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October 2, 2018

The Honorable Gina M. Raimondo
Governor
State of Rhode Island
State House
82 Smith Street (Room 224)
Providence, Rhode Island 02903

Dear Governor Raimondo:

In accordance with the requirements set forth in Section 1-7-6 of the Rhode Island General Laws, please find attached the 2018 air quality monitoring report prepared by the Rhode Island Department of Health (RIDOH). The report contains the RIDOH's findings, analysis, conclusions, and recommendations resulting from the air quality monitoring data generated by and from the air quality monitors located in certain neighborhoods near TF Green Airport, as well as a summary of the data collected from the monitors.

If you have questions regarding this report, please do not hesitate to contact Seema Dixit, Director of the RIDOH Division of Environment Health. Ms. Dixit can be reached either by phone, at 222-7463, or by email, at seema.dixit@health.ri.gov.

Sincerely,

Nicole Alexander-Scott, MD, MPH
Director, Rhode Island Department of Health

cc: The Honorable Nicholas A. Mattiello, Speaker of the House
The Honorable Dominick J. Ruggerio, Senate President
The Honorable Peter F. Kilmartin, Attorney General
The Honorable Joseph M. McNamara
The Honorable Michael J. McCaffrey
The Honorable Joseph J. Solomon, Mayor, City of Warwick
The Honorable Members of the Warwick City Council
Danica Iacoi, Chief Legal Counsel to the Speaker of the House
Kristen Silvia, Deputy Chief of Staff to the Senate President
Janet Coit, Director, RI Department of Environmental Management
Iftikhar Ahmad, President & CEO, RIAC

Air Monitoring at TF Green Airport

OCTOBER 2, 2018

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Introduction

Chapter 1-7 of the *Rhode Island General Laws*, the *Permanent Air Quality Monitoring Act* (the Act), requires the Rhode Island Airport Corporation (RIAC) to conduct long-term air monitoring at four sites located near TF Green Airport to determine the impact of *air pollutants, which may be harmful to public health* on the *densely populated, primarily residential area of the city of Warwick* that surrounds the airport.

§ 1-7-1 of the Act required RIAC to monitor the following pollutants:

1. Particulate matter, including $PM_{2.5}$, particles less than 0.1 microns, and black carbon
2. Volatile organic compounds (VOCs), including, but not limited to: benzene, 1,3-butadiene, and naphthalene and carbonyls including, but not limited to, formaldehyde and acetaldehyde
3. Polycyclic aromatic hydrocarbons, including those that are particulate bound and semivolatiles.

RIAC began monitoring for these pollutants in early 2008 using procedures and specifications outlined in a workplan developed in consultation with the Rhode Island Department of Environmental Management (DEM) and the Rhode Island Department of Health (RIDOH), as required in § 1-7-1. After consultation with RIDOH and RIDEM, RIAC has amended the workplan in subsequent years, and those amendments include a change in the location of the monitoring site east of the airport and a reduction in the frequency of collection of VOC and carbonyl samples.

Legislation enacted in 2017 (H 6055) extends the end date of the monitoring requirements, as specified in § 1-7-9 of the Act, from July 31, 2017, to July 31, 2019. That legislation also reduced the monitoring requirements to include only particles less than 0.1 microns and black carbon and specifies the following concerning the location of monitoring sites:

> *The ambient air quality monitors shall be set up in a network that shall include at least four (4) monitoring sites and shall be designed to measure air quality impacts from airport operations,* ***including those associated with planes operating on the extended runway and on neighborhoods adjacent to the airport facility, as well as at the Winslow Park playing fields****.*

The 2017 legislation also requires RIDOH to *prepare an annual report which shall contain the department's findings, analysis, conclusions, and recommendations resulting from the data generated by and from the permanent air quality monitors ("the monitors"), as well as a summary of the data collected from the monitors.* This document shall serve as the second annual report.

Inquiries about this report and its contents can be directed to:

Michael C. Byrns, PhD; Environmental Health Risk Assessment Toxicologist
Center for Healthy Homes and Environment
Rhode Island Department of Health
Michael.byrns@health.ri.gov

Monitoring strategy

Monitoring procedures used to measure the pollutants identified in § 1-7-1 of the Act following the 2017 amendments use continuous monitors—electronic devices that record the pollutant level every minute. The monitors are used to measure ultrafine particles (particles smaller than 0.1 microns, measured as particle count) and black carbon (an indicator of diesel/jet fuel exhaust).

Prior to the 2017 amendments, the Act required RIAC to measure pollutants at four locations--one north of the airport, one east of the airport, one south of the airport, and one west of the airport. Three of the locations were used in a monitoring study conducted by RIDEM and RIDOH in 2005-2006. Those sites are:

- The **Field View** site (south of the airport) is located on Field View Drive less than 0.1 miles west of the taxiway to the main runway (runway 5-23) and less than 0.2 miles northwest of the southwestern (5) end of that runway prior to the recent runway extension. Flights taking off on runway 5 (to the northeast) idle in line in the section of the taxiway near the monitoring site while waiting for clearance, and then they turn a corner and enter the runway to begin take off. The site is 0.1 – 0.2 miles south of airport parking areas. For the 2005-2006 monitoring study, the Field View monitoring shelter was in the yard of an occupied home, but RIAC has since purchased and removed that and neighboring homes. The closest residence is approximately 220 yards from the site.

- The **Lydick** site (north of the airport) is on Lydick Avenue in the Hoxsie section of Warwick, about 0.5 miles northeast of the northeast (23) end of the main runway. The area around this monitor is a residential neighborhood, and the closest residence is approximately 25 yards from the monitor.

- The **Fire Station** site (west of the airport) is behind Fire Station #8, off Post Road in the Hillsgrove section of Warwick. It is approximately 0.25 miles north-northwest of the northwest (16) end of the airport's secondary runway, 16-34; slightly more than 0.5 miles northwest of the main runway; and 0.57 miles north-northwest of the airport terminal building. The site is also near a variety of other pollution sources, including three high-traffic roadways--Post Road (about 0.07 miles to the east); Jefferson Boulevard (approximately 0.2 miles to the west); and Airport Road (less than 0.3 miles to the south).

RIAC initially located the fourth site, the **Pembroke** site, just east of the airport on Pembroke Avenue which was the street closest to that side of the airport. At that time, occupied residences were located adjacent to the site. Those homes and residences on the next parallel street, Gayton Avenue, have been purchased and removed by RIAC. Winslow Park, which was then located south of the airport, was moved to the Pembroke Avenue area to make room for the southern extension of the main runway.

