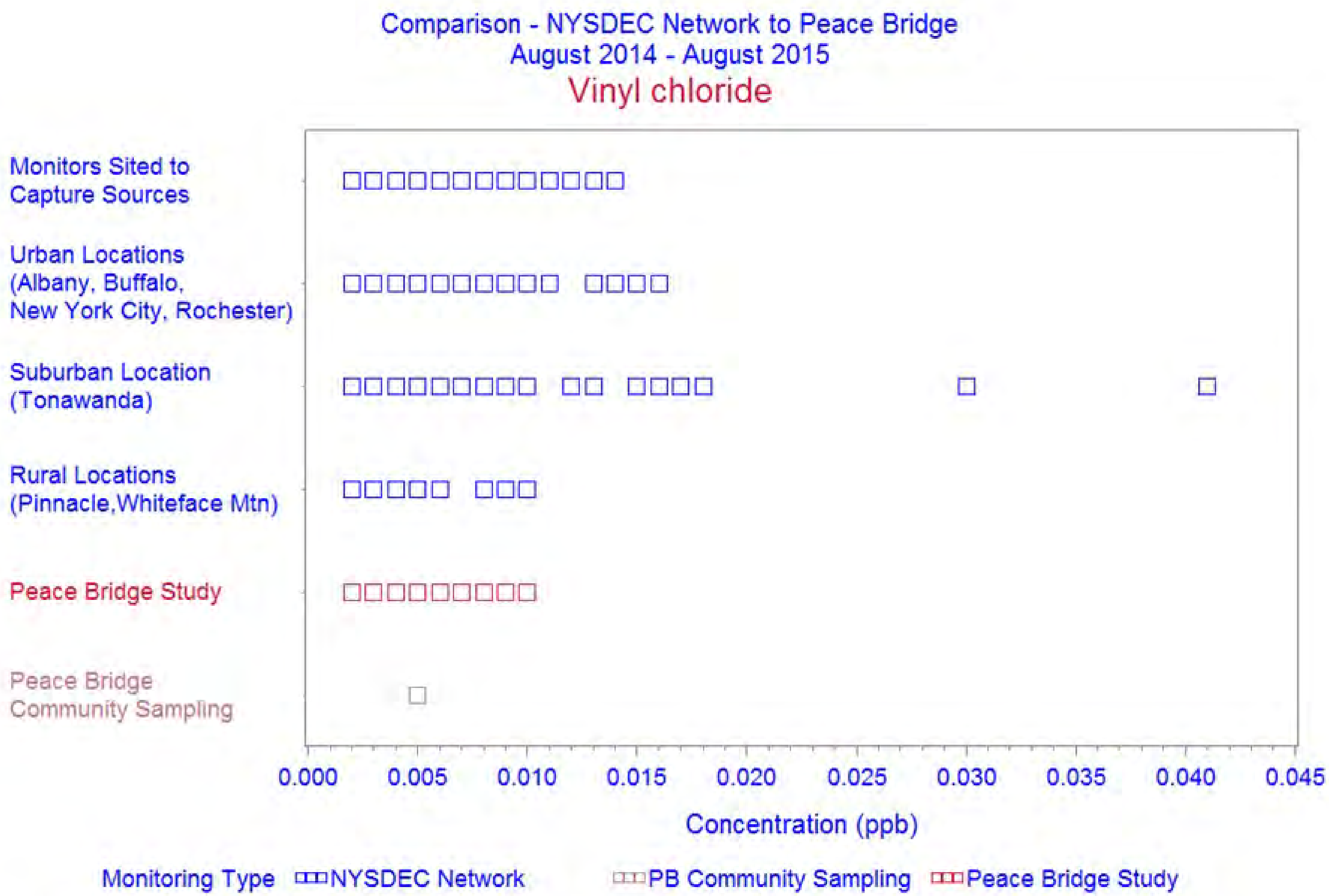
Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6



Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

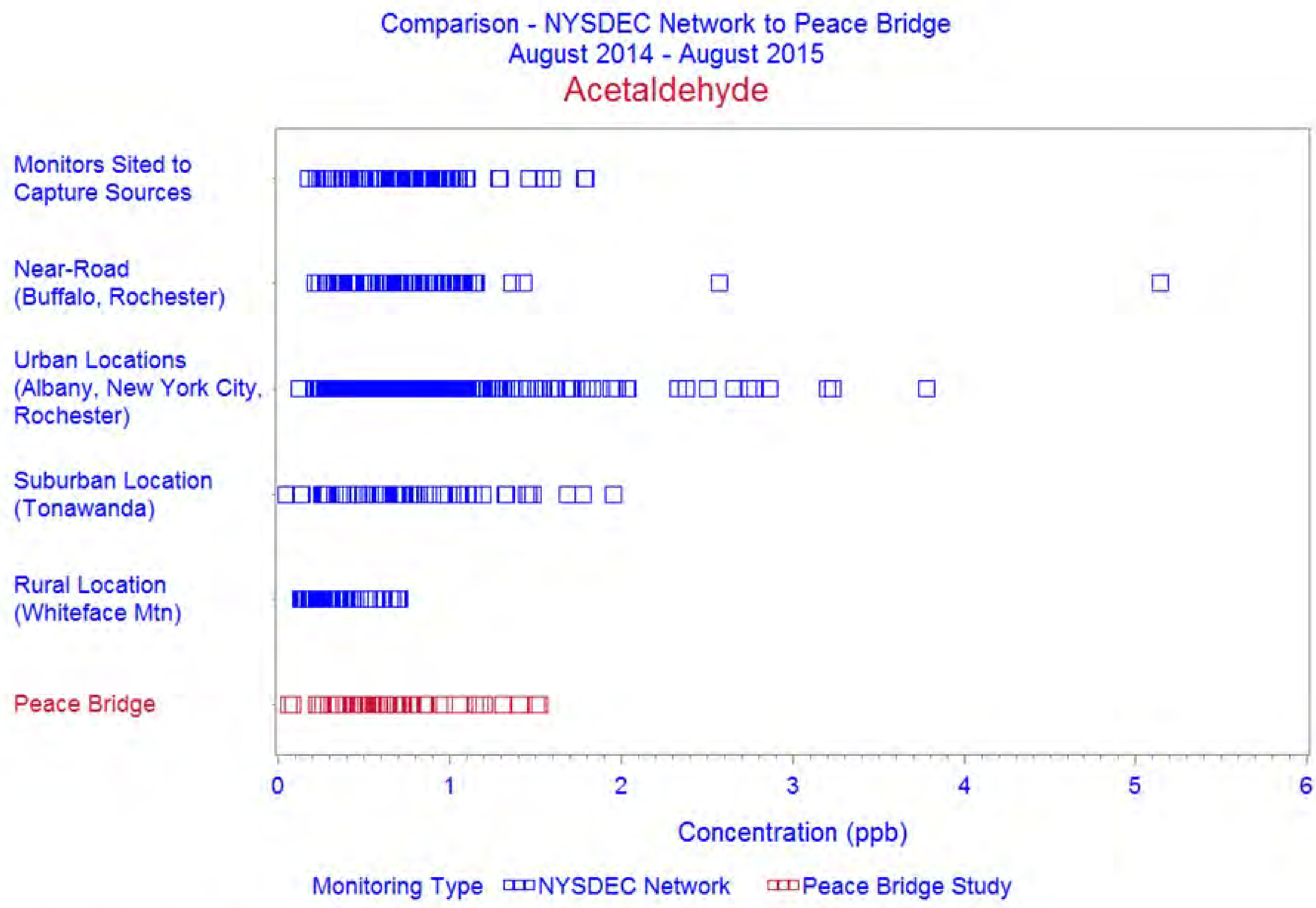


Community Samples are 1-hr collections on May 24 and September 15, 2015
All other results are 24-hr samples, collected 1 day in 6

