Using the Real-Time Air Quality Advisory Network

Version 3.0 Program Document

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In collaboration with:

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Overview

First launched in 2010, the Real-Time Air Advisory Network (RAAN) harnesses 21st Century technology in order to take the next step forward in providing Valley schools and the general public with the most accurate and timely information about local air quality. Developed through a partnership between the Valley Air District, UCSF-Fresno, and the American Lung Association in Central California, RAAN is the first communication network in the nation to provide automated notification of poor local air quality. By combining local air quality information with specific, concentration-based health recommendations, RAAN now makes it possible for schools, parents, and others to make informed decisions about when outdoor activities should be limited, and for whom.

This document provides a detailed explanation of why RAAN was developed, how it can be used effectively to protect public health, and how RAAN differs from the daily Air Quality Index (AQI) forecast and the corresponding Air Quality Flag Program. Overall, RAAN seeks to accomplish three key goals:

1. To quickly inform users via automated mobile device updates, email or text whenever local ozone or fine particulate (PM2.5) concentrations threaten health;
2. Using the latest health science, establish practical guidelines for when and how to limit outdoor exercise based on current hourly air quality levels; and
3. To provide schools and the general public with direct, 24/7 web access to the Valley's network of air quality monitor data at www.valleyair.org.

Why was RAAN created?

The following factors contributed to the development of RAAN:

The San Joaquin Valley's low "carrying capacity" for air pollutants: The Valley's topography and meteorology create ideal conditions for trapping, creating, and/or concentrating air pollutants. Although its air quality has improved measurably

over the past two decades, the Valley continues to experience days with fine particulate (PM2.5) and ozone levels that exceed current EPA standards. Because yearly exposure levels are general higher in the Valley, it is doubly important to minimize outdoor exercise during periods of peak pollution levels, especially for individuals with heightened sensitivity to air pollution.

New health science is redefining the health risks of air pollution: Every five years the US EPA reviews the national ambient air quality standards (NAAQS) for ozone, PM2.5, and other air pollutants. As the evidence of health impacts from air pollution has grown, these reviews have typically resulted in lower ambient (outdoor) standards, especially for ozone and PM2.5. For example, in 2006 the 24-hour standard for PM2.5 was lowered from an average of 65 micrograms per cubic meter ($\mu g/m^3$) to 35 $\mu g/m^3$. Additionally, in 2012 the annual standard for PM2.5 was lowered from 15.0 $\mu g/m^3$ to 12.0 $\mu g/m^3$. Furthermore, a 2011 CSU-Fresno/UCSF epidemiological study of Valley residents sponsored by the District found elevated emergency room admissions for asthma on days when the daily (24-hour) PM2.5 concentrations were lower than the current 24-hour standard of 35 $\mu g/m^3$ (see www.cvhpi.org for the report).

Exercising magnifies exposure: The role of exercise in magnifying the health risks of ozone and PM2.5 has been an important motivating factor in RAAN's development. Exercising magnifies risk in several ways: First, the amount of inhaled air per minute rises substantially when breathing faster and more deeply. Second, breathing harder means that air pollutants, especially the smallest particles within PM2.5 known as ultrafine particles (UFP or PM0.1), are more likely to penetrate the aveolar region of the lungs where absorption into the bloodstream occurs. A 2003 study found that during moderate exercise, 80% of inhaled ultrafine particles were deposited in the lungs, compared with 60% lung retention while at rest[1]. However, as shown below in Figure 1, because the volume of air exchanged per minute increases substantially during exercise, overall UFP deposition increased by 450%.

Pollution levels can vary greatly during the day: Access to real-time hourly air quality data helps insure that outdoor exercise can be limited to periods of the day when air quality is acceptable. Over the course of a given day, ozone and PM2.5 levels often vary significantly. In the case of ozone, health-threatening levels do not usually occur until mid-afternoon, and mornings are almost always safe. For PM2.5, early mornings and late afternoons are often much cleaner than late morning and evening periods.

