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September 21, 2017

The Honorable Dominick J. Ruggerio
Senate President
State of Rhode Island
State House
82 Smith Street (Room 318)
Providence, Rhode Island 02903

Dear Senate President Ruggerio:

In accordance with the requirements set forth in Section 1-7-6 of the Rhode Island General Laws, please find attached the 2017 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, or any aspect of the work of the RIDOH, 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 Gina M. Raimondo, Governor
The Honorable Nicholas A. Mattiello, Speaker of the House
The Honorable Peter F. Kilmartin, Attorney General
The Honorable Joseph M. McNamara
The Honorable Scott Avedisian, Mayor, City of Warwick
The Honorable Members of the Warwick City Council
Richard Raspallo, Chief Legal Counsel to the Speaker of the House
Kristen Silvia, Deputy Chief of Staff to the Senate President

Air Monitoring at TF Green Airport
Annual Report

SEPTEMBER 2017

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Introduction

Chapter 1-7 of the Rhode Island General Laws, the Permanent Air Monitoring Act (the Act, required the Rhode Island Airport Corporation (RIAC) to conduct long-term air monitoring at four sites, located north, east, south, and west of 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:

- Particulate matter, including $PM_{2.5}$, particles less than 0.1 microns, and black carbon;
- 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; and
- Polycyclic aromatic hydrocarbons (PAH), 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 (RIDEM) and the Rhode Island Department of Health (RIDOH), as required in § 1-7-1. RIAC amended the workplan in subsequent years, after consultation with RIDOH and RIDEM, as allowed in that section. Those amendments included 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 sunset date of the monitoring requirements, as specified in § 1-7-9 of the Act, from July 31, 2017, to July 31, 2019. The legislation also reduces 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 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 contains the department's findings, analysis, conclusions, and recommendations resulting from the data generated by and from the permanent air quality monitors as well as a summary of the data collected from the monitors. This document shall serve as the first annual report.

Monitoring Strategy

Two types of monitoring procedures are used to measure the pollutants identified in § 1-7-1 of the Act, prior to the 2017 amendments:

Intermittent Samples
Several of the pollutants are measured by collecting an air sample for a 24-hour period, followed by a laboratory analysis of the air sample. Those pollutants are:

- <u>$PM_{2.5}$</u>: fine particles with diameters of less than 2.5 microns; $PM_{2.5}$ samples have been collected at each site every sixth day since the beginning of RIAC's monitoring.
- <u>PAH, including naphthalene</u>: PAH samples have been collected every sixth day at each site.
- <u>VOCs, including benzene and 1,3-butadiene, and carbonyls, including formaldehyde and acetaldehyde</u>: VOC and carbonyl samples were initially collected every sixth day at each site, but a reduced frequency of one sample per month at each site was approved by RIDEM and RIDOH at the end of 2009.

Continuous Monitors
The other pollutants are measured with continuous monitors, which are electronic devices that record the pollutant level every minute. Continuous monitors are used to measure ultrafine particles (particles smaller than 0.1 microns which are measured as particle count), black carbon (an indicator of diesel/jet fuel exhaust), and particle-bound PAH.

Prior to the 2017 amendments, the Act required RIAC to measure pollutants at four sites, located north, east, south, and west of the airport. The initial monitoring locations are shown in Figure 1. Three of those locations were used in a monitoring study conducted by RIDEM and RIDOH in 2005-2006 and remain in operation. Those sites are:

- Field View (south) site: 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 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. After receiving clearance, the plane turns a corner to enter the runway to begin take off. The site is 0.1 – 0.2 miles south of airport parking areas. During the 2005-2006 RIDEM/RIDOH monitoring study, the Field View monitoring shelter was in the yard of an occupied home; however, the airport has since purchased and removed that and neighboring homes. Currently, the closest residence is approximately 220 yards from the site.
- Lydick (north) site: located on Lydick Avenue 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 home is approximately 25 yards from the monitor.
- Fire Station (west) site: located behind Fire Station 8 off Post Road. This site is approximately 0.25 miles north-northwest of the northwest (16) end of the airport's secondary runway (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 east site, the **Pembroke** site, just east of the airport on Pembroke Avenue, the street closest to the east side of the airport. Initially, occupied residences were located adjacent to the site; however, those homes and the homes on the next parallel street, Gayton Avenue, have since been purchased and removed by RIAC. Winslow Park, which was originally located south of the airport, was moved to the Pembroke Avenue area to accommodate the southern extension of the main runway. In September 2014, when construction of the new park began, the Pembroke monitoring shelter was moved from the construction area to a temporary site in a parking area on Wells Avenue. In June 2015, after soliciting neighborhood input, the monitoring shelter was moved to its current location off Rowe Avenue, on the edge of Winslow Park that is most distant from the airport, adjacent to the closest residences on Wilbur Street. The three different locations of the Pembroke site are shown in Figure 2.

Figure 1: Original Locations of RIAC Monitoring Sites

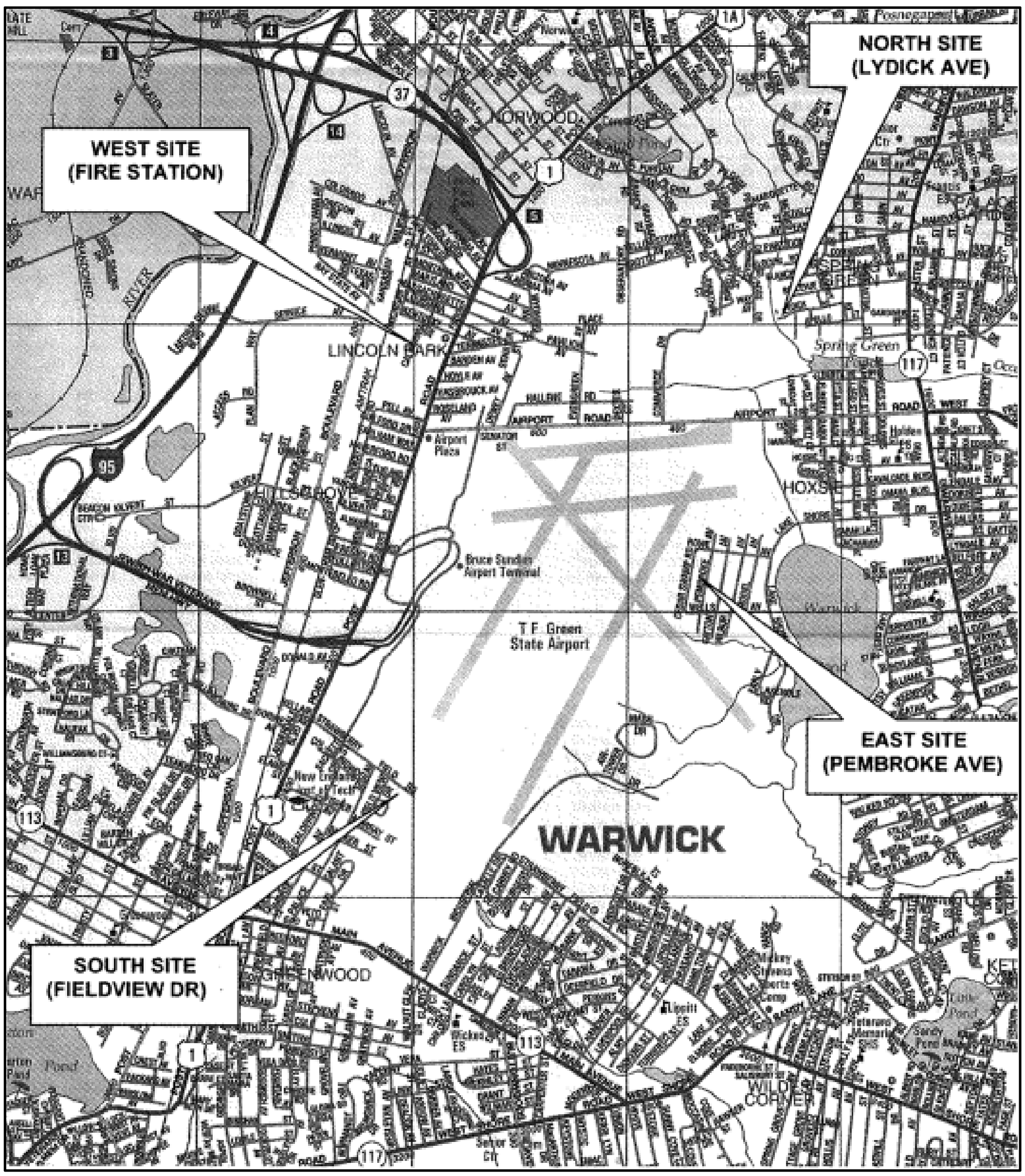


Figure 2: Pembroke Site Locations

Original Pembroke site: 2008 – 2014
Second (temporary) Pembroke site: September 2014 – June 2015
Current Pembroke site: July 2015 – present

Discussion of Intermittent Sampling Results

Concentrations of VOCs, carbonyls, PAHs, and $PM_{2.5}$ were measured by collecting air samples for 24-hour periods followed by laboratory analysis of the samples. The 2017 amendments remove the requirement to monitor for these pollutants, and RIDOH concurs with that decision due to the limited utility of the measurements.

VOCs and Carbonyls

VOC and carbonyl samples have been collected once a month at each of the airport monitoring sites since late 2009. Although the method used to analyze for these pollutants can detect a large number of substances, RIAC currently reports results for only the minimum VOCs and carbonyls specified in the Act – benzene, 1,3-butadiene, formaldehyde and acetaldehyde.

The four VOCs and carbonyls reported by RIAC are present in aircraft exhaust and in the exhaust of ground vehicles that burn fossil fuels. They are also emitted by stationary combustion sources, and benzene is a component of gasoline vapors. Formaldehyde is formed by chemical reactions in the atmosphere, particularly on hot, sunny days. Thus, these pollutants are almost always present in ambient air.

Benzene, 1,3-butadiene, and formaldehyde are classified by the International Agency for Research on Cancer (IARC) as carcinogenic to humans and acetaldehyde is classified as possibly carcinogenic to humans. Elevated concentrations of formaldehyde and acetaldehyde are irritating to the nose and respiratory tract.

RIAC's 2015 and 2016 VOC and carbonyl data are inconclusive, due largely to questionable data quality. The sampling and analytical methods used to measure those pollutants require very strict quality control, because a small amount of contamination in samplers or analytical equipment can invalidate the results. Procedures for assuring accurate data were set forth in a Quality Assurance Project Plan (QAPP) at the start of the project. Those procedures, which include the collection of duplicate samples and the periodic submittal of samples to RIDOH's Air Pollution Laboratory for verification, were followed at the beginning of the sampling study but have since been discontinued.

The VOC and carbonyl levels reported by RIAC in 2015 and 2016 were sometimes elevated at a site, but the higher levels did not occur more frequently when the site was downwind of the airport. For example, significantly elevated levels of formaldehyde were detected on some days, primarily at the Fire Station monitoring site. Those levels were, at times, considerably higher than the formaldehyde levels measured at the RIDEM/RIDOH monitoring stations in the Providence area; however, the elevated levels do not appear to be linked to airport operations. It is likely that the elevated measurements are due to a sampling or analytical problem. However, due to the quality-control issues, it is impossible to rule out the possibility that there is a formaldehyde source in the immediate vicinity of the Fire Station site.