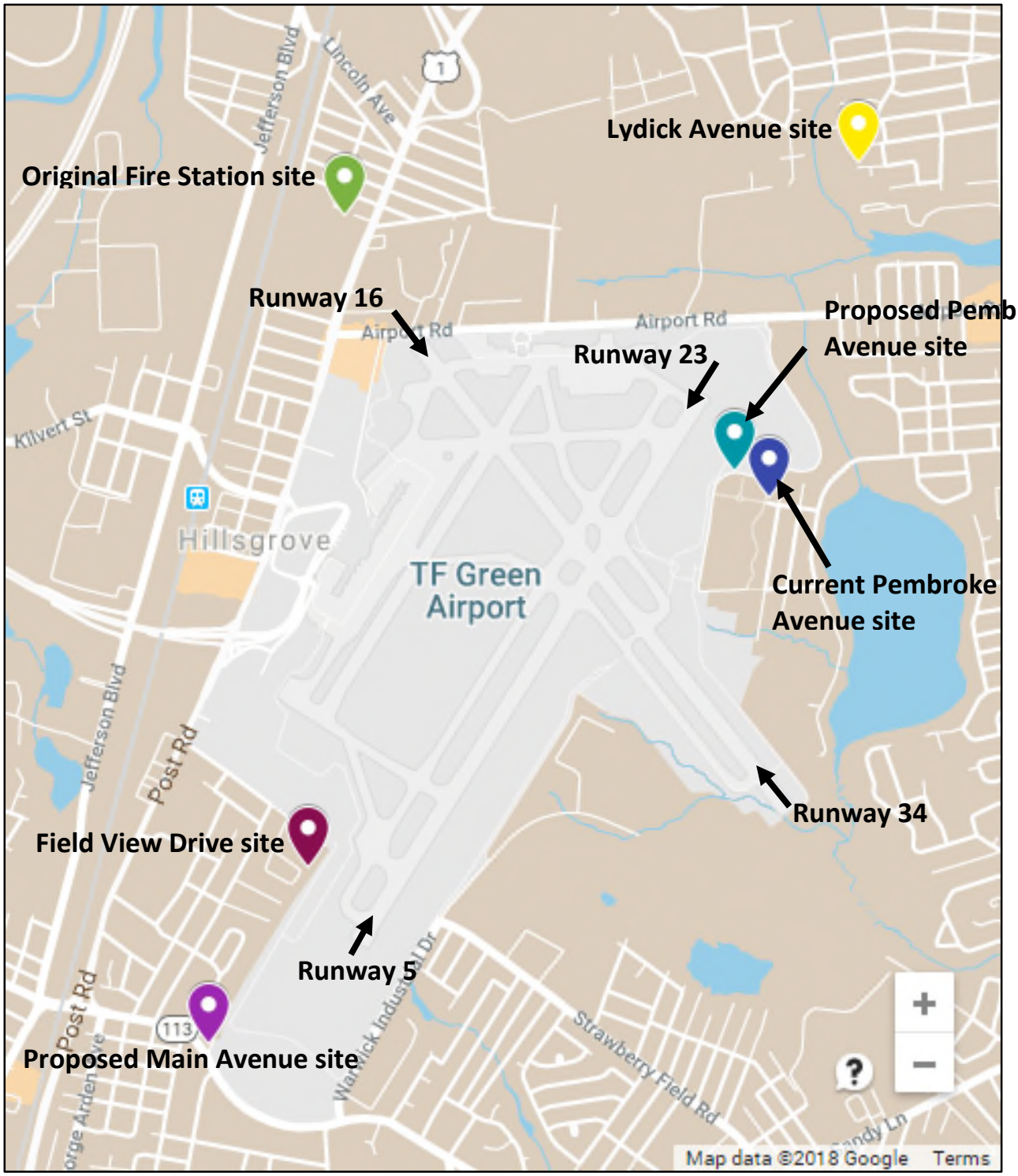
Since the Pembroke monitoring site was located in the area where the newly relocated park was being constructed, it was moved to a temporary site in a parking area on Wells Avenue in September 2014. The relocated Winslow Park opened in 2015. After soliciting neighborhood input, in June 2015, the monitoring site was moved to its current location

off Rowe Avenue on the side of the park that is furthest from the airport and is adjacent to the closest residences on Wilbur Street.

The 2017 amendments to the Act provided for more flexibility in the locations of the monitoring stations because the requirement that the monitors be placed in cardinal directions relative to the airport was removed. Previous data suggested that the airport was not a major source of pollution for the Fire Station site. Furthermore, the current location of the Pembroke monitor is on the side of the ball fields furthest from the runways, and it is likely that it significantly underestimates the ultrafine particulate exposure for children who play at the park.

In accordance with the Act, RIDOH and RIDEM submitted a letter to RIAC in January 2018 asking that RIAC make changes to the work plan following the procedures outlined in § 1-7-1 of the Act. The recommended updates reduced pollutants monitored to just ultrafine particulate matter and black carbon. RIDOH requested that the Pembroke monitor be moved closer to the runway and the Fire Station monitor be replaced with a monitor near the end of the recently extended runway. Finally, RIDOH requested RIAC make changes to improve the quality of the data, particularly black carbon, by using RIDOH's Air Pollution Laboratory and other resources to troubleshoot the problems RIAC was experiencing. RIAC submitted a draft of a revised workplan in March 2018. As of September 21, 2018, monitoring at the new sites has not begun, and the black carbon data remains compromised. Figure 1 provides the locations of the current and proposed monitoring sites.

Figure 1: *Current and Proposed Locations of RIAC Monitoring Sites and Locations of Runways*



Discussion of continuous monitoring data

Concentrations of two pollutants are measured using continuous monitors, which are electronic devices that record the pollutant level every minute. The pollutants monitored are:

- Ultrafine particles (particles smaller than 0.1 microns, measured as particle count)
- Black carbon (an indicator of diesel/jet fuel exhaust)

Particle count (PC) monitors are used to measure levels of extremely small particles, also known as ultrafine particles (UFP). Because UFPs are so small and light, they contribute very little to the more commonly measured $PM_{2.5}$, which measures the mass of particulate matter. Although UFPs contribute very little to the total particulate matter weight, they are far more numerous than other particles, so UFP levels correlate well with particle count.

UFPs are most likely to be emitted by combustion processes and tend to be highly elevated near areas with high levels of vehicle emissions, like busy roads and airports. UFP levels drop off quickly as distance from the source increases due to dispersion of the particles in the air and evaporation and condensation that reduces the number and increases the size of particles.

DEM and RIDOH routinely measures PC at two sites in Providence. One site is at the Urban League building in an urban, residential area in South Providence. The other site, the Near Road site, is immediately adjacent to the busiest, most congested section of Interstate Route 95 (I-95). The measurements from these two sites provide a context for the severity of the airport measurements, which was discussed in the 2017 report.

