Ministry of Environment and Climate Change Strategy

LOWER FRASER VALLEY AIR ZONE REPORT (2016-2018)

Introduction

This is the sixth annual quality report for the Lower Fraser Valley (LFV) Air Zone. Annual air zone reporting is a commitment under the national Air Quality Management System (AQMS). This report describes achievement of the Canadian Ambient Air Quality Standards (CAAQS) for ground-level ozone (O_3) and fine particulates ($PM_{2.5}$), the associated management levels and recent actions to improve air quality. A province-wide summary can be found at: http://www.env.gov.bc.ca/soe/indicators/air/.

Background

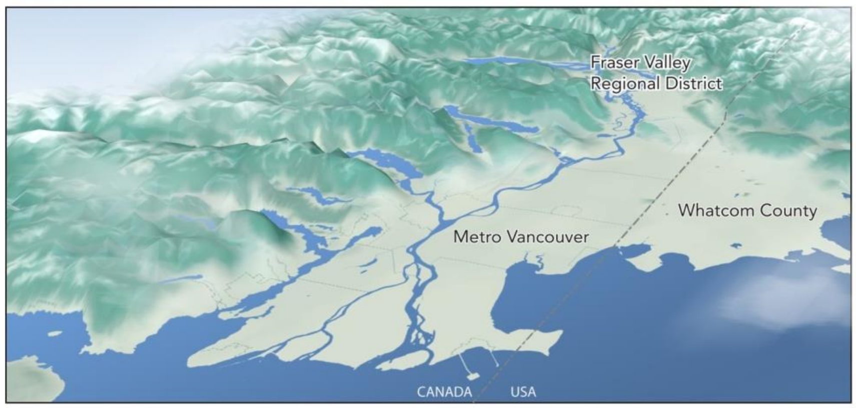


Figure 1. Lower Fraser Valley Air Zone.

The AQMS is the national approach to managing air quality in Canada. Under the AQMS, the CAAQS are developed to drive action to protect human health and the environment. Air zones are areas that exhibit similar air quality characteristics, issues and trends, and that form the basis for monitoring, reporting and taking action on air quality. The Lower Fraser Valley (LFV) Air Zone (see Figure 1) is one of seven broad air zones across the province. Under the AQMS, progressively more rigorous actions are expected as air quality approaches or exceeds the CAAQS. The level of action is guided by the Air Zone Management Framework outlined in Table 1.

Table 1. Air zone management framework for ground-level ozone and $PM_{2.5}$ defined based on 2015 CAAQS criteria.

Management Level	Objectives	Ozone	$PM_{2.5}$	
		8-hour (ppb)	Annual (µg/m³)	24-hour (µg/m³)
Red	Achieve CAAQS	>63	>10.0	>28
Orange	Prevent CAAQS Exceedance	>56 and ≤63	>6.4 and ≤10.0	>19 and ≤28
Yellow	Prevent Air Quality Deterioration	>50 and ≤56	>4.0 and ≤6.4	>10 and ≤19
Green	Keep Clean Areas Clean	≤50	≤4.0	≤10

Ozone Levels

Ozone measurements in the LFV Air Zone are summarized in Figure 2. Concentrations ranged from 36 ppb in downtown Vancouver to 66 ppb in Mission.[1] All sites achieved the national standard of 63 ppb, with the exception of Mission and Hope.

Trends in ozone levels are shown in Figure 3.[2] Over the 10-year period from 2009-2018, Hope, Chilliwack, Abbotsford-Mill Lake, Port Moody and Burnaby South recorded their highest ozone levels in either 2017 or 2018.