Neither the 2005-2006 airport monitoring study conducted by RIDEM/RIDOH nor RIAC's initial VOC and carbonyl sampling during the period when samples were collected every sixth day and quality control procedures were in place identified a significant impact from the airport on VOC or carbonyl levels in the surrounding areas. Levels of pollutants emitted by mobile sources, including benzene and 1,3-butadiene, at the Warwick sites tended to be higher than levels of those pollutants at the RIDEM/RIDOH rural site in West Greenwich, nearly the same as levels in a suburban area of East Providence which is sometimes downwind of Providence, and lower than levels in urban areas, including a site in a Providence residential neighborhood and a site in a residential area of Pawtucket that is adjacent to Interstate 95.

PAHs - Naphthalene

PAH samples have been collected for 24-hour periods and analyzed for naphthalene every sixth day since the start of the monitoring study. Unlike VOC and carbonyl data, the naphthalene data appear to be of sufficient quality for evaluation. Naphthalene is more volatile than other PAHs and, thus, is more likely to be present as a vapor in the air. As shown in Figure 3, naphthalene measurements at the Warwick sites tended to be lower than those at a site operated by RIDEM/RIDOH in Providence.

Naphthalene concentrations at the Warwick sites correlate well with each other, an indication that day-to-day variations in those concentrations are largely due to regional variations in air quality as opposed to the influence of a nearby source, such as the airport. Naphthalene levels were slightly elevated at some sites on some days, but those elevations did not occur more frequently when the site was downwind of the airport.

Naphthalene is classified by IARC as possibly carcinogenic to humans. The Agency for Toxic Substances and Disease Registry (ATSDR) has established a Minimal Risk Level for long-term exposures to naphthalene, based on respiratory effects, of 3.6 $\mu g/m^3$. As shown in Figure 3, the average levels measured at all of the Warwick sites were approximately 0.02 $\mu g/m^3$, substantially lower than the ATSDR health benchmark.

RIDOH determined that further measurements of naphthalene would be unlikely to show a link between airport emissions and ambient naphthalene levels.

$PM_{2.5}$

$PM_{2.5}$ measurements were taken throughout the RIAC monitoring study using US Environmental Protection Agency (EPA) Federal Reference Method equipment and procedures. $PM_{2.5}$ samples are collected on filters for a 24-hour period every sixth day. The filters are weighed at a laboratory before and after sample collection to determine the total mass of $PM_{2.5}$ that was collected.

$PM_{2.5}$ is the only pollutant measured at the airport for which the EPA has established a National Ambient Air Quality Standard (NAAQS). EPA's annual average NAAQS for $PM_{2.5}$ is 12 $\mu g/m^3$ and the 24-hour NAAQS is 35 $\mu g/m^3$.[1] Since the EPA determines compliance with both the annual and 24-hour standard for a three-year period, RIDOH evaluated the measurements taken in the 2014- 2016 for this report.

As shown in Figures 4 and 5, the annual average $PM_{2.5}$ concentrations at the Warwick sites 2014 to 2016 period, 6.4 – 7.1 $\mu g/m^3$, are similar to those measured at other urban and suburban sites throughout the state and are substantially lower than the annual average NAAQS of 12 $\mu g/m^3$. The 98th percentile 24-hour levels at the Warwick sites, 16.1 – 18.3 $\mu g/m^3$, (the values that EPA uses to determine compliance with the 24-hour NAAQS) are also considerably lower than the 24-hour NAAQS of 35 $\mu g/m^3$.

Of the four Warwick sites, $PM_{2.5}$ levels tend to be highest at the Field View site and lowest at the Pembroke site. An analysis of wind directions on the days that levels at the Field View site were

[1] The $PM_{2.5}$ NAAQS is exceeded if the average of the annual average concentrations in a three-year period is higher than 12 $\mu g/m^3$ or the three-year average 98th percentile 24-hour concentration is higher than 35 $\mu g/m^3$.

higher than at the other sites shows that airport emissions may contribute to those elevated levels. However, since $PM_{2.5}$ levels measured at all of the Warwick sites, including Field View, are substantially lower than the NAAQS, RIDOH did not recommend continued sampling for that pollutant.

Figure 3: Naphthalene Levels at the Four Airport Sites and a Providence Site, 2015 - 2016

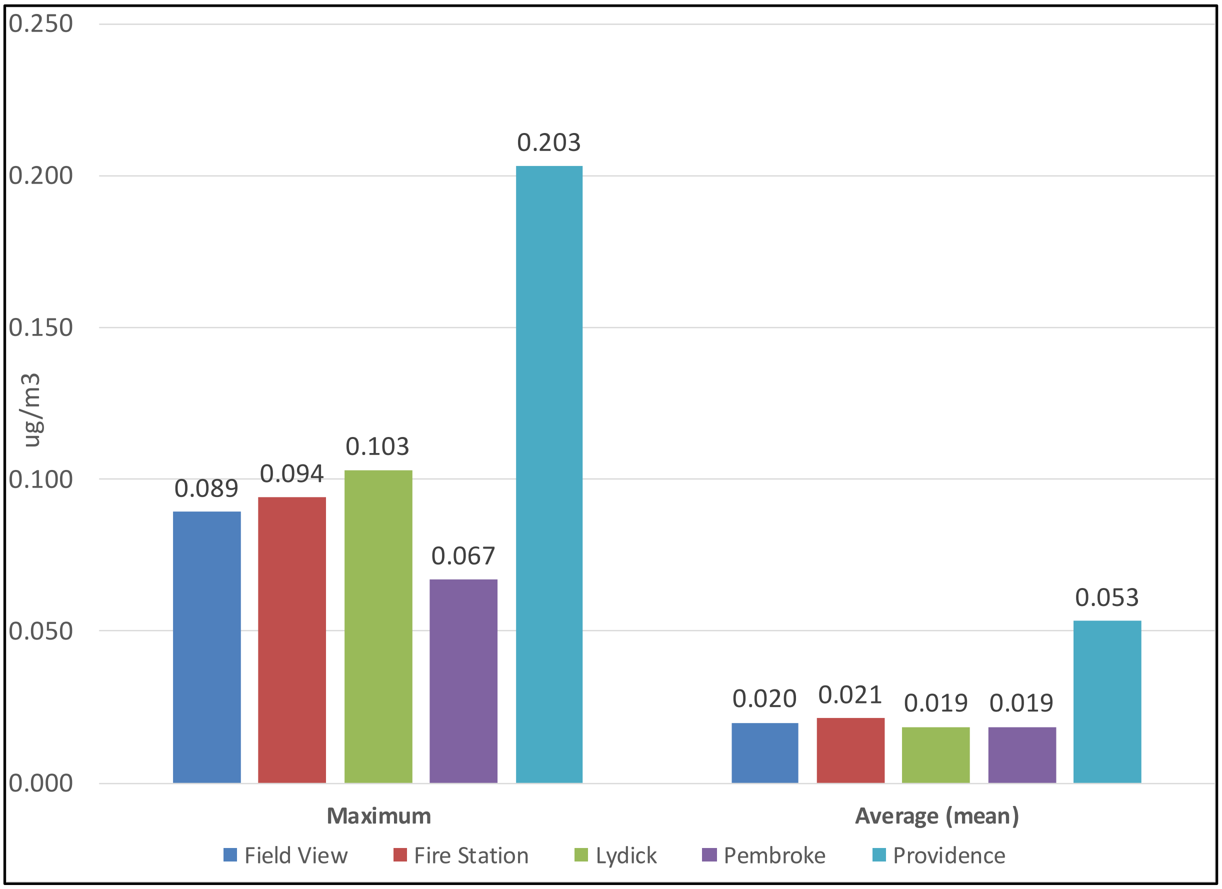


Figure 4: Annual Average $PM_{2.5}$ Levels at Airport Sites and Comparison Sites[2], 2014-2016

[2] Comparison site data used for this analysis are data for the days that the Warwick monitors operated. Since the monitors at the comparison sites operated on additional days, the annual and 24-hour average concentrations at those sites used to determine compliance with the NAAQS may be somewhat different.

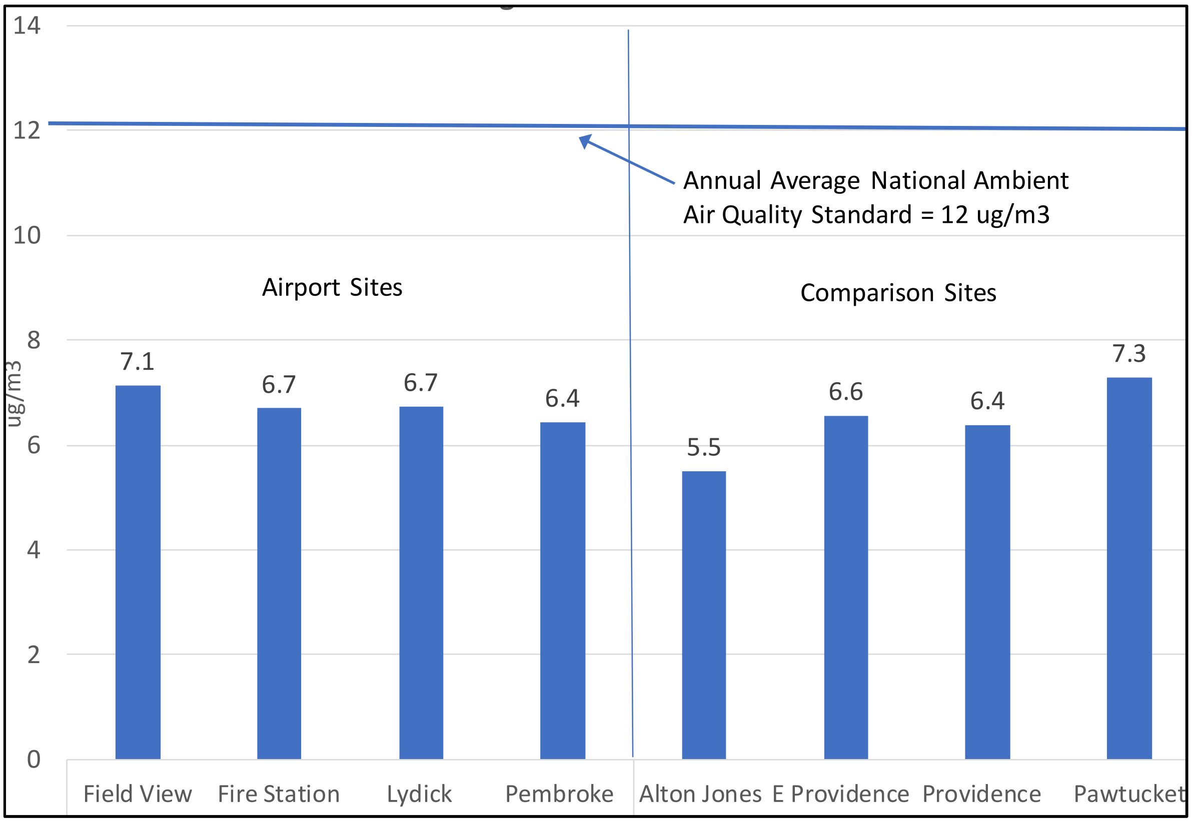
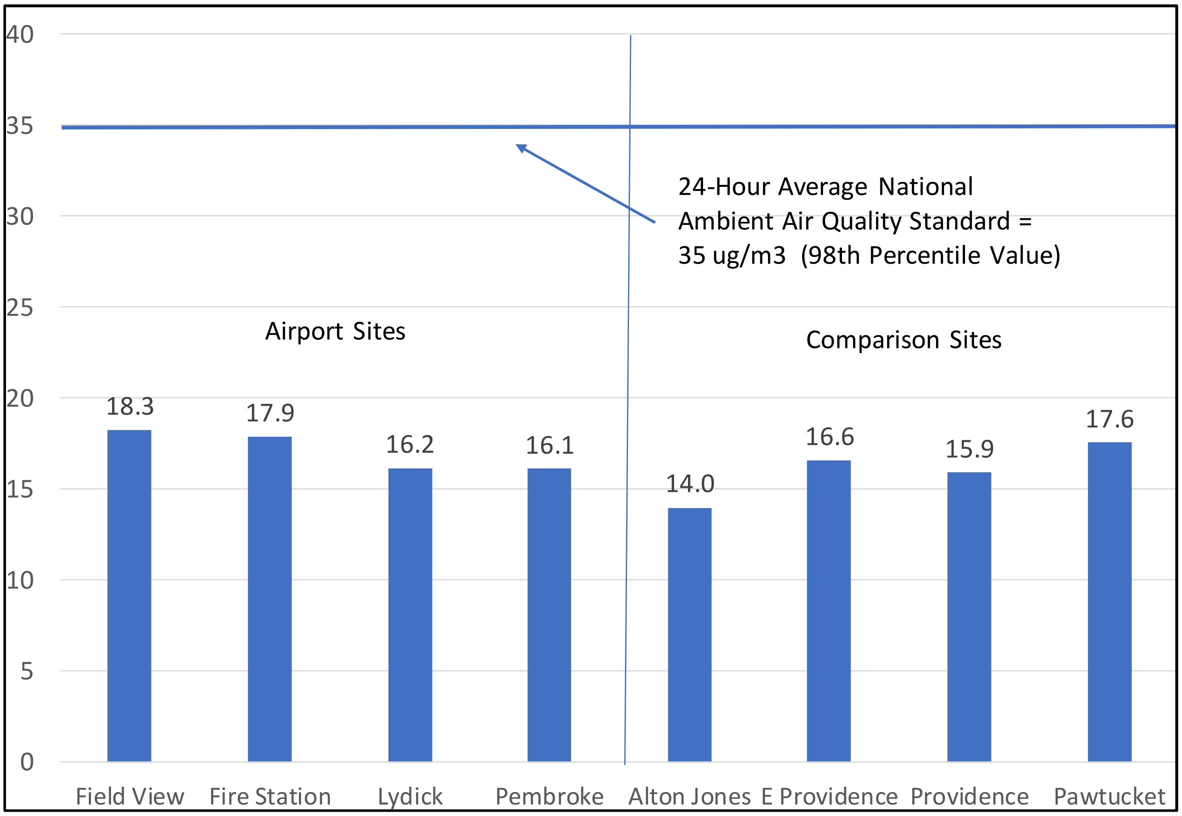