According to the Environmental Protection Agency (EPA), there is suggestive but limited evidence that short-term UFP exposures are linked to respiratory and cardiovascular health effects. Toxic substances tend to be concentrated on UFPs and more bioavailable, and thus are more likely to cause toxic effects than larger particles. Due to their very small size, UFPs, when inhaled, can travel deep into the respiratory tract and pass across membranes in the body that would block the movement of larger particles. A 2015 study by the California EPA demonstrated that long-term exposure to UFPs contributes to heart disease mortality. Certain constituents of UFPs, including copper, iron, other metal, and elemental carbon (soot) were strongly associated with death from heart attacks.[1]

Black carbon (BC) is also measured continuously at the airport sites because it is an indicator of diesel/jet fuel exhaust. In the 2005-2006 study, DEM and RIDOH documented elevated BC levels at sites near the airport, including three of the current monitoring locations, when the sites were downwind of the airport. However, BC monitors are very sensitive, so operational factors like the cycling on and off of air conditioners in monitoring shelters, can influence the accuracy of the results. Due to the "noise" created by these operational factors, the BC monitors operated by the RIAC contractor are not currently collecting useful data.

[1] Ostro, B et. Al, "**Associations of Mortality with Long-Term Exposures to Fine and Ultrafine Particles, Species and Sources: Results from the California Teachers Study Cohort," Environmental Health Perspectives 123(6), June 2015.**

Due to the lack of reliable BC data, the discussion in this report will focus on particle count (PC) results. However, RIDOH recommended that RIAC continue to measure BC, because if those data are collected correctly, they can provide additional useful information about the extent of airport impacts in the surrounding areas. DEM and RIDOH currently operate BC monitors at the sites where PC is collected and at a residential, suburban site in East Providence. Those data will provide a context for evaluating future BC results from the airport sites. Since RIDOH's Air Pollution Laboratory has extensive experience with BC monitoring, RIDOH strongly recommends that RIAC work with that laboratory to improve the quality of the BC data that are collected in the future at the airport sites.

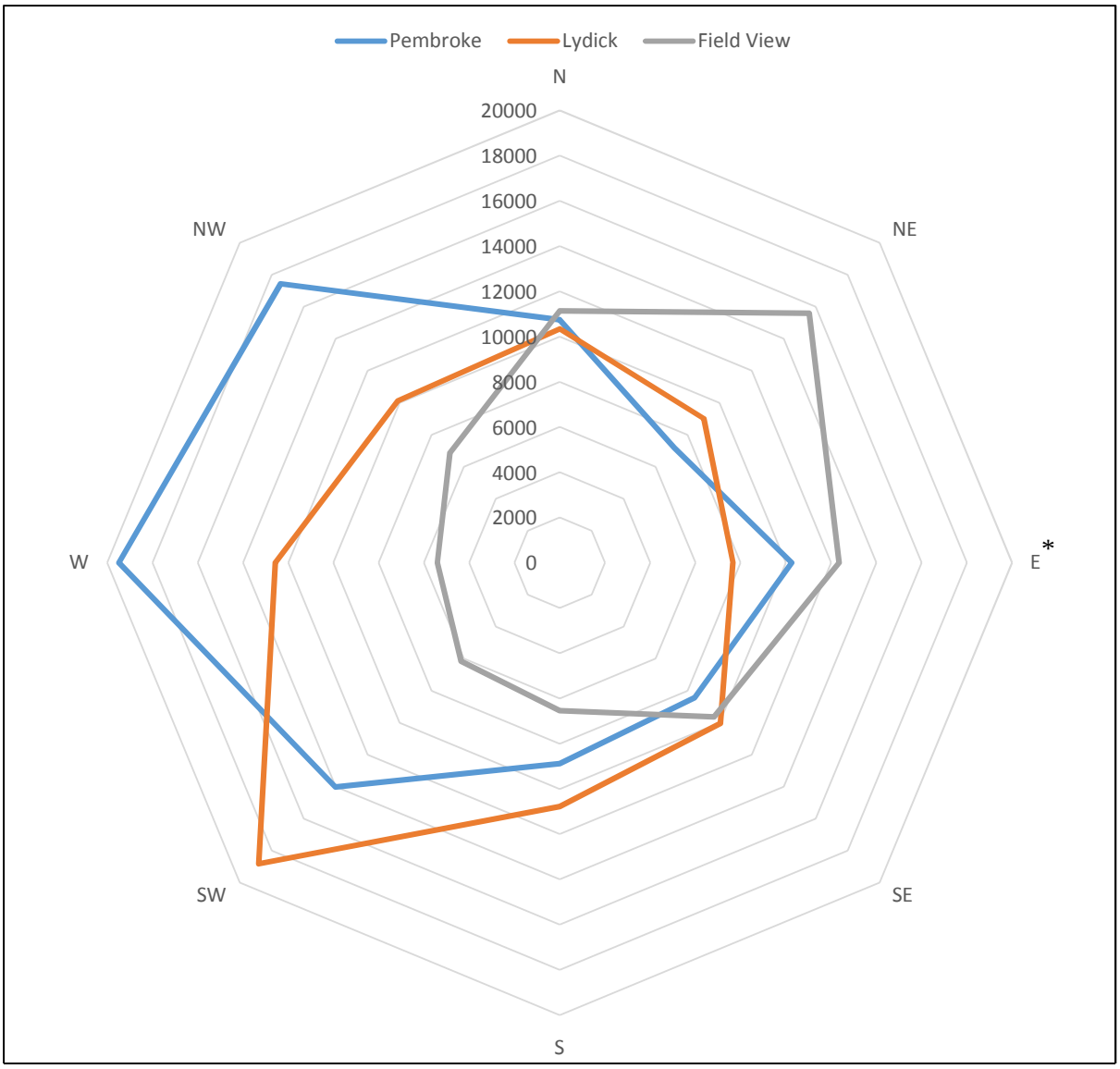
Particle Count (PC) Results

The 2017 Annual Report examined the PC data on a time scale of minutes to hours. That report examined the data in very fine detail. It examined the effects of individual planes on the PC counts at downwind sites that could be observed and trends in pollution levels during different times of day. These results were very interesting and helped clearly establish the role of airport traffic on the generation of ultrafine particulates. However, the fine level of detail will be less useful for establishing relationships between the airport and negative health effects, which are not typically measured on those time scales. This report focuses on examining the PC average per day. The use of daily averages allows for correlation of the pollution data that is collected to daily asthma and cardiovascular disease hospitalizations. Examination of the daily average data might also allow for a determination of the conditions that lead to high pollution levels and possibly allow for a daily forecast of airport-related pollution.

Weather is an important factor in determining PC. Wind direction, wind speed, and temperature each play an important role in helping to determine the formation and/or distribution of ultrafine particles.

