Public Health Assessment for

AMBIENT AIR QUALITY IN SUNCOOK VILLAGE,
MERRIMACK COUNTY, NEW HAMPSHIRE
EPA FACILITY ID: NHD000791509

SEPTEMBER 7, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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PUBLIC HEALTH ASSESSMENT

AMBIENT AIR QUALITY IN SUNCOOK VILLAGE, MERRIMACK COUNTY, NEW HAMPSHIRE
EPA FACILITY ID: NHD000791509

Prepared by:

New Hampshire Department of Environmental Services
Environmental Health Program
Under a Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AQAD	Air Quality Action Day
AQI	Air Quality Index
ARD	NH Department of Environmental Services, Air Resources Division
As_2O_3	Arsenic trioxide
ATSDR	US Agency for Toxic Substances and Disease Registry
CDC	US Centers for Disease Control and Prevention
CEMS	Continuous emission monitoring system
CI	Confidence interval
CO	Carbon monoxide
CREG	Cancer Risk Evaluation Guide
CSF	Cancer Slope Factor
CV	Comparison Value
DES	NH Department of Environmental Services
NHDHHS	New Hampshire Department of Health and Human Services
ED	Emergency department
EHP	NH Department of Environmental Services, Environmental Health Program
EPA	US Environmental Protection Agency
ESP	Electrostatic Precipitator
HAP	Hazardous Air Pollutant
Hg	Mercury
HSDM	Health Statistics and Data Management
LOAEL	Lowest Observable Adverse Effect Level
MRL	Minimum Risk Level
MW	Megawatts
NAAQS	National Ambient Air Quality Standards
NESCAUM	Northeast States for Coordinated Air Use Management
NHSCR	New Hampshire State Cancer Registry
NO_2	Nitrogen dioxide
NOAEL	No Observable Adverse Effect Level
NWS	National Weather Service
O_3	Ozone
PHA	Public Health Assessment
$PM_{2.5}$	Particulate matter 2.5 microns in diameter or smaller
PM_{10}	Particulate matter between 2.5 and 10 microns in diameter
ppb	Parts per billion
ppm	Parts per million
PSNH	Public Service of New Hampshire
RADS	Reactive airway dysfunction syndrome
RfC	Reference Concentration
RfD	Reference Dose
SCR	Selective Catalytic Reduction
SIR	Standardized Incidence Ratio
SO_2	Sulfur dioxide
TSP	Total suspended particulate matter
USDHHS	US Department of Health and Human Services
VOC	Volatile Organic Compounds

PUBLIC HEALTH ASSESSMENT
AMBIENT AIR QUALITY IN SUNCOOK VILLAGE, MERRIMACK COUNTY, NEW HAMPSHIRE

1.0 SUMMARY

The US Agency for Toxic Substances and Disease Registry (ATSDR) is a non-regulatory federal agency mandated by Congress to assess human health effects from exposure to hazardous substances at Superfund and other sites. To fulfill its mandate, ATSDR enters formal partnerships with state agencies throughout the nation to carry out site-related research on environmental exposures and public health. For 17 years, ATSDR and New Hampshire's Environmental Health Program (EHP) have maintained a cooperative agreement to conduct this research in the state. EHP is a non-regulatory program within the New Hampshire Department of Environmental Services (DES). (EHP transferred from the New Hampshire Department of Health and Human Services to DES in 2004.) It functions independently of regulatory programs within DES to assess the human health implications of hazardous chemical releases, and to make recommendations to protect the public health.

In 2001, ATSDR was petitioned by a resident of Suncook Village to examine air quality and certain health effects that might be associated with air emissions from the Merrimack Station Power Plant. In response, EHP prepared a health consultation for ATSDR that evaluated 2002-2003 air quality data and documented community health concerns for the Suncook area. To update and expand the original health consultation, EHP has prepared the current public health assessment. This update includes an evaluation of recent data on Suncook area air quality (2004-2006), cancer incidence and Emergency Department visits for respiratory-related diagnoses. Air quality and meteorological data used in this assessment are primarily from the Exchange Street air monitoring station located in Suncook Village.

Merrimack Station is a coal-fired power plant located along the western bank of the Merrimack River in Bow, New Hampshire (NH). It is owned and operated by Public Service of New Hampshire, the state's largest utility. The plant is located less than 1 mile across the Merrimack River to the northwest of Suncook Village, a residential area that is the population center of the towns of Pembroke and Allenstown, NH. The plant began commercial operation in 1968. DES is the regulatory authority responsible for issuing Merrimack Station's air quality operating permits, monitoring its compliance status, and conducting regular inspections of the facility.

In late 2003, EHP prepared a health consultation for ATSDR on ambient air quality in the Suncook area. That document presented an evaluation of air monitoring data collected during 2002-2003 for sulfur dioxide (SO_2) and coarse particulate matter (PM_{10}). It concluded that, although these pollutants were sometimes present, their levels were unlikely to result in significant adverse health effects. The current document updates and expands these findings.

The overall conclusion of the current report is that ambient air in Suncook Village does not present a health hazard to the general population. During the two-year study period, the Suncook area was in compliance with all National Ambient Air Quality Standards, including those for the three criteria pollutants examined in this report: sulfur dioxide, ozone, and $PM_{2.5}$. There are infrequent days (or hours) when air pollution levels in the Suncook area may result in adverse

health effects among asthmatics during outdoor exertion. These air pollution events fall into two distinct categories based on the pollutants involved, the proximity of their source, and the meteorological conditions associated with them. Sulfur dioxide events in Suncook Village are associated with local emissions that are transported a short distance by strong northwest winds primarily in winter months. Ozone events originate from regional and distant sources and are transported long distances primarily by southerly winds in summer months. $PM_{2.5}$ events usually share the same origin and transport characteristics as ozone events.

Sulfur dioxide levels in the Suncook area are not expected to pose a public health hazard. There are rare occasions, however, (less than 1% of the time) when SO_2 reaches levels at which unusually sensitive asthmatics should consider reducing prolonged or heavy exertion outdoors in order to avoid possible respiratory effects. These SO_2 events occur primarily when the wind is out of the northwest, the direction of Merrimack Station. They are also usually associated with cold, windy weather conditions, which are not conducive to outdoor activities for most people. This further reduces the probability of exposure. The few SO_2 events that take place during peak outdoor activity hours (e.g., summer mornings) are the most difficult to identify and predict. Fortunately, these incidents are rare and of short duration. Suncook's SO_2 events are local, not regional in origin.

Ozone and fine particulate matter ($PM_{2.5}$) are not expected to pose a health hazard to residents of the Suncook area. According to EPA Air Quality Index (AQI) categories, ozone levels in the Suncook area during the study period were "good" more than 92% of the time, "moderate" about 7% of the time, and "unhealthy for sensitive groups" in one instance. EPA's cautionary statement for "moderate" ozone days is: "*Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors*." During events categorized as "unhealthy for sensitive groups", the cautionary statement is, "*Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors*." Elevated ozone events occur primarily when the wind is out of the south, southeast, or southwest - prevailing wind directions in summer. During southerly winds, emissions from Merrimack Station do not contribute to air pollution levels in Suncook Village. Ozone events are regional, as confirmed by the high correlation in their day-to-day levels across the state, and often across the New England Region.

For $PM_{2.5}$ in the Suncook area, AQI levels were "good" about 82% of monitored days, "moderate" 17%, and "unhealthy for sensitive groups" in one instance. EPA's cautionary statement for "moderate" $PM_{2.5}$ days is, "*Unusually sensitive people should consider reducing prolonged or heavy exertion.*" For days categorized as "unhealthy for sensitive groups", EPA advises: "*People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.*" The only $PM_{2.5}$ reading to reach this level occurred during the same "air pollution event" as the highest ozone reading of the study period. Moderate $PM_{2.5}$ readings occurred with equal frequency in summer and winter. Two-thirds of summer events were associated with southerly winds (South, SE, SW), while two-thirds of winter events were associated with northerly winds (North, NE, NW). $PM_{2.5}$ events are primarily regional, as indicated by the high correlation of levels at Exchange Street with those at Manchester, Portsmouth, and other air monitoring stations.

Suncook Village air monitoring data for 15 additional air toxics indicate that they do not pose a health hazard to any groups. Air toxics levels at Exchange Street were consistent with those from other air monitors across the state regardless of season, wind direction, and other factors.

Levels of mercury in ambient air are difficult to monitor. DES modeling of mercury concentrations concludes that they pose no human health hazard through inhalation. Mercury can, however, be a human health hazard through consumption of certain species of fish. Mercury from local, regional, and distant industrial sources is deposited in water bodies, converted to methyl mercury through natural processes, and ingested by fish where the concentration increases. Consumption of these fish species in large quantities may pose a health hazard, especially to children and pregnant women.

In March 2006, the NH Legislature passed a bill that was signed into law requiring a major reduction in mercury emissions from power plants by 2013. Public Service of New Hampshire will achieve this reduction at Merrimack Station by installing new pollution control equipment. This equipment will not only reduce mercury emissions by at least 80%, but will also reduce emissions of SO_2 and particulate matter by similar amounts over the next five to seven years.

Finally, a review of health outcome data for the Suncook area (the towns of Pembroke and Allenstown) revealed no significant elevation in any type of cancer. Rates of asthma-related emergency department (ED) visits for children and the elderly were generally lower than expected. Asthma visit rates for 20-44 year-olds were somewhat higher than statewide rates. There is some evidence that physician diagnostic practices and higher overall emergency department utilization of these groups may contribute to some of the elevation. These and other factors will be explored in more detail in a future health consultation based on the ED hospitalization data set.

Based on the conclusions of this report, EHP has developed the following recommendations that will be implemented by DES:

- Continue to process SO_2 data from the Exchange Street air monitoring station.

- Continue routine inspections and monitoring of the Merrimack Station Power Plant to assess compliance with air quality regulatory requirements.

- Continue issuing Air Quality Action Days (AQAD) encouraging residents, especially children, the elderly, and those with asthma or other respiratory conditions to avoid prolonged outdoor activity and take precautions to protect their health during these days. Residents are also encouraged to conserve energy and electricity, and to minimize driving during these air quality events.

- Offer education (through EHP) to Suncook area school administrators, day care providers and others regarding the findings of this evaluation, particularly in relation to local ambient air quality.

- Continue efforts to encourage residents with respiratory conditions to pay attention to local wind direction and wind speed forecasts for the greater Concord area (including Suncook Village) at media outlets such as the National Weather Service web site: http://www.erh.noaa.gov/gyx/digital/NH08afm.htm

- Continue efforts to encourage residents interested in obtaining daily regional air quality information to register for EPA's AIR NOW website: http://airnow.gov/

- Continue to advise residents to limit their exposure to environmental mercury by following the recommendations of the NH Statewide Fish Consumption Advisory. The Advisory recommendations are included in the brochure "Is it safe to eat the fish we catch?" on the Department of Environmental Services website: http://www.des.state.nh.us/pdf/Mercury_Fish.pdf

2.0 PURPOSE AND HEALTH ISSUES

The US Agency for Toxic Substances and Disease Registry (ATSDR) is a non-regulatory federal agency mandated by Congress to assess human health effects from exposure to hazardous substances at Superfund and other sites. To fulfill its mandate, ATSDR enters formal partnerships with state agencies throughout the nation to carry out site-related research on environmental exposures and public health. For 17 years, ATSDR and New Hampshire's Environmental Health Program (EHP) have maintained a cooperative agreement to conduct this research in the state. EHP is a non-regulatory program within the New Hampshire Department of Environmental Services (DES). ATSDR functions independently of the US Environmental Protection Agency and regulatory programs within DES to assess the human health implications of hazardous chemical releases, and to make recommendations to protect the public health.

In 2001, ATSDR was petitioned by a resident of Suncook Village to examine air quality and certain health effects that might be associated with air emissions from the Merrimack Station Power Plant located in Bow, New Hampshire. In response, EHP prepared a health consultation for ATSDR that evaluated 2002-2003 air quality data and documented community health concerns for the Suncook area (1). To update and expand the original health consultation, EHP has prepared the current public health assessment (PHA). The PHA presents an evaluation of recent data on Suncook area air quality (2004-2006), cancer incidence (1987-2001) and Emergency Department visits for respiratory-related diagnoses (2000-2004).

Merrimack Station is a focus of this PHA because it was specifically mentioned in the ATSDR petition. (Throughout this document, Merrimack Station is referred to as the "Site" of potential contamination.) For this reason, the PHA focuses primarily on pollutants that are both emitted from the site and measured by the DES air monitoring station on Exchange Street in Suncook Village: sulfur dioxide, fine particulate matter and several air toxics. The PHA also examines ozone, a pollutant that is primarily transported to NH from regional and distant sources, as well as mercury, which is emitted by Merrimack Station but not monitored by DES because of cost constraints.

This PHA presents an evaluation of current air quality conditions and their potential public health implications in the Suncook area. It employs health-based benchmarks as well as regulatory air quality standards such as the US Environmental Protection Agency's (EPA) National Ambient Air Quality Standards (NAAQS). The use of regulatory standards in this document is for health-related comparative purposes only.

3.0 BACKGROUND

3.1 Site Description

Merrimack Station is owned by Public Service of New Hampshire (PSNH) and is the largest coal-fired electricity-generating station in New Hampshire. The facility's physical address is 97 River Road, which is on the west bank of the Merrimack River along the eastern edge of Bow, New Hampshire. The site is surrounded by a fence that has guarded gates to restrict public access to the plant and its surrounding area. The site is approximately 0.8 miles across the river to the northwest of Suncook Village; a residential area that is the population center of the towns of Pembroke and Allenstown (Figure 3-1) (1).

Merrimack Station generates 478 megawatts of electrical output, supplying power to 189,000 residential, commercial and industrial customers. Electrical power is generated using two coal-fired, steam-generating boilers, which operate independently. The two boiler stacks are 225 and 317 feet high, respectively. Each unit burns ground coal in a cyclone boiler that heats water to generate steam. The resultant steam is used to power a turbine, creating electricity. Merrimack Station operates the two boilers near full-capacity on a continual basis (base-loaded) and supplements output using two jet-fuel combustion turbines during periods of extreme electrical demand on the New England power grid (swing-loaded). Stack output is monitored by devices that measure emissions of criteria air pollutants and opacity in real time (1, 2). Coal used in the boilers is unloaded from railcars and trucks inside a large enclosure. During this process, the coal is sprayed with water to prevent fugitive dust releases. The coal is then loaded on to hoppers, in which it is transported inside to the facility's boilers. On average, there is enough coal on site to operate the plant for 1-2 days (1).

3.2 Site History

PSNH has two separate DES "Temporary Permits" to operate Merrimack Station's main steam-generating boilers. Additional permits have been issued for the plant's two jet-fuel combustion turbines and for a supplemental boiler utilized during operational maintenance. All permit requirements and stipulations remain in effect pending approval of Merrimack Station's EPA Title V Air Emissions Permit application. Upon completion of the Title V Permit, the facility's individual permits will be consolidated into one (3).

Merrimack Station utilizes two principal technologies to control facility emissions: 1) four Electrostatic Precipitators to control particulate matter (PM); and 2) two Selective Catalytic Reduction (SCR) systems to control oxides of nitrogen (NO_X). Sulfur dioxide (SO_2) emissions are managed by blending low-sulfur coal fuel with conventional coal prior to burning. As required by existing DES permits, Merrimack Station continuously monitors criteria air pollutants (at the boiler stacks) including SO_2, nitrogen oxides, carbon monoxide, and particulate matter (by measuring opacity). All monitoring information, fuel consumption data, and other operational data are maintained in facility records in accordance with State and Federal requirements. In the event that on-site monitoring emissions exceed permitted thresholds, Merrimack Station must submit a permit deviation notification within 24 hours of occurrence. Follow-up reports must be submitted to DES within 15 days of the event. The notification and reports are reviewed and logged into a database that DES maintains for permitted sources of air pollution in New Hampshire (3).

DES oversees and witnesses the performance of annual "relative accuracy test audits" and participates in "oversight visits" in order to ensure the accuracy of Merrimack Station's continuous monitoring program. DES also conducts full "Compliance Evaluations" at least every two years. In addition to maintaining compliance with various State and Federal air quality regulations and permits, Merrimack Station is required to comply with air quality initiatives including the Ozone Transport Commission and the Federal Acid Rain Program (3).

In the early 1980s, DES began monitoring SO_2 in the ambient air surrounding the site to ensure compliance with NAAQS. Ambient air monitoring is also used to assess potential impacts to human health and environmental quality in surrounding areas. Over the years, DES has had air monitoring stations at various locations within the Town of Pembroke. The location of air monitoring stations is determined by a number of factors including DES air modeling, logistics of access, security, and accessibility to electrical power. These monitoring data reflect emissions transported from Merrimack Station and a variety of other local and distant sources (e.g., cars, businesses, home heating) in the area (1, 3). The current evaluation is based on data from the Exchange Street air monitoring station located in the Suncook Village section of Pembroke. Exchange Street is the only air monitoring station currently in operation within five miles of Merrimack Station.

3.3 Demographics

Suncook Village is a Census Defined Place (CDP) that lies within the towns of Pembroke and Allenstown. It is the population center of the two towns, containing approximately half of Pembroke's and one-quarter of Allenstown's residents. The center of Suncook Village is approximately 1 mile from Merrimack Station. According to the 2000 US Census (Table 3-1), the population of the Suncook CDP is 5,362 (4). There are approximately 2,131 people living within a 1-mile radius of Merrimack Station and 25,801 living within a 5-mile radius (5). This includes residents of Suncook Village, Bow, Hooksett, and the non-Suncook areas of Pembroke and Allenstown. The majority of the population within the 1-mile radius of the site lives in Suncook Village (4). The Suncook Village population distribution is listed in Table 3-1.

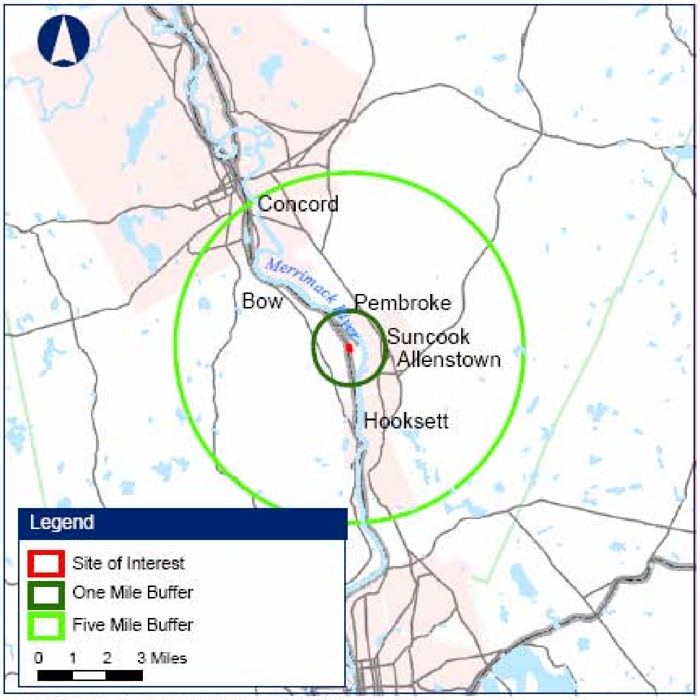
Table 3-1. Suncook Village population by age and sex (4).

Age	Both Sexes		Sex	
	Number	Percentage	Male	Female
< 5	351	6.5%	191	160
5-14	723	13.5%	364	359
15-44	2373	44.3%	1194	1179
45-64	1163	21.7%	552	611
65+	752	14.0%	277	475
Total	5362	100%	2578	2784

Source: 2000 US Census of the Population

Figure 3-1. Demographics of area surrounding Merrimack Station (5)

Merrimack Station Power Plant
Bow, NH
EPA Facility ID: NHD000791509



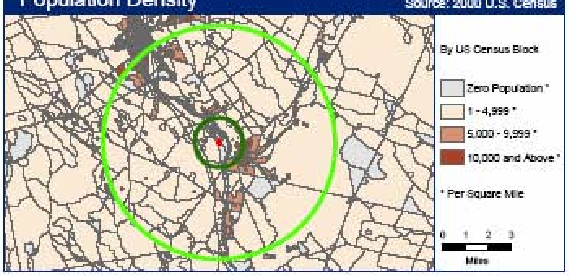
Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Public Health GIS Program, May 2005.
Coordinate System (All Panels): NAD 1983 StatePlane New Hampshire FIPS 2800 Feet

Site Location: Merrimack County, NH

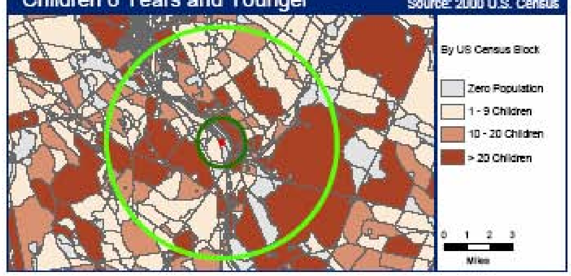
Demographic Statistics Within Specified Distance of Site*	1mi	5mi
Total Population	2,131	25,801
White Alone	2,082	25,165
Black Alone	11	103
Am. Indian & AK Native Alone	8	51
Asian Alone	8	205
Native Hawaiian & Other Pacific Islander Alone	0	2
Some Other Race Alone	1	59
Two or More Races	21	217
Hispanic or Latino**	16	201
Children Aged 6 and Younger	218	2,301
Adults Aged 65 and Older	250	2,918
Females Aged 15 to 44	470	5,535
Total Housing Units	948	10,261

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.

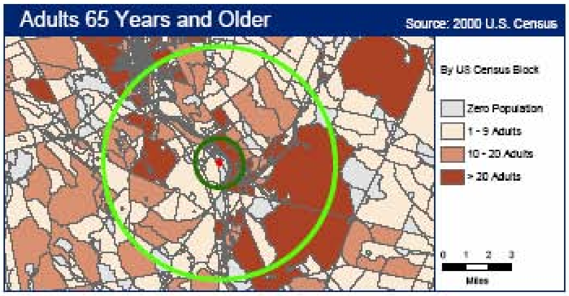
Population Density Source: 2000 U.S. Census



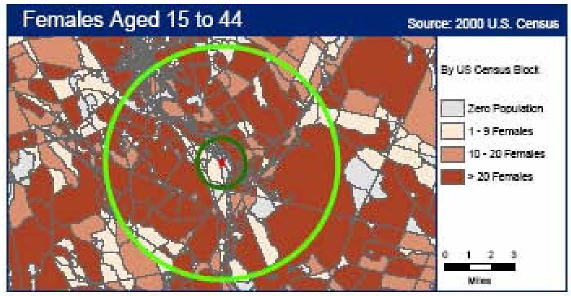
Children 6 Years and Younger Source: 2000 U.S. Census



Adults 65 Years and Older Source: 2000 U.S. Census



Females Aged 15 to 44 Source: 2000 U.S. Census



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Children and senior citizens residing near the site are of special interest since they are considered "sensitive" to air pollution. That is, they may be affected by lower levels of pollution or they may have more serious reactions to pollutants. According to the 2000 US Census, 6.5% of the Suncook Village population is less than 5 years of age, while 14.1% is 65 years and older. In comparison, the statewide percentage of children less than 5 years of age is 6.1% and the percentage of adults 65 years and older is 12.0% (4).

Schools and day care centers located near the site are listed in Table 3-2. Their geographic locations are plotted in Figure 3-2 along with modeled SO_2 concentration contours. Several parks and churches are also located in Suncook Village and surrounding towns. In addition, three senior housing complexes were identified within a 5-mile radius of the site: 1) White Rock Senior Living Community in Bow; 2) Taylor Homes in Pembroke; and 3) Suncook Pond in Allenstown.

