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2020 Lower Fraser Valley Air Quality Monitoring Report

SERVICES AND SOLUTIONS FOR A LIVABLE REGION

This report was prepared by the staff of the Air Quality and Climate Action Services Division of the Metro Vancouver Regional District ("Metro Vancouver"). The project was managed by Geoff Doerksen with a project team that included Ken Reid, Kyle Howe, and Julie Saxton.

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Summary

This annual report summarizes the air quality monitoring data collected by the Lower Fraser Valley (LFV) Air Quality Monitoring Network in 2020 and describes the air quality monitoring activities and programs conducted during the year. The focus is to report on the state of ambient (outdoor) air quality in the LFV.

LFV Air Quality Monitoring Network

Metro Vancouver operates a comprehensive network with stations in Metro Vancouver, as well as stations in the Fraser Valley Regional District (FVRD) in partnership with the FVRD. The LFV Air Quality Monitoring Network includes air quality monitoring stations located from Horseshoe Bay in West Vancouver to Hope. A map of the network is provided in Section C.

Air quality and weather data are collected automatically on a continuous basis, transmitted to Metro Vancouver's Head Office in Burnaby, and stored in an electronic database. The data are then used to communicate air pollutant information to the public, such as through air quality health index (AQHI) values and on airmap.ca.

Air quality monitoring stations are located throughout the LFV to provide an understanding of the air quality levels that residents are exposed to most of the time. This report shows how these levels have varied throughout the region and how these levels have changed over time. Trends in air quality measured by the Air Quality Monitoring Network are used to evaluate the effectiveness of pollutant emission reduction actions undertaken as part of Metro Vancouver's Clean Air Plan[1].

Specialized Air Quality Monitoring

In addition to the monitoring network stations, Metro Vancouver deploys portable air quality stations and instruments to conduct specialized monitoring studies. Specialized studies can target suspected problem areas at the local, neighbourhood or community level. In March 2020, Metro Vancouver's mobile air monitoring unit (MAMU) began a year-long air quality monitoring study at Musqueam's Indian Reserve No. 2 lands in Vancouver. The monitoring will provide information on air quality in the Musqueam community and support Metro Vancouver's Iona Island Wastewater Treatment Plant Biosolids Dewatering Facility project.

Pollutants Monitored

Pollutants are emitted to the air from a variety of human activities and natural phenomena. Once airborne, the resulting pollutant concentrations are dependent on several factors, including the weather, topography and chemical reactions in the atmosphere.

Common air contaminants, including ozone (O_3), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter are widely monitored throughout the network. Particulate matter is composed of very small particles that remain suspended in the air. They are further distinguished by their size, which is measured in units of a millionth of a metre (or micrometre).

Particles with a diameter smaller than 10 micrometres are referred to as inhalable particulate (PM_{10}), while those smaller than 2.5 micrometres are termed fine particulate ($PM_{2.5}$). Both PM_{10} and $PM_{2.5}$ concentrations are monitored at stations throughout the LFV.

Other pollutants less widely monitored in the network include black carbon (BC), ultrafine particles (UFP), ammonia (NH_3), volatile organic compounds (VOC), and total reduced sulphur compounds (TRS).

Air Quality Health Index (AQHI)

Developed by Environment and Climate Change Canada and Health Canada, the Air Quality Health Index (AQHI) communicates the health risks associated with a mix of air pollutants to the public and provides guidance on how individuals can adjust their exposure and physical activities as air pollution levels change. The AQHI is calculated every hour using monitoring data from stations in the LFV.

Current AQHI levels in the LFV as well as the AQHI forecasts and additional information about the AQHI are available at airmap.ca and

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[1] https://metrovancouver.org/services/air-quality-climate-action/Documents/clean-air-plan-2021.pdf

www.env.gov.bc.ca/epd/bcairquality/readings/aqhi-table.xml

Air Quality Objectives and Standards

Several pollutant-specific air quality objectives and standards are used as benchmarks to characterize air quality. They include Metro Vancouver and provincial ambient air quality objectives, and the federal Canadian Ambient Air Quality Standards for ozone, particulate matter, sulphur dioxide and nitrogen dioxide.

The federal Canadian Ambient Air Quality Standards (CAAQS) have been established as objectives under the Canadian Environmental Protection Act, and replaced Canada-Wide Standards. In 2015, Metro Vancouver adopted a 1-hour interim ambient air quality objective for SO_2 of 75 parts per billion (ppb). After establishment of the federal SO_2 CAAQS, Metro Vancouver's SO_2 objectives were revised in 2017, with a more stringent 1-hour objective of 70 ppb not to be exceeded and an annual objective of 5 ppb.

In 2019, Metro Vancouver aligned its objectives for CO, NO_2 and O_3 with federal and provincial standards. Metro Vancouver adopted a 1-hour and annual ambient air quality objective for NO_2 that is the same as the federal 2020 CAAQS. Similarly, the 8-hour O_3 objective was made the same as the 2020 CAAQS. The 1-hour and 8-hour CO objectives were set to 13,000 ppb and 5,000 ppb respectively, to match the more stringent Provincial objectives.

Priority Pollutants

Research indicates that adverse health effects can occur at the air contaminant concentrations measured in the LFV. Health experts have identified exposure to ozone, particulate matter, and nitrogen dioxide as being associated with the most serious health effects. Ozone is a strong oxidant that can irritate the eyes, nose and throat, and reduce lung function. $PM_{2.5}$ particles are small enough to be breathed deeply into the lungs, resulting in impacts to both respiratory and cardiovascular systems. Nitrogen dioxide can have adverse effects on human health and the environment. It can cause adverse effects on respiratory systems of humans, cause damage to vegetation, and contribute to the formation of ozone. Long-term exposure to these pollutants can aggravate existing health conditions and lead to premature mortality.

Of particular concern is $PM_{2.5}$ that is emitted from diesel fuel combustion in car, truck, marine, rail and non-road engines. These particles ("diesel PM") are carcinogenic and are believed to contribute significantly to the health effects described above. Instrumentation installed in some air quality monitoring stations in the LFV can be used to estimate the proportion of particles that originate from diesel engines.

Research presents evidence of harmful effects of air pollution on health, including mortality, at levels below current objectives and standards for many pollutants including fine particulate matter, nitrogen dioxide and ground-level ozone. These findings suggest there may be no safe levels of exposure to air pollution and there are important public health benefits from continued reductions of air contaminants.

Air Quality Advisories

In 2020, air quality advisories were issued during three separate periods for a total of thirteen days in the summer. There were two separate one-day ground-level ozone advisories (July and August) and an 11-day fine particulate matter and ozone advisory in September due to wildfire smoke from Washington, Oregon and California. In the last ten years, the number of days when air quality advisories were in place ranged from zero to as many as 22 days annually. Periods of degraded air quality can occur in the LFV for several reasons, such as summertime smog during hot weather or smoke from forest fires. Air quality advisories are issued to the public when air quality has deteriorated or is predicted to deteriorate within the LFV.

Wildfires and Climate Change

In recent years, wildfires in the Pacific Northwest have increased in severity and become more widespread. Wildfires can produce considerable amounts of smoke that can be transported great distances. Both 2017 and 2018 had significant wildfire seasons with 2018 experiencing one of the worst in British Columbia's history, with the largest area burned. Overall fire activity in 2019 and 2020 were both well below the 10-year Provincial average. However, in 2020 the region was impacted by wildfire smoke due to active wildfire seasons in Washington, Oregon and California.

Climate projections indicate the region will experience hotter, drier summers and wetter, warmer winters. A warming climate is likely to increase the frequency and duration of wildfires and associated smoke impacts, while also increasing in-region ground-level ozone formation through the intensity and duration of summer heatwaves.

Metro Vancouver's updated air quality management plan, the Clean Air Plan[1], considers the increasing impacts of wildfire activity when developing strategies and actions to reduce health risks for Metro Vancouver residents. In parallel, Metro Vancouver's series of Climate 2050 Roadmaps identify actions to help the region adapt to climate-related impacts on regional air quality.

Visual Air Quality

Visual air quality (sometimes referred to as visibility or haze) can become degraded in the LFV, causing local views to become partially or fully obscured. Haze may have different characteristics depending on the underlying cause. In parts of Metro Vancouver, especially more urbanized areas to the west, haze can have a brownish appearance due to nitrogen dioxide from transportation emissions. Further east in the LFV, impaired visual air quality can be more associated with a white haze caused by small particles ($PM_{2.5}$) in the air that scatter light.

Monitoring is conducted to assess how and by how much visual air quality has become impaired. Measurements of $PM_{2.5}$, particle constituents (for example, particulate nitrate, particulate sulphate, elemental carbon and organic carbon), nitrogen dioxide and other air contaminants as well as light scattering provide important data for visual air quality management activities. In 2020, automated digital cameras recorded views along specific lines-of-sight in six locations in the LFV. The camera in one additional location required maintenance, which could not be completed in 2020 due to restrictions related to COVID-19.

By examining photographs alongside data from monitoring equipment, visual air quality impairment can be related to pollutant concentrations and relevant emissions sources. These activities conducted through a multi-agency collaboration (BC Visibility Coordinating Committee) inform the development of policy options for improving visual air quality.

Regional Long-Term Trends

Long-term *regional* trends in air quality are the trends observed within the LFV as a whole. They are determined by averaging measurements from several stations distributed throughout the LFV.

Figures S1 to S4 show the average concentrations and the short-term peak concentrations of four common air contaminants for the last two decades. Average concentrations represent the ambient concentrations that the region experiences most of the time. Short-term peak concentrations show the relatively infrequent higher concentrations experienced for short periods (on the scale of one hour to one day). Specific locations may have experienced trends that differ slightly from the regional picture.

Despite significant population growth in the region over the same time period, actions to reduce emissions across a variety of sectors have brought about these improvements in air quality. Stricter vehicle emission standards and the AirCare program (1992 – 2014) are largely responsible for lower nitrogen dioxide (NO_2) and carbon monoxide (CO) levels.

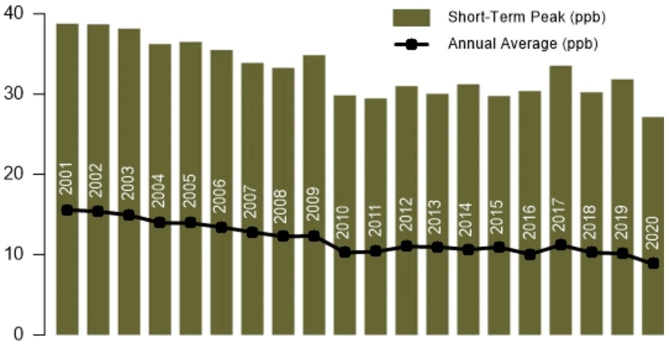

Figure S1: Nitrogen Dioxide Trend.

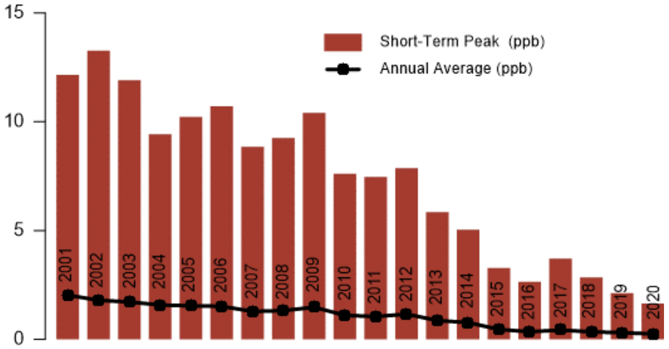

Figure S2: Sulphur Dioxide Trend.

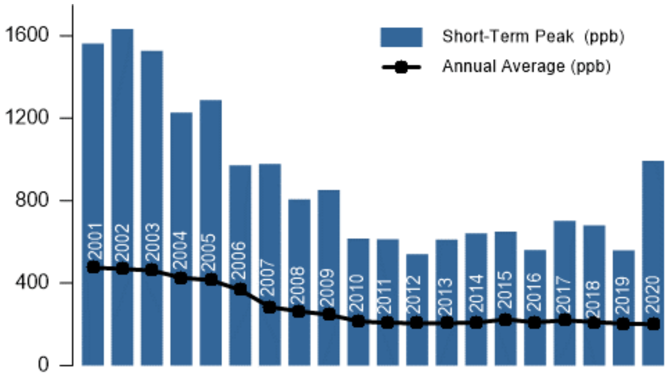

Figure S3: Carbon Monoxide Trend.

Despite significant population growth in the region over the same time period, actions to reduce emissions across a variety of sectors have brought about these improvements in air quality. Stricter vehicle emission standards and the AirCare program (1992 – 2014) are largely responsible for lower nitrogen dioxide (NO_2) and carbon monoxide (CO) levels.

Requirements for reduced sulphur content in marine, on-road and off-road fuels, and reduced emissions from the petroleum refining and cement industries have led to the considerable improvements in sulphur dioxide (SO_2) levels. Emission reductions from light duty and heavy duty vehicles, wood products sectors, and petroleum refining have contributed to the decline in $PM_{2.5}$ levels.

The regional $PM_{2.5}$ trends are illustrated in Figure S4. Wildfire effects are evident in 2017, 2018, and 2020. Fine particulate matter monitoring technology was upgraded in 2013 to continuous particulate monitors that met the U.S. Environmental Protection Agency $PM_{2.5}$ Federal Equivalent Method (FEM). The FEM monitors have the ability to measure a portion of particulate matter not previously measured.

For ozone, the same improvements seen for other pollutants have not been observed. In contrast, average regional ozone levels (Figure S5) have shown a slight increasing trend. Research suggests that background ozone (i.e., ozone from out of region) concentrations are rising and are one reason for the observed increase in average levels.

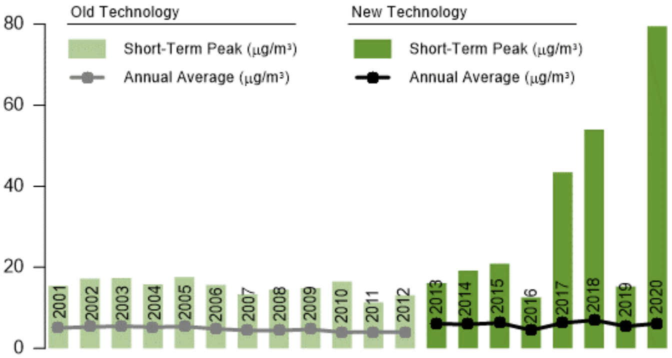

Figure S4: Fine Particulate Matter ($PM_{2.5}$) Trend.

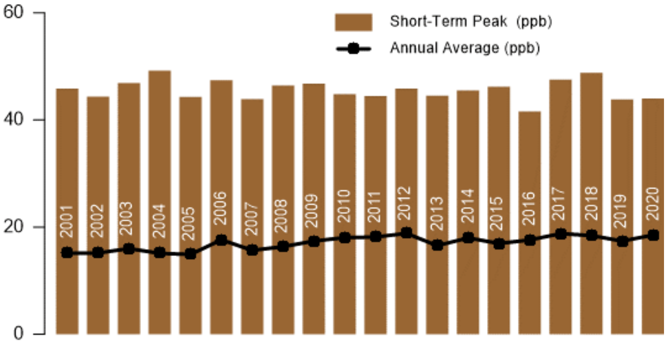

Figure S5: Ozone Trend.

Regionally averaged short-term peak ozone trends are also shown in Figure S5. The severity of peak ozone episodes greatly diminished in the 1980s when annual maximum concentrations were about twice as high as levels today. Short-term peak ozone levels have been mainly unchanged during the last two decades, despite large reductions in emissions of pollutants that contribute to ozone formation.

Metro Vancouver and the Fraser Valley Regional District adopted the Regional Ground-Level Ozone Strategy[2] in 2014, which provides strategic policy direction for ozone management in the LFV based on local scientific research. Research indicates that a spatial understanding of the ratio of concentrations of nitrogen oxides (NO_X) and volatile organic compounds (VOC), two precursor pollutants that react to form ozone, is key to determining which precursors to reduce in order to maintain and improve air quality in our region.

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[2] https://metrovancouver.org/services/air-quality-climate-action/Documents/regional-ground-level-ozone-strategy-2014.pdf

Ground-Level Ozone – 2020

Monitoring results for all ozone monitoring stations in 2020 are shown in Figure S6. The data show that peak ozone levels, as measured by the maximum 1-hour average and Metro Vancouver's 8-hour objective value, generally occurred in the eastern parts of Metro Vancouver and in the FVRD during sunny, hot weather.

In 2020, Metro Vancouver's 8-hour objective was met at all monitoring stations. The 1-hour Metro Vancouver objective was met at all monitoring stations with the exception of Chilliwack, Abbotsford Airport, Mission, and Pitt Meadows on a combination of two days (July 30 and August 16). Air quality advisories were in effect for three days (July 16, August 16 and September 9) due to elevated levels of ground-level ozone.

Ground-level ozone is a secondary pollutant formed in the air from other contaminants such as nitrogen oxides (NO_X) and volatile organic compounds (VOC). The highest concentrations of ozone occur during hot sunny weather and can be enhanced by wildfire smoke.

NO_X emissions are dominated by transportation sources, while VOC are emitted from natural sources (e.g., trees), cars, light trucks, and solvents found in industrial, commercial and consumer products.

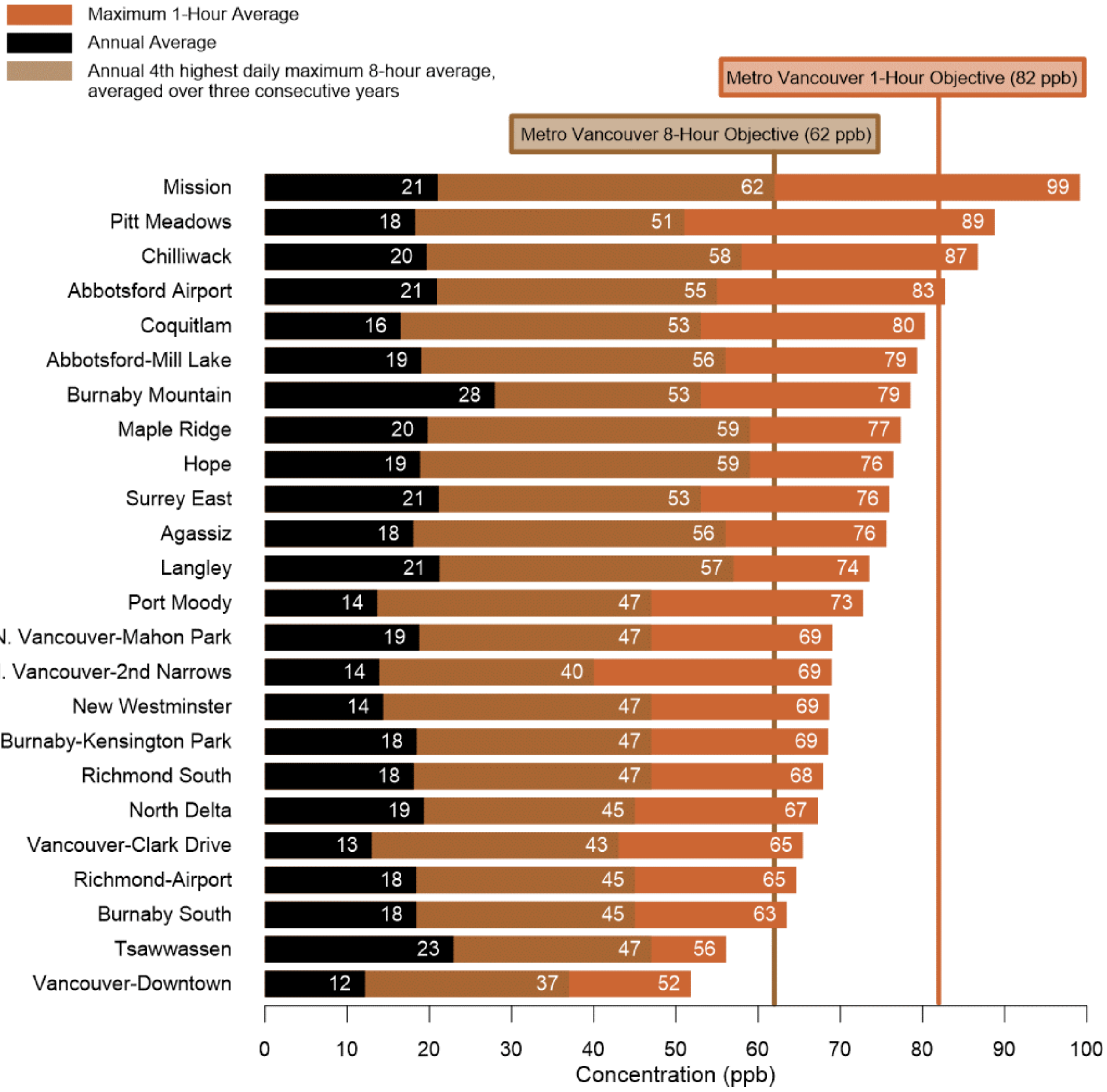


Figure S6: Ground-Level Ozone (O_3) 2020.

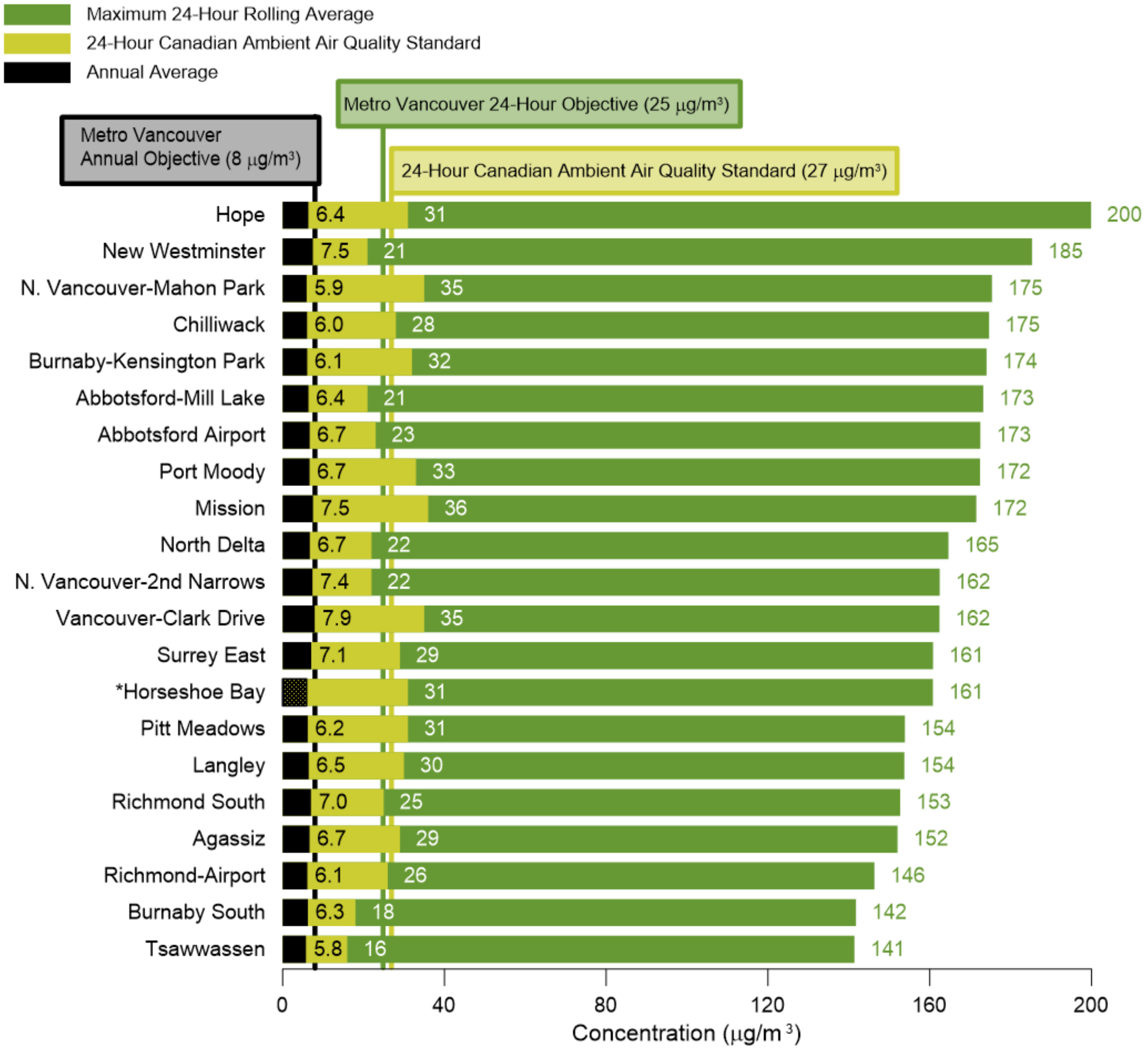
Fine Particulate Matter ($PM_{2.5}$) – 2020

Results for all $PM_{2.5}$ monitoring stations in 2020 are shown in Figure S7. All stations were below (i.e., better than) the Metro Vancouver annual objective of 8 µg/m^3, while exceedances of Metro Vancouver's 24-hour $PM_{2.5}$ objective occurred at all stations due to smoke in September from extensive wildfires burning in Washington, Oregon and California.

An 11-day air quality advisory was issued on September 8 due to elevated levels of $PM_{2.5}$ in Metro Vancouver and the Fraser Valley. On September 11 for nine straight days all monitoring stations throughout the region were in exceedance of the 24-hour $PM_{2.5}$ objective. The highest 24-hour $PM_{2.5}$ concentration was measured in Hope on September 15 at 200 µg/m^3. On September 19 the air quality advisory was ended due to cleaner marine air entering the region.

Over half of the stations exceeded the 24-hour Canadian Ambient Air Quality Standard (CAAQS) in 2020. The 24-hour $PM_{2.5}$ CAAQS value is calculated by taking the annual 98th percentile daily average concentration, averaged over three consecutive years. The 2020 CAAQS was influenced by active wildfire years in 2018 and 2020.

Fine particulate matter ($PM_{2.5}$) emissions are typically dominated by residential wood burning, non-road engines and equipment, and industrial sources. However, impacts of smoke from wildfires outside the region are becoming more apparent.



*Data completeness criteria was not met at this station. The average has been calculated with all available data.

Figure S7: Fine Particulate Matter ($PM_{2.5}$) 2020.

Nitrogen Dioxide – 2020

Results for nitrogen dioxide (NO_2) monitoring in 2020 are shown in Figure S8. All stations that measured nitrogen dioxide levels met Metro Vancouver's 1-hour objective. The 1-hour objective value is calculated by taking the annual 98th percentile of the daily maximum 1-hour concentration, averaged over three consecutive years. The annual objective was met at all monitoring stations.

As nitrogen dioxide emissions are dominated by transportation sources, the highest average nitrogen dioxide concentrations are measured in the more densely trafficked areas and near busy roads. Lower concentrations are observed where these influences are less pronounced, such as the eastern parts of Metro Vancouver and in the FVRD.

NO_X emissions are dominated by transportation sources, with nearly 77% of emissions coming from cars, trucks, ships, rail, planes, and non-road engines. Of those NO_X emissions, approximately 10% are originally emitted as NO_2, while the remaining 90% is NO, which rapidly converts to NO_2.

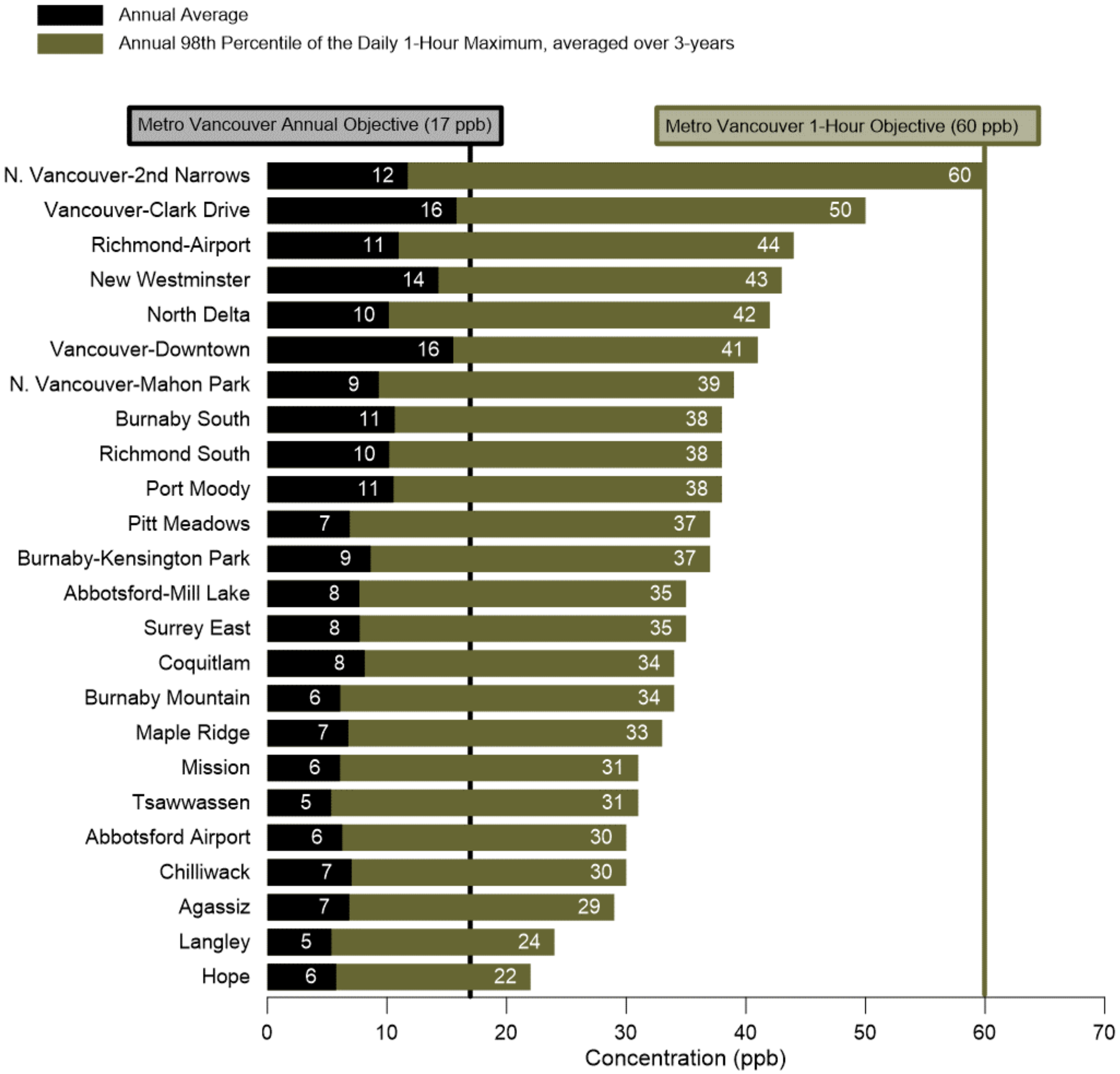


Figure S8: Nitrogen Dioxide (NO_2) 2020.

Sulphur Dioxide – 2020

Monitoring results for sulphur dioxide (SO_2) monitoring stations are shown in Figure S9. Sulphur dioxide levels were below Metro Vancouver's 1-hour objective and annual objective at all stations in 2020.

Average concentrations of sulphur dioxide in 2020 were less than 1 ppb at all stations. Average levels remain low in 2020 compared with previous years, which can be attributed to stricter marine fuel requirements that came into effect at the beginning of 2015.

Sulphur dioxide is formed primarily by the combustion of fossil fuels containing sulphur. Within the LFV the major sources of SO_2 are an oil refinery, marine vessels, a waste to energy facility and two cement plants. The geographical distribution of sulphur dioxide emissions is influenced mainly by the refinery in Burnaby and ocean-going vessels in the marine areas of Burrard Inlet, although in recent years, marine emissions have been reduced substantially. The highest sulphur dioxide levels are typically measured near the Burrard Inlet area. Away from the Burrard Inlet area, sulphur dioxide levels are considerably lower.

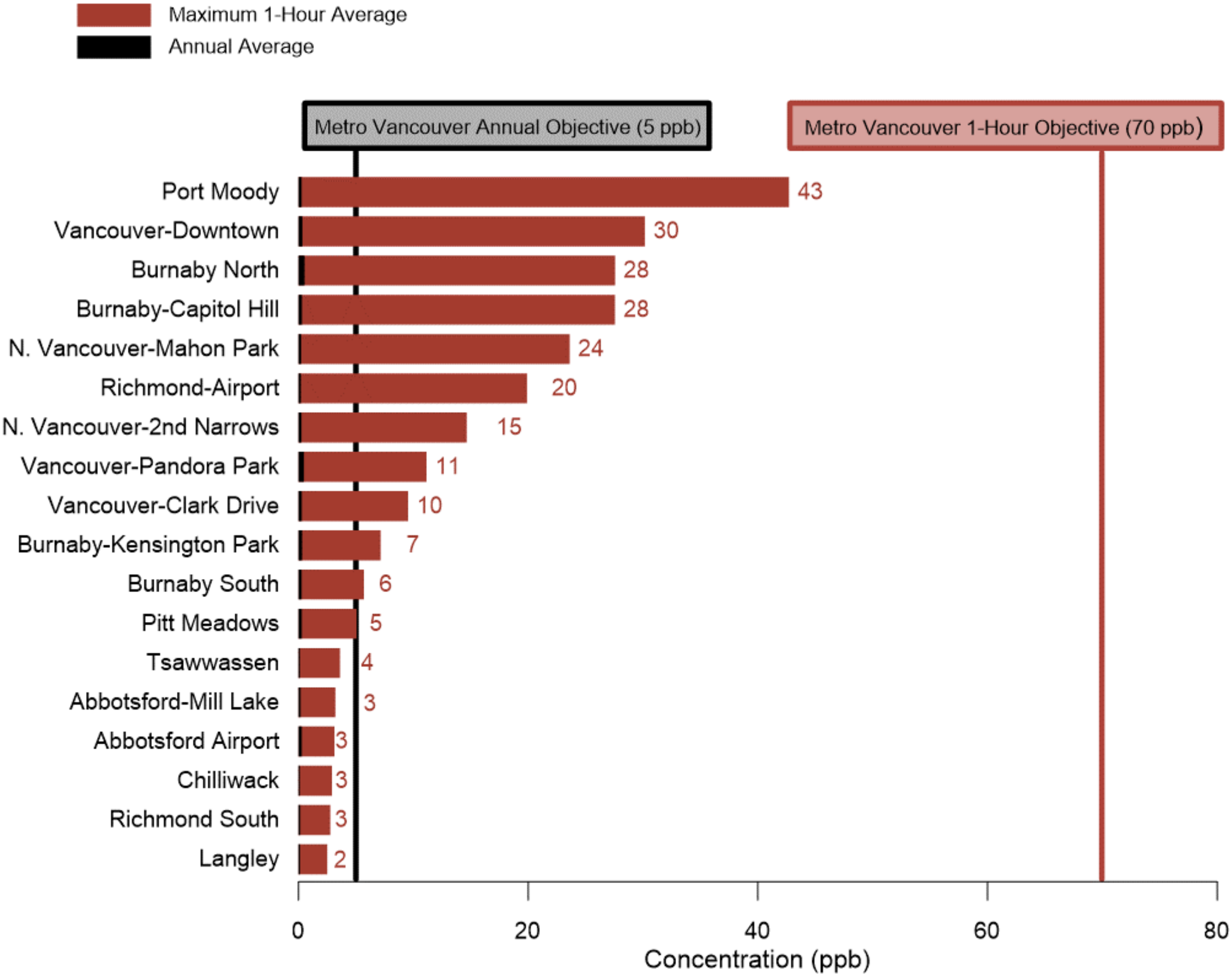
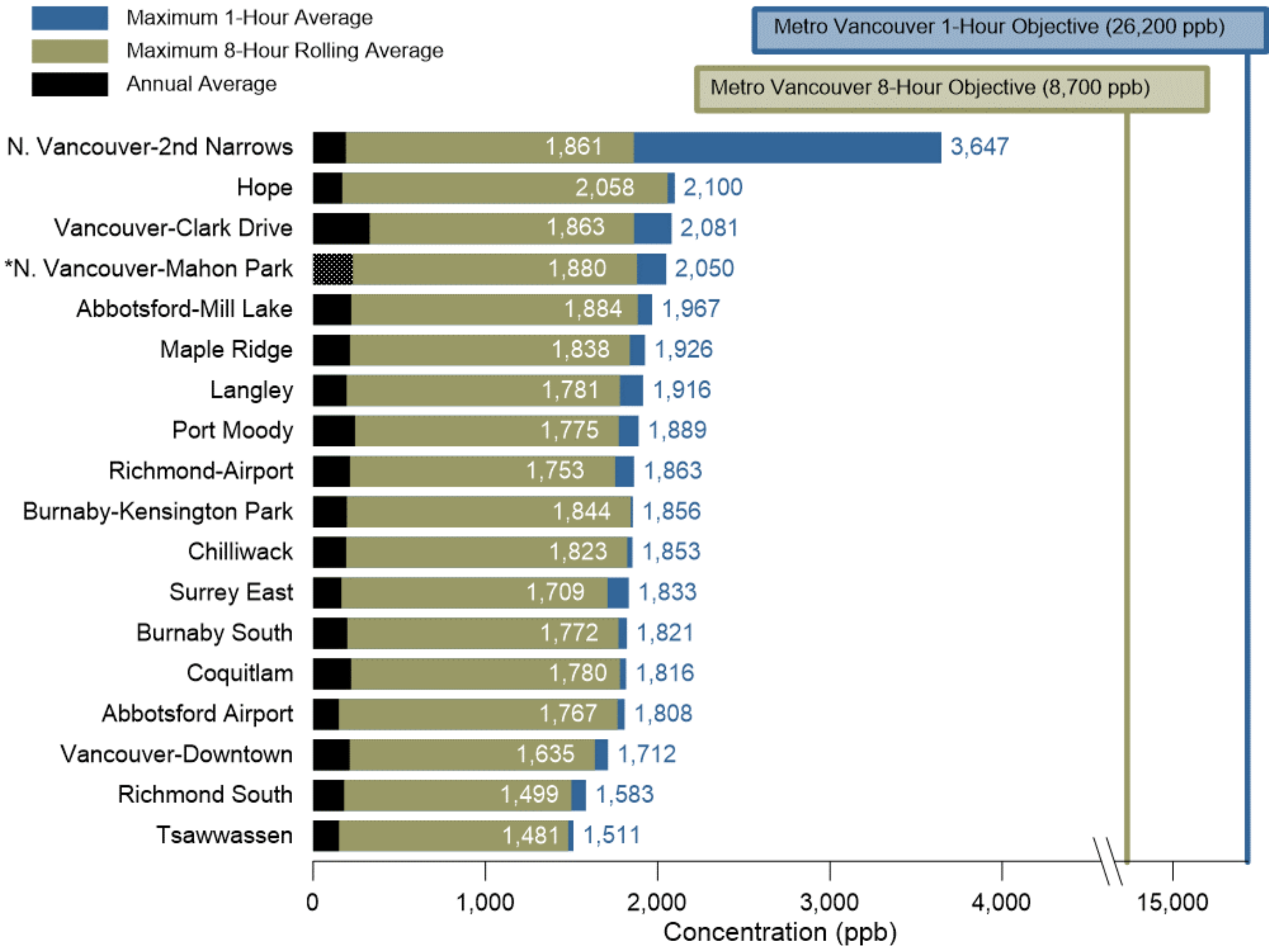


Figure S9: Sulphur Dioxide (SO_2) 2020.

Carbon Monoxide – 2020

Carbon monoxide (CO) monitoring results for 2020 are shown in Figure S10. Carbon monoxide levels were all well below the relevant Metro Vancouver air quality objectives at all stations throughout the LFV. The principal source of carbon monoxide continues to be emissions from motor vehicles. However, in 2020 carbon monoxide was highly influenced by wildfire smoke in September resulting in similar 1-hour and 8-hour maximum values at many of the stations.

Higher concentrations typically occur close to major roads during peak traffic periods. Like nitrogen dioxide, the highest average carbon monoxide concentrations are measured in the more densely trafficked areas and near busy roads. Lower concentrations are observed where these influences are less pronounced, such as the suburban and rural parts of Metro Vancouver and the FVRD.



*Data completeness criteria was not met at this station. The average has been calculated with all available data.

Note: The scale is broken in the x-axis between 4,500 and 8,000 ppb.

Figure S10: Carbon Monoxide (CO) 2020.