Access to real-time data compensates for inaccurate AQI predictions: Based on weather conditions, Valley Air District forecasters make a single, county-wide Air Quality Index (AQI) prediction for the next day. Similarly, AirNow makes a rolling eight hour predication, taking into account the past four hours of data and estimating the next four hours of data. Rapid changes in weather conditions

[1] See Daigle, C.C. et al. (2003) Ultrafine Particle Deposition in Humans During Rest and Exercise. Inhalation Toxicology, 15: 539-552.

mean that AQI forecasts are inaccurate about 20 to 25% of the time. Schools that only rely on the AQI forecast run the risk of allowing students, especially sensitive individuals, to exercise outdoors when the daily forecast has underestimated local pollution concentrations. Conversely, over-predicting pollution levels can force students to remain indoors unnecessarily.

Pressure on schools to increase student exercise and reduce obesity: The nation, California, and especially the Valley are facing a crisis of childhood obesity. California schools face increased pressure to expand exercise opportunities yet many schools lack indoor exercise facilities. Access to RAAN's real-time monitors provides schools with the knowledge they need to maximize student access to safe outdoor exercise.

Wildfires and other extreme air pollution events: In recent years the Valley has been significantly impacted by wildfires in the foothill and mountain regions surrounding the Valley. RAAN notifications are particularly important when wildfire plumes entering the Valley raise ozone and PM2.5 levels to particularly dangerous levels. However, in rare instances thick ash or smoke from wildfires may bypass detection by the RAAN monitors due to the large particulate size. For this reason the District always advises that if you can see or smell smoke, you are being impacted by it and should remain indoors.

How does RAAN work?

RAAN is based on the following elements:

1. Assigning RAAN hourly monitors their local areas: Using a geographic information system (GIS) and their knowledge of air pollution patterns in the Valley, Air District staff has assigned each District hourly ozone and PM2.5 monitor to its own geographic zone or catchment. Air quality readings from these monitors pertain only to their assigned zone. All school facilities within a given monitor zone are assigned to that monitor. In some cases, large school districts are assigned to several monitors, especially in the case of the more numerous ozone monitors. Individuals with school district-wide responsibility simply register for their district in order to be informed when any of the assigned monitors send a notification. Individuals who register for an individual facility only receive notification from the monitor assigned to that facility.

2. Orientation and signup: RAAN signup is as simple as inserting an address into the tool (either the website or the mobile app). District staff is available to work with schools to assist them with the sign-up process. Next, each person is asked to provide their name, phone number, email address, and password. This makes it possible for the District to inform users when technical problems arise with their monitors or when urgent notification is needed due to unusual air quality situations such as wildfire

ash impacts. Users then specify whether they want notification in the form of a mobile notification, text message or email.

3. RAAN **hourly** outdoor activity risk levels vs. the AQI's **daily** risk levels: Unlike the AQI's focus on estimating health risk based on average daily and/or eight hour concentration levels, RAAN is specifically designed to provide health risk guidance for short-term, hour-by-hour exposure when exercising outdoors. As shown in Table 1, RAAN uses Real-Time Outdoor Activity Risk (ROAR) levels 1 through 5.[2]

4. Interpreting the Outdoor Activity Guidelines: Shown in Table 1 below, these advisory guidelines are based on consultation with health researchers at US EPA, UCSF, CSU-Fresno, UC Berkeley, and the Fresno/Madera Medical Society. While these guidelines are applied to exercise options for students, these recommendations also apply to outdoor exercise of a similar duration for the general public as well. They are based on several important principles drawn from health research. First, the duration and relative intensity of the outdoor activity should be reduced in the face of poor air quality. Athletic practices are often the most prolonged and intensive of outdoor activities, and may need to be scaled back (ROAR levels 3 and 4) or moved indoors (ROAR level 5). (With respect to PM 2.5 and ozone, indoor air quality is typically much better than outdoor air quality.)

   Second, particularly sensitive students such as asthmatics are most vulnerable to short-term exposure to elevated ozone and PM 2.5. At ROAR level 4 and in some cases, ROAR level 3, sensitive individuals may respond negatively to these pollution concentrations. If they do not remain indoors, these individuals should not engage in prolonged exercise under those conditions to the extent possible. Putting RAAN to effective use therefore underscores the importance of a school district policy that takes formal note of which students have asthma or some other medical basis for vulnerability to ozone or PM2.5.