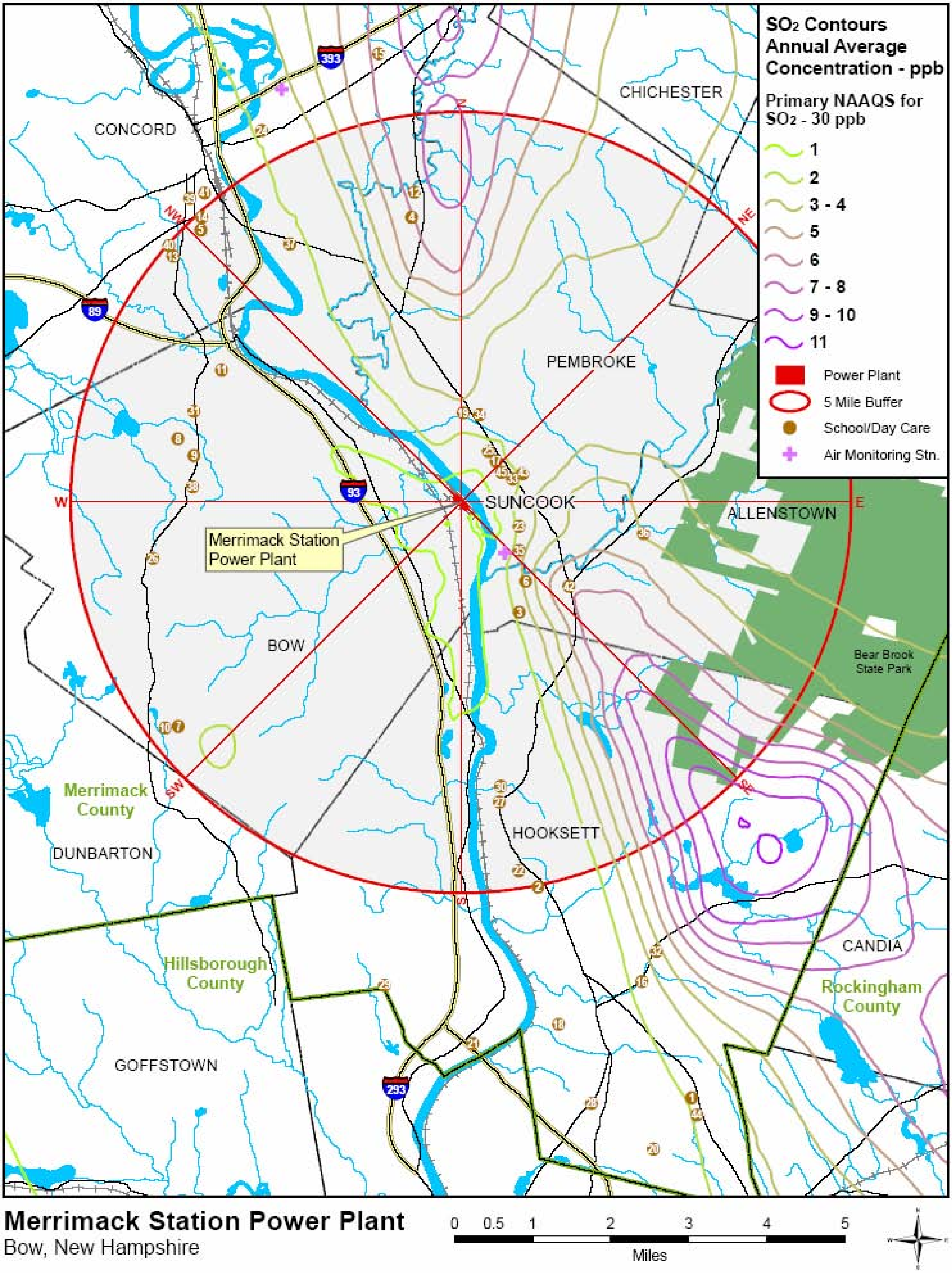
Table 3-2. Schools and day care facilities near Merrimack Station Power Plant: 2006 (7).

Map ID #	Facility Name	Map ID #	Facility Name
1	A Brighter Future Child Care Center	24	IHMNH: Little Hearts Preschool
2	Above and Beyond Childcare	25	Institute for Learning
3	Allenstown Elementary School	26	Joyful Noise Learning Center
4	Animation Station	27	Little Angels Learning Centre
5	Ann Mawees Kinder Kare	28	Little Apples Day Care Learning Ctr
6	Armand Dupont School	29	Lots of Love Family Childcare
7	Bow Elementary School	30	Mary-Go-Round Child Care Center
8	Bow High School	31	Meeting House Montessori School
9	Bow Kids (BES)	32	Miss Stephanie's Family Child Care
10	Bow Memorial School	33	Pembroke Academy
11	Celebrating Children	34	Pembroke Hill School
12	Center of Attention Day Care	35	Pembroke Village School
13	Conant School	36	Pine Haven Boys Center
14	Concord Cooperative Playschool	37	RCC After School Enrichment
15	Concord Head Start	38	Rockwood Acres Family Day Care
16	David R. Cawley Middle School	39	Rumford School
17	First Choice for Children	40	Rundlett Middle School
18	Fred C Underhill School	41	St. John Regional School
19	Green Valley School	42	Tender Years Childcare
20	Happy Bear Daycare Learning CT	43	Three Rivers School
21	HEAR In NH Pre-School	44	Tic-Tac-Tots Preschool
22	Hooksett Memorial School	45	Wonderland Preschool
23	Hurney's Nursery and Day Care		

3.4 Land Use

There are four main roads in or near Suncook Village. Route 3 is a major thoroughfare between Concord and Manchester that passes through Pembroke, Suncook Village, and Allenstown. Routes 3A and 28 are also nearby. Interstate 93, the main artery for traffic going from Boston to central and northern New Hampshire, is less than 2 miles from Suncook Village (1).

Figure 3.2. Location of Schools & Day Care Facilities near Merrimack Station (7)



4.0 METHODS

This section describes the methods and data employed in this public health assessment. It begins by delineating the standard methods employed in PHAs to assess whether or not a contaminant is a potential health threat. This includes discussion of “completed exposure pathways” and their exact definition in this study. This is followed by a discussion of meteorological and environmental data: their sources, quality, and limitations. Finally, “potential pollutants of interest” are discussed in the context of Merrimack Station emissions, DES-monitored pollutants, and emissions of other facilities in the Suncook area.

4.1 Health Risk Assessment Methods

EHP uses a conservative, protective approach to determine whether levels of air pollution constitute a potential health hazard. In general this involves a two-step methodology that is used to evaluate most of the potential pollutants identified in this PHA. First, air monitoring data are gathered and a comprehensive list of site-related pollutants is compiled. Second, health-based comparison values (CVs) are used to identify pollutants that do not have a realistic possibility of causing adverse health effects. These are eliminated from further analysis. The remaining contaminants are deemed “pollutants of interest” and subjected to thorough scientific literature reviews to determine whether or not their levels present a public health hazard (8).

The CVs used in this report represent concentrations of contaminants that current scientific literature suggests are "safe" or "harmless." CVs are conservative and protective of health, represent “worst-case” exposure assumptions, and include ample safety factors in consideration of sensitive populations such as children, the elderly, and those with chronic respiratory disease. Therefore, CVs are protective of public health in the vast majority of exposure situations. If a pollutant level does not exceed its CV, it is unlikely that harmful effects will result. If a pollutant exceeds its CV one or more times over the monitoring period, it is designated a “pollutant of interest” and is examined in greater detail. Because CVs are based on extremely conservative assumptions, the presence of concentrations greater than CV thresholds does not necessarily indicate that adverse health effects will occur among exposed populations (8).

Specific CVs used in this report include ATSDR Minimum Risk Levels (MRLs) for chronic inhalation, ATSDR Cancer Risk Evaluation Guides (CREGs), as well as EPA’s chemical-specific Reference Concentrations (RfCs), Reference Doses (RfDs), Lowest-Observed-Adverse-Effect Levels (LOAELs), and Cancer Slope Factors (CSFs). MRL is an ATSDR estimate of daily human exposure to a dose of a chemical that is likely to be without an appreciable risk of adverse noncancerous effects over a specified duration of exposure. CREGs are estimated contaminant concentrations in a specific medium (i.e., air) which are estimated to result in one excess cancer per one million persons exposed over a lifetime. RfDs and RfCs are analogous to ATSDR MRLs. They are estimates of daily human exposure to a contaminant that are unlikely to result in adverse non-cancer health effects over a lifetime. LOAELs are the lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in humans or animals. Lastly, CSFs aid in the determination of a theoretical estimate of lifetime cancer risk associated with exposure to a “known”, “probable”, or “possible” human carcinogen. When there is no established MRL, CREG, RfC, RfD or CSF, other sources for comparison can be used (e.g., regulatory values or reporting conventions such as the Air Quality Index) (8).

The CV comparison methodology is employed in this PHA for all potential pollutants. When a pollutant has no traditional CV (e.g., O_3 and $PM_{2.5}$), EPA's Primary National Ambient Air Quality Standards (NAAQS) and Air Quality Index (AQI) are employed for comparative purposes. Primary NAAQS set limits to protect public health, particularly sensitive groups such as children, the elderly, and those with asthma or other respiratory disease. The AQI is used for forecasting various levels of air quality. When ozone or $PM_{2.5}$ is predicted to reach a level that is "unhealthy for sensitive groups", DES declares an Air Quality Action Day to alert the public and encourage members of sensitive groups to take precautions to protect their health. The focus of these alerts is usually on regional events, not local pollution events.

4.2 Pathways of Exposure

Environmental contamination cannot affect a person's health unless there is a "completed exposure pathway." A completed exposure pathway exists when all of the following five elements are present: 1) a source of contamination; 2) transport through an environmental medium; 3) a point of exposure; 4) a route of human exposure; and 5) an exposed population. These five elements do not define exposure; rather they contribute to determining the probability of exposure (8).

The primary completed exposure pathway in this PHA is based on the following: 1) sources of contamination (all local and regional sources of air pollution, including Merrimack Station); 2) transport through an environmental medium (air); 3) a point of exposure (Suncook Village is the only point of exposure considered in this PHA); 4) a route of human exposure (respiration/breathing); and 5) a receptor population (residents of the Suncook area). For purposes of this PHA, the air monitoring station is assumed to be the surrogate for a human "receptor" that completes the exposure pathway.

An additional completed exposure pathway in this PHA is based on the ingestion of fish contaminated with mercury. All water bodies throughout the northeastern United States are subject to mercury pollution from local, regional, and distant industrial emissions. The mercury is ingested by fish which in turn are consumed by humans. This is the pathway by which mercury becomes a potential human health risk. It cannot be determined what amount of mercury contamination in area water bodies comes from any particular source, such as Merrimack Station, but DES modeling has predicted that there is some contribution. This is discussed in the Public Health Implications Section 6.1.4.8.

4.3 Data Sources, Quality, Limitations

This section describes the meteorological and environmental data employed in this PHA, including data sources, intervals of reporting, measurement specifications, and protocols employed to handle missing values.

4.3.1 <u>Meteorological Data</u>

Meteorological conditions are major determinants of variations in levels of air pollution. They can influence the distance contaminants are transported, their level of concentration, and their rates of mixing and dispersion. For example, wind speed can affect how far a contaminant plume travels, while wind stability ("Standard Deviation of Wind Direction") may influence the concentration of pollutants. Table 4-1 delineates conditions that influence industrial smokestack plumes and subsequent pollution levels. These factors may act independently, or in interaction with others in a complex manner (9).

Table 4-1. Meteorological conditions affecting dispersion of point source emissions (9).

Conditions Affecting the Contaminant Plume	Probable Outcome
Atmospheric Stability	Stagnant inversion conditions can cause pollutant buildup
Wind Speed	Light winds mean less dispersion, more concentrated plume
Wind	Direct wind flow causes higher downwind concentrations
Variability of Wind Direction	Consistency of wind direction causes less dispersion
Precipitation	Cleans/scavenges gases and particulates
Temperature	Affects height of plume and location of ground contact
Time of Day	Calm night time hours produce less mixing and dispersion
Stack Gas Parameters	Affect plume rise and dispersion of contaminants

This PHA employs meteorological (MET) data primarily from two sources: 1) DES Exchange Street Station in Suncook Village; and 2) the National Weather Service (NWS) Station at Concord Municipal Airport. MET data from Hazen Drive Station in Concord are used exclusively in the analysis of ozone, which is also monitored at Hazen Drive.

4.3.1.1 *Wind Direction*

"Wind direction" refers to the prevailing direction from which the wind originates (i.e., wind blowing from northwest to southeast is a northwest wind). Wind direction used in this report was recorded every 1 minute (Exchange Street) or every 2 minutes (NWS) and then averaged for a given hour. If the average wind speed in a given hour is 0 or 1 mph, wind direction is considered "Calm". This definition of calm is based on the specific calibration of DES wind speed monitors. Table 4-2 shows the eight cardinal wind directions employed in this study, along with the range of true north degrees associated with each.

Wind direction data employed in this study are primarily from Exchange Street. There are two reasons for using Exchange Street instead of NWS for this component of MET data. First, wind direction data at Exchange Street (and all DES MET stations) are reported with more specificity than are those by NWS. DES monitors record and report wind direction in single-digit "true north" degrees (0-359). NWS readings, on the other hand, are recorded in single-digit "magnetic north" degrees, adjusted to "true north" degrees, and rounded to the nearest ten degrees (0, 10, 20, etc.) for reporting. Rounding of NWS readings can result in a significant number of artifactual shifts in hourly wind direction measurements from one cardinal direction to another, whether 8 or 16 cardinal directions are employed (e.g., a "true" NNE wind may be reported as North due to rounding).

The second reason for employing Exchange Street over NWS wind direction data is Exchange Street's proximity to the site – less than one mile away. Concord Airport is more than 5 miles away. The use of Exchange Street data assures the most accurate depiction of wind direction in the Suncook Village section of the Merrimack River Valley.

Table 4-2. Cardinal wind directions and degree ranges.

Direction	Cardinal Format	Degree Range
North	N	338-22
Northeast	NE	23-68
East	E	69-112
Southeast	SE	113-158
South	SE	159-202
Southwest	SW	203-248
West	W	249-292
Northwest	NW	293-337

4.3.1.2 *Wind Speed*

Wind speed is defined as the rate at which air is moving horizontally past a given point. It is recorded in miles per hour or knots. Wind speeds used in this report were recorded every 1 minute (Exchange Street) or every 2 minutes (NWS) and then averaged for a given hour.

Wind speed data employed in this study are primarily from NWS at Concord Municipal Airport. There are two main reasons for choosing Concord Airport over Exchange Street for wind speed data. First, the Exchange Street monitor is located in a river valley and is surrounded by trees and other obstructions. Its wind-speed range for the two-year study period was 0-11 mph. This provides a realistic scenario for human exposure potential in that part of Suncook Village, but is not an accurate depiction of wind speeds associated with transporting plumes from Merrimack Station smoke stacks to the Suncook area. The wind-speed range for NWS at Concord airport for the study period was 0-31 mph.

The second reason for employing NWS over Exchange Street wind-speed data is a practical one. For Suncook residents wanting to forecast wind direction and speed, the best source of readily accessible data is NWS. This Concord-specific information is available online at the NWS website (http://www.erh.noaa.gov/gyx/digital/NH08afm.htm) and at many other public and private websites and media outlets.

4.3.2 <u>Environmental Data</u>

Environmental data are primarily from the DES air monitoring station at Exchange Street in Suncook Village, less than one mile southeast of Merrimack Station. Ozone data (not recorded at Exchange Street) were obtained from Hazen Drive Station in Concord and Pearl Street Station in Manchester. Air toxics data from four additional sites around the state (Manchester, Claremont, Portsmouth, and Brickett Hill in Pembroke) were used for comparison purposes.

SO_2 levels at Exchange Street Station are recorded continuously on a year-round basis and are reported as hourly averages. Ozone is collected during “ozone season” (April-September) on an hourly basis in Concord and Manchester. $PM_{2.5}$ daily averages are recorded every three days at

Exchange Street. The three-day interval is in accordance with EPA's protocol for PM data. SO_2 and $PM_{2.5}$ data for this study were from the period March 2004 through February 2006. Ozone was measured hourly from April through September 2004 and 2005 ("ozone season").

Air toxics were monitored at Exchange Street and four other sites around the state from September 2002 through December 2003. This was the time period of a special study conducted by DES and EPA. Air toxics have not been monitored since the conclusion of the project in December 2003. Air toxics were reported as daily averages every 12 days.

Environmental data were produced by DES air monitoring programs for internal use and for submission to EPA. DES uses accepted monitoring techniques, employs an extensive review process, and adheres to quality control and quality assurance protocols established by EPA. Thus, the quality of ambient air data is adequate to support public health decisions.

4.4 Potential Pollutants of Interest

This section contains site-specific information about potential pollutants of interest associated with Merrimack Station. Most of the pollutants evaluated in this PHA satisfy three criteria: 1) they are emitted from Merrimack Station; 2) they are included in Merrimack Station emissions data; and 3) they are (or were) monitored at Exchange Street Station (10, 11). Ozone, a seasonal pollutant that originates primarily south and west of New Hampshire, is also included in the assessment. It is not a pollutant emitted directly by Merrimack Station and is not monitored at Exchange Street. It is monitored at several DES stations in NH, including those in Concord and Manchester. Mercury is included in the PHA because it is emitted from Merrimack Station and was an expressed community concern in the ATSDR petition. Mercury in ambient air is difficult to monitor because it is present in four forms in the atmosphere: precipitation, gaseous elemental form, particulate matter form, and reactive gas-phase mercury (RGM). Each form presents its own challenges relative to sampling and analysis. This is due primarily to the low detection limit required for analysis as well as the high cost. RGM is expected to represent roughly half of what may be present, however, it is also the most costly to sample and analyze. Sampling and analyzing mercury are beyond the scope of this study. As an alternative to monitoring mercury directly, DES estimated mercury levels through analytical modeling. Table 4-3 lists all pollutants that were analyzed in this document to assess their impact on public health.

Table 4-3. Potential Pollutants of Interest in Suncook Village PHA (10, 11).

Criteria Pollutants (NAAQS)	Core Metals	Core VOC Hazardous Air Pollutants (HAPs)	Other VOC HAPs	Core Aldehydes
Sulfur Dioxide	Cadmium	1,3-butadiene	MtBE	Formaldehyde
$PM_{2.5}$	Total Chromium	Chloroform	Styrene	Acetaldehyde
Ozone	Lead	Tetrachloroethylene	Toluene	
	Nickel	Total-xylenes		
	Arsenic			
	Mercury			

All pollutants measured at Exchange Street except for ozone (Concord and Manchester) and Mercury (modeled only).
NAAQS = National Ambient Air Quality Standards; VOC = Volatile Organic Compounds; PM = Particulate Matter

4.5 Alternative Sources of Emission

DES routinely documents the quantity of pollutants emitted by Merrimack Station and all permitted emissions sources in its annual emissions inventories. Because these emissions are measured at the plant, they do not directly reflect potential exposure levels in surrounding areas such as Suncook Village. Quantifying exposure levels attributable to Merrimack Station emissions is further complicated by the presence of other sources of emissions in the area including industrial facilities, aircraft, trains, municipal waste combustors, wood-burning stoves, home heating systems, and automobiles. Table 4-4 presents a partial list of emissions sources located within a 15-mile radius of the site, along with their emissions quantities categorized by individual pollutant (6). (The facilities listed in Table 4-4 do not include potential sources outside the 15-mile radius. They also include only those with emissions of 20 tons or more in 2005. A list of all 69 permitted facilities within the 15-mile radius is presented in Appendix A.) The bottom line of Table 4-4 presents Merrimack Station emissions as a percent of emissions from all 69 permitted sites within a 15 mile radius. Merrimack Station's emissions of PM (87.4% of total), SO_2 (98.8%), and NO_2 (90.1%) far outweigh those of all other area facilities combined, while its emissions of Volatile Organic Compounds (VOCs) (14.6%) and Hazardous Air Pollutants (HAPs) (1.8%) are far lower (6). The geographic location of each facility is presented in Figure 4-1. Each facility's location is keyed to its "Map Number" in Column 1 of Table 4-4 below, or in Appendix 2.

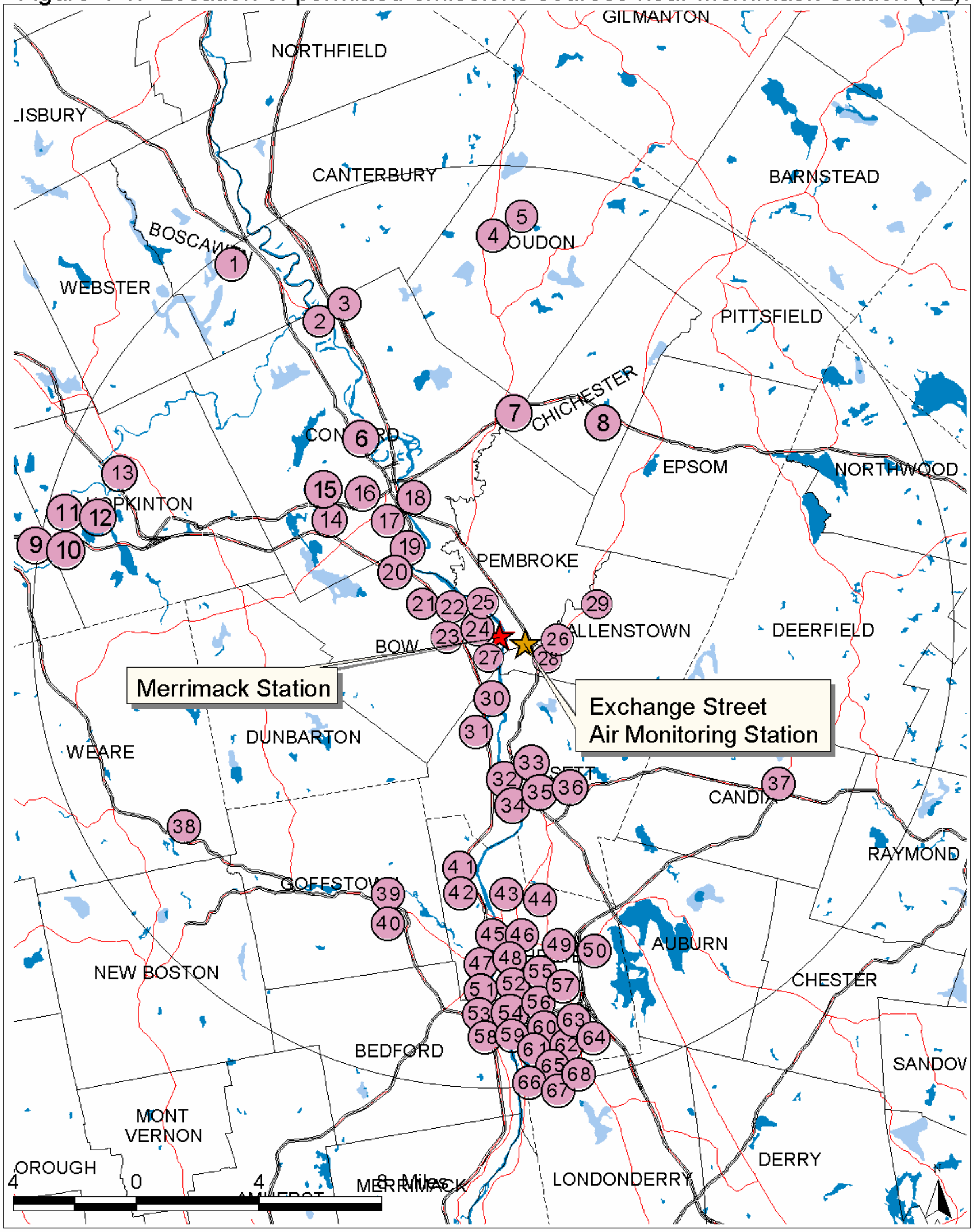
Table 4-4. Emissions Inventory (tons per year) of selected permitted emissions sources within 15 mile radius of Merrimack Station: Sources with 20 or more tons in any emissions category (6)

Map #	Name	PM	SO_2	NO_2	VOC	T/HAPS
5	ENVIRONMENTAL SOILS MANAGEMENT INC	6.22	34.52	19.70	1.84	0.60
6	NH Dept of Corrections CONCORD FACILITY	3.08	38.61	13.98	0.07	0.00
9	HHP INC	0.40	2.63	20.14	0.53	0.00
14	SAINT PAUL'S SCHOOL	2.25	22.62	15.80	0.08	0.00
16	CONCORD STEAM CORPORATION	36.82	61.39	39.17	0.94	0.00
21	KALWALL CORP- FLAT SHEET DIVISION	0.10	0.62	0.48	28.56	21.21
23	QUALITY WOOD PRIMING INC	0.00	0.00	0.00	41.27	0.00
34	CHURCHILL COATINGS CORP. HOOKSETT	0.00	0.00	0.00	44.53	0.00
43	NH DHHS YOUTH DEVELPOMENT CTR	2.11	30.68	5.37	0.03	0.00
50	KALWALL PANELS & ACCESSORIES	0.14	2.88	1.03	70.36	0.00
60	NYLON CORPORATION OF AMERICA	5.49	80.17	14.66	0.10	0.00
63	AVILITE CORPORATION	0.00	0.00	0.00	27.43	0.00
67	FREUDENBERG-NOK – MANCHESTER	0.03	0.03	0.45	28.20	0.00
	Facilities 1-68 Total (see Appendix A)	90	409	553	394	48
	Merrimack Station (# of tons)	622	33768	5033	67	1
	Merrimack Station (% of all emissions)	87.4%	98.8%	90.1%	14.6%	1.8%

See Appendix A for a complete list of permitted emissions sources.