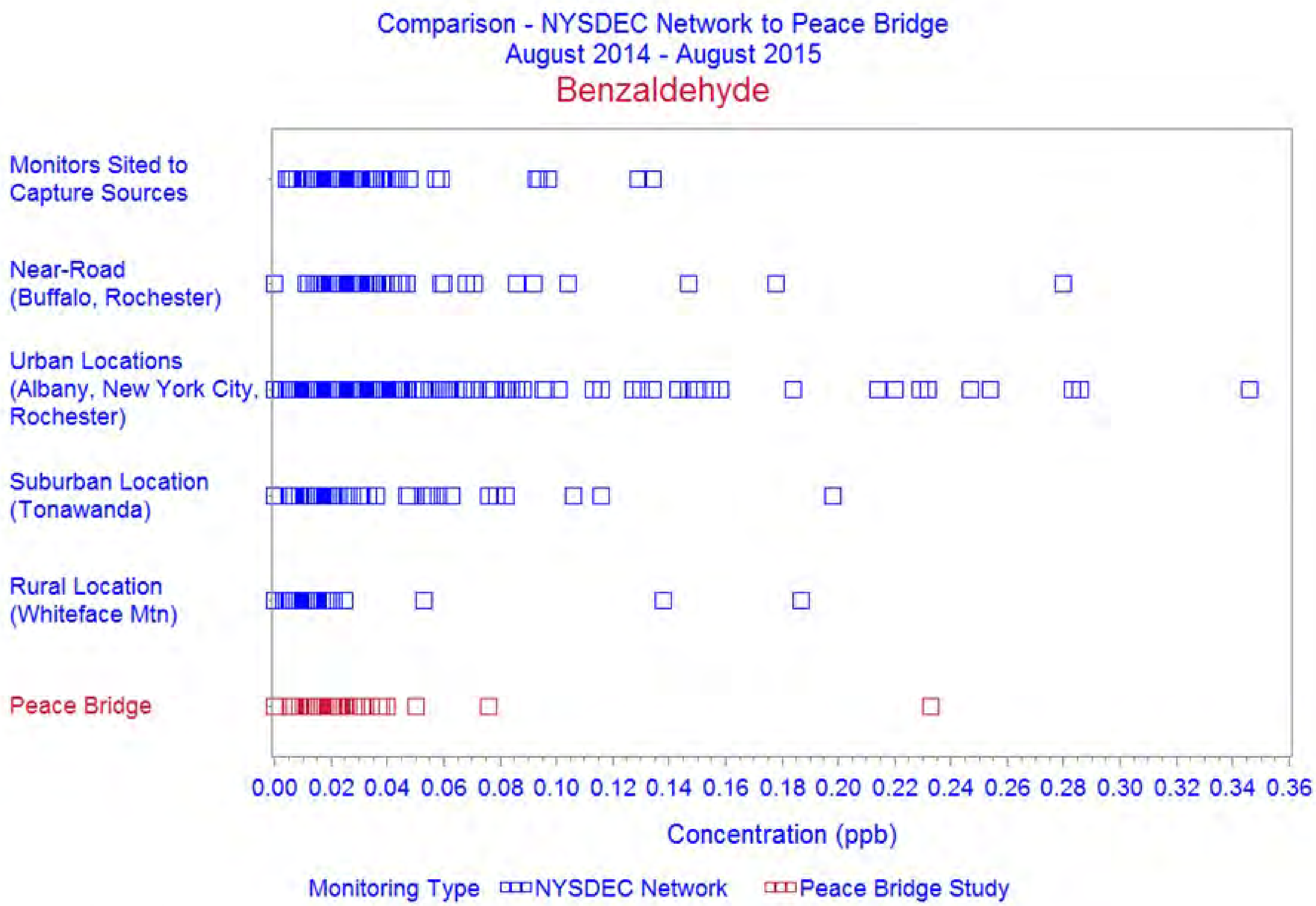
Appendix D – Graphical Comparisons

NYSDEC Monitoring Network to Peace Bridge Results for

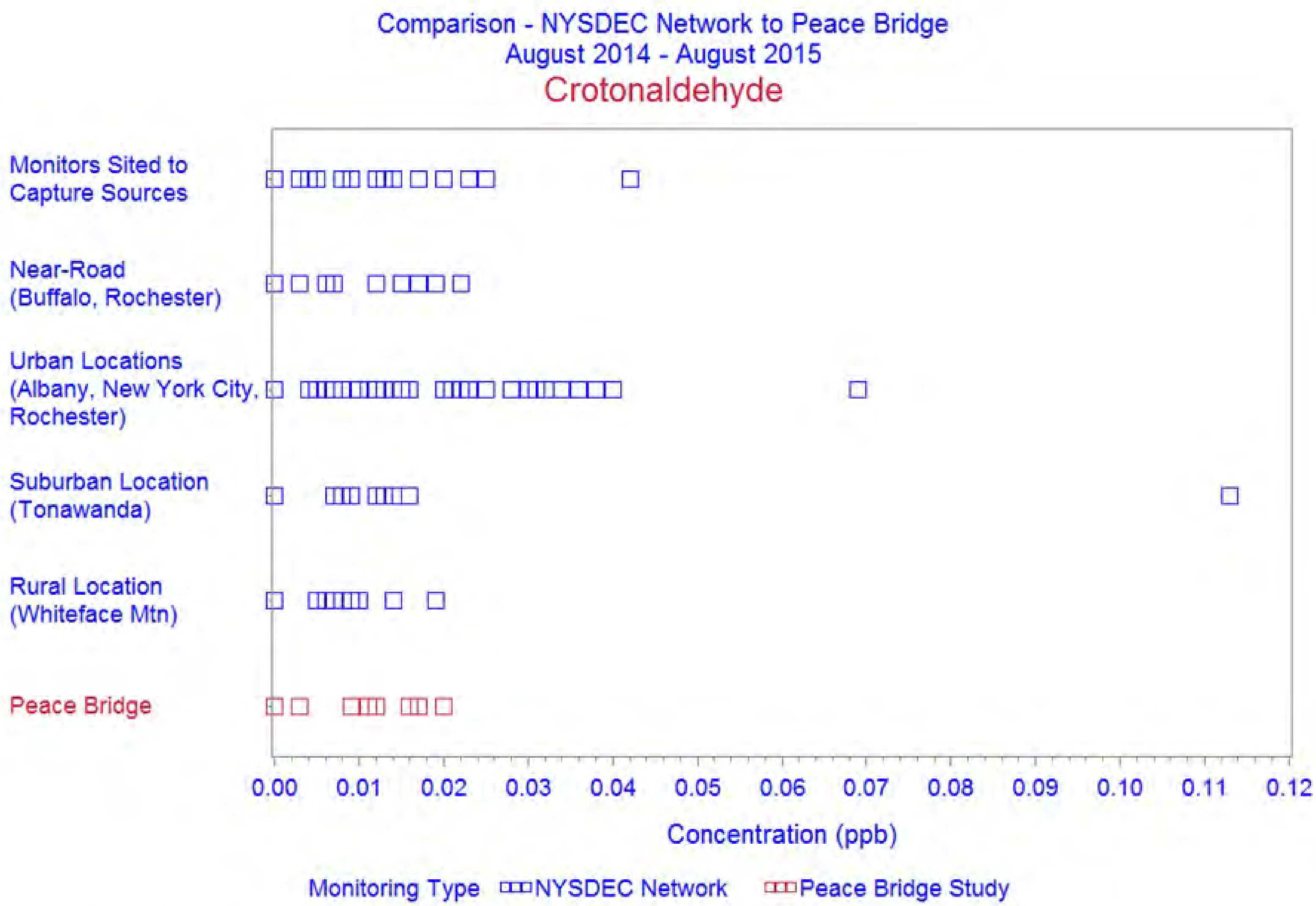
Carbonyl Compounds