5. Notification protocol: An automated RAAN email or text notifications is sent when local ozone or PM2.5 concentration levels enter the ROAR Level 3 range, Unhealthy for Sensitive Groups. This email will contain a link to a customized RAAN page similar to Figure 2 shown below. Subsequent emails will be sent if concentration levels rise to ROAR level 4, Unhealthy, or ROAR level 5, Very Unhealthy. When air quality improves to ROAR level 2, Moderate, you will also be notified.

[2] For ozone, the ROAR and AQI concentration ranges are equivalent. However, for PM2.5, ROAR level 5 differs significantly from the corresponding AQI Purple level. ROAR level 5, at which everyone should avoid outdoor exercise, begins at 76 $\mu g/m^3$ rather than the AQI's 150 $\mu g/m^3$.

6. Responding to the notification: Users should anticipate that a RAAN notification will commonly occur on days when the predicted AQI was either Orange (Unhealthy for Sensitive Groups) or Red (Unhealthy). Once receiving the notification by email or text, users have the option of (1) linking from the email to their school RAAN webpage in order to confirm the email or (2) waiting for a subsequent email should conditions change. In any case, specific ROAR advisory guidelines for different types of outdoor activities are found by clicking on the Outdoor Activity Guidelines tab above the graph of daily concentrations.

7. Interpreting RAAN monitor graphs and related information: The web link contained in a RAAN notification of worsening local air quality will direct you to your assigned monitor page (see Figure 2) which displays the following, starting from the top:
    a. The current concentration level for ozone and PM2.5;
    b. When the selected address has been entered, PM2.5 and Ozone data will be depicted with a graph showing the hours of the day on the horizontal scale, pollutant concentrations per hour on the vertical scale, and ROAR levels 1 to 5 displayed horizontally in successive ROAR ranges corresponding to increased pollution levels, shown in Figure 3 below. About 18 minutes after each hour, a new data point is depicted on the graph.
    c. By clicking on the calendar icon at the top of the page, it is possible to view pollution levels for the preceding day.
    d. To the right of the graph, a table provides hourly concentration averages for the day, updated about 18 minutes after the hour.
    e. On the left, general health recommendations are summarized for each of the five ROAR levels.

8. RAAN and the evolution of school policies: The Valley Air District believes that by providing this advisory information in a form that is easy to understand and access, schools will be able to put this information to good use. Given that the morning hours prior to 11am are typically the healthiest for both ozone and PM2.5, over time schools may shift more outdoor activities to the 7am to 10am time period. A formal accounting of all sensitive students per facility is also key to fully utilizing RAAN guidelines.

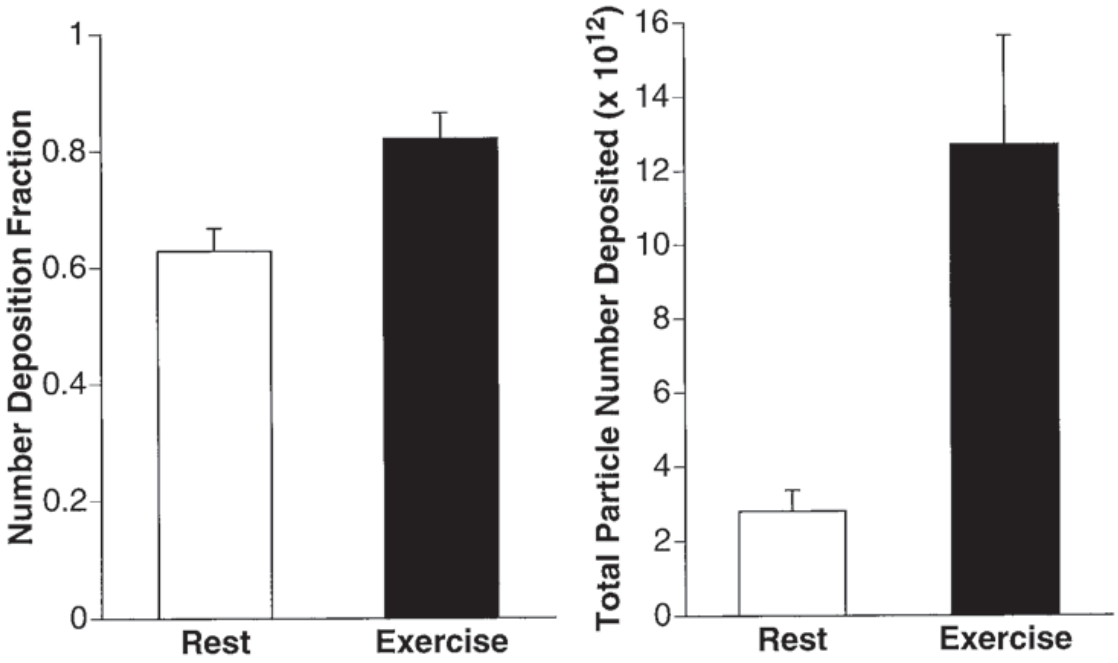
9. What about schools in rural areas? School districts on the west side the Valley, for example, experience lower ozone and PM2.5 concentrations than districts located in the more populated east side. Fortunately, the Air District has been installing air quality monitors in the west side. In the case of ozone, rural schools are sometimes downwind of metro areas such as Fresno and Bakersfield. These schools, despite being located in small towns with low populations, often experience some of the highest ozone concentrations in the Valley. In any case, District personnel are ready and