PM = Particulate Matter; SO_2 = Sulfur Dioxide; NO_2 = Nitrogen Dioxide; VOC = Volatile Organic Compounds; T/HAPS = Toxic/Hazardous Air Pollutants

Figure 4-1. Location of permitted emissions sources near Merrimack Station (12).



Circle represents 15 mile radius around Merrimack Station

5.0 RESULTS

This section presents findings from an analysis of meteorological and environmental data related to air quality in the Suncook area. Meteorological data on wind direction and wind speed are examined to assess the potential of emissions from the Merrimack Station Power Plant to be transported to the Suncook area. Air quality data from DES air monitoring stations in Suncook Village and other sites are analyzed to determine pollutant levels.

5.1 Meteorological Data Analysis

As noted in the Methods section (4.0), MET conditions play a major role in local source air pollution levels. This PHA includes an extensive examination of wind direction and wind speed as they affect Merrimack Station emissions. Time of year and time of day are also considered in connection with wind direction and speed.

5.1.1 Wind Direction

Among all meteorological conditions, wind direction is probably the predominant factor affecting local-source air pollution levels in Suncook Village. The prevailing wind direction in the Suncook area is from northwest to southeast. Merrimack Station is located directly northwest of Suncook Village and Exchange Street Station. Meteorological data from Exchange Street for the study period (March 2004 through February 2006) indicate that northwest winds are more than twice as common as those from any other direction (13) (Table 5-1).

Table 5-1. Hourly wind direction readings: Exchange Street, Mar 2004-Feb 2006 (13).

Wind	Number of Observations	Percent of Total
North	354	2%
NE	63	<0.5%
East	882	5%
SE	1000	6%
South	1199	7%
SW	674	4%
West	945	5%
NW	3268	19%
Calm	9135	52%
Total	17520	100%

Examination of wind direction by month (Table 5-2) shows that from December through April, Suncook Village experiences NW winds 25% of the time, compared to only 10% of the time in the summer months of June through August. Based on this analysis, the “Time of Year” variable employed in this report consists of two six-month periods: November-April and May-October. Table 5-3 presents the frequency of wind direction for these two periods, which are employed later in the report to analyze time-of-year differences in air quality (13).

Table 5-2. Percent NW winds by month: Exchange Street, Mar 2004-Feb 2006 (13).

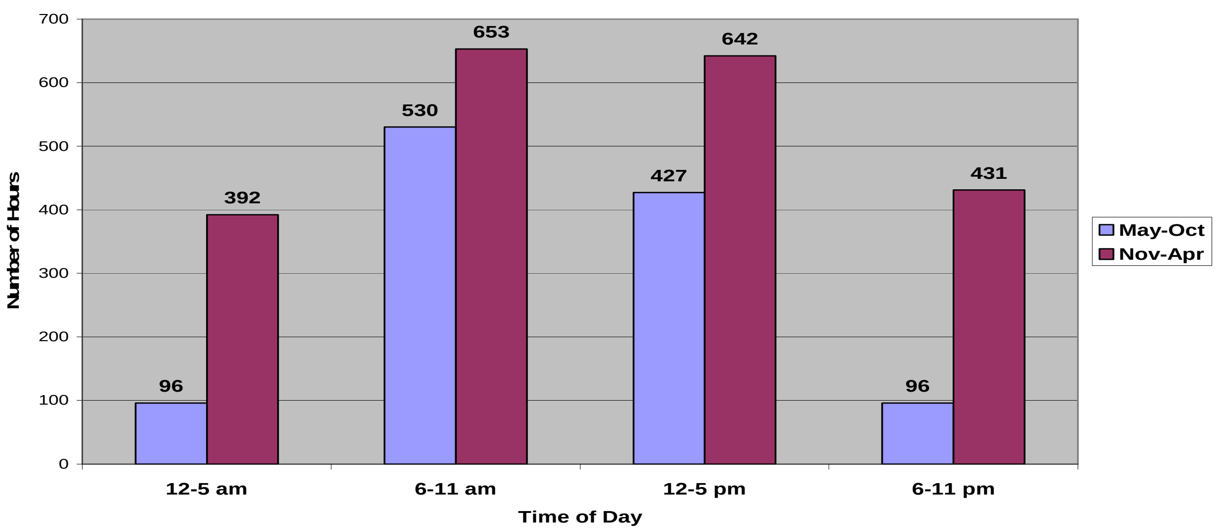
Month	Percent NW Winds	Month	Percent NW Winds	Month	Percent NW Winds
January	29%	May	15%	September	14%
February	26%	June	9%	October	18%
March	25%	July	11%	November	19%
April	23%	August	10%	December	23%

Table 5-3. Hourly wind direction by time of year: Exchange Street, Mar 2004-Feb 2006 (13).

Wind Direction	All Months	Time of Year	
		Nov-Apr	May-Oct
North	2%	2%	2%
NE	0%	1%	0%
East	5%	7%	4%
SE	6%	4%	7%
South	7%	4%	9%
SW	4%	3%	4%
West	5%	9%	2%
NW	19%	24%	13%
Calm	52%	46%	59%
Total Percent	100%	100%	100%
Total N	17520	8688	8832

Figure 5-1 presents the number of NW wind measurements by time of year and hour of day. The number of NW winds recorded between 6 and 11 a.m. in warmer months (N=530) is about 80% that of colder months (N=653). Between 6 p.m. and 5 a.m., however, the number of NW winds during May-October is less than one-quarter that of November-April (13).

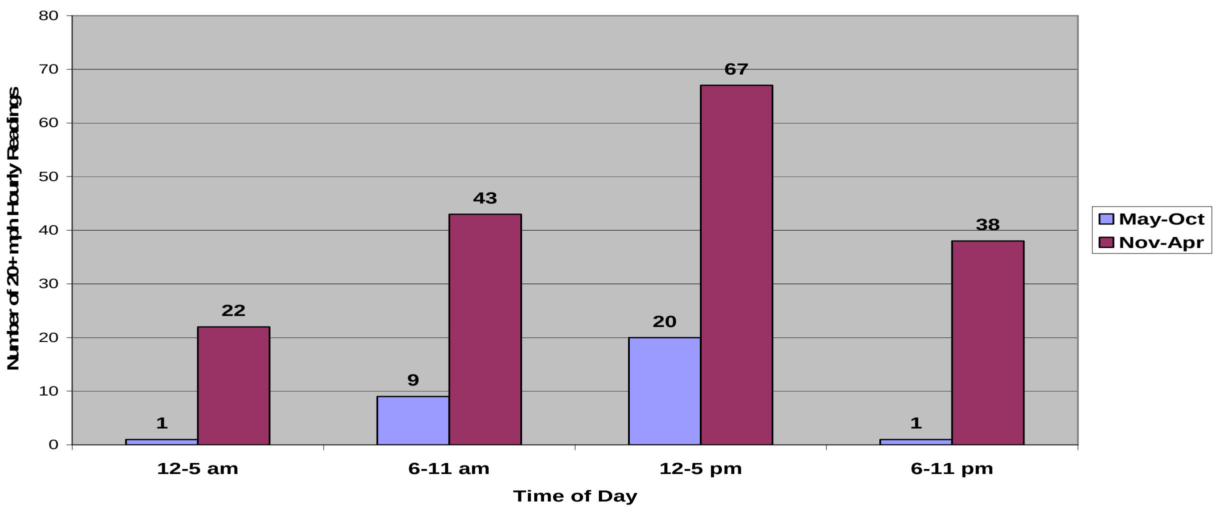
Figure 5-1. Number of hourly NW wind readings by time of year and time of day: Exchange St, Mar 2004-Feb 2006.



5.1.2 <u>Wind Speed</u>

Wind speed can play a major role in the transport and dispersion of air pollution. As noted in the previous section, northwest winds are of primary interest in this report because Merrimack Station is located directly northwest of Suncook Village. Figure 5-2 presents the number of times that NW winds at Concord Airport reached speeds of 20 mph or higher by time of year and hour of day during the two-year study period. This shows that, in addition to NW winds being more prevalent in colder months, they also occur at higher speeds during this period. Winds of 20+ mph are more than five times as likely to occur in the November-April period as in May-October (13).

Figure 5-2. Number of 20+ mph NW Wind Readings by Time of Year and Time of Day: Concord Airport NWS, Mar 2004-Feb 2006



5.2 Analysis of Environmental Data: Ambient Air in Suncook Village

This section presents the results of an in-depth analysis of air quality in Suncook Village. Results are presented for each pollutant of interest including sulfur dioxide, $PM_{2.5}$, ozone, mercury, and 15 air toxics.

5.2.1 <u>Sulfur Dioxide</u>

This section presents an evaluation of ambient air concentrations of sulfur dioxide collected at Exchange Street Station for the period March 2004-February 2006. The data consist of 24 separate 1-hour SO_2 measurements for each day during the two-year study period (13). They are first compared to ATSDR's MRL of 10 parts per billion (ppb) and LOAEL of 100 ppb. The LOAEL represents the <u>lowest level</u> at which adverse health effects have been documented in scientific literature (14). Next, average hourly SO_2 levels at Exchange Street are examined by wind direction, wind speed, time of year, and hour of day. Hourly SO_2 elevations and multi-hour elevation "events" are also analyzed in detail. Finally, Exchange Street data are compared to EPA's short- and long-term NAAQS. "Primary" NAAQS are employed in the analysis because they represent limits to protect public health, including the health of "sensitive populations" such as asthmatics, children, and the elderly (15).

5.2.1.1 *MRL and LOAEL Evaluation*

During the study period, a total of 17,298 1-hour sulfur dioxide measurements were collected at Exchange Street. As shown in Figure 5-3, hourly SO_2 levels exceeded the 10 ppb MRL 15.5% of the time (the four small slices combined; sample size N=2,684), while the 100 ppb LOAEL was exceeded 0.5% of the time (N=85). When expressed as 24-hour averages, the MRL of 10 ppb was exceeded 22.1% of days during the two-year period (Figure 5-4); while the 100 ppb LOAEL daily average was never exceeded (13). MRL is the point at which ATSDR warrants further examination of chemicals and their health effects. It is not a level at which adverse health consequences are normally expected. A LOAEL, on the other hand, is the lowest tested dose of a substance that has been reported to cause health effects.

Figure 5-3. Distribution of hourly SO_2 readings by selected ppb levels: Exchange Street, March 2004-February 2006 (12).

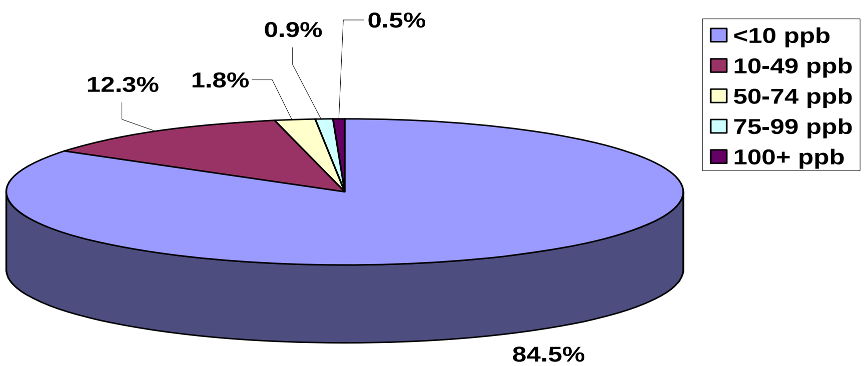
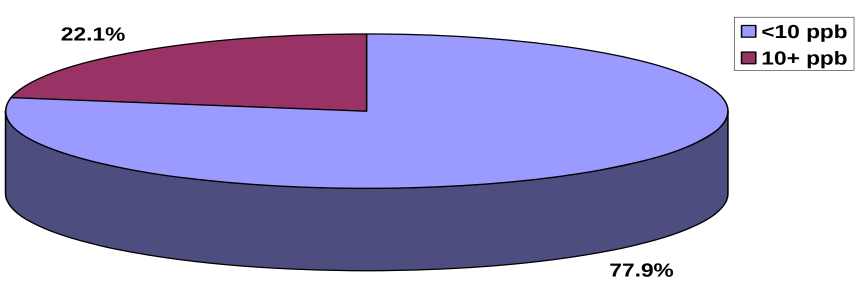


Figure 5-4. Average daily SO_2 levels by 10 ppb MRL status: Exchange Street Station, March 2004-February 2006.



5.2.1.2 *Average Hourly SO_2 by Meteorological Factors*

In accordance with ATSDR protocol, the occurrence of sulfur dioxide readings above the MRL prompted further examination of SO_2 in the Suncook area. Figure 5-5 illustrates the extent to which levels of SO_2 in Suncook Village are associated with winds from the northwest – the direction of Merrimack Station. The cone of the scatter plot narrows with increasing SO_2 levels to a range of 314 to 320 degrees northwest. According to DES global positioning system (GPS) analysis, Merrimack Station is between 318 and 319 degrees to the northwest of Exchange Street Station, about 4/5 of a mile away. This evidence suggests that emissions from Merrimack Station are primarily responsible for SO_2 elevations in the Suncook area.

Figure 5-5. Hourly Sulfur Dioxide Readings by Wind Direction: Exchange Street Station, March 2004-February 2006

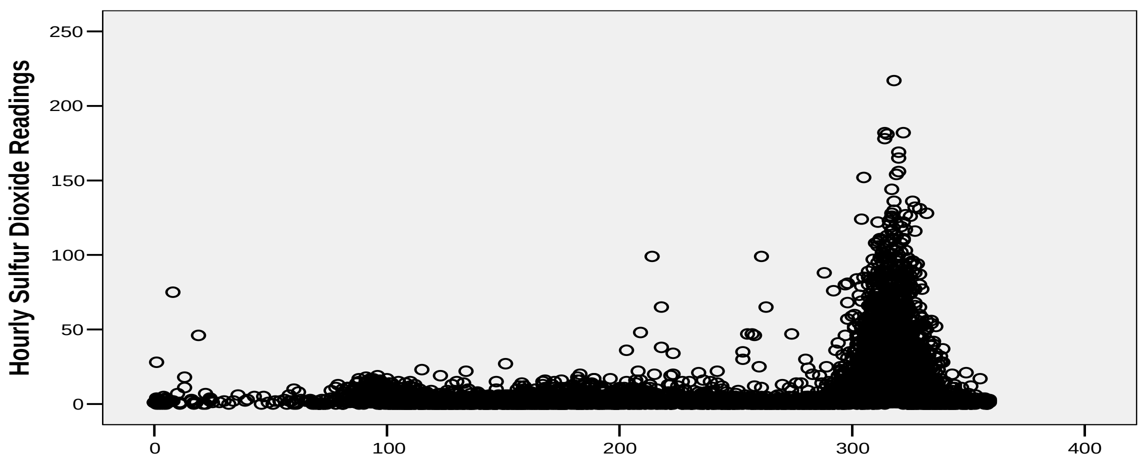
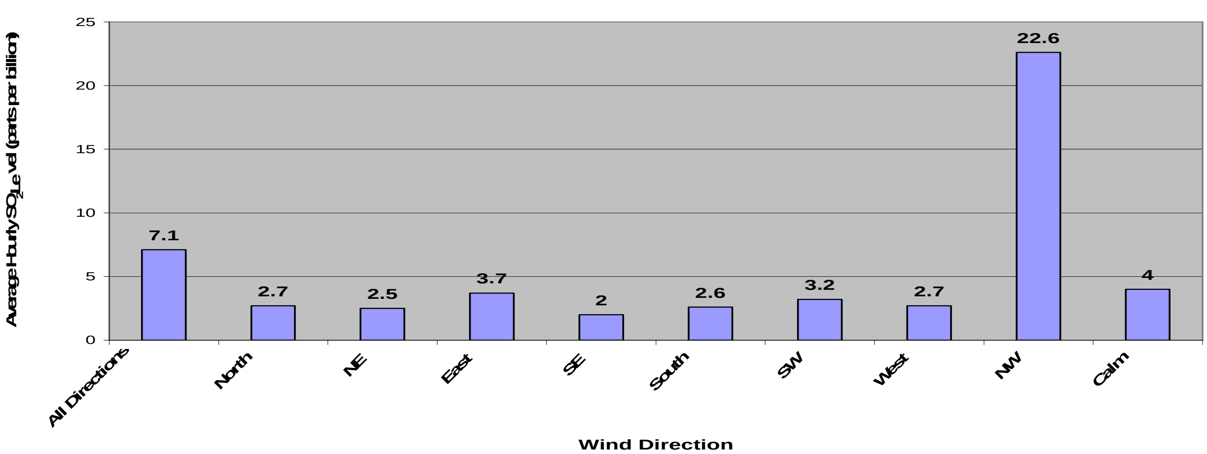


Figure 5-6 further substantiates the primary role of northwest winds in transporting sulfur dioxide to Suncook Village. The average hourly SO_2 level for NW winds in this study was 22.6 ppb. Winds from all other directions resulted in SO_2 averages between 2 and 4 ppb (13).

Figure 5-6. Average hourly SO_2 Levels by Wind Direction: Exchange Street, Mar 2004-Feb 2006



Analysis of wind speed provides further explanation of the conditions under which high SO_2 levels in Suncook Village can occur. Figure 5-7 presents average hourly SO_2 levels by wind speed for NW winds only. Very clearly, the higher the wind speed, the higher the level of SO_2 at Exchange Street (13).

Figure 5-7. Average hourly SO_2 levels by wind speed: Northwest winds only, Exchange Street, Mar 2004-Feb 2006

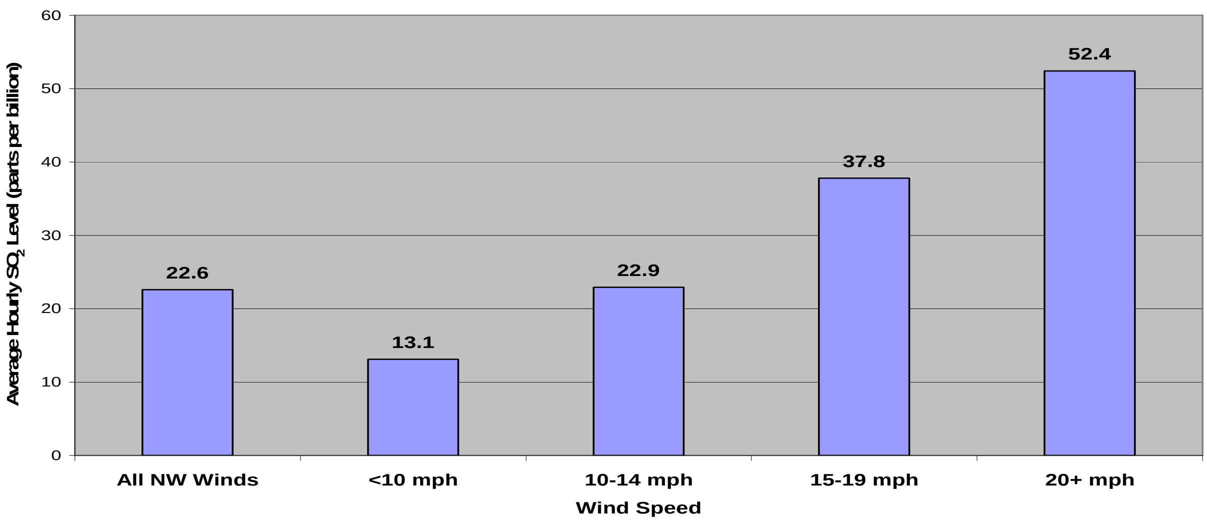
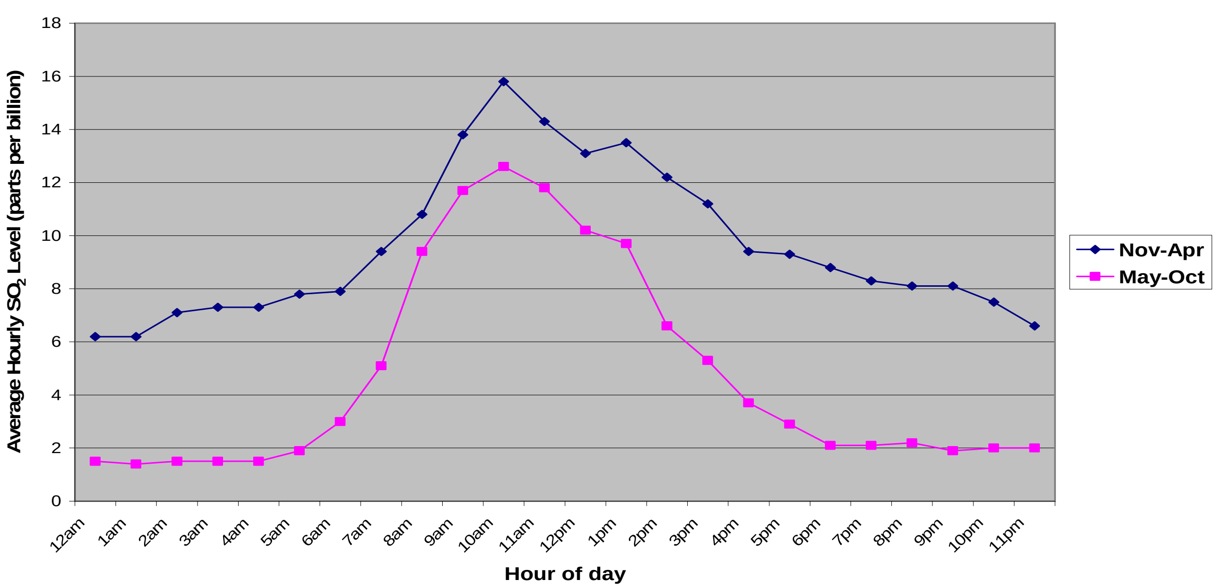


Figure 5-8 compares average SO_2 levels by hour of day for November-April and May-October. The most notable difference between the time periods is the disparity in SO_2 levels at night. This ties back directly to seasonal differences in nighttime NW wind prevalence as depicted in Figure 5-1. During November-April, nighttime NW winds occur more than four times as often as they do in May-October (13).

Figure 5-8. Average hourly SO_2 levels by time of year and hour of day: Exchange Street, Mar 2004-Feb 2006



5.2.1.3 *Hourly SO_2 Pollution Events*

This section focuses primarily on those instances when SO_2 levels exceed the ATSDR LOAEL of 100 ppb (SO_2 "pollution events"). Table 5-4 presents the distribution of various levels of SO_2 by wind direction. Consistent with findings in the last section, the vast majority of elevated sulfur dioxide levels occurred when winds were from the northwest, including 63% over the MRL (10 ppb), and 89% above the LOAEL (100 ppb). The only other instances in which the LOAEL was exceeded occurred when winds were "Calm", and therefore not assigned a direction (13).

Table 5-4. Distribution of selected levels of SO_2 ($10^{\dagger}$, 50, 75, and $100^{\ddagger}$ ppb) by wind direction (13).

Wind Direction	SO_2 readings greater than or equal to:							
	10 ppb		50 ppb		75 ppb		100 ppb	
	Percent	(N)	Percent	(N)	Percent	(N)	Percent	(N)
North	1%	18	<0.5%	1	<0.5%	1	0%	0
NE	<0.5%	3	0%	0	0%	0	0%	0
East	3%	87	0%	0	0%	0	0%	0
SE	1%	15	0%	0	0%	0	0%	0
South	2%	51	0%	0	0%	0	0%	0
SW	1%	36	<0.5%	2	<0.5%	1	0%	0
West	1%	33	1%	4	1%	3	0%	0
NW	63%	1690	86%	475	84%	203	89%	76
Calm	28%	751	12%	68	14%	33	11%	9
Total	100%	2684	100%	550	100%	241	100%	85

† ATSDR Minimal Risk Level (10 ppb).
‡ ATSDR LOAEL (100 ppb) - The lowest level at which health effects have been documented.

As noted previously, of the 17,298 hourly SO_2 readings during the study period, 85 (0.5%) exceeded 100 ppb, the level at which exposure to sulfur dioxide may result in adverse respiratory effects among sensitive asthmatics engaged in outdoor exertion. The previous section also documented that SO_2 levels increase as (NW) wind speed increases. Table 5-5 shows that almost all SO_2 events associated with high wind speed occur in colder months (Nov-Apr), while the vast majority of those associated with calm or light winds take place in warmer months (May-Oct) (13).