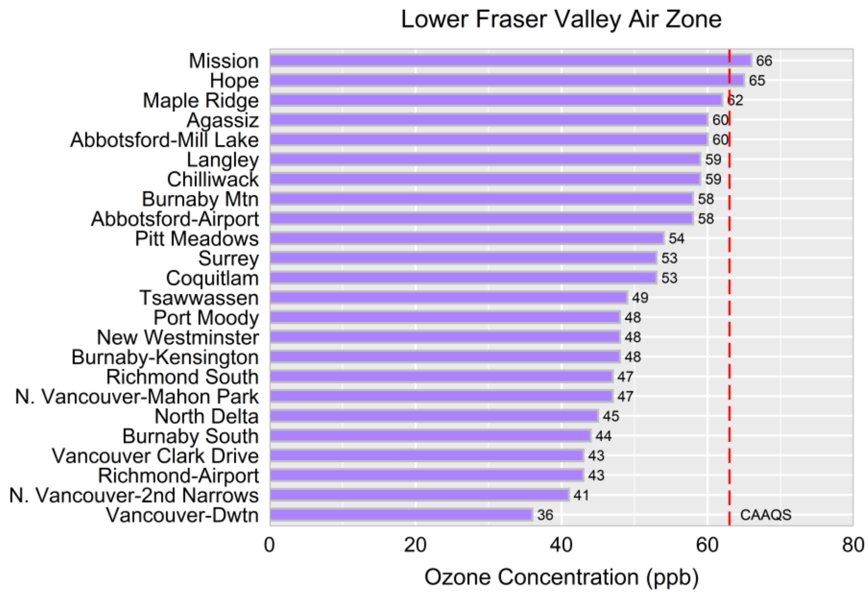


Figure 2. Ozone concentrations in the LFV Air Zone, based on annual 4th highest daily 8-hour maxima, averaged over 2016-2018. Red dashed line identifies the CAAQS of 63 ppb.

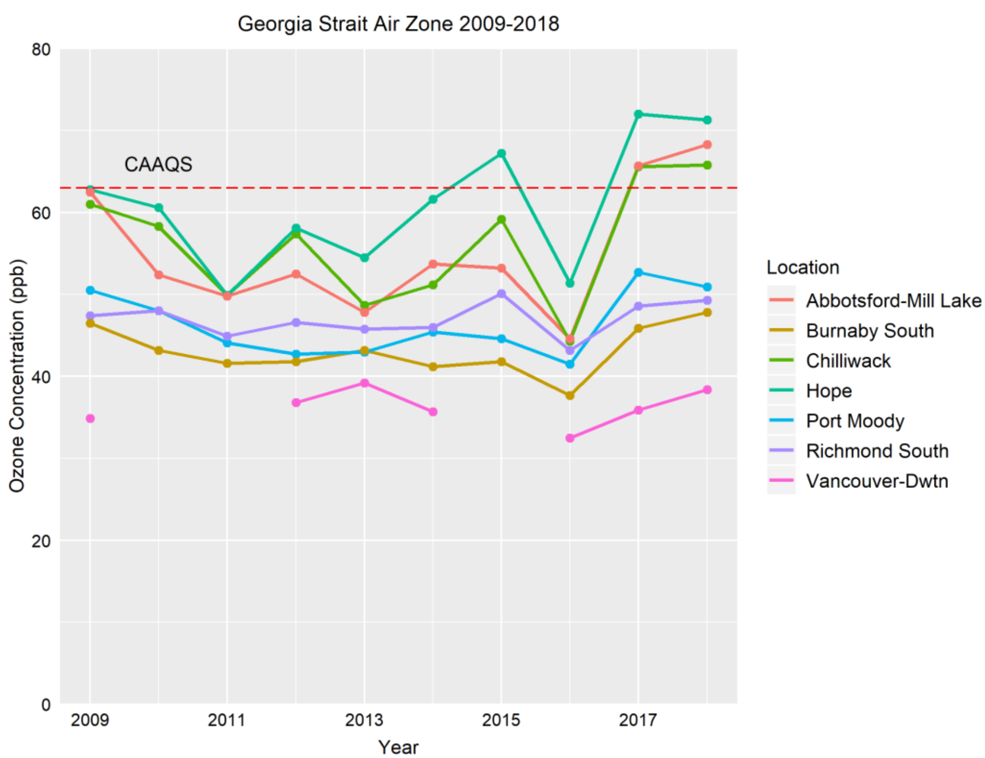


Figure 3. Trends in ozone concentrations (2009-2018), based on annual 4th highest daily 8-hour maxima for a single year. Red dashed line identifies CAAQS of 63 ppb.