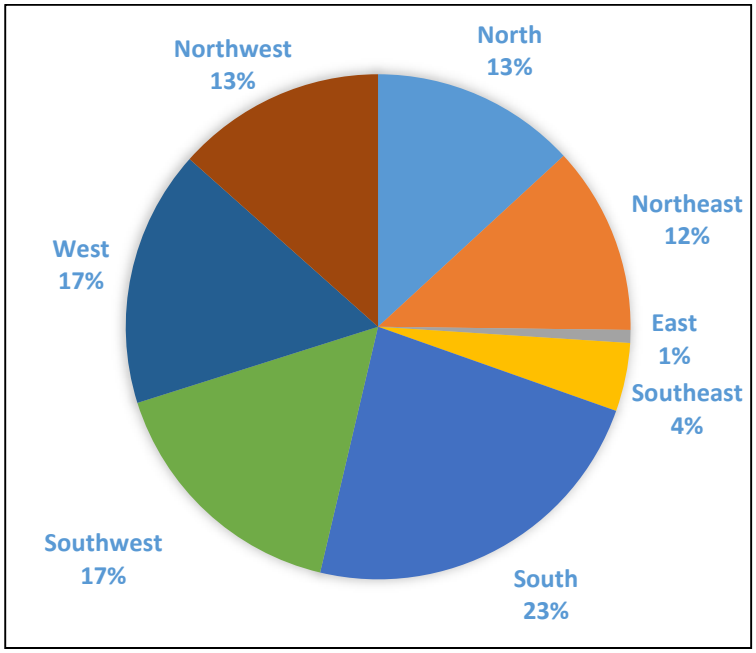
Wind direction appeared to be one of the biggest factors in determining PC at each site. PC were two- to three times higher on days when each monitor was downwind of the airport compared to when the same monitor was upwind (Figure 1). This observation is consistent with the hypothesis that the airport is a primary source of ultrafine particulates at these sites. Because wind directions are more commonly from the west, PC data at the Pembroke site, which is east of the airport, are generally affected more by airport activities than the Field View site, despite being slightly further from the nearest runway (Figure 2).

Figure 2: *Effect of Prevailing Wind Direction on Particle Count*



The average particle counts (PC) at each site are highest when the site is downwind of the airport. For instance, the airport is southwest of the Lydick site, and PC levels at that site are highest when the wind is from the southwest. The data from when the wind is from due east are not reliable, as the prevailing wind was only from that direction on three days.

Figure 3: *Percentage of Days with Each Prevailing Wind Direction*



Wind speeds were also associated with PC. Higher wind speeds resulted in lower PC at the Pembroke site (Figure 4) and at the Lydick site (Figure 5) and slightly lower PC at the Field View (Figure 6) site. Higher wind speeds are expected to reduce particle levels by increasing the rate of dispersion. This effect is partially confounded by the fact that Rhode Island experiences most of its high wind speeds from north or northeast winds. Eight of the nine days with the highest wind speeds during the period covered by this report had prevailing winds from the north or from the northeast, which may explain the negative association between wind speed and PC was most prominent at the Lydick site (northeast of the airport) and lowest at the Field View site (southwest of the airport). These effects may also be confounded by the effects of high winds on airport operations, as high winds make it harder to take off and land (Figure 7).