Table 5-5. One-hour SO_2 elevations by time of year and wind speed: Mar 2004-Feb 2006 (13).

Time of Year	Total	NW Wind Speed			
		<10/Calm	10-14mph	15-19 mph	20+ mph
May-Oct	17	10	6	1	0
Nov-Apr	68	3	13	28	24
Total	85	13	19	29	24

In discussing strong- vs. light-wind elevation hours, it is helpful to place them into the context of the multiple-hour "elevation events" of which they are a part. In this study, an "SO_2 elevation event" is defined by the number of consecutive hours surrounding a one-hour reading of 100+

ppb that reach levels of 10 ppb or higher. For example, the SO_2 elevation event of April 20, 2004 (Table 5-6) consisted of 12 consecutive hours of SO_2 readings greater than 10 ppb (13).

Table 5-6. Hour of day, SO_2 level, wind direction, and wind speed associated with a strong wind SO_2 elevation event: April 20, 2004 (13).

Hour of Day	SO_2 level	Wind Direction	Wind Speed
12:00 AM	0	W	22
1:00 AM	0	W	8
2:00 AM	0	W	9
3:00 AM	89	NW	10
4:00 AM	130	NW	12
5:00 AM	89	NW	13
6:00 AM	57	NW	14
7:00 AM	31	NW	15
8:00 AM	30	NW	15
9:00 AM	42	NW	16
10:00 AM	32	NW	16
11:00 AM	43	NW	14
12:00 PM	21	NW	13
1:00 PM	59	NW	16
2:00 PM	25	NW	9
3:00 PM	7	NW	12
4:00 PM	13	NW	12
5:00 PM	7	NW	15
6:00 PM	0	Calm	0
7:00 PM	1	Calm	0
8:00 PM	1	Calm	0
9:00 PM	3	Calm	0
10:00 PM	2	Calm	0
11:00 PM	2	Calm	0

Light-wind SO_2 events occur primarily in summer and last a very few hours. They usually occur between 8 a.m. and 11 a.m., and involve only a single hourly reading greater than 100 ppb. A typical light-wind event occurred on August 8, 2005 (Table 5-7). During this event, calm winds allowed pollutants to accumulate near the power plant in early morning hours. A light NW wind beginning at 8 a.m. transported contaminants across the river to Suncook Village to create a four-hour SO_2 elevation event (13).

Table 5-7. Light-wind SO_2 elevation event: August 8, 2005 (13).

Hour of Day	SO_2 Level	Wind Direction	Wind Speed
6:00 AM	2	Calm	0
7:00 AM	7	Calm	0
8:00 AM	22	NW	3
9:00 AM	21	NW	3
10:00 AM	118	Calm	0
11:00 AM	41	Calm	0
12:00 PM	5	Calm	0

Strong-wind SO_2 events occur primarily in winter. They are characterized by sustained high-speed NW winds that continuously transport SO_2 from Merrimack Station to Suncook Village. Strong-wind elevation events usually last for at least ten hours or as long as strong winds maintain. There are typically multiple hourly readings greater than 100 ppb within the same strong-wind event. The most notable strong-wind SO_2 elevation event of the two-year study period occurred over a 43-hour period in 2006, from January 14th at 9 p.m. until January 16th at 3 p.m. During this 43-hour period, there were 12 1-hour readings of 100 ppb or greater, including seven consecutive readings between midnight and 6 a.m. on January 15th (13). See Appendix B for a complete list of SO_2 events that occurred during the two-year study period.

In terms of exposure potential and prevention, strong-wind winter events may pose a threat to asthmatics that work outdoors, or to those who engage in outdoor "winter storm" activities such as snow shoveling. For the most part, however, these events are easy to forecast, identify, and avoid.

Light-wind SO_2 events are far fewer in number, but are more problematic in terms of exposure potential. First, they occur on warm summer mornings when outdoor activities are the norm. Second, they are more difficult to predict and identify because wind direction is not as easy to forecast or detect when wind speed is variable or light. Fortunately, however, these events are rare and do not usually last long.

5.2.1.4 *Exchange Street SO_2 Levels: Comparison with EPA Standards*

Exchange Street sulfur dioxide measurements were compared to EPA Primary NAAQS. These include both short-term (3-hour and 24-hour average) and long-term (annual) health-based regulatory benchmarks (Table 5-8). Data from the two-year study period show that all annual and maximum average readings from Exchange Street Station were well within NAAQS. The maximum 3-hour SO_2 average during the study period was 156 ppb, compared to the NAAQS of 500 ppb. Of the 17,298 hourly readings, only one exceeded 200 ppb (13, 15).

The two highest 24-hour SO_2 readings were 85 and 75 ppb. These are well within the EPA standard of 140 ppb. Finally, "annual averages" for the periods March 2004-February 2005 (7.1 ppb) and March 2005-February 2006 (7.1 ppb) were well below the NAAQS of 30 ppb (13, 15).

Table 5-8. Average SO_2 levels in Suncook Village compared to EPA NAAQS: Mar 2004-Feb 2006 (12).

Measurement Source	Annual Average		Maximum Average	
	3/04 – 2/05	3/05 – 2/06	3 Hour	24 Hour
Exchange Street	7.1 ppb	7.1 ppb	156 ppb	85 ppb
NAAQS	30 ppb	30 ppb	500 ppb	140 ppb

5.2.2 Fine Particulate Matter ($PM_{2.5}$)

Particulate matter (PM) samples are collected on filters that are then weighed. PM concentrations are reported in micrograms of particles per cubic meter ($\mu g/m^3$) of collected air (16). The current analysis examines air monitoring data for fine particulate matter ($PM_{2.5}$) collected at Exchange Street for the period March 2004-February 2006. The data include 241, 24-hour duration samples collected approximately every three days. Individual samples ranged from 0.9 to 44.0 µg /m^3. Data were converted to "annual" (12-month) averages for comparison with health-based NAAQS values (15, 17). Table 5-9 shows that $PM_{2.5}$ levels at Exchange Street compare favorably to NAAQS. The two "annual averages" and the 24-hour average were all well below their respective NAAQS. (EPA recently lowered the 24-hour average from 65 to 35 µg/m^3.)

Table 5-9. Annual and 24-hour average* $PM_{2.5}$ levels in Suncook Village compared to EPA NAAQS: Mar 2004-Feb 2006 (17).

Measurement Source	Annual Average		24-Hour Average
	3/04 – 2/05	3/05 – 2/06	3/04 – 2/06
Exchange Street	10.1 µg/m^3	10.3 µg/m^3	26.5 µg/m^3
NAAQS	15 µg/m^3	15 µg/m^3	35 µg/m^3

* 24-hour averages are usually based on three years of data. The Exchange Street average in this table is based on the only two years of data available.

$PM_{2.5}$ readings from Exchange Street were also compared to EPA's "Air Quality Index" (AQI). AQI indicates how clean or polluted the air is, and what associated health effects might be of concern to residents of a particular region. AQI focuses on health effects that may be experienced within a few hours or days after breathing polluted air. EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act: ozone, sulfur dioxide (SO_2), particulate matter, nitrogen oxides (NO_x), and carbon monoxide (CO). For each pollutant, the AQI is divided into six health-based air quality categories: 1) Good; 2) Moderate; 3) Unhealthy for Sensitive Groups (USG); 4) Unhealthy; 5) Very Unhealthy; and 6) Hazardous (18, 19). As shown in Table 5-10, $PM_{2.5}$ levels in Suncook Village were "good" more than 80% (N=192) of the days that readings were taken. The "moderate" category accounted for an additional 17.4% of monitored days (N=42). EPA's cautionary statement for moderate particle pollution days is, "*Unusually sensitive people should consider reducing prolonged or heavy exertion.*" There was only one daily average for which $PM_{2.5}$ was "unhealthy for sensitive groups". The cautionary statement for USG reads: "*People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.*" This elevated reading occurred on July 23, 2004, during a regional air quality event; the same event during which the highest O_3 reading of the two-year study period took place. The $PM_{2.5}$ level averaged 44.0 µg/m^3 on that day. This is on the lower end of the USG range of 40.5-65.4 µg/m^3. None of the daily averages in the two-year period reached "Unhealthy", "Very Unhealthy", or "Hazardous" levels.

Table 5-10. Distribution of average daily $PM_{2.5}$ levels by AQI category: Exchange Street, Mar 2004-Feb 2006 (17, 18).

Measurement Source	Air Quality Index Category					
	Good		Moderate		Unhealthy for Sensitive Groups	
	Number	Percent	Number	Percent	Number	Percent
Exchange Street	198	82.2%	42	17.4%	1	0.4%
AQI Range	0.0 - 15.4 µg/m^3		15.5 - 40.4 µg/m^3		40.5 - 65.4 µg/m^3	

Finally, Table 5-11 presents the number of “moderate” or “USG” $PM_{2.5}$ days by wind direction and time of year. Elevated $PM_{2.5}$ days are distributed evenly between warm and cold months, with southerly winds related to summer elevations and northerly winds related to winter elevations (17, 18).

Table 5-11. Number of “moderate” and “USG” $PM_{2.5}$ days by wind direction and time of year: Mar 2004-Feb 2006 (17, 18).

Wind Direction	Total	Time of Year			
		Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
North	2	1	0	1	0
NE	8	5	0	2	1
East	1	0	0	0	1
SE	5	2	1	2	0
South	6	0	1	3	2
SW	10	3	2	5	0
West	2	1	0	1	0
NW	9	6	1	1	1
Total N	43	18	5	15	5

5.2.3 Ozone

This section presents an evaluation of ozone (O_3) data collected at two DES air monitoring stations: Pearl Street Station in Manchester, NH, 8 miles south of Suncook Village; and Hazen Drive Station in Concord, NH, 7 miles north of Suncook Village. (Ozone is not monitored at Suncook’s Exchange Street Station because it is not associated with emissions from Merrimack Station.) O_3 is generally monitored only during “ozone season”, April through September, when long periods of sunlight and hotter temperatures can cause O_3 to form in higher concentrations.

Eight-hour average ozone levels from Manchester and Concord are compared with EPA’s AQI categories (Table 5-12). Eight-hour averages were “good” more than 92% of the time in both locations. Approximately 7% of days during the two ozone seasons were categorized as “moderate”. EPA’s cautionary statement for this category is, *“People who are unusually sensitive to ozone should consider reducing prolonged or heavy exertion outdoors.”* There was only one day in the two-year study period in which ozone was categorized as “unhealthy for sensitive groups” (USG): on July 22, 2004 Manchester’s average reading was 94 parts per billion (ppb), while Concord’s was 92. Each of these is in the mid-range of the “USG” category (85-104 ppb). During USG days, EPA advises that *“Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors.”* None of the ozone readings during the study period were categorized as “Unhealthy”, “Very Unhealthy”, or “Hazardous” (20).

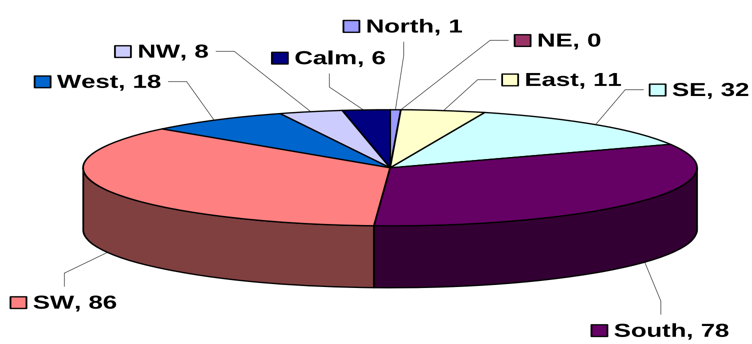
Table 5-12. Eight-hour average ozone levels by AQI category: Apr-Sep 2004 and Apr-Sep 2005 (18, 20).

Measurement Source and Year	Air Quality Index Category					
	Good		Moderate		Unhealthy for Sensitive Groups	
	Number	Percent	Number	Percent	Number	Percent
Concord 2004	168	92.8%	12	6.6%	1	0.6%
Manchester 2004	175	96.2%	7	3.8%	1	0.5%
Concord 2005	170	92.9%	13	7.1%	0	0%
Manchester 2005	171	93.4%	12	6.6%	0	0%
AQI Range	0-64 ppb		65-84 ppb		85-104 ppb	

According to EPA, peak ozone levels typically occur under hot, dry, stagnant air conditions. Semi-rural areas such as Suncook generally experience elevated levels in summer months when southerly winds transport ozone-forming pollutants (e.g., motor vehicle exhaust, industrial emissions) from major metropolitan and industrial areas located south and west of NH (21). Figure 5-9 illustrates the predominance of southerly winds in association with higher ozone levels. Of the 240 hours during which ozone readings were 65 ppb or higher, 196 (81.7%) were from either the south, southwest, or southeast.

As shown in the previous section, elevated SO_2 levels occur primarily when the wind is out of the northwest. Ozone elevations, on the other hand, usually occur in conjunction with southerly winds. This means that elevations of the two pollutants seldom occur simultaneously in the Suncook area. In fact, during the two-year study period, all instances in which one-hour SO_2 levels exceeded the LOAEL occurred during periods when the ozone AQI category was “good”. In terms of seasonality, SO_2 elevations occur primarily in fall, winter, and spring when the prevailing wind direction is northwesterly. Ozone elevations occur primarily during summer in conjunction with winds from the south, southeast, or southwest (13, 20).

Figure 5-9. Hourly ozone levels of 65+ ppb by wind direction: Hazen Drive Station, Concord, NH, 2004-2005.



EPA's 8-hour NAAQS for ground-level ozone is 0.08 parts per million (80 ppb). The Suncook area is currently in attainment of this standard and has had no violation since 1989. Recent regulatory levels measured in Concord (75 ppb) and Manchester (76 ppb) were each within the standard.

While elevated ozone and SO_2 levels seldom occur simultaneously in the Suncook area, this is not the case for ozone and $PM_{2.5}$. During ozone season, regional meteorological conditions that are favorable to ozone production and transport are also associated with elevated $PM_{2.5}$ levels. Therefore, it is common to have O_3 and $PM_{2.5}$ elevated during the same period of time in the Suncook area and statewide. For example, the maximum 8-hour average O_3 concentration monitored during the 2004-2005 ozone seasons occurred during the same "Air Quality Event" as the highest $PM_{2.5}$ measurement (July 22-23, 2004) (17, 20).

5.2.4 Air Toxics

This section presents an evaluation of data on air toxic pollutants collected between September 2002 and December 2003 at Exchange Street and four other monitoring locations around the state (23). These data were collected as part of a special DES project funded by EPA to investigate air toxics levels and variations in NH. Approximately 40 samples were collected for each pollutant at each monitoring location. They were collected for 24-hour durations every 12 days. Air toxics were selected for this analysis if they were included in the 2004 Merrimack Station Toxic Emissions Inventory and were measured at DES air monitoring stations (10, 11). Fifteen air toxics were included in the evaluation. Their levels were compared to ATSDR and EPA cancer and chronic non-cancer CVs. Of the fifteen pollutants, seven exceeded their cancer CVs and were analyzed further (Table 5-13, *italics*). The Public Health Implications Section of this report presents this more in-depth analysis.

Table 5-13. Ambient air toxics concentrations and comparison values: Exchange Street, September 2003-December 2004 (23, 24, 25, 26).

Substance	Average Daily Concentration Exchange Street ($\mu g/m^3$)	Cancer Comparison Value (CV) ($\mu g/m^3$)	Chronic Comparison Value (CV) ($\mu g/m^3$)
Benzene	**0.88**	*0.1$_{(1)}$*	**30.0$_{(5)}$**
1,3 Butadiene	**0.13**	*0.03$_{(1)}$*	**2.0$_{(5)}$**
Chloroform	**0.17**	*0.04$_{(1)}$*	**35.0$_{(4)}$**
Tetrachloroethylene	**0.24**	**1.7$_{(2)}$**	**300$_{(3)}$**
MtBE	**1.4**	**6.0$_{(2)}$**	**2000$_{(3)}$**
Styrene	**0.41**	**2.0$_{(2)}$**	**300$_{(3)}$**
Toluene	**2**	**None**	**300$_{(3)}$**
Total Xylenes	**1.5**	**None**	**200$_{(3)}$**
Arsenic	**0.0013**	*0.0002$_{(1)}$*	**0.5$_{(4)}$**
Cadmium	**0.0006**	**0.0006$_{(1)}$**	**3.5$_{(4)}$**
Lead	**0.0032**	**0.013$_{(2)}$**	**1.5$_{(4)}$**
Nickel	**0.0017**	**0.0042$_{(2)}$**	**0.09$_{(3)}$**
Chrome VI Particulates	**0.00126**	*0.00008$_{(1)}$*	**0.1$_{(5)}$**
Acetaldehyde	**2.04**	*0.5$_{(1)}$*	**9.0$_{(5)}$**
Formaldehyde	**4.29**	*0.08$_{(1)}$*	**10.0$_{(3)}$**

Comparison Value Sources
(1) ATSDR CREG (2) EPA CV (3) ATSDR Chronic MRL/EMEG (4) EPA Non-Cancer CV (5) EPA RfC

The DES *National Air Toxics Monitoring Grant Final Report* presents ambient air monitoring results for benzene, formaldehyde, and acetaldehyde in relation to wind direction around Merrimack Station (11). On days when the wind was predominantly from the northwest, there were no significant differences between concentrations detected at Exchange Street and those of the other four air toxics monitoring sites in the state (Manchester, Claremont, Portsmouth, and Brickett Hill in Pembroke). The report also notes that the majority of annual average concentrations of air toxics measured at the five sampling sites in New Hampshire were similar regardless of location, population density, or dominant source type. Furthermore, the report notes that the Exchange Street monitoring location generally followed the seasonal trends observed at the four other monitoring locations. In conclusion, air monitoring data of air toxics levels and trends in the Suncook area reveal no significant differences compared to other sites in the state. According to the DES *Report,* the results "do not indicate significant impacts of [Merrimack Station] either on an annual or 24-hour basis…." However, referring to the data-collection schedule employed, the report notes that "the frequency and duration of collected samples [every 12 days] do not allow for a thorough evaluation of potential short-term impacts of power plant emissions." (11).

In addition to analyzing air toxics data from the five monitoring stations, EHP evaluated theoretical air dispersion models of "24-hour" and "annual" ambient air mercury concentrations from DES Environmental Health & Modeling Section (24). Mercury was specifically mentioned as a contaminant of concern in the initial citizen petition. The analysis employed the highest, or "maximum impact" mercury concentration values predicted in the Suncook area for comparison purposes. These theoretical values are illustrated in Table 5-14.

Table 5-14. Predicted ambient air mercury concentrations in the Suncook area and ATSDR health standards (26,27).

Mercury Concentration	Maximum Impact Value	
	Annual	24-Hour
Predicted Suncook Level	0.0000357 μg/m^3	0.000419 μg/m^3
ATSDR Chronic MRL/EMEG	0.2 μg/m^3	0.2 μg/m^3

5.3 Summary of Environmental Data Results

Section 5.2 evaluated 18 potential pollutants of interest to determine whether they should be investigated further. Data from the Exchange Street air monitoring station and other sources were analyzed to assess levels of each pollutant in ambient air in the Suncook area. Based on this analysis, 11 pollutants of interest are subject to further examination in Section 6.0 below. This includes a review of the scientific literature on each pollutant: sulfur dioxide, $PM_{2.5}$, ozone, and eight air toxics (benzene, 1,3-butadiene, chloroform, arsenic, chromium, acetaldehyde, formaldehyde, and mercury). Seven of the air toxics occurred at low enough levels to conclude that they do not represent a health threat in the Suncook area and therefore are not included in Section 6.0.

6.0 PUBLIC HEALTH IMPLICATIONS

This section evaluates the public health implications of ambient air quality in the Suncook area. Analysis of DES air monitoring data identified 11 “pollutants of interest” out of the 18 contaminants originally considered. This section presents a literature review and summary of results for each pollutant of interest, and concludes with a discussion of childhood health considerations.

6.1 Pollutants of Interest

Following is a review of the scientific literature on health effects for each of the pollutants of interest listed below. The review is based on relevant environmental health studies and dose calculations (i.e., amount of contaminant that gets into a person’s body). Detailed health evaluations are provided for the following four categories of contaminants: 1) sulfur dioxide (SO_2); 2) fine particulate matter ($PM_{2.5}$); 3) ozone (O_3); and 4) air toxics (eight total, including mercury). Review of air toxics is restricted to those that exceeded a health-based CV in the initial assessment stage of this report.

6.1.1 <u>Sulfur Dioxide</u>

Sulfur dioxide, or SO_2, belongs to the family of sulfur oxide gases (SOx). Sulfur is prevalent in raw materials including crude oil, coal and ore. SOx gases are formed from the combustion of sulfur-containing fuel, such as coal, oil, diesel fuel, and gasoline. They are also created during the extraction of gasoline from oil, and metals from ore. Sulfur dioxide dissolves in water vapor to form sulfuric acid, and interacts with other gases and particles in the air to form sulfates and other compounds that can be harmful to people and the environment (28). It is estimated that sulfur dioxide concentrations can range from 0.4 - 1.9 ppb in very remote clean areas to at least 2,300 ppb in industrial areas. Between 1986 and 1995, composite SO_2 averages in the U.S. decreased an estimated 37%, while SO_2 emissions declined 18% (14).

Inhalation is the primary route of exposure for sulfur dioxide. SO_2 is a highly water-soluble gas that is rapidly absorbed by mucosa of the nose and upper respiratory tract. This can cause lung function changes indicative of bronchoconstriction, the contraction of muscle fibers surrounding the airway, making its opening considerably smaller. Bronchial hypersensitivity can develop following a single exposure to very high concentrations of sulfur dioxide; a syndrome referred to as reactive airway dysfunction syndrome or RADS. Populations susceptible to sulfur dioxide often exhibit a different or enhanced response than others exposed to the same level in the environment. Reasons for this may include genetic makeup, age, health and nutritional status, and exposure to other toxic substances (e.g., cigarette smoke). Scientific literature suggests that the main risk for an adverse reaction to SO_2 is respiratory health status (e.g, asthmatic), not age or other factors. This particular study found similar effects of breathing sulfur dioxide in healthy senior citizens and healthy adolescents. The findings parallel other studies showing that elderly adults with preexisting respiratory or cardiovascular disease may be susceptible to increased risk of mortality associated with acute-duration exposure to sulfur dioxide (14).

According to the 2003 New Hampshire Behavioral Risk Factor Surveillance System, 7.2% of NH adults, and 12.4% of the state’s children have asthma (29). As noted above, asthmatics are particularly sensitive to respiratory effects following acute exposure to sulfur dioxide. In fact, some sensitive asthmatics have been shown to respond to sulfur dioxide at concentrations as low as 100 ppb (ATSDR LOAEL). These sensitive asthmatics may be more susceptible and responsive to sulfur dioxide due to their lower reserve of lung function. Although sensitivity is important, adverse health responses to sulfur dioxide are variable among individual asthmatics. For example, exercising asthmatics are recognized as the most susceptible group to sulfur dioxide inhalation and significant increases in airway resistance have been clearly demonstrated. In addition, pulmonary effects (usually assessed by measurement of increases in specific airway resistance or decreases in forced expiratory volume or forced expiratory flow) of sulfur dioxide can be significantly enhanced by exercise. Furthermore, sulfur dioxide-induced bronchoconstriction can be made worse by cold or dry air during physical activity (14).

Studies of the relationship between sulfur dioxide and lung cancer have concluded that there is little, if any, causal connection. Similarly, epidemiological studies of occupational or environmental exposure to sulfur dioxide and other cancer types show no evidence of increased cancer potential in humans (14).

The ATSDR MRL (10 ppb) and minimal LOAEL (100 ppb) for sulfur dioxide were derived in part from a study in which exercising mild asthmatics were exposed to 100 ppb through a mouth piece for 10 minutes. The two most sensitive subjects of the ten experienced “some degree” of bronchoconstriction following exposure. The other subjects experienced no apparent reaction. The conservative MRL value (used for screening purposes) incorporates an uncertainty factor to address varying sensitivity among asthmatics and possible increased sensitivity in children. The minimal LOAEL is also a conservative, protective value. It represents the dose of sulfur dioxide for which health effects may be expected in exercising asthmatics (14).

Two years of hourly measurements collected at the Exchange Street Station demonstrate that ambient air levels of sulfur dioxide in Suncook Village comply with all EPA NAAQS. Of the 17,298 hourly sulfur dioxide measurements, 85 (0.5%) were higher than the ATSDR LOAEL of 100 ppb. As noted above, this a level at which sensitive asthmatics may experience some degree of respiratory effect.