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List of Acronyms

AQHI	Air Quality Health Index
BC	Black Carbon
BC ENV	British Columbia Ministry of Environment and Climate Change Strategy
BCVCC	BC Visibility Coordinating Committee
CCME	Canadian Council of Ministers of the Environment
CAAQS	Canadian Ambient Air Quality Standard
CO	Carbon Monoxide
FEM	Federal Equivalent Method
FVRD	Fraser Valley Regional District
LFV	Lower Fraser Valley
MAMU	Mobile Air Monitoring Unit
NAPS	National Air Pollution Surveillance
NO_X	Nitrogen oxides
NO_2	Nitrogen dioxide
NO	Nitric oxide
NH_3	Ammonia
O_3	Ozone
PM	Particulate matter
PM_{10}	Inhalable particulate matter (particles smaller than 10 micrometres in diameter)
$PM_{2.5}$	Fine particulate matter (particles smaller than 2.5 micrometres in diameter)
SO_X	Sulphur oxides
SO_2	Sulphur dioxide
THC	Total hydrocarbons
TRS	Total reduced sulphur compounds
UFP	Ultrafine particles
VOC	Volatile organic compounds

Section A – Introduction

This report summarizes data collected from air quality stations in the Lower Fraser Valley (LFV) Air Quality Monitoring Network in 2020 and describes the air quality monitoring activities and programs conducted during the year. The focus is to report on the state of ambient (outdoor) air quality in the LFV.

Metro Vancouver maintains one of the most comprehensive air quality networks in North America serving a large population with air quality stations located from Horseshoe Bay in West Vancouver to Hope. Pollutants monitored by the network include both gases and particulate matter. Common air contaminants include ozone (O_3), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter. These are all widely monitored throughout the network.

Particulate matter consists of very small solid and liquid material suspended in the air. This air pollutant is characterized by size and measured in units of a millionth of a metre, or micrometre (µm). Particles with a diameter smaller than 10 micrometres are referred to as inhalable particulate (PM_{10}), while those smaller than 2.5 micrometres are termed fine particulate ($PM_{2.5}$). Both PM_{10} and $PM_{2.5}$ concentrations are monitored throughout the LFV.

Other pollutants monitored by the network include ammonia, volatile organic compounds (VOC), black carbon, ultrafine particles (UFP) and odourous total reduced sulphur compounds (TRS). Additional information Metro Vancouver collects to help monitor air quality conditions includes weather (meteorological) data and images recording visual air quality conditions (visibility).

Priority Pollutants

Research indicates that adverse health effects can occur at air quality levels commonly measured in the LFV. Health experts have identified exposure to ozone and particulate matter as being associated with serious health effects. Ozone is a strong oxidant that can irritate the eyes, nose and throat, and reduce lung function. Fine particulate ($PM_{2.5}$) is small enough to be breathed deeply into the lungs, resulting in impacts to both respiratory and cardiovascular systems. Long-term exposure to these pollutants can aggravate existing heart and lung diseases and lead to premature mortality.

Of particular concern is $PM_{2.5}$ that is emitted from diesel fuel combustion in car, truck, marine, rail and non-road engines. These particles ("diesel PM") are carcinogenic and are believed to contribute significantly to the health effects described above. Instrumentation installed in some air quality monitoring stations in the LFV can be used to estimate the proportion of particles that originate from diesel engines.

Air Quality Trends

Improvements have been made in air quality over the last two decades for most pollutants, including nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), and volatile organic compounds (VOC). Despite significant population growth in the region over the same time period, emission reductions across a variety of sectors have brought about these improvements. The population increased in Metro Vancouver and the FVRD by about 50% from 1991 to 2016, from approximately 1.8 million to 2.8 million residents.

The long-term regional trends for ground-level ozone show a different story. Long-term trends of peak ozone concentrations show levels currently lower than those experienced in the 1980s, but peak levels have been largely unchanged over the last fifteen to twenty years. Average concentrations of ground-level ozone however have increased over the same period.

Metro Vancouver and the Fraser Valley Regional District adopted the Regional Ground-Level Ozone Strategy in 2014, which provides strategic policy direction for ozone management in the LFV based on local scientific research. Research indicates that a spatial understanding of the ratio of concentrations of nitrogen oxides (NO_X) and volatile organic compounds (VOC), two precursor pollutants that react to form ozone, is key to determining which precursors to reduce in order to maintain and improve air quality in our region.

Trends in air pollutants are discussed further by pollutant in Section D.

Air Quality Advisories

Periods of degraded air quality can occur in the LFV for several reasons, such as summertime smog during hot weather, smoke from forest fires and winter inversions preventing dispersion of emitted air contaminants. In cooperation with partner agencies, including the Fraser Valley Regional District, Vancouver Coastal Health Authority, Fraser Health Authority, Environment Canada and the BC Ministry of Environment and Climate Change Strategy, Metro Vancouver operates an air quality advisory program.

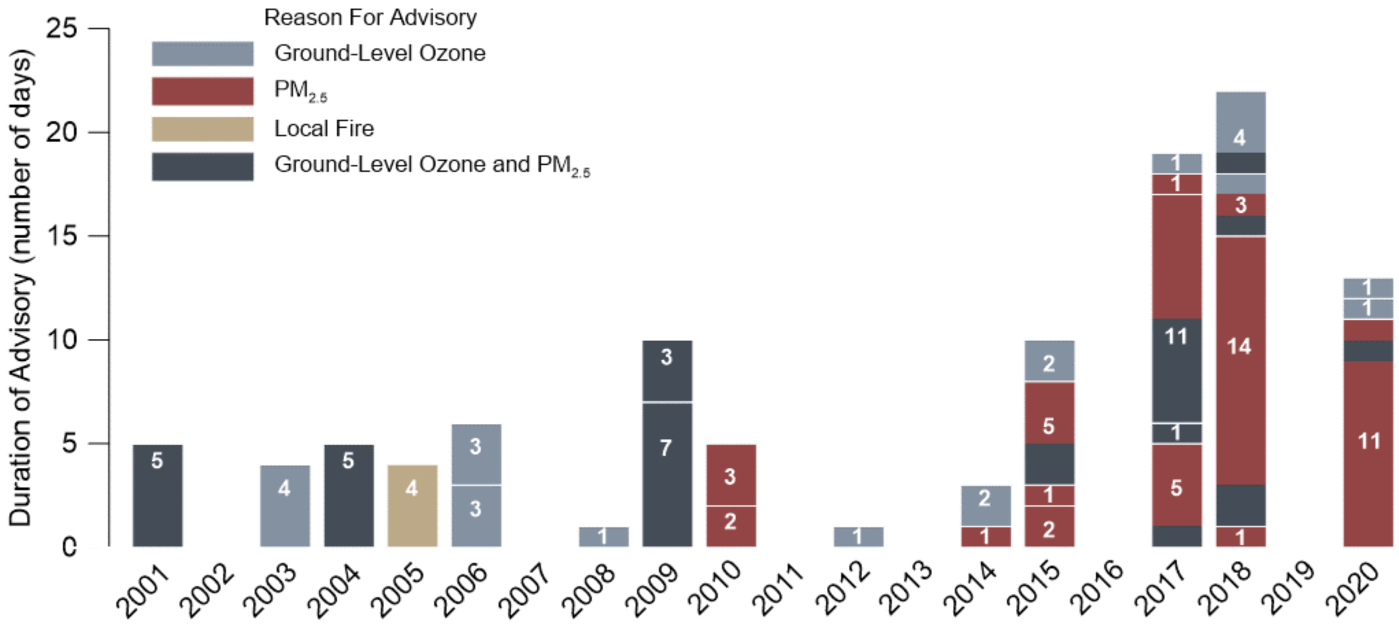
Air quality advisories are issued to the public when air quality has deteriorated or is forecast to deteriorate significantly within the LFV. Typically air quality advisories are issued when a pollutant exceeds or is predicted to exceed an air quality objective or standard at more than one monitoring location.

In the last ten years, the number of days on which air quality advisories were in place has ranged from zero to twenty-two days annually. Shown in Figure 1 is the historical trend of the number of days the LFV was under an advisory. The total number of advisory days is shown as a bar while the number of consecutive days of an advisory period is given by the number in white.

Air quality bulletins are used to advise the public of the occurrence of localized degraded air quality during cool weather months and actions that may be taken to reduce the emissions contributing to degraded air quality conditions.

In 2020, air quality advisories were issued during three separate periods for a total of thirteen days in the summer. Two separate one-day ozone advisories were initiated on July 30 and August 16 during hot and sunny weather, due to high concentrations of ground-level ozone in the eastern parts of Metro Vancouver and the Fraser Valley.

On September 8, a fine particulate matter advisory was issued for the both Metro Vancouver and the Fraser Valley due to smoke moving into the region from wildfires burning in Washington, Oregon and California. The following day, September 9, the fine particulate matter advisory was continued and an ozone advisory was added. On September 10, the ozone advisory was ended, and the $PM_{2.5}$ advisory continued despite lower $PM_{2.5}$ concentrations. The following day on September 11, $PM_{2.5}$ concentrations rapidly increased resulting in exceedances at all monitoring station within the region for nine straight days. The 11-day advisory was ended on September 19 due to cleaner marine air flowing into the region.



Notes:

- Trigger levels for advisories have changed over the years; care must be taken when interpreting advisory trends.
- The advisory in 2005 was the result of a large fire in Burns Bog.

Figure 1: Number of days of air quality advisories in the LFV.

Wildfires and Air Quality

In recent years, wildfires in the Pacific Northwest have increased in severity and become more widespread. Wildfires can produce considerable amounts of smoke that can be transported great distances. Both 2017 and 2018 were significant wildfire seasons with 2018 being one of the worst in British Columbia's history, with the largest area burned. Overall fire activity in 2019 and 2020 were both well below the 10-year provincial average. However, in 2020 the region was impacted by wildfire smoke due to active wildfire seasons in Washington, Oregon and California. More information on wildfire smoke impacts are provided in Section I.

Climate Change

Climate projections indicate the region will experience hotter, drier summers and wetter, warmer winters. A warming climate is likely to increase frequency and duration of wildfires and associated smoke impacts, while also increasing in-region ground-level ozone formation through the intensity and duration of summer heatwaves.

A study of the extreme 2017 wildfire season in British Columbia, found that human-induced climate change contributed greatly to the extreme warm temperatures, high wildfire risk, and large burned areas. The conclusions of the study indicated that as the climate continues to warm, it is expected that extreme wildfire seasons like 2017 and 2018 in BC will become more likely in the future.

Public awareness of air quality and health has also grown with the recent summer wildfire smoke impacts. The public has inquired about air quality, health effects, and steps that can be taken to reduce their own health risk during these events. Since 2017, Metro Vancouver has been working with local health authorities, BC Centre for Disease Control, Health Canada, the BC Ministry of Environment and Climate Change Strategy (BC ENV) the FVRD and experts from outside BC to develop communication materials for residents on wildfire smoke health impacts and interventions for reducing these impacts.

Metro Vancouver is also looking at further developing collaborations, such as working with member jurisdictions on provision of clean air shelters, to ensure that people will be better protected from the health impacts of wildfire smoke going forward.

Metro Vancouver's updated air quality management plan, the Clean Air Plan[1], considers the increasing impacts of wildfire activity when developing strategies and actions to reduce health risks for Metro Vancouver residents. In parallel, Metro Vancouver's Climate 2050 Roadmaps[3] identify actions to help the region adapt to climate-related impacts on regional air quality.

Visual Air Quality

Degraded air quality can cause views to be partially or fully obscured by haze at times in the LFV. This is referred to as visual air quality impairment.

Throughout the LFV, the contaminant with the greatest impact on visual air quality is $PM_{2.5}$. However, the appearance of haze can also be affected by the presence of a number of other air contaminants. In more urbanized areas in the west, haze may have a brownish colour. Nitrogen dioxide emissions from sources such as transportation contribute to this brown appearance. Further east in the LFV, a white haze can sometimes be observed as a result of small particles in the air ($PM_{2.5}$) scattering light. Secondary $PM_{2.5}$, such as that formed by reactions of NO_X and SO_2 with ammonia, as well as emitted (or primary) $PM_{2.5}$ contribute to this haze. Smoke, windblown dust and soil particles, as well as moisture levels in the air can also affect visibility.

Analysis of the air contaminants present under different visual air quality conditions is being used to understand the factors contributing to visual air quality impairment in the LFV and to develop tools to evaluate visual air quality quantitatively. Data collected as part of the visual air quality monitoring program include measurements of nitrogen dioxide and $PM_{2.5}$, measurements of the constituents of particulate matter (for example particulate nitrate, particulate sulphate, elemental carbon and organic carbon) and the optical (light scattering) characteristics of ambient air samples.

In 2020, automated digital cameras were used to record visual air quality conditions in several locations. One of the cameras required maintenance which could not be completed in 2020 due to restrictions related to

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[3] https://metrovancouver.org/services/air-quality-climate-action/climate-2050

COVID-19. Images from the cameras show views along specific lines-of-sight with recognizable topographical features at known distances. The images are archived for various uses, including:

- relating air contaminant measurements to visual range and visual air quality degradation under a variety of air quality and meteorological conditions;
- assessing public perceptions of the different visual air quality conditions found in the LFV; and
- developing visual air quality measurement metrics.

Images from each of the monitoring locations are shown on [www.clearairbc.ca.](http://www.clearairbc.ca)

The monitoring data and images collected provide important input to a collaborative multi-agency initiative to develop a visual air quality management strategy for the LFV. Visual air quality is further discussed in Section F.

Air Quality Measurements

The LFV Air Quality Monitoring Network primarily employs continuous monitors which provide data in real-time every minute of the day. The network also contains specialized air quality monitors that sample the air non-continuously. Non-continuous 24-hour (daily) samples are collected on filters and/or in canisters every sixth or twelfth day depending on the site. The sampling is scheduled in accordance with the National Air Pollution Surveillance (NAPS) program. After sample collection, filters and canisters are analyzed in a federal laboratory to determine pollutant concentrations. Non-continuous samples of volatile organic compounds (VOC) are collected at several sites throughout the LFV. VOC refers to a group of organic chemicals. A large number of chemicals are included in this group but each individual chemical is generally present at relatively low concentrations in air compared to other common air contaminants.

Non-continuous particulate samples are collected at four monitoring stations in the LFV where pollutant concentrations are determined. A detailed analysis is conducted by the federal laboratory for these stations (Port Moody, Burnaby South, Abbotsford Airport and Vancouver-Clark Drive).

Chemicals contained in $PM_{2.5}$ and VOC samples are identified and quantified at a federal laboratory. These data can then be used to help determine the emission sources contributing to the contaminants in the air.

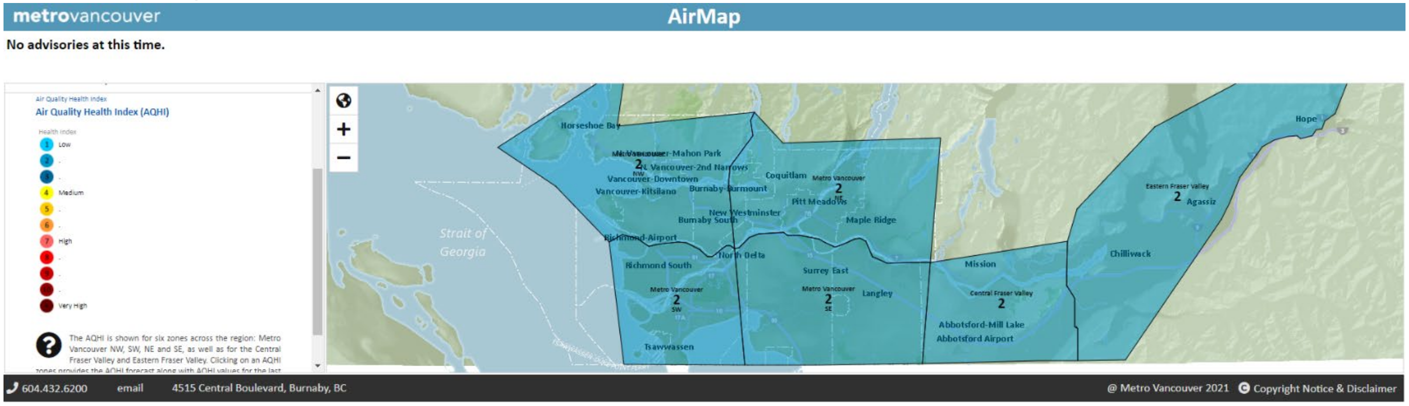
Non-continuous measurements are discussed in Section E.

Air Quality Health Index (AQHI)

The national health-based Air Quality Health Index (AQHI), developed by Environment Canada and Health Canada, has been in use since 2008. The AQHI communicates the health risks associated with a mix of air pollutants to the public and provides guidance on how individuals can adjust their exposure and physical activities as air pollution levels change.

The AQHI is calculated every hour using monitoring data from stations in the LFV. Current AQHI levels in the LFV, AQHI forecasts, and additional information about the AQHI are available at:

- airmap.ca
- weather.gc.ca/airquality/pages
- www.env.gov.bc.ca/epd/bcairquality/readings/aqhi-table.xml



No advisories at this time.

The AQHI is shown for six zones across the region: Metro Vancouver NW, SW, NE and SE, as well as for the Central Fraser Valley and Eastern Fraser Valley. Clicking on an AQHI zones provides the AQHI forecast along with AQHI values for the last

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Section B – Air Quality Objectives and Standards

Several air quality objectives and standards are used as benchmarks to characterize air quality including the federal Canadian Ambient Air Quality Standards (CAAQS), and Metro Vancouver's ambient air quality objectives. Metro Vancouver's ambient air quality objectives are shown in Table 1. The objective or standard is achieved if the ambient concentration is at or lower than (i.e., better than) the objective.

The federal Canadian Ambient Air Quality Standards (CAAQS) have been established as objectives under Canadian Environmental Protection Act 1999, and replaced the Canada-Wide Standards for fine particulate matter and ground-level ozone. The CAAQS were implemented in 2015 for particulate matter (PM) and ozone (O_3). In 2020, the numerical value of the CAAQS became more stringent for $PM_{2.5}$ and O_3 and nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) were also added. These set specific limits for $PM_{2.5}$, O_3, NO_2, and SO_2 based on concentrations averaged over a three-year period with the exception of the annual metric, which are averaged over one year.

The CAAQS for $PM_{2.5}$ is a value that is calculated by taking an annual 98th percentile value using daily averages, averaged over three consecutive years. Achievement of the $PM_{2.5}$ CAAQS is attained when the CAAQS value is less than or equal to 27 µg/m^3.

The CAAQS for ozone is a value that is calculated by the 4th highest annual 8-hour daily maximum, averaged over three consecutive years. Achievement of the ozone CAAQS is attained when the CAAQS value is less than or equal to 62 ppb.

The NO_2 CAAQS include metrics for both 1-hour and annual averages. The 1-hour CAAQS for NO_2 is a value that is calculated by taking an annual 98th percentile value using daily maximum 1-hour measurements, averaged over three consecutive years. Achievement of the 1-hour NO_2 CAAQS is attained when the CAAQS value is less than or equal to 60 ppb. The annual NO_2 CAAQS is a value of 17 ppb that is compared to the average of all 1-hour concentrations collected within the year.

In 2005, as part of the Air Quality Management Plan, Metro Vancouver adopted health-based ambient air quality objectives for ozone (O_3), particulate matter ($PM_{2.5}$ and PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and carbon monoxide (CO).

In 2009 the provincial government established air quality objectives for $PM_{2.5}$. The province's annual objective is eight micrograms per cubic metre (µg/m^3) and annual planning goal is six micrograms per cubic metre for $PM_{2.5}$.

An objective or standard is achieved if the ambient concentration is at or lower than (i.e., better than) the objective.

Metro Vancouver aligned its annual objectives for $PM_{2.5}$ in the 2011 Integrated Air Quality and Greenhouse Gas Management Plan, as well as adopting a one-hour ozone objective of 82 parts per billion.

Metro Vancouver's 24-hour $PM_{2.5}$ objective of 25 µg/m^3 is numerically the same as the province, but compliance with Metro Vancouver's objective requires that there are no exceedances and is applied as a rolling average.

In 2015, Metro Vancouver adopted a 1-hour interim ambient air quality objective for SO_2 of 75 parts per billion (ppb) prior to establishment of the federal SO_2 CAAQS. After establishment of the federal SO_2 CAAQS, Metro Vancouver's SO_2 objectives were revised in November 2017, with a more stringent 1-hour objective of 70 ppb not to be exceeded and an annual objective of 5 ppb.

In 2019, Metro Vancouver aligned its objectives for CO, NO_2 and O_3 with federal and provincial standards. Metro Vancouver adopted a 1-hour and annual ambient air quality objective for NO_2 that is the same as the federal 2020 CAAQS. Similarly, the 8-hour O_3 objective was made the same as the 2020 CAAQS. The 1-hour and 8-hour CO objectives were set to 13,000 ppb and 5,000 ppb respectively, to match the more stringent Provincial objectives.

Several of Metro Vancouver's objectives are intended to be compared with *rolling averages*. A *rolling average* is an average that is calculated by averaging the concentrations from a number of previous consecutive hours. For example, a 24-hour rolling average is calculated by averaging the concentrations measured during the previous 24 hours. A 24-hour rolling average is calculated for each hour of the day.

Table 1: Metro Vancouver's ambient air quality objectives.

Air Contaminant	Averaging Period	Ambient Air Quality Objective[a]	
		µg/m^3	ppb
Carbon monoxide (CO)	1-hour	14,900	13,000
	8-hour[b]	5,700	5,000
Nitrogen dioxide (NO_2)	1-hour[c]	113	60
	Annual	32	17
Sulphur dioxide (SO_2)	1-hour	183	70
	Annual	13	5
Ozone (O_3)	1-hour	161	82
	8-hour[d]	122	62
Inhalable particulate matter (PM_{10})	24-hour[b]	50	
	Annual	20	
Fine particulate matter ($PM_{2.5}$)	24-hour[b]	25	
	Annual	8 (6[e])	
Total reduced Sulphur (TRS)	1-hour (acceptable)	14	10
	1-hour (desirable)	7	5

[a] Except where noted, Metro Vancouver objectives are "not to be exceeded", meaning the objective is achieved if 100% of the validated measurements are at or below the objective level.

[b] Achievement based on rolling average.

[c] Achievement based on annual 98th percentile of the daily maximum 1-hour concentration, averaged over three consecutive years.

[d] Achievement based on annual 4th highest daily maximum 8-hour average concentration, averaged over three consecutive years.

[e] Metro Vancouver's annual $PM_{2.5}$ planning goal of 6 µg/m^3 is a longer term aspirational target to support continuous improvement.

Section C – Lower Fraser Valley Air Quality Monitoring Network

Metro Vancouver operates the LFV Air Quality Monitoring Network, which consists of air quality monitoring sites located between Horseshoe Bay in West Vancouver and Hope. The locations of the monitoring stations operated in 2020 are shown in Figure 2 while the pollutants and meteorology measured at each station are identified in Table 2.

Air quality monitoring sites are located in both Metro Vancouver and the FVRD. There are also a few stations in Metro Vancouver that provide only weather data. Air quality and weather data are collected automatically on a continuous basis, transmitted to Metro Vancouver's head office in Burnaby, and stored in a database. The data are then used to provide information to the public through the AQHI, Metro Vancouver's website, the BC air quality website, and reports.

Many pollutants measured are discussed in this report with a focus on common air contaminants: particulate matter (PM_{10} and $PM_{2.5}$), ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

Comparisons of measured levels of these air contaminants with federal, provincial and Metro Vancouver air quality objectives and standards and an assessment of regional trends are provided in Section D. The locations of SO_2, O_3, NO_2 and $PM_{2.5}$ monitoring in 2020 are shown in Figures 3 to 6.

Portable equipment was used to carry out short-term air quality monitoring studies (specialized studies) in 2020. The equipment employed in specialized studies includes Metro Vancouver's Mobile Air Monitoring Unit (MAMU), which is capable of monitoring gaseous and particulate pollutants in the same way as other monitoring stations in the network. Specialized studies and other monitoring activities undertaken are described in Sections G and H.

Real-time data from the LFV Air Quality Monitoring Network can be accessed on Metro Vancouver's website at: www.airmap.ca

Additional information on the LFV Air Quality Monitoring Network is available in the 2012 report "Station Information: Lower Fraser Valley Air Quality Monitoring Network". This report is available at: www.metrovancouver.org

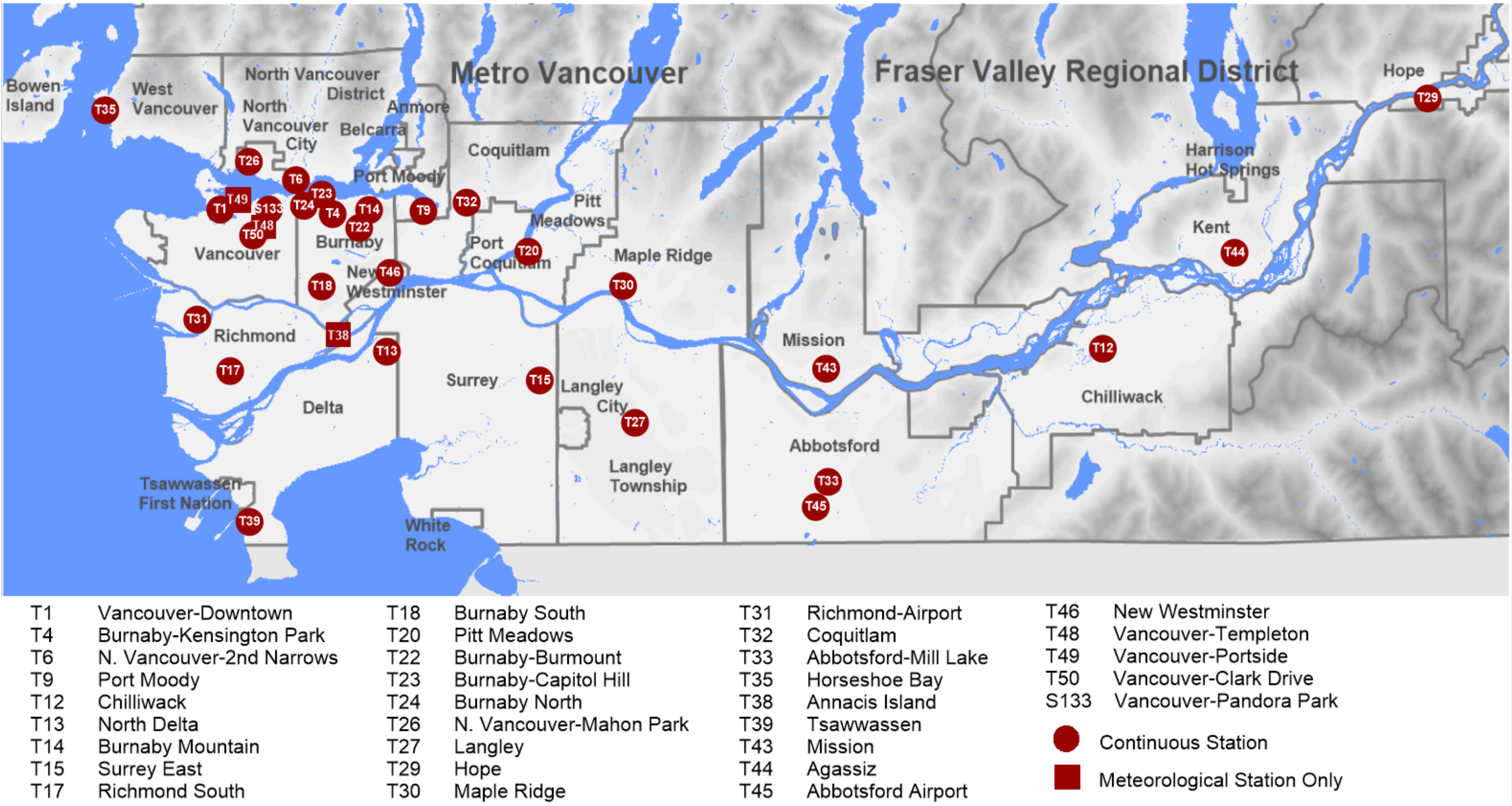
Data completeness for the year 2020 is shown in Table 3. In Table 3 the annual completeness is provided numerically while each quarter is shown as green if completeness for that quarter is greater than or equal to 75%, red if below 75% and white if no data exists.

Network Changes

There are ongoing enhancements to stations and equipment that occur throughout the air quality monitoring network.

Changes to the network in 2020 include:

- Anemometer translator modules were fully retired in 2020, replaced with Campbell Scientific data loggers at all stations where meteorology is measured. All wind measurement data collected from January 1, 2020 onward will no longer require adjustments for calm conditions for use in dispersion modelling. The new loggers are programmed to set the wind speed and wind direction to zero when wind speeds are below the stall speed of the anemometer.
- The Partisol sampler that collected integrated $PM_{2.5}$ measurements from the White Rock station was removed in 2020. Replacement of the integrated sampler with a continuous monitor is being considered.



T1	Vancouver-Downtown	T18	Burnaby South	T31	Richmond-Airport	T46	New Westminster
T4	Burnaby-Kensington Park	T20	Pitt Meadows	T32	Coquitlam	T48	Vancouver-Templeton
T6	N. Vancouver-2nd Narrows	T22	Burnaby-Burmount	T33	Abbotsford-Mill Lake	T49	Vancouver-Portside
T9	Port Moody	T23	Burnaby-Capitol Hill	T35	Horseshoe Bay	T50	Vancouver-Clark Drive
T12	Chilliwack	T24	Burnaby North	T38	Annacis Island	S133	Vancouver-Pandora Park
T13	North Delta	T26	N. Vancouver-Mahon Park	T39	Tsawwassen		
T14	Burnaby Mountain	T27	Langley	T43	Mission	●	Continuous Station
T15	Surrey East	T29	Hope	T44	Agassiz	■	Meteorological Station Only
T17	Richmond South	T30	Maple Ridge	T45	Abbotsford Airport		

Figure 2: Lower Fraser Valley air quality monitoring network, 2020.

Table 2: Air quality monitoring network, 2020.

Stations		Air Quality Monitors														Meteorology					
		Continuous											Non-Continuous								
		Gases							Particulate Matter												
ID	Name	SO_2	TRS	NO_2	CO	O_3	THC	NH_3	PM_{10}	$PM_{2.5}$	BC	UFP	VOC	SP	D	Wind	T_{air}	SR	RH	BP	Precip
T1	Vancouver-Downtown	√		√	√	√															
T4	Burnaby-Kensington Park	√	√	√	√	√			√	√						√	√		√		
T6	N. Vancouver-2nd Narrows	√		√	√	√				√	√					√	√		√		√
T9	Port Moody	√	√	√	√	√			√	√	√		√		√	√	√	√	√		√
T12	Chilliwack	√		√	√	√		√	√	√	√		√			√	√	√	√	√	√
T13	North Delta			√		√				√						√	√		√		√
T14	Burnaby Mountain			√		√										√	√		√		√
T15	Surrey East			√	√	√				√						√	√		√		√
T17	Richmond South	√		√	√	√				√						√	√		√		√
T18	Burnaby South	√		√	√	√			√	√	√		√	√	√	√	√		√	√	√
T20	Pitt Meadows	√		√		√				√	√					√	√		√	√	√
T22	Burnaby-Burmount		√				√						√			√	√				
T23	Burnaby-Capitol Hill	√	√													√	√		√		
T24	Burnaby North	√	√				√		√				√			√	√	√	√		√
T26	N. Vancouver-Mahon Park	√		√	√	√				√						√	√		√	√	√
T27	Langley	√		√	√	√			√	√						√	√		√	√	√
T29	Hope			√	√	√			√	√						√	√		√		√
T30	Maple Ridge			√	√	√										√	√		√		√
T31	Richmond-Airport	√		√	√	√			√	√	√		√			√	√	√	√	√	√
T32	Coquitlam			√	√	√										√	√		√	√	√
T33	Abbotsford-Mill Lake	√		√	√	√		√	√	√						√	√		√		√
T35	Horseshoe Bay				√					√						√	√		√		√
T38	Annacis Island															√	√		√		√
T39	Tsawwassen	√		√	√	√				√						√	√		√		√
T43	Mission			√		√				√						√	√		√		√
T44	Agassiz			√		√		√		√						√	√		√		√
T45	Abbotsford Airport	√		√	√	√		√	√	√	√		√	√	√	√	√	√	√	√	√
T46	New Westminster			√		√				√						√					
T48	Vancouver-Templeton															√	√		√		
T49	Vancouver-Portside															√	√		√		√
T50	Vancouver-Near-Road	√		√	√	√				√	√	√	√	√	√	√	√		√		
S133	Vancouver-Pandora	√																			
Total Monitoring Units		**18**	**5**	**24**	**19**	**24**	**2**	**4**	**10**	**21**	**8**	**1**	**8**	**3**	**4**	**30**	**29**	**5**	**28**	**8**	**24**

SO_2 = sulphur dioxide; TRS = total reduced sulphur; NO_2 = nitrogen dioxide; CO = carbon monoxide; O_3 = ozone; THC = total hydrocarbon; NH_3 = ammonia;

PM10 = inhalable particulate matter; $PM_{2.5}$ = fine particulate matter; UFP = ultrafine particulate; VOC = volatile organic compounds; SP = particulate speciation;

D = dichotomous particulate; BC = Black Carbon; Wind = wind speed and direction; T_{air} = air temperature; SR = incoming solar radiation; RH = relative humidity;

BP = barometric pressure; Precip = precipitation; √ = monitored at this location.

Table 3: Annual and quarterly data completeness, 2020.

Stations		Air Quality Monitors											Meteorology						
		Gases							Particulate Matter										
ID	Name	SO_2	TRS	NO_2	CO	O_3	THC	NH_3	PM_{10}	$PM_{2.5}$	BC	UFP	Wind Spd	Wind Dir	Tair	SR	RH	BP	Precip
T01	Vancouver-Downtown	97		100	100	98													
T04	Burnaby-Kensington Park	100	100	93	99	100				97			100	98	100		100		
T06	N. Vancouver-2nd Narrows	100		100	99	100				99	100		100	100	100		100		100
T09	Port Moody	100	99	99	99	99			98	99	100		100	100	100	100	100		100
T12	Chilliwack	98		98	98	99		98	99	98	100		100	100	100	100	100	100	100
T13	North Delta			98		🟥90				94			100	100	100		100		100
T14	Burnaby Mountain			100		98							99	99	99		99		99
T15	Surrey East			99	99	99				98			100	100	100		100		100
T17	Richmond South	97		98	100	100				99			100	100	100		100		
T18	Burnaby South	97		99	97	99			99	99	100		100	100	100		100	100	100
T20	Pitt Meadows	94		98		98				97	98		100	100	100		100	100	100
T22	Burnaby-Burmount		96				96						100	100	100				
T23	Burnaby-Capitol Hill	99	96										100	100	100		100		
T24	Burnaby North	98	99				99		🟥54				98	98	98	98	98		98
T26	N. Vancouver-Mahon Park	99		100	🟥🟥74	100				99			18🟥	100	100		100	100	100
T27	Langley	99		99	98	99			99	97			100	100	100		100	100	100
T29	Hope			99	99	99			99	97			98	98	98		98		98
T30	Maple Ridge			94	94	94							100	100	100		100		100
T31	Richmond-Airport	99		99	99	99			98	99	98		100	100	100	100	100	100	100
T32	Coquitlam			100	99	100							100	100	100		100	100	100
T33	Abbotsford-Mill Lake	100		99	99	100		99	99	98			100	100	100		100		100
T35	Horseshoe Bay				🟥15					🟥85			100	100	100		100		100
T38	Annacis Island												100	100	100		100		100
T39	Tsawwassen	100		100	100	99				99			100	100	100		100		100
T43	Mission			100		95				98			100	100	100		100		100
T44	Agassiz			99		98		99		96			100	100	100		100		100
T45	Abbotsford Airport	100		99	99	99		99	96	99	99		100	100	100	100	100	100	100
T46	New Westminster			96		96				95			100	100					
T48	Vancouver-Templeton												100	100	100		100		
T49	Vancouver-Portside												100	100	100		100		100
T50	Vancouver-Clark Drive	99		99	99	99				99	97	99	100	100	100		100		
S133	Vancouver-Pandora Park	90🟥											99	99	99		99	99	

Note: Quarterly completeness ≥ 75% is shown in green, < 75% is shown in red, and no data is white, while annual completeness is shown numerically.

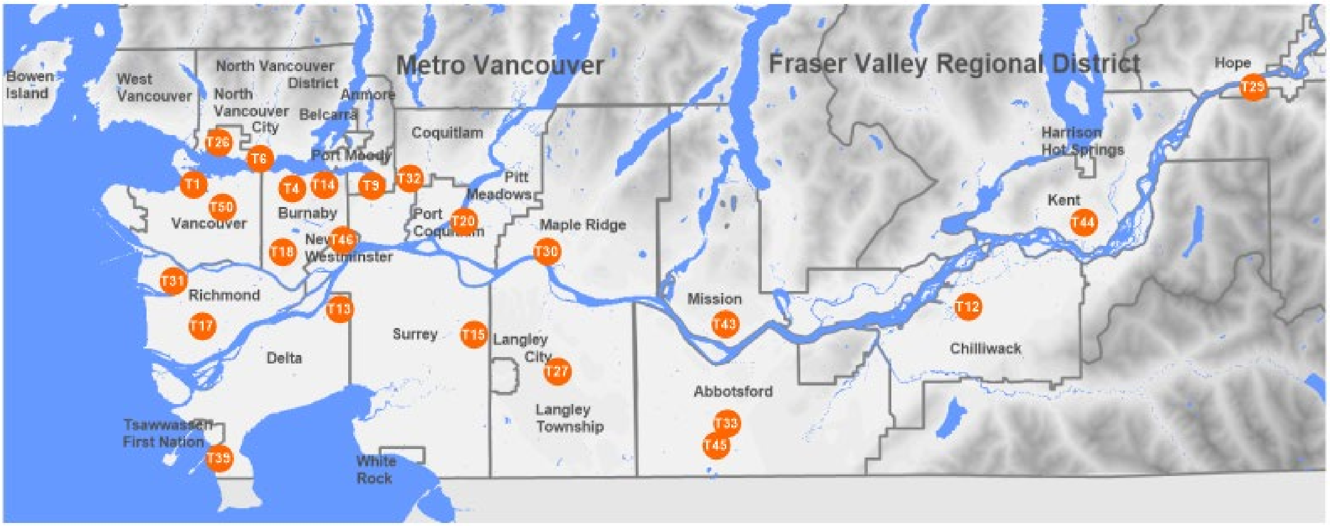


Figure 3: Ground-level ozone and nitrogen dioxide monitoring stations, 2020.

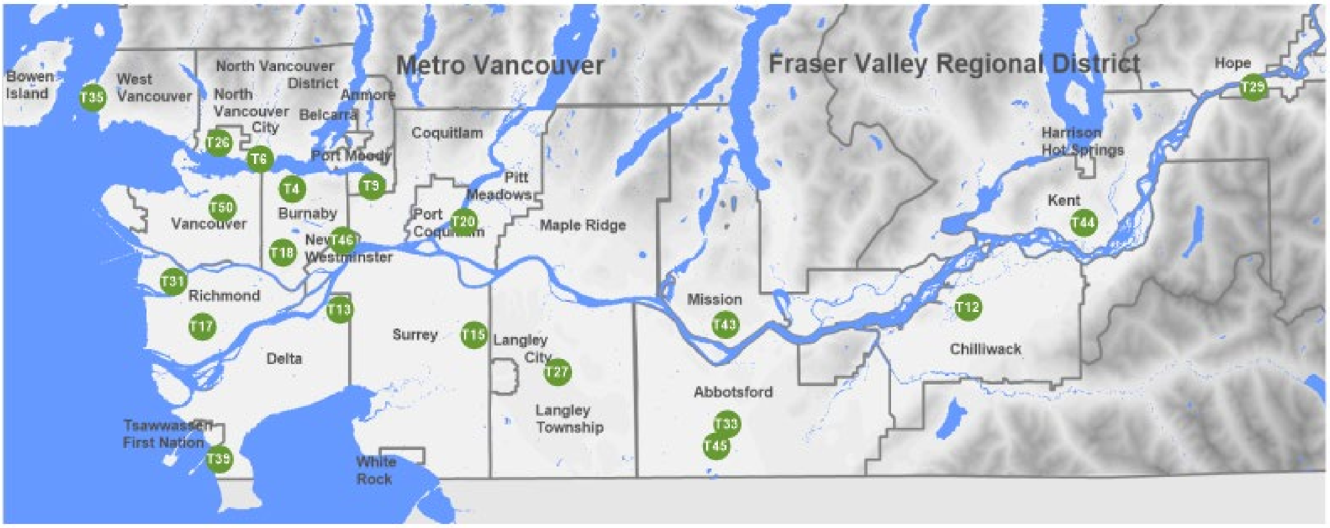


Figure 4: Fine particulate matter ($PM_{2.5}$) monitoring stations, 2020.

