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INFLUENCE OF PEACE BRIDGE TRAFFIC ON DOWNWIND AIRBORNE PARTICLES

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ABSTRACT: *The Peace Bridge Plaza Complex (PBC) is located in Buffalo, NY on the U.S. side of the Peace Bridge. This bridge is one of the busiest border crossings in the northeastern United States. Residents of adjacent neighborhoods are experiencing health problems including the respiratory disease, asthma. Airborne particulates are believed a contributing factor for asthma. Airborne particles were sampled using three types of samplers, at locations upwind and downwind of the PBC, to determine if there is a significant increase in downwind particulates attributed to the PBC. Samples collected downwind of the PBC repeatedly exhibited higher fine and coarse particle counts than that of the upwind site, with the largest increase occurring during the winter months.*

INTRODUCTION

The Peace Bridge, which connects Buffalo NY, to Fort Erie, Canada, is one of the busiest border crossings in the northeastern United States. The Peace Bridge Plaza Complex (PBC) is located on the U.S. side of the bridge, and is used for inspection of trucks/cars and tolls. The PBC is adjacent to Buffalo's lower Westside, a heavily populated community consisting of mostly residential and commercial properties. The residents of these neighborhoods are experiencing health problems including the respiratory disease, asthma. The diesel exhaust and re-suspended particulates from moving and idling trucks that reach the community may be significant contributors to their respiratory disease. Airborne particulates were sampled, at locations upwind and downwind of the PBC, to determine if there is a significant increase in downwind particulates attributed to vehicle activity.

BACKGROUND

The PBC is a busy hub, with approximately 20,000 automobiles and 7,000 diesel trucks crossing the Peace Bridge daily. Proposed expansions will see these numbers double. Surveys show that Buffalo's lower Westside has the highest percentage of people with respiratory disease in all of Western New York (Lwebuga-Mukasa and Dunn-Georgiou, 2000). Asthma was the most frequent disease reported, with 60% of households (128 out of 214) having at least one asthmatic (Lwebuga-Mukasa et al., 2002). Preliminary studies have found an association between traffic volume and health care utilization rates among residents (Lwebuga-Mukasa et al., 2002). Further research is needed to quantify the impact of the Peace Bridge on air quality.

According to the Asthma and Allergy Foundation of America, asthma is a progressive disease, which inflames the bronchioles in one's lungs, making breathing difficult. A thick mucus forms within the lungs, which swells the lining due to constriction of the muscle. Environmental factors are the main triggers for asthma attacks. Although effects differ from person to person, common factors include cold air, pets, smoking, exercise and inhalable particles.

Inhalable particles exhibit a bi-modal distribution of fine and coarse particles. Fine particles (≤2.0 μm) are usually attributed to combustion sources (e.g. automobile and diesel exhaust) and course particles (2.0 to 10 μm) are usually attributed with break-up and resuspension (e.g. wind-blown dust) (Whitby, 1978). Inhalable particles are also differentiated between primary and secondary sources. Particles associated with primary sources are attributed to specific emission or suspension sources, whereas particles attributed to secondary sources form as a result of chemical reactions that take place in the atmosphere. Given that these reactions are formed slowly in an air mass, primary particles usually exhibit a far greater spatial variability (DEFRA, 2001).

Numerous studies have linked inhalable particle air pollution with mortality (Dockery, 2001), and increased asthma morbidity (Goldsmith and Kobzik, 1999). While combustion sources are an obvious source of airborne fine particulates, dusts from re-suspended particles account for a substantial fraction of the coarse particulates found in the air (Wolff and Korsog, 1985; DEFRA, 2001), and resuspended road dust accounts for a large fraction in urban areas (Environment Canada, 1982). Airborne particulate derived from tire debris (the wearing away of tire rubber) has been identified as an important factor in producing allergy and asthma symptoms (Miguel et al., 1996).

