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MEMORANDUM

To: Robert Hewitt, Mill Creek Residential Trust
From: Marc C. Wallace, QEP
Date: November 19, 2013
Subject: Needham Mews Development: Ultrafine Particles Response Ref 3821

Tech Environmental, Inc. (Tech) performed a review of presentation materials and studies submitted to the Needham Zoning Board of Appeals (ZBA) regarding the potential impacts from ultrafine particles (UFP) emitted from Interstate 95 (I-95) located adjacent to the proposed Needham Mews residential development (Project) at 692-744 Greendale Avenue, Needham, MA (the "Project Site"). The documents included as part of my review included:

- Tufts Now, *Big Road Blues – Living near a highway can be bad for your health in a million small ways*, August 16, 2012.
- Particle Pollution, 2013.
- H.E. Volk, et al, *Traffic-related air pollution, particulate matter, and autism*, Abstract in JAMA Psychiatry, January 2013.
- Environmental Health Policy Institute, D.M. Brugge, PhD, MS and Wig Zamore, *Particulate Pollution: Regulated, but Still Killing*.
- Environmental Health Policy Institute, D. Brugge, J.L. Durant and C. Rioux, *Near-highway pollutants in motor vehicle exhaust: A review of epidemiologic evidence of cardiac and pulmonary health risks*, August, 9, 2007.
- Mike Kraft, PhD, *Health Risks of Close-Proximity Highways* presented at Needham Zoning Board, July 2013.
- Cathryn Smith, Power Point Presentation
- Cathryn Smith written testimony.
- Needham Board of Health, Residential Construction and Particulate Pollution, Presented at Needham Zoning Board of Appeals on October 17, 2013.
- U.S. EPA, Region IX, South Mountain Freeway Project, Maricopa County, Arizona [CEQ#20130104], July 23, 2013.

Summary

As discussed further below, this report reviews how (i) the science behind understanding UFP impacts is in its early stages, and EPA believes there is insufficient health and environmental evidence to support regulating UFPs; (ii) EPA mandated reductions to vehicle emissions have and will continue to improve air quality nationwide; (iii) the vegetative buffers along I-95 near the Project Site reduce UFP concentrations; and (iv) the prevailing westerly wind in the Project area also reduce UFP concentrations.

My main finding from reviewing these documents is that properly assessing the potential health and environmental impacts and accurately measuring UFP near major roadways is in its early stages. Recent field programs that have been performed to quantify UFP concentrations near highways are still a work in progress. Proper test protocols and sampling procedures have not been formally finalized to provide a method that consistently, accurately and meaningfully compares UFP measurements from different studies. EPA has also specifically noted that there is not sufficient evidence to support a separate regulatory standard for UFPs from fine and coarse particulate matter ($PM_{2.5}$ and PM_{10}).[1]

Over the past two decades, EPA has taken steps to reduce overall particulate matter (PM) emissions and has revised and lowered the ambient air quality standards based on EPA and independent health studies. These more stringent regulatory standards have led to significant reductions in particulate matter emissions in the past decade and will continue to do so in the future. As noted further below, this means that future emissions, when the Project is constructed, in any case, will be less than the emissions existing during the time of the studies presented to the ZBA.

Additional UFP sampling studies performed in the U.S. and the United Kingdom (UK) on the potential benefits of vegetative barriers reducing UFP concentrations are also encouraging. Given that there will be an existing mature tree line between the edge of I-95 and the Project Site both PM and UFP should be further reduced near the Project. More importantly, the Project will be located upwind from I-95. The predominant wind direction in the area is westerly; therefore, I-95 will be downwind (i.e., the predominant winds blow from the Project Site toward I-95), which will tend to keep UFP near background levels at the Project Site and will continue to reduce the UFP reaching the Project Site from I-95.

Presented below is a summary of my findings based on review of the recent EPA regulatory changes to improve vehicle emissions standards and PM ambient air quality standards; EPA's current position regarding UFP; a California air quality agency report noting a lack of consistent UFP measurement procedures; studies performed indicating the potential benefits of vegetative barriers on reducing UFP; an assessment of wind conditions demonstrating that the predominant wind direction in the area of the Project Site is westerly (i.e., winds blowing away from the Project Site), and review of the Needham Board of Health presentation and EPA Region IX Arizona freeway decision.