Figure 4: *Effect of Wind Speed on PC at Pembroke Site*

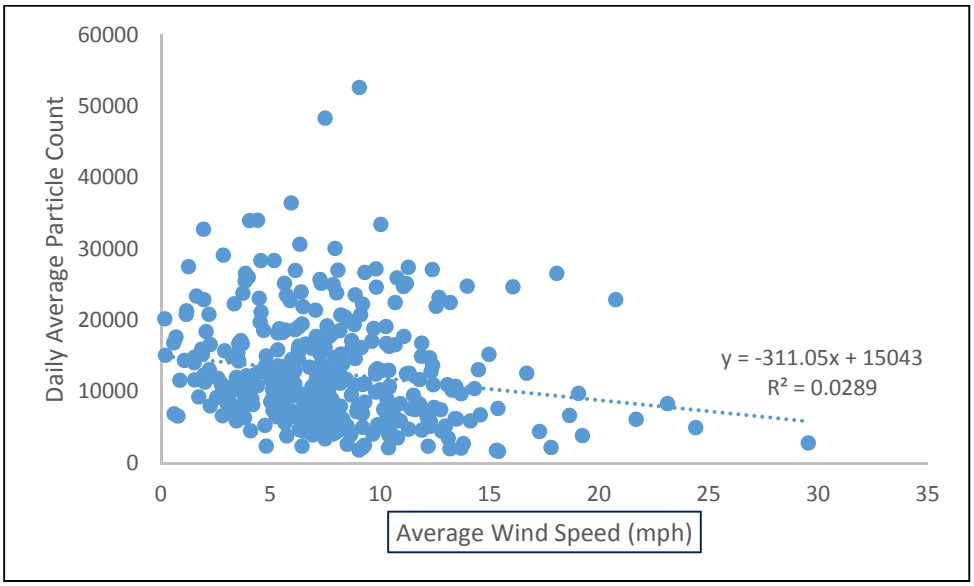


Figure 5: *Effect of Wind Speed on PC at Lydick Site*

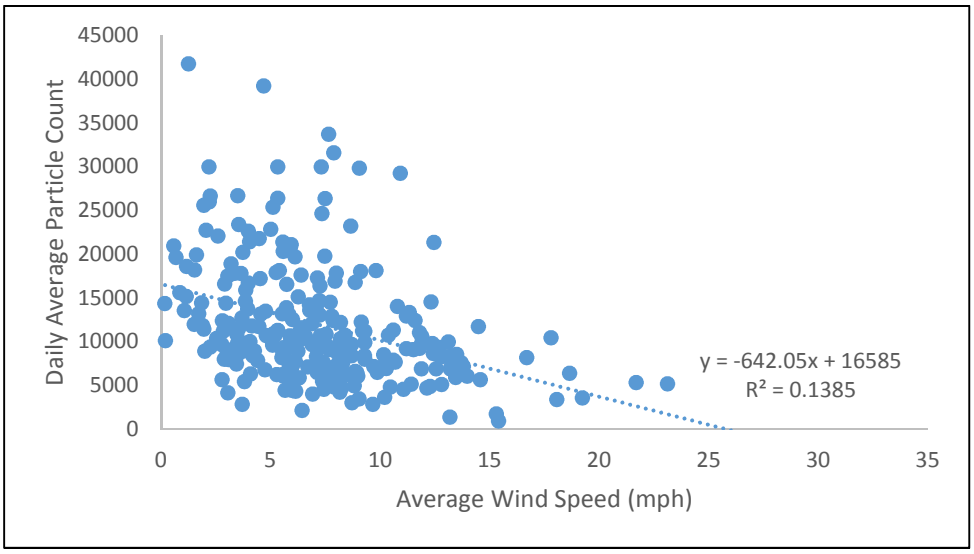


Figure 6: *Effect of Wind Speed on PC at Field View Site*

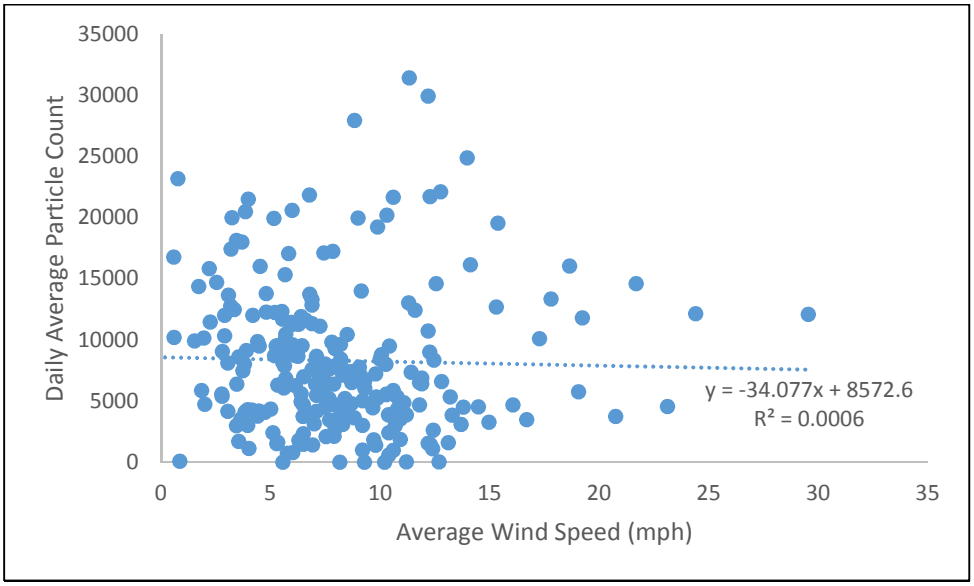
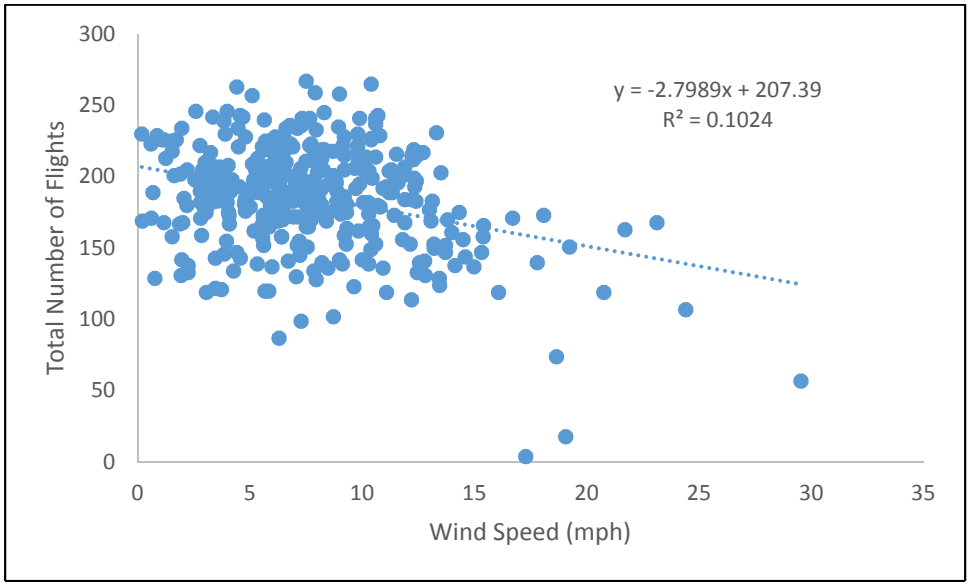


Figure 7: *Effect of Wind Speed on Total Number of Flights*



Temperature is another factor that was associated with PC. Lower temperatures are expected to facilitate particle formation, especially ultrafine particles, by increasing the rate at which semi-volatile components of exhaust condense to form particles, and may also help to reduce particle dispersion and/or aggregation through evaporation. Higher temperatures were associated with lower PC at all three sites, but the effect was much more clear at the Pembroke site (Figure 8) compared to the Lydick site (Figure 9) or the Field View site (Figure 10). This may be partially due to the fact that both the Lydick and Field View sites experienced outages for significant portions of the winter. The effect is again likely confounded by wind directions, as cold weather is associated with winds coming off the continent to the northwest, while warmer temperatures

are observed with winds coming from the south (Figure 9). This association between temperature and PC was not clearly observed when data was averaged over hours instead of days (see 2012 report), potentially due to the confounding effect of day-night variation in both flight numbers and temperature.