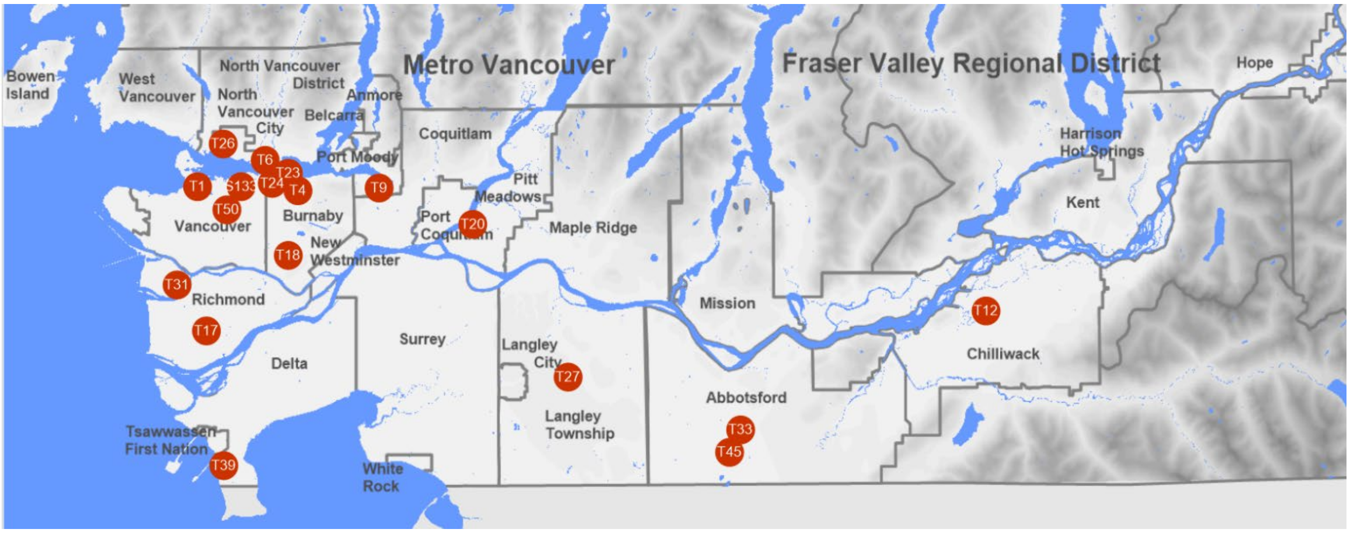


Figure 5: Sulphur dioxide monitoring stations, 2020.

Section D – Continuous Pollutant Measurements

Ozone (O_3)

Characteristics

Ozone (O_3) is a reactive form of oxygen. It is a major pollutant formed when NO_X and reactive volatile organic compounds (VOC) react chemically in the presence of heat and sunlight. Sunlight plays a significant role in O_3 production and as such, local maximum O_3 concentrations are usually experienced during the summer in the LFV.

Naturally occurring O_3 in the upper level of the atmosphere, known as the stratosphere, shields the surface from harmful ultraviolet radiation. However, at ground level, O_3 is a major environmental and health concern. Ozone is a significant oxidant and can irritate the eyes, nose and throat as well as reduce lung function. High concentrations can also increase the susceptibility to respiratory disease and reduce crop yields.

Sources

Ozone is termed a secondary pollutant because it is not usually emitted directly into the air. Instead, it is formed from chemical reactions involving pollutants identified as precursors, including NO_X and reactive VOC. The levels of O_3 measured depend on the emissions of these precursor pollutants.

Nitrogen oxide (NO_X) emissions are dominated by transportation sources. About 60% of the emissions come from cars, trucks, ships, rail and planes. Other sources include non-road engines, boilers and building heating systems.

The main contributors to VOC emissions are chemical products use (industrial, commercial and consumer products such as paints, varnishes and solvents), cannabis production, natural sources (trees and vegetation), cars and light trucks and non-road engines.

The formation of O_3 occurs readily during hot and sunny weather conditions with peak levels observed in the summer. Under these conditions, the highest levels generally occur downwind of major precursor emissions such as in eastern parts of Metro Vancouver and in the FVRD under specific wind conditions. The presence of wildfire smoke can also enhance ozone production.

Monitoring Results

Figures S6 (shown in the previous summary) and 6 illustrate the results of O_3 monitoring in 2020. Figure 6 represents a bubble plot, which shows three types of information: maximum 1-hour, Metro Vancouver's 8-hour objective value and annual average concentrations for each ozone monitoring station. In Figure 6 the bubble position on the x-axis denotes the maximum 1-hour average, the position on the y-axis denotes the 8-hour value and the size of the bubble is proportional to the annual average. The Metro Vancouver 1-hour and 8-hour objectives are also provided on the plot as lines and areas of exceedance are shaded grey. The four stations plotted to the right of the 1-hour objective line (82 ppb) all exceeded the 1-hour objective while all stations below the 8-hour objective line (62 ppb) met the 8-hour objective. The same values are represented spatially in Figures 7 to 9.

In 2020, the 8-hour objective was not exceeded, however Metro Vancouver's 1-hour objective was exceeded at four stations due to a combination of local emissions and hot and sunny weather.

In 2020, there were no exceedances of Metro Vancouver's 8-hour objective or the Canadian Ambient Air Quality Standard, which both have the same numerical value (62 ppb). Both Metro Vancouver's 8-hour objective and the Canadian Ambient Air Quality Standard are calculated as the annual 4th highest daily maximum 8-hour average concentration, averaged over three consecutive years.

Metro Vancouver's 1-hour objective was exceeded at four stations on a combination of two days, with the highest concentration of 99 ppb measured in Mission. The 1-hour objective was exceeded on July 30 at

Chilliwack, Abbotsford Airport, and Mission, and on August 16 at Pitt Meadows.

Air quality advisories were in effect for three days (July 16, August 16 and September 9) due to elevated levels of ground-level ozone. The advisory issued on September 9 was based on the expectation of ozone exceedances, however exceedances were not measured after the advisory had been issued.

The Burnaby Mountain station measured the highest average ozone level, which is typical given the station's high elevation on the top of Burnaby Mountain.

The highest short-term concentrations occur in the eastern parts of Metro Vancouver and in the FVRD (Figures 8 and 9). The lowest annual O_3 averages (Figure 7) occur in highly urbanized areas due to O_3 scavenging. Ozone scavenging occurs in locations where higher levels of NO_x are found (e.g. urban areas or near busy roadways). In these areas, emissions containing NO_x, react quickly with O_3 to form NO_2 (nitrogen dioxide) and O_2 (oxygen) thus decreasing O_3 concentrations.

Figure 10 shows the seasonal trend of O_3 with the monthly average provided with highest 1-hour concentration from each month. In both figures, concentrations from selected stations are shown alongside the range of concentrations measured at all stations (shown as a grey band). The seasonal variation evident in Figure 10 is typical of historical ozone trends in the LFV with higher values in spring and summer, and lower values during fall and winter. Since O_3 is produced by photochemical reactions, there is greater production in spring and summer with the presence of sunlight and land- and sea-breeze wind patterns. Spring exhibits the highest average O_3 concentrations (Figure 10 left) while the highest short-term hourly concentrations (Figure 10 right) occur in the summer.

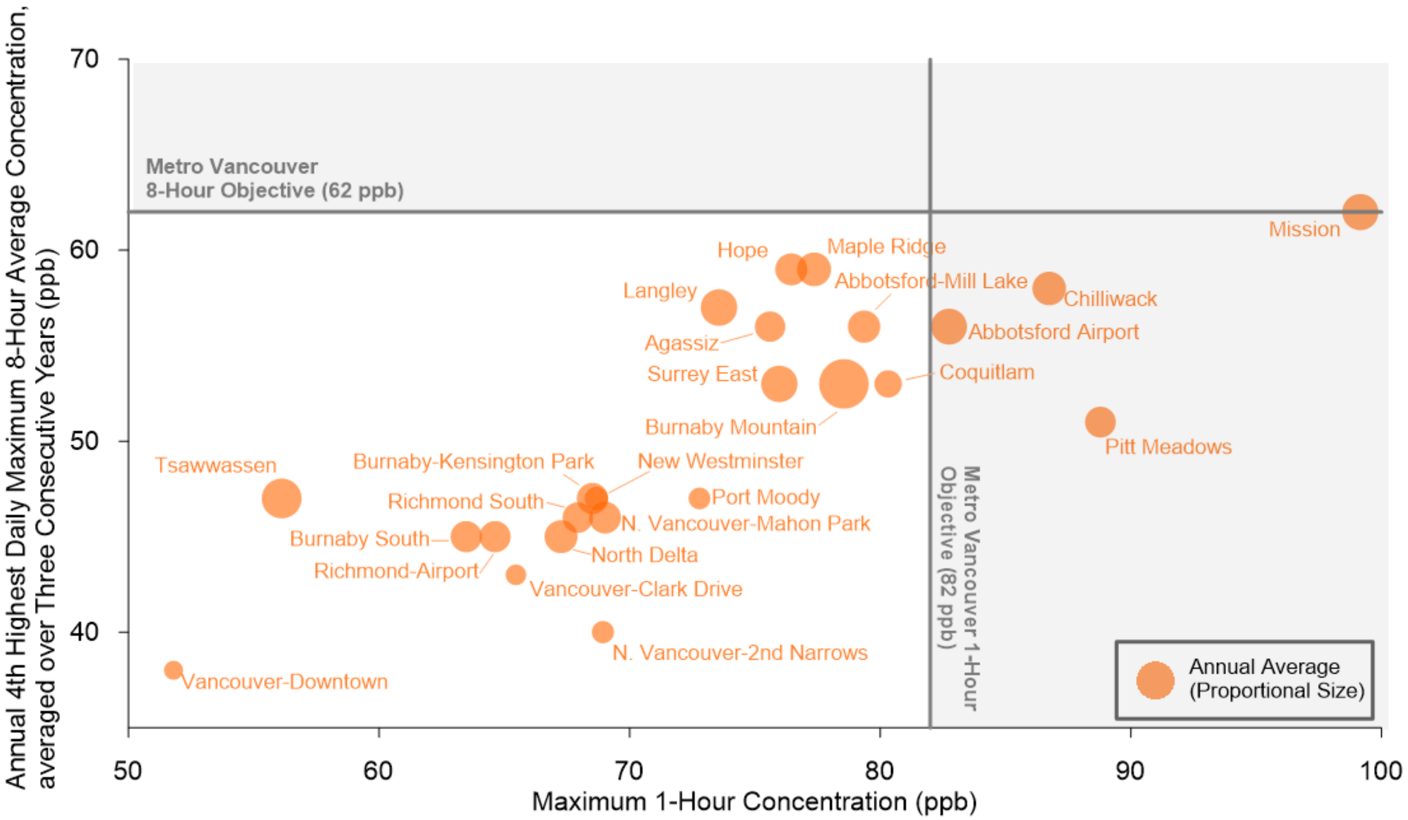
Figure 11 illustrates the long-term annual average O_3 trend in the LFV. The annual average trend is given in the left plot with the short-term peak trend given in right plot for the last two decades. Annual O_3 levels have shown an upward trend in the last several decades. Research indicates that background ozone concentrations are rising and is one factor for observed increases in average levels.

A trend in short-term peak O_3 concentrations (Figure 11 right) is less apparent. Yearly differences are likely related to variability in meteorology, however there doesn't appear to be a trend in peak concentrations. Peak ozone levels have been mostly unchanged during the last fifteen to twenty years, despite significant reductions in ozone precursor pollutants over the same time period.

Metro Vancouver and the Fraser Valley Regional District adopted the Regional Ground-Level Ozone Strategy in 2014, which provides strategic policy direction for ozone management in the LFV based on local scientific research. Research indicates that a spatial understanding of the ratio of concentrations of nitrogen oxides (NO_X) and volatile organic compounds (VOC), two precursor pollutants that react to form ozone, is key to determining which precursors to reduce in order to maintain and improve air quality in our region.

The values in Tables 4 and 5 represent the frequency distribution (or count) of how many hourly and 8-hour rolling average measurements were in the specified ranges, respectively. The frequency distributions in these tables show how often various O_3 levels are reached. It can be seen that stations located in the eastern parts of Metro Vancouver and in the FVRD measured the greatest frequency of high O_3 concentrations.

A series of diurnal plots are shown in Figure 12 for each O_3 monitoring station. The plots demonstrate the differences between weekdays and weekends along with differences between summer and winter. Most of the stations exhibit similar diurnal trends. In the summer, O_3 concentrations are low through the night and begin increasing near sunrise with the highest (peak) concentration occurring in the afternoon. Examining the timing of the peak shows in general the stations in the west peak first while the stations in the east peak a few hours later with Hope typically experiencing the latest peak in the day. Noon is marked on the figure as a black vertical line for reference. On very hot sunny days, typically during a summertime episode, the O_3 peak occurs later in the day. Winter shows a similar trend of an afternoon peak although it is greatly attenuated compared with the summer.



Note: Stations contained within the grey area denote an exceedance of an objective.

Figure 6: Ground-level ozone monitoring, 2020.

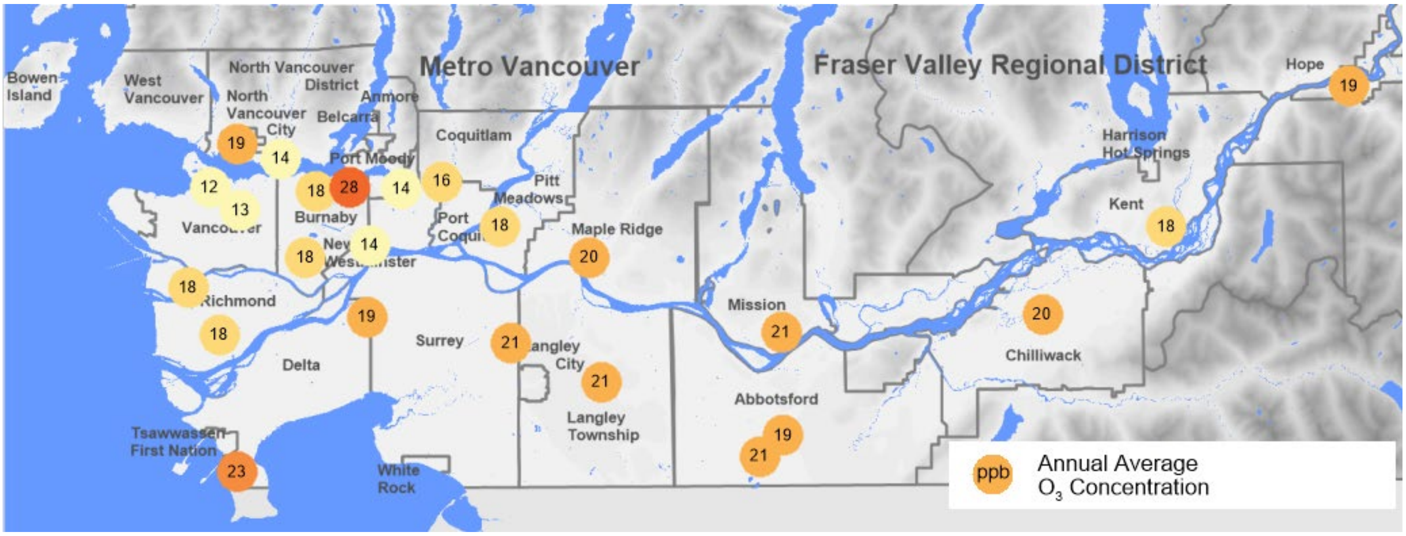


Figure 7: Annual average ozone in the LFV, 2020.

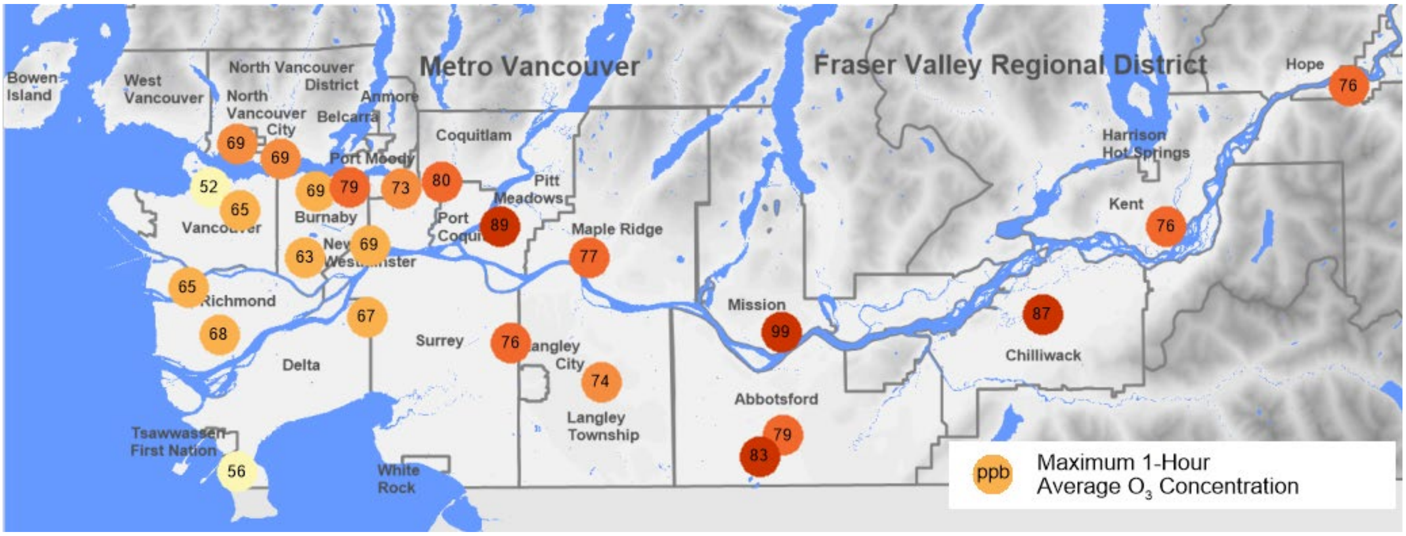


Figure 8: Short-term peak (1-hour) ozone in the LFV, 2020.

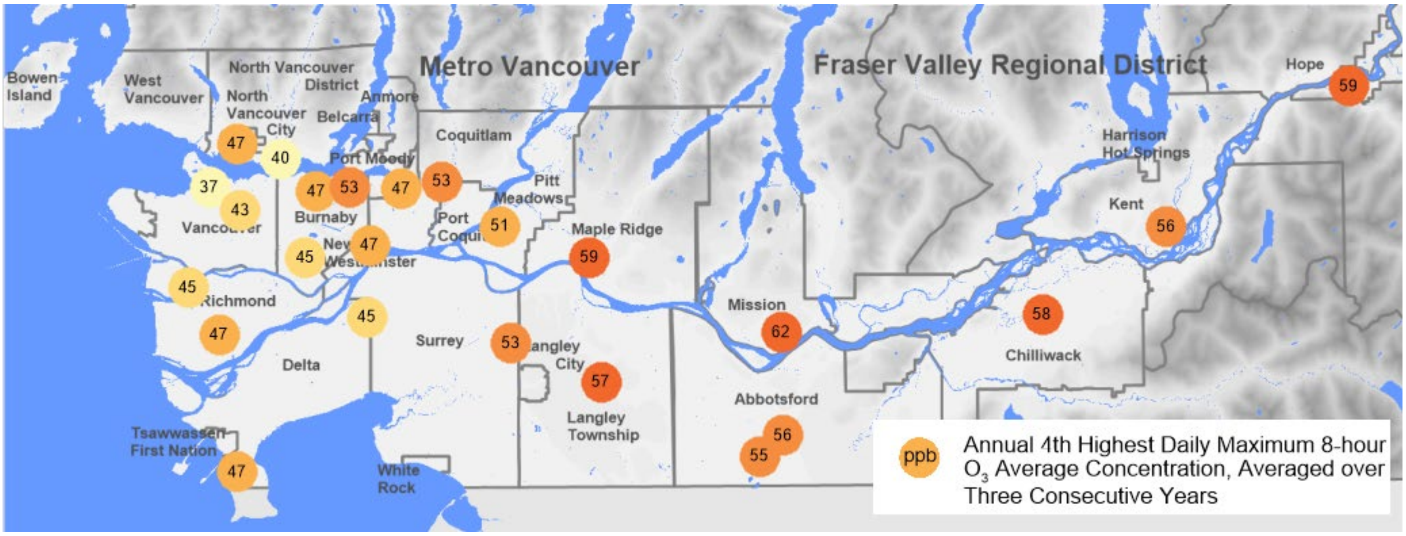


Figure 9: Short-term peak (8-hour) ozone in the LFV, 2020.

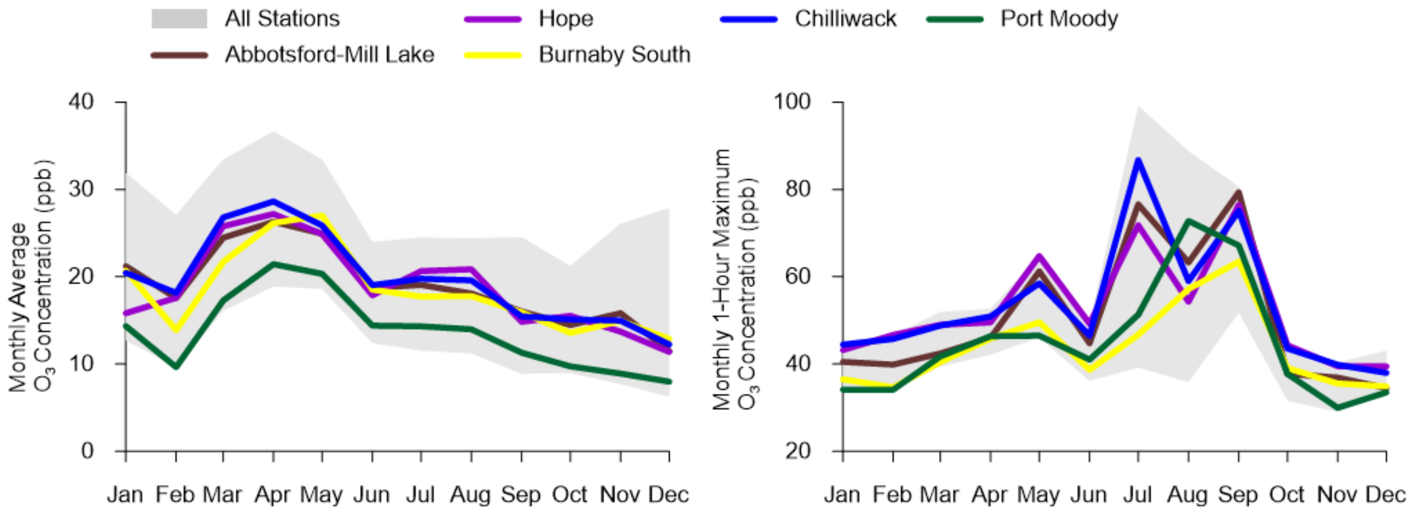


Figure 10: Monthly average (left) and short term peak (right) ozone, 2020.

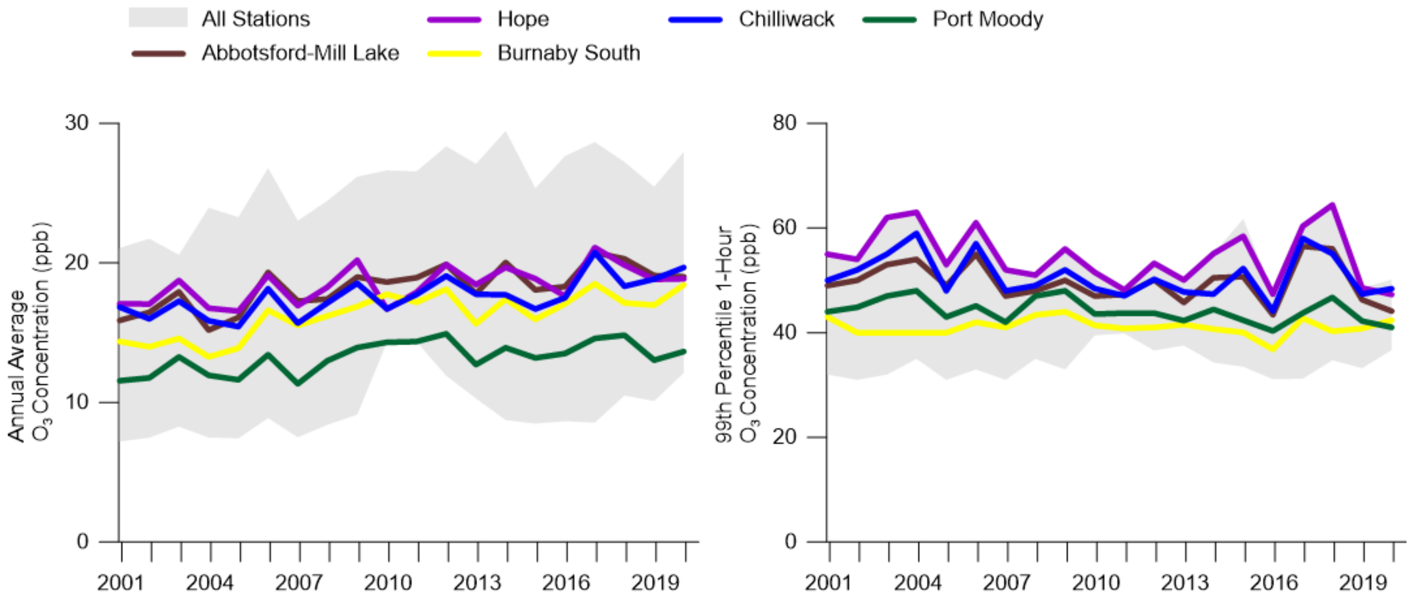


Figure 11: Annual (left) and short term peak (right) ozone trend, 2001 to 2020.

Table 4: Frequency distribution of hourly ozone, 2020.

O_3 Conc. (ppb)	Vancouver-Downtown	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	North Delta	Burnaby Mountain	Surrey East	Richmond South	Burnaby South	Pitt Meadows	N. Vancouver-Mahon Park	Langley	Hope	Maple Ridge	Richmond-Airport	Coquitlam	Abbotsford-Mill Lake	Tsawwassen	Mission	Agassiz	Abbotsford Airport	New Westminster	Vancouver-Clark Drive
0 to 6	3239	1210	2092	2817	1571	1087	87	997	2090	1154	1845	1289	1233	1859	1262	1753	1857	1376	613	1013	1760	1171	2974	3075
6 to 12	1642	1569	1963	1549	1317	1153	278	1113	1051	1445	1061	1354	973	1230	1223	1192	1588	1417	838	1089	1343	1241	1291	1509
12 to 18	1347	1627	1876	1435	1289	1394	854	1418	1220	1662	1267	1578	1239	1218	1292	1324	1639	1462	1338	1345	1414	1292	1168	1385
18 to 24	1136	1579	1445	1229	1258	1416	1660	1560	1294	1794	1389	1651	1494	1262	1332	1418	1376	1332	1780	1546	1265	1281	1002	1171
24 to 30	757	1416	916	942	1178	1367	2105	1461	1314	1477	1417	1414	1549	1117	1362	1328	1195	1428	1781	1425	1212	1453	852	818
30 to 36	387	866	342	438	1031	924	2047	1212	1043	829	1034	926	1305	1061	1057	1016	702	1148	1423	1062	965	1325	622	510
36 to 42	109	342	92	233	755	421	1152	662	565	273	424	384	669	657	514	522	285	451	753	613	518	717	372	172
42 to 48	16	115	8	41	217	87	316	219	143	78	107	136	191	193	169	142	81	83	185	183	108	146	129	62
48 to 54	4	18		7	41	6	107	32	17	11	17	18	32	41	30	10	19	20	19	40	21	25	26	1
54 to 60			2	4	25	4	21	15	4	6	7	2	19	18	10	4	8	12	5	21	15	20	5	1
60 to 66		7	2	5	11	1	9	6	1	2	5	2	9	9	10	3	7	14		17	6	9	5	1
66 to 72		1	1	3	9	1	2	2	1		3	1	5	3	7		4	4		10	5	6	3	
72 to 78				1	4		2	2			2		1	4	4		1	2		5	3	2		
78 to 84					1		1				1						1	1		3		2		
84 to 90					1						1									1				
90 to 96																								
>=96																				1				
Missing	147	34	43	79	72	923	143	76	41	53	203	29	65	111	496	70	21	30	49	405	148	94	327	79
Data Completeness	98%	100%	100%	99%	99%	90%	98%	99%	100%	99%	98%	100%	99%	99%	94%	99%	100%	100%	99%	95%	98%	99%	96%	99%

Table 5: Frequency distribution of 8-hour rolling average ozone, 2020.

O_3 Conc. (ppb)	Vancouver-Downtown	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	North Delta	Burnaby Mountain	Surrey East	Richmond South	Burnaby South	Pitt Meadows	N. Vancouver-Mahon Park	Langley	Hope	Maple Ridge	Richmond-Airport	Coquitlam	Abbotsford-Mill Lake	Tsawwassen	Mission	Agassiz	Abbotsford Airport	New Westminster	Vancouver-Clark Drive
0 to 4	1636	430	955	1609	684	488	10	455	1047	477	996	521	514	934	553	881	902	550	252	374	818	403	1696	1765
4 to 8	1786	880	1393	1247	858	655	34	597	834	760	827	826	627	979	757	824	1014	884	368	601	990	763	1256	1354
8 to 12	1452	1152	1511	1331	1074	851	204	815	988	1081	827	938	815	916	912	979	1174	1129	606	822	1068	967	1155	1430
12 to 16	1154	1304	1554	1200	1011	1066	433	1002	1101	1282	963	1270	925	882	957	1097	1373	1144	924	1005	1098	981	1008	1105
16 to 20	913	1204	1297	1117	1024	1084	847	1177	1011	1313	1092	1314	1079	1028	1056	1091	1242	1031	1161	1126	1053	1035	880	1044
20 to 24	747	1240	944	877	965	1017	1191	1159	1006	1419	1143	1219	1151	966	1050	1069	1037	1067	1384	1230	957	1012	753	836
24 to 28	506	1063	686	689	866	1064	1534	1052	943	1054	993	1114	1120	885	1029	947	940	1078	1255	1064	896	1075	633	538
28 to 32	280	759	259	301	828	778	1635	1013	758	712	937	781	999	757	884	838	540	892	1091	861	759	976	441	298
32 to 36	112	391	83	191	616	504	1346	725	567	368	474	461	811	663	546	538	309	609	921	636	571	858	291	244
36 to 40	45	203	51	109	490	247	877	452	340	185	226	196	449	414	332	292	148	255	532	376	298	460	192	69
40 to 44	5	99	2	28	180	77	282	178	124	56	80	106	155	148	145	136	52	71	216	160	80	119	103	25
44 to 48	3	15		8	62	7	172	52	17	13	17	17	50	47	35	17	10	20	18	63	14	43	18	4
48 to 52		5	2	2	23	7	57	15	4	5	2	2	15	16	16	7	11	19	6	22	8	19	7	1
52 to 56		3	2	4	7		15	11	4	2	3	2	12	8	11	1	5	10		21	5	10	7	
56 to 60		2		3	9		9	2			5		6	6	5		3	6		5	4	6	3	
60 to 64					4		2	2			3		3	1	1		4	1		7	2	3		
64 to 68					4		5							4	3					2	2			
68 to 72					1															2				
>=72																				2				
Missing	145	34	45	68	78	939	131	77	40	57	196	17	53	130	489	67	20	18	50	405	161	54	341	71
Data Completeness	98%	100%	100%	99%	99%	89%	99%	99%	100%	99%	98%	100%	99%	99%	94%	99%	100%	100%	99%	95%	98%	99%	96%	99%

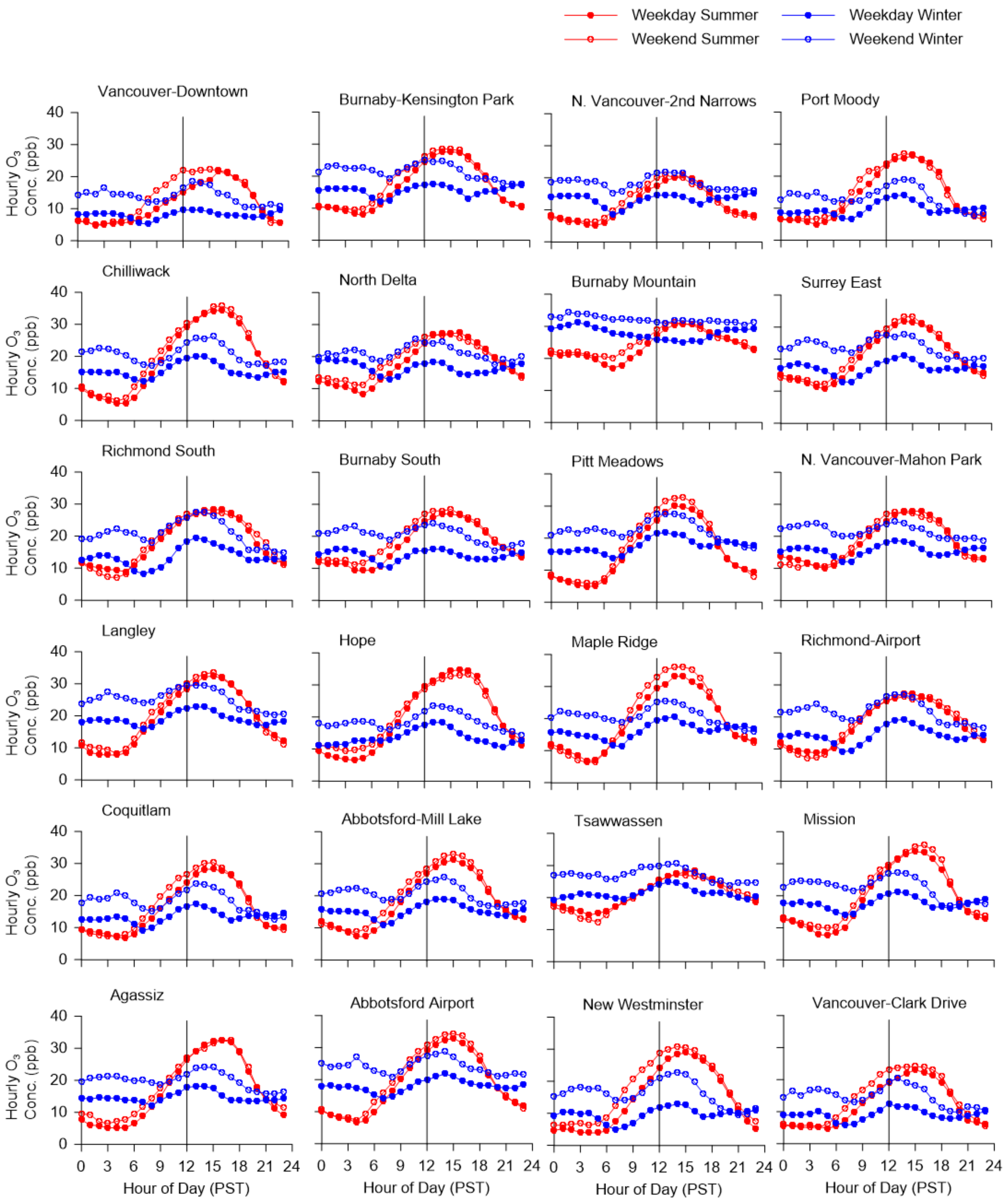


Figure 12: Diurnal trends ozone, 2020.

Fine Particulate ($PM_{2.5}$)

Characteristics

The term '$PM_{2.5}$' has been given to airborne particles with a diameter of 2.5 micrometres (μm) or less, also known as fine particulate matter. Given the very small size of these particles, they can penetrate into the finer structures of the lungs. Exposure to fine particulate ($PM_{2.5}$) can lead to both chronic and acute human health impacts, aggravate pulmonary or cardiovascular disease, increase symptoms in asthmatics and increase mortality. Fine particulate matter is considered by health experts to be an air pollutant of serious concern because of these health effects.

Fine particulate is also effective at scattering and absorbing visible light. In this role $PM_{2.5}$ contributes to regional haze and impaired visual air quality.

Sources

Emissions of $PM_{2.5}$ are dominated by residential wood burning (32%), non-road engines and equipment (15%), and industrial sources (19%)[4]. In addition to local sources, $PM_{2.5}$ can be transported long distances from sources such as wildfires in other parts of western Canada, the US or more distant.

Scientific investigations in the LFV indicate that a proportion of ambient $PM_{2.5}$ is also formed by reactions of NO_X and SO_2 with ammonia in the air (mainly from agricultural sources in the LFV). Fine particulate produced in this manner is called secondary $PM_{2.5}$ and accounts for a percentage of $PM_{2.5}$ in summer. Therefore, emissions of precursor gases of secondary $PM_{2.5}$ are also important sources in the region.

Monitoring Results

The $PM_{2.5}$ annual average, maximum 24-hour rolling average and Canadian Ambient Air Quality Standard (CAAQS) values are shown in Figures S7 and 13 for 2020. The same values are shown spatially in Figures 14, 15 and 16, respectively.

Over half of stations with sufficient data available to calculate a CAAQS value were found to exceed the Standard of 27 μg/m^3. Canadian Ambient Air Quality Standard values for 2020 ranged from 16 to 36 μg/m^3. The $PM_{2.5}$ 24-hour standard is a value that is calculated by taking an annual 98th percentile value using daily averages, averaged over three consecutive years. The 2020 CAAQS values were also influenced by an active wildfire year in 2018.

All stations were below the Metro Vancouver annual objective of 8 μg/m^3 and all but six stations exceeded the planning goal of 6 μg/m^3. Metro Vancouver's planning goal is a longer term aspirational target to support continuous improvement.

Exceedances of Metro Vancouver's 24-hour $PM_{2.5}$ objective were widespread in 2020 due to smoke from wildfires. An extensive smoke plume extending several hundred kilometers from wildfires in Washington, Oregon and California blanketed our region for 11 days.

Exceedances of Metro Vancouver's 24-hour $PM_{2.5}$ objective were widespread in 2020. The region was impacted in September by extensive wildfires burning in Washington, Oregon and California.

Metro Vancouver's 24-hour $PM_{2.5}$ objective was exceeded at three stations on September 8 and an air quality advisory was issued due to wildfire smoke from fires burning in eastern Washington. On September 9 more than half of the monitoring stations exceeded the objective while air quality improved on September 10 with lower $PM_{2.5}$ concentrations.

Fine particulate matter levels increased substantially on September 11 with the arrival of an extensive smoke plume from wildfires burning in Washington, Oregon and California. By early afternoon all monitoring stations throughout the region were in exceedance of Metro Vancouver's $PM_{2.5}$ 24-hour objective.

For nine straight days every station within the region experienced elevated levels of $PM_{2.5}$ and exceedances of the 24-hour objective. The highest $PM_{2.5}$ 24-hour average

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[4] https://metrovancouver.org/services/air-quality-climate-action/Documents/lower-fraser-valley-air-emissions-inventory-forecast-2015.pdf

was measured in Hope on September 15 with a value of 200 μg/m^3. On September 19 the 11-day air quality advisory was ended due to cleaner marine air flowing into the region.

The impacts of wildfire smoke and climate change are discussed further in Section I.

In addition to wildfire influences, there were other $PM_{2.5}$ exceedances that occurred throughout the year. Exceedances were experienced in Mission on March 21, Mission and Langley on March 22, Abbotsford Airport on April 6, Abbotsford-Mill Lake on October 6, Langley on October 26, Vancouver-Clark Drive on October 31, and Surrey East, Richmond South, New Westminster and Vancouver-Clark Drive on November 1. These exceedances were likely a result of a combination of fireworks, residential wood burning and/or open burning.

Table 6 gives the frequency distribution of $PM_{2.5}$ concentrations for the year. In 2020, Hope experienced the highest frequency of elevated $PM_{2.5}$ concentrations, a result of wildfire smoke.

Seasonally, $PM_{2.5}$ levels are typically higher in the summer with the highest values typically experienced during the dry summer months (Figure 17), due to the formation of secondary $PM_{2.5}$ and smoke from wildfire activity. The influence of wildfire smoke is evident in both monthly average and 24-hour maximum rolling average concentrations in September.