How Does UFP Form?

Ultrafine particles (UFP) are emitted from both natural and anthropogenic sources, although the majority comes from fuel combustion including diesel, gasoline and jet fuel as well as wood burning. UFP are defined as particles having an aerodynamic diameter of less than 0.1 microns (um), which form due to hot vapors in tailpipe emissions. These particles can grow in size by coagulation (i.e., aerosol particles collide due to their random motions and coalesce to form larger particles) and eventually can become larger particulate matter. Once released into the atmosphere, UFPs dilute and disperse in ambient air and are subject to chemical reactions and physical processes such as evaporation, condensation, and coagulation. Thus, particles measured away from roadways and other emission sources generally have

[1] EPA, Policy Assessment for the Review of the Particulate Matter National Ambient Air Quality Standards, EPA 452/R-11-003, April 2011, p.2-52.

different characteristics than those measured immediately after formation. Meteorological factors that affect UFP transport include wind speed and direction, precipitation, relative humidity and temperature.[2]

The major contributor to UFP is from diesel exhaust. Diesel exhaust is a complex mixture of hundreds of constituents in either a gas or particle form. Gaseous components of diesel exhaust include carbon dioxide, oxygen, nitrogen, water vapor, carbon monoxide, nitrogen compounds, sulfur compounds, and numerous low-molecular-weight hydrocarbons.

New Federal Emissions and Air Quality Standards

Over the last several years, EPA promulgated multiple new vehicle emissions standards. In 2000, EPA moved forward on schedule with its rule to make heavy-duty trucks and buses run cleaner, and the Highway Diesel Rule (the "2007 Highway Rule") was finalized in January 2001. As a result of the 2007 Highway Rule, beginning with the 2007 model year, the harmful pollution from heavy-duty highway vehicles, including UFPs, was anticipated to be reduced by more than 90 percent. [3]

Sulfur in diesel fuel is a major contributor to the formation of PM emissions from the vehicle tailpipe. Sulfur in diesel fuel must be lowered to enable modern pollution-control technology to be effective on these trucks and buses. As a result, EPA has also required a 97 percent reduction in the sulfur content of highway diesel fuel from 500 parts per million (ppm) (low sulfur diesel, or LSD) beginning in 2006 to 15 ppm (ultra-low sulfur diesel, or ULSD) in 2010. As of December 1, 2010, only ULSD has been available for highway use.[4] ULSD enables advanced pollution control technology for cars, trucks, and buses so that engine manufacturers can meet the 2007 Highway Rule.

For cars and light-duty trucks, EPA promulgated Tier 2 emissions standards in December 1999 that began phasing in with the 2004 model year. While cars and small pickup trucks reached full phase-in with the 2007 model year, heavy-duty pickup trucks and sport utility vehicles (SUVs) were phased into the more stringent standards by the 2008 model year, with 100 percent of heavy-duty pickup trucks and SUVs required to meet the Tier 2 standards beginning with the 2009 model year. These new standards required passenger vehicles to be 77 to 95 percent cleaner than those on the road and also reduced the sulfur content of gasoline by up to 90 percent.[5]

In March 2013, EPA proposed new Tier 3 tailpipe standards for the sum of non-methane organic gases (NMOG) and nitrogen oxides (NO_x), presented as NMOG+NO_x and for particular matter (PM) that would apply to all light-duty vehicles and some heavy-duty vehicles. Compared to current Tier 2 standards, the proposed Tier 3 emissions standards would represent another 70% reduction in per-vehicle PM standards. The proposed standard would also include more stringent gasoline sulfur standards and would also achieve significant immediate benefits by reducing emissions from existing

[2] South Coast Air Quality Management District, Final 2012 AQMP, Chapter 9 Near Roadway Exposure and Ultrafine Particles, 2012.
[3] http://www.epa.gov/oms/highway-diesel
[4] Clean Diesel Fuel Alliance, Information Center, www.clean-diesel.org.
[5] EPA, EPA's Program for Cleaner Vehicles and Cleaner Gasoline, December 1999.

vehicles. EPA is proposing that federal gasoline contain no more than 10 parts per million (ppm) of sulfur on an annual average basis by January 1, 2017.[6]

This means, that by the time any residents are living at the Project, emissions will be even further reduced from those existing today, and even more so when compared against some of the data analyzed in the studies presented by others to the ZBA, not only for the Project Site but all existing homes near I-95 and other highways.