14
12
10
8
6
4
2
0
ug/m3
Annual Average National Ambient Air Quality Standard = 12 ug/m3
Airport Sites
Comparison Sites
7.1
6.7
6.7
6.4
5.5
6.6
6.4
7.3
Field View
Fire Station
Lydick
Pembroke
Alton Jones
E Providence
Providence
Pawtucket

Figure 5: 24-Hour Average $PM_{2.5}$ Levels at Airport Sites and Comparison Sites[3], 2014-2016



[3] Comparison site data used for this analysis are data for the days that the Warwick monitors operated. Since the monitors at the comparison sites operated on additional days, the annual and 24-hour average concentrations at those sites used to determine compliance with the NAAQS may be somewhat different.

Discussion of Continuous Monitor Data

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

- Ultrafine particles (particles smaller than 0.1 microns, measured as particle count);
- Black carbon (an indicator of diesel/jet fuel exhaust); and
- Particle-bound Polycyclic Aromatic Hydrocarbons (PAH).

The 2017 amendments removed the requirement to monitor for particle-bound PAH but retained the monitoring requirements for the other two pollutants. RIDOH concurs with this decision because particle count and black carbon levels are strongly impacted by airport emissions and measurement of those pollutants allows RIDOH to track how changes in airport operations affect air quality. In addition, RIDEM/RIDOH measures those pollutants at other sites in the state, and those measurements provide a context to evaluate the severity of the airport air-quality impacts.

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

UFPs are largely emitted by combustion processes, and levels tend to be highly elevated in areas with high levels of vehicle emissions, like neighborhoods near busy roadways and airports. UFP levels drop off quickly with distance from the source, due to dispersion of the particles in the air and agglomeration – the particles collide and stick together to form larger particles.

RIDEM/RIDOH operates PC monitors at two sites in Providence – one at the Urban League building in a residential area in South Providence and the other at the Near Road site immediately adjacent to the busiest, most congested section of Interstate 95. The measurements from the two sites will be used to provide a context for the severity of the airport measurements. In addition, in March 2017, RIDEM/RIDOH began measuring PCs at four sensitive receptors (schools, residential areas) near the highway as part of an EPA-funded study. The measurements at those sites will serve as additional comparative data for RIDOH’s 2018 airport report.

According to the 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 more concentrated and bioavailable (more likely to cause toxic effects) on UFPs than on larger particles. Due to their very small size, inhaled UFPs, 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. In particular, certain constituents of UFP, including copper, iron, other metal, and elemental carbon (soot) were strongly associated with heart attack deaths.[4]

[4] 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.

Black carbon (BC) is also measured continuously at the airport sites because it is an indicator of diesel/jet fuel exhaust. In its 2005-2006 study, RIDEM/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 the monitoring shelters, can influence the accuracy of the results. Due to the “noise” created by operational factors, the BC monitors operated by the RIAC contractor are not currently collecting useful data. Similarly, the particle bound-PAH monitors are not currently collecting good data that can be used for detailed analyses.

Even though RIAC’s recent BC measurements are problematic, RIDOH recommends that RIAC continue to measure that pollutant, since BC measurements, if collected correctly, can provide useful information about the extent of airport impacts in surrounding areas. RIDEM/RIDOH currently operates BC monitors at the sites where PC is measured, as well as at a residential, suburban site in East Providence. These 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 collected in the future at the airport sites.

Particle Count (PC) Results
PC levels at all of the airport sites tend to be higher when wind speeds are low, as shown in Figure 6, because higher wind speeds increase dispersion rates. The PC levels measured at all of the sites correlate with wind direction. As shown in Figure 7, average PC levels are highest at each site when the site is downwind of the airport. The nature and extent of the impacts vary by site, as discussed below. The frequency of wind directions for which each monitoring site is downwind of the airport is shown in Figure 8. The Pembroke site is downwind of the airport most often, and the Fire Station site is downwind least often.

As shown in Figure 7, the average PC levels at the Field View site are highest when the wind direction is between 10º and 130º (wind from the north-northeast to southeast). Wind directions in that range occur about 20% of the time. As shown in Figure 9, the Field View site is downwind of the southwest (5) end of the main runway (Runway 5) and the taxiways leading to that runway when the wind is from those directions. Flights departing on Runway 5 idle in line on the section of the taxiway adjacent to the Field View site while waiting for clearance, and then turn the corner and enter the runway to begin take off.

Monitoring results clearly show that PC levels at the Field View site are highly impacted by aircraft operations on Runway 5. Average PC levels measured by that monitor increase as both the number of arrivals (Figure 10) and departures (Figure 11) on Runway 5 increase.

Figure 12 shows the one-minute average PC readings at the four airport sites on March 14, 2016, a day when the Field View site was downwind of the airport and Runway 5 was in use all day. On that day, PC concentrations recorded at the Field View monitor dwarf those at the other three sites. Figure 13 shows the hourly average PC levels at the Field View site and the frequency of hourly arrivals and departures on that day. While additional meteorological and operational factors influence Field View site PC concentrations, the impact of flights departing from and arriving on Runway 5 is clear. However, the extension of the runway, as shown in Figure 9, may change these impacts as the Field View site will no longer be near the end of the runway.

The impact of airport traffic on the Fire Station site is less clear. Figure 7 shows average PC levels at the Fire Station site to be highest when the wind direction is between 130° and 180° (winds from the southeast to south). Those wind directions occur approximately 14% of the time. As shown in Figure 14, the Fire Station site is downwind of the airport when the wind is from the southeast, and the site is approximately 600 yards northwest of the 16 end of Runway 16-34, the secondary runway. However, that end of the runway is used relatively infrequently for arrivals and departures, as shown in Figure 15.

Figure 16 shows PC levels at the four sites on two days (February 3, 2016, and June 29, 2016) when the Fire Station site was downwind of the airport. Wind directions and wind speeds were similar on the two days. Departures, arrivals, and PC levels on those days, as reported by RIAC, are shown in Table 1:

Table 1: Aircraft Operations and Particle Count[5]

	# of Departures		# of Arrivals		Particle Count- Fire Station	
	Runway 23	Runway 16	Runway 23	Runway 16	Maximum	Average
2/3/2016	54	8	56	4	45,716	24,230
6/29/2016	77	31	74	2	3,026	1,717

Although the numbers of operations, including departures on Runway 16, were higher on June 29 than on February 3 and wind directions and speeds were similar on those days, PC levels were substantially higher on February 3. This may be explained by differences in the operation of the monitor on these two days, but a review of the data revealed similar inconsistencies on other days as well. In addition, e PC levels at the Fire Station site were not higher during hours when there was a high level of activity on any or all of the runways than in other periods.

It is possible that airport operations contributed to the elevated PC levels recorded at the Fire Station site on March 3, 2016 and on certain other days that that site was downwind of the airport. However, other pollutant sources closer to the monitor, including trucks at the fire station, traffic on Post Road, and activity in the Ann & Hope parking lot (immediately south of the monitoring site) may have also contributed to the elevated PC levels.

Figure 7 shows that the average PC levels at the Lydick site are highest when the wind direction is between 190° and 260° (wind from the south-southwest to west-southwest). Wind directions in that range occur about 30% of the time. As shown in Figure 17, the site is about 1,000 yards northeast of the northeast (23) end of the main runway (Runway 23).

As shown in Figure 18, average PC levels at the Lydick site increase as the number of arrivals on Runway 23 increase and, for hours with two or more arrivals on Runway 23, average PC levels were higher at the Lydick site than at any of the other sites. Figure 19 shows a different picture for Runway 23 departures, which tend to have a greater impact on the Pembroke site.

Figure 20 shows the one-minute average PC readings at the four airport sites on February 28, 2016, a day when the Lydick site was downwind of the airport and Runway 23 was in use all day. On that day, beginning at approximately 11 a.m., PC concentrations recorded by the Lydick

[5] Data as reported by RIAC

monitor were considerably higher than those at the other three sites. As shown in Figure 21, while departures predominate early in the day, the frequency of arriving flights increases during the morning hours and remains high in the afternoon. In the late-night and very-early-morning hours, arrivals continue with few to no departures. This pattern of aircraft arrivals is consistent with the times of elevated PC readings on February 28, 2016, as shown in Figure 20, and with the pattern of average hourly particle counts at the Lydick site, shown in Figure 22.

Figure 22 shows that average PC levels at the Lydick site increase in the late-night and early-morning hours, when levels measured at the other sites tend to be low, because the Lydick site is heavily impacted by arriving flights. Since arrivals continue during that time period and wind conditions tend to be calm during the late-night hours, impacts of emissions from incoming flights during the nighttime hours cause greater impacts than flights during the day.

As shown in Figure 7, the average PC levels at the Pembroke site are highest when the wind direction is between 240º and 330º (wind from the west-southwest to northwest). Wind directions in that range occur about 37% of the time. As shown in Figure 2, the site is about 380 yards east of the main runway, near the 23 end. While the current site is adjacent to the houses on the residential street, it does not represent maximum exposures in Winslow Park. Areas of Winslow Park are about twice as close to Runway 23 (about 200 yards) as the distance from the runway to the current monitoring station. Since PC levels drop off quickly as distance from the source increases, short-term exposures to people using the park may be substantially higher than those measured by the Pembroke site in its current location.