6.1.2 Particulate Matter (PM)

Particulate matter (PM) is the term used for a mixture of solid particles and liquid droplets found in the air (30). This mixture can vary greatly in size, composition, and concentration, depending on the sources generating the particles and such factors as geographic location, topography of the locale, climate, season, day, and time of day (31). PM originates from a variety of combustion sources, including motor vehicles, power plants, incinerators, soil burners, flares and after-burners, industrial furnaces and boilers (30, 32). Natural processes also generate PM sources (e.g., pollen, bacteria, viruses, fungi, yeast, salt spray, soil from erosion) (33). Indoor PM can be generated from cigarette smoke, home heating sources, and cooking. It can also originate from outdoor PM sources that penetrate the indoor environment (31). Because of the large number of sources, PM particles can be formed in many different ways and have widely varying compositions. Particles may contain hundreds of different elements in complex chemical compounds including metals, organic compounds, biological materials, positively or negatively charged ions, reactive gases, and the pure (or elemental) carbon particle core (31, 33, 34).

PM pollution ranges in size from tiny to microscopic. *Total suspended particulate matter* (TSP) refers to “all” particles in the atmosphere and was the first indicator used to represent suspended particles in the ambient air (33). “Coarse” particles fall between 2.5 microns and 10 microns in diameter and are called $PM_{10\text{-}2.5}$. “Fine” particles are 2.5 microns in diameter or smaller and are called $PM_{2.5}$. Fine particles are formed mostly by gases emitted from combustion processes. The gases condense to become a particle of the same chemical compound, or can react with other gases or particles in the atmosphere to form a particle of a different chemical compound (34). By contrast, coarse particles are generated mainly by mechanical processes that break down material from a variety of non-combustion sources into dust (31).

Fine particles can remain suspended in the air for long periods of time and travel long distances. For example, diesel truck exhaust from Los Angeles can end up over the Grand Canyon, where one-third of the haze comes from Southern California. Oil refinery emissions from Los Angeles can also form particles that affect visibility in the Rocky Mountain National Park days later. Twenty percent of the problem in that Park is attributed to Los Angeles-generated smog (30).

Levels of particulate matter vary during the course of the day, and peak values can be quite high. Few studies have evaluated the effect of these short-term "spikes." However, at least one epidemiological study of children with asthma suggests that changes in symptoms and lung function correlate more strongly with 1-hour peaks than with 24-hour average concentrations (14).

PM size plays a role in how exposed individuals are affected. Larger, coarse particles, interacting with receptors on nerve cells in the airways, are trapped and removed by the nose and throat through sneezing, coughing, spitting, or swallowing (31, 32). However, fine particles, also called "respirable particles", pass through the nasal passage and trachea entering deep-lung capillaries and air sacs (alveoli) (33, 34). Ultra-fine particles (less than 0.1 micron in diameter) are small enough to slip through the lung into the blood stream, circulating like oxygen molecules themselves (34). If these particles are soluble in water, they pass directly into the blood stream within minutes. If they are not soluble in water, they are retained in the deep lung for long periods (months or years) (32). For these reasons the National Research Council, in 1979, said that measuring particles by weight, without regard to particle size, has "little utility for judging effects." Particle size is everything when it comes to air pollution and health. This has led EPA to promulgate the $PM_{2.5}$ nationwide standard to reduce exposure (14).

The main target of PM exposure is the respiratory system (35). Scientific studies have linked PM, especially fine particles (alone or in combination with other air pollutants), with a series of significant health problems, including: premature death; respiratory related hospital admissions and emergency room visits; aggravated asthma; acute respiratory symptoms, including aggravated coughing and difficult or painful breathing; chronic bronchitis; decreased lung function (i.e., shortness of breath); and work and school absences (30). Particle deposition in the airways can also trigger responses that potentially result in changes in tissues and organs at sites progressively farther away from the initial stimulus. For instance, studies in humans and other species have linked PM exposure with changes in cardiac function, including inducing arrhythmias and increasing the incidence of heart attack (31). The elderly, children, asthmatics, and individuals with pre-existing heart or lung disease are most at risk from PM exposure (35). According to the World Health Organization and others, there is no scientific evidence that particle pollution has any minimum threshold at which human health is not affected, particularly among more sensitive populations (36).

PM mixtures are variable and extremely complex. They depend on the source of the particles. Attempting to identify which components of PM result in a particular adverse effect is extremely challenging. Furthermore, ambient air contains gaseous pollutants such as ozone that can exert adverse effects similar to those ascribed to components of PM. The choice of appropriate endpoints of PM effects is also complicated both by variations in the solubility of PM particles (in the lung) and the potential mechanisms by which individual PM mixture components cause toxic effects (31).

Air monitoring data from Suncook Village between March 2004 and February 2006 reveal that annual and 24-hour average concentrations of $PM_{2.5}$ meet EPA standards, and are below levels normally associated with adverse health outcomes. Of the 241 days in which $PM_{2.5}$ was monitored during the study period, 42 (17.4%) were in the "moderate" category of the AQI. At this level, EPA advises, *"Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors."* There was one day in which the level of $PM_{2.5}$ reached a level categorized as "Unhealthy for Sensitive Groups" (i.e., asthmatics and those with preexisting heart or lung disease). This occurred during the same air pollution event as the highest ozone level of the study period (July 22-23, 2004). The air pollution event was regional in origin and scope. Elevated levels of $PM_{2.5}$ were experienced in parts of every New England state except Rhode Island.

EPA has recently published revised NAAQS for $PM_{2.5}$ in the Federal Register. Based on the latest scientific, health and technical information, EPA has changed the 24-hour $PM_{2.5}$ standard from 65 to 35 µg/m^3, but has retained the existing annual standard of 15 µg/m^3. As part of its review process, EPA solicited public comment on alternative standards as well as other approaches to selecting the standards (37). A study published by the Northeast States for Coordinated Air Use Management (NESCAUM) assessed the public health implications of compliance with alternative EPA standards. NESCAUM estimated the potential benefits to the general population and susceptible subgroups in the northeastern United States (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island & Vermont). The study recommended that the most appropriate 24-hour and annual standards would be 30 and 12 µg/m^3, respectively. NESCAUM asserts that implementing such standards would provide a stringent level of short- and long-term protection for a substantial proportion of both the Northeast and U.S. populations (38).

6.1.3 Ozone

Ozone (O_3) is a colorless gas that is formed mainly as a result of the interaction between organic compounds (i.e., hydrocarbons and nitrogen oxides) in the presence of heat and sunlight. Ozone is one of the major air pollutants in industrialized areas and cities with a large number of automobiles. In fact, more than half of the ingredients needed to produce ozone come from automobile exhaust and evaporative emissions. Ozone is slow to form and slow to dissipate. It forms most often in mid-morning, and begins to dissipate in late afternoon or early evening (39). After it forms, winds may carry ozone long distances causing elevated levels over wide regions, including rural areas (40).

Ozone reacts with biological membranes in both the upper and lower respiratory tract (41). Symptoms from exposure to low concentrations of ozone include eye, nose, throat, and lung irritation which can cause coughing and wheezing (39). Increased bronchial responsiveness (an alteration of lung function – mainly in expiratory flow) has been observed following 7-hour exposures to 80, 100, or 120 ppb (with moderate exercise); and to 1-hour exposure to 350 ppb of ozone. Responses occur almost immediately following exposure to ozone and can persist for at least 18 hours. Human population studies indicate that people living in communities with high background ozone levels experience a greater decrease in lung function over a five-year period than people living in communities with lower background levels. These studies are consistent with animal studies in suggesting that long-term exposure to ozone may result in impaired lung function. Animal evidence also suggests that exposure to ozone may increase susceptibility to bacterial infections of the respiratory system (41).

Some people are more sensitive to the effects of ozone than others. Children and individuals with existing lung disease, including asthma, bronchitis, and emphysema, are more sensitive to lower levels of ozone. Athletes and workers who are more active outdoors also can be affected when ozone levels are high. When ozone levels are elevated, chances of being adversely affected increase the longer a person is active outdoors and the more strenuous the activity that person engages in. Exertion generally causes one to breathe harder and faster. When this happens, more ozone is taken into the lungs that may reach tissues susceptible to injury. Children have some unique susceptibilities to ozone exposure because they are more likely to spend time outside in active play during warm sunny days and they have smaller and undeveloped lungs. Scientists also have found that about one of every three individuals without a preexisting medical condition is sensitive to the effects of ozone (40).

No synergism has been observed between ozone and either nitrogen dioxide or sulfuric acid in terms of impaired respiratory function. There is also no human information available regarding the carcinogenic effects of ozone exposure, and animal studies are inconclusive (41).

Two years of ozone measurements collected in 2004-2005 at Manchester’s Pearl St. and Concord’s Hazen Drive air monitors demonstrate that ambient air levels of ozone near Suncook Village are well below current air quality standards. Ozone levels, categorized by EPA’s AQI, were “good” more than 92% of the time. About 7% of ozone 8-hour averages reached the “moderate” category, for which EPA advises, *“People unusually sensitive to ozone should consider reducing prolonged or heavy exertion outdoors.”* The one occurrence when the ozone level was “Unhealthy for Sensitive Groups” took place during a regional air pollution event and was not attributable to local sources (25). EPA’s cautionary statement for this level of ozone is, *“Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors.”*

Meteorological data for Suncook Village indicate that the wind patterns associated with increased ozone concentrations (from the south) very seldom coincide with those responsible for higher levels of SO_2 (from the northwest). However, meteorological conditions supporting ozone production and transport can be associated with elevated $PM_{2.5}$ levels. In fact, the highest “monthly average” and “maximum 24-hour” $PM_{2.5}$ concentrations during the 2004-2005 monitoring period (June and July) occurred in the summer ozone season. This seasonal correlation between ozone and $PM_{2.5}$ indicates that adverse health effects (especially in sensitive populations) may result from these infrequent, short-term events. These summer events are not associated with Merrimack Station, but rather originate primarily to the south and west of NH and spread throughout the state and region.

DES issues daily advisories on ozone and $PM_{2.5}$ levels for each of NH's ten counties. When there are indications that either or both of these contaminants can reach unhealthy levels, DES issues warnings for appropriate populations. Suncook residents are encouraged to follow the warnings issued on days when these pollutants are expected to be high.

6.1.4 <u>Air Toxics</u>

This section presents a detailed review of the scientific literature and of findings of this PHA for eight air toxics: benzene, 1,3-butadiene, chloroform, arsenic, chromium, acetaldehyde, formaldehyde, and mercury. The other toxics included in this report are not reviewed below because it was determined in the initial stages of the analysis that they do not represent a health threat in the Suncook area.

6.1.4.1 *Benzene*

Benzene is commonly found in the environment with industrial processes being the main source. Exposure of the general population to benzene is mainly through breathing air that contains the toxic. Benzene levels in the air can increase from industrial emissions, waste and storage operations, motor vehicle exhaust (about 20% of the total nationwide exposure), and evaporation from gasoline service stations. Tobacco smoke also contains high levels of benzene; with about 50% of the entire nationwide exposure to benzene resulting from smoking tobacco or from exposure to environmental ("secondhand") tobacco smoke (42).

Benzene causes problems in the blood. Human studies show that chronic inhalation exposure to benzene can result in harmful effects in the tissues that form blood cells, especially the bone marrow. Excessive exposure to benzene can be harmful to the immune system, increasing the chance for infection and perhaps lowering the body's defense against cancer of the blood-forming organs (leukemia). The U.S. Department of Health and Human Services (USDHHS) categorizes benzene as a known carcinogen (42).

The average ambient air concentration of benzene at Exchange Street during the study period (0.88 ug/m^3) exceeded the ATSDR CREG comparison value (0.1 ug/m^3) (26), but was on the lower end of typical ambient benzene background levels nationwide (0.86 to 5.2 ug/m^3) (43). It was also virtually the same as average benzene levels measured at the five air monitors statewide. There were no significant differences in benzene levels between the five sites. Based on available data, there is no evidence that Merrimack Station has a significant impact on benzene levels in the ambient air in Suncook Village. *Lifetime exposure to benzene levels at Exchange Street would result in a theoretical excess cancer risk of 2.8 per million exposed, which would result in no detectable effect on cancer rates in the Suncook area now or in the future.*

The potential for non-carcinogenic health effects of benzene was also evaluated through comparison with EPA's RfC of 30 ug/m^3 and an average daily dose calculated for benzene (25). Average ambient benzene concentrations measured in Suncook Village were below the RfC, and the average daily inhalation dosage was less than the RfD. Furthermore, human studies of non-cancer health outcomes related to benzene have shown no adverse hematological effects at levels even 2000 times higher than those recorded at Exchange Street. Therefore, *non-cancer health effects are not expected from this exposure* (42).

6.1.4.2 *1,3-Butadiene*

1,3-butadiene is a colorless gas with a mild gasoline-like odor that breaks down quickly in the air. In fact, half of 1,3-butadiene goes away from the air in about 2 hours during sunny weather. 1,3-butadiene is produced from petroleum and is used to make man-made rubber (car and truck tires) and plastics. 1,3-butadiene is also found in gasoline, automobile exhaust, cigarette smoke, and wood fires. Thus, it is always present at very low levels in the air around cities and towns. (44).

Heart disease, blood disease, lung disease, and certain cancers are the principal health effects that can result from long-term exposure to low levels of 1,3-butadiene combined with other chemicals. The exact composition and proportion of these chemical combinations are unknown. Inhalation of 1,3-butadiene is mildly narcotic in humans at low concentrations and may result in a feeling of lethargy and drowsiness (44).

The average ambient air concentration of 1,3-butadiene at Exchange Street during the study period (0.13 ug/m^3) exceeded the ATSDR CREG comparison value (0.03 ug/m^3) (25), but was about one-fifth that typically found in the ambient air of cities and suburbs in the US (0.66 ug/m^3). Results of the DES *Air Toxics Report* revealed no statistically significant difference in 1,3 butadiene levels between the five monitoring locations across the state. This suggests the existence of a statewide background level of this compound, and also provides no evidence that Merrimack Station impacts significantly on 1,3 butadiene levels in Suncook Village. Lifetime exposure to 1,3-butadiene levels at Exchange Street would result in a theoretical excess cancer risk of 1.7 per million exposed, which would result in no detectable effect on cancer rates in the Suncook area now or in the future. Therefore, *exposure to 1,3-butadiene in the ambient air of Suncook Village is not expected to significantly impact cancer rates* (44).

The potential for non-carcinogenic health effects of 1,3 butadiene was also evaluated through comparison with EPA's RfC of 2.0 ug/m^3 and an average daily dose calculated for 1,3-butadiene (25). Average ambient 1,3 butadiene concentrations measured in Suncook Village were below the RfC, and the average daily inhalation dosage was less than the RfD. The NOAEL for animals (based on studies of laboratory mice) is roughly 100,000 times higher than levels recorded in Suncook Village. Furthermore, there is evidence that mice may be more susceptible to 1,3 butadiene-induced effects than primates. Therefore, *non-cancer health effects are not expected from this exposure* (44).

6.1.4.3 *Chloroform*

Chloroform is a colorless liquid with a pleasant, non-irritating odor and a slightly sweet taste. Most of the chloroform found in the environment comes from chemical manufacturing, paper mills, and from sewage treatment and water-treatment plants. Chloroform persists in the air, but is eventually broken down. Chloroform was also one of the first inhaled anesthetics to be used during surgery, but it is not used for anesthesia today (45).

Most research on inhalation exposure to chloroform in humans is based on clinical reports describing health effects in patients under anesthesia. In humans, chloroform affects the central nervous system (brain), liver, and kidneys after a person breathes air or drinks liquids that contain large amounts of chloroform. Breathing elevated levels of chloroform for a short time also causes fatigue, dizziness, and headache. Based on animal studies, USDHHS concludes that chloroform may reasonably be anticipated to be a carcinogen. EPA has also determined that chloroform is a probable human carcinogen. These studies are based on oral, not inhalation exposure. However, because chloroform has identical toxicological end points following oral or inhalation exposure, CVs based on oral exposure to chloroform can be used to evaluate inhalation exposure (45).

The average ambient air concentration of chloroform at Exchange Street during the study period (0.17 ug/m^3) exceeded the ATSDR CREG comparison value (0.04 ug/m^3), but was virtually identical to the average level of the five air monitors statewide (0.16 ug/m^3). There were no significant differences in chloroform levels between any of these five monitors. These results present no evidence that Merrimack Station has a significant impact on chloroform levels in the ambient air in Suncook Village. *Lifetime exposure to chloroform levels at Exchange Street would result in a theoretical excess cancer risk of 1.6 per million exposed, which would result in no detectable effect on cancer rates in the Suncook area now or in the future*.

The potential for adverse non-carcinogenic health effects of chloroform was also evaluated through comparison with an EPA Chronic CV of 35.0 ug/m^3 and an average daily dose calculated for chronic chloroform inhalation (24). Average ambient air concentrations measured in Suncook Village were below the CV, and the average daily inhalation dosage was less than the RfD. The LOAEL for chloroform is 50,000 times higher than the Exchange Street level. Scientific literature also documents that average background concentrations of chloroform range from 2-5 micrograms per day in rural areas, to 6-200 micrograms per day in cities (45). Therefore, *it is unlikely that inhalation of chloroform in the ambient air near Suncook Village would result in adverse non-cancer health effects* (45).

6.1.4.4 *Arsenic*

Arsenic is a naturally occurring element that is usually found in the environment (i.e., soil, rocks, and minerals) combined with other elements such as oxygen, chlorine, and sulfur. Arsenic combined with these elements is called inorganic arsenic. Arsenic combined with carbon and hydrogen is referred to as organic arsenic, which is usually less harmful than the inorganic forms. Larger arsenic particles enter the air from windblown dust and soil as well as volcanic eruptions. Anthropogenic (man-made) sources of arsenic also include nonferrous metal smelting, coal, oil and wood combustion, and municipal waste incineration. This arsenic is attached to fine particles (<2.5 µm) and may be transported through the air for many days and over long distances. Mean ambient air arsenic levels in urban areas range from 0.020 to 0.030 ug/m^3. A more regional average annual ambient air arsenic concentration measurement collected at Nahant, MA (between September 1992 and September 1993) was 0.0012 µg/m^3; with 75% of the arsenic particles less than 2.5 µm. This concentration of arsenic is nearly identical to that of the Suncook area (0.0013 µg/m^3) (46).

Most cases of human toxicity from arsenic have been associated with exposure to inorganic arsenic. The most common inorganic arsenical in air is arsenic trioxide (As_2O_3) which was used for comparative purposes in this paper. This is a conservative assumption because Exchange Street monitoring data are reported as total arsenic, and the respective amounts of each arsenic compound can not be determined. An additional conservative assumption concerns the bioavailability of inhaled arsenic. Bioavailability refers to the fraction of the inhaled amount of arsenic that is absorbed into the body. The lower the bioavailability of an inhaled toxin, the less toxic its effect. Studies have shown that the amount of arsenic bioavailable to humans is less than levels monitored in the environment, so the actual dose is lower. Therefore, inhalation of arsenic from ambient air is usually a minor exposure route for the general population (46).

Inhalation of inorganic arsenic is associated with sore throat, lung irritation (possibly leading to laryngitis, bronchitis, or rhinitis), adverse skin effects (dermatitis, warts, and corns) as well as circulatory and peripheral nervous disorders. Evidence from several epidemiological studies demonstrates that inhalation exposure to inorganic arsenic also increases the risk of several lung cancers in humans (epidermoid carcinoma, small cell carcinoma, and adenocarcinoma). However, most studies involved occupational exposure to large doses of arsenic trioxide dust in air at copper smelters and mines, and arsenate exposure at chemical plants. Several environmental and health organizations including EPA and USDHHS have concluded that inorganic arsenic is carcinogenic to humans (46).

The average ambient concentration of arsenic at Exchange Street during the study period (0.0013 ug/m^3) exceeded the ATSDR CREG comparison value of 0.0002 ug/m^3 (26). *Lifetime exposure to arsenic levels at Exchange Street (based on the worst-case scenario of exposure to inorganic arsenic) would result in a theoretical excess cancer risk of 2.3 per million exposed, which would result in no detectable effect on cancer rates in the Suncook area now or in the future*.

The potential for non-carcinogenic health effects of arsenic was also evaluated through comparison with an EPA Chronic CV of 0.5 ug/m^3 and an average daily dose calculated for chronic arsenic inhalation (24). Average ambient arsenic concentrations measured in Suncook Village were below the CV, and the average daily inhalation dosage calculated by EHP was less than the RfD. The LOAEL for inorganic arsenic is 5,000 times higher than the Exchange Street level. Therefore, *adverse non-cancer health effects from arsenic are not expected, even in the worst-case scenario* (that all arsenic measured is in its inorganic form) (46).

6.1.4.5 *Chromium*

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases. Chromium is also released into the atmosphere mainly by anthropogenic stationary point sources, including industrial, commercial, and residential fuel combustion, via the combustion of natural gas, oil, and coal. Additional anthropogenic sources of chromium air emissions include the metal industries, cement-producing plants, the erosion of asbestos brake linings that contain chromium, incineration of municipal refuse and sewage sludge, and emission from chromium-based automotive catalytic converters (47).

Chromium is present in the environment in several different forms (or "valence states"). The most common forms are chromium (0), trivalent [or chromium (III)], and hexavalent [or chromium (VI)]. Chromium (III) occurs naturally in the environment and is an essential nutrient required by the human body. However, chromium (VI) and chromium (0) are generally produced by industrial processes (by the oxidation of chromium (III) compounds). In general, chromium

(VI) is more toxic than chromium (III). Of the estimated 2,700–2,900 tons of chromium emitted to the atmosphere annually from anthropogenic sources in the United States, 0.35% is in the hexavalent form (47).

In air, chromium compounds are present mostly as fine dust particles. The level of chromium in air is generally low. According to a study by Fishbein, the atmospheric total chromium concentration [both chromium (III) and chromium (VI)] in the United States is typically <0.01 ug/m^3 in rural areas and 0.01 - 0.03 ug/m^3 in urban areas. Chromium is primarily removed from the atmosphere by fallout and precipitation. According to Nriagu, the residence time of chromium in the atmosphere is expected to be <10 days (47).

The respiratory tract in humans is a major target of inhalation exposure to chromium compounds. When chromium particles in the air are inhaled, they can be deposited in the lungs. Particles that are deposited in the upper part of the lungs are likely to be coughed up and swallowed. However, particles deposited deep in the lungs are likely to remain long enough for some of the chromium to pass through the lining of the lungs and enter the bloodstream. Once in the bloodstream, chromium is distributed to all parts of the body. Chromium will then pass through the kidneys and be eliminated in the urine in a few days (47).

Occupational exposure to high levels of chromium (VI) compounds has been associated with increased risk of respiratory system cancers, primarily bronchogenic and nasal. The inhalation risk may be exacerbated by cigarette smoking or exposure to environmental (secondhand) tobacco smoke. On the other hand, studies have shown that inhaling small amounts of chromium (VI) for even long periods of time does not cause a problem in most people. An epidemiological study by Axelsson and Rylander found no indication that residence near two chromium industries was associated with increased lung cancer risk. Based on occupational and animal studies, USDHHS has categorized certain chromium (VI) compounds as “known human carcinogens”. Hexavalent chromium is categorized by EPA as a human carcinogen via the inhalation route. Trivalent chromium is not (47).

The average ambient air concentration of chromium at Exchange Street during the study period (0.00126 ug/m^3) exceeded the ATSDR CREG comparison value (0.00008 ug/m^3). Since Exchange Street air monitoring data are reported as total chromium, respective concentrations of hexavalent and trivalent chromium are not known. As noted earlier, less than one percent of chromium emitted from man-made sources is in the hexavalent form (45). To approximate a worst-case scenario, however, the assumption of this analysis is that all of the total chromium reported was hexavalent chromium. *Lifetime exposure to these hypothetical hexavalent chromium levels at Exchange Street would result in a theoretical excess cancer risk of 6.2 per million exposed, which would result in no detectable effect on cancer rates in the Suncook area now or in the future.*

The potential for chronic non-carcinogenic health effects of chromium was also evaluated through comparison with EPA’s RfC of 0.1 ug/m^3 and an average daily dose calculated for chromium (VI) particulates (25). Average ambient chromium concentrations measured in Suncook Village were below the RfC, and the average daily inhalation dosage calculated by EHP was less than the RfD. The lowest LOAEL for less serious respiratory effects related to chromium (VI) is 1,600 times higher than the Exchange Street level. The lowest NOAEL for the renal effects in humans exposed to the less toxic trivalent chromium is 60,000 times higher than levels recorded in Suncook Village. Therefore, *non-cancer health effects are not expected from exposure to chromium at levels detected in ambient air* (47).