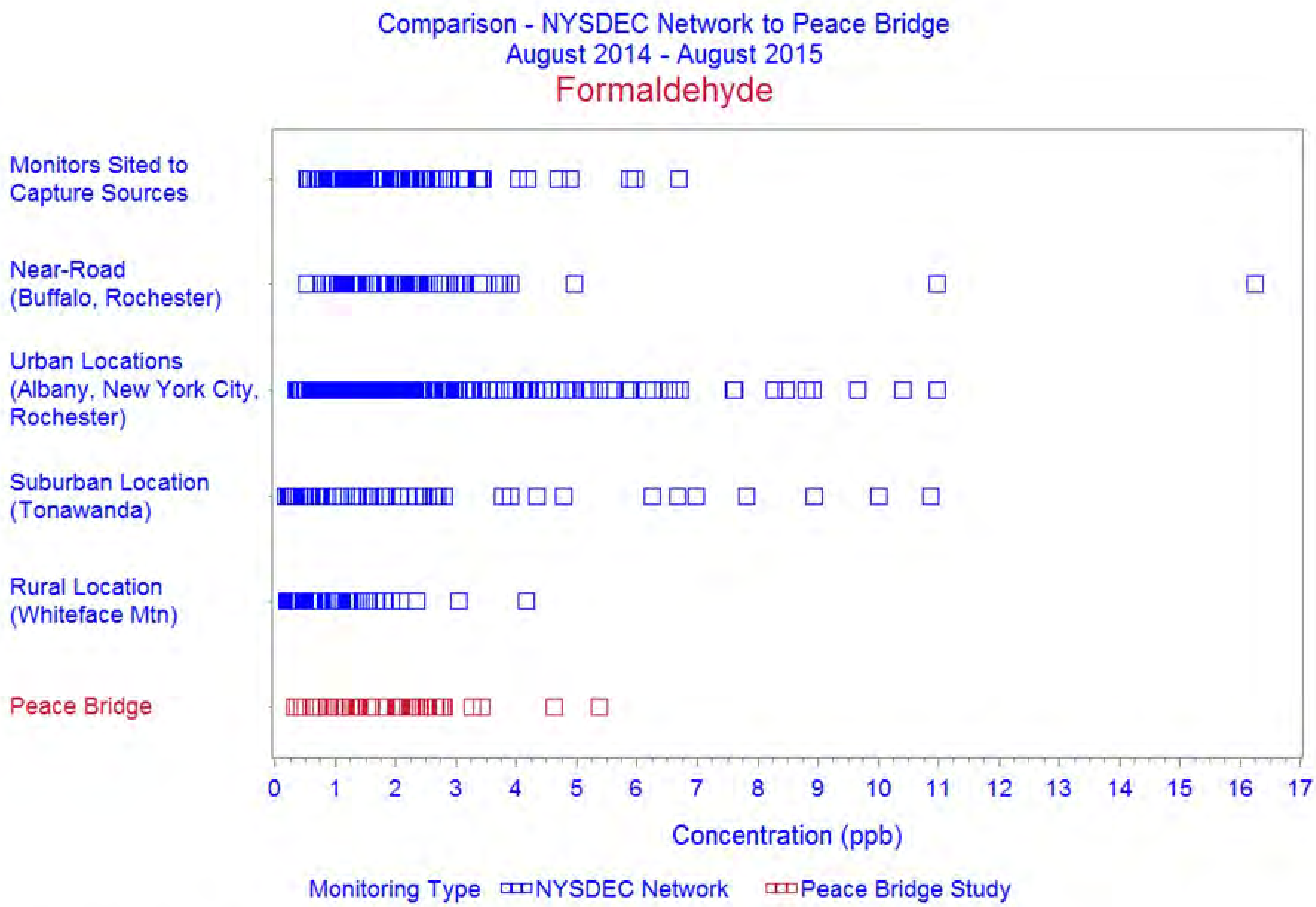
All results are 24-hr samples, collected 1 day in 6



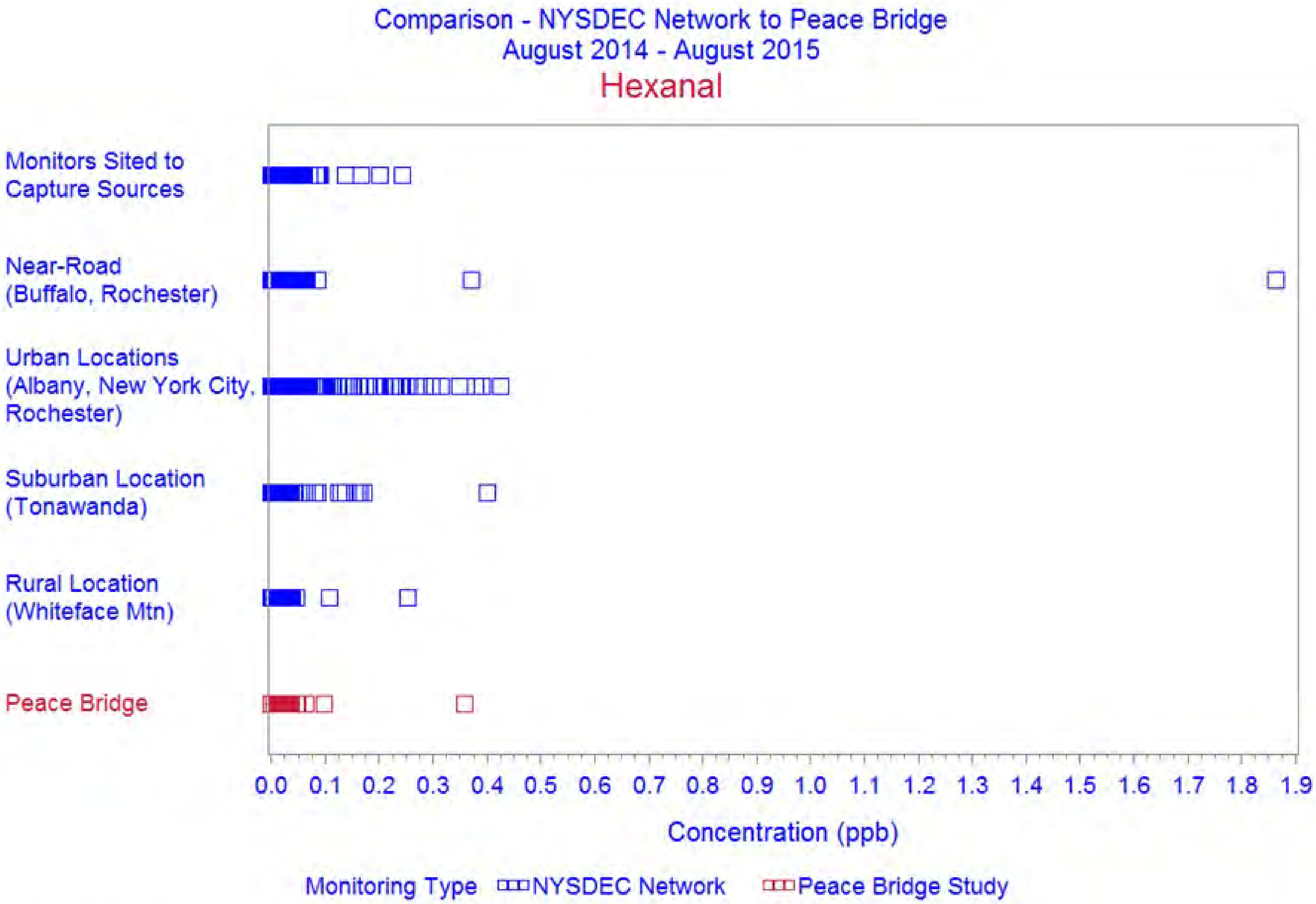
All results are 24-hr samples, collected 1 day in 6