---

[1] Concentrations based on 4th highest daily 8-hour maximum, averaged over three years (2016-2018).
[2] Concentrations based on 4th highest daily 8-hour maximum, averaged over a single year.

$PM_{2.5}$ Levels

$PM_{2.5}$ refers to inhalable particles up to 2.5 micrometres in diameter. $PM_{2.5}$ measurements are summarized in Figure 4. All measurements for this reporting period were based on the Federal Equivalent Method (FEM), which provides a more complete measure of $PM_{2.5}$ than the older TEOM instruments.

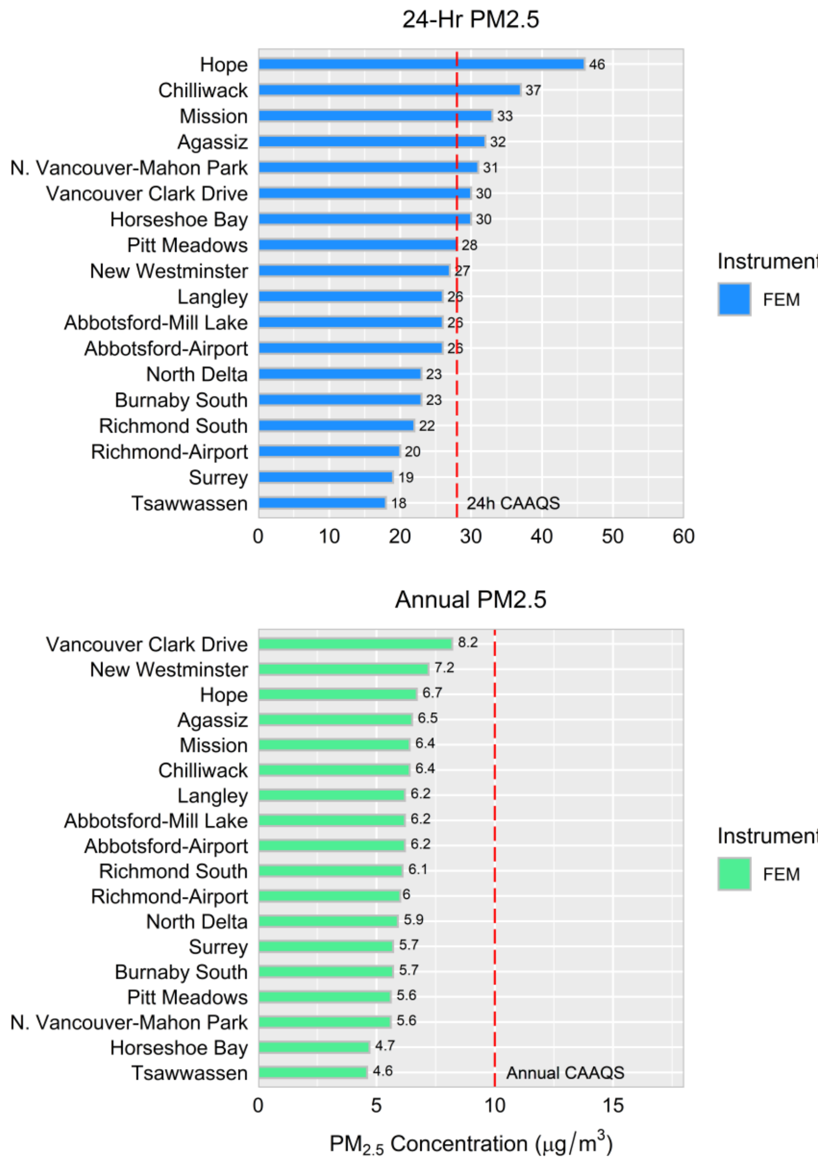


Figure 4. $PM_{2.5}$ concentrations in the LFV Air Zone. Upper plot based on 24-hour concentration (annual 98th percentile, averaged over 2016-2018). Lower plot based on annual mean concentration (averaged over 2016-2018). The red dashed lines identify CAAQS of 28 μg/m^3 (upper plot) and 10 μg/m^3 (lower plot).