METHODOLOGY

Sample Collection

The influence of automobile and diesel truck traffic on airborne particulate concentrations downwind of the PBC was studied from two sampling sites - located on either side of the PBC. The sites were designated as upwind and downwind, based on prevailing southwest winds. Only samples associated with southwest to west winds were studied. The upwind samples were taken from the Great Lakes Field Station, located off of Porter Avenue, at the confluence of Lake Erie and the Niagara River. The upwind site is not influenced by local urban sources of particulates, as southwest to west winds blow off of Lake Erie. The downwind sample was taken at the Episcopal Church, located on Rhode Island Avenue, approximately 100 feet downwind from the PBC (Figure 1).

Airborne particulates were collected using three types of samplers, sampling over three lengths of time. Samples were collected at both the upwind and downwind sites.

One-minute samples were taken periodically using a laser particle counter (Met One). Airflow was one cubic foot per minute. The collected particles were sorted and counted into six different size categories ranging from 0.3 to 5.0 μm.

A 24-hour sample was taken once every three days using a Gent Stacked Filter Unit (FSU). The air is rushed through a 40-cm long tube to a dual filtered cassette, where the particles passed through nuclepore filters of different size fractions. Coarse sized particulates, (>2-10 μm) are gathered first, then, the air is passed through a fine size fraction filter, (≤2 μm). The cassette is a black polyethylene container where the filters are stacked inside vertically. The nuclepore filters are pre-greased with a toluene based solution to prevent excessive bouncing of the particles. An hour meter, vacuum gauge, volume meter and rotameter are checked before sampling to ensure consistent, uninterrupted airflow (15-16 liters/min.).

A one-hour sample was taken periodically using a Phallus II air sampler. Collected particulates were forcefully imprinted onto a germanium slide. The sampler acts like a vacuum, where the air is pushed through a small opening on a plastic cap. The cap is covering the germanium slide from other environmental factors. The airflow is purposely forced onto one spot so that the highest concentrations of matter will be found in the center of the slide, with the material fining outward.

The findings reported in this paper are based on a sampling period from January and February, 2002 (winter), and from September and October, 2002 (summer). FSU findings are reported for January and February 2002. Additional dates were