As shown in Figures 18 and 19, average PC levels at the Pembroke site increase as the number of departures on Runway 23 increase. For hours with one or more arrivals on Runway 23, average PC levels at the Pembroke and Lydick sites were higher than at any of the other sites. When Runway 34 is in use, PC levels tend to be highest at the Pembroke site, although levels don't increase as the number of flights on that runway increase (see Figures 23 and 24). The location of the ends of Runways 23 and 34 and the current Pembroke site are shown on Figure 25.

Figure 26 shows the one-minute average PC readings at the four airport sites on December 2, 2016, a day when the Pembroke site was downwind of the airport and Runway 23 and 34 were in use. On that day, Pembroke PC levels were substantially higher than at any of the other sites all day.

PC levels in the areas of Winslow Park that are closer to the main runway are likely to be higher than those monitored at the current site. Figure 27 shows average hourly PC levels measured by the Pembroke monitor in three different years. In the first year, the monitor was located in the area that is now the tot lot in the park, as shown in Figure 2. During most of the second year, the monitor was in the temporary location in the parking area south of the park. In the third year, the monitor was at its current location. PC levels measured at the first location were considerably higher than those at the current location, and levels at the temporary location were midway between measurements at the other two sites. Although other factors may also be in play, this is indicative of the fact that the measurements at the current location under-predict exposures in the park.

Particle count is a measure of UFP levels. The EPA cites "suggestive but limited" evidence that short-term UFP exposures are linked to respiratory and cardiovascular health effects, and a 2015 study by the California EPA demonstrated that long-term exposure to UFP contributes to heart disease mortality. However, a health-protective level has not yet been established for UFP. Therefore, it is not possible to determine the health implications of exposures to the UFP associated with airport emissions.

UFP (particle count) was also measured at two sites in Providence in 2016. Figure 28 shows the average hourly PC levels measured at those sites compared to measurements at the airport sites. The PC levels at the airport sites were, for the most part, similar to those at the Urban League site in Providence; however, average levels of PC at the Pembroke site from 6 a.m. to 8 a.m. and at the Lydick site in the late evening and night were considerably higher than at the Urban League.

Levels at the Near Road site were considerably higher than at the airport and Urban League sites, since it is located within feet of the highway. Further comparisons will be available in the 2018 report when data from sites that are impacted by I-95 and are near sensitive receptors will be available.

Figure 6: Effect of Wind Speed on Particle Count (Ultra-Fine Particle Concentration), 2016

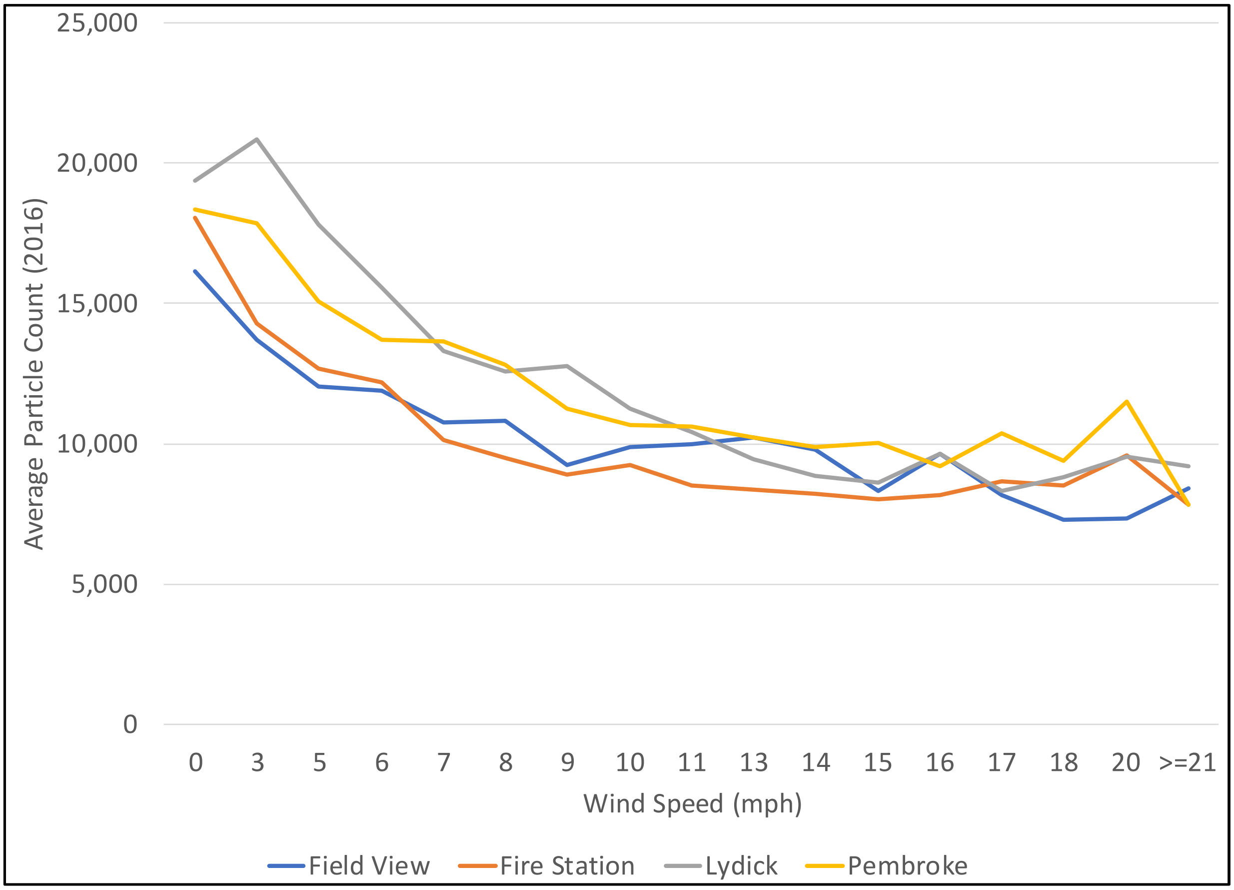
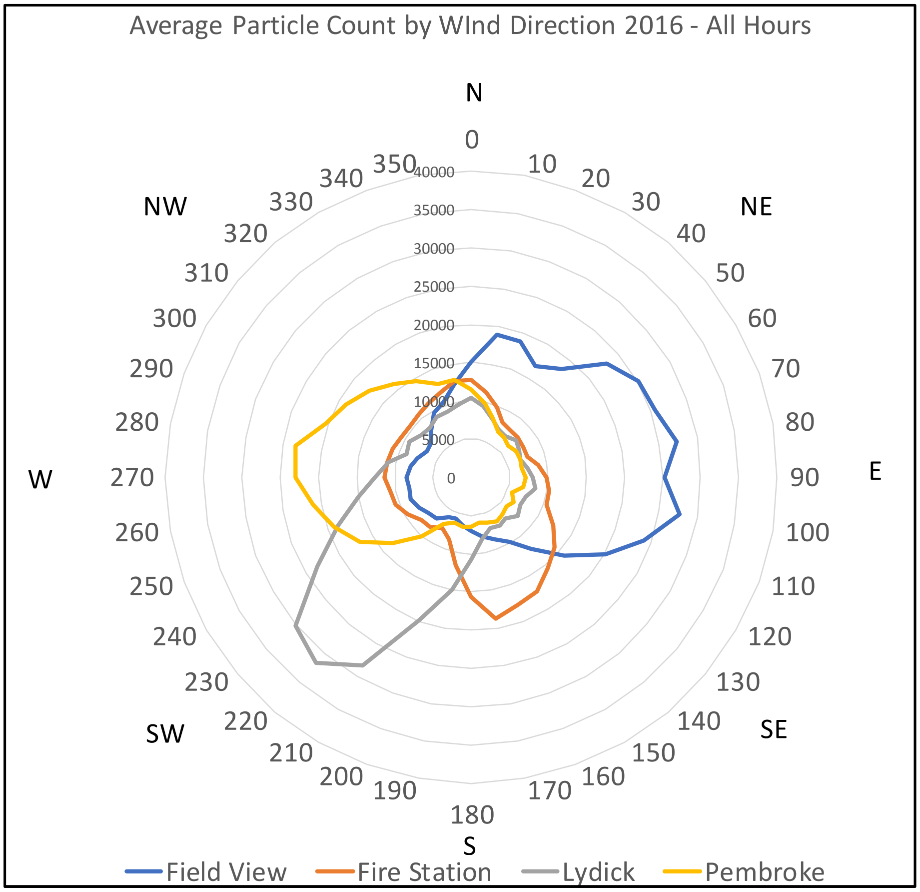


Figure 7: Effect of Wind Direction on Particle Count, 2016



Note: Average particle counts (PC) at each site are highest when the site is downwind of the airport. The Lydick site is southwest of the airport, and PC levels at that site are highest when the wind is from the southwest.