Daily (24-hour) concentrations (upper plot) ranged from 18 to 46 μg/m^3.[3] Seven of 18 sites exceeded the national 24-hour standard of 28 μg/m^3. Annual concentrations (lower plot) ranged from 4.6 to 8.2 μg/m^3.[4] All monitoring sites achieved the national annual standard of 10 μg/m^3.

Trends in annual mean concentrations between 2009 and 2018 are shown in Figure 5 for a subset of these sites.[5] A shift to higher reported concentrations is seen with the change from TEOM to FEM instruments from 2013 onward. Five of the eight sites shown in Figure 5 recorded their highest annual average $PM_{2.5}$ concentration in 2017 or 2018. All eight sites recorded their highest daily concentrations in 2017 or 2018 (not shown). Smoke from wildfires within and outside of the air zone had a major influence on $PM_{2.5}$ levels in 2017 and 2018 (see Appendix II for more information).

---

[3] Concentrations based on the annual 98th percentile of 24-hour values, averaged over three years (2016-2018).
[4] Concentrations based on the annual average of 24-hour values, averaged over three years (2016-2018).
[5] Concentrations based on the annual average of 24-hour values over single year.

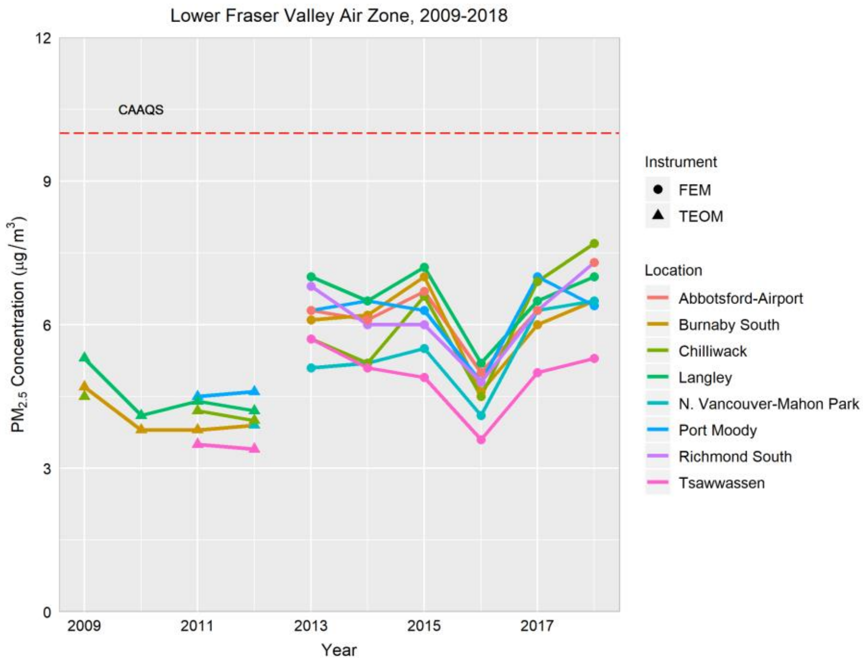


Figure 5. Annual trends in $PM_{2.5}$ concentrations (2009-2018), based on annual mean concentrations from a single year. The CAAQS value of 10 $\mu g/m^3$ is shown by the dashed line. $PM_{2.5}$ measurements prior to 2011 are reported at 25°C and 1 atm. From 2011 onward, measurements are reported at local conditions. The shift from TEOM to FEM instruments in 2013 resulted in higher monitored concentrations due to a more complete measure of $PM_{2.5}$.