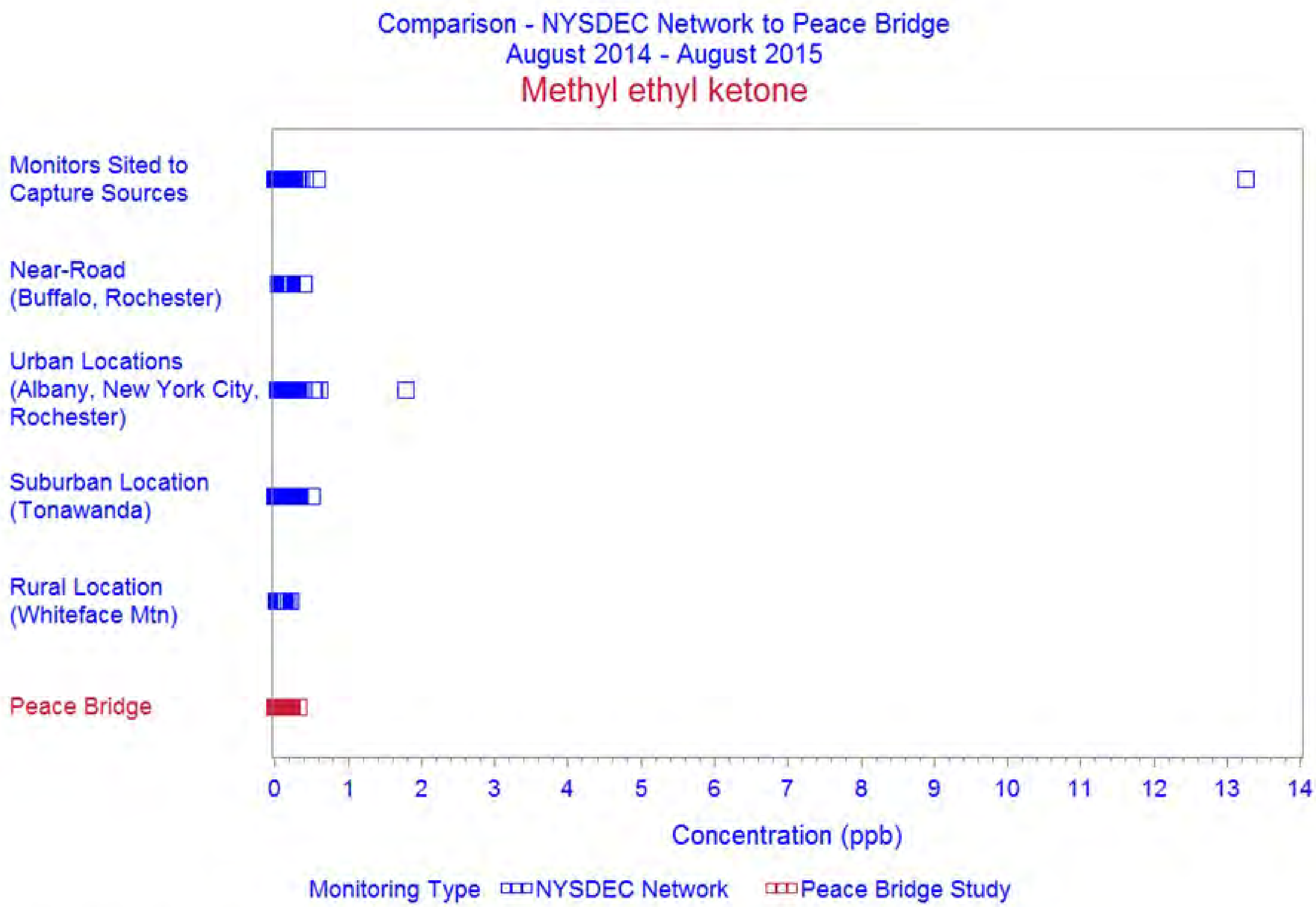
All results are 24-hr samples, collected 1 day in 6



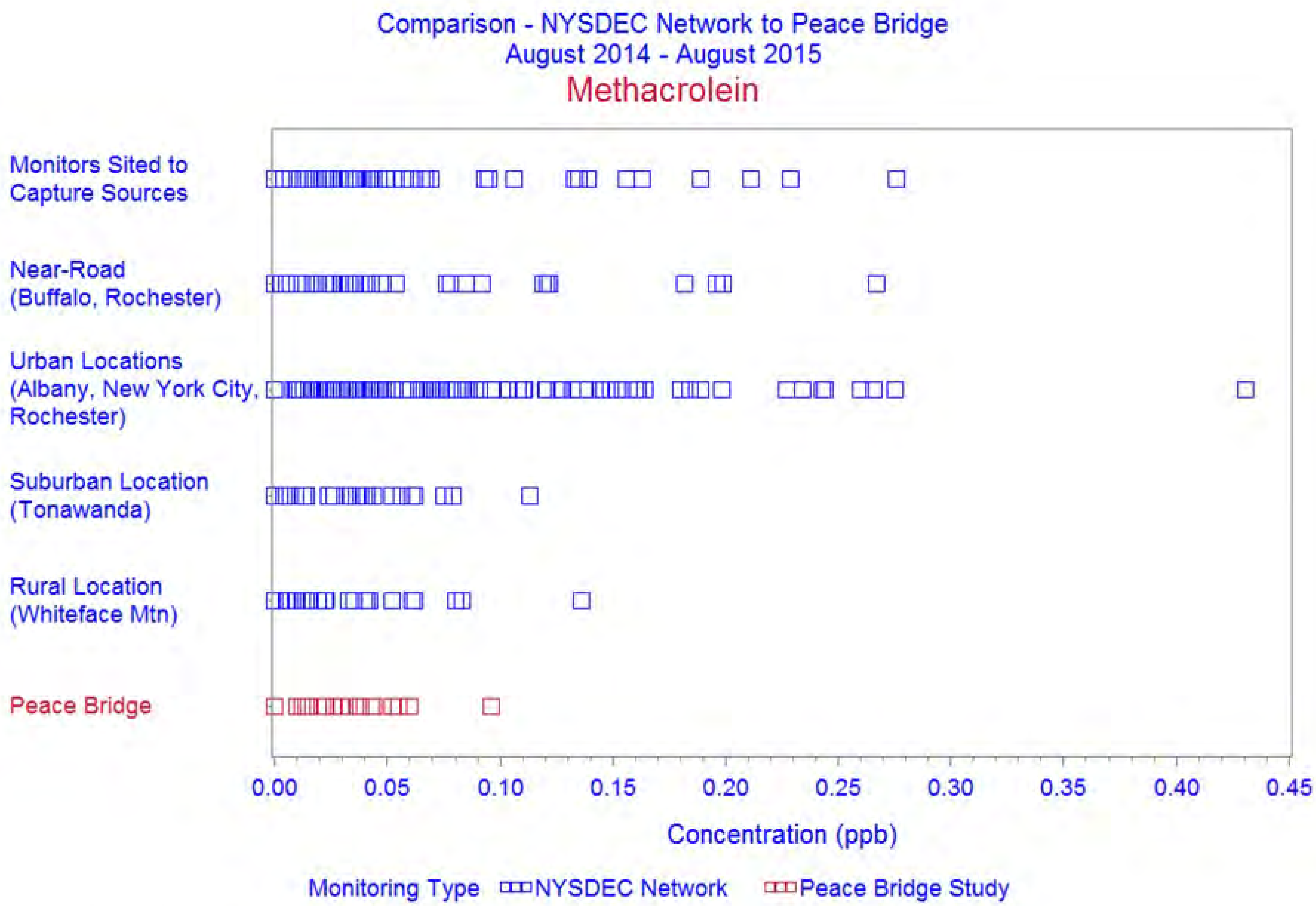
All results are 24-hr samples, collected 1 day in 6