Figure 8: Frequency of Wind Directions for Which Sites are Downwind of Airport

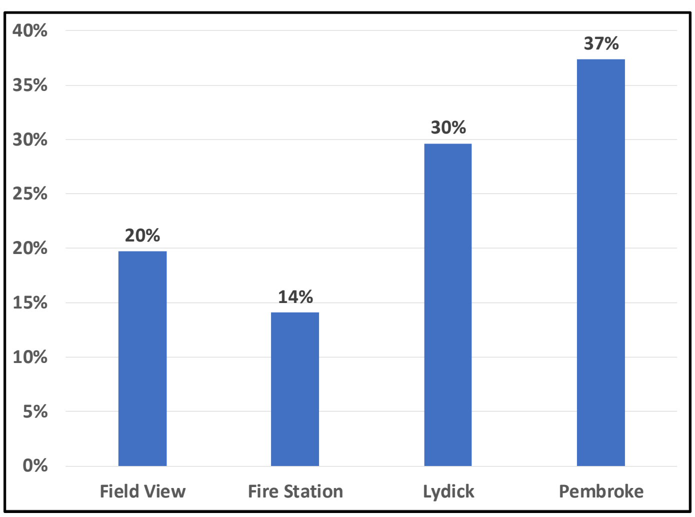


Figure 9: Location of Field View Site Relative to Airport

Figure 10: Impact of Runway 5 Arrivals on Particle Count Levels, 2016

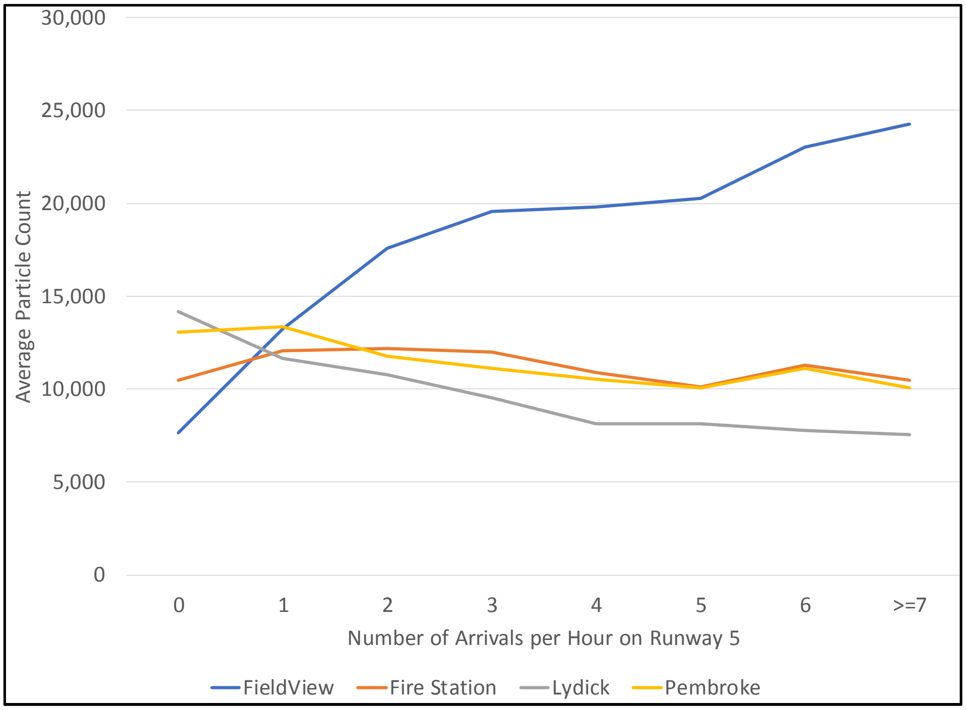


Figure 11: Impact of Runway Departures on Particle Count Levels, 2016

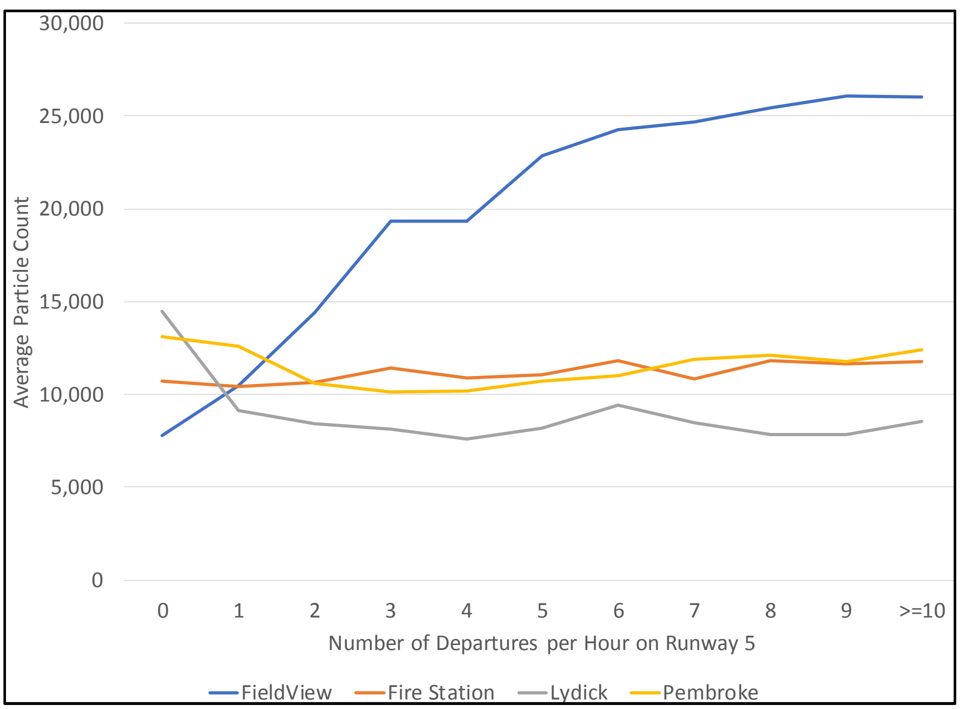


Figure 12: Particle Count At Field View Site, Downwind of Airport, March 14, 2016

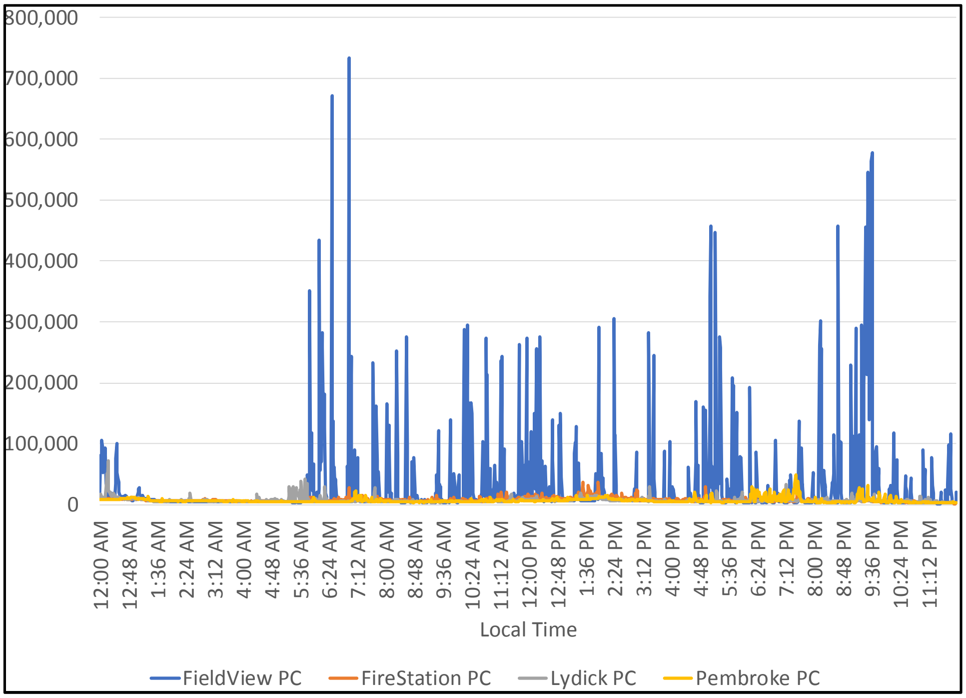


Figure 13: Hourly Operations Versus Field View Particle Count, March 14, 2016

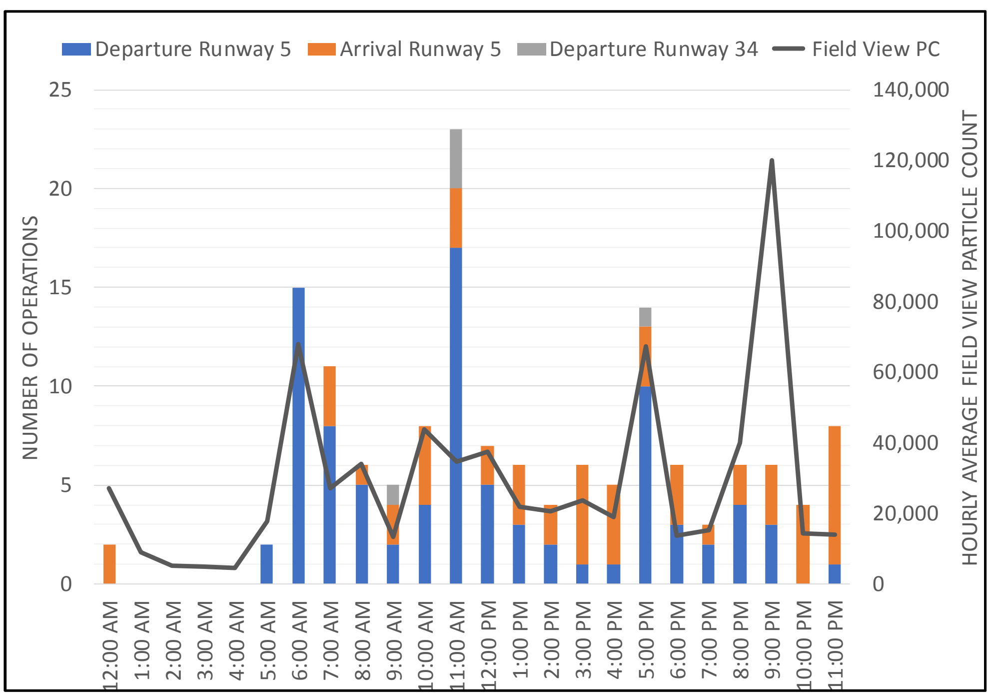
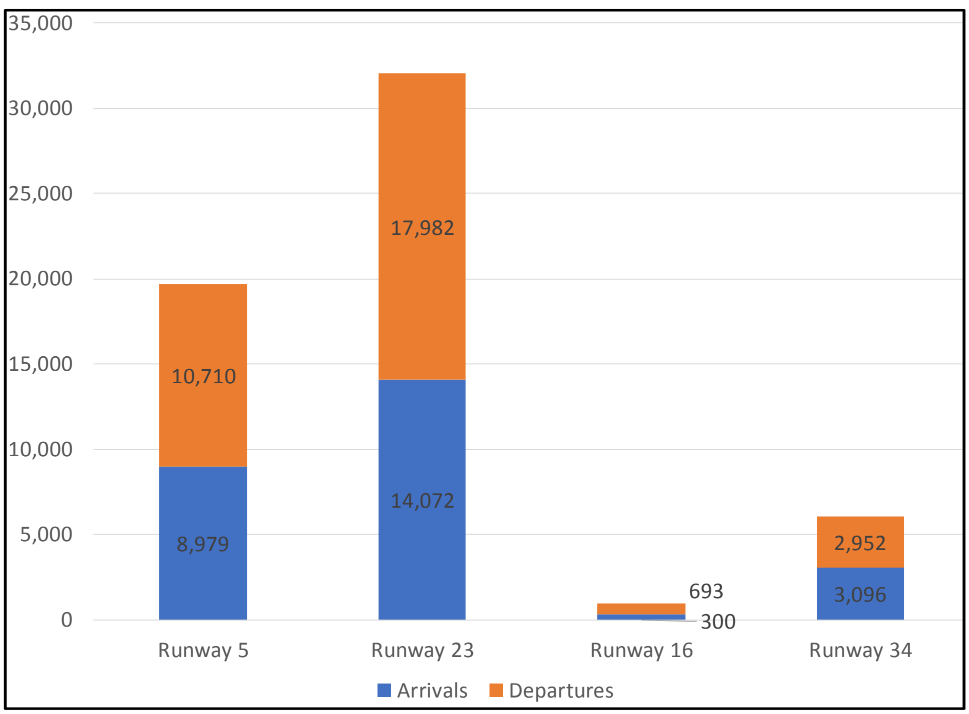


Figure 14: Location of Fire Station Site Relative to Airport

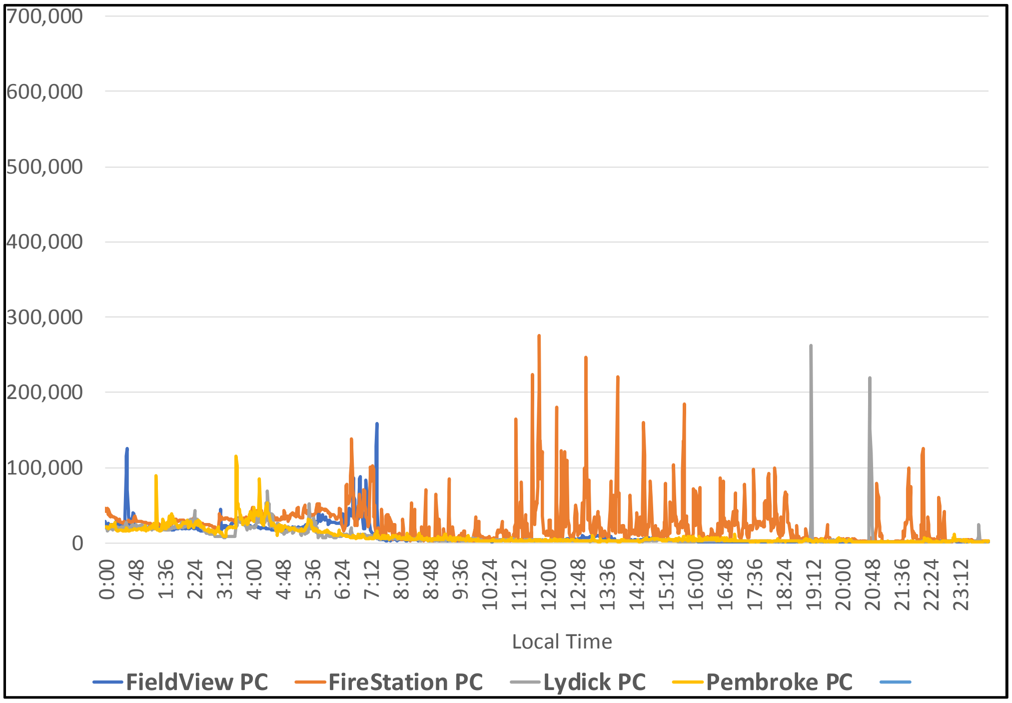
Figure 15: Number of Departures and Arrivals, TF Green Airport Runways, 2016[6]



[6] Data supplied by RIAC.