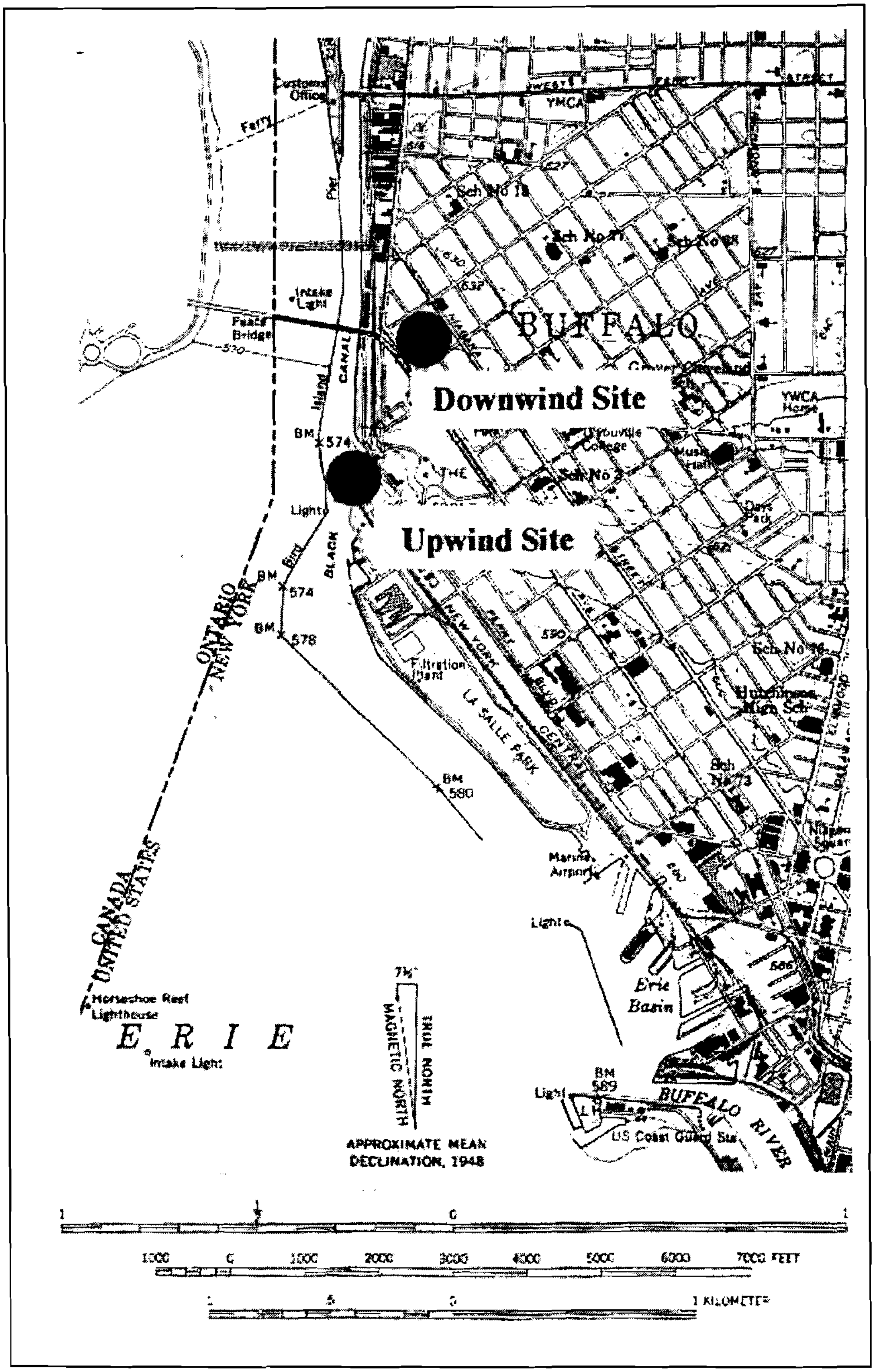

Figure 1: Study area, showing the location of the Peace Bridge, and the upwind and downwind sampling sites (black circles). Base map is Buffalo NW N.Y. 15' quadrangle.

sampled, but the filters were not available for analysis.

Sample Analysis

The collected samples were analyzed for size distribution, weight, and chemical content. While the laser particle counter provided a particle count in six size fractions, analysis was conducted after combining the size fraction counts into a fine (≤2 μm) and course (>2-5 μm) fraction. To ensure quality and consistency, two-1 minute laser particle samples were taken consecutively. The average of those numbers are used as the data sets. Filters collected from the GENT-FSU sampler underwent gravimetric analysis, providing an independent fine (≤2 μm) and a course (>2-10 μm) loading. The germanium filters underwent chemical analysis using a Scanning Electron Microscope (SEM), and dispersive x-ray (EDX) spectroscopy.

Source Identification

Particulate loadings and counts were contrasted between the upwind and downwind sampling sites. A percent difference was calculated by subtracting particulate loadings or counts between the two sites and dividing the product by the upwind value:

(1) ((Downwind – Upwind) / Upwind) * 100

A positive percent difference was attributed to activity from the PBC. An increase in the course fraction was attributed to re-suspended road dust, and an increase in the fine fraction was attributed to vehicle exhaust.

By comparing the relative heights of elemental peaks on each spectrum, EDX provided a qualitative measure for individual elements. Elemental ratios were derived, allowing for the calculation of enrichment factors. Enrichment factors (EF) compare the ratio of a given element to a reference element in aerosols with that of its assumed source (reference material). The nomenclature used is

(2) EF (X) = (X/C) aerosol / (X/C) reference material

Where X is the relative concentration of the element of interest and C is the relative concentration of a reference element. EF values were calculated using either silicon or aluminum as reference elements for natural soils. Concentrations for the natural soils were taken from Wedepohl (1971). An EF value of 10 represents a ten-fold increase from the natural ratio and suggests a source other than natural soils.