willing to provide individual consultation with rural school districts regarding their interpretation of RAAN notifications.

10. Technical problems: For RAAN to function properly, a number of technical systems have to work in unison. All RAAN users need to anticipate technical problems. Most often, air pollution monitors experience temporary technical problems related to missing or inaccurate data. Both the RAAN mobile device, home page and the email messages sent by RAAN contain a phone number and email that allows users to quickly report technical problems. If there is an extended technical problem with a RAAN monitor, you will receive notification.

11. Questions and comments? Please submit any comments or questions to jaime.holt@valleyair.org or heather.heinks@valleyair.org.

Figure 1. Particle number deposition fraction (DF) and total particle deposition of UFPs at rest and exercise.



Left panel shows the DF when breathing at rest, and during exercise. Right panel shows the calculated total particle deposition over 1 hr. at rest and when exercising. (Source: Daigle et al., 2003).

Table 1. RAAN Outdoor Activity Guidelines for San Joaquin Valley Schools

Real-Time Outdoor Activity Risk (ROAR) Levels for Hourly Ozone and PM2.5

RAAN

Real-time Outdoor Activity Risk (ROAR) Guidelines

	Level 1	Level 2	Level 3	Level 4	Level 5
Recess (15 min)	Outdoor activity OK for all.	Ensure that sensitive individuals are medically managing their condition.*	Sensitive individuals should exercise indoors or avoid vigorous outdoor activities.*	Exercise indoors or avoid vigorous outdoor activities. Sensitive individuals should remain indoors.*	No outdoor activity. All activities should be moved indoors.
P.E. (1hr)	Outdoor activity OK for all.	Ensure that sensitive individuals are medically managing their condition.*	Sensitive individuals should exercise indoors or avoid vigorous outdoor activities.*	Exercise indoors or limit vigorous outdoor activities to a maximum of 15 minutes. Sensitive individuals should remain indoors.	No outdoor activity. All activities should be moved indoors.
Athletic Practice & Training (2-4hrs)	Outdoor activity OK for all.	Ensure that sensitive individuals are medically managing their condition.*	Reduce vigorous exercise to 30 minutes per hour of practice time with increased rest breaks and substitutions. Ensure that sensitive individuals are medically managing their condition.	Exercise indoors or reduce vigorous exercise to 30 minutes of practice time with increased rest breaks and substitutions. Sensitive individuals should remain indoors.	No outdoor activity. All activities should be moved indoors.
Scheduled Sporting Events	Outdoor activity OK for all.	Ensure that sensitive individuals are medically managing their condition.*	Increase rest breaks and substitutions per CIF guidelines for extreme heat.** Ensure that sensitive individuals are medically managing their condition.	Increase rest breaks and substitutions per CIF guidelines for extreme heat.** Ensure that sensitive individuals are medically managing their condition.	Event must be rescheduled or relocated.
PM2.5 Range	1-12 µg/m³	13-35 µg/m³	36-55 µg/m³	56-75 µg/m³	>75 µg/m³
Ozone Range	1-59 ppb	60-75 ppb	76-95 ppb	96-115 ppb	>115 ppb