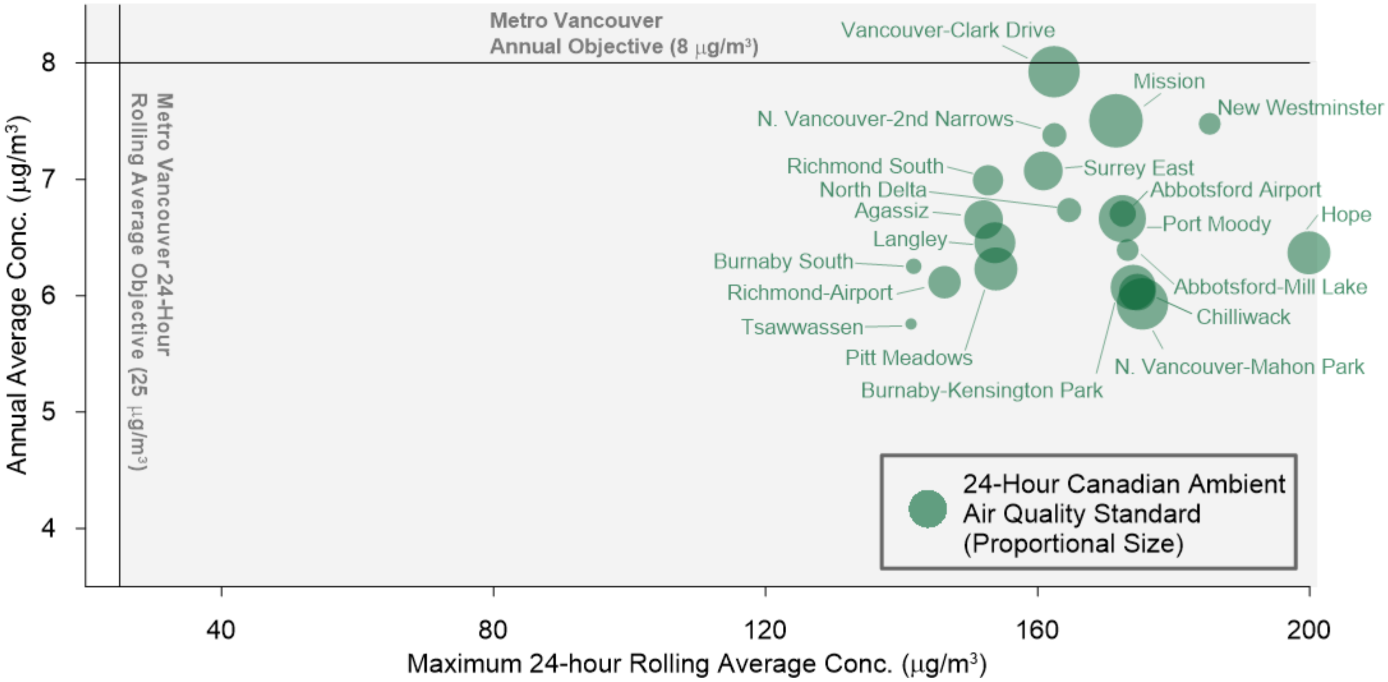
Figure 18 illustrates the long-term $PM_{2.5}$ trends in the LFV with annual average and peak concentrations shown respectively. Monitoring technology was upgraded in 2013 to continuous particulate monitors that met the US Environmental Protection Agency $PM_{2.5}$ Federal Equivalent Method (FEM). The FEM monitors have the ability to measure a portion of particulate matter not previously measured. The short-term peak concentrations reflect the highest levels that occur, represented by the 99th percentile of the 24-hour rolling average for each year. Given that it will take several years to establish a long-term record of $PM_{2.5}$ with the FEM monitor, both the older monitor (TEOM) data and FEM data are shown together.

In Figure 18 the TEOM data is shown as solid lines with a grey band displaying the range of values from all TEOM stations, while the FEM data is shown as dotted lines with an orange band showing the range from all FEM stations.

It is evident that the FEM monitor measures higher $PM_{2.5}$ concentrations compared to the TEOM monitor. Long-term average trends of the TEOM data show that 2015 was not appreciably different than previous years. However, the FEM data shows a step increase compared with the TEOM, which is a result of the FEM monitor's ability to measure some particles not previously measured by the TEOM monitor.

The differences in peak trends from year to year are driven by meteorological variability and wildfire activities. The long-term peak trend shows that 2017, 2018 and 2020, three very active wildfire years, measured much higher peak concentrations compared with other years.

A series of diurnal plots are shown in Figure 19 for each $PM_{2.5}$ monitoring station. Typically, the summer exhibits little diurnal variation while the winter displayed higher $PM_{2.5}$ concentrations in the evenings compared with the daytime. The evenings in winter were likely elevated due to reduced atmospheric mixing depths coupled with regional and local emission sources. North Vancouver-Second Narrows may be influenced by local construction activity in the summer especially on weekdays.



Note: Stations contained within the grey area denote an exceedance of an objective.

Figure 13: Fine particulate ($PM_{2.5}$), 2020.

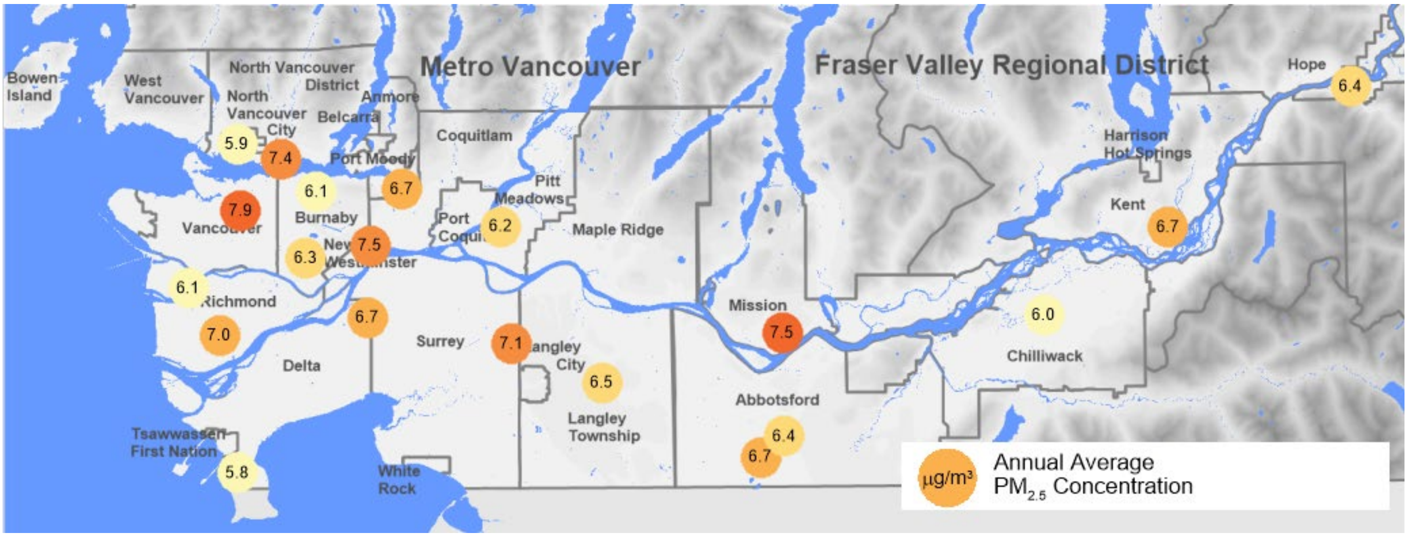


Figure 14: Annual average fine particulate ($PM_{2.5}$) in the LFV, 2020.

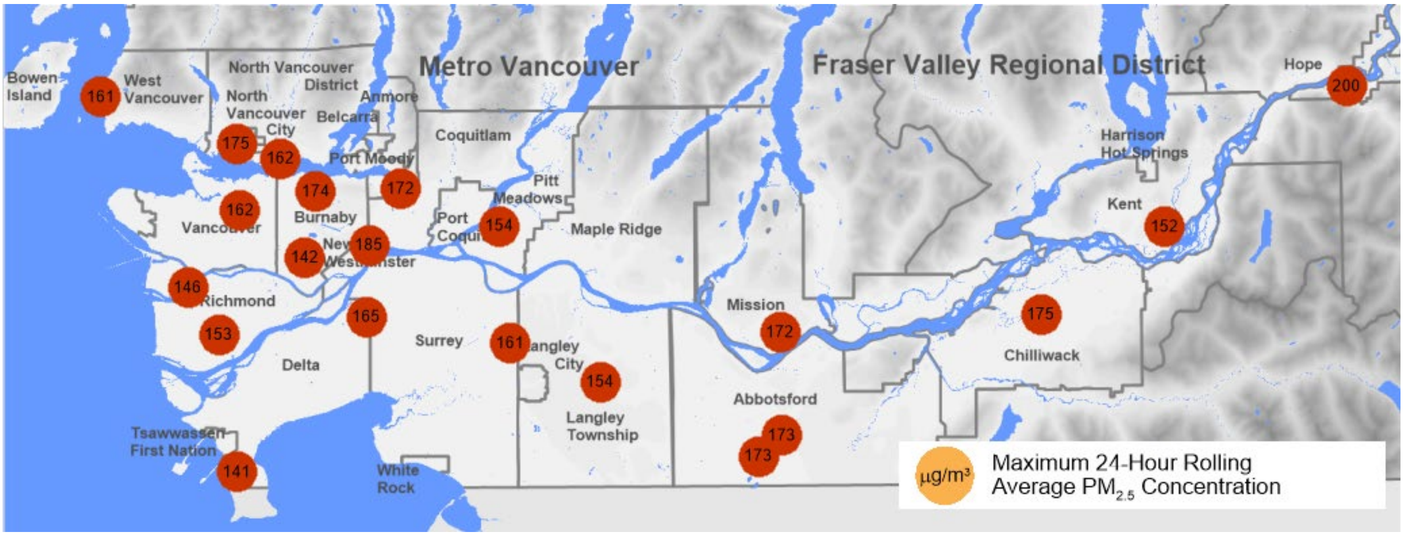


Figure 15: Short-term peak fine particulate ($PM_{2.5}$) in the LFV, 2020.

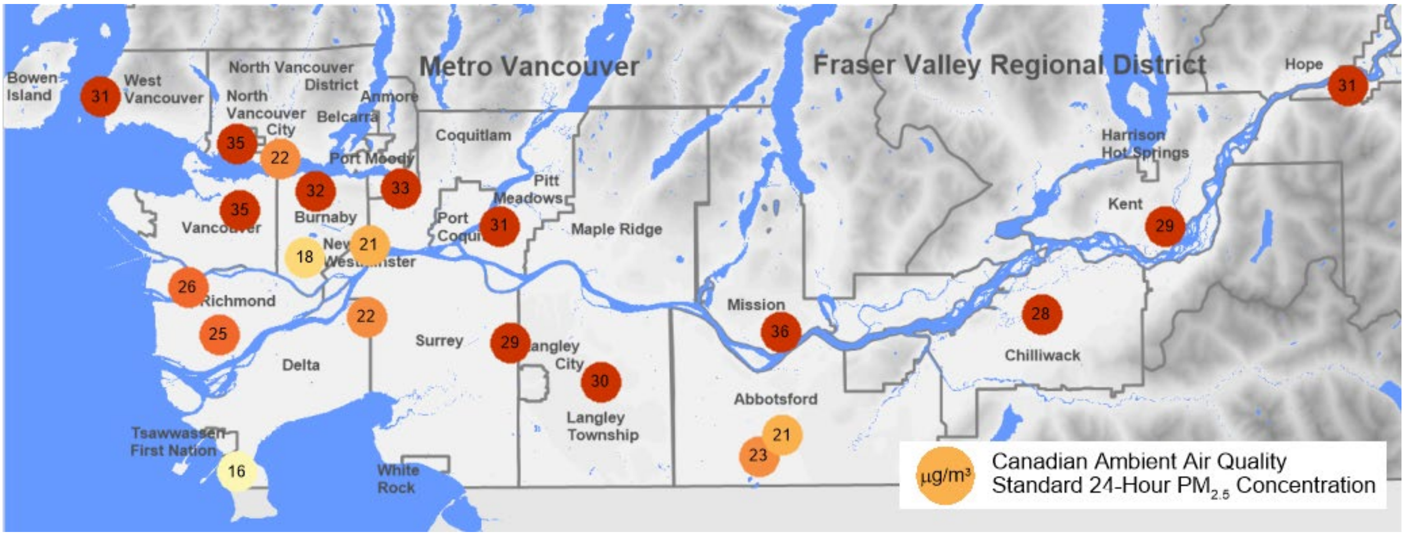


Figure 16: Canadian Ambient Air Quality Standard value for fine particulate ($PM_{2.5}$), 2020.

Table 6: Frequency distribution of 24-hour rolling average fine particulate ($PM_{2.5}$), 2020.

$PM_{2.5}$ Conc. ($\mu g/m^3$)	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	North Delta	Surrey East	Richmond South	Burnaby South	Pitt Meadows	N. Vancouver-Mahon Park	Langley	Hope	Richmond-Airport	Abbotsford-Mill Lake	Horseshoe Bay	Tsawwassen	Mission	Agassiz	Abbotsford Airport	New Westminster	Vancouver-Clark Drive
0 to 12.5	8155	8231	8268	8184	7894	8170	8366	8415	8112	8407	8065	8169	8334	8202	7081	8487	7978	8006	8227	7861	8261
12.5 to 25	98	238	165	184	172	202	157	125	143	108	206	123	141	235	105	69	358	149	261	246	234
25 to 37.5	8	23	11	9	24	41	46	10	15	8	55	6	11	33	7	11	38	8	43	17	22
37.5 to 50	9	9	8	33	9	10	20	12	10	8	23	27	14	21	35	15	8	35	17	6	16
50 to 62.5	12	8	19	42	22	50	35	27	66	24	45	24	46	52	30	36	55	47	23	16	60
62.5 to 75	54	43	56	11	36	17	10	26	10	54	9	24	11	7	33	8	19	8	14	38	34
75 to 87.5	18	35	9	7	12	7	9	10	9	13	7	4	10	6	7	9	7	6	7	7	7
87.5 to 100	8	13	6	7	5	5	6	12	9	9	7	4	10	5	8	7	6	8	7	8	6
100 to 112.5	6	5	7	20	6	7	12	5	7	8	8	17	12	5	8	12	6	46	8	3	7
112.5 to 125	9	4	8	13	1	8	10	6	27	8	11	20	9	7	9	12	6	8	30	5	8
125 to 137.5	8	8	9	5		22	33	9	29	11	47	3	43	12	8	29	35	9	14	11	8
137.5 to 150	38	1	38	6	10	39	35	27	7	23	15	5	22	4	3	17	16	12	15	4	42
150 to 162.5	8	12	8	5	17	17	5		9	9	7	7		5	24		7	2	9	3	20
162.5 to 175	15		15	12	7					14		4		12			18		13	6	
175 to 187.5										2		6								3	
>=187.5												12									
Missing Data	338	154	157	246	569	189	40	100	331	78	279	329	121	178	1426	72	227	440	96	550	59
Completeness	96%	98%	98%	97%	94%	98%	100%	99%	96%	99%	97%	96%	99%	98%	84%	99%	97%	95%	99%	94%	99%

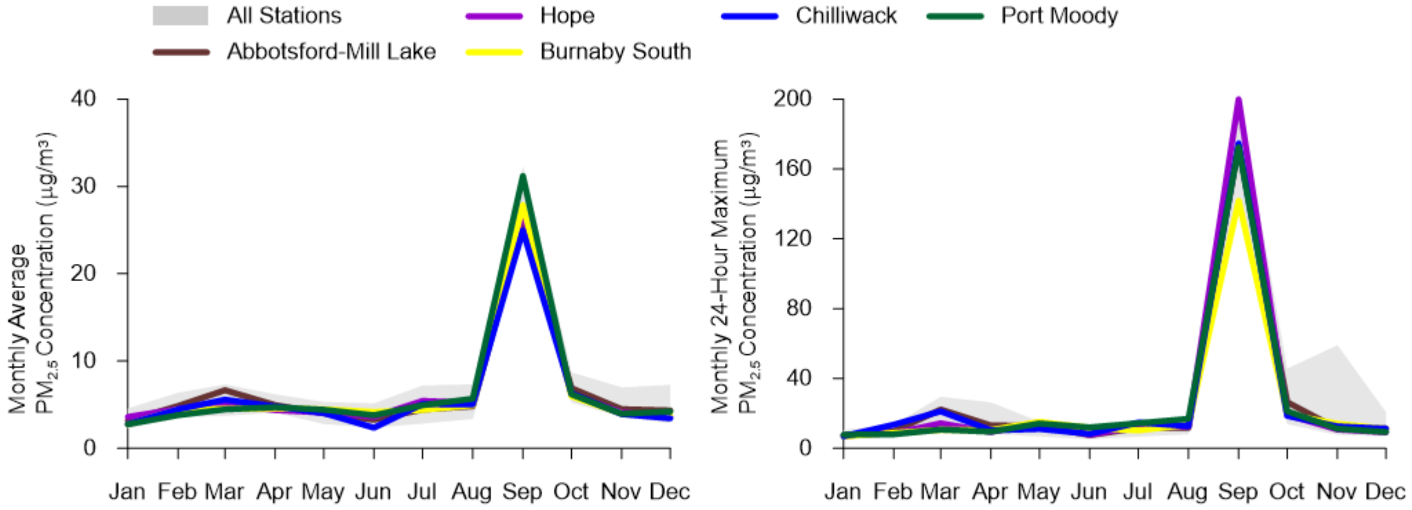


Figure 17: Monthly average (left) and short term peak (right) fine particulate ($PM_{2.5}$), 2020.

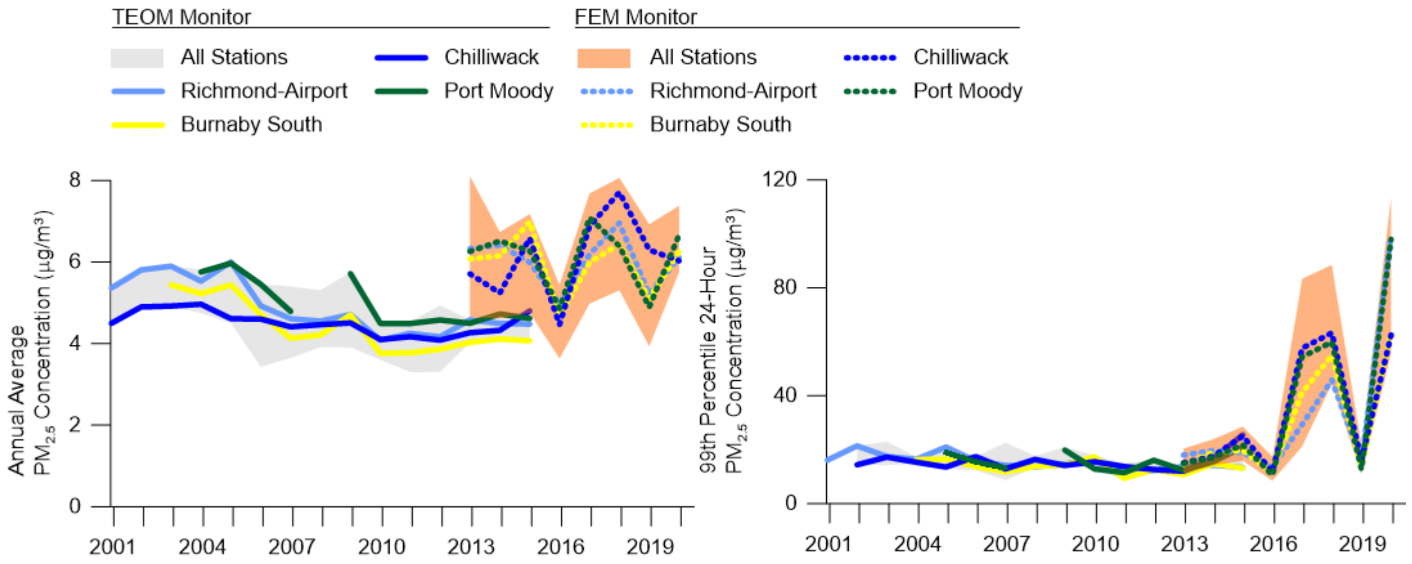
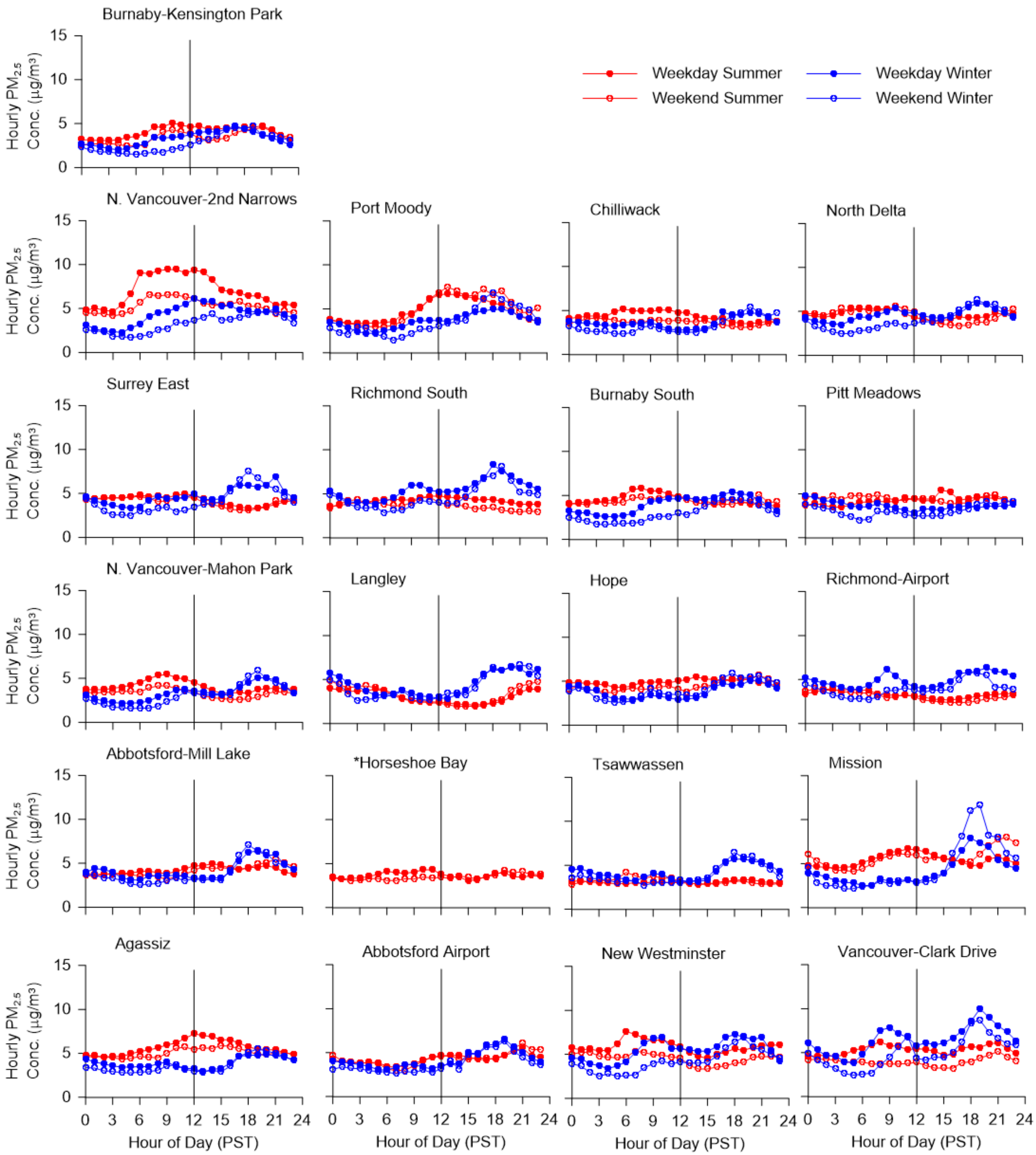


Figure 18: Annual (left) and short term peak (right) fine particulate ($PM_{2.5}$) trend, 2001 to 2020.



*Data completeness requirements were not met at this site in winter.

Figure 19: Diurnal trends fine particulate ($PM_{2.5}$), 2020.

Nitrogen Dioxide (NO_2)

Characteristics

Of all the different oxides of nitrogen (NO_X), nitric oxide (NO) and nitrogen dioxide (NO_2) are of most concern in ambient air quality. Both are produced by the high temperature combustion of fossil fuels, and are collectively referred to as NO_X. Nitric oxide generally predominates in combustion emissions but rapidly undergoes chemical reactions in the atmosphere to produce NO_2.

Nitrogen dioxide is a reddish-brown gas with a pungent, irritating odour. It has been implicated in acute and chronic respiratory disease and in the creation of acid rain. It also plays a major role in ozone formation, and as a precursor to secondary particulate formation ($PM_{2.5}$), both of which can affect visual air quality in the region.

Sources

Common NO_X sources include boilers, building heating systems and internal combustion engines. In the LFV, transportation sources account for approximately 77% of NO_X emissions, with stationary and area sources contributing the remainder.

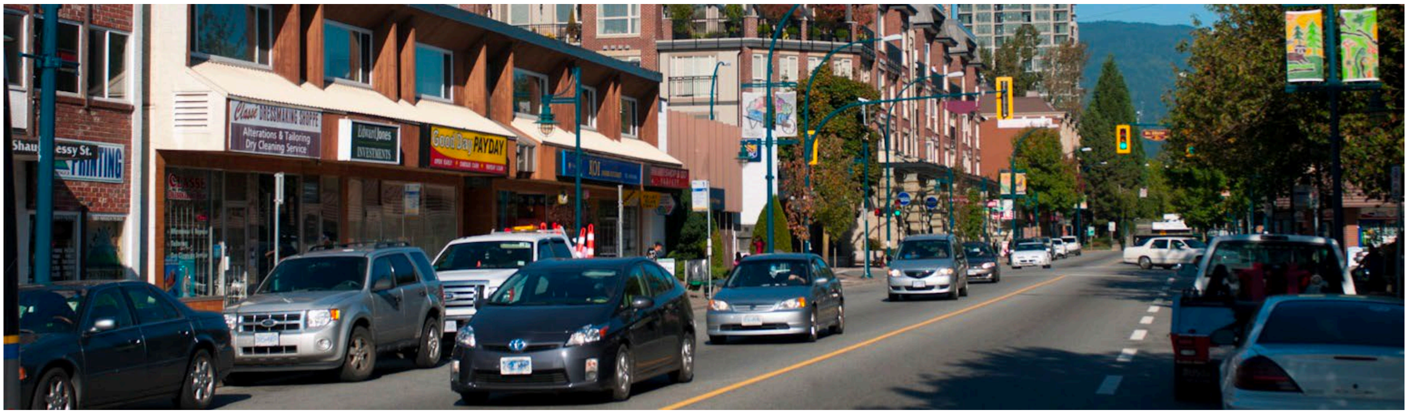
Monitoring Results

Figures S8 and 20 shows NO_2 monitoring levels in 2020, while Figures 21 and 22 shows the same values spatially. All 1-hour NO_2 concentrations met Metro Vancouver's objective at all stations. Figure 20 shows the annual average, 1-hour maximum and Metro Vancouver's 1-hour objective value. Metro Vancouver's 1-hour NO_2 objective level is the same as the 1-hour NO_2 Canadian Ambient Air Quality Standard which is calculated by taking an annual 98th percentile value using daily maximum 1-hour measurements, averaged over three consecutive years.

Average levels for the year were below Metro Vancouver's annual objective at all sites.

The majority of nitrogen oxides are from transportation sources such as cars, trucks, rail, planes and ships. These sources play a large role in ozone formation in the summer, which can lead to an air quality advisory.

Emissions affecting NO_2 concentrations are dominated by transportation sources, which is indicated by the locations of the highest concentrations. The highest concentrations are measured in more densely trafficked areas near busy roads. Lower concentrations were observed where traffic influences were less pronounced, such as the eastern parts of Metro Vancouver and in the FVRD.



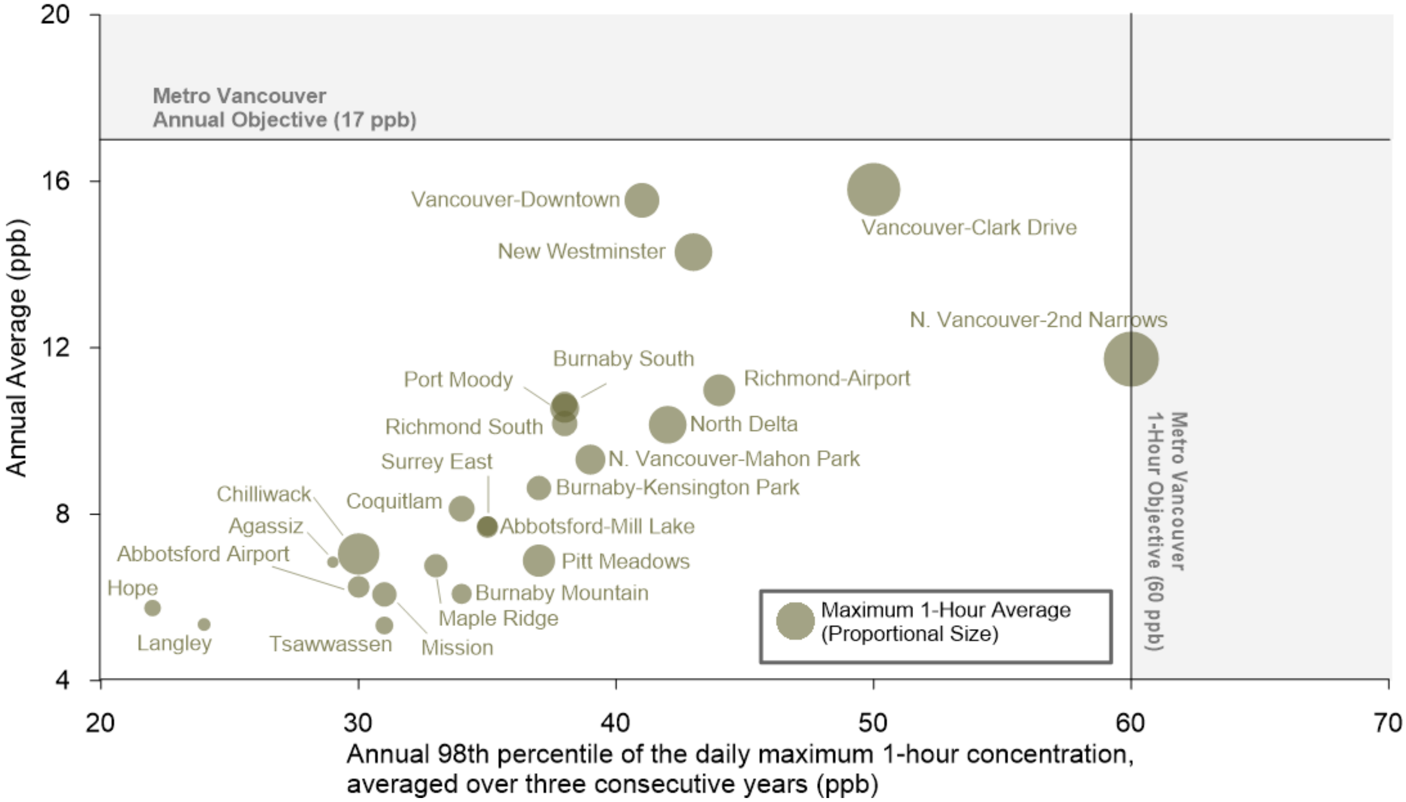
The seasonal trend for NO_2 in 2020 is shown by monthly averages and the monthly maximum 1-hour concentrations in Figure 23. On average, NO_2 concentrations were higher in the winter and lower in the summer. This seasonal trend is typical of the region and is the result of lower atmospheric mixing heights in winter along with increased residential, commercial and industrial heating that uses fossil natural gas.

The long-term NO_2 trends are shown in Figure 24. The annual average and short-term peak trends are provided in Figure 24 for the last two decades.

The trend for average and peak (99th percentile of 1-hour) concentrations continued to decline for most stations, showing constant improvement in NO_2 levels since the mid 1990's. Long-term changes in air quality can be attributed to changes in emissions while the yearly variation is likely attributable to meteorological variability. The improvements in the long-term trends shown here are largely due to improved vehicle emission standards and the AirCare program, which was operated in BC from 1992 to 2014.

The frequency distribution of hourly concentrations measured in 2020 is given in Table 7. The North Vancouver-Second Narrows experienced the greatest frequency of elevated NO_2 concentrations likely due to construction activities that were present near the monitoring station.

A series of diurnal plots are shown in Figure 25 for each station that monitors NO_2. The plots demonstrate the differences between weekdays and weekends along with differences between summer and winter. Most stations exhibit higher concentrations on weekdays compared with weekends and show a peak in the morning along with a peak in the afternoon. Higher concentrations correspond relatively well with traffic volume patterns.



Note: Stations contained within the grey area denote an exceedance of an objective.

Figure 20: Nitrogen dioxide monitoring, 2020.

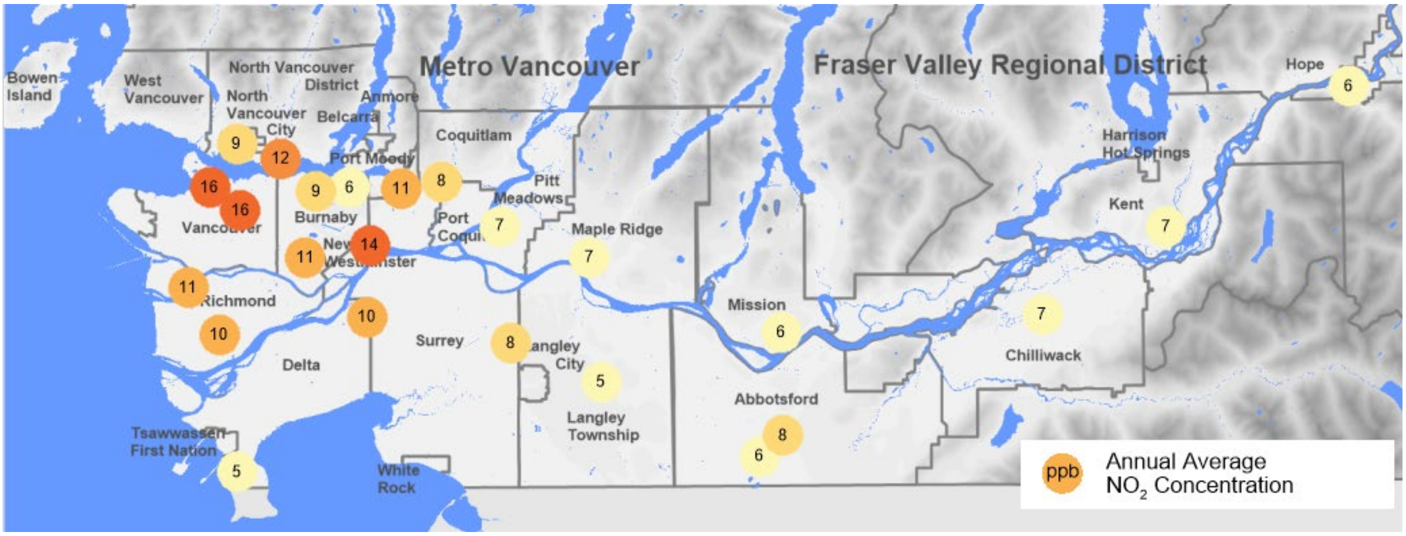


Figure 21: Annual average nitrogen dioxide in the LFV, 2020.

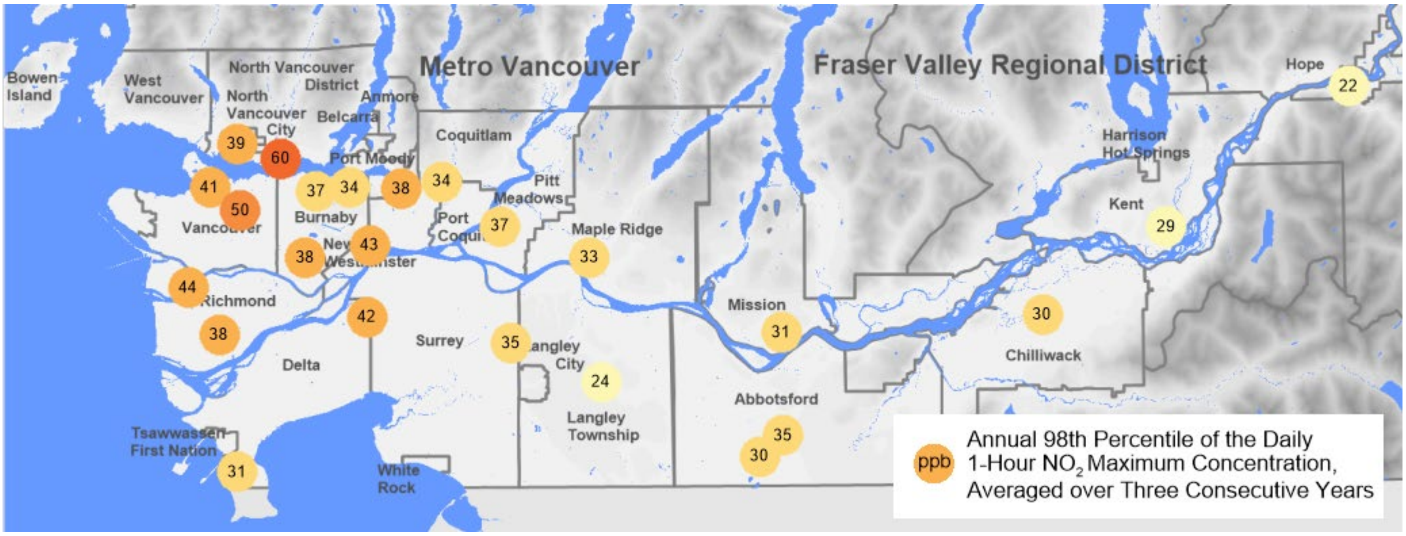


Figure 22: Short-term peak nitrogen dioxide in the LFV, 2020.

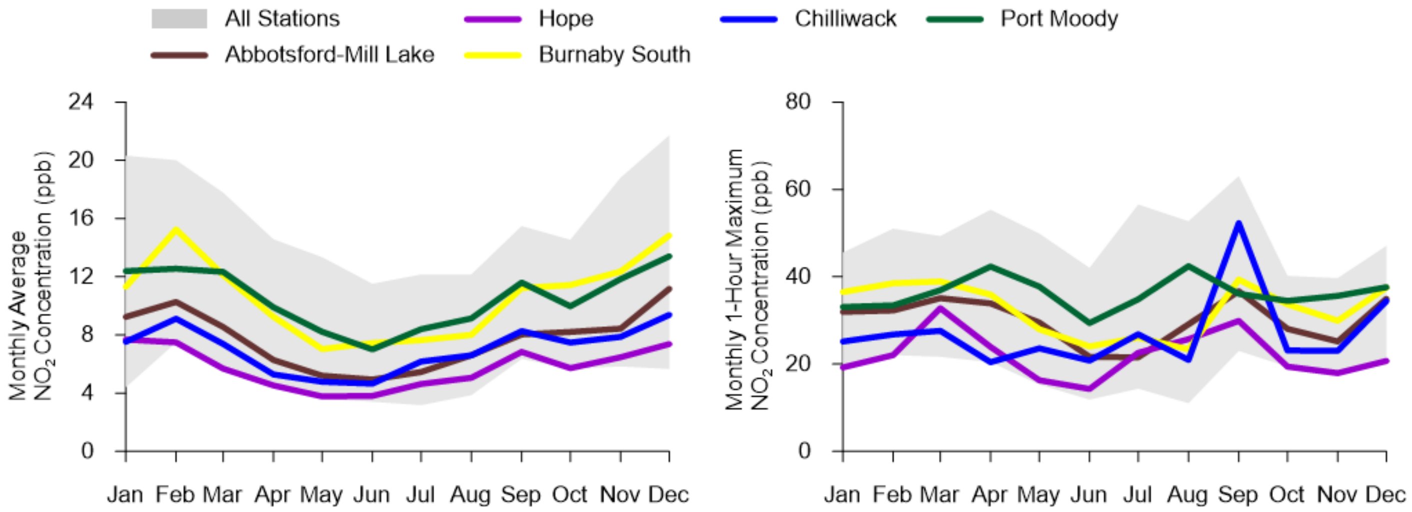


Figure 23: Monthly average (left) and short term peak (right) nitrogen dioxide, 2020.