RESULTS AND DISCUSSION

Analysis of weather data collected from the National Weather Service site in Buffalo (about 5 miles inland from the Peace Bridge) revealed that during our months of sampling, winds blew from the southwest and west 61% of the time. The frequency of southwest and west winds was greatest during the winter months (78%), and least during the summer months (45%).

A critical value was calculated for the "percent difference" particle calculation. Multiple counting runs were taken within minutes at the same site. The mean percent difference was 4.9% and 56.3% for the fine and course particles, respectively. As a 4.9% (fine particles) and a 56.3% (course particles) percent difference can be expected from samples taken within minutes at the same site, between site values below the critical value were considered to show no difference in particle counts between the upwind and downwind sites.

With the exception of two events, the downwind site repeatedly exhibited higher fine particle counts than that of the upwind site (Figure 2). Only one event showed a count below the set critical value of 4.9%. The downwind site showed an average percent difference of +25% in the winter, while the summer showed a percent difference of +9% (Figure 3).

With the exception of one event, the downwind site exhibited higher coarse particle counts than that of the upwind site. The downwind site showed an enormous increase in measured particles compared to the upwind site, during winter sampling days (Figure 4). The downwind site showed an average percent difference of +653% in the winter,

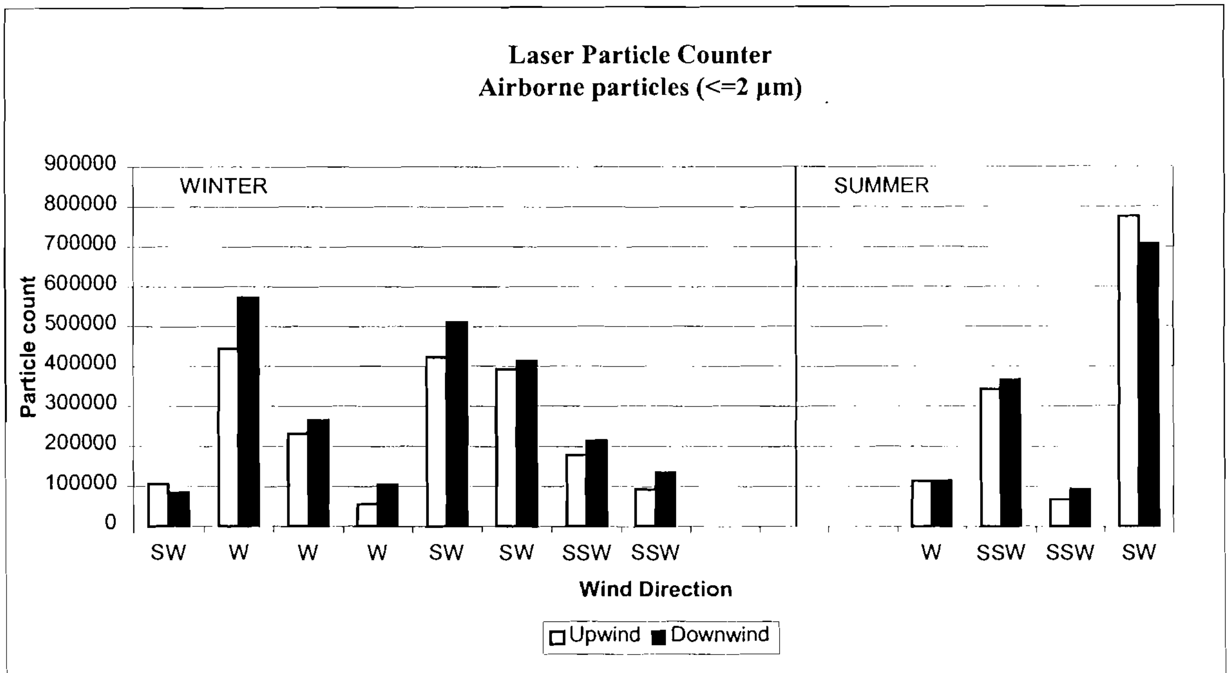

Figure 2: Fine airborne particle counts (≤2 µm) sampled at the upwind and downwind sites.