Air Zone Management Levels

Air zone management levels are assigned on the basis of the highest concentrations within an air zone, excluding contributions from transboundary flows (TF) and exceptional events (EE) such as wildfires, and preferentially based on those sites with three complete years of data. TF/EE influences are removed so that long-term management strategies are not developed on the basis of events that are beyond local or provincial control.

Across B.C., wildfires are the primary contributor to TF/EE. The methodology for identifying wildfire-influenced data is provided in Appendix I and excluded data are summarized in Appendix II. Both the summers of 2017 and 2018 were characterized by hot, dry conditions and an above-average number of hectares burned. These fires created smoky conditions and periods of degraded air quality in several communities across the air zone.

Table 2 summarizes ozone concentrations as measured and after TF/EE influences have been considered. The LFV Air Zone is assigned an "orange" management level on the basis of ozone concentrations in Maple Ridge and several sites in the eastern and central Fraser Valley. This highlights a need for actions to prevent future exceedances of the ozone CAAQS in the air zone.

Table 2. Summary of ozone concentrations as measured and air zone management levels for the LFV Air Zone (based on 2016-2018 data).

Location	No. Valid Years	4th Highest Daily 8-hour Maxima		Air Zone Management Level
		As Measured	TF/EE Influences Removed	
Abbotsford-Airport	3	58	58	**Goal: Preventing CAAQS Exceedance**
Abbotsford-Mill Lake	3	60	60	
Agassiz	3	60	60	
Burnaby-Mtn	3	58	58	
Burnaby-South	3	44	44	
Burnaby-Kensington	3	48	48	
Chilliwack	3	59	59	
Coquitlam	2	53	53	
Hope	3	65	60	
Langley	3	59	59	
Maple Ridge	3	62	62	
Mission	3	66	60	
N. Vancouver-2nd Narrows	3	41	41	
N. Vancouver-Mahon Park	3	47	47	
New Westminster	3	48	48	
North Delta	3	45	45	
Pitt Meadows	3	54	54	
Port Moody	3	48	48	
Richmond South	3	47	47	
Richmond-Airport	3	43	43	
Surrey	3	53	53	
Tsawwassen	3	49	49	
Vancouver-Clark Dr.	3	43	43	
Vancouver-Dwtn	3	36	36	

Table 3 summarizes $PM_{2.5}$ concentrations as measured and with TF/EE influences removed for each monitoring site. Overall, the LFV Air Zone is assigned an “orange” management level, based on $PM_{2.5}$ levels at Vancouver-Clark Drive. The “orange” management level indicates that $PM_{2.5}$-related actions should focus on actions to prevent CAAQS exceedance in the air zone. As the Vancouver-Clark-Drive monitoring station is located near a busy roadway, transportation-related actions may be particularly relevant.

Table 3. Summary of $PM_{2.5}$ concentrations as measured and air zone management levels for the LFV Air Zone (based on 2016-2018 data).

Location	Monitor Type	No. Valid Years	Daily Mean (98th Percentile)		Annual Mean		Air Zone Management Level
			As Measured	TF/EE Removed	As Measured	TF/EE Removed	
Abbotsford-Airport	FEM	3	26	16	6.2	5.4	**Goal: Preventing CAAQS Exceedance**
Abbotsford-Mill Lake	FEM	3	26	14	6.2	5.5	
Agassiz	FEM	3	32	15	6.5	5.4	
Burnaby-South	FEM	3	23	14	5.7	5.0	
Burnaby-Kensington	FEM	3	30	13	5.7	4.8	
Chilliwack	FEM	3	37	14	6.4	5.2	
Hope	FEM	3	46	14	6.7	4.9	
Horseshoe Bay	FEM	3	30	11	4.7	3.8	
Langley	FEM	3	26	18	6.2	5.6	
Mission	FEM	3	33	16	6.4	5.8	
New Westminster	FEM	3	27	17	7.2	6.4	
N. Vancouver-2nd Narrows	FEM	3	30	14	6.9	5.9	
N. Vancouver-Mahon Park	FEM	3	31	14	5.6	4.7	
North Delta	FEM	3	23	15	5.9	5.2	
Pitt Meadows	FEM	3	28	15	5.6	4.8	
Port Moody	FEM	3	29	13	6.1	5.2	
Richmond South	FEM	3	22	16	6.1	5.6	
Richmond-Airport	FEM	3	20	16	6.0	5.6	
Surrey	FEM	3	19	15	5.7	5.2	
Tsawwassen	FEM	3	18	13	4.6	4.2	
Vancouver-Clark Dr.	FEM	3	30	20	8.2	7.5	