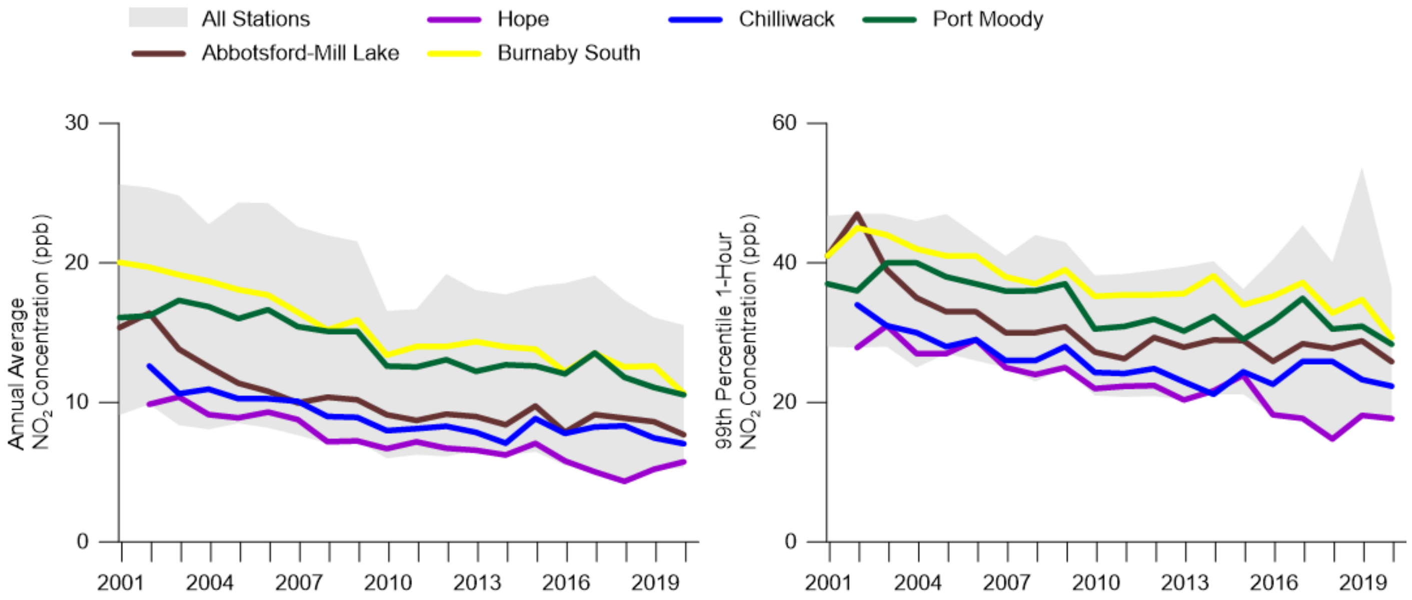


Figure 24: Annual (left) and short term peak (right) nitrogen dioxide trend, 2001 to 2020.

Table 7: Frequency distribution of hourly nitrogen dioxide, 2020.

NO_2 Conc. (ppb)	Vancouver-Downtown	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	North Delta	Burnaby Mountain	Surrey East	Richmond South	Burnaby South	Pitt Meadows	N. Vancouver-Mahon Park	Langley	Hope	Maple Ridge	Richmond-Airport	Coquitlam	Abbotsford-Mill Lake	Tsawwassen	Mission	Agassiz	Abbotsford Airport	New Westminster	Vancouver-Clark Drive
0 to 4	218	1507	860	1066	2886	1858	3291	2884	2476	1134	3349	1880	4247	3862	3108	2049	2282	2678	4797	3962	3350	3830	537	604
4 to 8	1380	2957	2436	2498	2754	2365	3339	2675	1937	2480	2532	2698	2725	2551	2660	1975	2917	2842	2079	2562	2390	2355	1432	1179
8 to 12	1628	1875	2127	2018	1676	1554	1294	1343	1204	2029	1315	1810	1110	1482	1308	1386	1676	1534	939	1168	1484	1395	1631	1371
12 to 16	1571	1036	1343	1523	829	1104	482	875	927	1387	721	1031	471	625	660	1098	966	881	485	600	887	674	1566	1593
16 to 20	1513	464	785	940	323	690	184	501	781	831	383	640	126	145	338	810	541	439	252	273	393	310	1353	1332
20 to 24	1141	217	511	419	127	470	89	229	622	474	200	367	48	20	134	611	230	224	132	134	125	113	1017	1066
24 to 28	795	89	323	159	38	296	42	123	433	234	79	194	6	4	57	407	84	82	52	40	28	36	556	768
28 to 32	381	22	179	53	9	155	18	55	171	92	37	69	2	2	17	229	27	38	13	14	6	8	248	482
32 to 36	108	6	80	28	3	54	4	11	48	27	11	48		1	5	97	16	12	1	3		1	85	197
36 to 40	22	2	49	8		20			11	10	4	11			3	33	3	1		1		1	27	76
40 to 44	5		33	3							2	2				8	1						6	25
44 to 48	1		11								1					1							1	13
48 to 52			4			1																	1	1
52 to 56			1		1																			1
56 to 60			1																					
>=60			1																					1
Missing	21	609	40	69	138	217	39	88	174	86	150	34	49	92	494	80	41	53	34	27	121	61	324	75
Data Completeness	100%	93%	100%	99%	98%	98%	100%	99%	98%	99%	98%	100%	99%	99%	94%	99%	100%	99%	100%	100%	99%	99%	96%	99%

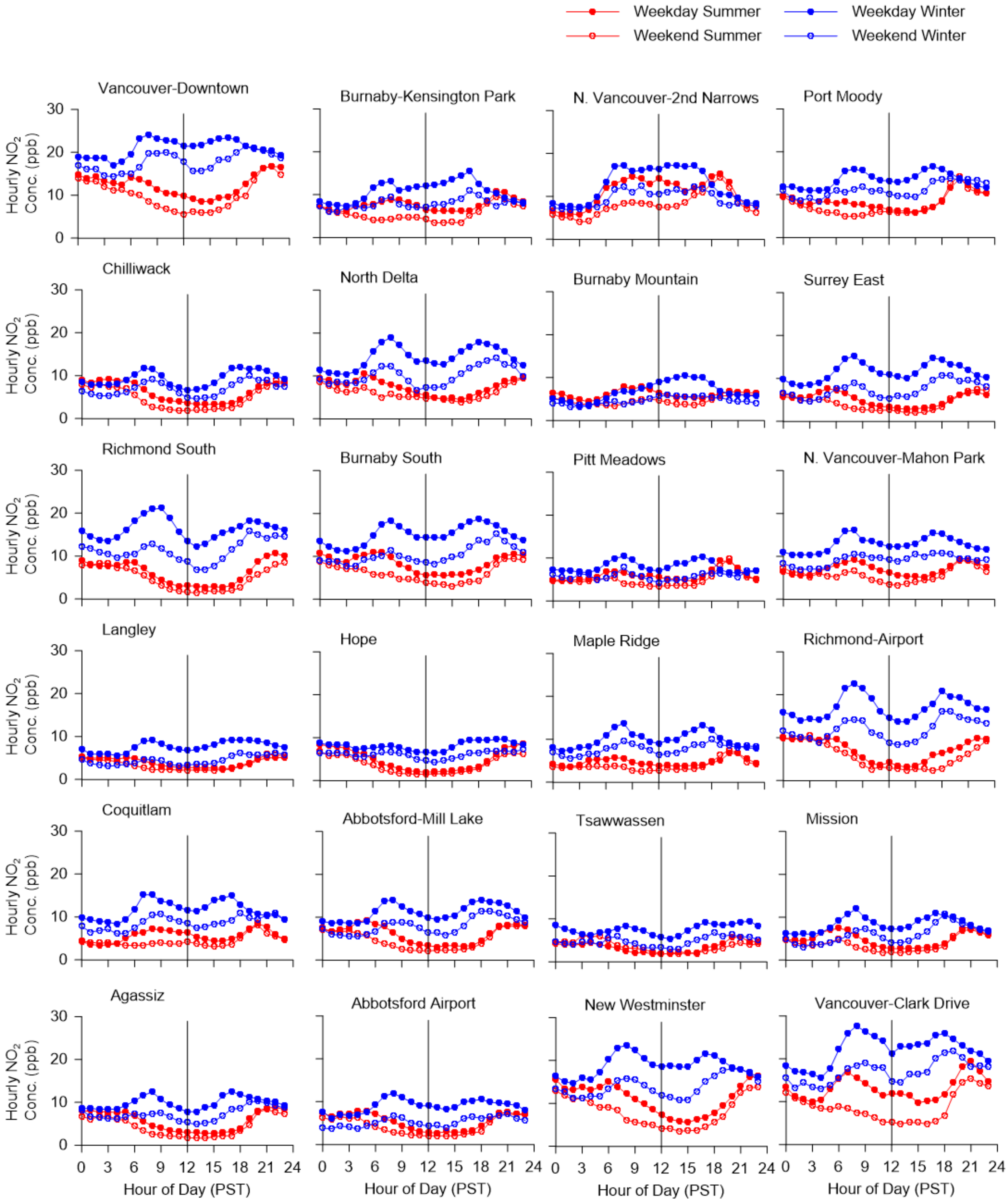


Figure 25: Diurnal trends nitrogen dioxide, 2020.

Sulphur Dioxide (SO_2)

Characteristics

Sulphur dioxide (SO_2) is a colourless gas with a pungent odour. It reacts in the air to form acidic substances such as sulphuric acid and sulphate particles.

Brief exposure to high concentrations of SO_2 and its by-products can irritate the upper respiratory tract and aggravate existing cardiac and respiratory disease in humans. Long-term exposure may increase the risk of developing chronic respiratory disease.

The environmental effects of SO_2 and its reactive products have been studied for many years. These compounds can cause damage to vegetation and buildings, they play a role in the formation of acid rain and they may affect the natural balance of waterways and soils. Sulphur oxides (SO_X) including SO_2 can also combine with other air contaminants to form the fine particulates ($PM_{2.5}$) that are thought to be one of the contributing factors in the degradation of visual air quality in the region.

Sources

Sulphur dioxide is emitted when fossil fuels containing sulphur are burned. The largest source of SO_2 emissions in the region an oil refinery, marine vessels, a waste to energy facility and two cement plants. The geographical distribution of sulphur dioxide emissions is influenced mainly by a petroleum refinery in Burnaby and ocean-going vessels in the marine areas of Burrard Inlet, although in recent years, marine emissions have been reduced substantially.

Local SO_2 emissions are low relative to other cities of similar size because fossil natural gas and electricity, rather than coal or oil, is used in almost all residential, commercial and industrial heating in the region.

Monitoring Results

Sulphur dioxide levels measured in 2020 are shown in Figures S9 and 26. Figure 26 displays the maximum 1-hour and annual average concentrations for each SO_2 monitoring location. The same values are represented spatially in Figures 27 and 28.

Sulphur dioxide levels were below Metro Vancouver's 1-hour objective and annual objective at all stations in 2020. The annual average SO_2 levels were less than 1 ppb at all stations. Average levels remained low in 2020 compared with previous years and can be attributed to stricter marine fuel requirements that came into effect at the beginning of 2015.

Average sulphur dioxide levels have improved significantly in recent years due to stricter requirements for lower sulphur content marine fuels.

The highest levels of SO_2 are typically measured in the northwest (Figures 27 and 28), particularly close to the dominant sources of SO_2 emissions (i.e., the petroleum refinery, marine vessels, and port areas) in the Burrard Inlet area.

There is little or no discernible seasonal trend in SO_2 concentrations throughout the year (Figure 29). The stations nearest to Burrard Inlet generally experienced the highest average concentrations through most of the year while the highest 1-hour measurements were recorded at Port Moody in May.

The long-term SO_2 trends in the LFV are shown in Figure 30. Average sulphur dioxide levels have improved significantly in recent years due to stricter requirements for lower sulphur content marine fuels. Overall, the yearly variation can be attributed in part to meteorological variability while the major long-term changes in air quality are mainly a result of changes in emissions.

Long-term trends provide information to help assess the impact of emission reduction efforts, policy changes and technology advances. For example, emissions of SO_2 declined during the early 1990s due to reduced sulphur content in on-road fuels and reduced emissions from oil refining and cement industries. In recent years, measurements of both the annual short-term peak (99^{th} percentile of the 1-hour values) and the annual average are markedly lower than they were in the 1990s.

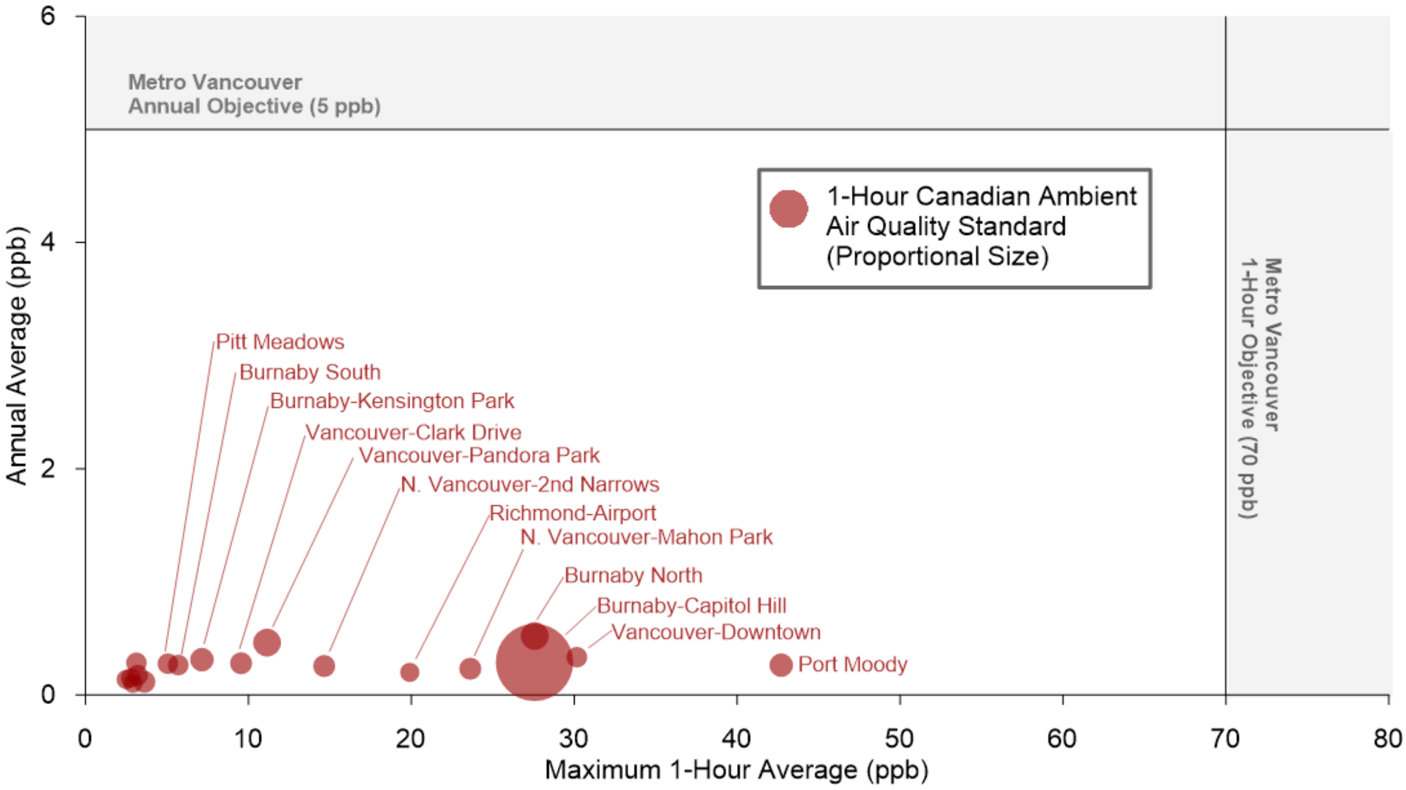
A series of diurnal plots are shown in Figure 31 for each SO_2 monitoring station. The diurnal plots illustrate the weekday/weekend differences along with summer/winter differences. Stations located away from Burrard Inlet show little diurnal variation while stations located near the inlet show trends indicative of nearby emission sources.

The diurnal patterns of SO_2 measured near Burrard Inlet in the summer are mainly influenced by wind flow and marine and oil refinery emissions. Port Moody experiences higher concentrations during the middle of the day in summer when winds are blowing from marine areas and the oil refinery toward the station.

Stations historically influenced by marine vessel emissions such as North Vancouver-2nd Narrows and North Vancouver-Mahon Park show attenuated levels compared with previous years.

The Burnaby-Capitol Hill and Burnaby North stations show diurnal variation with sporadic peak SO_2 concentrations during the morning and evening periods when mixing layer depth is reduced and dispersion is limited. Measurements of SO_2 at these stations are influenced by their proximity to the oil refinery.

The values in Table 8 represent the frequency distribution (or count) of how many hourly average measurements were in the specified ranges, respectively. It is evident that stations located near the Burrard Inlet area experience a greater occurrence of higher concentrations compared with areas away from the Inlet.



Note: For clarity, some stations have not been labelled due to several stations clustered together.

Figure 26: Sulphur dioxide monitoring, 2020.

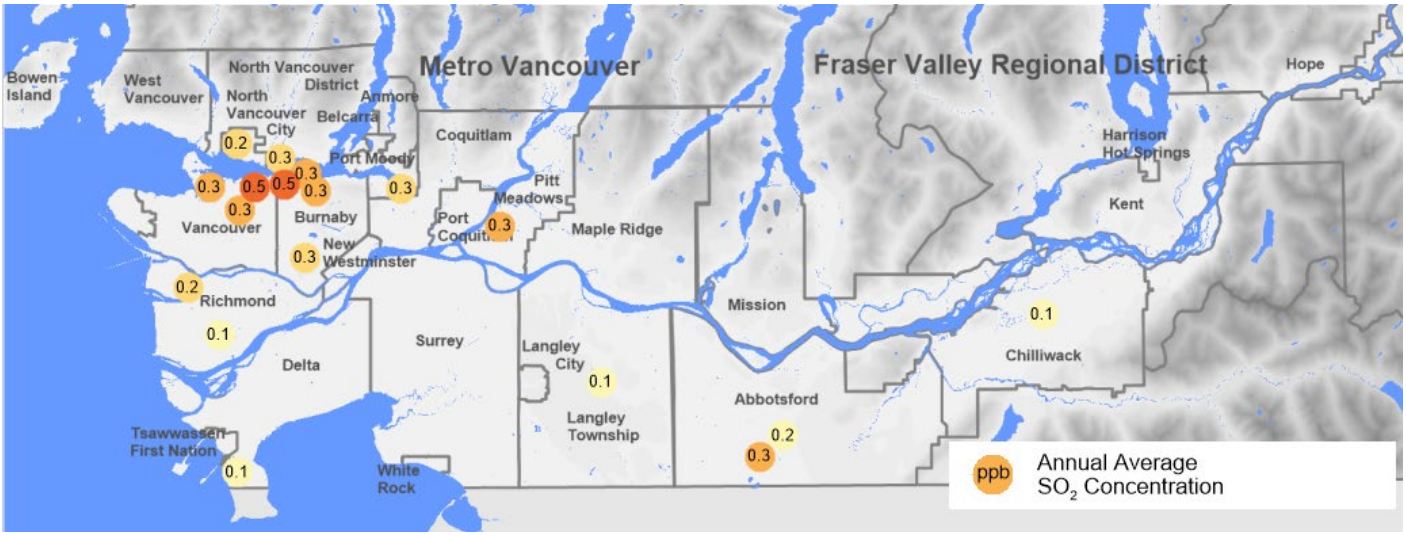


Figure 27: Annual average sulphur dioxide in the LFV, 2020.

Figure 28: Short-term peak sulphur dioxide in the LFV, 2020.

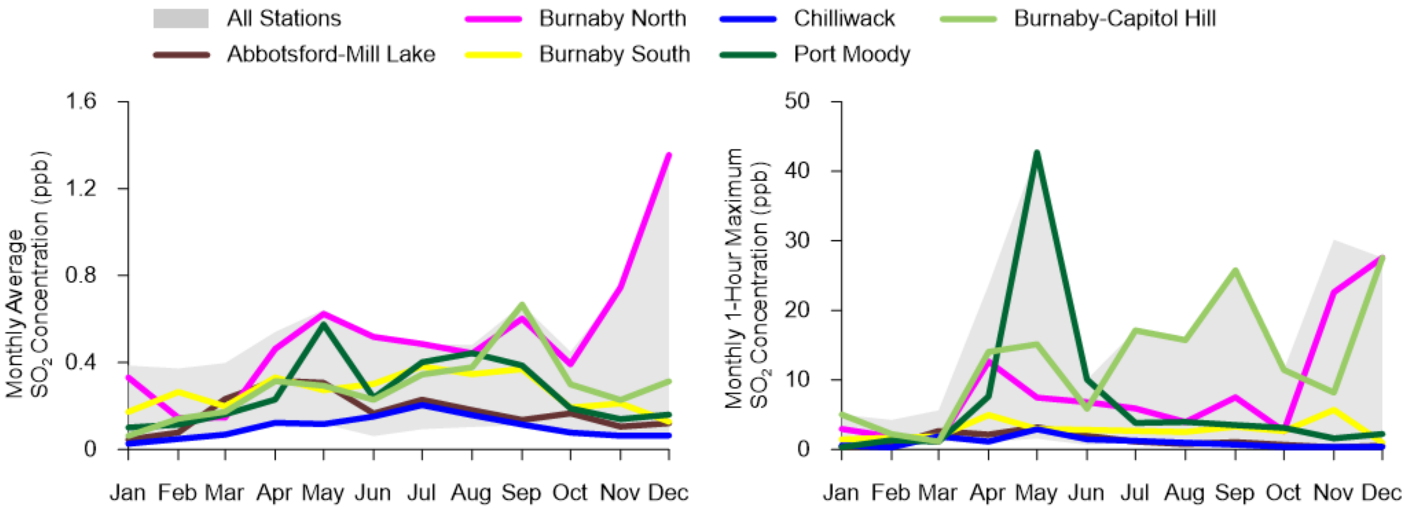


Figure 29: Monthly average (left) and short-term peak (right) sulphur dioxide, 2020.

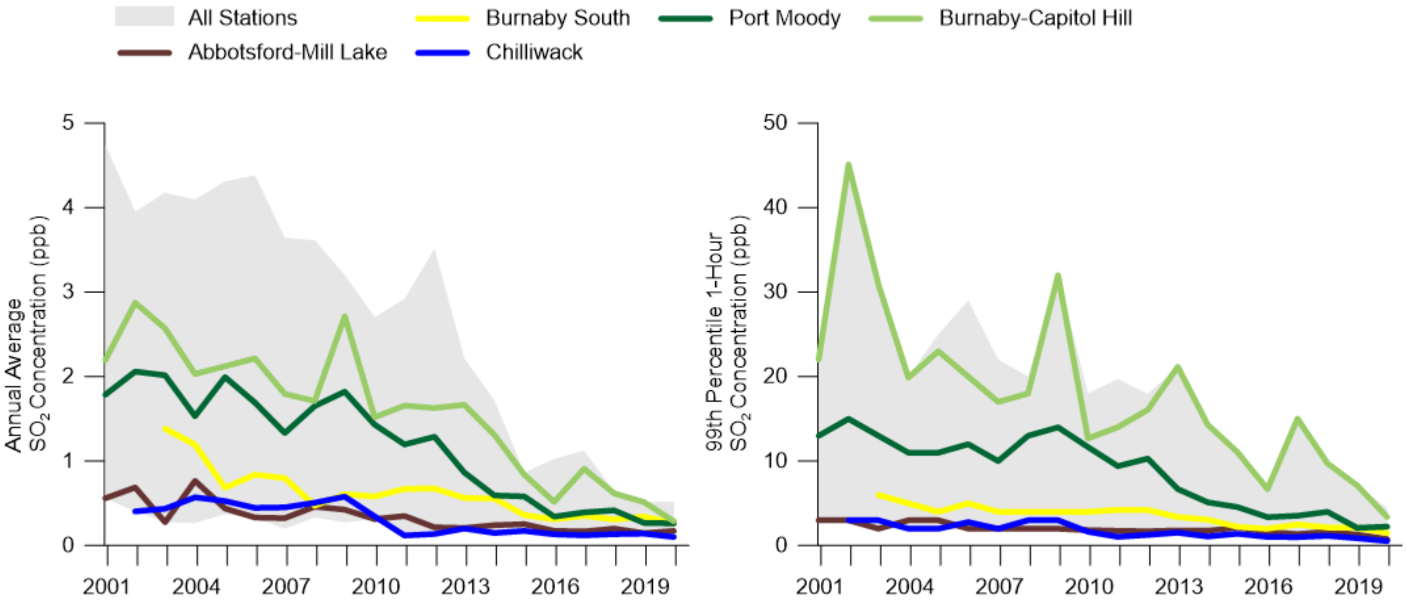


Figure 30: Annual (left) and short-term peak (right) sulphur dioxide trend, 2001 to 2020.

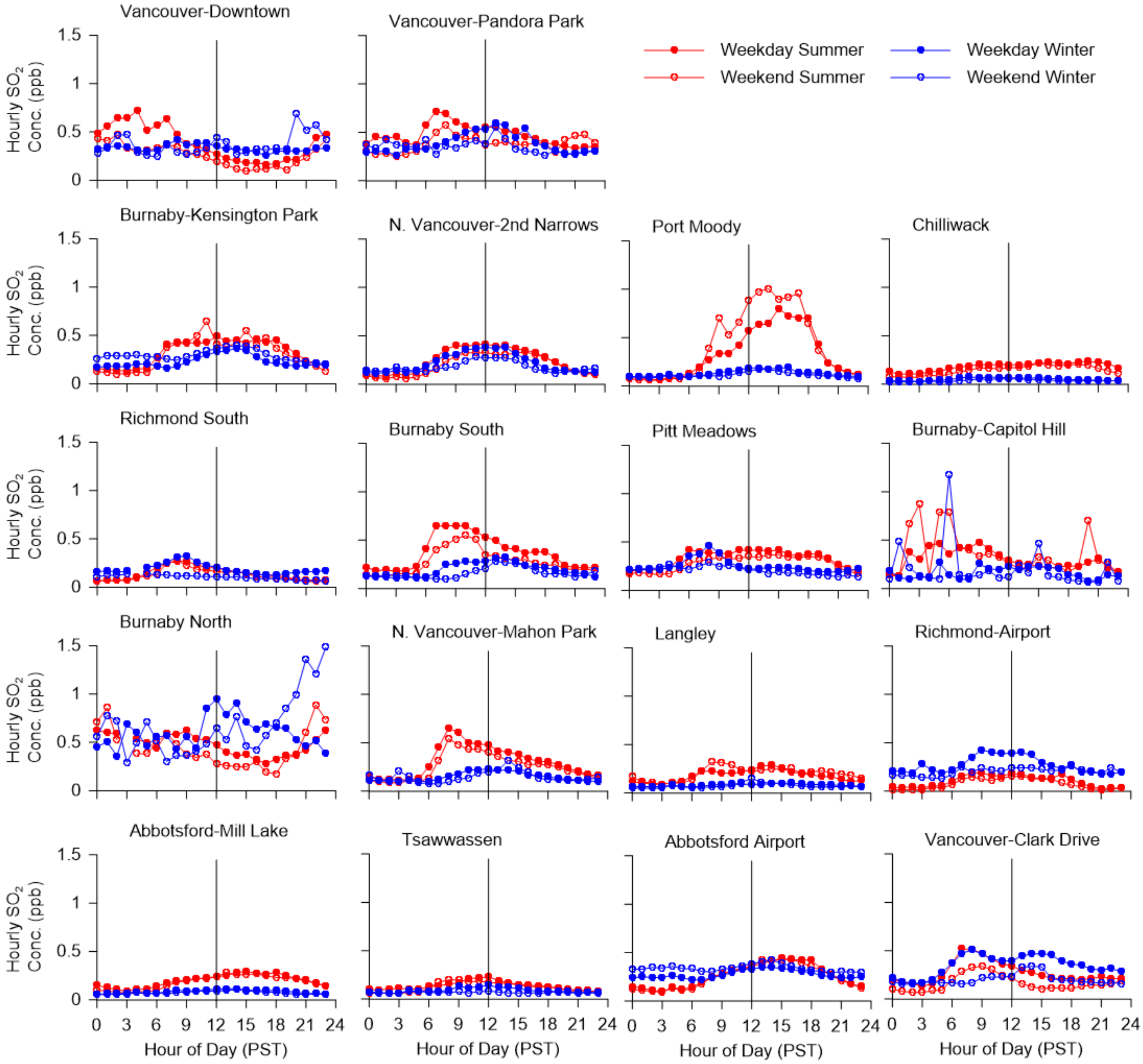


Figure 31: Diurnal trends sulphur dioxide, 2020.

Table 8: Frequency distribution of hourly sulphur dioxide, 2020.

SO_2 Conc. (ppb)	Vancouver-Downtown	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	Richmond South	Burnaby South	Pitt Meadows	Burnaby-Capitol Hill	Burnaby North	N. Vancouver-Mahon Park	Langley	Richmond-Airport	Abbotsford-Mill Lake	Tsawwassen	Abbotsford Airport	Vancouver-Clark Drive	Vancouver-Pandora Park
0 to 3	8230	8670	8677	8595	8134	7809	8478	7839	8118	8221	8512	8680	7958	8527	8417	8707	8454	7802
3 to 6	32	11	2	23			7	3	54	124	5		10	1	6	1	12	35
6 to 9	5	1	3	2					23	16	2						1	2
9 to 12	1			2					12	8	1		1				1	1
12 to 15			1	2					3	6								
15 to 18				1					6	4	1							
18 to 21									1	1	1		1					
21 to 24				1						3	1							
24 to 27									1									
27 to 30									1	2								
30 to 33	1																	
33 to 36																		
36 to 39				1														
>=39				1														
Missing Data	261	23	43	42	137	247	227	532	61	184	49	53	97	33	27	47	73	857
Completeness	97%	100%	100%	100%	98%	97%	97%	94%	99%	98%	99%	99%	99%	100%	100%	100%	99%	90%

Carbon Monoxide (CO)

Characteristics

Carbon monoxide (CO) is a colourless, odourless and tasteless gas produced by the incomplete combustion of fuels containing carbon. It has a strong affinity for haemoglobin and thus reduces the ability of blood to transport oxygen. Long-term exposure to low concentrations may cause adverse effects in people suffering from cardiovascular disease.

Sources

Carbon monoxide is the most widely distributed and commonly occurring air pollutant. The principal sources are non-road engines and motor vehicles. In the LFV, over 91% comes from mobile sources, which include cars, trucks, buses, planes, trains, ships and non-road engines. Other sources contributing to measured CO levels are building heating, commercial and industrial operations, and smoke from wildfires.

Monitoring Results

Figures S10 and 32 illustrate the results of CO monitoring in 2020 for stations with sufficient data completeness. Figure 32 displays the maximum 1-hour and 8-hour average as well as the annual average for each CO monitoring location. The same results are represented on maps in Figures 33, 34 and 35.

Measured carbon monoxide levels were well below Metro Vancouver's objectives at all stations throughout the LFV. Typically, the highest concentrations occur in the west where highly urbanized areas experience large volumes of traffic.

Average levels remained low throughout the LFV with the lowest readings recorded at stations away from heavily trafficked areas.

With the majority of CO released from cars, trucks, buses and non-road engines, significant improvements have occurred in the last two decades due to improved vehicle emission standards and vehicle emissions testing.

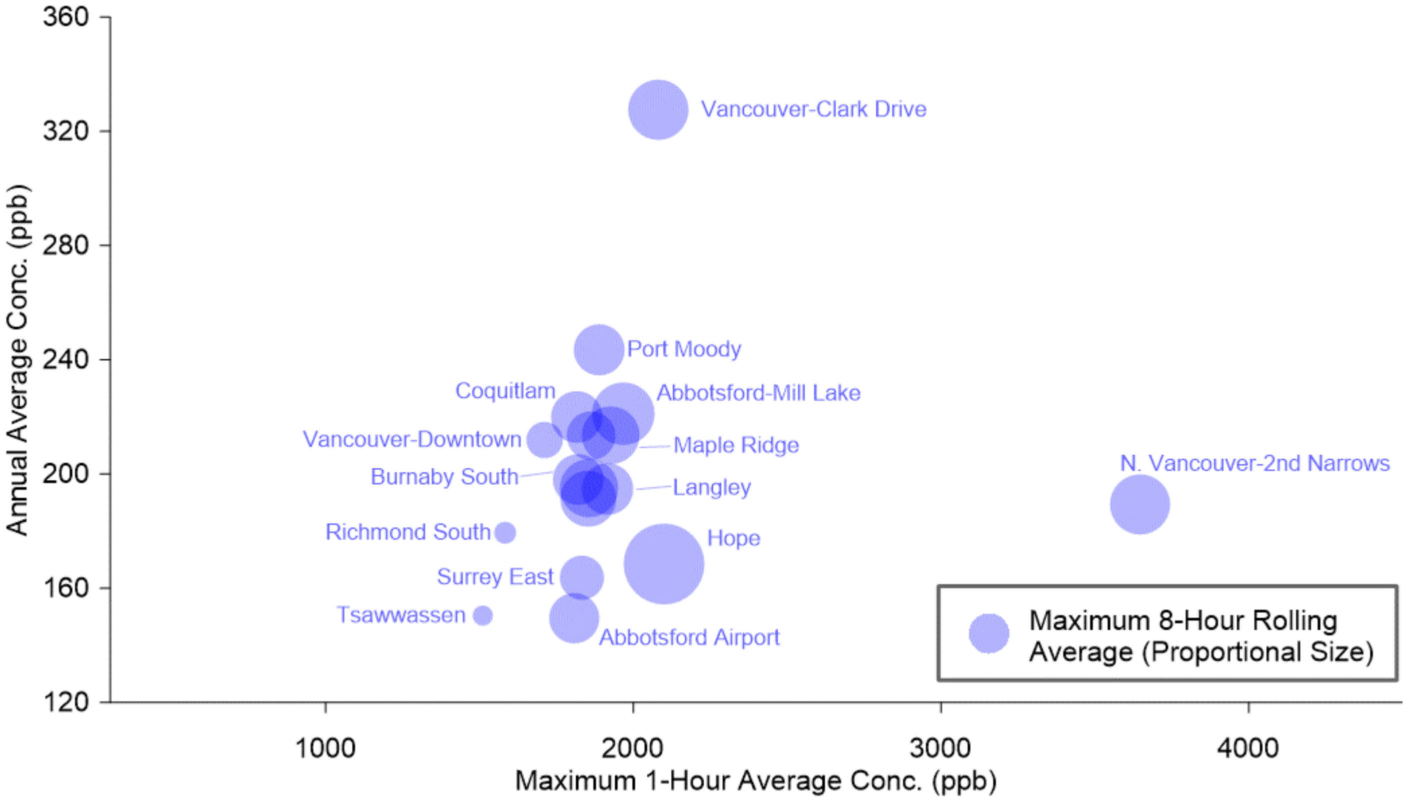
The seasonal trends for CO in 2020 are plotted as monthly average and maximum 1-hour concentrations in Figure 36. Typically average CO concentrations are higher in the winter compared with the summer, however the influence of wildfire smoke in September is evident in the monthly average concentration (left) as well as the monthly 1-hour maximum (right).

Figure 37 illustrates the long-term average and peak CO trends in the LFV. Some year-to-year variation is evident in the peak trends, however long-term changes in air quality are mainly attributed to changes in emissions. Improvements in both the average and the short-term peak concentrations (99th percentile of the 1-hour values) appear to be leveling off in recent years.

In the LFV average levels have decreased dramatically since the early nineties. Declining CO concentrations are largely due to improved vehicle emission standards and the AirCare program, which was operated in BC from 1992 to 2014.

A series of diurnal plots are shown in Figure 38 for each station that monitors CO. Most stations exhibit higher winter concentrations on weekdays compared with weekends, with many stations showing a large peak in the morning that corresponds relatively well with morning traffic patterns.

Stations that appear to be strongly influenced by CO emission sources such as traffic include Vancouver-Clark Drive where a well-defined peak is evident in the mornings on weekdays during the winter.



Notes:

- Air contaminant levels shown here are well below (i.e., better than) air quality objectives.
- For clarity, some stations have not been labelled due to several stations clustered together.

Figure 32: Carbon monoxide monitoring, 2020.

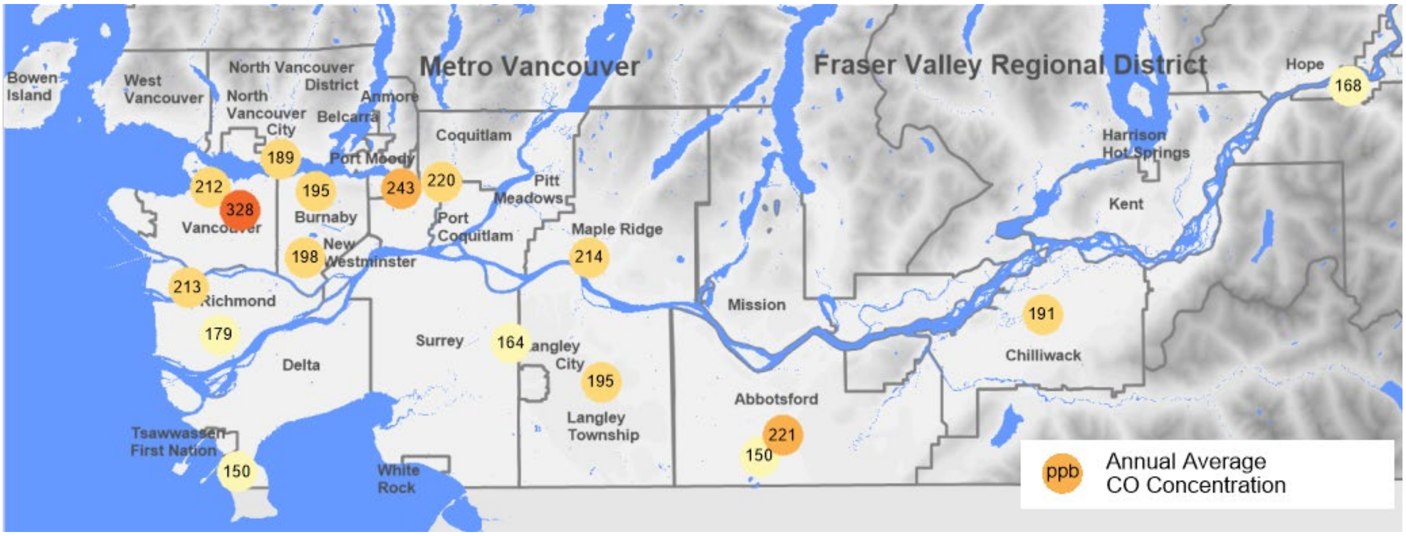


Figure 33: Annual average carbon monoxide in the LFV, 2020.

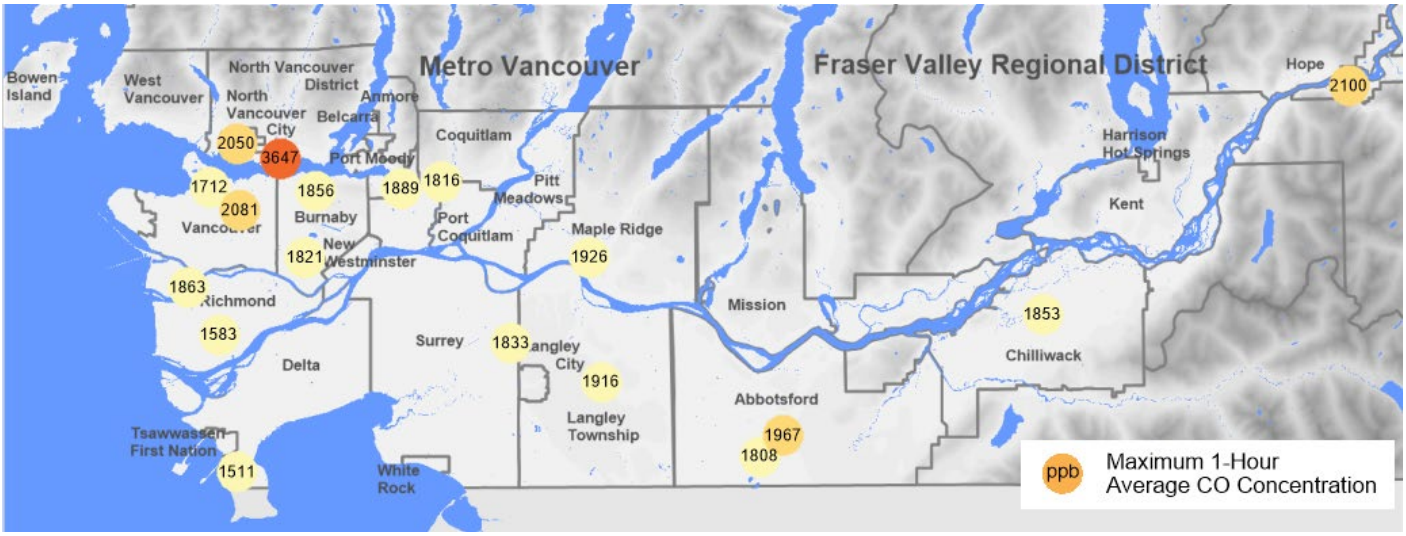


Figure 34: Short-term peak (1-hour) carbon monoxide in the LFV, 2020.