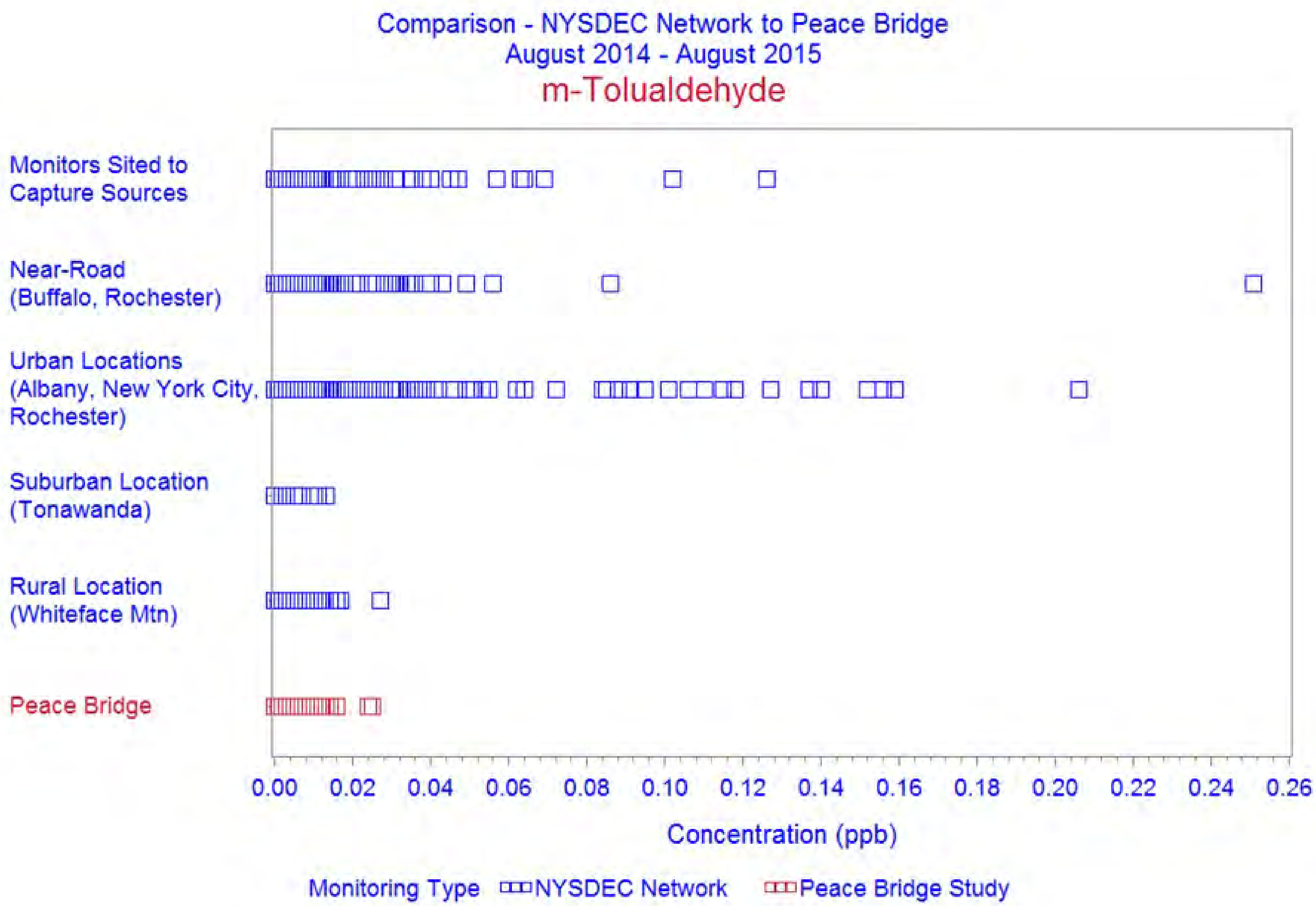
All results are 24-hr samples, collected 1 day in 6



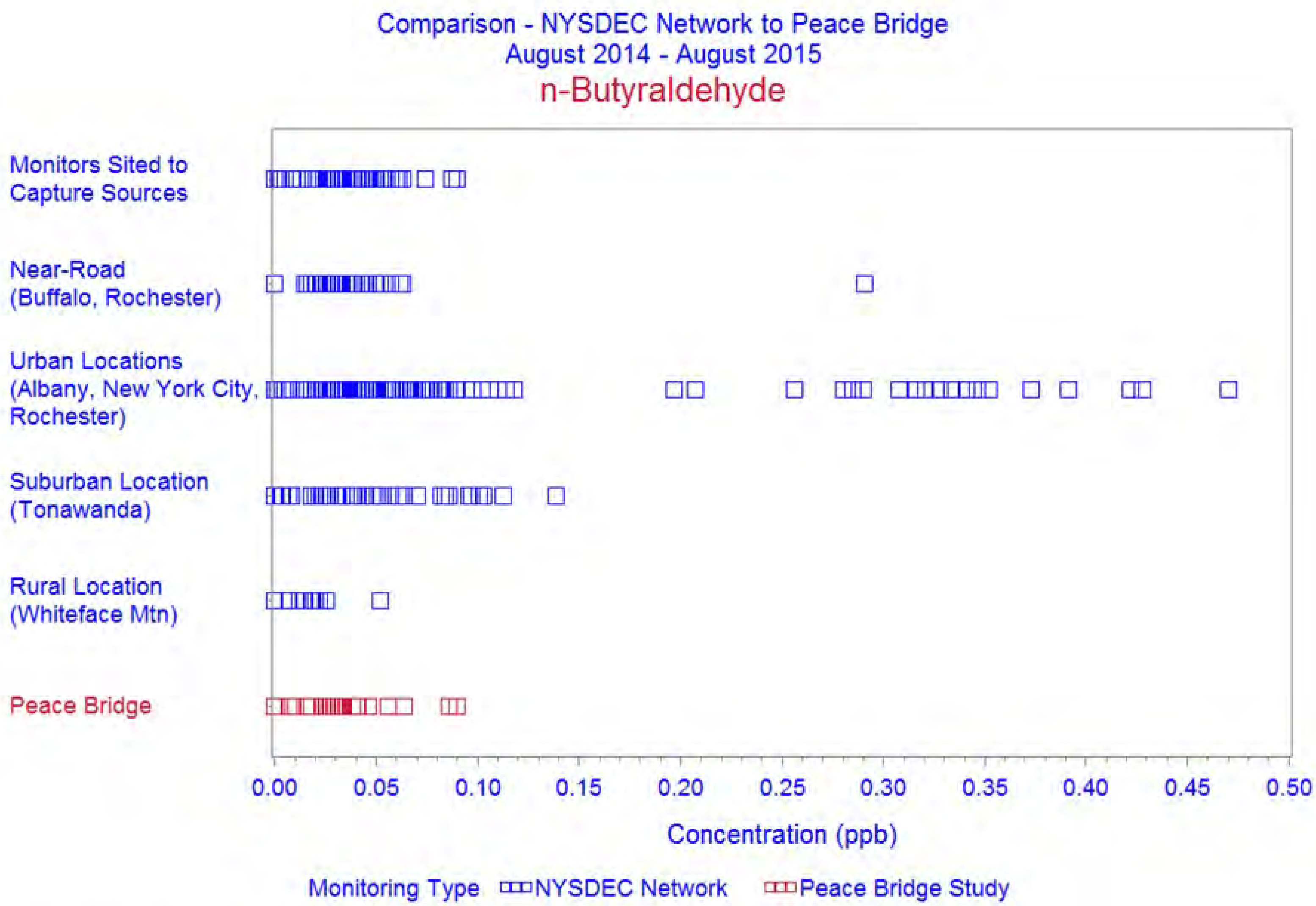
All results are 24-hr samples, collected 1 day in 6