The National Ambient Air Quality Standards (NAAQS) set by EPA are designed to protect public health and the environment. The standards are developed based on a variety of scientific studies, including the results of epidemiologic studies that evaluate how human health has been affected by pollutant concentrations in the past. These standards are periodically reviewed and updated based on recent scientific developments. On December 14, 2012, EPA revised the National Ambient Air Quality Standard (NAAQS) for $PM_{2.5}$ (fine particulate matter) and for the first time included near-roadway monitoring requirements for $PM_{2.5}$. The annual standard was reduced from 15.0 micrograms per cubic meter (ug/m^3) to 12.0 ug/m^3. EPA confirmed that most of the U.S. already meets the new standard, including all of Massachusetts.[7]

As described above, EPA has taken steps in reducing overall particulate matter emissions and increasing $PM_{2.5}$ ambient air quality standards. **These regulatory standards have significantly reduced PM emissions, including UFP, in the past decade and will continue to do so in the future for the Project Site and all existing homes near I-95 and other highways.**

<u>EPA's Position on UFPs</u>

In a recent study performed by EPA reviewing the PM National Ambient Air Quality Standards (NAAQS)[8], EPA concluded the following: "*…there is insufficient information at this time to consider supplementing the mass-based $PM_{2.5}$ indicator by considering a separate indicator for ultrafine particles or for a specific $PM_{2.5}$ component or group of components associated with any source categories of fine particles, or for eliminating any individual component or group of components from the mix of fine particles included in the $PM_{2.5}$ mass-based indicator.*"

EPA's conclusion was based on the following analysis:

New evidence, primarily from controlled human exposure and toxicological studies, expands our understanding of UFP-related cardiovascular and respiratory effects. However, this evidence is still very limited and largely focused on exposure to diesel exhaust (DE), for which the ISA[9] concludes it is unclear if the effects observed are due to UFPs, larger particles within the $PM_{2.5}$ mixture, or the gaseous components of DE. In addition, the ISA notes uncertainties associated with the controlled human exposure studies as CAP systems have been shown to modify the composition of UFPs. Relatively

[6] EPA, EPA Proposes Tier 3 Tailpipe and Evaporative Emission and Vehicle Fuel Standards, EPA-420-F-13-018a March 2013.
[7] EPA, http://www.epa.gov/airquality/particlepollution/2012/20092011map.pdf
[8] EPA, April 2011, p. 2-52.
[9] ISA is the Integrated Science Assessment.

few epidemiological studies have examined potential cardiovascular and respiratory effects associated with short-term exposures to UFPs. These studies have reported inconsistent and mixed results.

In considering both the currently available health effects evidence and the air quality data for UFPs, we conclude that this information is still too limited to provide support for consideration of a distinct PM standard for UFPs.

As indicated above, EPA believes there is insufficient health and environmental evidence to support regulating UFPs.

SCAQMD UFP Measurements Concerns

The South Coast Air Quality Management District (SCAQMD) of California has always been on the cutting edge when it comes to developing new air quality and emissions standards. In Chapter 9 of the Final 2012 Air Quality Management Plan (AQMP), Near Roadway Exposure and Ultrafine Particles, SCAQMD raised similar concerns regarding measurement procedures that EPA raised in their 2011 report. SCAQMD presented the following findings:

Currently, there is no standard method for conducting size-classified or particle number measurements. The terms UFP and NP[10] are not clearly defined and often used improperly. In addition, the UFP characteristics measured in ambient and emission testing studies (e.g. volatile vs. solid components; mass vs. number concentration) are highly dependent on the measurement instrument/protocol used and its setting.

Again, another leading air quality agency raises concerns with the approaches and methodologies for properly quantifying UFP.