Figure 16: Particle Counts, Fire Station, Downwind of Airport

February 3, 2016



June 29, 2016

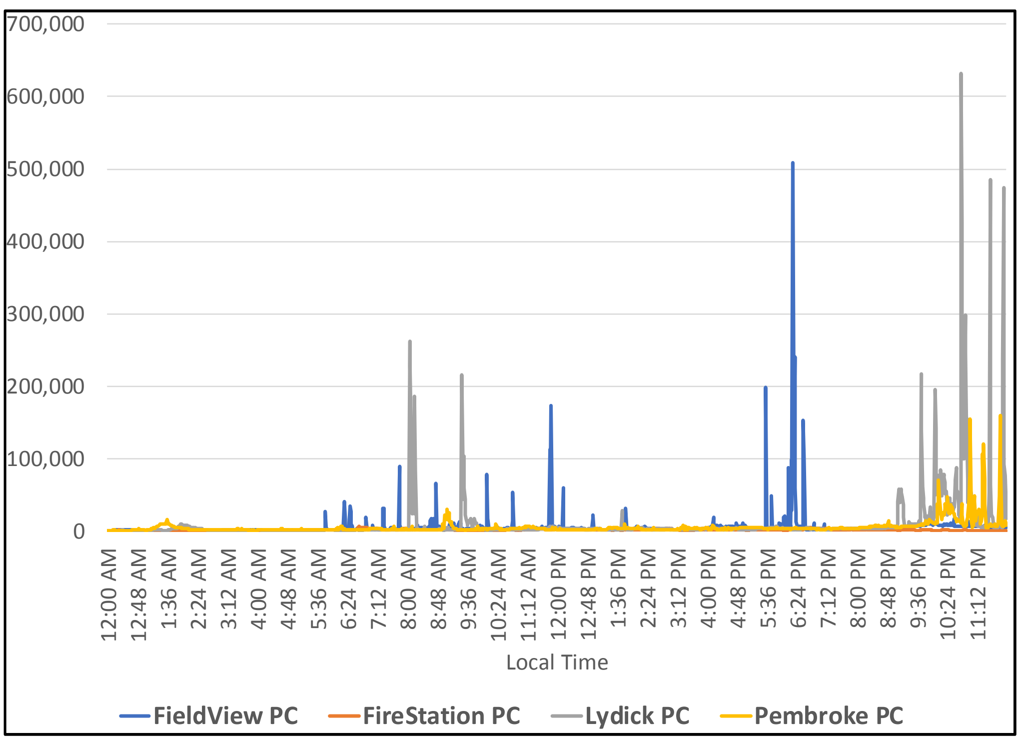


Figure 17: Location of Lydick Site Relative to Airport

Figure 18: Impact of Runway 23 Arrivals on Particle Count Levels, 2016

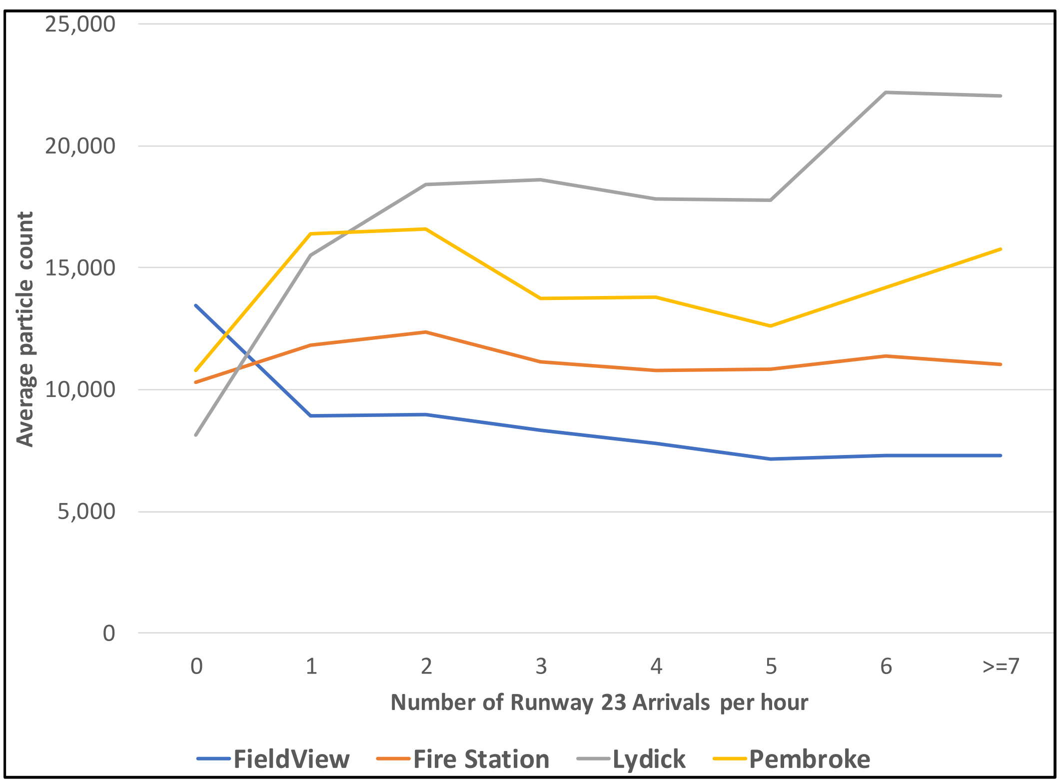


Figure 19: Impact of Runway 23 Departures on Particle Count Levels, 2016

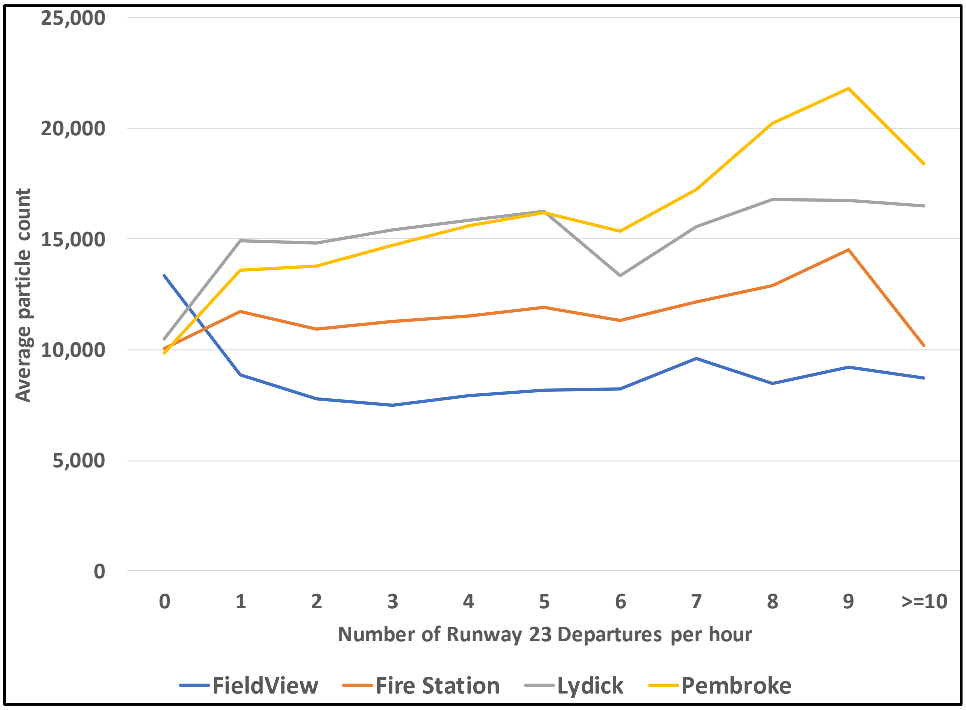


Figure 20: Particle Count, Lydick Site, Downwind of Airport, Runway 23 in Use, February 28, 2016