* Sensitive Individuals include all those with asthma or other heart/lung conditions

** California Interscholastic Federation

San Joaquin Valley AIR POLLUTION CONTROL DISTRICT

www.valleyair.org/myraan

Figure 2. Sample RAAN web page

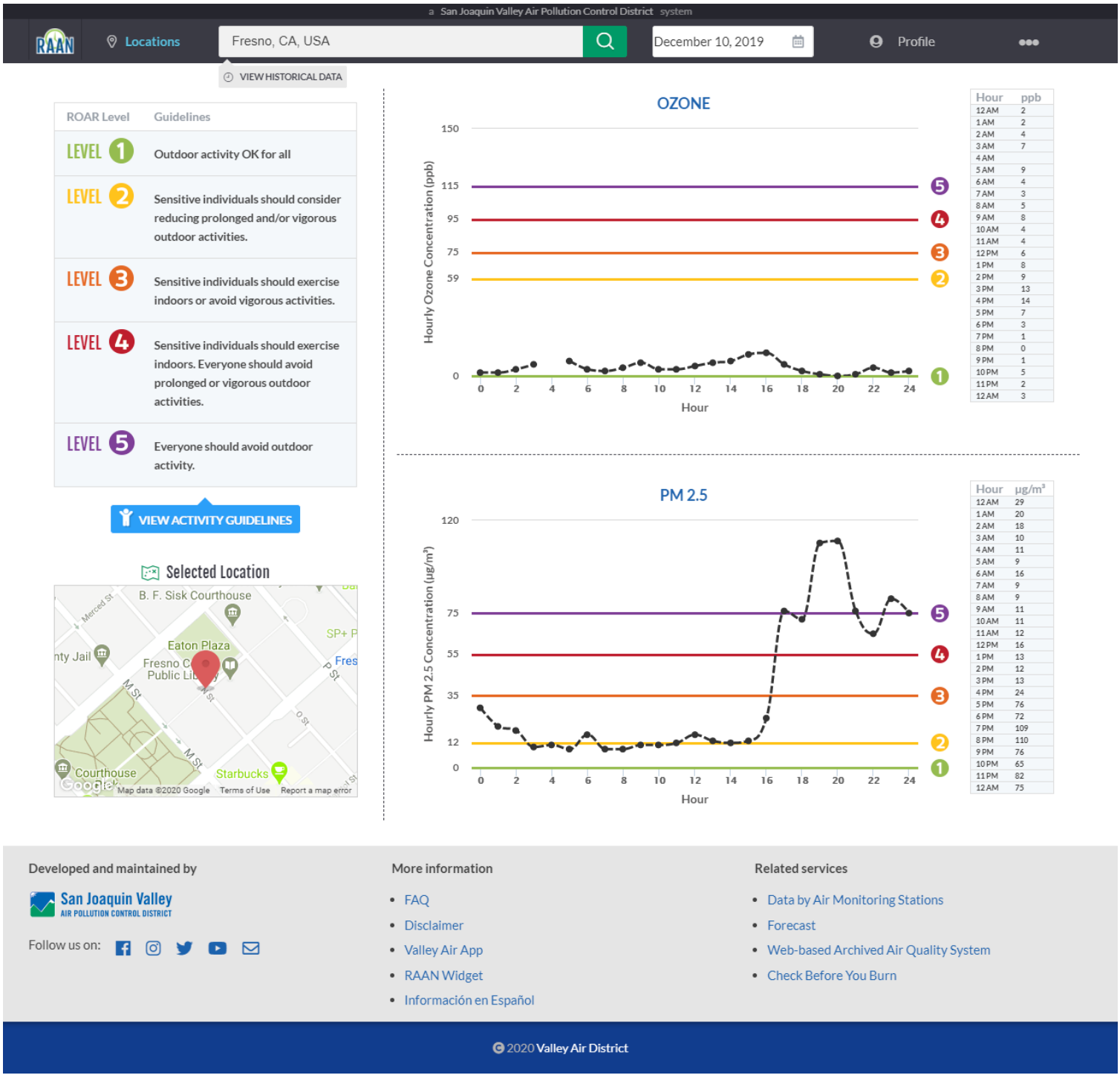