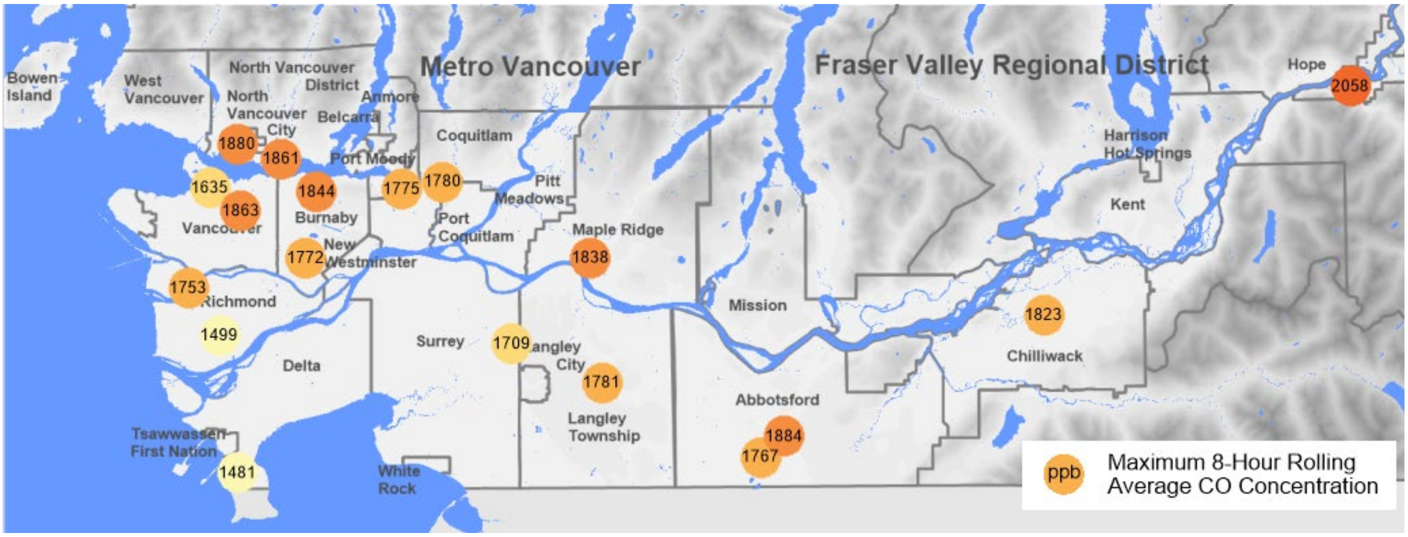


Figure 35: Short-term peak (8-hour) carbon monoxide in the LFV, 2020.

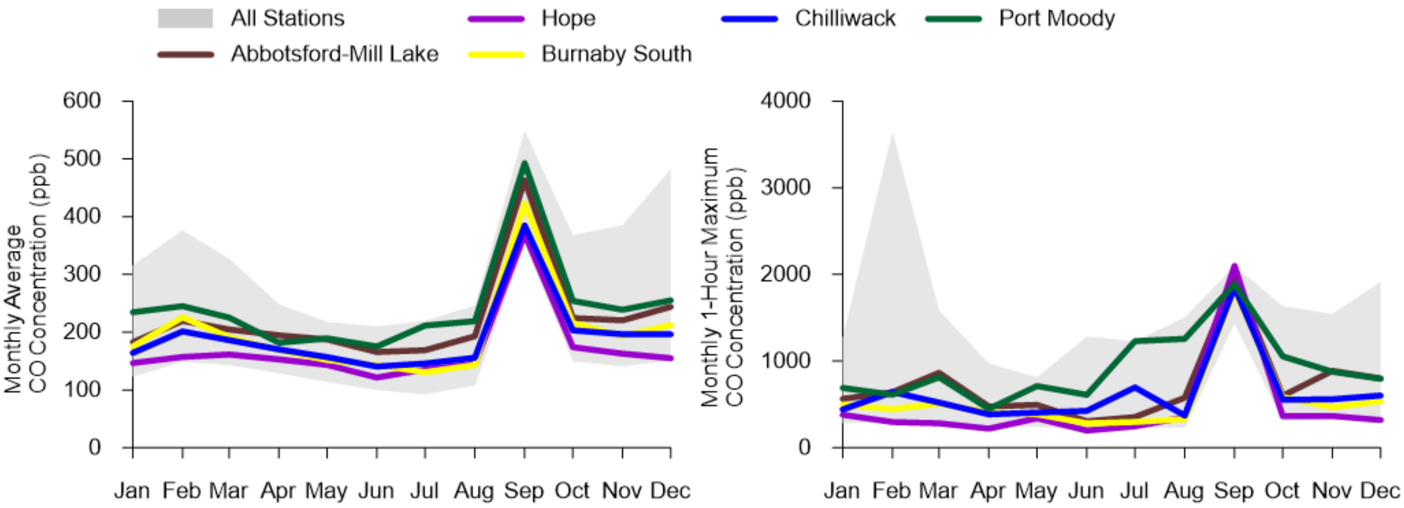


Figure 36: Monthly average (left) and short term peak (right) carbon monoxide, 2020.

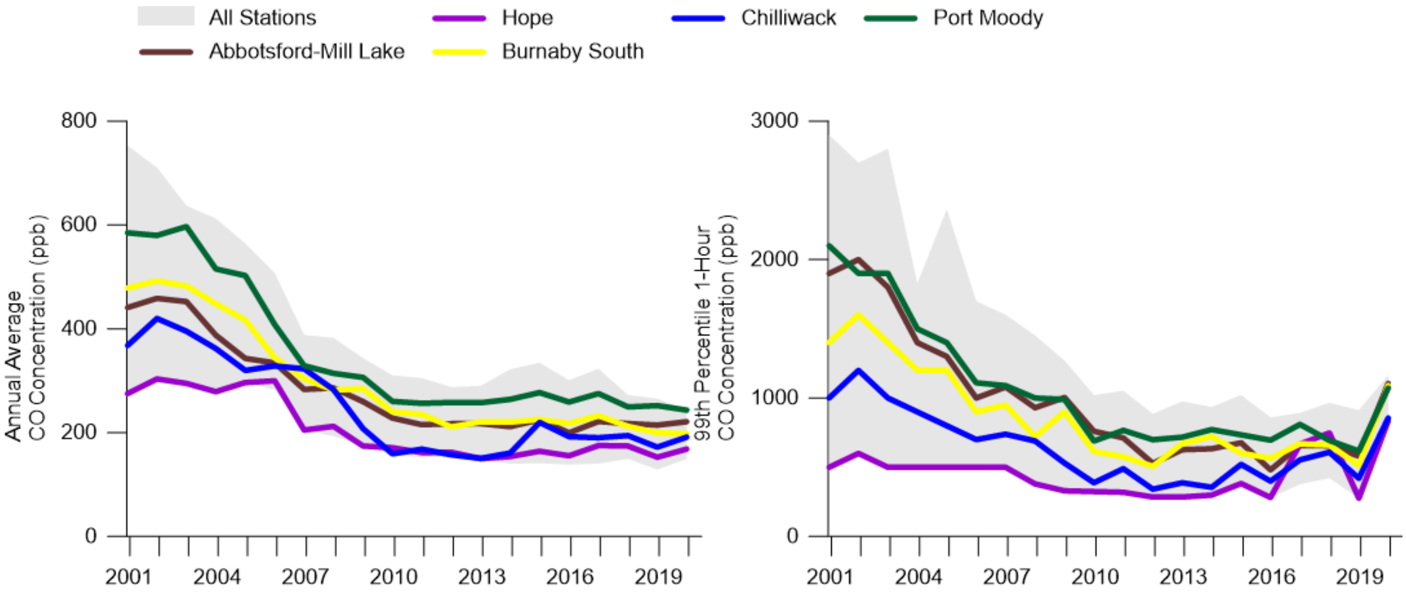
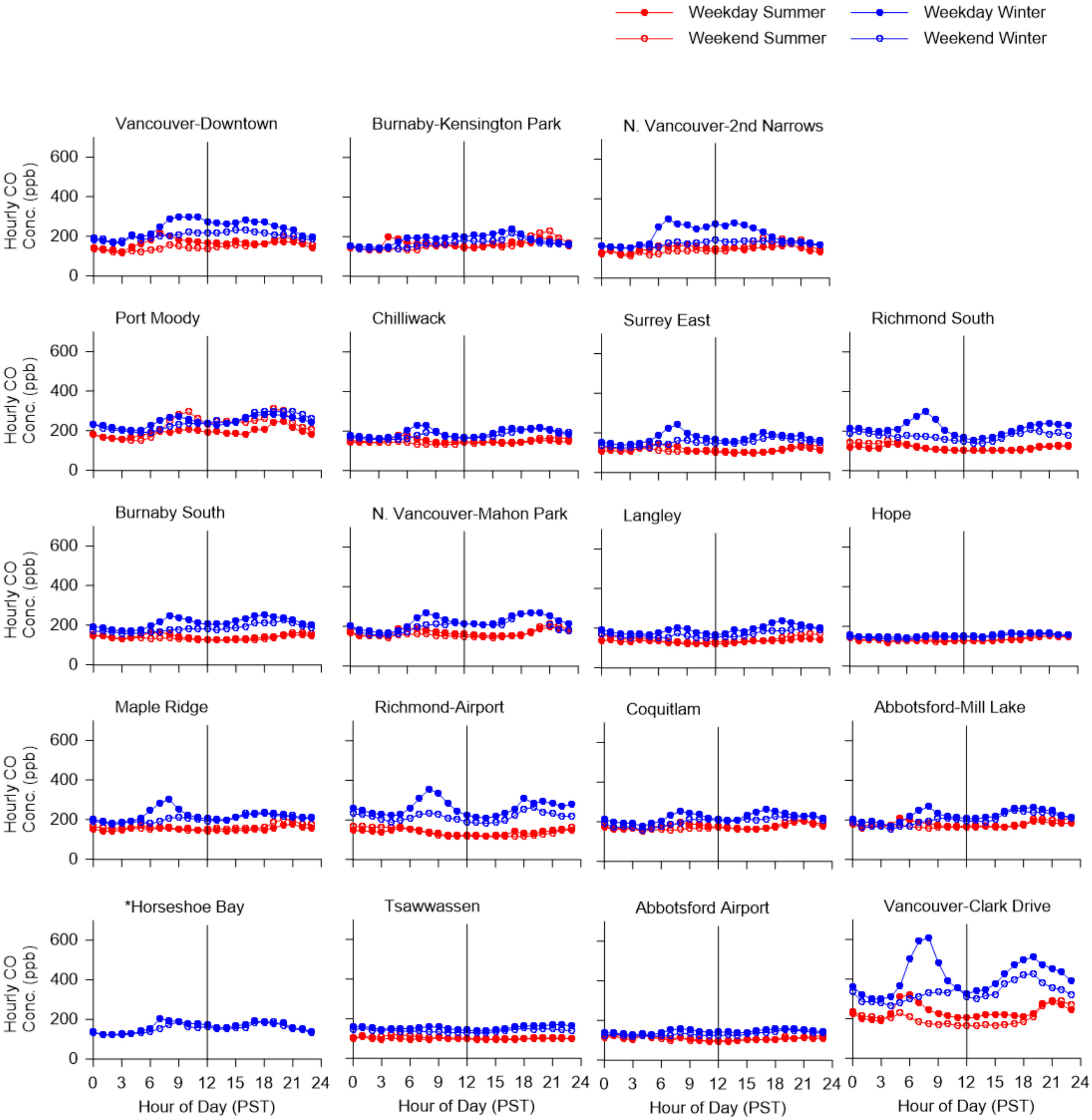


Figure 37: Annual (left) and short term peak (right) carbon monoxide trend, 2001 to 2020.



*Data completeness requirements were not met at this site in summer.

Figure 38: Diurnal trends carbon monoxide, 2020.

Inhalable Particulate (PM_{10})

Characteristics

The term 'PM_{10}' refers to airborne particles with a diameter of 10 micrometres (μm) or less. These particles are also known as inhalable particulate matter which, given their small size, can be inhaled and deposited in the lungs.

Exposure to PM_{10} can lead to both chronic and acute human health impacts, particularly pulmonary function. Inhalable particulate can aggravate existing pulmonary and cardiovascular disease, increase symptoms in asthmatics and increase mortality. High PM_{10} levels can also increase corrosion and soiling of materials, and may damage vegetation. The smaller particles also contribute to degraded visual air quality.

Sources

Inhalable particulate is emitted from a variety of sources with the largest contribution from construction and demolition activities (23%) followed by residential wood burning (21%). Other major contributors to PM_{10} are industrial sources, and non-road engines and equipment. There are also natural sources of PM_{10} such as wind-blown soil, wildfires, ocean spray and volcanic activity.

Monitoring Results

Figures 39 and 40 illustrates the PM_{10} monitoring in 2020, while Figures 41 and 42 shows the same values spatially. Annual averages ranged from 10.0 to 12.3 $\mu g/m^3$, which are all below Metro Vancouver's annual PM_{10} objective.

Widespread exceedances of Metro Vancouver's 24-hour PM_{10} objective were experienced in 2020. The Metro Vancouver 24-hour objective was exceeded on September 11 at all stations with the exception of Hope, which exceeded on September 12. All stations exceeded the objective each day until September 18 with the exception of Burnaby-South, Richmond-Airport, and Abbotsford-Airport, which exceeded until September 17. As discussed in the $PM_{2.5}$ section, the 2020 year was heavily impacted by extensive wildfires burning in Washington, Oregon and California.

On October 31, the Langley station exceeded the short-term PM_{10} objective for one day, which was likely related to firework emissions on Halloween.

Improvements in PM_{10} concentrations have occurred in the last two decades, however widespread exceedances were measured in September 2020 due to wildfire smoke.

Table 9 gives the frequency distribution of PM_{10} concentrations for the year. It can be seen that Hope and Burnaby North experienced the greatest frequency of elevated PM_{10} concentrations.

The seasonal trend of monthly average PM_{10} was similar to previous wildfire years, with the highest concentrations occurring during hot and dry periods of the summer (Figure 43). The highest average and peak level concentrations were experienced in the month of September. These trends were a result of wildfire smoke impacts to the region.

The long-term PM_{10} trends (2001 to 2020) are shown in Figure 44 with the annual average trend provided on the left and the short-term peak trend is on the right. The annual average PM_{10} trend shows a general improvement in the last 20 years. The peak trend, represented by the 99th percentile of the 24-hour rolling average shows a trend of degradation in the most recent years where wildfire impacts have been experienced (2015, 2017, 2018 and 2020). The years 2017, 2018 and 2020 were influenced by widespread wildfire smoke that covered the region. The 2005 peak was the result of a large fire in Burns Bog in Delta.

A series of diurnal plots are shown in Figure 45 for each PM_{10} monitoring station. The plots show the differences between weekdays and weekends along with differences between summer and winter.

Historically most stations exhibit higher concentrations on weekdays than weekends, likely the result of greater traffic volumes (road dust) and work related activities (outdoor burning, agricultural activities, industrial processes, etc.).

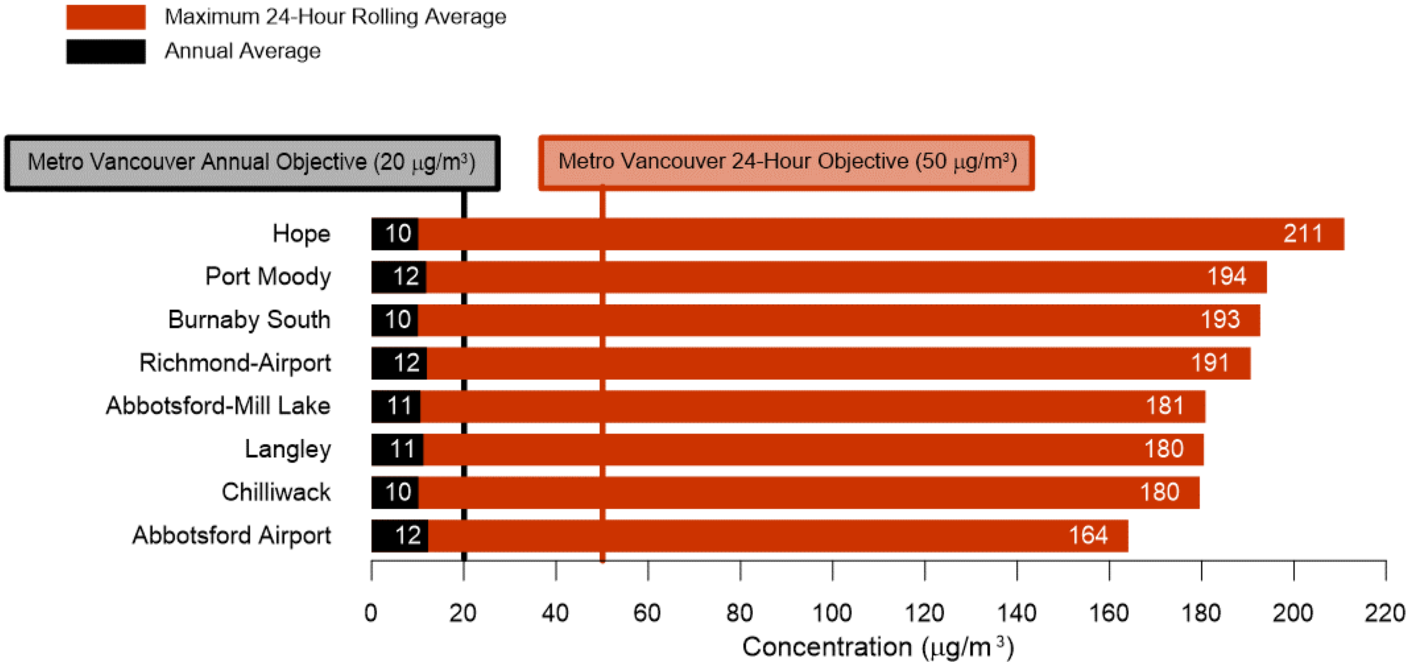
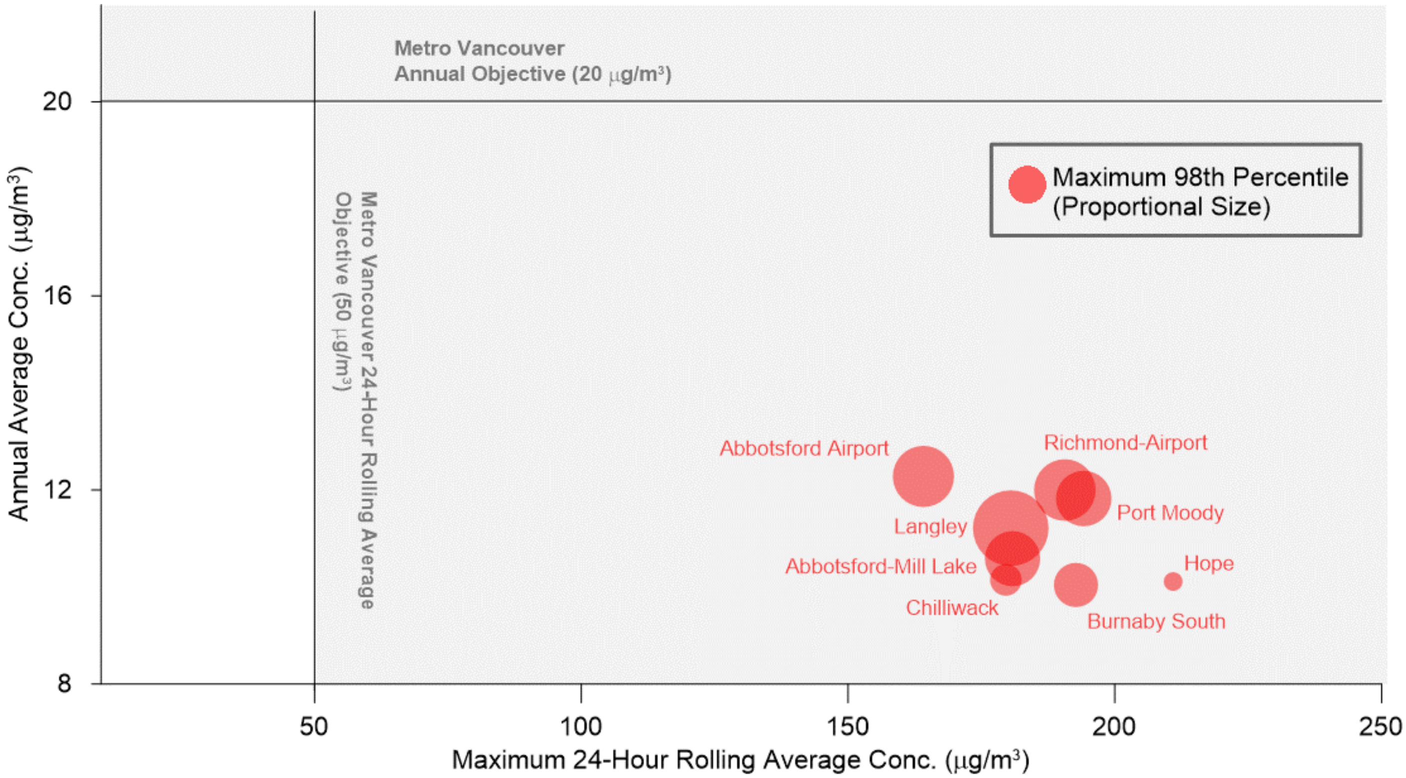


Figure 39: Inhalable particulate (PM_{10}) monitoring, 2020.



Note: Stations contained within the grey area denote an exceedance of an objective.

Figure 40: Inhalable particulate (PM_{10}) monitoring, 2020.

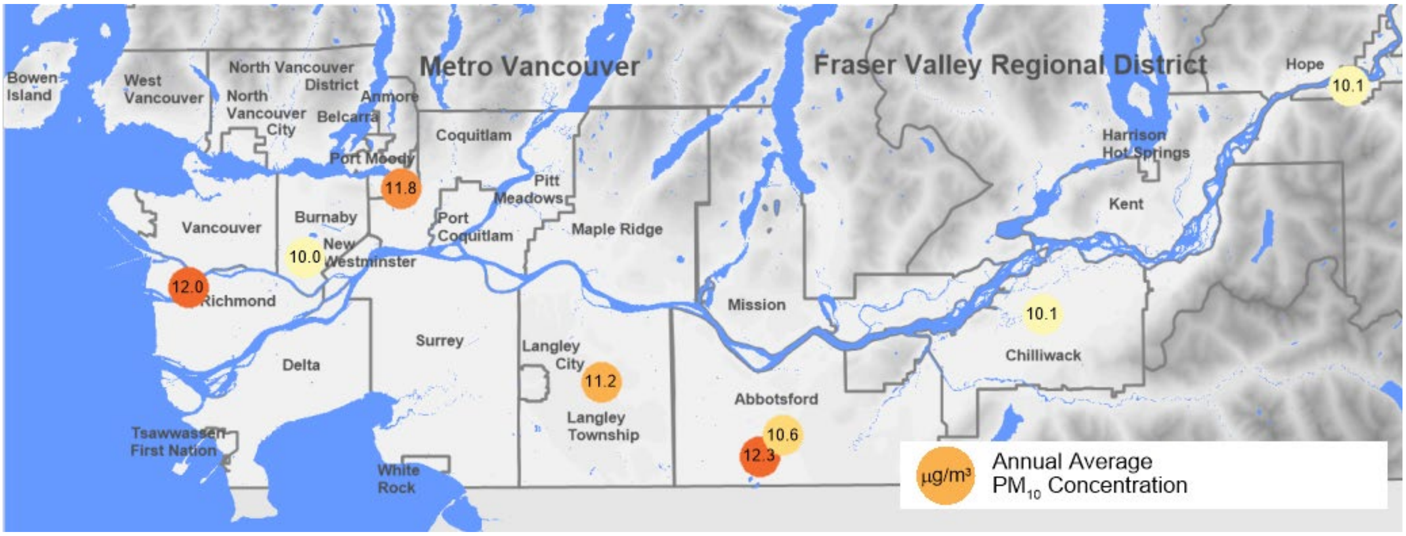


Figure 41: Annual average inhalable particulate (PM_{10}) in the LFV, 2020.

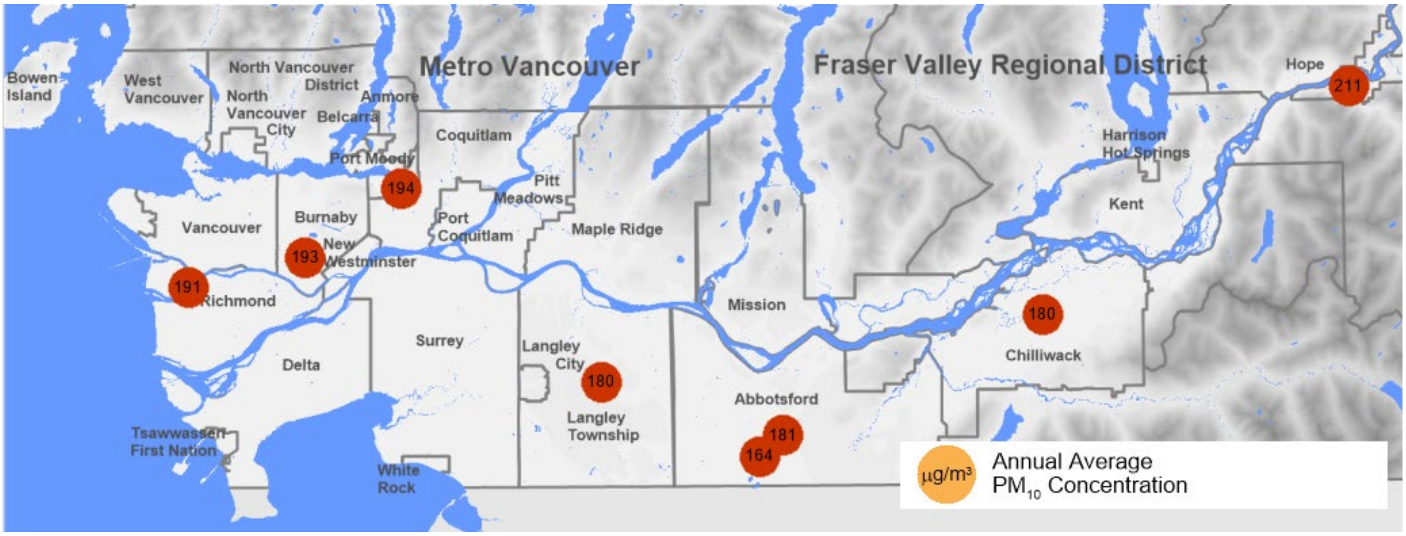


Figure 42: Short-term peak inhalable particulate (PM_{10}) in the LFV, 2020.

Table 9: Frequency distribution of 24-hour rolling average inhalable particulate (PM_{10}), 2020.

PM10 Conc. (ug/m3)	Port Moody	Chilliwack	Burnaby South	Burnaby North	Langley	Hope	Richmond-Airport	Abbotsford-Mill Lake	Abbotsford Airport
0 to <12.5	6574	7428	7822	3290	7395	7571	7006	7476	5989
12.5 to <25	1638	1070	725	1124	1035	911	1417	1049	2081
25 to <37.5	56	41	34	79	52	19	83	25	155
37.5 to <50	17	23	12	17	51	20	25	22	28
50 to <62.5	8	29	8	9	40	22	41	15	53
62.5 to <75	36	34	51	10	47	26	26	53	15
75 to <87.5	37	9	11	55	14	27	8	10	8
87.5 to <100	7	6	11	15	8	6	10	5	9
100 to <112.5	7	11	7	8	7	6	8	6	6
112.5 to <125	6	23	6	4	7	14	7	4	11
125 to <137.5	5	24	8	7	6	26	7	5	43
137.5 to <150	6	8	6	6	8	5	8	38	13
150 to <162.5	29	5	32	8	48	4	7	22	13
162.5 to <175	21	6	15	36	15	4	30	11	3
175 to <187.5	8	7	11	8	8	5	26	7	
187.5 to <200	10		8	9		6	6		
200 to <212.5				7		11			
>=212.5									
Missing Data	319	60	17	4092	43	101	69	36	357
Completeness	96%	99%	100%	53%	100%	99%	99%	100%	96%

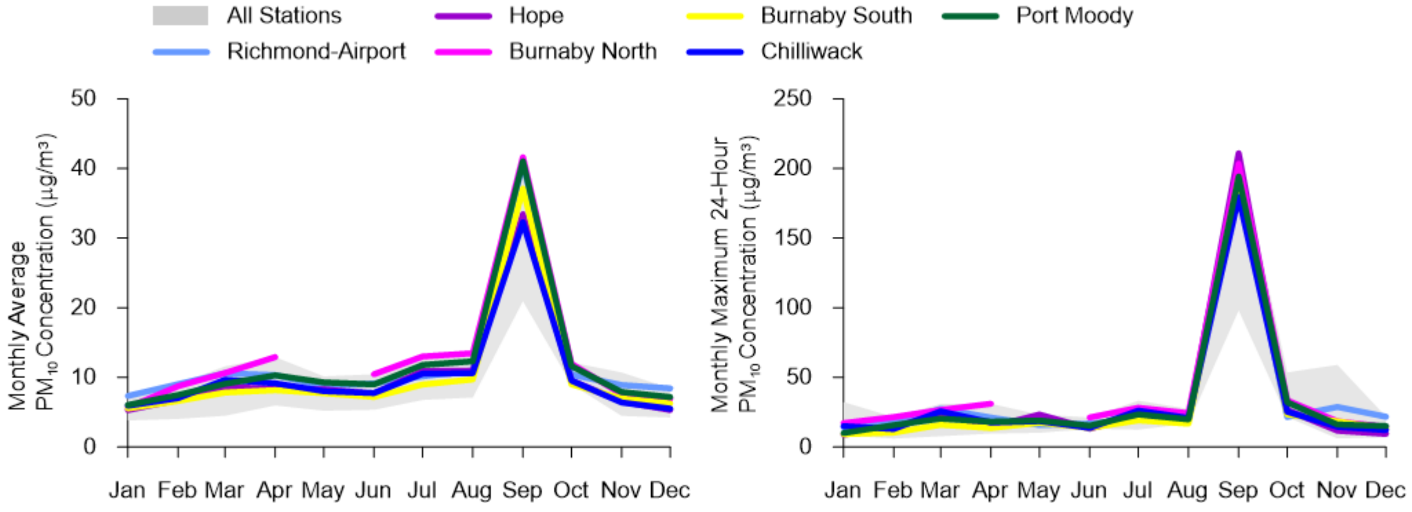


Figure 43: Monthly average (left) and short term peak (right) inhalable particulate (PM_{10}), 2020.

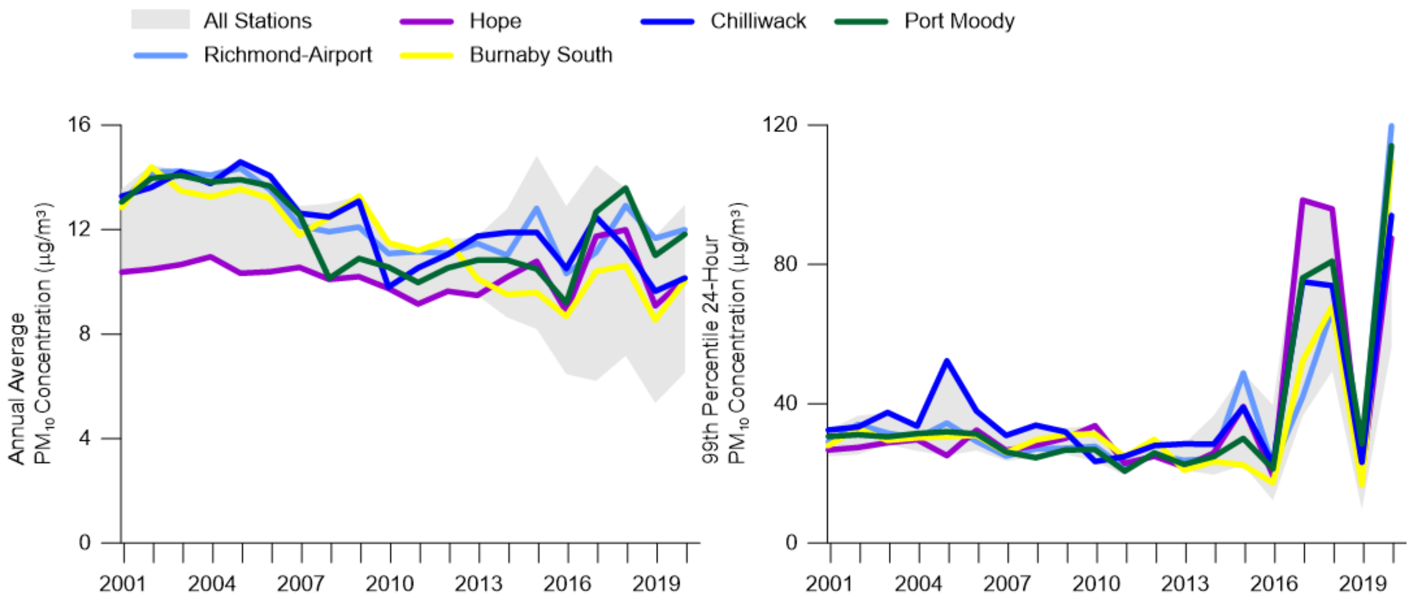
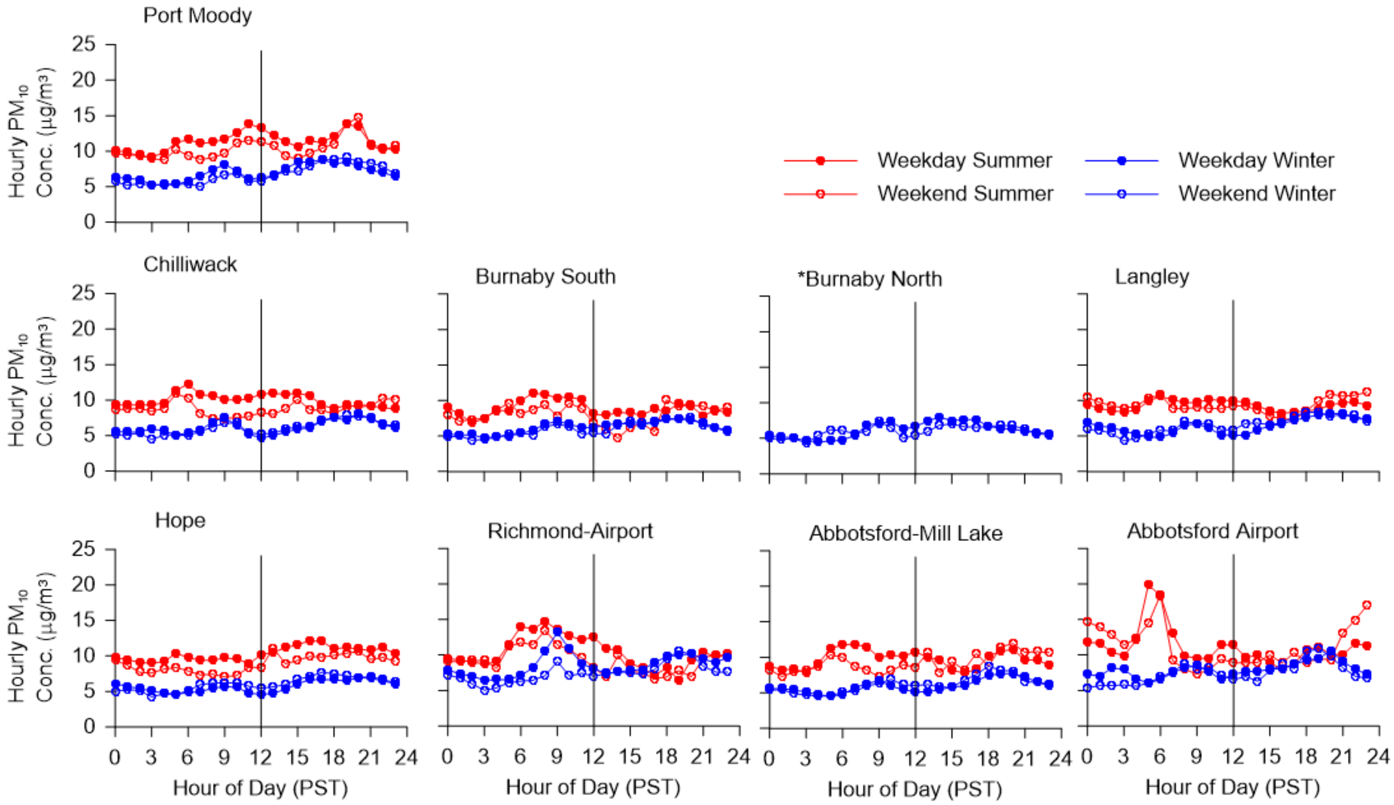


Figure 44: Annual average (left) and short term peak (right) inhalable particulate (PM_{10}) trend, 2001 to 2020.



*Data completeness requirements were not met at this site in summer.

Figure 45: Diurnal trends inhalable particulate (PM_{10}), 2020.

Black Carbon (BC)

Characteristics

Black carbon (BC) is carbonaceous material formed by the incomplete combustion of fossil fuels, biofuels, and biomass, and is emitted directly in the form of fine particles ($PM_{2.5}$). BC is a major component of "soot", a complex light-absorbing mixture that also contains some organic carbon.

The terms black carbon and soot are sometimes used interchangeably. Although BC has a very short residence time in the atmosphere (about a week), it is a strong absorber of solar radiation and can absorb much more energy than carbon dioxide (CO_2). As a result, BC is considered a "short-lived climate forcer". Black carbon contributes to the adverse impacts on human health, ecosystems, and visibility associated with fine particulate matter ($PM_{2.5}$).

Sources

Mobile sources are the largest contributors of BC emissions in the LFV, emitting over 80% of the BC emissions in the region. Non-road engines (primarily diesel fuelled), heavy duty vehicles, rail and marine vessels are significant sources of BC emissions. Other significant sources in the region are biomass burning activities, including agricultural burning, open and prescribed burning, wildfires and residential heating.

Monitoring Results

Figures 46 and 47 illustrates the results of continuous BC monitoring for 2020. Figure 46 displays the value of the maximum 1-hour and 24-hour average as well as the annual average for each station with the same information shown in a bubble plot in Figure 47.

There are no provincial, federal or Metro Vancouver objectives for black carbon. The highest 1-hour average BC concentration occurred at North Vancouver-Second Narrows.

In Figure 48 the seasonal trends for BC shows average values higher in September with the highest peak level occurring in July and September.

Black carbon is generally greater on weekdays compared with weekends, shown in Figure 49. This trend is especially evident at the Vancouver-Clark Drive station where greater amounts of BC are measured in the winter and on weekdays compared with weekends.

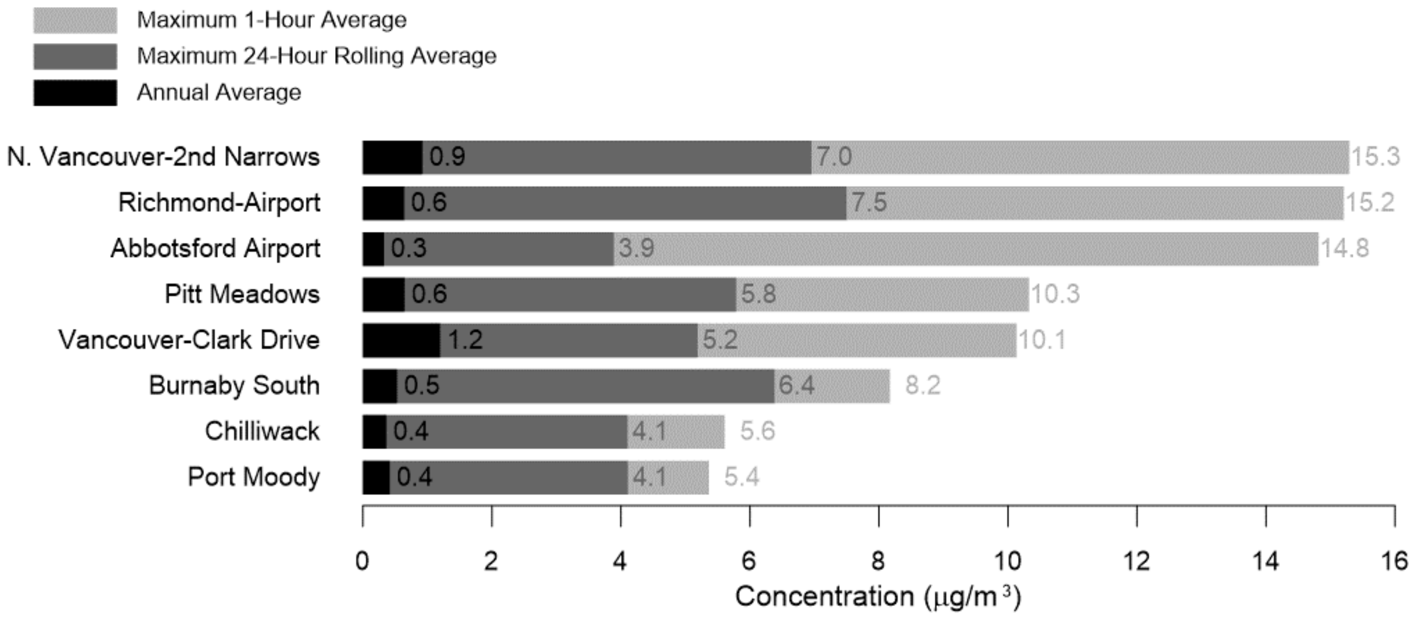


Figure 46: Black carbon monitoring, 2020.