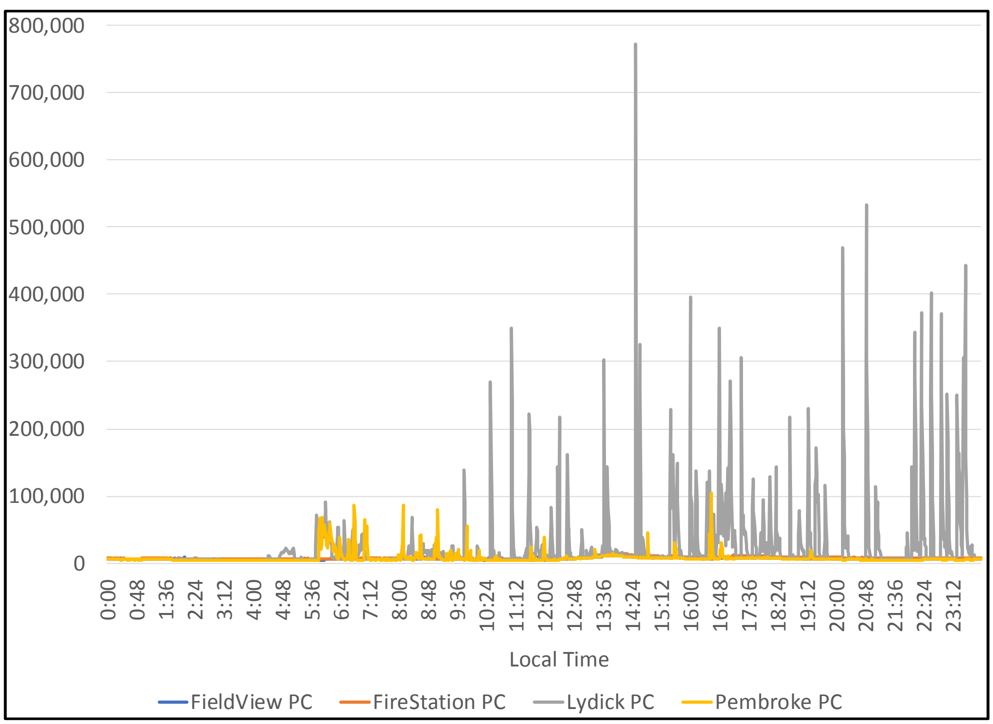


Figure 21: Arrivals and Departures, By Time of Day, 2016

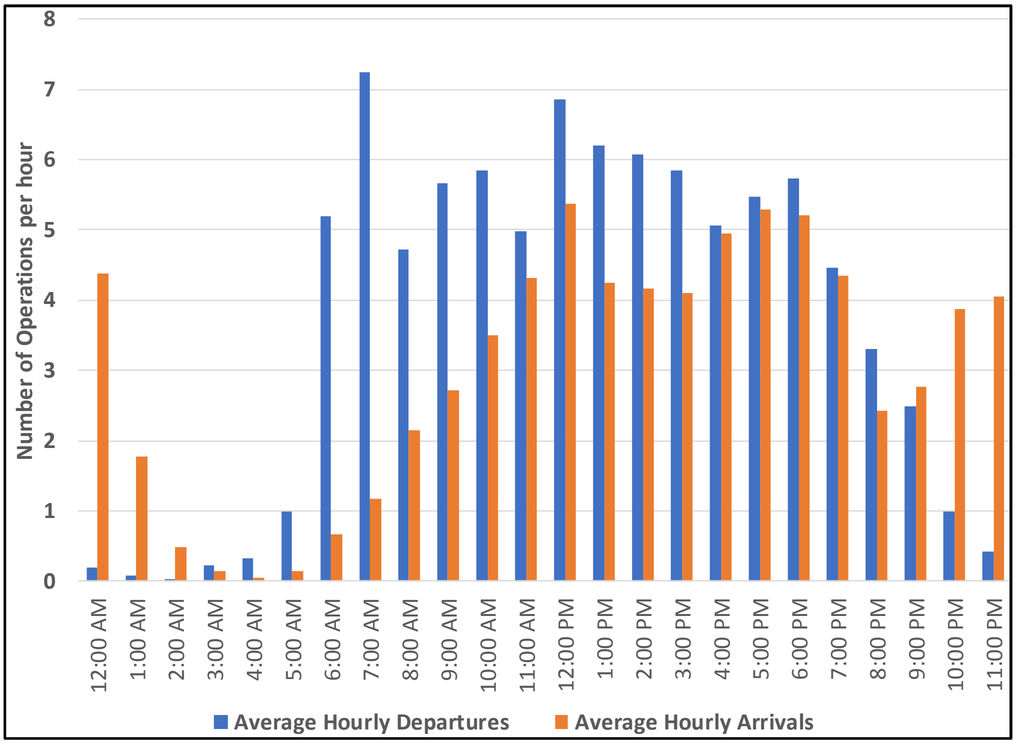


Figure 22: Average Particle Count, By Time of Day, 2016

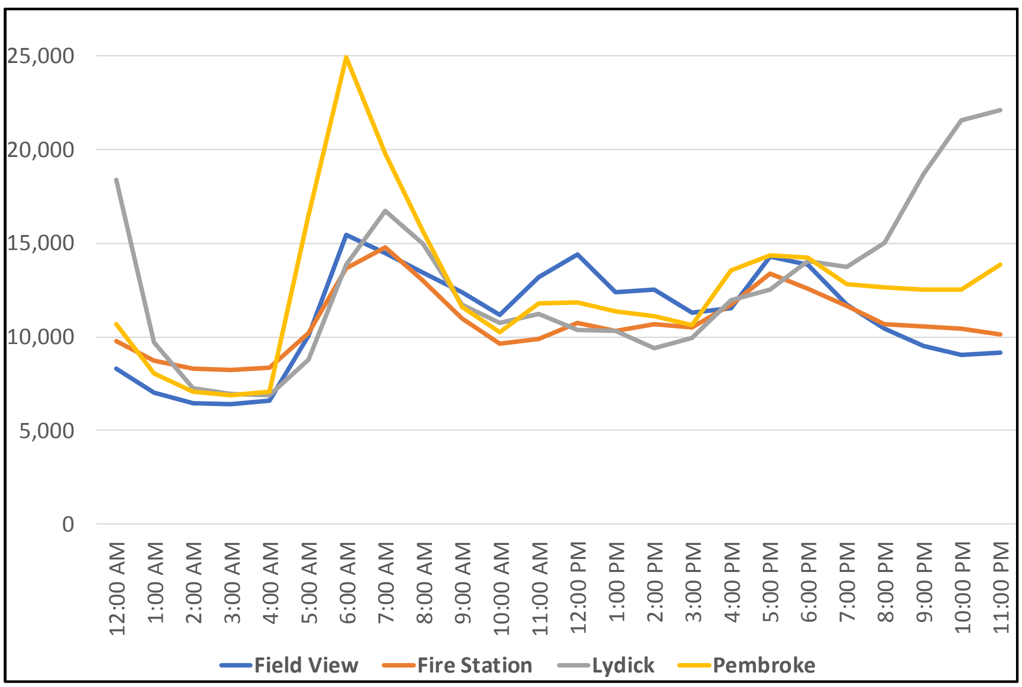


Figure 23: Impact of Runway 34 Arrivals on Particle Count Levels, 2016

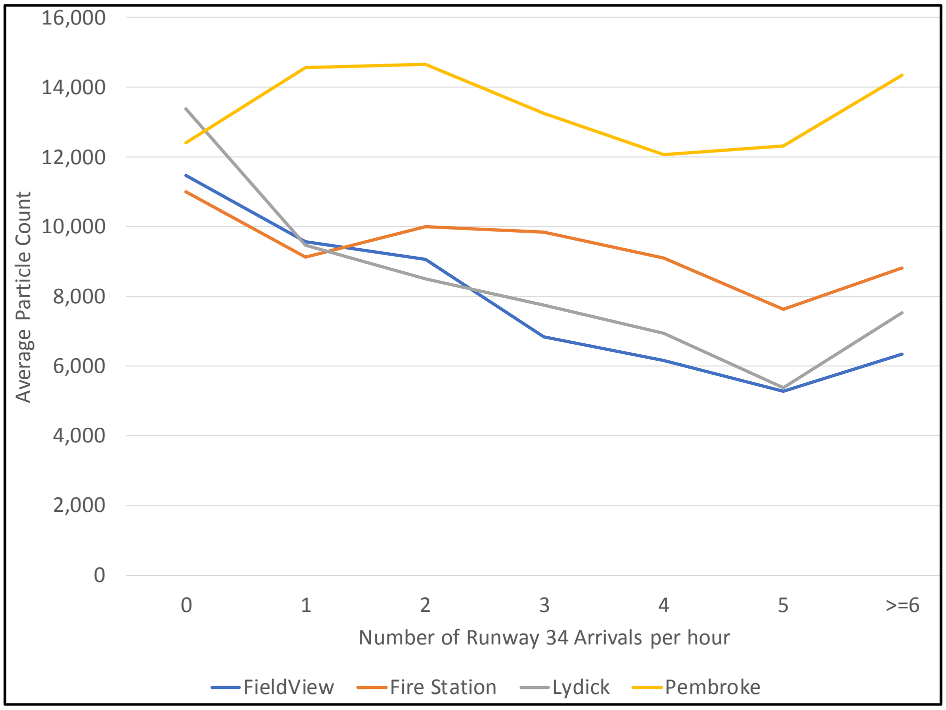


Figure 24: Impact of Runway 34 Departures on Particle Count Levels, 2016

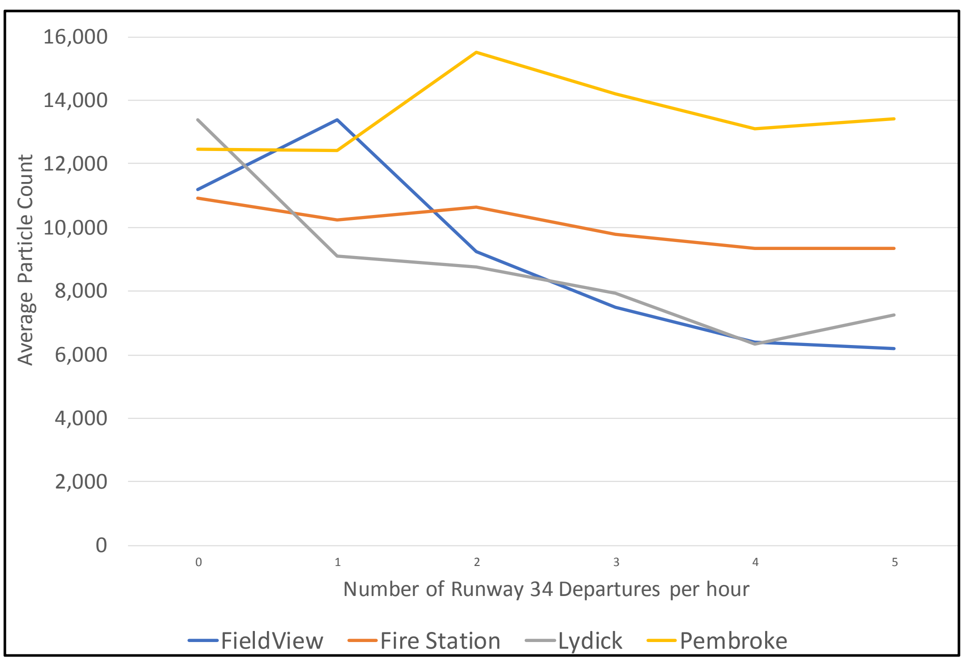


Figure 25: Location of Pembroke Site, Relative to Runways 23 and 34

Figure 26: Particle Count, Pembroke Site, Downwind of Airport, Runways 23 and 34 in Use, December 2, 2016

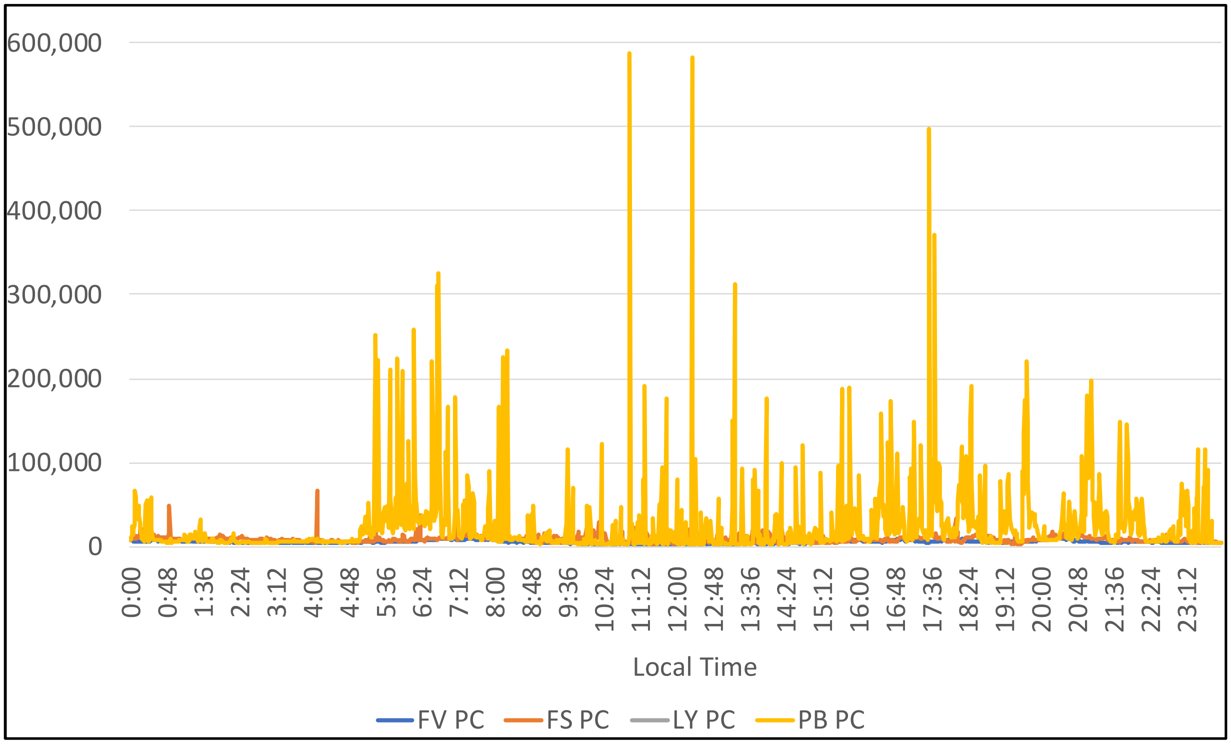


Figure 27: Average PC Levels at Pembroke Monitor; Original, Temporary, Current Site Locations