Needham Board of Health Presentation

EPA has acknowledged there are health risks associated with fine and coarse PM emissions and, as stated above, the Agency has promulgated more stringent vehicle emissions standards and ambient air quality standards to further reduce the potential health risks. EPA is also proposing more stringent vehicle emissions and fuel sulfur content standards starting in 2017. However, the Agency also recognizes that there is insufficient health and environmental evidence to support regulating UFPs.

The Board of Health presentation referenced the Massachusetts Department of Public Health (DPH) study regarding the relationship of asthma from particulate matter emissions from motor vehicle traffic. Although the study was released in 2008, it was based on coarse particulate matter (PM_{10}) data from the late 1990s and early 2000s. Since that time, PM_{10} and $PM_{2.5}$ emissions have been decreasing due to improvements in vehicle emissions standards and lower sulfur contents in gasoline and diesel fuel. The Massachusetts Department of Environmental Protection (MassDEP) air monitoring data network shows that a significant improvement in PM_{10} and $PM_{2.5}$ ambient air concentrations over the past decade.[11]

[10] NP = nanoparticles.
[11] MassDEP, http://www.mass.gov/eea/docs/dep/air/priorities/12aqrpt.pdf, July 2013.

Therefore, the data analyzed in the DPH study is already outdated – cars and trucks are cleaner running and burn cleaner fuel. As such, the current ambient particulate matter is lower than that study reviewed.

The recommendations in the Board of Health presentation to limit new construction to greater than 100 meters (328 feet) from major highways and ideally 150 meters (500 feet) does not take into account (i) improved ambient air concentrations due to improved emissions and fuel standards; (ii) the potential benefits of natural tree barrier between I-95 and the Project Site; nor (iii) that the prevailing westerly winds at the Project Site will keep I-95 downwind the majority of the time, which will tend to keep UFP near background levels at the Project Site.

We think the Board of Health's statement that there may be liability risks associated with living in proximity to a highway are unfounded because (i) the science concerning the potential health and environmental impacts of UFP and their dispersal near major roadways is still in its early stages; (ii) emission and fuel standards have been strengthened, thereby reducing UFPs; (iii) EPA believes there is insufficient health and environmental evidence to support regulating UFPs; and (iv) the Project Site is located upwind from and separated by a vegetated buffer from I-95. Therefore, we do not think that a written disclosure to future residents, as proposed by the Board of Health is warranted. We note that we are aware of no other project in Massachusetts, including those located adjacent to or near a major highway, that is subject to a disclosure related to UFP, so any disclosure would be an "outlier" in the multi-family apartment market.

Arizona Freeway Project

The EPA Region IX ruling on the South Mountain Freeway Project in Maricopa County Arizona is for a new 24 mile long, 8-lane freeway that may displace 845 existing residential units within the project area. The EPA ruling points out that State did not complete several air quality and health risk studies that are typically needed to be completed for a large and complex transportation project, such as a new freeway. This ruling has no bearing on the Project, since comparing the potential air quality impacts from I-95 to the Project to a new freeway project in Arizona is not a true "apples to apples" comparison. First, Maricopa County and the Phoenix area are located in a desert valley surrounded by mountains that trap pollutants due to an atmospheric inversion that forms during the early morning hours causing a brown haze to form from burning of fossil fuels. Needham is not located in such a valley area and the prevailing westerly winds in Massachusetts disperse and dilute pollutant concentrations such as PM emissions from fossil fuel burning. Second, Maricopa County does meet 24-hour and annual $PM_{2.5}$ NAAQS, but does not the meet 24-hour PM_{10} NAAQS. In Massachusetts, we meet both the $PM_{2.5}$ and PM_{10} NAAQS and we continue to see improvements in both standards based on air quality monitoring data from MassDEP.[12] Finally, the rapid population growth in the Phoenix metropolitan area continues to increase vehicle traffic volumes and housing construction that surpasses the growth in the Boston metropolitan area.[13] Therefore, the Arizona Freeway Project does not provide any relevant information to compare against the Project.

[12] MassDEP, Ibid, July 2013.
[13] Forbes, America's Fastest- And Slowest-Growing Cities, March 18, 2013.