6.1.4.6 *Acetaldehyde*

Acetaldehyde is widely distributed in the environment. Consequently, individuals are exposed to acetaldehyde by breathing ambient air. Acetaldehyde has a pungent odor at high concentrations, but has a fruity and pleasant odor at dilute concentrations. Acetaldehyde is used in the production of perfumes, polyester resins, and basic dyes. Acetaldehyde is also used as a fruit and fish preservative, as a flavoring agent, and as a denaturant for alcohol, in fuel compositions, for hardening gelatin, and as a solvent in the rubber, tanning, and paper industries. Acetaldehyde is created naturally by plant respiration, but is also formed by incomplete wood combustion in fireplaces and woodstoves (the two highest sources of emissions) as well as coffee roasting, burning of tobacco, vehicle exhaust fumes, and coal refining and waste processing (48).

Symptoms of chronic intoxication of acetaldehyde in humans resemble those of alcoholism (acetaldehyde is formed in the body from the breakdown of alcohol). In hamsters, chronic inhalation exposure to acetaldehyde has produced changes in the nasal mucosa and trachea, growth retardation, slight anemia, and increased kidney weight. Human data regarding the carcinogenic effects of acetaldehyde are inadequate. However, acetaldehyde is considered a probable human carcinogen by EPA (Group B2) based on animal studies that have shown tumor growth in rats and in hamsters. The RfC for acetaldehyde is 9.0 ug/m^3 based on rat studies (48).

The average ambient air concentration of acetaldehyde at Exchange Street during the study period (2.04 ug/m^3) exceeded the ATSDR CREG comparison value (0.5 ug/m^3) (25), but was close to the median ambient concentration for all five sites of the DES *Air Toxics Report* (1.9 ug/m^3). Trends over time were also similar for all five sites. These results present no evidence that Merrimack Station has a significant impact on acetaldehyde levels in the ambient air in Suncook Village. *Lifetime exposure to acetaldehyde levels at Exchange Street would result in a theoretical excess cancer risk of 1.9 per million exposed, which would result in no detectable effect on cancer rates in the Suncook area now or in the future*.

The potential for non-carcinogenic health effects of acetaldehyde was also evaluated through comparison with EPA's RfC of 9.0 ug/m^3 and an average daily dose calculated for acetaldehyde (25). Average ambient acetaldehyde concentrations (2.04 ug/m3) measured in Suncook Village were below the CV, and the average daily inhalation dosage calculated by EHP was also less than the RfD. Scientific literature shows that the lowest levels at which adverse health effects result from exposure to acetaldehyde are 4,200 times higher than those recorded at Exchange Street. Therefore, *non-cancer health effects are not expected from this exposure* (48).

6.1.4.7 *Formaldehyde*

Formaldehyde is a colorless, flammable gas at room temperature with a pungent, distinct odor. Formaldehyde is released to outdoor air from both natural and industrial sources. Combustion processes account directly or indirectly for most of the formaldehyde entering the environment. Direct combustion sources include power plants, incinerators, refineries, wood stoves, and diesel and gasoline-powered engines. Formaldehyde is also used in the production of embalming fluid, fertilizer, paper, particle board and plywood, resins, cosmetics, as well as agriculture, rubber, latex, wood preservation, leather, metal (foundry), and the photographic film industries. Natural sources of formaldehyde include forest fires, animal wastes, microbial products of biological systems, and plant volatiles (49).

Median ambient formaldehyde concentrations are estimated to be between 2.5 - 7.4 ug/m^3 (2–6 ppb) in suburban areas, and 12.3 – 24.6 ug/m^3 (10–20 ppb) in urban or industrial areas. Formaldehyde concentrations in urban atmospheres are usually highest during, or shortly after, periods of high vehicular traffic with downwind locations spiking later in the same day. These daily changes in formaldehyde concentrations were found to be consistent with initial direct vehicles emissions followed by secondary photochemical production (from photochemical oxidation of hydrocarbons or other formaldehyde precursors released from combustion processes) and, ultimately, atmospheric removal (breakdown) (49).

Generally, indoor residential formaldehyde concentrations are significantly higher than outdoor ambient air concentrations. Formaldehyde is released into indoor air from many home products including latex paint, new carpets/carpet-cleaning agents, particle board, furniture, cosmetics, fiberglass products, plastics/laminates, glues and adhesives, lacquers, paper, and some permanent press fabrics. Indoor concentrations of formaldehyde are increased by un-vented gas or kerosene heaters and smoking tobacco products indoors. Families can reduce their risk of exposure to formaldehyde by:

1. removing the sources of formaldehyde;
2. not using un-vented heaters, such as portable kerosene heaters;
3. not smoking indoors;
4. washing new clothes made from permanent press fabrics; and
5. providing adequate ventilation when using consumer products, or when installing pressed wood products, new carpets, or new furniture (49).

Inhalation exposure to formaldehyde can be irritating to the upper respiratory tract (nose and throat) and eyes, with the lungs being a secondary target at high exposure levels. However, because formaldehyde is rapidly metabolized (detoxified), concentrations normally encountered in ambient or workplace atmospheres do not usually result in adverse effects in other parts of the body. The effects of formaldehyde inhalation have been shown to be similar between normal or asthmatic individuals (either at rest or after exercise), however conflicting data may require further study of potentially sensitive populations. The chronic inhalation MRL is based on a minimal LOAEL for mild damage to the nasal tissue in chemical workers exposed to formaldehyde. In 1991, EPA determined that formaldehyde is a probable human carcinogen (Group B1) based on limited evidence in humans and sufficient evidence in laboratory animals (49).

The average ambient air concentration of formaldehyde at Exchange Street during the study period (4.29 ug/m^3) exceeded the ATSDR CREG comparison value (0.08 ug/m^3) (26), but was within typical background levels, and is lower than in most conventional homes. In addition, the DES *Air Toxics Report* found that there was no statistically significant difference in median ambient air concentrations of formaldehyde between the five sampling sites statewide, and seasonal concentration trends were similar for all five sites. These results present no evidence that Merrimack Station has a significant impact on formaldehyde levels in the ambient air in Suncook Village. *Lifetime exposure to formaldehyde levels at Exchange Street would result in a* *theoretical excess cancer risk of 23 per million exposed, which would result in no detectable effect on cancer rates in the Suncook area now or in the future.*

The potential for non-carcinogenic health effects of formaldehyde was also evaluated through comparison with the ATSDR Chronic CV of 9.8 ug/m^3 and an average daily dose calculated for formaldehyde (26). Average ambient formaldahyde concentrations measured in Suncook Village were below the CV, and the average daily inhalation dosage calculated by EHP was less than the RfD. A review of the literature shows that harmful health effects do not begin to occur until formaldehyde levels are 70 times higher than those recorded at Exchange Street. Therefore, *non-cancer health effects are not expected from this exposure* (49).

6.1.4.8 *Mercury*

Mercury occurs naturally in the environment and exists in several forms including: metallic mercury (also known as elemental mercury), inorganic mercury, and organic mercury (i.e., methylmercury). Approximately 80% of the total mercury released from human activities is elemental mercury released to the air, primarily from fossil fuel combustion, mining, smelting, and solid waste incineration. The remaining 20% is released to the soil from fertilizers, fungicides, forest fires, volcanoes, and municipal solid waste (i.e., discarded batteries, electrical switches, or thermometers). Mercury is also released to water from industrial wastewater discharges. The major target organs of elemental mercury-induced toxicity are the kidneys and the central nervous system. Typical levels of mercury in urban air (0.01-0.02 ug/m^3) do not pose a health risk through inhalation (50). Maximum ambient mercury concentrations in the Suncook area (modeled by DES) of 0.000419 ug/m^3 (24-hour) and 0.0000357 ug/m^3 (annual) do not exceed the ATSDR CV of 0.2 ug/m^3 (26). Therefore, *health effects are not expected to occur from inhalation exposure to mercury*.

The general population is most commonly exposed to mercury from eating fish containing methylmercury in their tissues. After mercury compounds are released into the environment and deposited in water and sediment (washed out of the air by precipitation), microorganisms such as bacteria, phytoplankton in the ocean, and fungi convert it to methylmercury. In aquatic environments, methylmercury subsequently accumulates in edible fish to levels that are many times greater than levels in the surrounding water. The primary effect of methylmercury exposure in humans is neurotoxicity. Methylmercury can cause adverse developmental effects in young children because it easily passes into the developing brain. Furthermore, methylmercury can accumulate in an unborn baby's blood at concentrations higher than in the mother, and can be passed from a mother's breast milk to a nursing infant (50). Accordingly, EHP has issued a fish consumption advisory which outlines specific local water bodies where fish have shown to be contaminated with methylmercury. EHP's advisory also provides safe eating guidelines (limits on certain fish types and sizes), as well as fish preparation guidelines to limit exposure (51).

Since 1998, statewide mercury emissions in New Hampshire have been reduced by approximately 60% through a number of projects and regulatory actions initiated by DES, the NH legislature, and the federal government (52). These initiatives have resulted in reductions from municipal waste combustors and medical waste incinerators, as well as the elimination of mercury in batteries and product packaging, promotion of mercury-containing waste recycling, and prohibiting mercury-containing pesticides. Information concerning these initiatives is available at: http://www.des.state.nh.us/nhppp/merc20.htm.

There is no doubt that some of the methylmercury deposited in New Hampshire's lakes and streams originates from sources within the State. Unfortunately, current methods of evaluating links between the emission, transport, and deposition of mercury in particular water bodies are not highly accurate (53). In addition, water bodies exhibit a wide variation in their propensity to convert mercury from its inorganic to organic state, regardless of the amount deposited. DES recently spearheaded a bill in the New Hampshire Legislature to reduce mercury emissions from power plants. Based on 2003 testing, Merrimack Station has released about 125 pounds of mercury annually into the environment in recent years. The bill, which was passed in March 2006, requires a reduction in these emissions by at least eighty percent by the year 2013. The pollution control equipment installed to reduce mercury emissions will also significantly reduce the amount of SO_2 and particulate emissions. In addition, DES continues to work with other New England states and Eastern Canadian provinces to curtail the amount of mercury released into the environment (53).

6.1.5 <u>Summary: Public Health Implications of Pollutants of Interest</u>

The public health implications of the 11 pollutants of interest are summarized below.

- Sulfur dioxide (SO_2) – Ambient air levels of SO_2 recorded at Exchange Street Station during the two-year study period are not expected to result in adverse health effects among members of the general public. There were infrequent instances, usually of 1-2 hours duration, in which SO_2 reached levels during which unusually sensitive asthmatics should consider reducing prolonged or heavy exertion outdoors.

- Fine particulate matter ($PM_{2.5}$) – Levels of $PM_{2.5}$ recorded at Exchange Street during the two-year study period are not expected to result in adverse health effects among members of the general public. There were several days during which $PM_{2.5}$ reached AQI's "moderate" category. EPA recommends that *"unusually sensitive people should consider reducing prolonged or heavy exertion"* during moderate $PM_{2.5}$ days. There was one instance during this period in which the average daily $PM_{2.5}$ reached a level defined as "unhealthy for sensitive groups" such as those with heart or lung disease, older adults, and children. This particular event was regional in nature and therefore not associated with emissions from Merrimack Station.

- Ozone – Levels of ozone recorded at Concord and Manchester air monitoring stations during the two-year study period are not expected to result in adverse health effects among members of the general public. There were several days during which ozone reached AQI's "moderate" category. EPA recommends that *"people unusually sensitive to ozone should consider reducing prolonged or heavy exertion"* during moderate ozone days. There was one day during which the 8-hour average ozone reading reached a level defined as "unhealthy for sensitive groups" such as active children and adults, and people with respiratory disease (such as asthma). As with most ozone elevations, this was a multi-state event attributable to regional sources and not associated with Merrimack Station.

- Air Toxics – Levels of air toxics recorded during the study period are not expected to result in adverse health effects. Air toxics levels at Exchange Street Station were consistent with those from other air monitors across the state regardless of season, wind direction, and other factors. The levels recorded across the state are expected to have no effect on rates of non-cancer diseases. Their effect on cancer rates across the state is expected to be undetectable now and in the future.

6.2 Child Health Considerations

There are many differences between children and adults with respect to potential adverse effects of air pollution. During exercise, children take in 20-40% more air per unit body weight than do adults in comparable activities. When air pollution is at higher levels, children are therefore more susceptible to its effects. Children spend more time outside than adults, and are often outdoors during periods when air pollution is at its highest (e.g., late afternoon summer days when ozone levels can be highest). The typical adult spends 85 to 95 percent of their time indoors, compared to less than 80 percent for children. When playing outside, children also generally exert themselves more than adults.

One of the most important differences between adults and children with regard to air pollution is that children are growing and developing. Along with their increasing body size, children's lungs are growing and changing (16). The human lung contains more than 40 different kinds of cells. Each of these cell-types is important to health and fitness. Air pollution can temporarily or permanently damage lung cells. If cells that play a role in the development of a child’s lung are damaged by air pollution, then the lung may not achieve full growth and function as the child matures to adulthood.

Children are also more susceptible to short-term effects of air pollution. A study of asthmatic children who engage in competitive sports in twelve California communities showed that those living in areas with high pollution levels were more likely to experience asthma exacerbation events than their counterparts in low-pollution areas (16). Although Suncook is not a “high-pollution area” as defined in the California study, it does experience occasional air pollution events during which asthmatic children should take necessary precautions.

The use of conservative CVs in this public health assessment ensures that the health interests of children are taken into account at every step in this evaluation. Parents, school administrators, educators, and other custodial adults should adhere to the recommendations of DES “Air Quality Action Days” (AQAD) and be cognizant of health symptoms related to air pollution. DES disseminates information regarding forecasted AQADs through formal press releases, and posts the information on the DES website at: (www.des.state.nh.us). Daily air quality information is also available at: http://www.des.state.nh.us/airdata/air_quality_forecast.asp. Finally, Suncook area parents and other adults should also be aware of the conclusions and recommendations of this report, particularly those addressing local air pollution events.

7.0 HEALTH OUTCOME DATA REVIEW

7.1 Background

A health outcome data review is used to evaluate disease burden in a community. The objective is to determine if rates of certain adverse health effects in an area are higher than expected when compared to a standard reference group. EHP follows a prescribed process to determine if health outcome data should be reviewed. If the review of environmental data concludes that a completed exposure pathway exists and may lead to adverse health effects, then a Health Outcome Data Review is conducted.

The environmental data review of ambient air in Suncook Village identified short-term elevations in SO_2, $PM_{2.5}$, and ozone as being of some concern, especially to asthmatics. Based on these findings, EHP conducted a review of emergency department (ED) hospitalization data on respiratory-related diagnoses among Suncook area residents from 2000-2004. (For purposes of this analysis, the “Suncook Area” is comprised of the towns of Pembroke and Allenstown.)

In addition to reviewing hospital ED information, cancer data for the Suncook area were analyzed to address a “community concern” about cancer rates. In this case, the community concern was expressed by a Suncook resident in response to an EHP needs assessment inviting community members to share any concerns they might have about air quality or its possible health effects. The findings of this Health Outcome Data review are presented below.

7.2 Respiratory-Related Emergency Department Visits, 2000-2004

As noted in previous sections, short term elevations in SO_2 or $PM_{2.5}$ can result in adverse health effects among asthmatics and others with chronic respiratory disease. Most patients who receive an emergency department (ED) principal diagnosis of asthma or other respiratory disease are seeking care for an exacerbation of an existing respiratory condition. Thus, respiratory ED rates are commonly used as indicators of respiratory exacerbation events. This section compares respiratory-related ED visit rates of the towns of Pembroke and Allenstown (the “Suncook area”) with those of the state as a whole.

The NH Department of Health and Human Services (DHHS) began collecting inpatient hospital discharge data in 1986, and has been collecting outpatient data since 1995. Health Statistics and Data Management, within DHHS, is responsible for collecting the data. Beginning in 1999, the outpatient discharge data set specifically differentiated among three types of outpatient discharges: ambulatory surgery; emergency department visits; and observation stays. The current analysis is based on emergency department visits. Data are abstracted from medical records upon patient discharge and submitted electronically to the DHHS contractor responsible for compiling and creating the data set. The data set includes information from the emergency departments of all 26 of NH’s acute care hospitals. It does not include NH resident ED visits to out-of-state facilities. For most communities, out-of-state utilization does not significantly impact their ED rates. Out-of state visits also account for a small proportion of overall state ED utilization.

Another limitation of most routinely-collected hospitalization data is that they are collected for billing purposes, not for epidemiological analysis. The extent of this limitation for the study of any given disease or diagnostic category varies widely. Its effect on the current examination of asthma and other respiratory disease cannot be quantified.

7.2.1 Data Analysis

In the current study, ED respiratory-related rates of Suncook area residents are compared with those of all NH residents. ED discharges with principal diagnosis of asthma (International Classification of Diseases – 9th revision [ICD-9] 493) and non-asthma respiratory disease (ICD-9 460-492, 494-496) are analyzed by gender and age (0-19, 20-44, 45-64, and 65+) for the five-year period 2000-2004. Suncook and State ED rates for “non-respiratory admissions” are also examined in order to place respiratory-related rates into the context of overall ED utilization.

Along with age-sex specific rates, this analysis includes statistics based on the number of “expected” and “observed” ED visits for Suncook area residents (see Table 17-1). The expected number of visits for the Suncook area is calculated by applying the statewide age-sex specific rate to the Suncook area population. The “observed/expected” ratio is calculated to represent the relative relationship between each Suncook rate and the corresponding state rate. The “observed – expected difference” indicates the theoretical number of “excess” or “avoided” visits attributable to the difference between the state and local rates.

Interpretation of rates based on hospital discharge data is often complex, and results are usually open to many alternative explanations. Following is a discussion of several of these alternatives. The discussion is based on a comparison of two hypothetical communities of equal size, with the exact age-race-sex composition as one another. The only known difference between them is that one community has an asthma ED rate that is higher than that of the other community by a statistically significant margin. Below is a brief discussion of each of six “ideal type” explanations that compete to explain the difference. In real-world situations, each of these explanations contributes in varying degrees to differences between the ED rates of any two groups or communities, including those of the Suncook area and the State of NH in this analysis.
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1) According to the **true incidence explanation**, there is a “real” difference in the rate of asthma exacerbation events that are severe enough to result in an ED visit. There are several possible causes of this actual difference including: a) lack of primary care and asthma management (often related to health insurance status) which can allow a condition to worsen to the point where an asthmatic requires ED care; and b) a noxious stimulus in the environment (e.g., indoor or outdoor allergens or air pollutants) that is more common in one community than the other and therefore triggers a greater number of exacerbation events. These two phenomena are not necessarily mutually exclusive. For example, communities with higher levels of air pollution often require more asthma management resources than do those with lower levels of pollution.
2) The **true prevalence explanation** posits that it is the difference in the number of asthmatics between the two communities that accounts for the difference in asthma ED rates. In other words, the visit rate per asthmatic is the same, but there are more asthmatics in one community than the other.
3) The **severity explanation** proposes that the two communities have the same prevalence (number) of asthmatics, but that one community has a higher proportion of “severe” asthmatics than the other, resulting in more ED visits.

4) According to the **access/utilization explanation,** there is no difference in the incidence of severe asthma events, the prevalence of asthmatics, or the proportion of severe asthmatics in a community. Rather, there is a greater tendency for members of one community than the other to use the ED for “non-emergent care”. This phenomenon is usually associated with a lack of access to primary care in a community.
5) The **diagnosis shift explanation** is based on the idea that ED physicians in one community are more likely to choose “asthma” over competing diagnoses than are physicians in the other community. In the current analysis, this shift is most likely to occur between asthma and other respiratory diseases.
6) Finally, there is the **chance explanation**, which is posited in recognition of the fact that even “statistically significant” differences are sometimes due to random fluctuation.

As noted above, these are “ideal types”. In real life they all interact to some degree to impact ED rates. The challenge is to empirically determine which among them contribute most to differences in reported rates. Given the limitations of hospital discharge data, more definitive answers can often be answered only by more in-depth study.

Analysis of ED rates for the Suncook area and the State of NH is presented below for the five-year period 2000-2004. This time period was selected because it is the most recent data available, and because multiple years of data are needed to provide large enough numbers to yield meaningful statistics for smaller areas such as the two towns of Pembroke and Allenstown. Variables analyzed include city/town of residence at time of discharge, principal diagnosis, date of discharge, age at discharge, and sex. Information on other risk factors, such as health-related behaviors, environmental and occupational exposures, or access to medical care, is not available in the abstracted medical billing data used in this review.

Population data for the State of NH and the towns of Pembroke and Allenstown are from the 2000 US Census of the Population. Tests of statistical significance (based on the Poisson distribution) were calculated to determine whether or not each age-sex rate for the Suncook area population is different from the corresponding State rate at the .05 level of statistical significance ($p<.05$).

7.2.2 Results

Table 7-1 presents ED visit rates and related statistics for the State of NH and the Suncook area. Among the 0-19 age group, the only Suncook rate that is higher than the state rate is male asthma visits. The difference is not statistically significant and results in only 5 additional ED visits over the 5-year period (Observed-Expected Difference). “Other respiratory” ED rates for males and females in this age group are significantly lower than the corresponding state rates, as is the male non-respiratory rate.

Asthma ED visit rates for males and females age 20-44 are both significantly elevated compared to the state as a whole. The Suncook male rate is 43% higher than the corresponding state rate, resulting in 22 more hospital visits than “expected” over the five-year period. The female rate for Suncook is 26% higher with 25 “excess” ED visits (5 per year). The fact that non-respiratory ED rates of both males and females in this age group are significantly elevated compared to the state suggests that "overutilization" of ED services in general plays a role in the elevated asthma rates, although the magnitude of the non-respiratory differential is somewhat less than that for asthma. Significantly "lower-than-expected" ED rates for "other respiratory" diagnoses keeps open the possibility of some diagnosis shifting from this category to asthma in some cases. The overall rate of respiratory-related ED visits (combining asthma and "other" categories) is higher for the state than for the Suncook area.

Table 17-1. Emergency Department visits per 10,000 population (NH Total and Suncook area), and related statistics for Suncook area ED visits: 2000-2004

Age	Gender	Diagnosis	State Rate	Suncook Area			Observed/ Expected Ratio	Observed - Expected Difference
				Rate	Observed Number	Expected Number		
Age 0-19	Male	Asthma	57.4	62.5	56	51	1.09	+5
		Other Resp	401.9	356.9	320	360	0.89*	-40
		Non-Resp	2943.0	2711.7	2431	2638	0.92*	-207
	Female	Asthma	44.4	42.0	35	37	0.95	-2
		Other Resp	426.9	302.5	252	356	0.71*	-104
		Non-Resp	2720.1	2609.8	2174	2266	0.96	-92
Age 20-44	Male	Asthma	47.0	67.2	74	52	1.43**	+22
		Other Resp	298.9	256.1	282	329	0.86*	-47
		Non-Resp	3659.1	4300.6	4735	4029	1.18**	+706
	Female	Asthma	82.3	104.1	118	93	1.26**	+25
		Other Resp	439.2	368.8	418	498	0.84*	-80
		Non-Resp	3866.9	4262.0	4831	4383	1.10**	+448
Age 45-64	Male	Asthma	21.8	####	####	14	####	-13 to -10
		Other Resp	179.7	163.8	106	116	0.91	-10
		Non-Resp	2380.7	2357.0	1525	1540	0.99	-15
	Female	Asthma	47.1	54.3	36	31	1.15..	+5
		Other Resp	248.3	294.3	195	165	1.19**	+30
		Non-Resp	2416.8	2700.4	1789	1601	1.12**	+188
Age 65+	Male	Asthma	16.3	####	####	4	####	-3 to 0
		Other Resp	309.0	160.7	38	73	0.52*	-35
		Non-Resp	3109.1	2135.3	505	735	0.69*	-230
	Female	Asthma	24.1	19.4	7	9	0.81*	-2
		Other Resp	281.1	133.3	48	101	0.47*	-53
		Non-Resp	3078.6	2063.9	743	1108	0.67*	-365

*** Suncook area rate significantly lower than State rate (p<.05)**

**** Suncook area rate significantly higher than State rate (p<.05)**

Statistics based on 1 through 4 events are suppressed for confidentiality purposes.