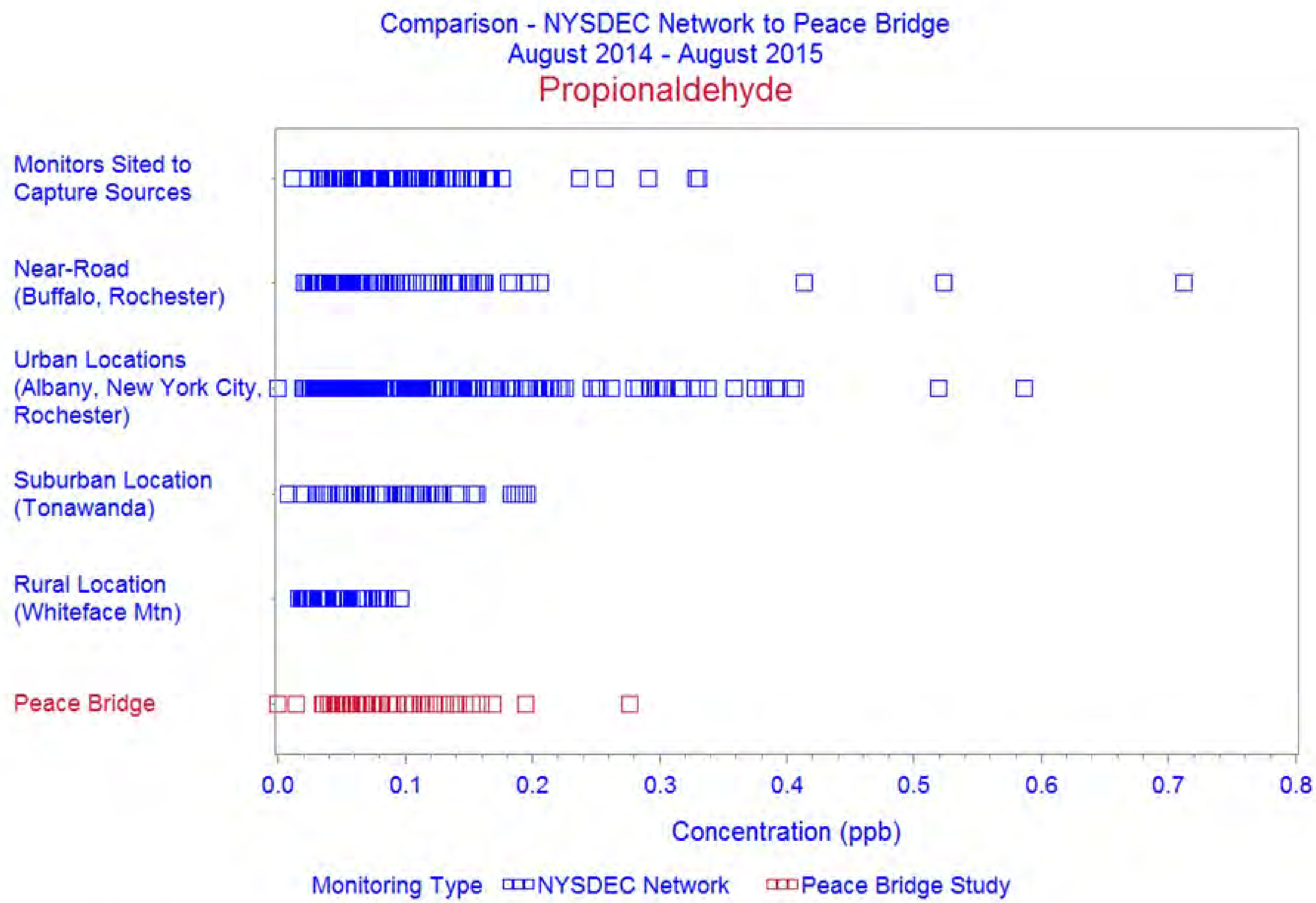
All results are 24-hr samples, collected 1 day in 6



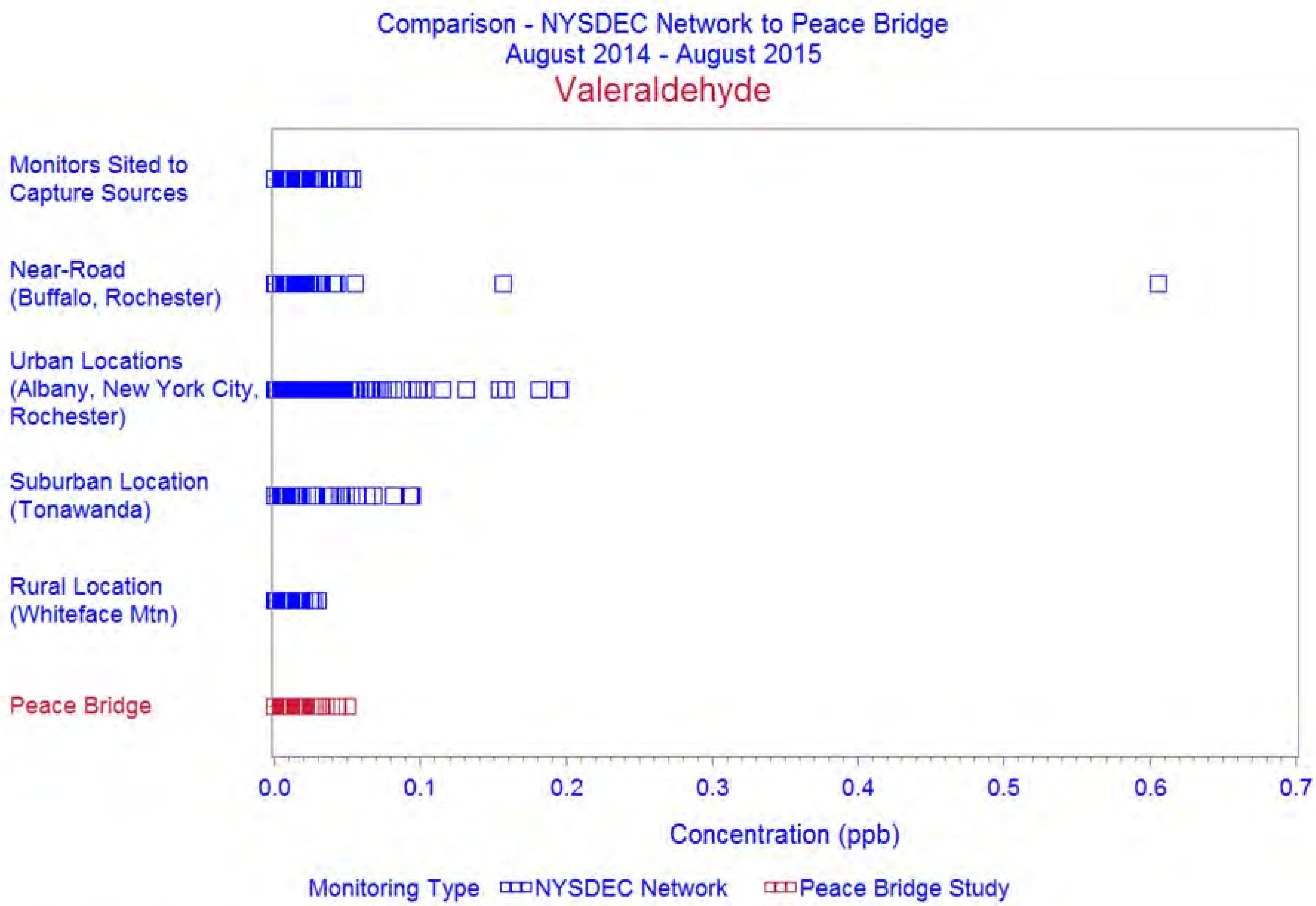
All results are 24-hr samples, collected 1 day in 6