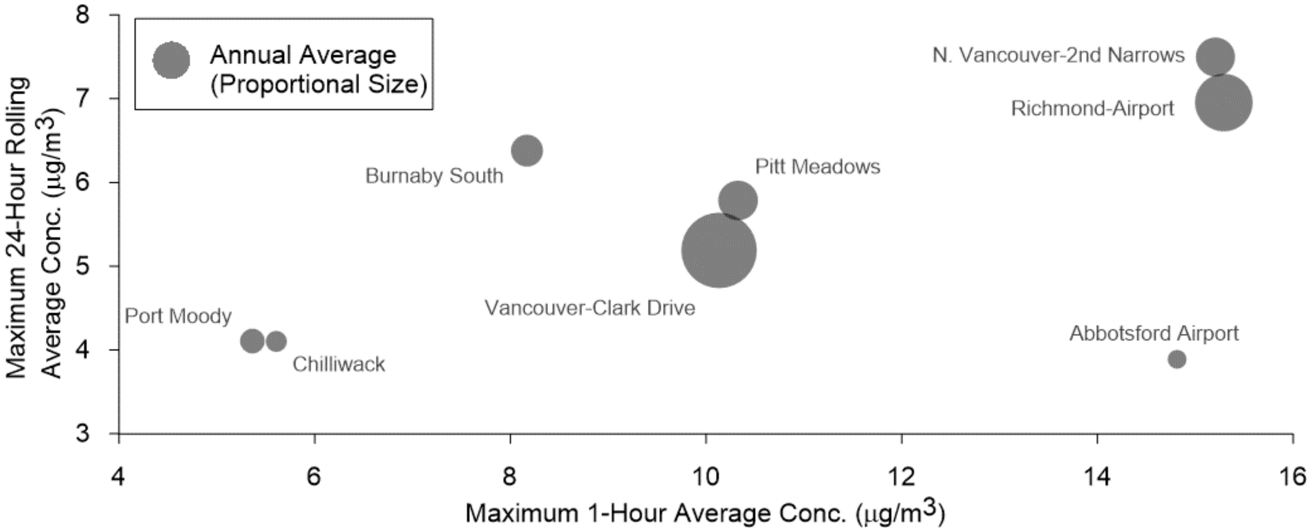


Figure 47: Black carbon monitoring, 2020.

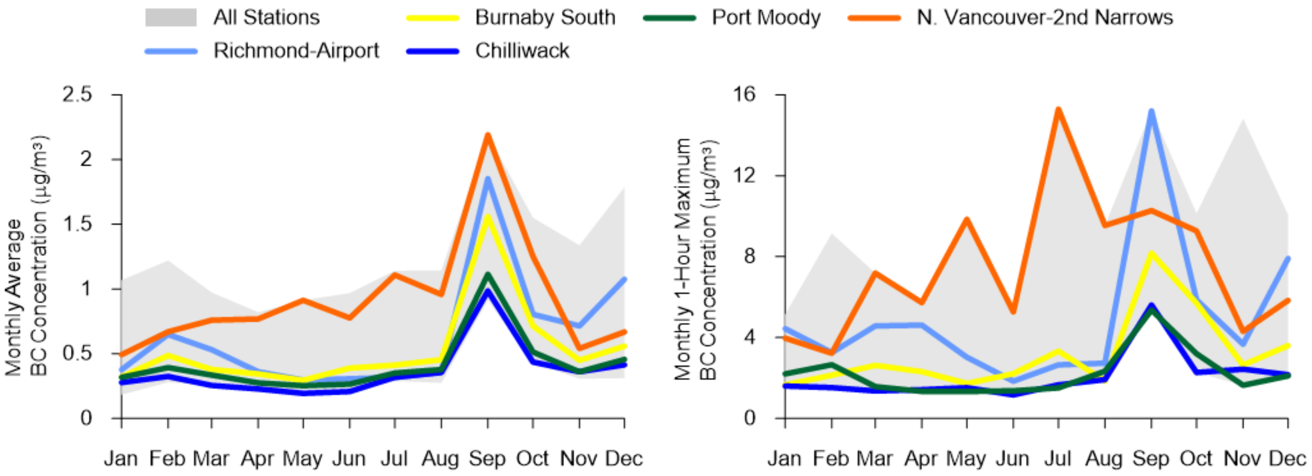


Figure 48: Monthly average (left) and short term peak (right) black carbon, 2020.

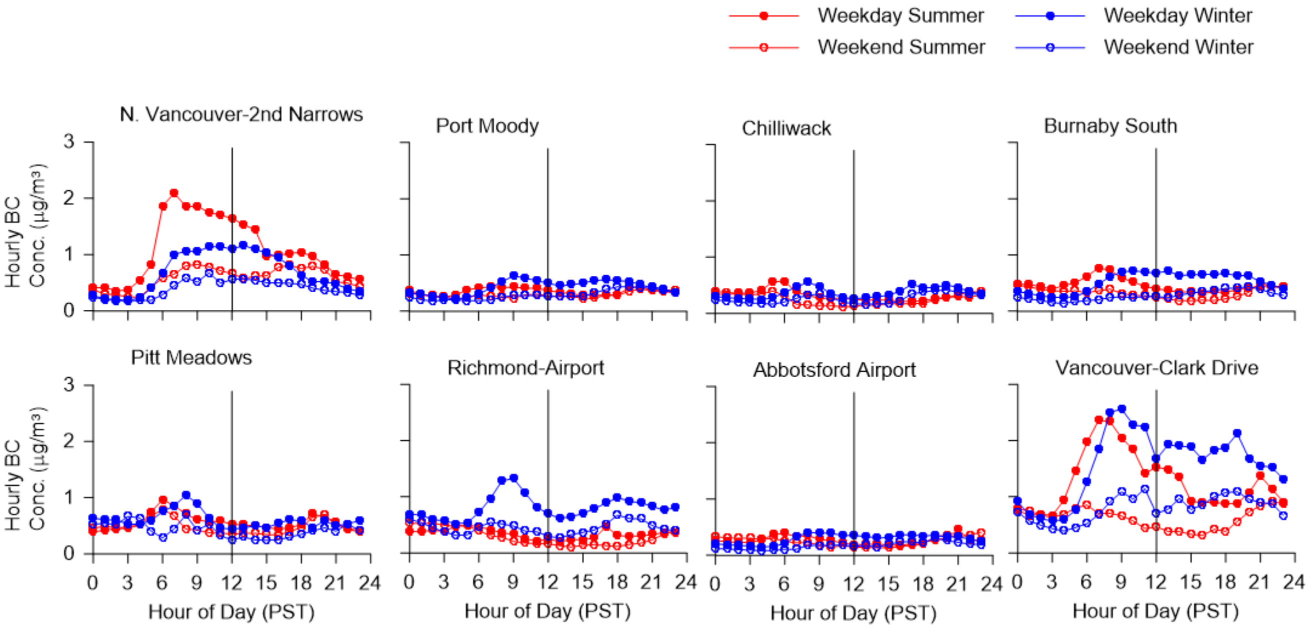


Figure 49: Diurnal trends black carbon, 2020.

Ultrafine Particles (UFP)

Characteristics

Ultrafine particles (UFP) consist of a combination of suspended solids and liquid droplets having aerodynamic diameters less than 0.1 microns (100 nanometers). These particles are measured based on their numbers (units of 10^3 #/cm^3) in the atmosphere rather than fine particulate matter that is measured based on its mass (µg/m^3).

Ultrafine particles are relatively short-lived, as compared to longer-lived $PM_{2.5}$ particles, which may persist in the atmosphere for up to several weeks. The short lifetime for UFP results from their very high number concentrations upon emission. Levels may peak near strong UFP sources such as busy freeways. These exceptionally concentrated UFP rapidly agglomerate (stick together) with each other and with larger particles (e.g. $PM_{2.5}$) to yield particles with diameters larger than 0.1 microns. Agglomeration, dispersion, and advection are the dominant atmospheric processes determining the UFP spatial distribution. Deposition (settling onto surfaces) plays a minor role in the UFP spatial distribution because gravity does not have a strong influence on UFP. Typically, the UFP level decreases exponentially to reduced levels within 500 metres of a strong source.

Sources

There are several sources of UFP, including manufacturing, combustion sources, and nucleation events. It is generally recognized that smaller particles are more harmful to human health. Unlike larger particles, UFP can penetrate pulmonary tissue, enter the bloodstream, and circulate throughout the body. Thereby, UFP can damage a number of internal systems that may be inaccessible to larger particles.

Monitoring Results

Ultrafine particle monitoring has not been conducted in the region prior to a near-road air quality monitoring study. The results from the near-road monitoring study are the first collected in the Metro Vancouver region due to availability of new monitoring technology and interest in these particles from a health perspective.

Figure 50 illustrates the results of continuous UFP monitoring for 2020. The figure displays the value of the maximum 1-hour and annual average for the single UFP station. There are currently no federal, provincial or regional air quality objectives for UFP.

In Figure 51 the seasonal trends for UFP shows average values higher in the winter months with the highest peak level occurring in February and lowest peak and average in May.

Ultrafine particles are generally greater on weekdays compared with weekends, shown in Figure 52. The winter weekday trend is the most prominent with a peak count of ultrafine particles in the morning corresponding with traffic.

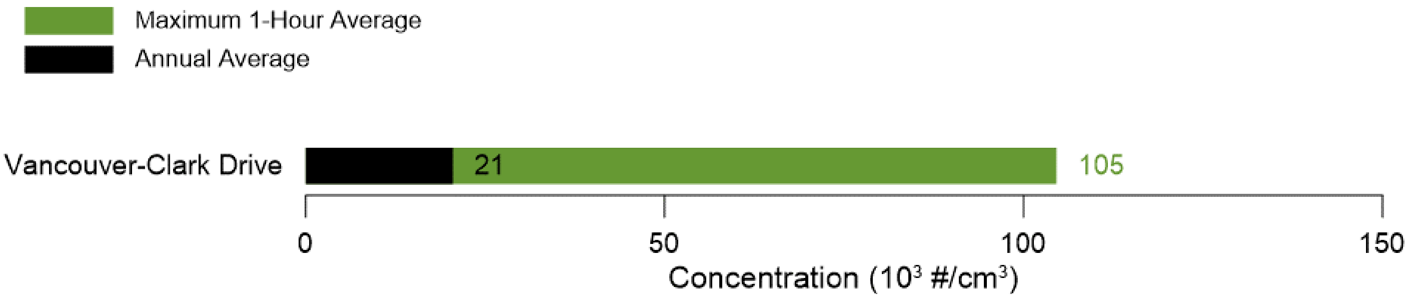


Figure 50: Ultrafine particle monitoring, 2020.

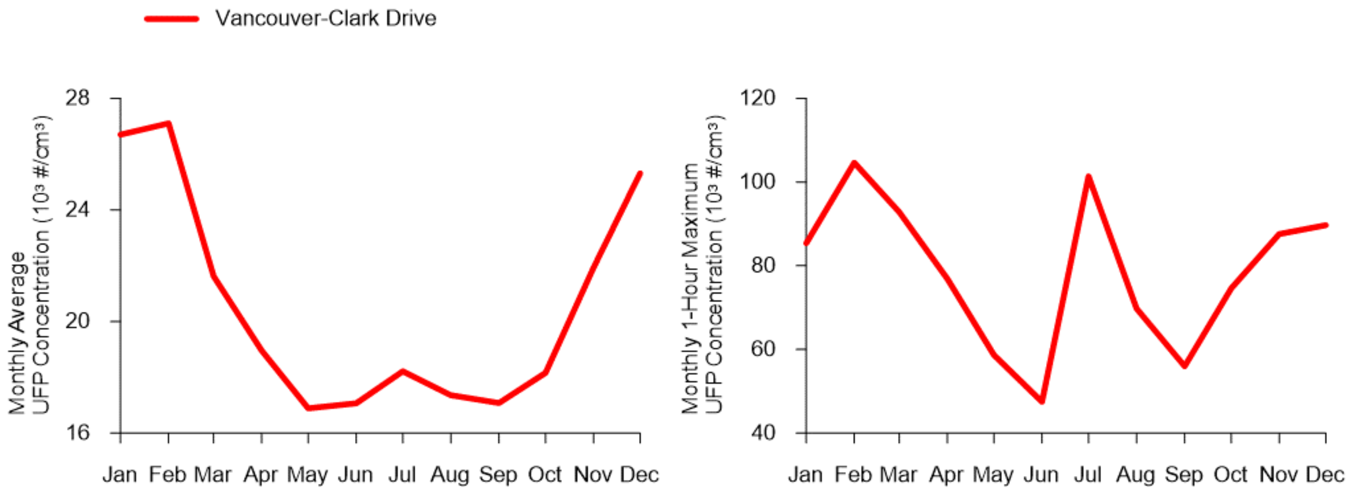


Figure 51: Monthly average (left) and short-term peak (right) ultrafine particles, 2020.

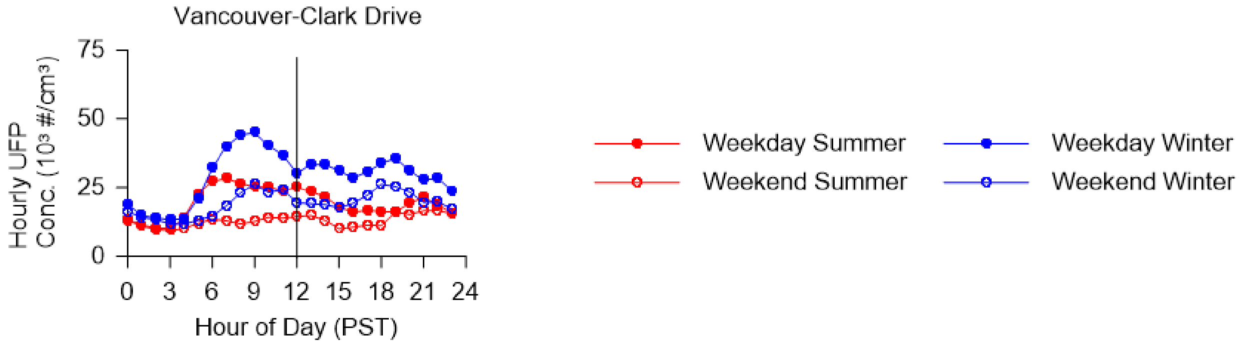


Figure 52: Diurnal trends ultrafine particles, 2020.

Total Reduced Sulphur (TRS)

Characteristics

Total reduced sulphur (TRS) compounds are a group of sulphurous compounds that occur naturally in swamps, bogs and marshes. They are also created by industrial sources such as pulp and paper mills, petroleum refineries and composting facilities. These compounds have offensive odours similar to rotten eggs or rotten cabbage, and at high concentrations can cause eye irritation and nausea in some people.

Sources

Most public complaints regarding these odours are associated with composting facilities and with the petroleum refining and distribution industry located along Burrard Inlet. A few periodic inquiries also occur as a result of natural emissions from such locations as Burns Bog in Delta.

Monitoring Results

Figure 53 illustrates the TRS measurements in 2020. Average levels continued to be near or below detectable limits. Peak levels during 2020, indicated by the maximum 1-hour concentrations, exceeded the Desirable Objective for a total of fifteen hours and the Acceptable Objective for three hours. The occurrences of elevated TRS are of short duration and generally during the night or early morning. The exceedances occurred in January, February, September, November and December.

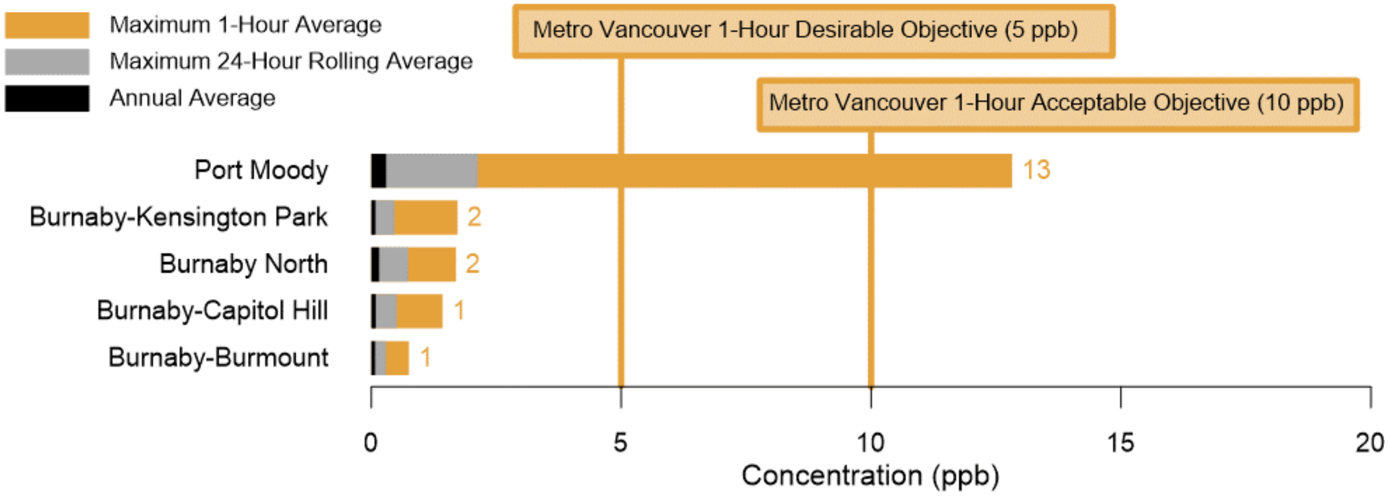


Figure 53: Total reduced sulphur monitoring, 2020.

Ammonia (NH_3)

Characteristics

Ammonia (NH_3) can contribute to the formation of fine particles when chemical reactions occur between ammonia and other gases in the atmosphere including sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). The resulting ammonium nitrate and ammonium sulphate particles are efficient at scattering light and can impair visual air quality with a white haze.

Sources

The largest contribution to ammonia in the LFV comes from the agriculture sector. The majority of ammonia emissions come from cattle, pig, and poultry housing, land spreading and storage of manure, and fertilizer application.

Monitoring Results

Continuous measurements of ammonia were made at four sites in the monitoring network in 2020. The 2020 data are presented in Figure 54, shown as the maximum 1-hour average, maximum 24-hour rolling average and annual average ammonia concentrations. There are no applicable objectives for ammonia.

Continuous measurements of ammonia began in 2005. Due to the relatively short period for which data are available, no clear long-term trend in ammonia is evident.

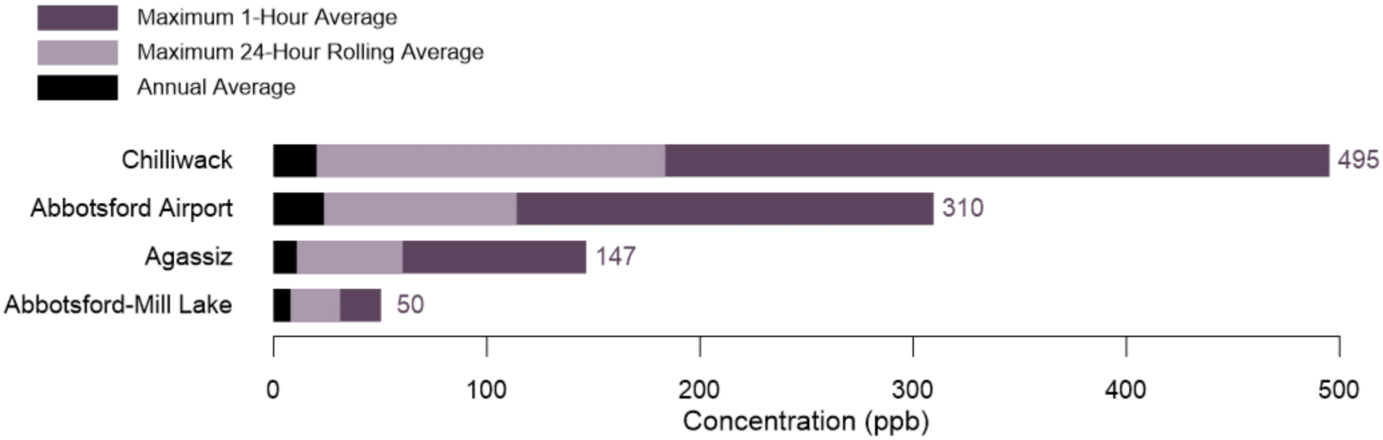


Figure 54: Ammonia monitoring, 2020.

Section E – Non-Continuous Pollutant Measurements

Non-continuous samples are collected in accordance with the National Air Pollution Surveillance (NAPS) program. After collection, samples are transported to and analyzed in a federal laboratory in Ottawa to determine pollutant concentrations.

Analysis results of non-continuous (integrated) sampling from the federal laboratory can take considerable time. Therefore, analysis of non-continuous results will be conducted when available and appended to this report.

Particulate Sampling

Non-continuous 24-hour (daily) $PM_{2.5}$ and PM_{10} samples are collected on filters every sixth day depending on the site. Non-continuous particulate samples are collected at a few monitoring stations in the LFV and pollutant concentrations are determined. A detailed analysis is conducted by the federal laboratory for some of these stations (Port Moody, Burnaby South, Abbotsford Airport and Vancouver-Clark Drive).

Using specialized PM speciation instrumentation, additional detailed information about the chemical composition of $PM_{2.5}$ is obtained from a subset of stations in the network (Burnaby South, Abbotsford Airport and Vancouver-Clark Drive) as a result of analyses carried out by the federal NAPS program. From the 24-hour samples collected at these sites, the various compounds that form $PM_{2.5}$ are identified.

Volatile Organic Compounds (VOC)

Volatile Organic Compounds (VOC) refers to a combination of organic chemicals. A large number of chemicals are included in this group but each individual compound is generally present at relatively low concentrations in air compared to other common air contaminants. The gaseous VOC present in the air can originate from direct emissions and from volatilization (*i.e.* changing into the gas phase) of substances in the liquid or solid phase.

Locally, some VOC can be pollutants found in urban smog and are precursors of other contaminants present in smog such as ozone and fine particulates. Some materials in this class (*e.g.* carbon tetrachloride) can contribute to depletion of the stratospheric ozone layer and may contribute to climate change. Other VOC (*e.g.* benzene) can pose a human health risk.

Sources of VOC in Metro Vancouver include, but are not limited to emissions from the combustion of fossil fuels, industrial and residential solvents and paints, vegetation, agricultural activities and cannabis production, petroleum refineries, fuel-refilling facilities, the burning of wood and other vegetative materials, and large industrial facilities.

Under the Canadian Environmental Protection Act some VOC are included in the Toxic Substances List.

Emissions of some VOC are managed under permits and industry-specific regulations within Metro Vancouver.

Non-continuous 24-hour (daily) sampling of VOC is conducted every sixth or twelfth day on a national schedule at several sites in the LFV. In cooperation with the federal National Air Pollution Surveillance (NAPS) program, canister sampling of VOC has been conducted in the LFV since 1988. Canisters sent to the federal laboratory are analyzed for up to 175 VOC. These data can then be used to help determine the emission sources contributing to contaminants in the air.

In addition to the canister sampling, continuous measurements of total hydrocarbons (THC) are made at the Burnaby North and Burnaby-Burmount stations (results not shown). Both of these are adjacent to petroleum industry facilities.

Network history and collaboration with the federal government on non-continuous sampling are provided in Section H.

Section F – Visual Air Quality Monitoring

Characteristics

When light between an object and the eye of an observer is scattered and/or absorbed by particles and gases in the air, views can look hazy or even be fully obscured. The term visual air quality refers to the impacts air contaminants have on our ability to see through the atmosphere, affecting the appearance of views including the distance at which the elements of a scene can be clearly seen. It does not refer to the direct effects of clouds, fog, rain or mist on a view.

Visual air quality studies conducted in the LFV have concluded that the major contributor to visual air quality impairment in the LFV is $PM_{2.5}$ and have shown that visual air quality degradation occurs at relatively low air contaminant concentrations, below Metro Vancouver's ambient air quality objectives for $PM_{2.5}$. However, the effects of visual air quality impairment can have different characteristics in different locations within the airshed due to the air contaminants present.

For example, in more urbanized areas of the western LFV, nitrogen dioxide emitted when fuels are burned contributes to the yellow-brown discolouration of the view. Further east in the LFV, visual air quality impairment usually occurs as white haze due to the presence of $PM_{2.5}$. Sources of particulate matter contributing to visual air quality impairment include anthropogenic activities as well as natural sources such as windblown dust, soil, sea salt and smoke.

Monitoring Program

To assess visual air quality in the LFV, Metro Vancouver, FVRD, BC Ministry of Environment and Climate Change Strategy (BC ENV) and Environment and Climate Change Canada (ECCC) jointly established a visual air quality monitoring network and reporting metrics. Continuous measurements of light scattering and the species responsible for light absorption are complemented by particulate speciation sampling, meteorological measurements and images of views along specific lines-of-sight. Measurements of views or both views and air contaminants are typically made at the monitoring locations identified in Figure 55.

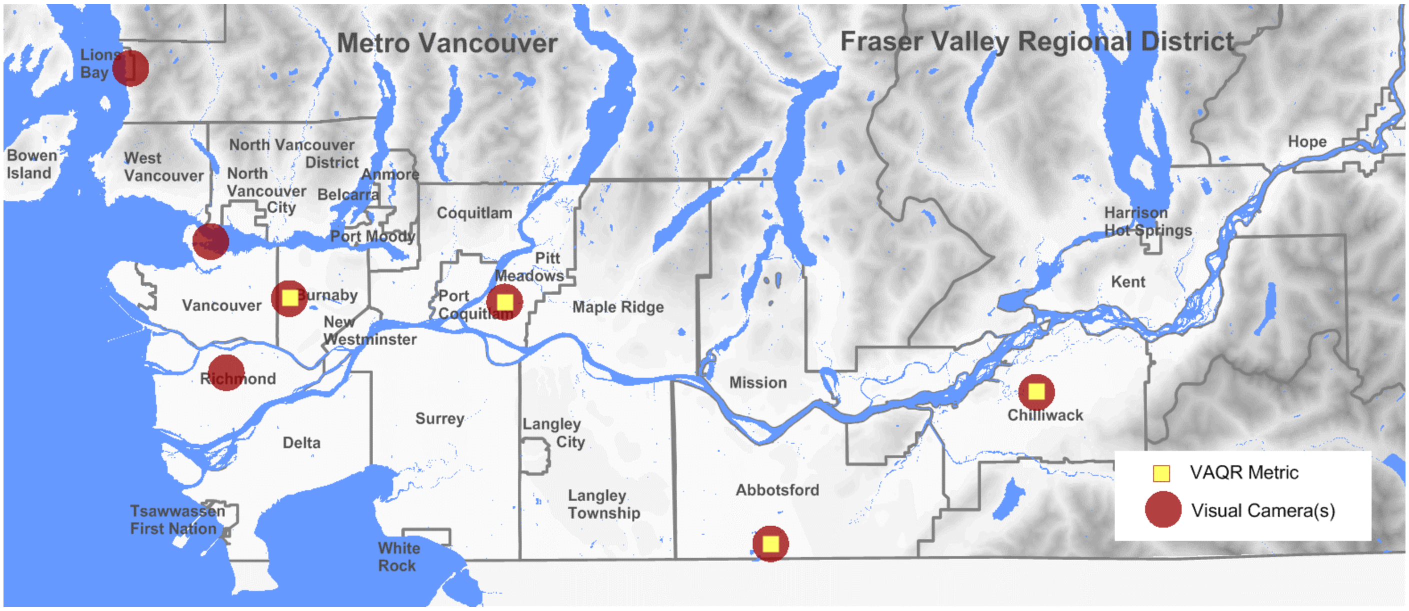


Figure 55: Visual air quality monitoring locations in the LFV, 2020.

Light scattering measurements are made using nephelometers for visual air quality analysis in five locations. Aethalometers and nitrogen dioxide analyzers are also located at these sites and are used to characterize light absorption. Analysis of monitoring data to reconstruct light extinction has indicated that scattering by particles generally has the most influence on visual air quality in the LFV. Modelling work has determined that the highest contributions to extinction, and consequently visual air quality degradation, in the LFV on the most impaired visual air quality days are generally from particulate nitrate and organic matter. However, observations have shown that intense wildfire smoke can also cause severe impairment. The extent of the influence of other species, such as particulate sulphate, on visual air quality degradation is dependent on meteorological conditions.

Automated digital cameras are operated at the locations shown in Figure 55. Cameras in Chilliwack, Abbotsford, Pitt Meadows, Burnaby, Richmond and Lions Bay provided images in 2020. The camera in Vancouver did not provide images in 2020. The camera in Vancouver required maintenance, which could not be completed in 2020 due to restrictions related to COVID-19. Images are captured at 10 or 30 minute intervals along specific lines-of-sight with recognizable topographical features at defined distances.

Visual Air Quality Pilot Project

A visual air quality pilot project was established in the LFV by the BC Visibility Coordinating Committee (BCVCC). The BCVCC was established in 2006 and is a collaborative venture between Metro Vancouver, FVRD, ECCC, Health Canada and BC ENV. An objective of the pilot project is to determine the actions necessary to protect and improve visual air quality in the LFV.

Key components of the pilot project include:

- The establishment and ongoing operation of a visual air quality monitoring network;
- The development of a visual air quality reporting tool and recommendations for a visual air quality goal;
- The identification of the causes and impacts of impaired visual air quality in the LFV;
- An improvement of our understanding of the economic drivers for visual air quality management; and
- The creation of a strategy to engage and inform stakeholders and members of the public about visual air quality issues.

Visual Air Quality Rating

The visual air quality rating (VAQR), with descriptors of excellent, good, fair, poor or very poor, is the reporting metric developed by the BCVCC, to enhance outreach about visual air quality in the LFV and to provide mechanisms to track changes in visual air quality. The VAQR was launched in 2015 and was reported at sites shown in Figure 55 in 2020.

The VAQR reflects residents' perceptions of visual air quality conditions. Historical images from visual air quality monitoring network cameras were used to survey residents in Metro Vancouver and FVRD to relate perceived visual air quality to measured air contaminant concentrations and the estimated resulting optical characteristics of the atmosphere along the line-of-sights to the views.

Visual air quality conditions recorded by the camera in Chilliwack in 2020 are shown in Figure 56.

Images from the visual air quality monitoring cameras can be viewed at: [http://www.clearairbc.ca/community.](http://www.clearairbc.ca/community)

Figure 56: Images showing good and very poor visual air quality ratings at the Chilliwack site in August and September 2020.

Section G – Meteorological Measurements

Purpose

An understanding of meteorology is integral to understanding and forecasting air quality and visual air quality patterns. The state of the atmosphere determines pollutant dispersion and the resultant ground-level concentration. Meteorology is observed at LFV air quality monitoring network stations for several purposes:

- To allow for a characterization of meteorological patterns throughout the LFV.
- To assist with the linkage between pollutant emission sources and ambient concentrations.
- To provide data to be used as input in dispersion modelling.
- To provide real-time data to numerous agencies including Environment Canada, which are used for weather and air quality forecasting in the region.

It should be noted that the LFV network's primary purpose is for the collection of air quality measurements and secondary purpose is for meteorological observation. Attempts have been made to site meteorological instruments to provide representative observation, however due to restrictions at some stations, not all instruments are sited to capture spatially representative measurements.

Monitoring Program

Various meteorological parameters are observed as part of the LFV air quality monitoring network (see Section C Table 2). Meteorological parameters observed in the network include:

- wind speed and direction
- air temperature
- relative humidity
- precipitation
- barometric pressure
- incoming solar radiation
- net radiation

Wind speed and direction observations allow for the characterization of pollutant transport and dispersion and are used to understand the relationships between pollutant sources and measurements at air quality monitoring stations.

Air temperature and incoming solar radiation measurements can be used to determine the potential for ozone formation during the summer. Ozone concentrations are dependent on sunshine to cause photochemical reactions among air pollutants. Higher air temperatures are necessary for these reactions to occur.

Humidity is important in the formation and growth of visibility reducing particles, and its measurement is a key to understanding the many factors responsible for visual air quality degradation.

Precipitation can remove particles from the atmosphere and may help explain differences in air quality from one part of the region to another. In addition, precipitation data are used by Metro Vancouver's Wastewater Collection and Watershed Management functions.

Meteorological Observations

Figure 57 shows the annual precipitation totals for 2020 at Lower Fraser Valley air quality monitoring network stations. The greatest precipitation was observed near the local mountains. Historical 30-year climate normals (1981-2010) obtained from Environment Canada are also shown in Figure 57 for several stations. Figure 58 displays the seasonal variation as observed by the LFV air quality network stations (shown as a gray band). Historical 30-year climate normals (1981-2010) obtained from Environment Canada are also shown in Figure 58 for Vancouver International Airport, Port Moody and Chilliwack.

Compared to climate normals, monthly precipitation in 2020 was drier in February, March, April, and October, and was wetter in January and December.

Figure 59 illustrates the seasonal variation of air temperatures observed throughout the monitoring network stations. The hourly maximum and minimum, daily maximum and minimum, and average temperatures are given with the range in values shown as bands. Also shown in Figure 59 are the 30-year climate normals (1981-2010) for Environment Canada's Vancouver International Airport and Agassiz stations.

The data observed in 2020 indicate that average temperatures recorded in January, February, March, June and July were cooler than the 30-year average. During these months, lower averages and daily minimums were experienced compared with the climate normals. The lowest air temperatures were measured in January. September and December were on average warmer than normal. The highest air temperatures were measured in August.

Table 10 provides the average temperature along with the lowest and highest hourly air temperatures observed throughout the year. Air temperatures are milder near the water and exhibit a greater range inland. The highest hourly temperature in 2020 was 35.0°C observed at Maple Ridge and Burnaby-Burmount.

Table 11 gives the frequency distribution of hourly air temperature for the year. Stations located inland, such as those in eastern parts of Metro Vancouver and the Fraser Valley Regional District exhibit the greatest frequency of both very low and high air temperatures.

Wind patterns vary between stations as shown by the frequency distributions in Figure 60. The distributions are shown as a "wind rose", which is a bar chart in a polar format. The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence.

Figure 60 shows observed annual wind roses for selected stations including (in order of west to east): Horseshoe Bay, Richmond-Airport, Burnaby North, Pitt Meadows, Abbotsford Airport, Chilliwack, and Hope. The patterns shown during 2020 reflect the predominant winds in those areas. Richmond exhibits a predominant easterly wind with a smaller component from the west, and very little wind from either the north or south. Horseshoe Bay shows wind patterns aligned with Howe Sound with a strong north-south component.

The climate of the region in 2020 included wetter than normal winter months, a cool and dry spring, a normal summer with a hotter than normal September and typical fall.

Burnaby North shows several northerly wind components along with a predominant east-north east component. This wind pattern is reflective of the North Shore mountain wind flows and drainage flow from Indian Arm. Pitt Meadows shows a somewhat similar pattern with predominant directions from the valleys of Pitt Lake and Alouette Lake. Abbotsford, Chilliwack and Hope experience similar wind flow patterns, with strong east-west components driven by the channelling of winds in the narrower portion of the Fraser Valley.

Figures 61 to 64 show wind roses for winter, summer, spring and fall, respectively. The contrast between winter and summer can be seen in Figures 61 and 62 with winds predominantly from the east in winter switching to southwest in summer. The more westerly flow seen in the summer is the development of a daytime sea breeze during anti-cyclonic (high pressure) weather.