Figure 5: *Effect of Temperature on Particle Count at Pembroke Site*

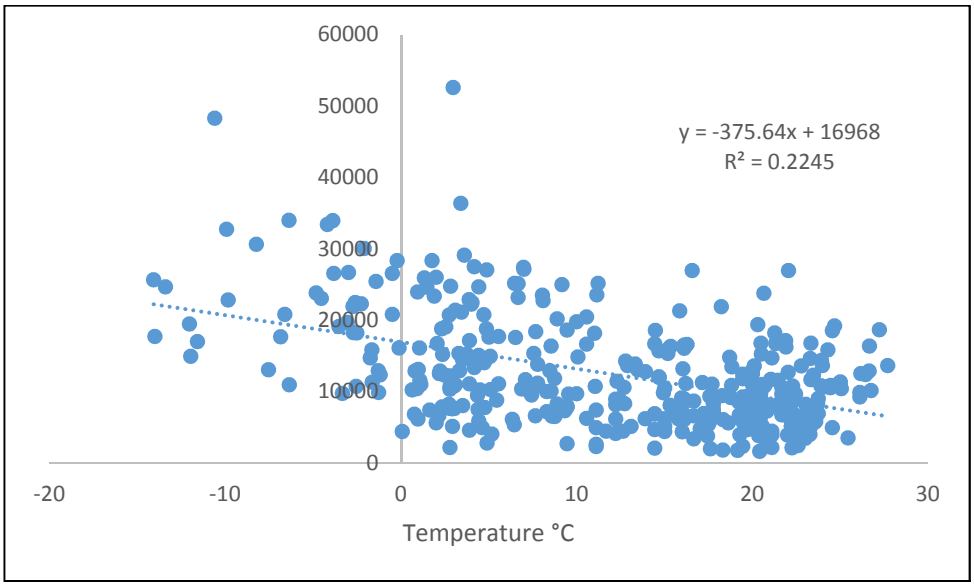


Figure 6: *Effect of Temperature on Particle Count at Lydick Site*

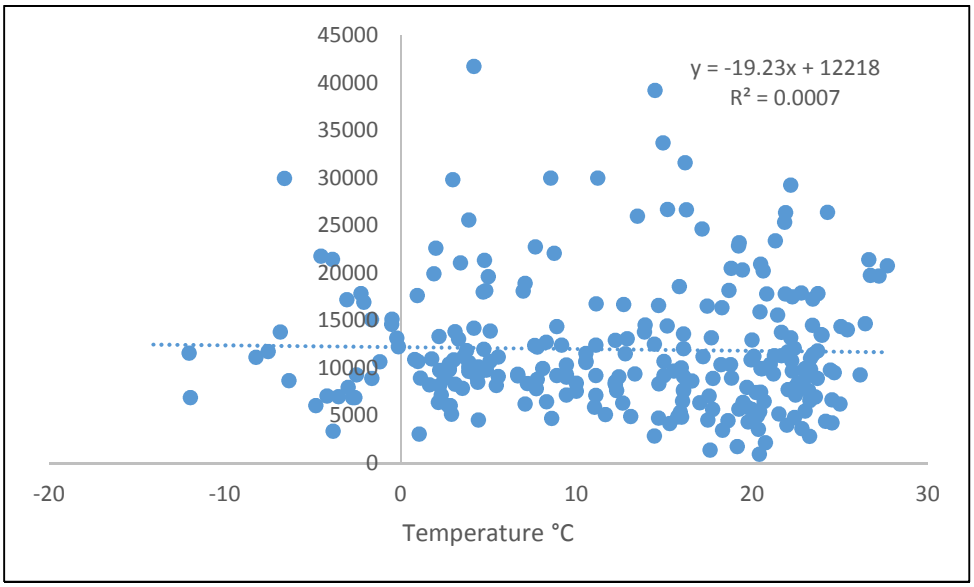


Figure 7: *Effect of Temperature on Particle Count at Field View Site*

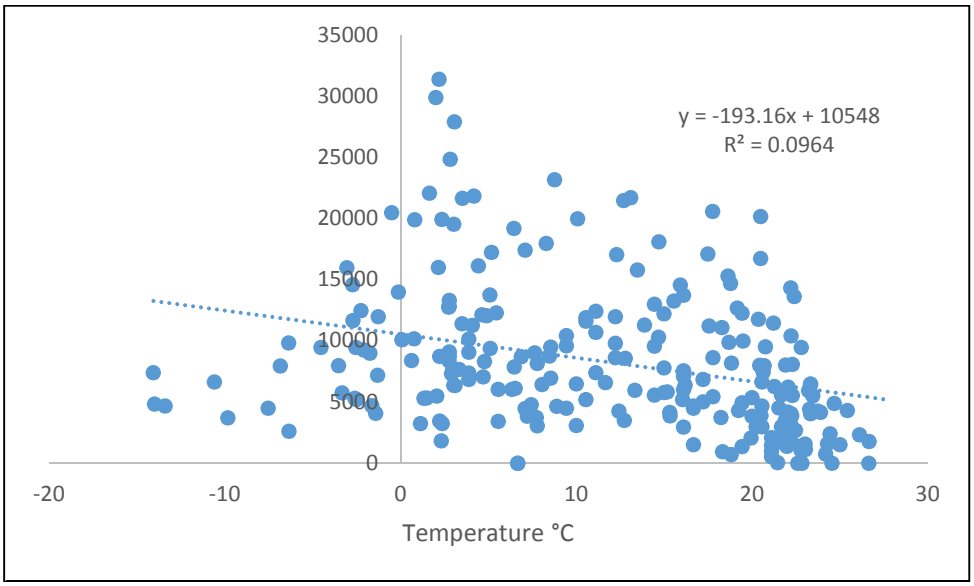
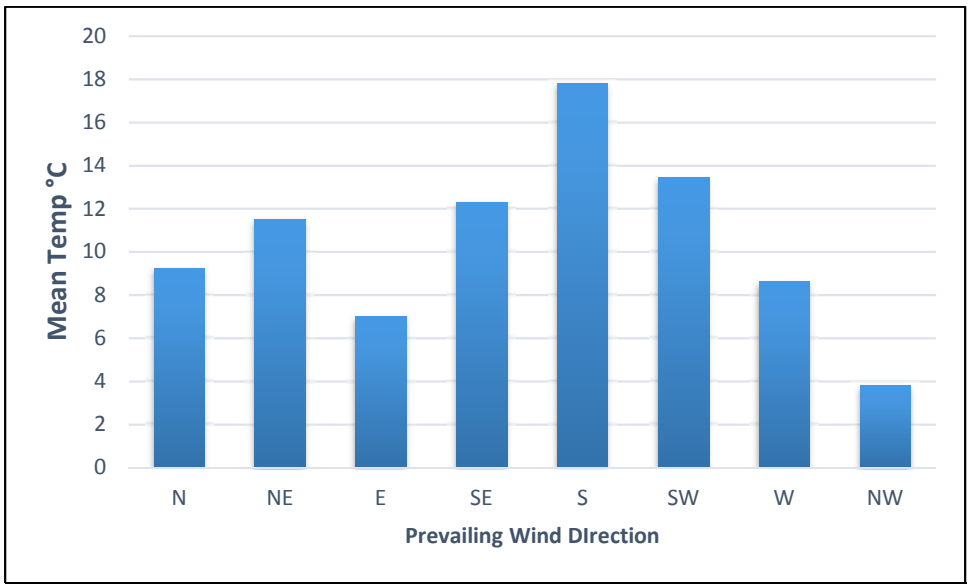


Figure 8: *Effect of Wind Direction on Temperature*



While there was an expected positive association between the number of total flights at the airport and the PC levels at the Pembroke site (Figure 9) and the Lydick site (Figure 10), this effect was not observed at the Field View site (Figure 11). The effects of total flight numbers on daily PC were potentially confounded by the effect of wind speed on flight numbers (Figure 7). It is also confounded by increased ultrafine particulate generation due to diesel or gasoline use for snow removal activities on many of the days with very low flight numbers. For example, March 13, 2018, had only four total flights, because of a winter storm that generated blizzard conditions across the region. That day, there were moderate PC levels at the Pembroke site and relatively high levels at the Field View site (the Lydick site monitor was not collecting data that day),

despite the very low numbers of flights. The confounding effect of snow removal activities is particularly strong for the Field View site as many of the snowfall events in Rhode Island are the result of nor'easters, whose prevailing winds will bring pollution from the airport to that site. Because of these issues and the limited amount of variability in the total numbers of flights in a day without a major weather event, flight operations are not a good overall predictor of average daily PC. This was still true even when corrected for wind direction or focusing on only arrivals or departures (data not shown). This observation contrasts with the effectiveness of flight activities at predicting PC during shorter time frames (see 2017 report).