All results are 24-hr samples, collected 1 day in 6



All results are 24-hr samples, collected 1 day in 6



All results are 24-hr samples, collected 1 day in 6

Appendix E – Results from Community Volunteer Sampling

Table 1. Volatile Organic Compounds 1-hour Samples

Chemical	Busti Ave. at NYSDEC monitoring station 5/24/2015 (ppb)	Columbus Parkway, North of Rhode Island St. 5/24/2015 (ppb)	Corner Rhode Island St. and Columbus Parkway 9/15/2015 (ppb)	Rhode Island St. 50 yards East of Busti Ave. 9/15/2015 (ppb)	Short-Term Health-Based Air Guideline Concentration (SGC) (ppb)
1,1,1-Trichloroethane	0.0070	0.011	0.0090	0.0080	1600
1,1,2,2-Tetrachloroethane	0.0040	0.0070	nd	nd	na
1,1,2-Trichloroethane	0.0030	0.0030	nd	nd	na
1,1-Dichloroethane	0.0050	0.0050	nd	nd	na
1,1-Dichloroethylene	0.0030	0.0040	nd	nd	na
1,2,4-Trichlorobenzene	0.0080	0.0070	0.0020	0.0020	500
1,2,4-Trimethylbenzene	0.021	0.023	0.053	0.042	na
1,2-Dibromoethane	0.0020	0.0040	nd	0.0010	na
1,2-Dichlorobenzene	0.0040	0.0050	nd	nd	5000
1,2-Dichloroethane	0.018	0.020	0.0080	0.0090	na
1,2-Dichloropropane	0.0070	0.0080	nd	0.0020	na
1,3,5-Trimethylbenzene	0.0070	0.0080	0.015	0.012	na
1,3-Butadiene	0.014	0.016	0.025	0.022	na
1,3-Dichlorobenzene	0.0040	0.0050	0.0010	0.0020	na
1,4-Dichlorobenzene	0.0050	0.0060	0.0030	0.0040	na
aChlorotoluene	0.0040	0.0050	nd	0.0020	46
Benzene	0.10	0.090	0.14	0.11	400
Bromodichloromethane	0.0040	0.0050	nd	0.0020	na
Bromomethane	0.010	0.012	0.0060	0.0070	1000
Carbon tetrachloride	0.081	0.081	0.076	0.079	300
Chlorobenzene	0.026	0.028	0.0060	0.0060	na
Chloroethane	nd	nd	nd	nd	na
Chloroform	0.021	0.025	0.018	0.020	31
Chloromethane	0.52	0.52	0.43	0.43	11000
cis1,3-Dichloropropylene	0.0020	0.0040	nd	nd	na
Dichlorodifluoromethane	0.51	0.49	0.50	0.50	na
Dichloromethane	0.073	0.089	0.050	0.049	4000
Dichlorotetrafluoroethane	0.015	0.017	0.014	0.015	na
Ethylbenzene	0.019	0.025	0.063	0.046	12000
Hexachloro1,3-Butadiene	0.0070	0.0070	nd	nd	na
m,p-Xylene	0.083	0.10	0.25	0.17	5100

Chemical	Busti Ave. at NYSDEC monitoring station 5/24/2015 (ppb)	Columbus Parkway, North of Rhode Island St. 5/24/2015 (ppb)	Corner Rhode Island St. and Columbus Parkway 9/15/2015 (ppb)	Rhode Island St. 50 yards East of Busti Ave. 9/15/2015 (ppb)	Short-Term Health-Based Air Guideline Concentration (SGC) (ppb)
Methyl *tert*-butyl ether	0.0020	0.0050	nd	nd	na
o-Xylene	0.033	0.038	0.077	0.054	5100
Styrene	0.0070	0.014	0.017	0.014	4000
Tetrachloroethylene	0.0080	0.010	0.0070	0.0090	44
Toluene	0.15	0.16	0.22	0.15	9800
trans 1,2-Dichloroethylene	0.0020	0.0030	nd	nd	na
trans 1,3-Dichloropropylene	0.0020	0.0030	nd	nd	na
Trichloroethylene	0.0040	0.0050	0.0010	0.0020	2600
Trichlorofluoromethane	0.24	0.28	0.24	0.24	1600
Trichlorotrifluoroethane	0.072	0.072	0.062	0.063	130000
Vinyl chloride	0.0050	0.0050	nd	nd	71000

na – A short-term health-based guideline concentration has not been derived by NYSDEC at the time of this report.
nd – Not detected

Appendix F – Analysis of Air Pollution during Sporting Events

A Buffalo Bills home game was played on September 21, 2014. The truck traffic was typical for both the eastbound and westbound directions. Automobile traffic was a little higher than expected for a Sunday and increased in the east direction earlier than normal and in the west direction later than normal.

As shown in Figure 1, analysis of data from other $PM_{2.5}$ monitors in Erie County illustrate the same hourly pattern for this date which reflects a regional influence on concentrations. The same type of comparison can't be made for BC because this pollutant is not routinely monitored. Instead, comparisons were made to monitor concentrations before and after September 21. Because of seasonal differences, diurnal pollutant concentrations for the month preceding and following the event have been summarized as an average across this time. As illustrated, BC concentrations for this date are below average and the profile does not follow the traffic pattern. UFP were not collected at the Busti monitor on this date. The monitored pollutant concentrations do not appear to be affected by the sporting event.

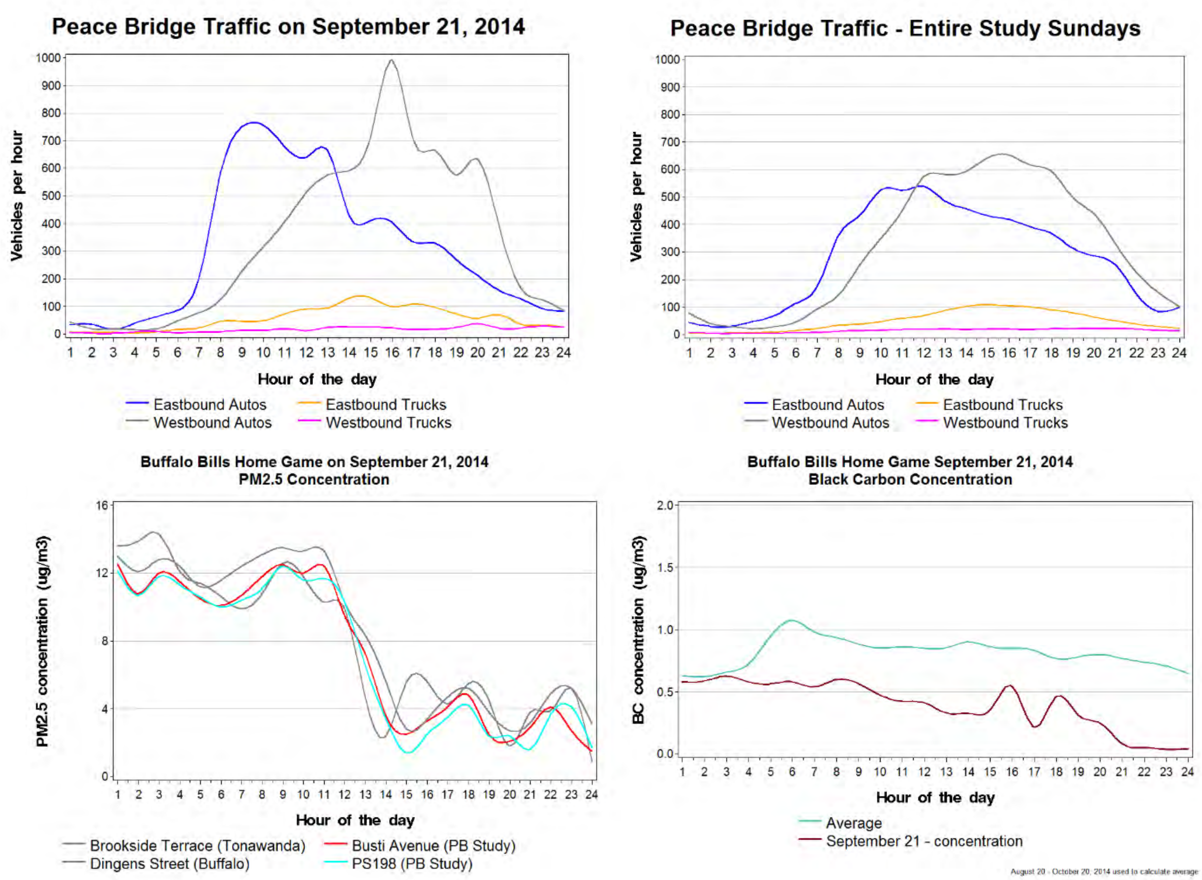


Figure 1. September 21, 2014, Sporting Event, Traffic and Pollutant Concentrations

A Buffalo Bills home game on Sunday, November 30, 2014 game was evaluated. The automobile traffic was higher than expected for a Sunday with eastbound traffic peaking around 9 am and westbound traffic high for the period from noon to 8 pm. None of the pollutant profiles reflect the traffic pattern for this date. The PM2.5 concentrations are regional in nature as shown in the figure below. BC concentrations and UFP counts are either below or around the average for this time period.