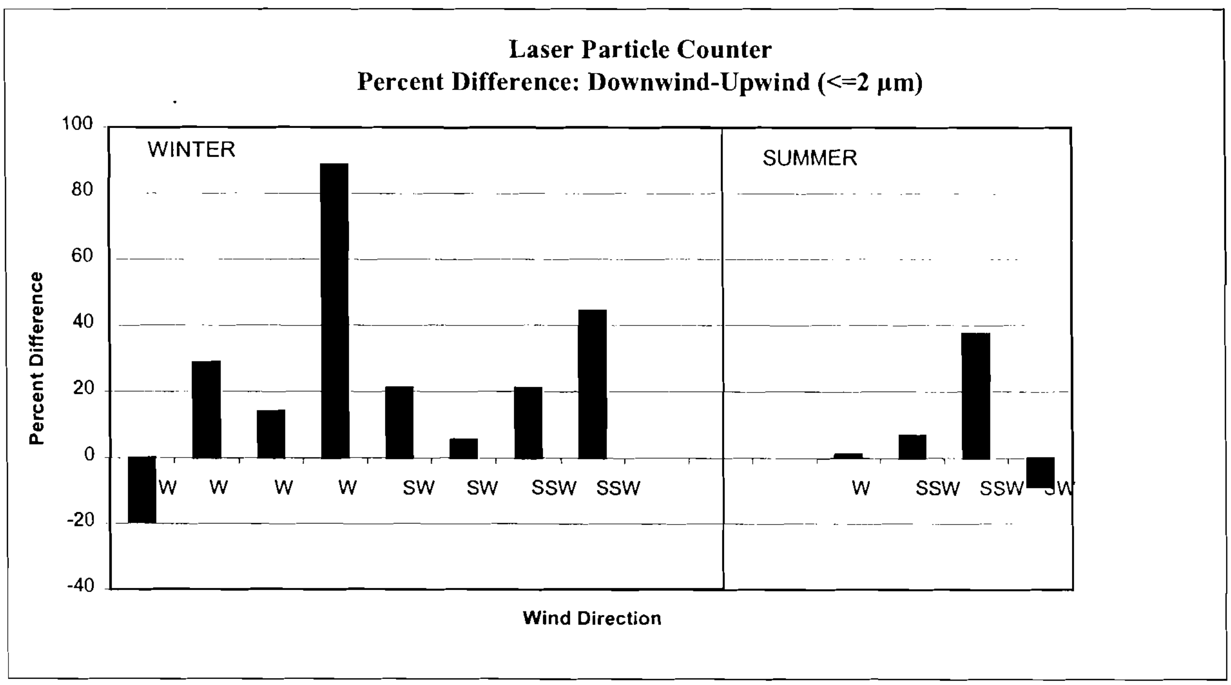

Figure 3: Fine particle counts expressed as a percent difference between upwind and downwind sites. A positive value indicates higher counts at the downwind site.

while the summer showed a percent difference of +57% (Figure 5). The percent increase of the summer samples is only slightly above the critical value of 56.3%.

Data derived from the Gent Sampler filter weights (winter only) show similar percent increases for coarse particulates measured at the downwind site. The average particulate weight increase was 573%. Samples were not available from the summer.

The downwind site shows a greater number and concentration of both fine and course airborne particles, as compared to the upwind site. A higher count of coarse particles and the percent difference increase at the downwind site appears greatest during the winter months. The higher counts may be attributed to road sanding and salting during the winter months. The lower percent difference exhibited during the summer months may be attributed to the absence of sanding and salting, coupled with increased activity around the upwind site. The upwind site is located approximately 50 feet downwind from a gravel parking lot. The lot is seldom used in the winter but sees increased activity during the summer months. In addition, increased summer activity at the Field Station dock and along the Black Rock canal may have contributed fine particles to the air.Chemical analysis of the germanium slides (using SEM-EDX spectroscopy) identified the presence of aluminum (Al), calcium (Ca), chlorine (Cl), iron (Fe), potassium (K), silicon (Si), and sulfur (S). Enrichment factor calculations (<10X) attributed K and Fe to natural soil sources. Sulfur was enriched 100X, but showed no differences between the upwind and downwind site. Sulfur was attributed to a regional signature for secondary pollutants (sulfate). Only Ca and Cl showed enrichments (30X and 1000X, respectively) at the downwind site (<10X and not detected at the upwind site). Enrichment factors were recalculated using urban road dust as a source (Vermette et al., 1987), and Ca EF values approached one. Calcium was attributed to suspended road dust and Cl was attributed to suspended road salt. These findings are consistent with the PBC as a source for suspended road dust. SEM-EDX is capable of detecting elemental carbon (EC), and EC can be used as a signature element for diesel exhaust. The absence of carbon is puzzling, as SEM-EDX offers no support for a diesel exhaust source.