Figure 8: *Effect of the Number of Flights on Particle Count at Pembroke Site*

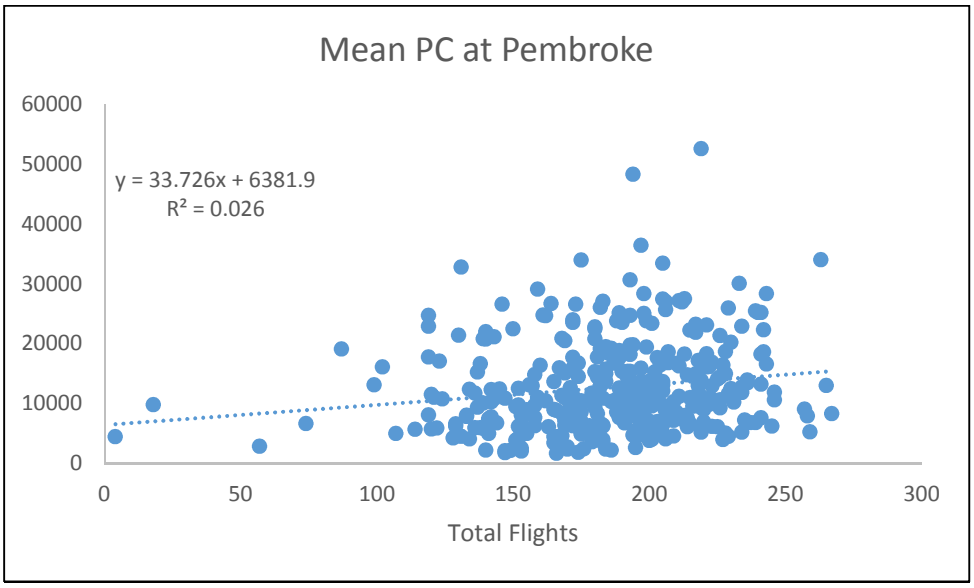


Figure 9: *Effect of the Number of Flights on Particle Count at Lydick Site*

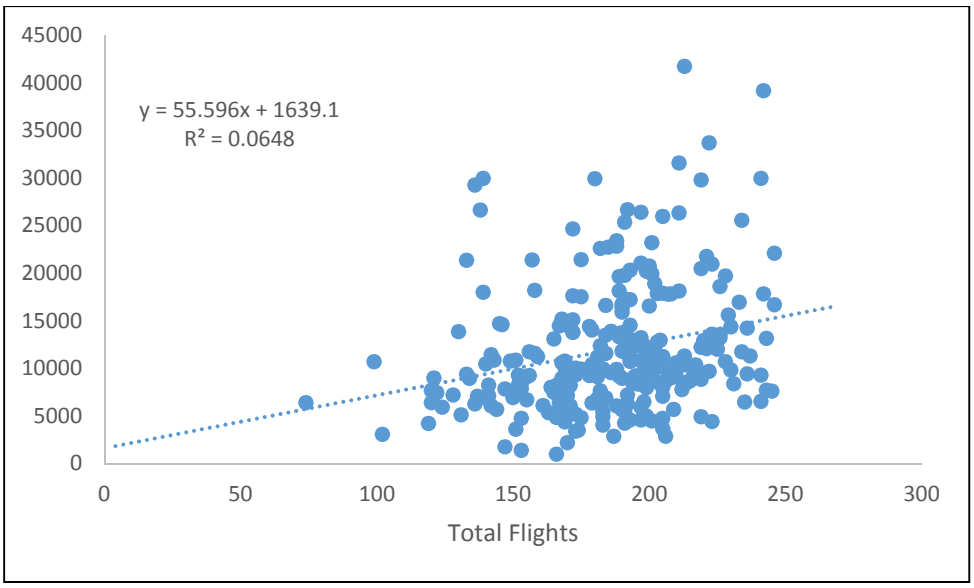
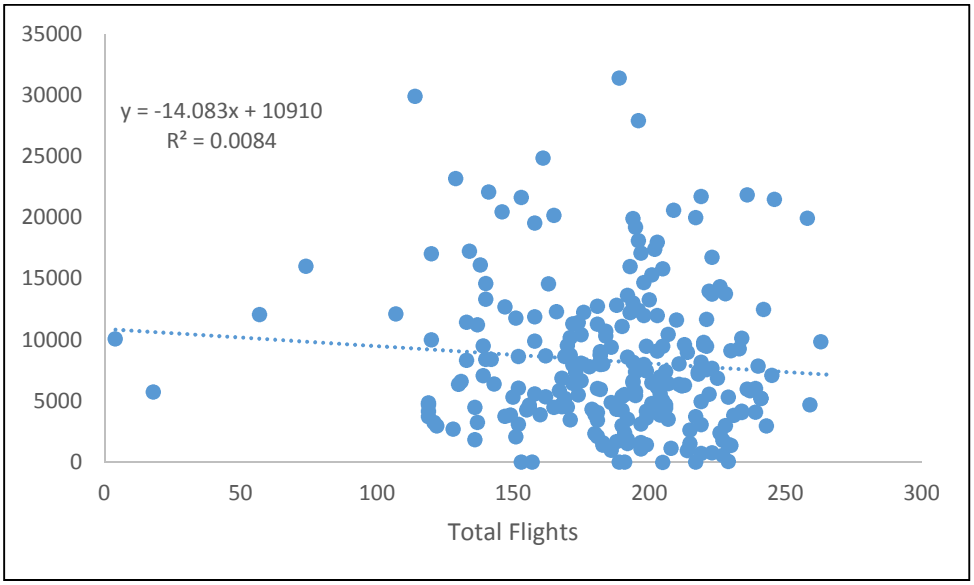
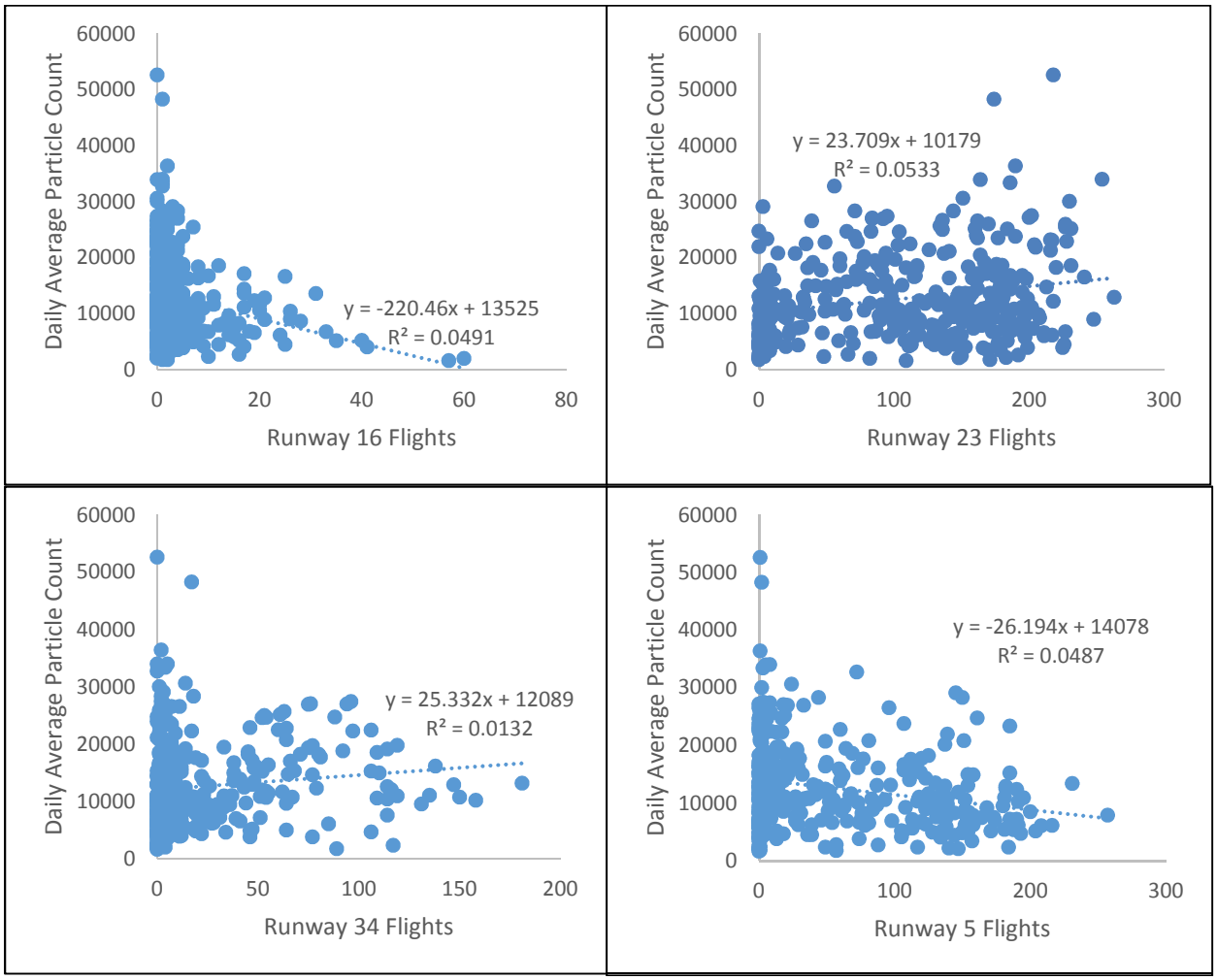