Among 45-64 year-olds, male rates for Suncook residents are not significantly different than those statewide. Suncook area female rates for other respiratory and non-respiratory ED visits are each significantly higher than state rates, while Suncook asthma rates are higher, but account for only one excess ED visit per year.

Among the Suncook population age 65 and older, all age-sex diagnostic categories with sufficient enough numbers to report ED rates are significantly lower than the corresponding state rates. The magnitude of the difference between the two groups indicates some major underlying factor, perhaps relating to differences in the age distribution within this age cohort between the two populations.

To summarize, there are at least two age-sex groups in the Suncook area whose asthma ED visit rates warrant further exploration: males and females age 20-44. The current analysis presents some evidence that diagnosis shifting may contribute to these elevated visit rates. It also cites higher overall ED utilization by these groups as possibly contributing to the elevation. A future health consultation will explore these and other possible explanations in more depth by examining rates based on the number of **patients**, in addition to those based on the number of **visits** employed in the current analysis. This will enable calculation of “visits per patient” and other rates that will provide evidence relating to the true incidence and severity explanations. The diagnosis shift explanation will be explored further by comparing the distribution of diagnoses received by Suncook area residents with those received by non-Suncook residents in the same hospital ED settings. These will in turn be compared with diagnostic patterns statewide. The health consultation will also include a year-to-year trend analysis of respiratory ED rates for each population, as well as a comparison of seasonality trends between the Suncook area and the state. All of these analyses will be carried out with the same aggregate-level database employed in the current analysis.

7.3 Cancer Incidence, 1987-2001

Cancer incidence data for the Suncook area were analyzed in response to a community concern about local cancer rates. The review of environmental data in this PHA did not identify any possible pathways between ambient air measurements in Suncook Village and any type of cancer.

Cancer became a reportable disease in New Hampshire in 1985, and since 1986 the New Hampshire State Cancer Registry (NHSCR) has been charged with identifying all new cases of cancer occurring among New Hampshire residents. Health Statistics and Data Management (HSDM), under the New Hampshire Department of Health and Human Services (NHDHHS) has overall responsibility for the NHSCR, which it funds through a state contract. Dartmouth College has continuously held the contract to operate the NHSCR since its inception. The registry is administratively located in the Norris Cotton Cancer Center. The US Centers for Disease Control and Prevention (CDC) currently provides a grant to NHDHHS, and these funds have been used to help increase the scope of registry information and to assure the quality of the data collected. Cancer data is collected in accordance with NH Administrative Rules. HSDM receives the cancer data set from the NHSCR. NHSCR currently collects reports from hospital registrars operating in all the large hospitals in NH. Hospitals with relatively smaller caseloads of cancer (fewer than 100 cases per year) generally do not have their own cancer registry, so NHSCR staff assists these hospitals with their reporting duties. NHSCR also receives reports of cases from physician practices, freestanding radiation oncology centers, out-of-state pathology laboratories and other sources, as required by NH Administrative Rules. In addition, the NHSCR receives reports for NH residents who are diagnosed outside of NH, based on agreements of information exchange with other states.

The time period 1987-2001 was selected for evaluation of cancer incidence data because it was the most recent data available, and because multiple years of data are needed to provide large enough numbers to yield meaningful statistics for smaller areas such as individual cities or towns. An incident case was defined as an individual residing within the towns of Pembroke or Allenstown who was diagnosed with a new primary malignant cancer during the evaluation period. The variables analyzed included: city/town of residence at time of diagnosis, primary cancer type, date of diagnosis, age at diagnosis, and sex. Information on other risk factors, such as health-related behaviors, environmental and occupational exposures, or access to medical care, is not available in the abstracted medical data used in this review.

Population estimates for 1987-2001 were calculated by combining the 1990 and 2000 US Census enumerations for the towns of Pembroke and Allenstown, and for the State of New Hampshire.

7.3.1 <u>Data Analysis</u>

A descriptive epidemiological analysis of cancer incidence for the Suncook area was conducted using the Standardized Incidence Ratio (SIR) technique. The SIR is used to analyze disease incidence in small areas, and is the first step in NH's disease cluster investigation protocol. The SIR compares the actual (observed) number of cancer cases in the study population (residents of the Pembroke and Allenstown) to the number that would be expected to occur if the towns had the same age- and sex-specific cancer rates as the State of NH. An SIR is the ratio of the observed number of cases to the "expected" number of cases in the study population. These ratios were calculated for all 24 major cancer types.

The purpose of an SIR study is to identify unusually high (or low) disease rates in an area. Once identified, an assessment is made as to whether the disease in question might be amenable to public health intervention. It is important to emphasize that the term "expected" as used in this study is based only on the characteristics of age and gender. It does not take into account other determinants of disease rates such as health-related behaviors (e.g., tobacco and alcohol use, diet), environmental or occupational exposures, or access to health care (e.g., insurance status, other financial and personal barriers).

The SIR tells us how much higher or lower Suncook Area cancer rates are than those of the comparison population (State of New Hampshire) based on age and sex. If the observed number of cases is the same as the age-sex expected number, the SIR will equal 1. If there are more observed cases than would be expected, then the SIR will be greater than 1. If there are fewer observed cases than expected, the SIR will be less than 1. For example, if 10 cases are observed in the study population, but 5 cases were expected, then the SIR = 10/5 = 2.0 and the area has twice number of cancer cases as expected. But if 20 cases were expected, then the SIR = 10/20 = 0.5, meaning that the area has half the expected number.

Caution should be exercised when interpreting the SIR. The interpretation must take into account the actual number of cases observed and expected, not just the ratio. Two SIRs can have the same ratio, but represent very different scenarios. For example, a SIR of 1.5 could mean 3 cases were observed and 2 were expected (3/2 = 1.5). Or it could mean 300 cases were observed and 200 were expected (300/200 = 1.5). In the first instance, only 1 "excess" cancer case occurred, which would most likely have been due to chance. But, in the second instance, 100 excess cancers occurred, which would most likely not be a chance occurrence. This elevated ratio would then be investigated further to determine if it can be linked to any known cause or set of causes.

To help interpret the SIR, the statistical significance of the difference between state and local disease rates is calculated. In other words, the number of observed cases can be determined to be significantly different from the age-sex expected number of cases, or the difference can be due to chance alone. "Statistical significance" for this review means that there is less than 5 percent chance (p-value <0.05) that the observed difference is merely the result of random fluctuation in the number of observed cancer cases. If the SIR is found to be statistically significant, then the difference between the expected and observed cases is probably due to some set of factors that influences the rate of that disease. If the lower 95% confidence interval (CI) is over 1.00, then the observed number of cancer cases in the time period is “significantly higher” than expected. If the upper 95% CI is below 1.00, then the observed number is “significantly lower” than expected.

New Hampshire’s average annual age-sex specific cancer incidence rates were used to derive the expected number of cancer cases for the Suncook Area. SIRs were calculated for each cancer type and reported when 5 cases or more were observed among Suncook Area residents within the reporting period. Cells with between one and four cases are suppressed at the town level in accordance with the HSDM data release policy.

7.3.2 <u>Results</u>

Table 7-2 presents cancer incidence statistics based on the SIR analysis for the Suncook Area. The data are presented for each of the 24 major cancer types. Statistics include:

1) **Observed** number of cancer cases in the Suncook area for the 1987-2001 period;
2) **Expected** number of cases based on the State age-sex average;
3) Ratio of Observed-to-Expected cases (**SIR**) for each cancer type; and
4) 95% **confidence intervals** for each SIR.

There were no statistically significant elevations in cancer rates among Suncook residents for the 1987-2001 period. The SIR of 1.01 for “TOTAL INVASIVE” cancer indicates that the Suncook Area had only about 1% more cancer cases than “expected” over the 15-year period. This “excess” is most likely due to chance fluctuation.

Of the 25 separate ratios calculated for this analysis, none of the Suncook Area observed number of cancers was significantly higher than expected. One of the 25 observed numbers, however, was significantly lower than the age-sex expecteds. Kidney and Renal cancer for Suncook Area residents was significantly lower than expected.

Table 7-2. Cancer incidence by type: Suncook area residents, 1987-2001.

Cancer Site	Observed Number	Age-Sex Expected Number	SIR (Obs/Exp)	95% CI Lower	95% CI Upper
Bladder	31	34	0.91	0.62	1.29
Brain & other CNS	6	11	0.53	0.19	1.15
Breast (female)	107	104	1.03	0.84	1.24
Cervical	5	8	0.60	0.19	1.40
Colorectal	76	77	0.99	0.78	1.24
Esophagus	7	7	1.01	0.41	2.08
Hodgkins Disease	#	6	#	#	#
Kidney & Renal Pelvis	5	14	0.36**	0.12	0.85
Larynx	11	8	1.45	0.72	2.59
Leukemia	14	15	0.94	0.51	1.57
Liver	6	4	1.40	0.51	3.05
Lung & Bronchus	106	93	1.14	0.93	1.38
Melanoma of the Skin	25	24	1.02	0.66	1.51
Multiple Myeloma	5	6	0.78	0.25	1.81
Non-Hodgkins Lymphoma	21	24	0.89	0.55	1.36
Oral Cavity & Pharynx	21	16	1.32	0.81	2.01
Other	57	45	1.28	0.97	1.66
Ovary	10	13	0.76	0.36	1.40
Pancreas	16	13	1.19	0.68	1.94
Prostate	82	82	1.00	0.79	1.24
Stomach	7	9	0.78	0.31	1.61
Testis	5	6	0.88	0.28	2.06
Thyroid	#	7	#	#	#
Uterine	22	19	1.15	0.72	1.74
TOTAL INVASIVE	654	646	1.01	0.94	1.09

** SIR is significantly lower than expected at p<.05 (Kidney and Renal only)
# Statistics based on 1 through 4 events are suppressed for confidentiality

7.4 Conclusions

- Analysis of emergency department (ED) data for asthma and other respiratory disease for 2000-2004 shows that Suncook area residents for the most part compare favorably to their counterparts statewide. Asthma ED visit rates of males and females age 20-44 were somewhat higher than statewide. There is some preliminary evidence of that these elevations may be influenced by diagnostic practices or a higher rate of overall ED use in these groups. This will be the subject of a future health outcome data review.

- A standard incidence ratio (SIR) analysis for the Suncook area for the years 1987-2001 found that cancer rates for 24 major cancer types were all within their expected ranges based on corresponding rates for the state as a whole.

8.0 COMMUNITY HEALTH CONCERNS

When performing any public health assessment, EHP gathers health concerns from people living in the vicinity of the site. The health concerns that people express help direct the focus of the evaluation. Health concerns of Suncook area residents were solicited in two ways: 1) an EHP needs assessment allowed residents to submit concerns in writing; and 2) an open meeting ("public availability session") to let residents voice their concerns directly to EHP staff, who recorded them for inclusion in the current document. Residents' concerns, mostly in the form of questions, are listed *verbatim* below, along with EHP responses. Because they are so similar, the first eight community questions listed immediately below are addressed with a single response. The remaining questions receive individual responses.

<u>Health Concerns</u>

- Is chronic cough a result of airborne particles?
- Will the chemicals being emitted harm my children or myself?
- Do the chemicals from the site affect our health in any way?
- What is the site doing to our quality of air; causing possible cancer, asthma, and other respiratory ailments to family, friends and pets?
- Any health concerns related to smoke stack emissions?
- Is the air safe to breathe?
- Is it safe for my children to play outside?
- Is everything safe in the air?

Reply (to 8 questions listed above): This PHA finds no evidence that site-related emissions are likely to cause **chronic** *adverse health effects in people who live near the Merrimack Station Power Plant. According to the best and most objective scientific research, levels of air contaminants detected in Suncook Village do not pose a risk for developing chronic respiratory disease (such as asthma or COPD), and do not increase the risk of developing cancer.*

There are, however, rare occasions when the air quality in the Suncook area may pose a risk to "sensitive populations" – those with asthma or other existing chronic respiratory disease. Some of these occasions are attributable to Merrimack Station emissions (particularly sulfur dioxide). Others are due to regional "ozone events" that originate primarily in metropolitan areas south of NH and affect the entire northeast region. It is during these peak "air quality" events that residents should take precautions to minimize exposure to outdoor air.

- If the asthma and cancer rates were tracked in Suncook, could it be our area will possibly be on top?

Reply: This study examined rates of all cancer types as well as rates of Emergency Department (ED) visits for asthma and other respiratory disease. The results show that Suncook residents generally compare favorably to the rest of the State on these health indicators. One area designated for further study by EHP involves asthma ED rates of Suncook residents age 20-44. These rates are somewhat higher than the corresponding rates of the state as a whole, although it is not clear whether their elevation is due to an *actual elevation in asthma-related events or to other causes such as physician diagnostic practices or overall ED utilization patterns.*

- Does the plant have passing grades for air emissions? Can any air quality checks be done? When will the air quality be improved? Is the technology available to demand compliance with modern air pollution standards?

Reply: Merrimack Station is required by law to maintain compliance with applicable state and federal air regulations, and to the terms and conditions contained in their current air quality permits. According to the data reviewed by EHP, levels of contaminants in ambient air near Suncook Village were well within relevant health-based National Ambient Air Quality Standards (NAAQS).

In accordance with permit requirements, both units at Merrimack Station are monitored by a continuous emission monitoring system (CEMS) for oxides of nitrogen (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), and opacity. DES oversees the operation of CEMS as well as the compliance status of the facility with its permit conditions.

In the event that emissions exceed permitted thresholds, Merrimack Station must submit a permit deviation notification within 24 hours of occurrence. Subsequent reports submitted within 15 days of the occurrence are reviewed and logged into a database. On a quarterly basis, Merrimack Station must submit excess emissions reports as well as audit reports to DES for each CEM.

Merrimack Station currently utilizes two principle technologies to control facility emissions: 1) four Electrostatic Precipitators (ESP) control particulate matter (PM); and 2) two Selective Catalytic Reduction (SCR) systems controls NO_x. Sulfur dioxide emissions are managed by blending low-sulfur coal fuel with conventional coal prior to burning. HB 1673-FN *was passed by the Legislature and signed into law by the Governor in March 2006. This bill requires the installation of scrubber technology at Merrimack Station no later than July 2013. This will reduce mercury emissions by 80%, and achieve SO_2 reductions of similar or greater magnitude. The bill also requires that PSNH submit a permit application for construction of the scrubber within one year.*

- What are the particles made of that we see on our cars, homes, and outside furniture? What is the brown residue that settles over my property?

Particulate concentrations in the Suncook area as measured at the DES monitoring stations are not significantly different from those measured at other locations in the state. Particulates can consist of products of fuel combustion as well as pollen, and dust from roadways and other human activities. The specific composition of deposits cannot be determined without testing of the residue. Merrimack Station may occasionally experience operational problems at the plant (such a temporary malfunction of a control device or from fugitive coal dust blowing off of the coal piles or conveyer system) that can result in emissions of heavier dust particles that may settle on outdoor surfaces in the vicinity of the plant. Since the air samplers only measure "respirable" PM, these larger particles are not detected or measured; but since these particles are too large to breathe, the dust seen on cars and outdoor furniture does not in itself represent a respiratory health issue. However, if such an event occurs in the future, *DES can collect samples of the deposited dust for microscopic analysis to attempt to determine its origin.*

Conditions in State Operating Permits require Merrimack Station to control fugitive dust emissions from its equipment, and from vehicular movement within the facility's property. Merrimack Station is also required to control particulate emissions from coal-crushing operations in order to comply with requirements of Env-A 1002 Fugitive Dust. If anyone observes excessive dust emissions, DES encourages them to notify the Complaints Manager at (603) 271-0907.

- What is emitted from the smoke stack? Are the chemicals being released to the air poisonous? Are the chemicals being released to the air dangerous?

Reply: The combustion of coal (and all fuels) can create emissions of pollutants including volatile and semi-volatile organic compounds, inorganic compounds, and metals. These byproducts of combustion can vary in type and quantity based on the fuel that is burned.

Although combustion of virgin fuels (such as coal) is exempt from the NH Air Toxics Control Program, a June 2003 report from the Legislative Committee to Study the Public Health and Environmental Benefits of Requiring Stationary and Mobile Sources that Burn Virgin Petroleum Products or Coal to Comply with the NH Air Toxics Control Act (SB 93, Chapter 088, Section 001, Laws of 2001) specifically examined emissions from Merrimack Station and found that "emissions from stationary and area sources burning coal, wood, or virgin petroleum products already comply with the requirements of the New Hampshire Air Toxics Control Program". The Committee's report further concludes that these sources "do not currently represent major health risks from toxic air pollutant emissions, and that expanding the New Hampshire Air Toxics Control Act to include these sources would do little at this time to improve air quality and human health in the state".

- Why does it seem they burn the worst stuff on rainy days?

Reply: Merrimack Station has a consistent coal supply which is set by the conditions of their DES permit. In general there is little day-to-day difference in the type or amount of coal that the plant burns. Certain weather conditions can cause pollution impacts to be higher on some days than others. In addition, smoke stack plumes are often more visible under particular weather conditions, as well as during certain times of the day.

With regard to data from this PHA, of the 42 days in which sulfur dioxide levels reached the highest levels in Suncook Village, only four had any precipitation associated with them. Most of the high SO_2 readings occurred under clear skies.

- Are there profit-driven decisions made without regard to health issues?

Reply: Merrimack Station is regulated by standards developed to protect the public health and the environment. Beyond this, DES has no regulatory authority over issues relating to financial decisions of corporations.

9.0 CONCLUSIONS

The overall conclusion of this report is that ambient air in Suncook Village does not present a health hazard to the general population. During the two-year study period, the Suncook area was in compliance with all National Ambient Air Quality Standards, including those for the three criteria pollutants examined in this report: sulfur dioxide, ozone, and $PM_{2.5}$. There are infrequent days (or hours) when air pollution levels in the Suncook area may result in adverse health effects among asthmatics or other sensitive groups – especially if they are exercising or otherwise exerting themselves outdoors. These air pollution events fall into two distinct categories based on the pollutants involved, the proximity of their source, and the meteorological conditions associated with them. Sulfur dioxide events in Suncook Village are associated with local emissions that are transported a short distance by strong northwest winds primarily in winter months. Ozone events originate from regional and distant sources and are transported long distances primarily by southerly winds in summer months. $PM_{2.5}$ events usually share the same origin and transport characteristics as ozone events.

Based on analysis of two years of hourly measurements from Exchange Street Station, EHP concludes that levels of sulfur dioxide in the Suncook area pose *no apparent public health hazard*. This is a category in ATSDR's Hazard Classification System that "applies to sites where exposure to site-related chemicals might have occurred in the past or is still occurring, but *the exposures are not at levels likely to cause adverse health effects*." This conclusion notwithstanding, there are rare occasions (less than 1% of the time) when SO_2 reaches levels in Suncook Village at which unusually sensitive asthmatics should consider reducing prolonged or heavy exertion outdoors in order to avoid possible respiratory effects. These SO_2 events occur primarily when the wind is out of the northwest (the direction of Merrimack Station). They are also usually associated with cold, windy weather conditions, which are not conducive to outdoor activities for most people. This further reduces the probability of exposure. The few SO_2 events that take place during peak outdoor activity hours (e.g., summer mornings) are the most difficult to predict. Fortunately, these incidents are rare and of short duration. Suncook's SO_2 events are local, not regional in origin.

Ozone and fine particulate matter ($PM_{2.5}$) pose *no apparent public health hazard* to residents of the Suncook area. According to EPA Air Quality Index categories, ozone levels in the Suncook area during the study period were "good" more than 92% of the time, "moderate" about 7% of the time, and "unhealthy for sensitive groups" in one instance. For "moderate" ozone days, EPA provides the following cautionary statement: "*People who are unusually sensitive to ozone should consider reducing prolonged or heavy exertion outdoors*." During events categorized as "unhealthy for sensitive groups", the cautionary statement is, "*Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors*." Elevated ozone events occur primarily when the wind is out of the south, southeast, or southwest - prevailing wind directions in summer. During southerly winds, emissions from Merrimack Station do not contribute to air pollution levels in Suncook Village. Ozone events are regional, as confirmed by the high correlation in their day-to-day levels across the state, and often across the New England Region

For $PM_{2.5}$ in the Suncook area, AQI levels were "good" about 82% of monitored days, "moderate" 17%, and "unhealthy for sensitive groups" in one instance. EPA's cautionary statement for "moderate" $PM_{2.5}$ days is, "*Unusually sensitive people should consider reducing* *prolonged or heavy exertion.*" For days categorized as "unhealthy for sensitive groups", EPA advises: "*People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.*" The only $PM_{2.5}$ reading to reach this level occurred during the same "air pollution event" as the highest ozone reading of the study period. Moderate $PM_{2.5}$ readings occur with equal frequency in summer and winter. Two-thirds of summer events are associated with southerly winds (South, SE, SW), while two-thirds of winter events occur in conjunction with northerly winds (North, NE, NW). $PM_{2.5}$ events are primarily regional, as indicated by the high correlation of levels at Exchange Street with those at Manchester, Portsmouth, and other air monitoring stations.

Suncook Village air monitoring data for 15 additional air toxics suggest that they pose *no apparent public health hazard* to any groups in the Suncook area. Air toxics levels at Exchange Street Station were consistent with those from other air monitors across the state regardless of season, wind direction, and other factors.

Levels of mercury in ambient air are difficult to monitor. DES modeling of mercury concentrations in the Suncook area concludes that they pose *no apparent public health hazard* through inhalation. Mercury can be a human health hazard, however, through fish consumption. Mercury from local, regional, and distant industrial sources is deposited in water bodies, converted to methyl mercury through natural processes, and is ingested by fish where it bioaccumulates. Consumption of these fish in large quantities may pose a health hazard, especially to children and pregnant women

Finally, a review of health outcome data for the Suncook area (the towns of Pembroke and Allenstown) revealed no significant elevation in any type of cancer. Rates of respiratory-related emergency department visits for children and the elderly were generally lower than expected, while asthma-ED visit rates for males and females age 20-44, and females age 45-64 were higher than expected. Alternative explanations of these elevated rates were explored, but further analysis of ED hospitalization data will be conducted.

10.0 RECOMMENDATIONS

Based on the conclusions of this report, the following public health recommendations will be implemented by DES:

- Continue to collect and compile SO_2 data at the Exchange Street air monitoring station.

- Continue routine inspections and monitoring of the Merrimack Station Power Plant to assess compliance with applicable air quality regulatory requirements.

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- Continue to issue DES Air Quality Action Days (AQAD) encouraging residents, especially children, the elderly, and those with asthma or other respiratory conditions to avoid prolonged outdoor activity and take precautions to protect their health. Residents are encouraged to conserve energy and electricity, and to minimize driving. NH Air Quality information is available at: http://www.des.state.nh.us/airdata/air_quality_forecast.asp

- Offer education (through EHP) to Suncook area school administrators, day care providers and others regarding the findings of this evaluation, particularly in relation to local ambient air quality.

- Continue to encourage residents to monitor local wind direction and wind speed forecasts for the Concord area at the National Weather Service web site: http://www.erh.noaa.gov/gyx/digital/NH08afm.htm

- Continue to encourage residents interested in obtaining daily regional air quality information to register for EPA's AIR NOW website: http://airnow.gov/

- Continue DES efforts to advise residents to limit their exposure to environmental mercury by following the recommendations of the NH Statewide Fish Consumption Advisory. The Advisory recommendations are included in the brochure "Is it safe to eat the fish we catch?" on the DES website: http://www.des.state.nh.us/pdf/Mercury_Fish.pdf

11.0 PUBLIC HEALTH ACTION PLAN

The purpose of the Public Health Action Plan is to ensure that the current document not only identifies exposure potentials and possible health risks, but also provides a plan of action to mitigate and prevent adverse human health effects resulting from exposures to air pollutants. The first section of the Public Health Action Plan contains a description of completed and ongoing actions taken to mitigate air pollution. The second section presents a list of public health actions planned for the future.

Actions Completed

1. In the early 1980s, DES began monitoring the ambient air surrounding Merrimack Station to ensure compliance with the National Air Ambient Air Quality Standards (NAAQS).

2. DES worked with PSNH to reduce nitrogen-oxide (NOx) emissions through installation of two Selective Catalytic Reduction (SCR) systems on Merrimack Station's boiler units in 1995 & 1999

3. In 2002, EHP performed a Community Needs Assessment in the Suncook area.

4. In 2002, EHP conducted a Public Availability Session to discuss the Merrimack Station Power Plant with Suncook area residents.

5. On September 11, 2003, EHP conducted a Public Meeting to discuss the Merrimack Station Power Plant with Suncook area residents.