The limited sampling presented here, is consistent with our hypothesis that the PBC increases downwind concentrations of both fine and coarse

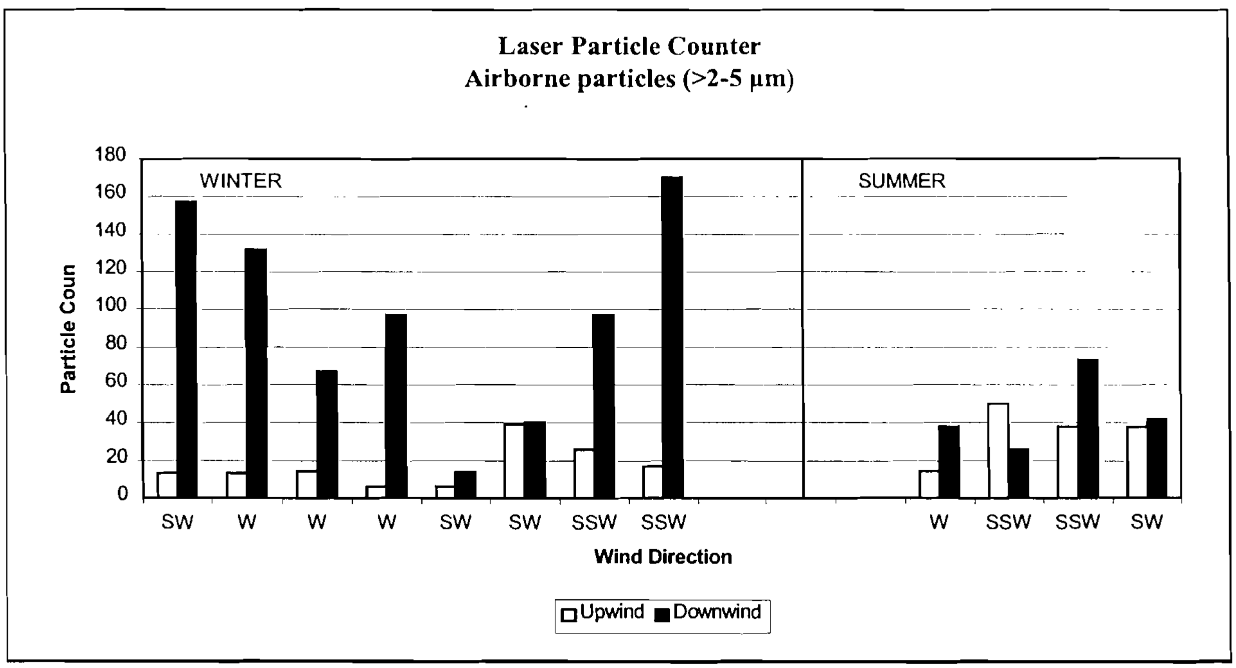

Figure 4: Course airborne particle counts (> 2-5 µm) sampled at the upwind and downwind sites.