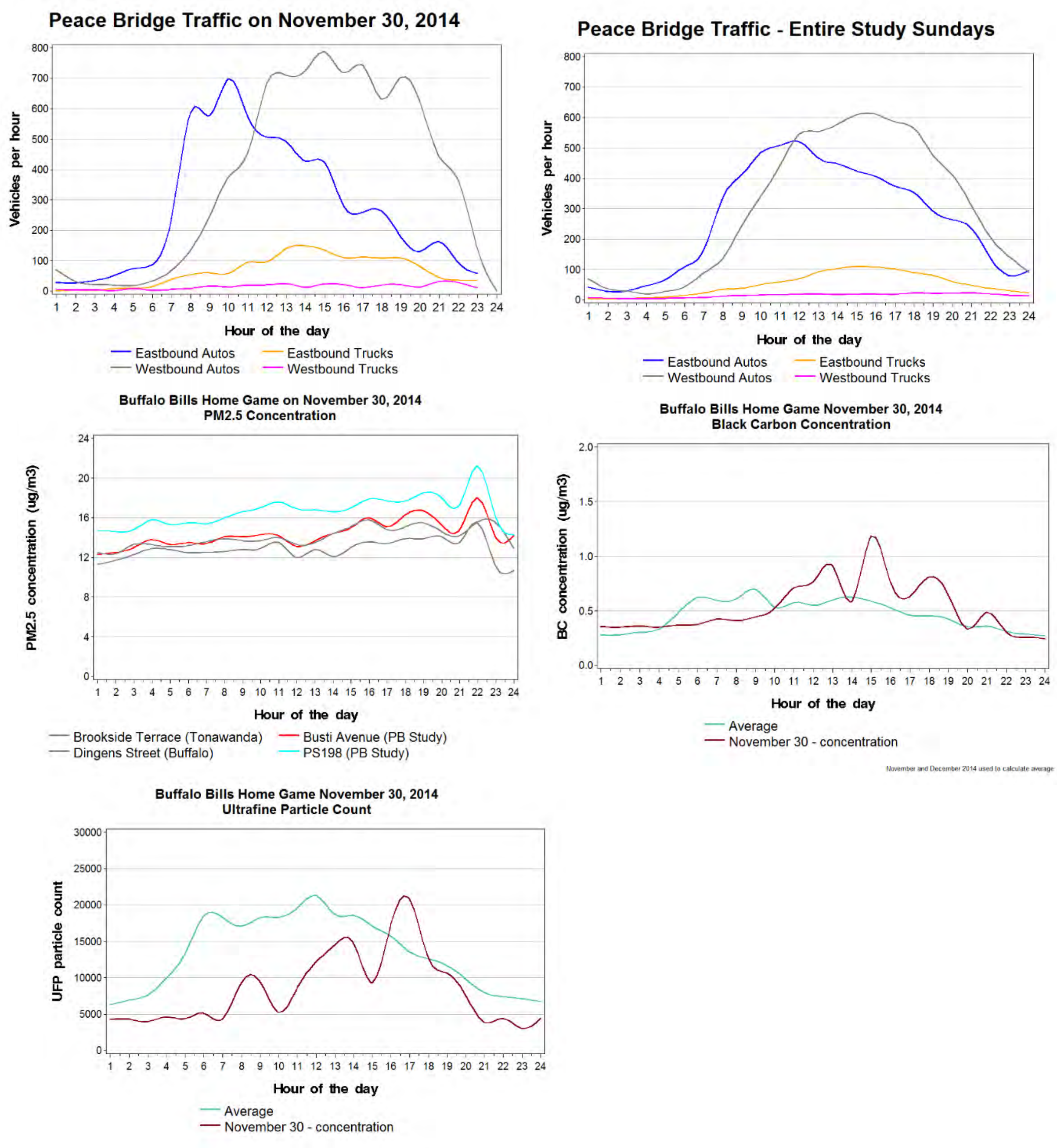


Figure 2. November 30, 2014, Sporting Event, Traffic and Pollutant Concentrations

A Buffalo Sabres home game on Wednesday, April 1, 2015 against the Toronto Maple Leafs was evaluated. The automobile traffic was higher than expected in the evening and late night for a Wednesday with eastbound traffic peaking around 6 pm and westbound traffic peaking at 11 pm. None of the pollutant profiles reflect the traffic pattern for this date. As shown in Figure 3, the $PM_{2.5}$ and BC concentrations peak in the morning, reflecting commuter traffic. A similar profile is seen for UFP counts where morning is higher than the evening when the game was played.

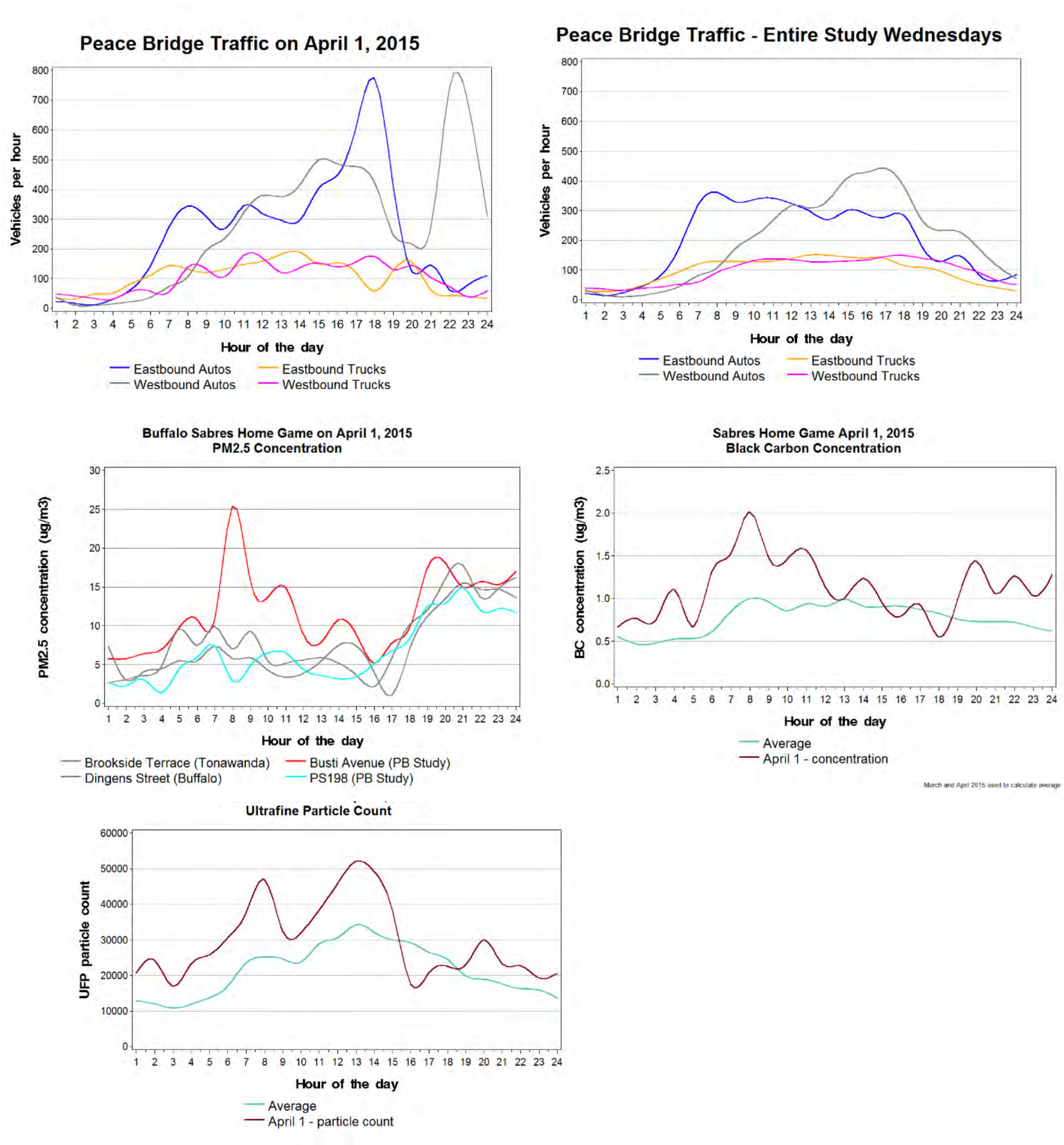


Figure 3. April 1, 2015 Sporting Event, Traffic and Pollutant Concentrations