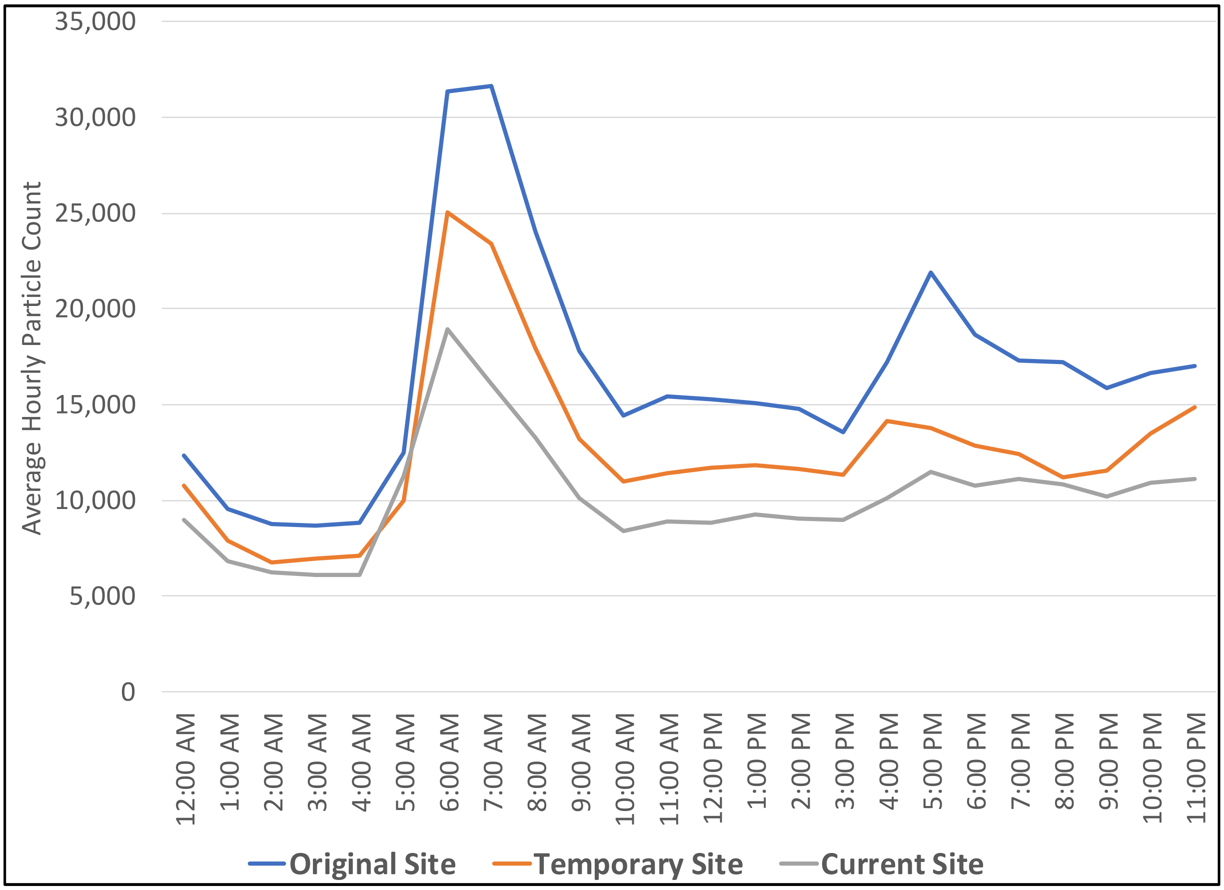
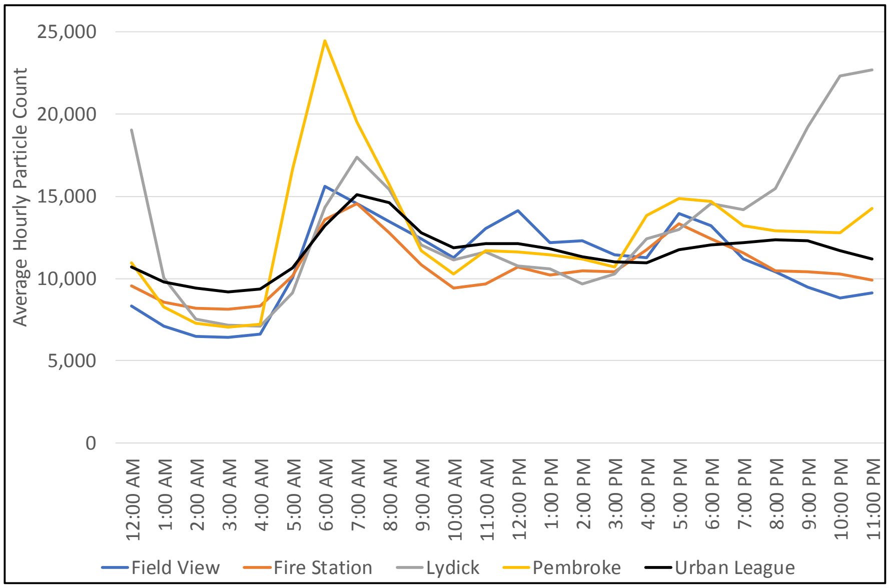
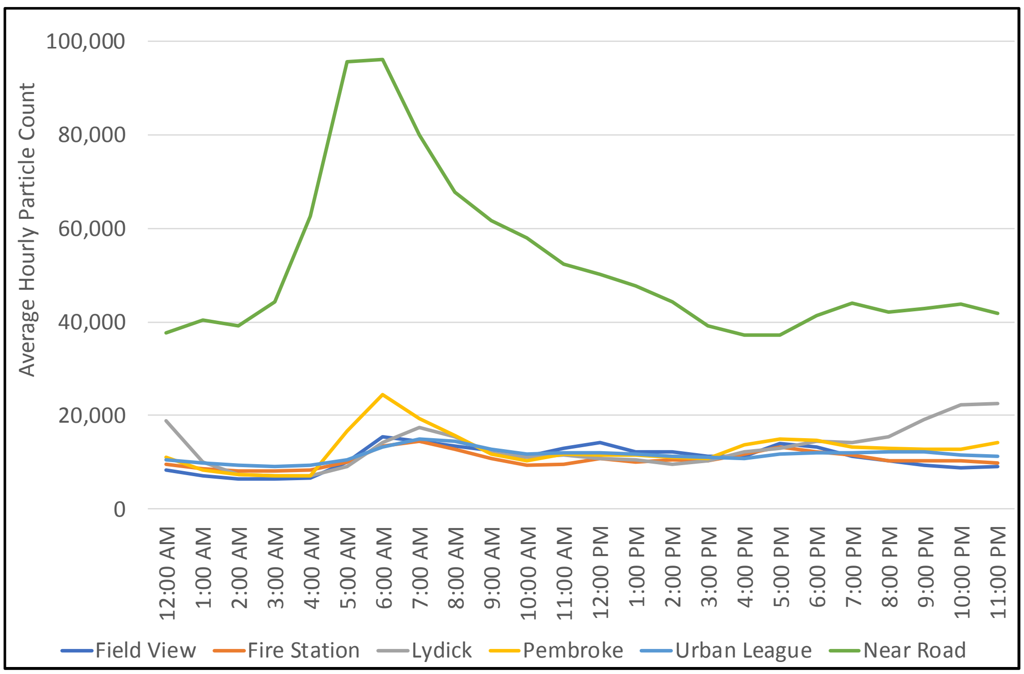


Figure 28: Average PC Levels Measured by Airport and Providence Monitors- 2016





Conclusions and Recommendations

After review of the monitoring results for 2016, RIDOH has the following conclusions and recommendations:

- RIDOH continues to be in full support of the 2017 amendments to the Act, which, by streamlining the list of required pollutants, will allow RIAC to focus on collecting useful data for the pollutants most closely associated with airport emissions that impact the surrounding neighborhoods.

- A review of the current data and data collected earlier by RIAC and RIDEM/RIDOH, shows that the continuous monitor measurements of BC and PC are the best measures for evaluating airport impacts on surrounding areas. PC is a measure of UFP levels and BC is a measure of diesel particulate exhaust.

- While the PC data supplied by RIAC appear to be of reasonable quality, operating procedures for the BC monitors must be improved for the RIAC BC data to be usable. RIDOH's Air Pollution Laboratory has considerable experience with operating monitors successfully and should be consulted to improve the quality of the data collected by the RIAC BC monitors.

- The PC monitors show impacts from aircraft operations when the sites are downwind of the airport. Impacts at the Field View site tend to be elevated when the wind is from the north-northeast to southeast and Runway 5 is in use. Impacts at the Lydick site are highest when the wind is from the south-southwest to west-southwest, especially when flights are landing on Runway 23. Impacts at the Pembroke site are highest when the wind is from the west, and appear to be impacted by air traffic on the main and the secondary runways. Impacts at the Fire Station site are less clear, due to the presence of other sources, including vehicles on Post Road.

- The EPA has found “suggestive but limited” evidence that short-term UFP exposures are linked to respiratory and cardiovascular health effects. A 2015 study by the California EPA demonstrated that long-term exposure to UFP contributes to heart disease mortality; however, a health-protective level has not yet been established for UFP. Considerable research is now under way to quantify those health effects.

- The PC levels measured at the airport sites tend to be similar to those at the RIDEM/RIDOH Urban League site in Providence, which is located in an urban residential neighborhood. PC levels at the Pembroke site tend to be higher than those at Urban League and at the other airport sites from 6 a.m. to 8 a.m., and PC levels at the Lydick site tend to be elevated in the evening and at night.

- PC levels measured at the airport and Urban League sites are considerably lower than those at the RIDEM/RIDOH Near Road site, which is immediately adjacent to the busiest section of Interstate 95 in Providence. This is expected, due to the very close proximity of that monitor to the highway. RIDEM/RIDOH are currently conducting a study that includes measuring PC and BC at several sites that are impacted by I-95 and are near residential or other sensitive receptors. Measurements from those sites will provide more comparative data for the 2018 airport report.

- The amended Act specifies that the monitoring network “shall be designed to measure air-quality impacts from airport operations, including those associated with planes operating on the extended runway on neighborhoods adjacent to the airport facility and at the Winslow Park playing fields. Fulfilling that mandate will require the relocation of one or more monitors.

- Since the Fire Station monitors have not yielded conclusive data about airport impacts, RIDOH recommends that monitoring at that location be discontinued and that the monitoring shelter currently at that site be moved to a location near the end of, and generally downwind of, the extended runway.

- In order to track the changes in impacts associated with the runway extension, RIDOH recommends that the Field View site should remain in place for the coming year.

- The current location of the Pembroke monitor is not appropriate for measuring airport impacts at Winslow Park. Sections of that park are considerably closer to the runway than the current monitoring location is, and since PC and BC levels decline with increased distance from a pollutant source, it is likely that exposures in the park are substantially higher than at the current monitoring location. Therefore, RIDOH strongly recommends that the Pembroke monitors be moved to a section of Winslow Park which is closer to the airport.

- RIDOH looks forward to working with RIAC to implement these recommendations so that RIAC’s investment in monitoring will provide the most useful information.