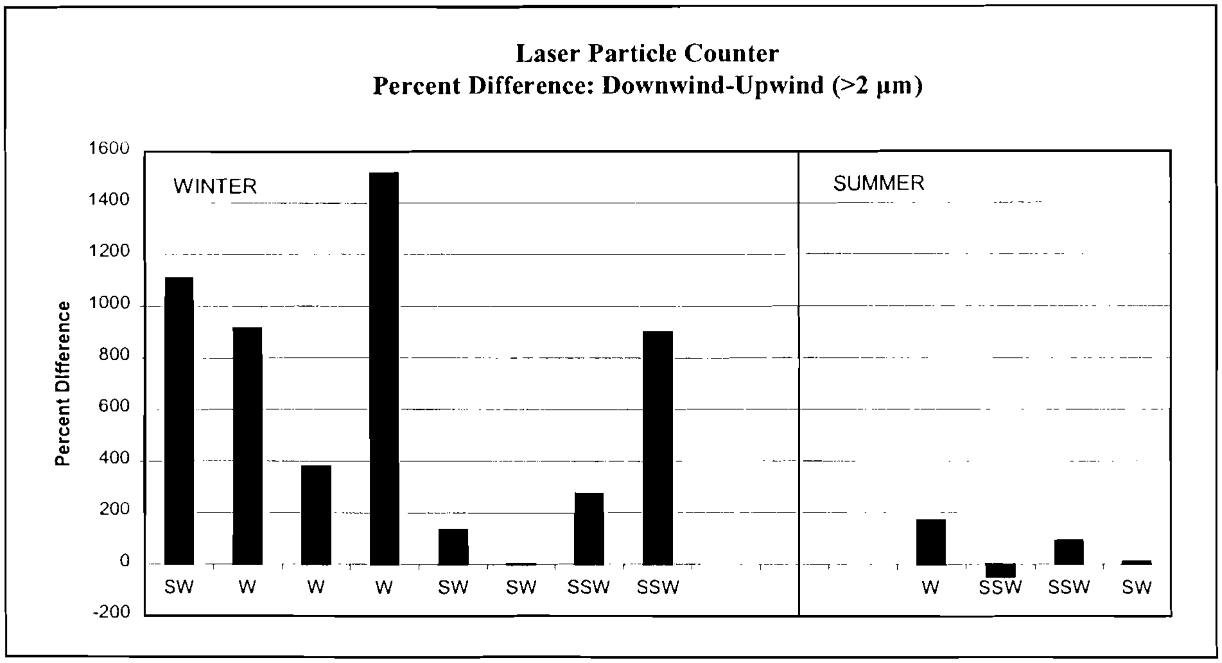

Figure 5: Coarse particle counts expressed as a percent difference between upwind and downwind sites. A positive value indicates higher counts at the downwind site.

airborne particles. This increase appears confined to the winter months. The impact of increased downwind particle concentrations in the winter is made more significant with the dominance of southwest and westerly winds during this same period.

Conclusive support for the downwind influence of the PBC requires a more detailed sampling regime, which includes the setup of control sites, a detailed chemical analysis of the filters (including signature elements for vehicle exhaust and other potential sources), and the collection of a source signature from the PBC (road dust and exhaust). In addition, use of dispersion modeling could be used to isolate the PBC as a source of airborne particles, and to direct the placement of samplers to better effect.

CONCLUSION

Samples collected downwind of the PBC repeatedly exhibited higher fine and coarse particle counts than that of the upwind site. The downwind site showed an average percent difference for fine particles of +25% in the winter, and +9% in the summer. The downwind site showed an average percent difference of +653% in the winter for coarse particles, while the summer showed a percent difference of +57 %. The percent increases reported for the winter months were considered significant, while values reported during the summer months were considered barely significant. The impact of increased downwind particle concentrations in the winter is made more significant with the dominance of southwest and westerly winds during this same period. Chemical analysis identified the presence of aluminum (Al), calcium (Ca), chlorine (Cl), iron (Fe), Potassium (K), silicon (Si), and sulfur (S) in the samples. Of these elements Ca and Cl were attributed to resuspended road dust, supportive of a winter source of airborne particles. The other elements were attributed to either natural soil, or regional pollution sources. Elemental carbon was not detected downwind of the PBC, thus there is no support for vehicle exhaust as a source of airborne particles.

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