Vegetative Barriers and Wind Direction

Recently, EPA has initiated research to examine the role roadside vegetation may play in reducing near-road air pollution[14]. These included field studies, wind tunnel assessments and computation fluid dynamics (CFD) modeling. Two sampling studies were performed in Chapel Hill and Mebane, North Carolina to assess the effects of vegetation on UFP concentrations. The site in Chapel Hill had primarily pine trees and the Mebane site had hardwood trees. UFP concentrations were generally reduced downwind of a vegetation stand and the most reduction in UFP occurred closer to ground level. The studies did find that for thin tree stands, variable results were seen under changing wind conditions.

A similar study was performed in the United Kingdom. The main purpose of the study was to investigate the influence of near road vegetative barriers on UFPs in the range of 5-560 nanometers (nm). The field monitoring program was conducted on a small section of the A3 highway connecting Guilford town to London and Portsmouth, UK. The highway consists of six traffic lanes, with 3 lanes carrying the traffic in each direction. Measurements were taken at four different locations at the same vertical height. Two of these locations were at either side of the vegetation barrier, the third one was in the middle of the barrier and the fourth one was at a place without any vegetation. This was to develop an understanding about the effect of wind direction on the efficiency of the vegetation barrier and to see the dispersion of particles as they move away from source (vehicle tailpipe) through the vegetation barriers. Preliminary results from the study showed that UFP gradually decrease with increasing distance while passing through the vegetation barrier, especially when the wind was blowing perpendicular to the road.[15]

The Project will have an approximately 60- to 75-foot vegetative barrier between its edge and I-95, consisting of deciduous and evergreen trees. Although the science is still inconclusive on how to calculate with specificity the full benefits of vegetative barriers, the Project Site will almost definitely have reduced potential UFPs because of the vegetative buffer.

More importantly, the Project is located upwind from I-95. The primary wind direction is from a westerly direction throughout the year. Figure 1 shows a windrose based on five years of historic wind data from Hanscom Airport, Bedford MA, which is approximately 13 miles away from the Project. This meteorological station was selected because it represents the nearest National Weather Service station that will have similar weather conditions as the Project Site. The figure indicates that wind direction is westerly approximately 62% of the time, winds are calm approximately 20 percent, and the wind direction is easterly approximately 18 percent of the time. Therefore, the winds blowing from I-95 toward the Project will only occur approximately 18 percent of the time. The remaining 82 percent of the winds will either be calm or only blowing away from the Project Site and towards the highway. Although these actual percentages can change slightly year to year, the key is that the predominant wind direction is westerly; therefore, I-95 will be downwind, which will tend to keep UFP near background levels and with a reduced potential of UFP reaching the Project from I-95.

[14] Balaulf, R., EPA Presentation, Examining the Role of Vegetation in Mitigating Near-Road Air Pollution, June 5, 2012.
[15] Abdullah N., et al, Influence of Roadside Vegetation Barriers on Concentrations of Traffic-Spewed Ultrafine Particles, 15th conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, May 6-9, 2013.

Infiltration Systems

According to AirFilters.com, a manufacturer of air filters, MERV is the Minimum Efficiency Reporting Value, which is the scale designed by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) to rate the effectiveness of air filters. MERV 13-16 filters are suggested for uses like hospital inpatient care general surgery, not for residential uses. We understand the Project anticipates utilizing MERV 4 filters, which is a type of filter commonly used in multi-family residential construction.

Conclusions

Properly measuring and assessing the potential health and environmental impacts and the dispersal of UFP near major roadways is still in its early stages and EPA believes there is insufficient health and environmental evidence to support regulating UFPs. In the past decade, EPA has strengthened both federal emissions standards and ambient air quality standards to reduce PM emissions by 90 percent and emissions will continue to be reduced in the future for the Project Site and existing homes along I-95 and other highways as a result of EPA rules and regulations already in place or proposed.

The Project is located upwind from I-95 the majority of the time and, with a mature vegetative barrier between the Project Site and the edge of I-95, it is anticipated that UFP will tend to be near background levels and with a reduced potential of UFP reaching the Project Site from I-95. The Project will include the type of air filters commonly used in multi-family residential projects. Finally, any disclosure related to UFP would be unusual and is not warranted for the reasons summarized above.