Figure 10: *Effect of the Number of Flights on Particle Count at Field View Site*



There was a positive association between flights at the runway(s) nearest to each monitor and the PC at that monitor and a negative association with flights farther away from that monitor (see Figure 11 for the Pembroke site as an example). However, these results may be secondary to the effect of wind direction. Planes generally take off and land into the wind, so flight numbers at a given runway are not an independent variable from wind direction. Wind direction is likely to be the more important causal factor in pollution levels at any given monitor, but the effects of wind direction and runway use cannot be easily evaluated independently of each other.

Figure 11: *Effect of the Number of Flights, Using Each Runway, On Particle Count at the Pembroke Site*



Conclusions and Recommendations

After review of the monitoring results for 2017-2018, RIDOH has the following conclusions and recommendations:

- The particle count (PC) data that is currently being collected allows for an examination of the health impacts of the airport on the surrounding community.
- The measurement of black carbon (BC) levels is currently not producing useable data. RIDOH urges RIAC to work with DEM and RIDOH's Air Pollution Laboratory to obtain accurate data on the levels of BC associated with the airport.
- The three sites analyzed in the current report, Pembroke site (east of airport), Lydick site (northeast of airport), and Field View site (southwest of airport) see increased PC levels due to the presence of the airport.
- Meteorological conditions are major determinants of the levels of ultrafine particulate exposure experienced by Warwick residents, as predicted by PC measurements at each of the monitoring stations.
    - Prevailing wind direction was the biggest factor predicting pollution levels at each site. When a site was downwind of the airport, more pollution was observed. When sites were upwind of the airport, less pollution was observed.
    - Increased wind speeds were associated with lower PC levels. Higher wind speeds will hasten particle dispersion/dilution and prevent the buildup of higher particle levels.
    - Lower temperatures were associated with higher PC levels because lower temperatures speed the condensation of semi-volatile vapors to form particles and limit evaporation of particles.
- The effect of airport operations on daily PC measurements at the monitoring sites was confounded by associations between meteorological conditions and airport activities:
    - There was a positive association between total flights and PC at two of the three sites. Because winds from the north or northeast are associated with adverse weather events (high winds and snowfall) that affect airport operations, the association between the number of flights and PC may have been suppressed at the Field View site and amplified at the Lydick site. The lack of effect at the Field View site could also be because snow removal activities following nor'easters likely increased particulate emissions on days with fewer flights.
    - There were positive associations between operations on the runway(s) nearest to a given site and PC at that site and negative association between operations on the runways further away from a given site. These effects could be the result of the increased flight activity nearby, but they could also be the result of wind directions that led to use of that runway.
- Ultrafine particulates are likely to be at least as toxic as larger particles, as they can deposit deeper in the respiratory tract and more easily cross over to the cardiovascular system. There is evidence from several studies that suggest that exposure to ultrafine

particulates is associated with a variety of respiratory and cardiovascular health effects, independent of the effects of larger particle sizes. The quantity of ultrafine particles decreases rapidly with increased distance from the source through dilution with fresh air and evaporation/condensation processes that form fewer, larger particles. Exposure levels to ultrafine particulates are likely to be significantly lower than the levels measured at locations further from the airport but will be significantly higher at sites even a relatively short distance closer to the airport.

- One area of concern where exposures are likely higher than what has been measured is at the Winslow Park ballfields to the west of the Pembroke site monitor. RIDOH encourages RIAC to move the Pembroke site monitor to a site that more accurately reflects the impact of the airport on children in that area. (See 2017 report for more detail).
- The 2017 amendments to the Act require RIAC to assess the effect of the runway extension on pollution levels. RIDOH encourages RIAC to follow through with moving the monitoring station from the Fire Station site (northwest of the airport), which currently sees little impact from airport activities, to a location near Main Avenue. This relocation should be made with input from the public about specific locations of concern (i.e. schools or parks). A location east of the extended runway is less likely to overlap in the data collected from the current sites, particularly the Field View site, than a location to the west. The prevailing wind directions are also likely to lead to more pollution impact to the east of the runway. A monitoring station along Warwick Industrial Drive might therefore provide more valuable data than the currently proposed site.
- RIDOH would like to see usable PC and BC data collected at the current Lydick and Field View sites, and at sites to the west of the Winslow Park ballfields and to the east of the extended runway for at least one full year. This will require extending the sunset date of the *Permanent Air Quality Monitoring Act*, as it is currently set to sunset as of July 31, 2019. RIDOH encourages RIAC to move the two monitoring stations, in accordance with the 2017 amendments to the Act, and to make whatever adjustments are needed to collect accurate BC data as soon as possible. RIDOH is willing to assist however it can.