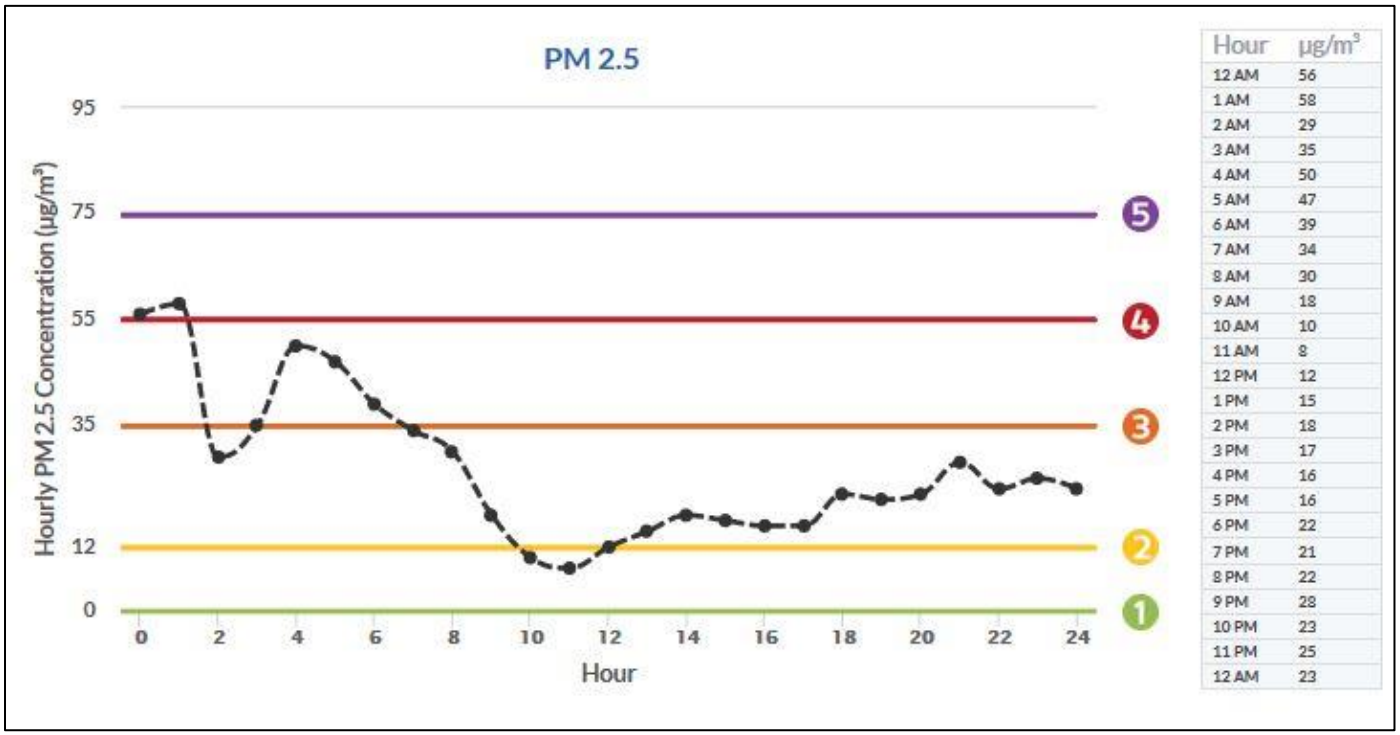


Figure 3. RAAN Monitor Graph



Hour	µg/m³
12 AM	56
1 AM	58
2 AM	29
3 AM	35
4 AM	50
5 AM	47
6 AM	39
7 AM	34
8 AM	30
9 AM	18
10 AM	10
11 AM	8
12 PM	12
1 PM	15
2 PM	18
3 PM	17
4 PM	16
5 PM	16
6 PM	22
7 PM	21
8 PM	22
9 PM	28
10 PM	23
11 PM	25
12 AM	23