6. In 2002, EHP distributed public health fact sheets to residents of the Suncook area.

7. In 2003, EHP published a Health Consultation for the Suncook area and Merrimack Station. It presented findings of an evaluation of air monitoring data collected in Suncook Village for the years 2002-2003.

8. From September 2002 through December 2003, DES collected air toxics data at five sampling sites in New Hampshire (Exchange Street, Brickett Hill, Manchester, Claremont, and Portsmouth).

9. DES has responded to, and investigated, approximately 20 citizen complaints from Suncook area residents regarding Merrimack Station since 2003.

Actions Planned

1. EHP will update health outcome reports for Pembroke and Allenstown as additional years of cancer incidence and hospitalization data become available. In addition, EHP will expand its analysis of asthma emergency department rates of Suncook area residents age 20-44 in a future health consultation.

2. DES will continue to support efforts in the NH Legislature to achieve additional reductions in air emissions. HB 1673-FN was recently passed by the Legislature and signed into law by the Governor in March 2006. This bill requires the installation of scrubber technology at Merrimack Station no later than July 2013 which will reduce mercury emissions by 80%, and achieve SO_2 reductions of similar or greater magnitude. The bill also requires that PSNH submit a permit application for construction of the scrubber within one year.

3. DES is currently collaborating with PSNH to evaluate coal dust emissions associated with coal-handling operations at Merrimack Station. The purpose of this evaluation is to ensure that Merrimack Station meets health-based standards for coal dust adopted under RSA-125I.

EHP will reevaluate and expand the Public Health Action Plan as needed. New environmental, health outcome data, or the results of implementing the above actions may warrant additional actions at this site.

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13.0 CERTIFICATION

This public health assessment on the evaluation of ambient air data for Suncook Village was prepared by the New Hampshire Department of Environmental Services, Environmental Health Program, under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was prepared in accordance with methods and procedures approved at the time the consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

Technical Project Officer, Cooperative Agreement Team, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with its findings.

Cooperative Agreement Team Leader, CAPEB, DHAC, ATSDR

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15.0 APPENDICES

Appendix A. Emissions Inventory (tons per year 2005*) of permitted emissions sources within 15 mile radius of Merrimack Station (9)

Map #	Name	PM	SO2	NO2	VOC	T/HAPS
1	COLD BROOK GRAVEL	0.44	0.67	7.98	0.06	0.00
2	BOYCE HIGHLANDS INC	0.30	0.02	0.49	18.40	5.04
3	WHEELABRATOR CONCORD COMPANY LP	3.33	37.09	292.21	1.29	15.40
4	FILLMORE INDUSTRIES INC	0.53	0.33	4.95	0.00	0.00
5	ENVIRONMENTAL SOILS MANAGEMENT INC	6.22	34.52	19.70	1.84	0.60
6	NH Dept of Corrections CONCORD FACILITY	3.08	38.61	13.98	0.07	0.00
7	CONCORD SAND & GRAVEL INC	0.34	3.28	4.47	0.31	0.00
8	MTS ENVIRONMENTAL	0.00	0.00	0.00	9.27	0.00
9	HHP INC	0.40	2.63	20.14	0.53	0.00
10	PIKE INDUSTRIES INC - HENNIKER	0.00	0.00	0.00	0.00	0.00
11	BIO ENERGY LLC	0.00	0.00	0.00	0.00	0.00
12	HERRICK MILLWORK	0.34	0.04	0.34	0.03	0.00
13	MILTON CAT INC - CONTOOCOOK	0.00	0.00	0.00	1.17	0.00
14	SAINT PAUL'S SCHOOL	2.25	22.62	15.80	0.08	0.00
15	CONCORD HOSPITAL	0.24	0.55	5.97	0.23	0.00
16	CONCORD STEAM CORPORATION	36.82	61.39	39.17	0.94	0.00
17	NEW HAMPSHIRE HOSPITAL	0.50	4.74	4.06	0.09	0.00
18	CONCORD LITHO GROUP	0.02	0.01	0.99	9.99	0.00
19	GRAPHIC PACKAGING INTERNATIONAL INC	0.00	0.00	0.00	13.26	0.00
20	BLUE SEAL FEEDS INC	0.52	7.22	1.69	0.03	0.00
21	KALWALL CORPORATION - FLAT SHEET DIVISION	0.10	0.62	0.48	28.56	21.21
22	STRUCTURES UNLIMITED INC	0.00	0.00	0.00	8.68	0.00
23	QUALITY WOOD PRIMING INC	0.00	0.00	0.00	41.27	0.00
24	ANTIFREEZE TECHNOLOGY SYSTEMS	0.00	0.00	0.00	0.96	0.00
25	ENSIO RESOURCES INC (FORMERLY REED MINERALS)	2.96	0.22	0.78	0.01	0.00
26	PLOURDE SAND & GRAVEL - ALLENSTOWN	0.32	0.30	4.60	0.00	0.00
27	CONPROCO CORPORATION - BOW	1.83	0.00	0.00	0.00	0.00
28	PERFECT FIT INDUSTRIES INC	0.15	3.30	0.44	0.01	0.00
29	COMPLETE COVERAGE WOOD PRIMING INC	0.00	0.00	0.00	7.45	0.00
30	PLOURDE SAND & GRAVEL - HOOKSETT	1.69	0.71	10.85	0.00	0.00
31	PIKE INDUSTRIES INC - HOOKSETT	7.43	3.97	5.08	1.13	0.00
32	BROX INDUSTRIES INC - HOOKSETT	1.98	0.36	1.37	0.65	0.00
33	BROX INDUSTRIES INC - HOOKSETT (BARRETT)	0.00	0.00	0.00	0.00	0.00
34	CHURCHILL COATINGS CORP. - HOOKSETT	0.00	0.00	0.00	44.53	0.00

Map #	Name	PM	SO2	NO2	VOC	T/HAPS
35	GENERAL ELECTRIC TRANSPORT	0.04	0.00	0.00	0.00	0.00
36	MANCHESTER SAND, GRAVEL & CEMENT CO	1.66	1.79	14.35	0.39	0.00
37	CANDIA INCINERATOR	1.23	1.15	1.13	0.54	0.81
38	JOHN BROWN & SONS INC	0.00	0.00	0.00	0.00	0.00
39	HILLSBOROUGH COUNTY COMPLEX	0.00	0.00	0.00	0.00	0.00
40	HILLSBOROUGH COUNTY NURSING HOME	0.31	6.62	0.94	0.02	0.00
41	MANCHESTER LANDFILL FLARE	0.00	0.00	0.00	0.00	0.00
42	DUNBARTON ENERGY PARTNERS LP	1.79	0.44	9.25	0.24	0.00
43	NH DHHS - YOUTH DEVELPOMENT CENTER	2.11	30.68	5.37	0.03	0.00
44	VETERANS ADMINISTRATION MEDICAL CENTER	0.28	5.60	3.00	0.03	0.00
45	ELBES ASSOCIATES - BEDFORD STREET	0.49	7.08	1.24	0.03	0.00
46	ONE DOW COURT	0.70	10.17	1.78	0.01	0.00
47	MANCHESTER MILLS	0.15	3.30	0.44	0.00	0.00
48	ALLTEX UNIFORM RENTAL SERVICE	0.91	13.28	2.33	0.01	0.00
49	ELLIOT HOSPITAL	0.26	0.15	13.49	0.72	0.00
50	KALWALL PANELS & ACCESSORIES	0.14	2.88	1.03	70.36	0.00
51	ELBES ASSOCIATES - MCGREGOR STREET	0.76	10.46	2.44	0.03	0.00
52	KEYSPAN ENERGY DELIVERY - MANCHESTER	0.10	0.09	1.10	0.00	0.00
53	SAU #37 - WEST HIGH SCHOOL	0.03	0.61	0.78	0.03	0.00
54	ELECTROPAC COMPANY INC	0.00	0.00	0.00	10.07	4.83
55	SAU #37 - CENTRAL HIGH SCHOOL	0.04	0.75	0.94	0.04	0.00
56	SAU #37 - MEMORIAL HIGH SCHOOL	0.03	0.83	0.55	0.02	0.00
57	UNION LEADER CORPORATION	0.02	0.01	0.94	0.05	0.00
58	OAK DESIGNS INC	0.00	0.00	0.20	20.60	0.00
59	MANCHESTER HIGHWAY DEPT.	0.01	0.02	0.35	0.01	0.01
60	NYLON CORPORATION OF AMERICA	5.49	80.17	14.66	0.10	0.00
61	VELCRO USA INC - MANCHESTER	0.82	0.52	14.97	19.41	0.00
62	MOORE WALLACE (formerly Moore Label Systems)	0.09	6.17	0.9	12.97	0.00
63	AVILITE CORPORATION	0.00	0.00	0.00	27.43	0.00
64	HARVEY INDUSTRIES INC	0.00	0.00	0.00	11.86	0.00
65	US POSTAL SERVICE - MANCHESTER	0.01	0.00	0.54	0.03	0.00
66	MANCHESTER SLUDGE INCINERATOR	0.61	2.91	2.94	0.06	0.06
67	FREUDENBERG-NOK - MANCHESTER	0.03	0.03	0.45	28.20	0.00
68	MANCHESTER AIRPORT	0.03	0.02	1.16	0.05	0.00
	Facilities 1-68 Total	90	409	553	394	48
---	PSNH - MERRIMACK STATION	622	33768	5033	67	1

*** All Emissions Inventories are for 2005 except for Sites #4, #23, and #27 (2004).**

Appendix B: One-hour SO_2 pollution events: Date, Number of Events, Hour of Day

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Date	# of Events	Hour of Day
2004 Mar 21	2 hours	10-11 pm
2004 Apr 5	1 hour	1 pm
2004 Apr 6	1 hour	10 am
2004 Apr 20	1 hour	4 am
2004 Apr 24	4 hours	10 am, 5-7 pm
2004 Apr 25	1 hour	10 am
2004 May 12	1 hour	8 am
2004 Jun 19	4 hours	7-8 pm, 10-11 pm
2004 Jun 23	1 hour	11 am
2004 Aug 24	1 hour	10 am
2004 Sep 10	1 hour	1 pm
2004 Sep 19	1 hour	1 pm
2004 Oct 3	1 hour	11 am
2004 Nov 3	5 hours	7, 10 am, 12, 14-15 pm
2004 Nov 8	1 hour	1 am
2004 Nov 25	1 hour	7 pm
2004 Dec 14	1 hour	3 pm
2004 Dec 20	9 hours	11 am-3 pm, 6-9 pm
2005 Jan 18	5 hours	7-8, 11 am, 12-1 pm
2005 Jan 25	1 hour	10 am
2005 Feb 11	1 hour	7 am
2005 Feb18	2 hours	9-10 pm
2005 Feb 27	2 hours	9-10 am
2005 Mar 8	3 hours	4-6 pm
2005 Mar 14	2 hours	2, 5 pm
2005 Mar 23	1 hour	1 pm
2005 Apr 10	1 hour	10 am
2005 Apr 13	1 hour	1 pm
2005 Apr 17	1 hour	10 am
2005 May 20	1 hour	8 am
2005 May 28	2 hours	8-9 am
2005 Jul 30	2 hours	11 am, 12 pm
2005 Aug 8	1 hour	10 am
2005 Oct 30	1 hour	9 am
2005 Nov 23	1 hour	3 am
2005 Dec 27	3 hours	7, 10 am, 1 pm
2005 Dec 30	2 hours	3, 5 pm
2006 Jan 15	7 hours	12-6 am
2006 Jan 16	5 hours	12, 7-8, 11 am, 2 pm
2006 Jan 22	1 hour	5 am
2006 Jan 26	1 hour	11 am
2006 Feb 24	1 hour	9 pm

Appendix C: Written Comments to Public Comment Release

On March 8, 2007, the Department of Environmental Services, Environmental Health Program (DES) released the Draft Public Health Assessment entitled Ambient Air Quality in Suncook Village for public comment. The public comment period for the draft document lasted 46 days (March 8, 2007 through April 23, 2007). To help facilitate public comments, the draft public health assessment was posted on the DES website, a media event was held on March 8, 2007, and a public meeting was held on March 21, 2007. In addition, 47 copies of the public health assessment were disseminated to residents and interested parties via land mail and e-mail.

Local residents were encouraged to submit their comments and questions about the document to DES. These comments have been transcribed or paraphrased in the next section. Each comment is followed by a response from DES.

1. **The statement "*no apparent public heath hazard*" is mentioned a few times throughout the report. Is there, or isn't there a health hazard to the residents in this area?**

Ambient air in Suncook does not present a health hazard to the general population. There are rare occasions (less than 1% of the time) when pollutant levels in Suncook (i.e., sulfur dioxide) may affect unusually sensitive individuals such as asthmatics. These rare occasions are associated with strong northwest winds in winter months. These cold, windy winter days are not conducive to outdoor activities for most people.

This public health assessment evaluated the potential for adverse health effects to occur from breathing ambient air in Suncook. It was based on health and environmental data available at the time. Nevertheless, it updated and expanded on the previous health consultation (expanded pollutant list, more data points, more in-depth analysis).

DES is required to categorize exposures according to a protocol set forth by ATSDR. The ATSDR category "no apparent public health hazard" applies when exposures are not at levels likely to cause adverse health effects.

2. **How are the residents going to be assured there is no health hazard if in years to come there proves to be a health hazard to residents?**

The health of residents is the primary concern whenever DES conducts a public health assessment. The Suncook area assessment carefully evaluated 2004-2006 environmental data, meteorological conditions, morbidity status of the community, and the public health implications for each specific pollutant. DES concluded that the ambient air in Suncook does not present a hazard to the general public. There are however, individuals such as sensitive asthmatics that may be impacted on infrequent occasions. The circumstances whereby these occurrences may occur are identified in the document (see pages 61-62). Furthermore, as additional pollution-control equipment is constructed and put into service at Merrimack Station, pollution levels will continue to decrease.

3. The report says *"people who are unusually sensitive to ozone should consider reducing prolonged or heavy exertion outdoors."* Why should residents have to change their lifestyle to accommodate a business that may have hazardous substances?

DES is not suggesting that residents alter their lifestyles to accommodate a business. Some people are more sensitive to the effects of ozone than others. The cautionary statement mentioned above is intended for sensitive populations that may have a preexisting respiratory condition.

DES issues warnings when ozone reaches unhealthy levels. These precautionary advisories are regional, infrequent, and occur during "ozone season" (April through September). During these months, longer periods of sunlight and hotter temperatures can cause ozone to form in higher concentrations. Southerly winds carry pollutants generated by sources far upwind such as Boston and New York City. This occasionally results in elevated ozone levels in portions of New Hampshire including Suncook Village. During these southerly winds, emissions from Merrimack Station do not contribute to air pollution levels in Suncook Village. The cumulative vehicular traffic and industrial emissions responsible for ozone events in New Hampshire originate largely from out-of-state and not local sources.

4. High levels of mercury (up to 50 parts-per-million) are routinely land applied in sewage sludge within the immediate Allenstown, Pembroke, Suncook area where contained mercury can become airborne through wind action.

DES rules (Env-Wq 807.03) state that biosolids cannot receive a "Sludge Quality Certification (SQC)" from DES if mercury concentrations exceed 10 parts-per-million (ppm), and therefore are prohibited from being land applied in New Hampshire. In the event that mercury concentrations exceed this standard (during on-going testing required by SQC conditions), then land application must immediately cease, and the biosolids generator must implement an enhanced analytical testing protocol. Land application can only resume after a thorough analytical data review by DES. Currently, two permitted biosolids land application sites are located in the vicinity of Allenstown, Pembroke, and Suncook. During 2006, the biosolids applied onto these permitted sites did not exceed 1.4 ppm of mercury.

DES' mercury analysis for this document utilized the highest, or "maximum impact" mercury concentration values predicted for the Suncook area. This approach assumed that the entire Suncook area would experience the worst-case ambient mercury levels. These values were approximately 500-times (maximum 24-hour) and 5000-times (maximum annual) lower than the levels considered harmless in scientific literature. Although not expressly noted, this deliberately cautious analysis attempted to account for mercury emissions from sources beyond the scope of this document.

5. It should be noted that PSNH-Merrimack Station has a National Pollutant Discharge Elimination System (NPDES) permit which is renewed each five years. While this permit does not measure mercury or arsenic levels in discharges to the Merrimack River, cadmium, chromium, lead, copper, zinc, and aluminum are measured ONCE a year.

Merrimack Station was granted a NPDES permit to discharge non-contact cooling water and other supplemental waste water (generated once every 3-4 years). These waste waters are treated prior to final discharge. The testing protocol and discharge limitations established in the permit were derived from a review of: 1) facility operational information provided in the permit application; and 2) supplementary compliance sampling data that included analyses of mercury and arsenic. Based on this information, DES currently requires Merrimack Station to periodically test for all water quality contaminants that could potentially result in a violation of surface water quality standards.

DES concurs that mercury is a contaminant of concern when it enters aquatic environments. For this reason, Section 6.1.4.8 of this document included a discussion of mercury levels in fish, and the DES fish consumption advisory.

6. **It is stated that "Sampling and analyzing mercury are beyond the scope of this study… due to high cost" even though "(mercury) was an expressed community concern in the ATSDR petition." In light of the furor over mercury emissions from PSNH-Merrimack Station which has resulted in estimates of $76,000,000 to correct, and $10,000,000 a year to maintain (at the two major PSNH power plants), this decision not to address the mercury problem through field testing appears "penny wise and pound foolish." While aquatic mercury is routinely monitored through fish studies, it gets there primarily through air transport.**

Section 4.4 – Pollutants of Interest stated: "Mercury in ambient air is difficult to monitor because it is present in four forms in the atmosphere: precipitation, gaseous elemental form, particulate matter form, and reactive gas-phase mercury (RGM). Each form presents its own challenges relative to sampling and analysis. This is due primarily to the low detection limit required for analysis as well as the high cost. RGM is expected to represent roughly half of what may be present, however, it is also the most costly to sample and analyze. Sampling and analyzing mercury are beyond the scope of this study. As an alternative to monitoring mercury directly, DES estimated mercury levels through analytical modeling."

Environmental data is a valuable tool for evaluating human health exposures. The usefulness of such data is, however, dependent on a variety of factors (i.e., sample location, quantity, and frequency, as well as detection limits, contaminant reactions, etc.). This is especially true with respect to ambient air mercury levels, which occur in different phases. When technological, quantitative, or monetary obstacles exist, analytical modeling can effectively provide the necessary data to adequately assess human health risk. DES employed EPA approved modeling methodology for this assessment and ensured that the model inputs accurately depicted the specific conditions present in Suncook.

7. **The 780 megawatt Granite Ridge plant in Londonderry, NH is within the designated 15-mile radius of Suncook and requires mention. This plant uses treated wastewater effluent from the Manchester, NH POTW (Publicly Owned Treatment Works) for coolant and significant levels of chromium, zinc, and lead have been measured in their cooling tower pollutant emissions. When there is a SE wind, these contaminants could affect Suncook residents.**

Based on the GIS coordinates the AES Londonderry, L.L.C. Granite Ridge Energy Plant (GREP) is not within the 15-mile radius of Merrimack Station. On April 26, 1999, DES issued a supporting document (Final Determination) that explained their justification for issuing the GREP permit. In accordance with DES rules (Env-A 1400) the Final Determination document evaluated the potential impacts of toxic air pollutants. All impacts were compared against New Hampshire health-based Ambient Air Limits (AALs) for both 24-hour and annual averaging periods. The DES rules require AALs to be met at or beyond the facility property line.

The Final Determination stated: "Minor impacts of toxic air pollutants are anticipated due to drift from the cooling tower system. Emission rates of both metals and volatile compounds were determined from test data, water treatment plant effluent limits and reported values from a study performed for a similar facility in Maryland. The maximum predicted impacts are no more than 25% of the AAL for any compound."

8. **Section 6.1.4.8 Mercury- "The remaining 20% (of mercury) is released to the soil from fertilizers, fungicides, forest fires, volcanoes, and municipal solid waste." "Mercury is also released to water from industrial water discharges." This statement ignores the fact that, in New Hampshire, NHDES encourages the application of up to 5-pounds/acre of mercury in land-applied sewage sludge – as noted in the discussion of arsenic (Section 6.1.4.4) these toxic heavy metals can enter the atmosphere through "windblown dust and soil." There are many land-application sewage sludge sites immediately upwind from the Suncook area that have been, and still are subject to sewage sludge application. The report should investigate, and note, the impact of land-applied sewage sludge on resident populations.**

Currently, two permitted biosolids land application sites are located in the vicinity of Allenstown, Pembroke, and Suncook. During 2006, the specific biosolids applied onto these permitted sites met EPA, as well as the more protective DES regulatory standards. DES rules (Env-Wq 806.08) also limit the lifetime, cumulative loading rate for mercury to 5-pounds per acre of land. Furthermore, if mercury soil concentrations exceed residential health-based soil standards set forth in the DES Risk Characterization and Management Policy, land application of biosolids is prohibited.

DES' discussion of arsenic stated: "Larger arsenic particles enter the air from windblown dust and soil as well as volcanic eruptions." Be that as it may, inhalation health effects (as discussed in Section 6.1.2 – Particulate Matter) are largely associated with the fine or "respirable particles" that enter deep-lung capillaries and air sacs (alveoli). For this reason, DES conducted a thorough assessment of site-specific environmental monitoring data to evaluate these potential health effects. The monitors used to collect air data did not distinguish between emission sources, and served as a surrogate receptor for a full-time Suncook resident. DES' assessment concluded that "levels of air toxics recorded during the study period are not expected to result in adverse health effects. Air toxics levels at Exchange Street Station were consistent with those from other air monitors across the state regardless of season, wind direction, and other factors."

9. **The 2003 EHS/NHDES Ambient Air Report for Allenstown/Pembroke mentioned that "The highest average sulfur dioxide reading over a one-hour period (2002-2003) was 147 parts-per billion." (Concord Monitor, pg. B1 and B7, September 11, 2003). The 2007 report has numerous readings over 147 ppb (see Fig 5-5. Hourly Sulfur Dioxide Readings by Wind Direction March 2004-February 2006). An explanation for the increase in these high level values should be provided.**

DES conducted a more detailed investigation of sulfur dioxide data for the 2007 Public Health Assessment than was possible for the 2003 Health Consultation. This in-depth analysis was facilitated partly by the larger data set available. The 2004-06 data set (24-month duration) provided DES with more than seventeen thousand 1-hour data points for 24 consecutive months (March 2004-February 2006). The previous data set consisted of only nine consecutive months of data for a total of 5814 1-hour data points.

Various trends were identified in the 2004-06 sulfur dioxide data that enabled DES to more effectively evaluate human exposure. These trends also assisted DES in creating a set of predictive factors whereby residents were empowered to limit their exposure. Nevertheless, data comparisons illustrated that the frequency of high-wind weather events (i.e., winter storms) and other seasonal factors influenced the occurrence of elevated 1-hour sulfur dioxide levels in Suncook. Because year-to-year weather conditions are highly variable, and the 2002-03 sulfur dioxide data was not representative of a full seasonal continuum, it is inappropriate to compare the incidence of elevated sulfur dioxide levels. Nonetheless, incidence of sulfur dioxide levels >100ppb for the time periods 3/04-2/06 and 9/02-5/03 were 0.5% and 0.3% respectively.

10. **A recent New York University study of childhood asthma (NY Times, October 29, 2006, page 26) found a direct correlation between particle pollution from diesel exhaust and asthma levels. Since Suncook is exposed to considerable diesel exhaust from the Everett Turnpike (Interstate 93) and Route 3, both immediately upwind, the significance of this pollutant on Suncook asthma rates – 4 of 6 groups reported greater than expected asthma-related emergency room visits (Table 17-1) – should be addressed.**

Dozens of scientific studies have demonstrated a direct correlation between air pollution (especially ozone and fine particulate matter) and asthma attacks in children and other sensitive populations. Childhood asthma ED rates among Suncook area residents were virtually identical to statewide rates and therefore do not suggest any unusual trend related to particle pollution or any other contaminant.

Two of the eight age-sex groups in Suncook (males age 20-44 and females age 20-44) had asthma ED rates significantly higher than expected. Explanations for these elevated rates are discussed at length in the document (pp. 52-53), and are undergoing further statistical analysis to be published in a future Health Consultation document.

Regarding the possibility of excess particle pollution in Suncook due to highway traffic: levels and trends of $PM_{2.5}$ from the Suncook Village air monitor are similar to those from other air monitoring stations in the Merrimack Valley and across the state. This means that there is no evidence of Suncook having more particle pollution than other areas of the state in which it is monitored.