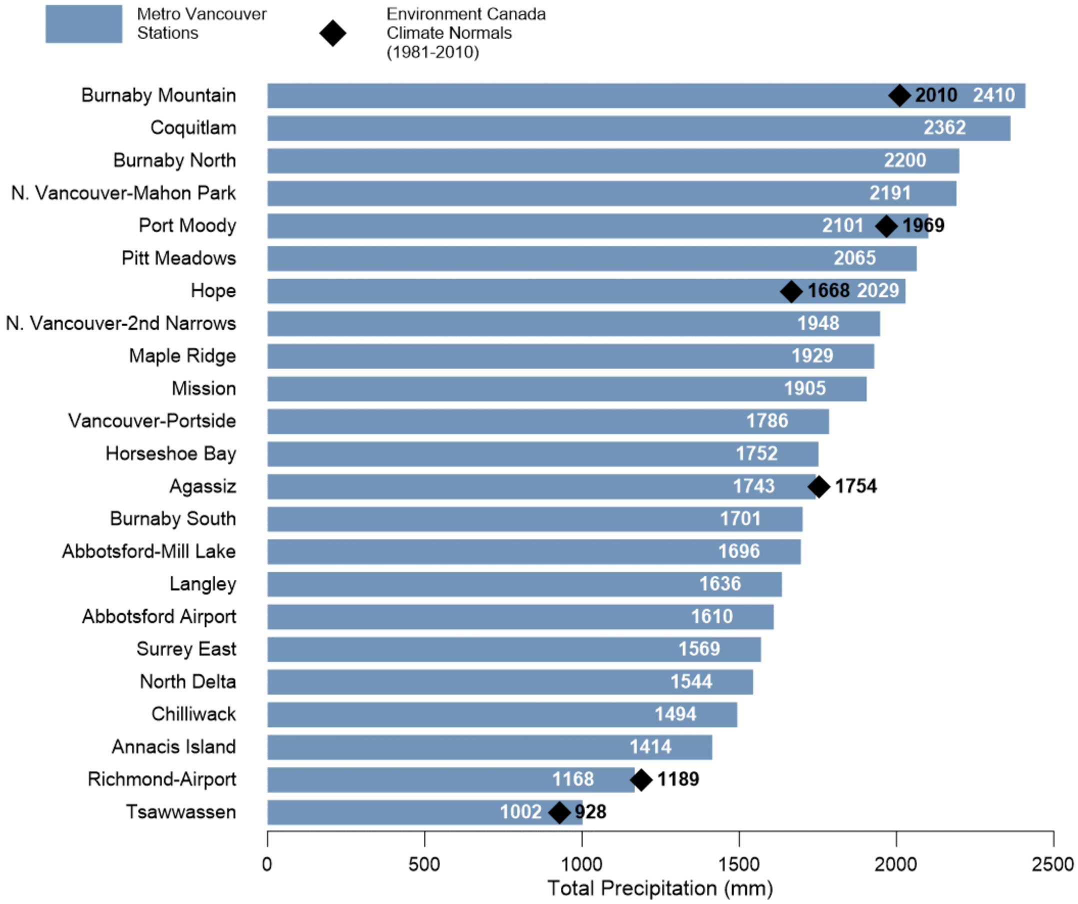
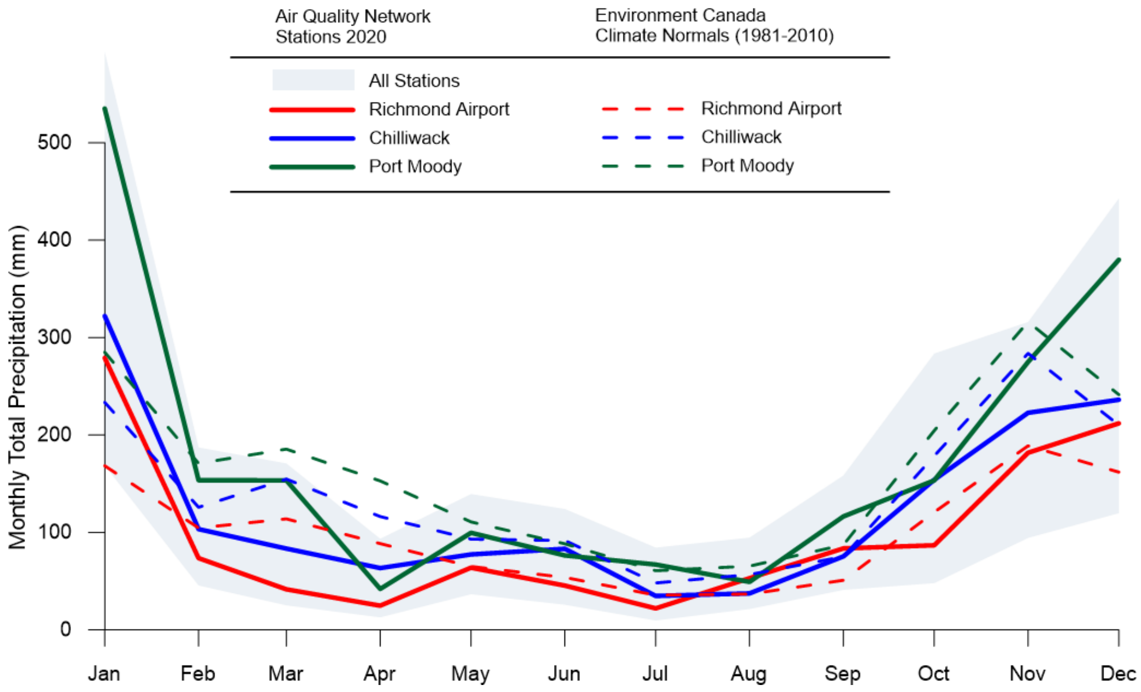
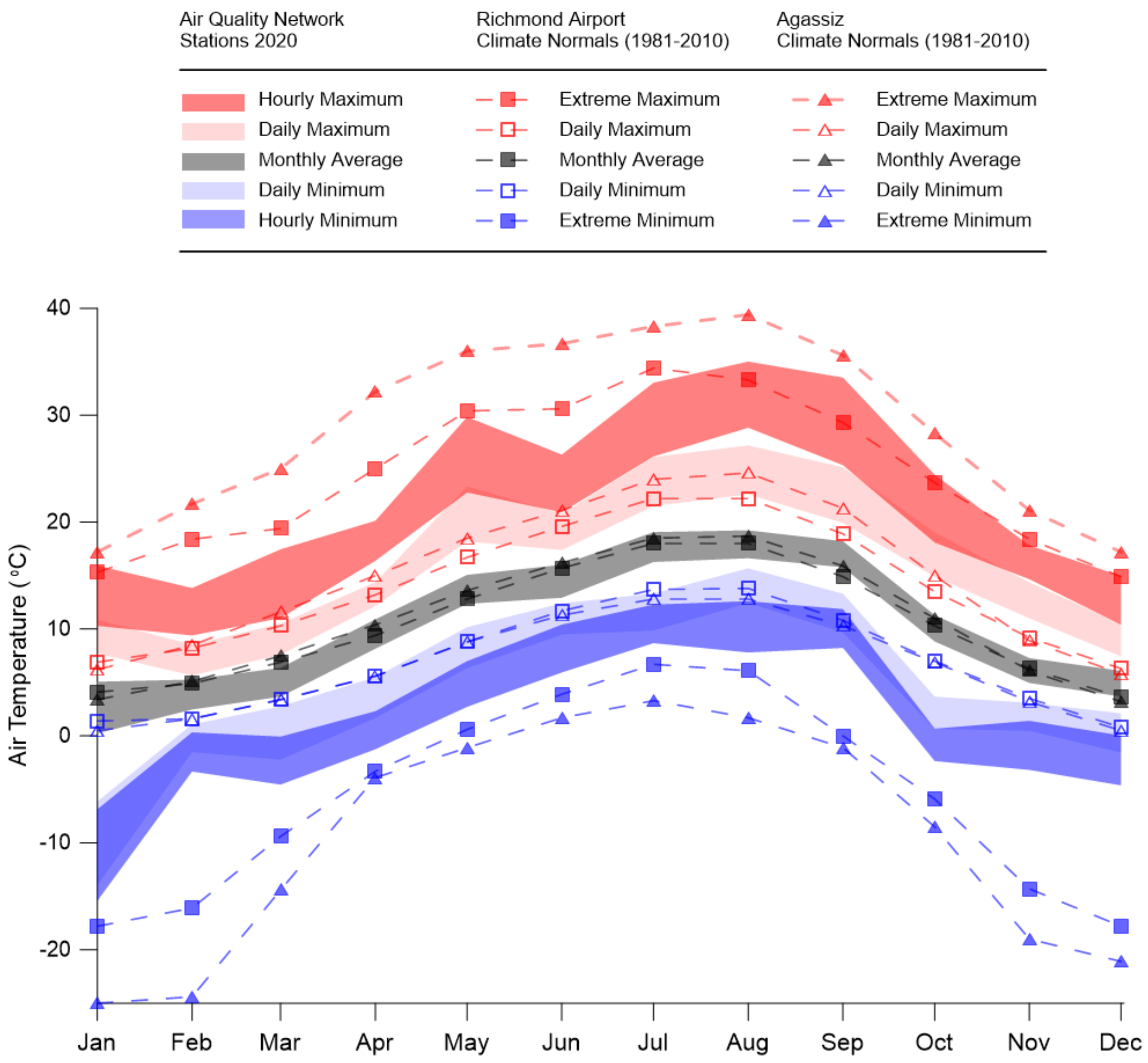


Figure 57: Annual precipitation totals in the LFV, 2020.



Note: The range of values observed at LFV air quality network stations are shown as a blue band and Environment Canada climate normals are shown as dotted lines.

Figure 58: Total monthly precipitation in the LFV, 2020.



Note: LFV air quality network stations are shown as colour bands and Environment Canada 30-year climate normals are shown as dotted lines.

Figure 59: Monthly air temperatures in the LFV, 2020.

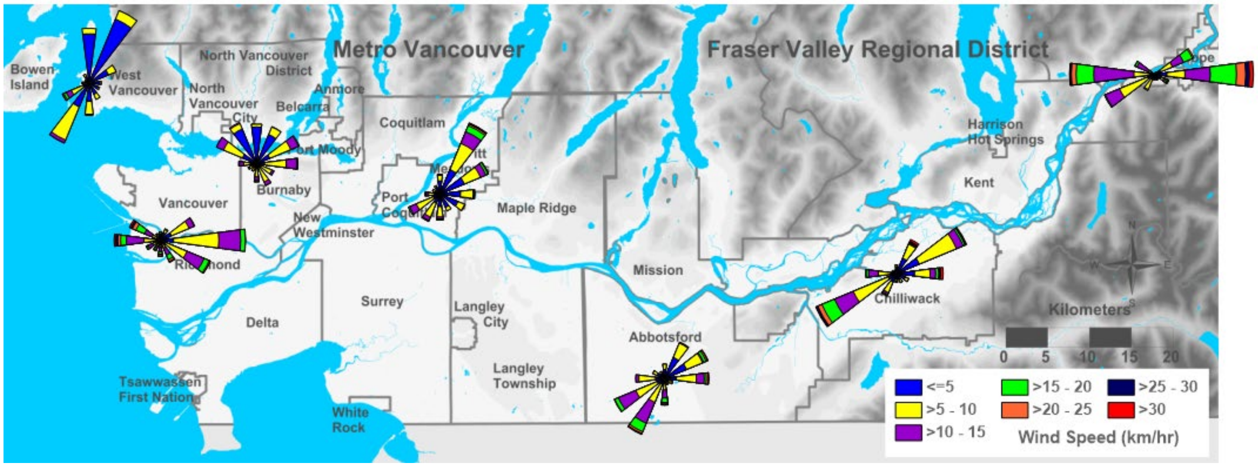


Figure 60: Selected annual wind roses throughout the LFV, 2020.

Table 10: Air temperature in LFV, 2020.

Station	Hourly Maximum (°C)	Hourly Minimum (°C)	Annual Average (°C)
Burnaby-Burmount	35.0	-9.0	11.5
Maple Ridge	35.0	-10.3	10.5
Coquitlam	34.7	-9.4	10.7
Chilliwack	34.6	-13.5	10.8
Abbotsford-Mill Lake	34.6	-11.9	10.6
Agassiz	34.6	-13.4	11.1
Pitt Meadows	34.5	-9.9	10.4
Mission	34.2	-13.0	10.5
Abbotsford Airport	34.2	-13.2	10.4
Hope	34.1	-15.4	10.2
Burnaby-Kensington Park	33.8	-8.7	10.6
North Delta	33.5	-10.1	10.2
Annacis Island	33.4	-8.2	11.6
Langley	33.4	-11.1	10.3
Burnaby North	33.2	-8.6	10.6
Surrey East	33.2	-10.5	10.7
Vancouver-Clark Drive	32.9	-7.8	11.2
Burnaby South	32.7	-9.3	10.7
Burnaby-Capitol Hill	32.5	-10.1	9.4
N. Vancouver-Mahon Park	31.7	-8.0	10.5
Vancouver-Templeton	31.5	-8.9	10.7
Burnaby Mountain	31.3	-10.8	9.2
Richmond South	31.2	-8.9	10.2
Port Moody	30.9	-9.3	10.6
N. Vancouver-2nd Narrows	30.9	-7.7	10.8
Horseshoe Bay	29.5	-6.9	10.5
Tsawwassen	29.5	-9.6	10.1
Vancouver-Portside	29.3	-7.5	11.1
Richmond-Airport	28.8	-8.4	10.7

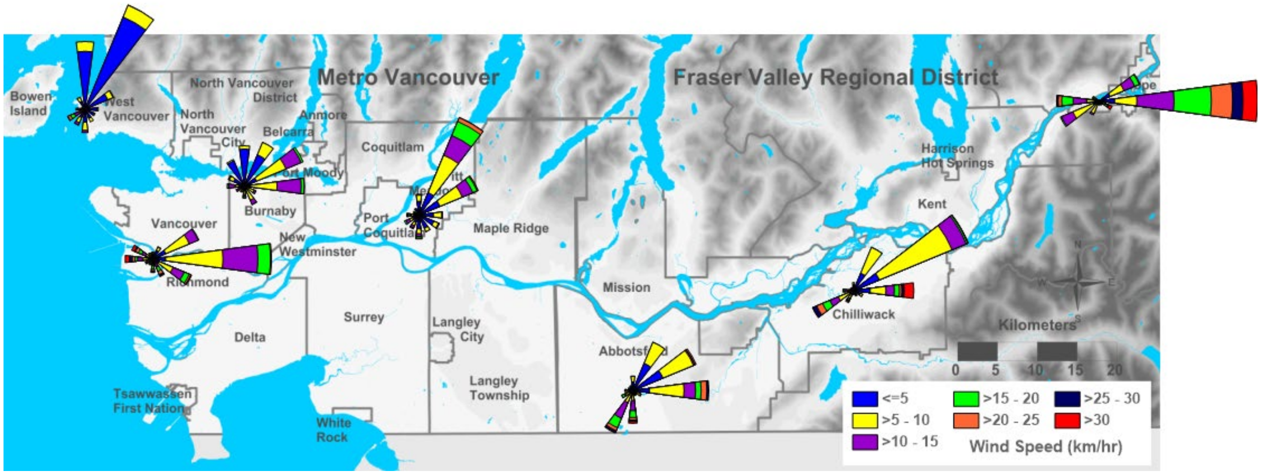


Figure 61: Winter (Jan, Feb, Dec) representative wind roses throughout the LFV, 2020.

Table 11: Frequency distribution of hourly air temperature, 2020.

Air Temp (deg C)	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	North Delta	Burnaby Mountain	Surrey East	Richmond South	Burnaby South	Pitt Meadows	Burnaby-Burmount	Burnaby-Capitol Hill	Burnaby North	Burnaby North	N. Vancouver-Mahon Park	Langley	Hope	Maple Ridge	Richmond-Airport	Coquitlam	Abbotsford-Mill Lake	Horseshoe Bay	Annacis Island	Tsawwassen	Mission	Agassiz	Abbotsford Airport	Vancouver-Templeton	Vancouver-Portside	Vancouver-Clark Drive
< -15																	9													
-15 to -12				21													63								20	14	16			
-12 to -9			3	66	26	28	33		3	13		17				37	37	27		5	55			5	40	34	47			
-9 to -6	49	26	53	32	38	21	31	57	49	46	48	40	44	45	43	34	32	31	49	53	42	20	44	52	36	37	44	51	31	34
-6 to -3	20	37	18	27	28	20	38	33	16	53	14	18	22	22	18	46	37	54	22	17	31	29	25	18	31	40	23	22	35	33
-3 to 0	64	93	249	166	173	245	118	230	74	260	41	248	64	74	91	226	198	263	68	128	194	53	50	151	207	118	178	108	28	118
0 to 3	709	669	783	735	769	1304	676	630	606	789	434	1168	684	707	710	777	1062	766	490	789	730	704	422	724	882	658	754	689	406	527
3 to 6	1758	1491	1373	1684	1682	1584	1537	1571	1680	1554	1464	1801	1667	1675	1630	1440	1581	1570	1543	1580	1607	1762	1260	1358	1380	1536	1537	1556	1507	1375
6 to 9	1346	1516	1405	1158	1345	1297	1405	1456	1462	1302	1614	1123	1423	1412	1449	1355	1021	1268	1633	1337	1220	1372	1730	1639	1292	1380	1291	1459	1742	1639
9 to 12	1149	1093	1069	991	1188	1338	1171	1180	1176	1176	1186	1225	1066	1070	1147	1294	988	1157	1101	1124	1105	1061	1054	1250	1194	989	1181	1109	1089	1103
12 to 15	1344	1414	1382	1342	1420	1091	1418	1527	1376	1356	1325	1210	1322	1319	1434	1414	1234	1362	1528	1365	1425	1345	1405	1630	1373	1302	1447	1378	1413	1356
15 to 18	1119	1207	1188	1079	1040	929	1097	1113	1152	982	1151	996	1096	1114	1172	964	941	991	1288	1107	1088	1412	1389	1186	1051	1092	1045	1185	1318	1187
18 to 21	664	752	690	694	572	514	634	632	676	586	763	568	714	702	686	579	666	606	722	627	623	670	789	569	626	737	583	760	827	773
21 to 24	379	341	363	385	320	235	383	263	351	357	423	258	311	305	291	362	370	359	255	371	393	223	421	164	386	433	369	348	295	446
24 to 27	125	111	155	248	113	90	133	68	113	185	206	79	108	108	87	140	225	199	54	176	168	77	140	33	171	253	146	94	82	143
27 to 30	43	21	39	98	39	14	59	14	36	72	65	22	28	26	19	65	86	79	7	64	63	14	45	5	66	96	65	19	11	43
30 to 33	9	1	5	34	8	4	15	2	11	25	19	4	4	4	2	17	29	30		16	21		8		18	32	19	2		5
>=33	2			5	1		2			4	4		1	1		3	6	4		4	3		2		4	3	3			
Missing	4	12	9	19	22	70	34	8	3	24	27	7	230	200	5	31	199	18	24	21	16	42			7	30	36	4		2
Data Completeness (%)	100	99.9	99.9	99.8	99.7	99.2	99.6	99.9	100	99.7	99.7	99.9	97.4	97.7	99.9	99.6	97.7	99.8	99.7	99.8	99.8	99.5	100	100	99.9	99.7	99.6	100	100	100

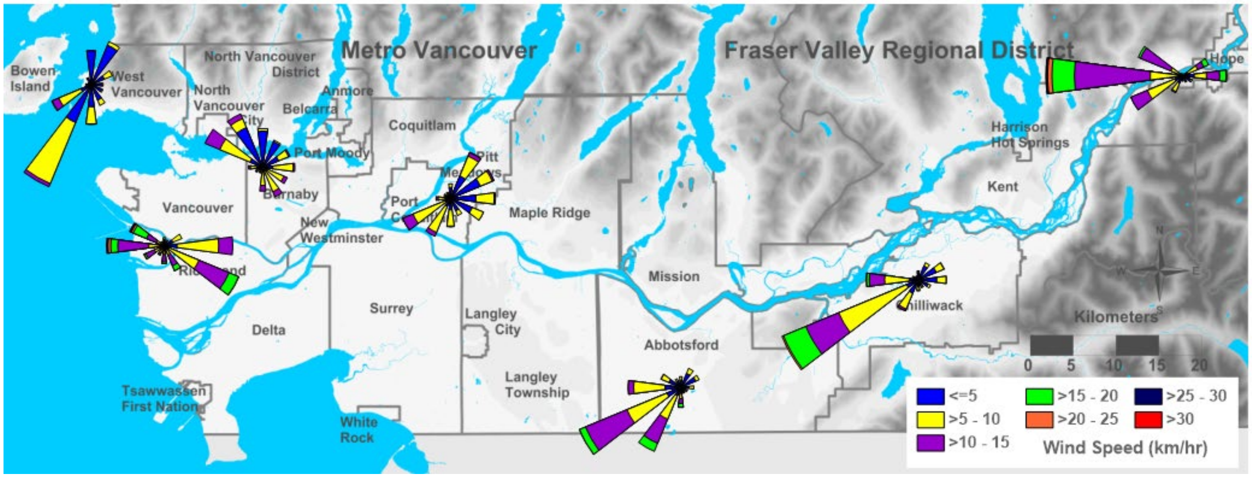


Figure 62: Summer (Jun, Jul, Aug) representative wind roses throughout the LFV, 2020.

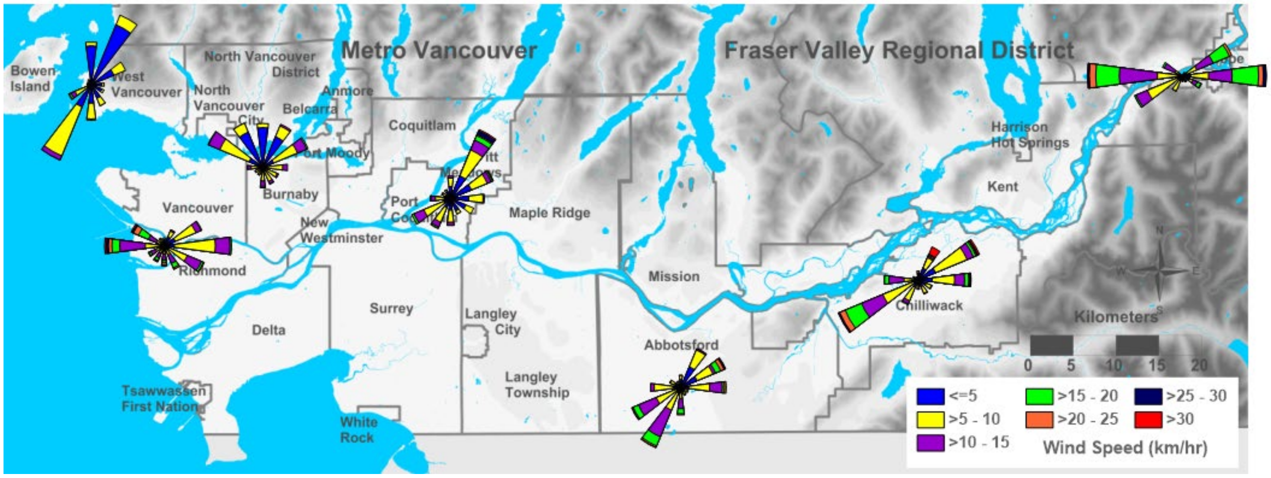


Figure 63: Spring (Mar, Apr, May) representative wind roses throughout the LFV, 2020.

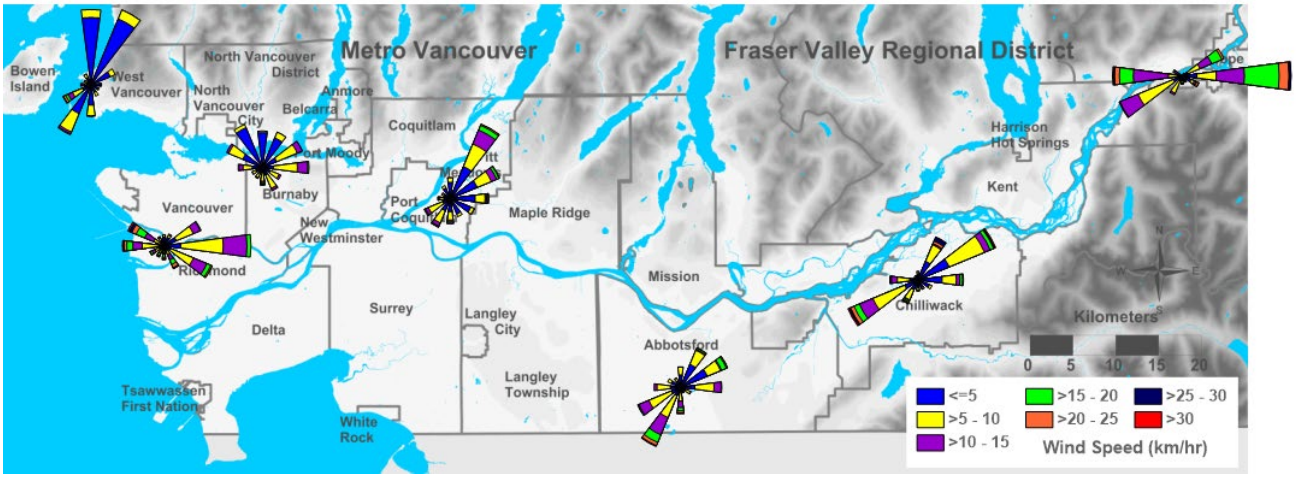


Figure 64: Fall (Sep, Oct, Nov) representative wind roses throughout the LFV, 2020.

Section H – Monitoring Network Operations

Network History

Air monitoring in the region began in 1949, when the City of Vancouver established a dustfall monitoring network. Monitoring for total suspended particulate was added in later years. Following the Pollution Control Act (1967), provincial air quality programs initiated monitoring of dustfall and total suspended particulate in other areas of the region.

In 1972, provincial and municipal air quality responsibilities were transferred to Metro Vancouver, including operation of air quality monitoring programs. In 1998, a Memorandum of Understanding established cooperative management of the monitoring network by both Metro Vancouver and the Fraser Valley Regional District.

Continuous monitoring of gaseous pollutants began in 1972 under the auspices of the federal National Air Pollution Surveillance (NAPS) program. Several new stations were established to measure SO_2, O_3, CO, NO_X and VOC. Over the years, stations and equipment have been added or removed in response to changing air quality management priorities. Mobile Air Monitoring Units and portable instruments provide added flexibility to carry out measurements at many locations. Some monitoring is part of co-operative programs with industry and other governments.

Specialized Monitoring Initiatives

Specialized air quality monitoring studies complement the monitoring network. The studies typically allow for characterization of air quality at finer spatial scales, such as at the neighbourhood scale, and allow investigation of air quality problems on the local scale. The regional monitoring network may not be ideally suited to address local scale issues and therefore performing specialized local air quality studies is an important component to characterizing air quality in the LFV.

A Mobile Air Monitoring Unit (MAMU) that is capable of monitoring particulate and gaseous pollutants along with meteorology is utilized throughout the region to conduct specialized air quality studies. In addition to MAMU, Metro Vancouver utilizes small mobile units along with several portable air quality monitors.

In March 2020, Metro Vancouver's mobile air monitoring unit (MAMU) began a year-long air quality monitoring study at Musqueam's Indian Reserve No. 2 lands in Vancouver. In cooperation with Musqueam's public works department, MAMU was located beside the Musqueam Cultural Pavilion, near the shore of the north arm of the Fraser River. The monitoring will provide information on air quality in the Musqueam community and support Metro Vancouver's Iona Island Wastewater Treatment Plant Biosolids Dewatering Facility project.

A specialized study site was established at Metro Vancouver's Waste-to-Energy facility in Burnaby, in late 2020. The specialized study site includes the measurement of NO_2, SO_2 and hydrochloric acid (HCl) as well as meteorological data. As part of the study, HCl measurements were also added to the Burnaby South monitoring station.

Monitoring Network Partners

Several partners contribute to the on-going management and operation of the Lower Fraser Valley Air Quality Monitoring Network. The government partners include:

- Fraser Valley Regional District
- Environment and Climate Change Canada
- BC Ministry of Environment and Climate Change Strategy

Other monitoring network partnerships:

- The Vancouver International Airport Authority provides partial funding for the Vancouver International Airport station (T31).
- Parkland Refining (BC) Ltd. provides funding for the Burnaby North (T24) and Capitol Hill (T23) stations.
- Trans Mountain Pipeline LP provides funding for the Burnaby-Burmount (T22) station.
- Port of Vancouver provides funding for the Tsawwassen (T39) station in Delta.

Metro Vancouver continues to operate and maintain the monitoring stations and equipment, and to collect real-time data from the regional monitoring network on behalf of all partners.

Federal Government

Metro Vancouver co-operates with the federal government by providing field services for three major nation-wide sampling programs under the National Air Pollution Surveillance (NAPS) program of Environment Canada.

- Canister sampling of VOC has been conducted in the LFV since 1988. The federal government supplies equipment and Metro Vancouver staff provide field exchange of canisters, calibration and routine maintenance. Sample canisters are sent to the federal laboratory in Ottawa, for analysis of up to 175 VOC.
- A second program involves dichotomous particulate sampling at three sites where two size fractions: 10 to 2.5 μm (coarse), and under 2.5 μm (fine) are collected every sixth day for detailed chemical analysis in Ottawa.
- A $PM_{2.5}$ speciation sampling program, initiated in 2003, includes sampling at the Vancouver-Clark Drive, Burnaby South and Abbotsford Airport stations where samples are taken every sixth day and sent to Ottawa to be analyzed for various particulate species.

Quality Assurance and Control

Air quality monitoring data is regularly reviewed and validated. Technicians perform regular inspections and routine maintenance of the monitoring equipment and stations. In addition, technicians perform major repairs to any instrument in the network, as required. Through the data acquisition system, technicians can check on instruments remotely prior to site visits. This system also allows for calibration of the instruments either automatically or upon demand.

Continuous air quality monitors are subject to performance audits and multi-point calibration every four to six months. In addition, all other instruments in the network are subjected to annual and/or biannual calibrations. All reference materials and quality control procedures meet or exceed Environment Canada and/or US Environmental Protection Agency requirements. Metro Vancouver coordinates quality assurance procedures and activities with both the provincial and federal government.

Section I –Wildfires, Air Quality Events and Climate Change

In recent years, wildfire activity has increased in severity, become more widespread and linked to a changing climate. Wildfires produce considerable amounts of smoke that can be transported great distances. Wildfire smoke is a complex mixture of many gases and small particles. The mixture can change quickly depending on the weather, what is burning, the temperature of the fire, and how far the smoke has travelled. Of all the pollutants in wildfire smoke, fine particulate matter ($PM_{2.5}$) poses the greatest risk to human health.

Locally, the presence of wildfire smoke can result in two differing outcomes for ground-level ozone production. Wildfire smoke can either enhance or inhibit ozone production depending on the amount of smoke present. The mixture of chemical contaminants in wildfire smoke includes ozone precursors, which can enhance ozone production. A past study by Teakles et al. (2017)[5] indicated that a wildfire smoke event in 2012 was responsible for an enhancement of 8-hour ozone concentrations at coastal BC sites by as much as 10 ppb. Conversely, if wildfire smoke becomes dense enough, the smoke can block solar radiation, decrease air temperatures and inhibit the production of ozone. Both effects of inhibition and enhancement of ozone due to smoke have been experienced in the LFV.

Wildfires and Air Quality

Historically, episodes of degraded air quality due to smoke from wildfires outside the region have been infrequent. Since 2015, however, wildfire smoke impacts have increased significantly. In 2015 eight air quality advisory days occurred due to wildfire smoke, primarily associated with large fires north of Pemberton. There were no air quality advisories in 2016 or 2019, while 2017, 2018 and 2020 experienced significant and lengthy smoke-related air quality impacts due to wildfires burning throughout the Pacific Northwest, including BC. There were 19 advisory days in 2017, 22 advisory days in 2018, and 13 advisory days in 2020.

In 2018, the total number of fires in British Columbia were nearly twice as many as 2017. In 2018, the total area burned was over three times greater than the 10-year average with 13,543 km^2 burned (Table 12). The 2018 wildfire season was one of the worst in British Columbia's history, with the largest area burned. This led to the most air quality advisory days that the region has experienced in a single year.

In both 2019 and 2020, the total number of fires and area burned was well below the 10-year average in BC. However, in 2020 Washington, Oregon and California states had active wildfire seasons.

Table 12. Total fires and area burned in British Columbia.

Year	Total Fires	Area Burned (km^2)
2015	1,858	2,806
2016	1,050	1,004
2017	1,353	12,161
2018	2,117	13,543
2019	825	2,114
2020	670	1,454
10-year average	***1,352***	***3,489***

Figure 65 shows summertime exceedance days due to elevated $PM_{2.5}$ in four wildfire years: 2015, 2017, 2018 and 2020. The colour corresponds to the maximum $PM_{2.5}$ 24-hour rolling average with dark red signifying concentrations greater than 150 $\mu g/m^3$.

In 2020, after a quiet wildfire season in BC with below average wildfire activity, the Lower Fraser Valley was severely impacted by smoke in September from wildfires burning in Washington, Oregon and California (Figure 66).

On labour day (September 7) a chain of events including extreme winds, hot temperatures and record drought conditions led to explosive wildfire growth in Washington, Oregon and California resulting in some of the largest fires on record in these states.

On September 8 smoke from wildfires burning in eastern Washington reached some parts of the Lower Fraser Valley and Metro Vancouver issued an air quality advisory due to elevated levels of fine particulate matter. Metro

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[5] Teakles, A.D., So, R., Ainslie, B. et al. (2017) Impacts of the July 2012 Siberian fire plume on air quality in the Pacific Northwest. Atmos. Chem. Phys. 17, pp. 2593-2611.

Vancouver's 24-hour $PM_{2.5}$ objective was exceeded at three stations: North Vancouver-Second Narrows, Port Moody and Abbotsford Airport. Light smoke can be seen covering the region on September 8 in Figure 66.

The fine particulate matter advisory was continued on September 9 and an advisory for ground-level ozone was added. Metro Vancouver's $PM_{2.5}$ objective was exceeded at more than half of the monitoring stations throughout the region.

The ozone advisory was cancelled the following day (September 10) while the $PM_{2.5}$ advisory was continued although air quality improved with lower $PM_{2.5}$ concentrations.

Over the course of these days the number of wildfires and size of the fires in Washington, Oregon and California increased dramatically. Strong eastward winds blew smoke from these fires over the Pacific Ocean, which resulted in the generation of an extensive plume of smoke larger than the state of California. The daily sequence of the growth of the smoke plume can be seen on satellite imagery in Figure 66. As the smoke plume grew larger it also moved northward, while being fed by wildfires in all three states.

By September 11 the extensive smoke plume reached the Lower Fraser Valley and fine particulate matter levels increased substantially. By early afternoon all monitoring stations throughout the region were in exceedance of Metro Vancouver's $PM_{2.5}$ 24-hour objective.

For nine straight days every location within the region experienced elevated levels of $PM_{2.5}$ and exceedances of the 24-hour objective. The highest 24-hour average $PM_{2.5}$ was measured in Hope on September 15 with a concentration of 200 $\mu g/m^3$. On September 19 the 11-day air quality advisory was ended due to cleaner marine air flowing into the region.

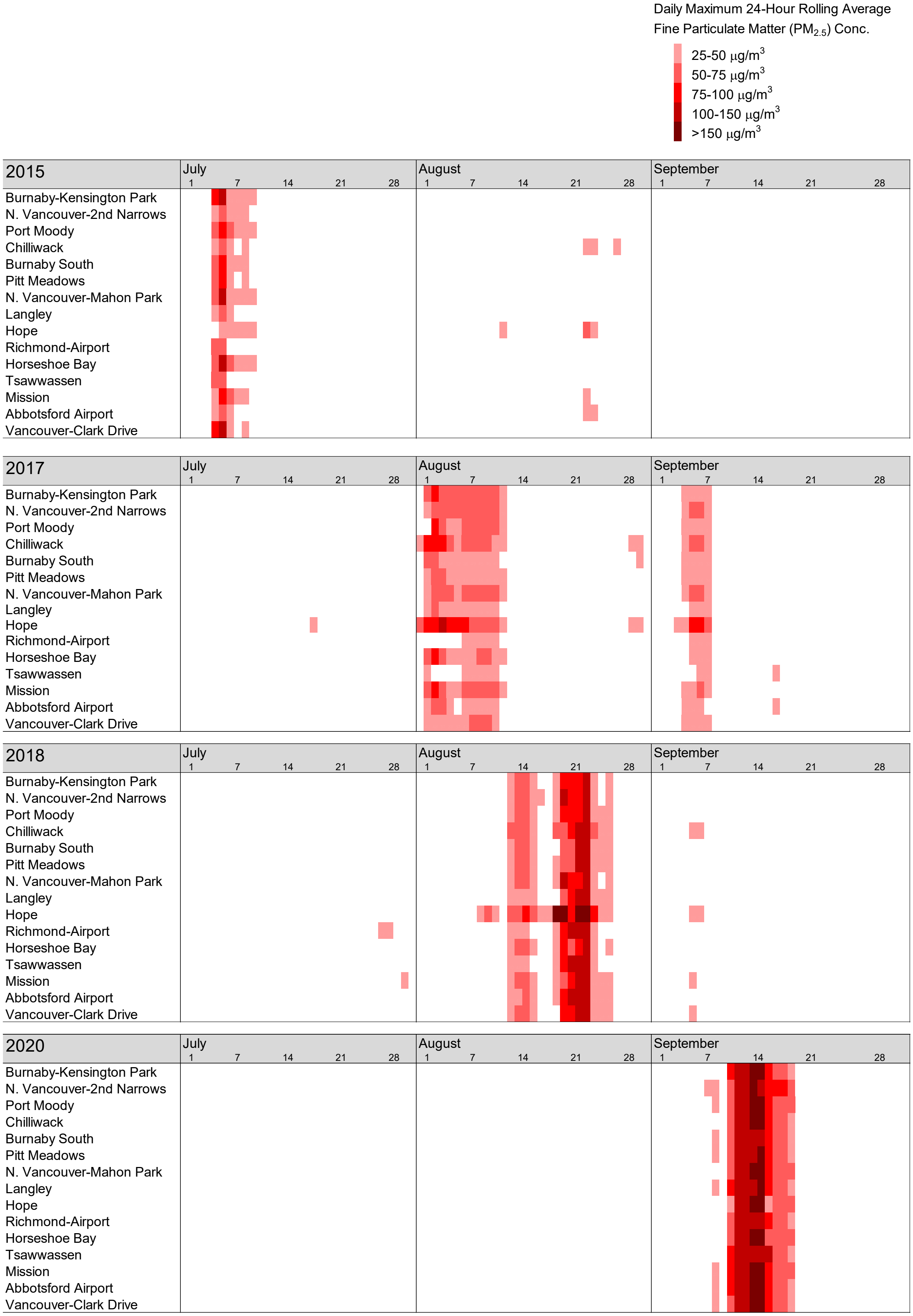

Figure 65: Comparison of exceedances days on four wildfire influenced years: 2015, 2017, 2018 and 2020.

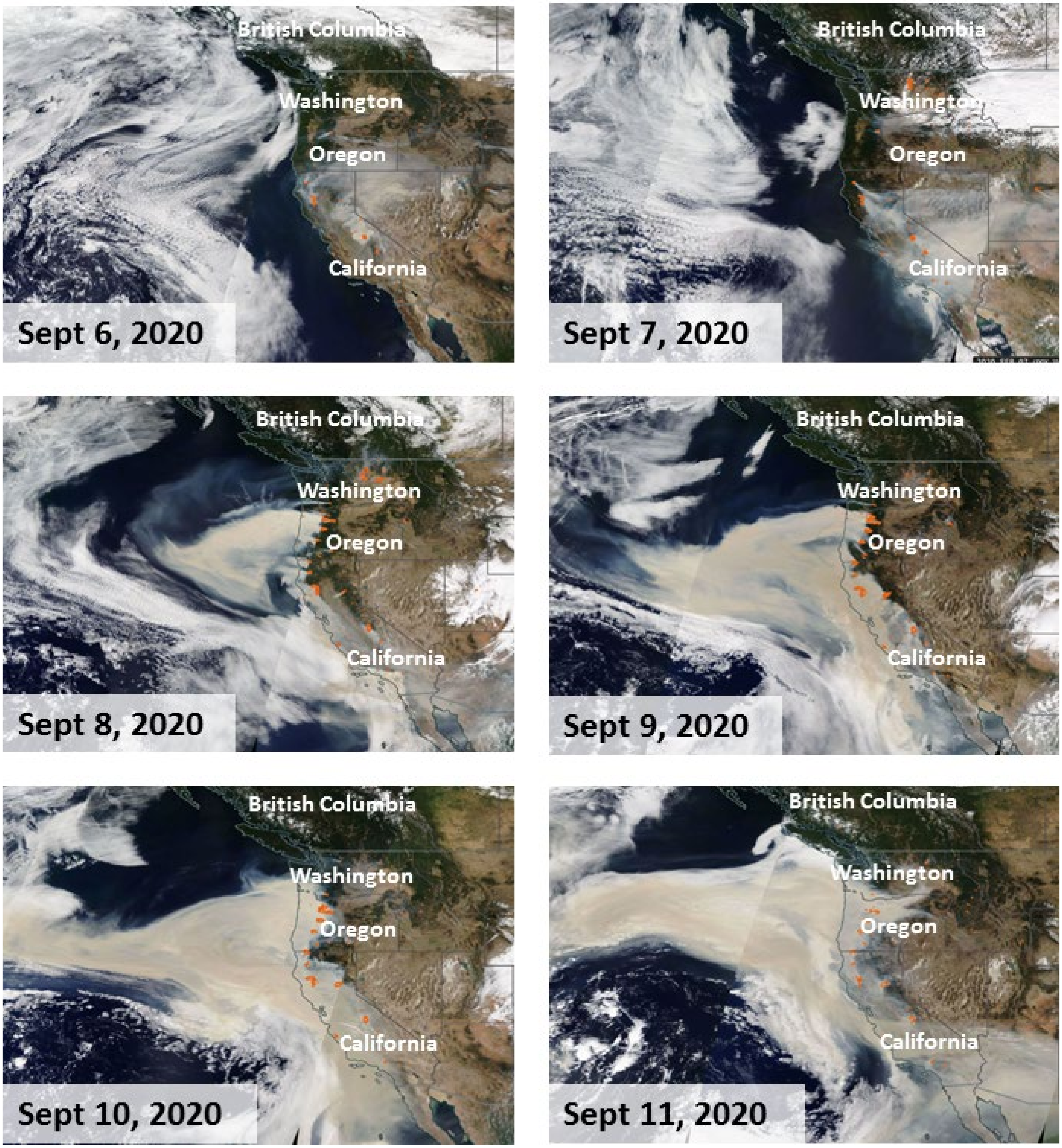

Figure 66: Satellite imagery taken from NASA Worldview during days impacted by wildfire smoke in 2020.

Climate Change

Climate projections indicate the region will experience hotter, drier summers and wetter, warmer winters. A warming climate is likely to increase frequency and duration of wildfires and associated smoke impacts, while also increasing in-region ground level O_3 formation through the intensity and duration of summer heatwaves.

A study of the extreme 2017 wildfire season in British Columbia, found that human-induced climate change contributed greatly to the extreme warm temperatures, high wildfire risk, and large burned areas (Kirchmeier-Young, Gillett, Zwiers, Cannon, & Anslow, 2019[6]). The authors concluded that as the climate continues to warm, it can be expected that extreme wildfire seasons like 2017 in BC will become more likely in the future.

Public awareness of air quality and health has also grown with the recent summer wildfire smoke impacts. Since 2017, Metro Vancouver has been working with local health authorities, BC Centre for Disease Control, Health Canada, the BC ENV, the FVRD and experts from outside BC to develop communication materials for residents on wildfire smoke health impacts and interventions for reducing these impacts.

Metro Vancouver is also looking at further developing collaborations, such as working with member jurisdiction on provision of clean air shelters, to ensure that people will be better protected from the health impacts of wildfire smoke going forward.

Metro Vancouver’s updated air quality management plan, the Clean Air Plan[1], considers the increasing impacts of wildfire activity when developing strategies and actions to reduce health risks for Metro Vancouver residents. In parallel, Metro Vancouver’s Climate 2050 Roadmaps identifies actions that will help the region adapt to climate-related impacts on regional air quality.

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[6] Kirchmeier-Young, M. C., Gillett, N. P., Zwiers, F. W., Cannon, A. J., & Anslow, F. S. (2019). Attribution of the Influence of Human-Induced Climate Change on an Extreme Fire Season. *Earth's Future, 7*(1), 2-10. doi:10.1029/2018EF001050