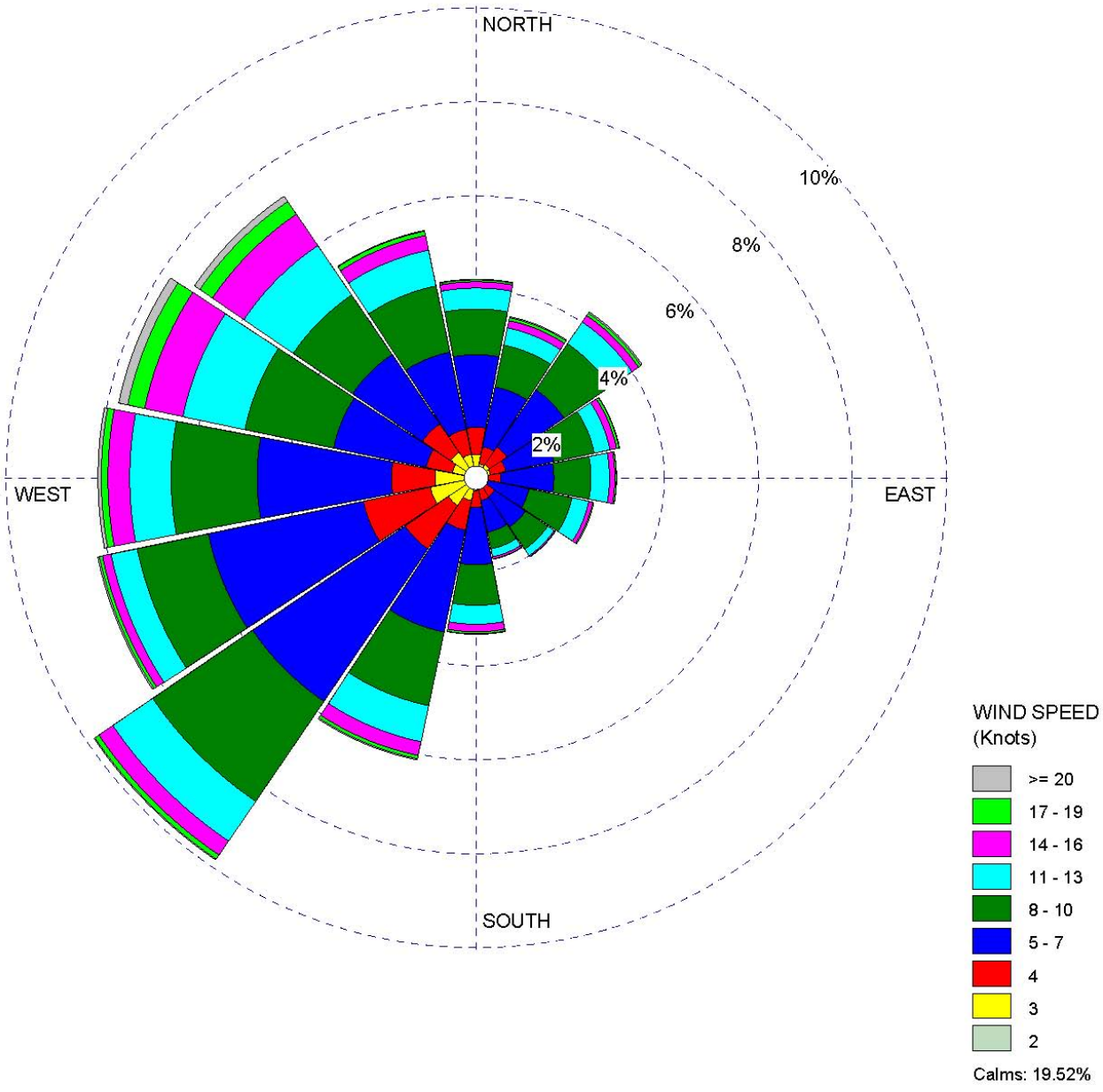

Figure 1.
Five-Year Windrose
Hanscom Airport, Bedford, MA