Actions to Protect Air Quality

Through delegated authority under the *Environmental Management Act*, Metro Vancouver has responsibility for managing air emissions within its boundaries.

Metro Vancouver developed an Integrated Air Quality Management and Greenhouse Gas Management Plan in 2011.[6] This plan sought to reduce levels of $PM_{2.5}$, ground-level ozone, and other priority pollutants to protect human health and the environment, improve visual air quality and minimize contributions to climate change. Progress on the implementation of this plan can be found here:

[6] http://www.metrovancouver.org/services/air-quality/AirQualityPublications/IntegratedAirQualityGreenhouseGasManagementPlan-October2011.pdf

http://www.metrovancouver.org/services/air-quality/plans-reports/iaqggmp/Pages/default.aspx. Metro Vancouver is currently developing a Clean Air Plan to accelerate actions to improve regional air quality and reduce greenhouse gas emissions reduce regional air contaminants, including greenhouse gases, over the next decade. For more information on Clean Air Plan development, see: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/CleanAirPlanBackgrounderSeptember2019.pdf.

The Fraser Valley Regional District (FVRD) is in the process of updating its Air Quality Management Plan that was first developed in 1998.[7] This plan highlights several air quality issues, including ground-level ozone and $PM_{2.5}$. The FVRD is currently reviewing options for developing alternatives to open burning.

Regional air quality agencies including Metro Vancouver and the Fraser Valley Regional District developed a Regional Ground-Level Ozone Strategy in 2014.[8] This strategy identifies goals and strategic policy direction for the LFV. The strategy is currently being updated.

A description of other activities underway in B.C. air zones can be found in the “Air Zone Management Response for British Columbia” (see: www.gov.bc.ca/bcairquality).

[7] http://www.fvrd.ca/assets/Services/Documents/FVRD%20AQManagementPlan.pdf

[8] http://www.metrovancouver.org/services/air-quality/AirQualityPublications/RGLOS2014.pdf

Appendix I – Approach to Identify Wildfire-influenced Data

Summertime air quality in British Columbia is periodically influenced by wildfire smoke – from local fires as well as long-range transport from outside of the province. The wildfire season in B.C. typically occurs between May and September, when warm and dry conditions prevail.

A myriad of different pollutants is emitted from wildfires. These include $PM_{2.5}$ and gases such as nitrogen oxides and volatile organic compounds that can react in the atmosphere to form ground-level ozone and additional $PM_{2.5}$.

Given that smoke-affected areas may be extensive, and that smoke may linger for days before being fully dispersed from an airshed, the current analysis has focussed on those periods when wildfire smoke may have contributed to an exceedance of the CAAQS levels for ground-level ozone or $PM_{2.5}$. Criteria used to flag and evaluate wildfire-influenced data included the following:

- 24-hour $PM_{2.5}$ concentrations in excess of the CAAQS level of 28 $\mu g/m^3$ and/or 8-hour daily maximum ozone concentrations in excess of the CAAQS level of 63 ppb between May and September,
- Wildfires of interest identified based on data from the B.C. Wildfire Management Branch,
- Wildfire-related air quality advisories issued by Metro Vancouver during the period of interest,
- NASA satellite images showing smoke impacts over the region and
- Multiple monitoring sites in the area of concern showing similar air quality characteristics, suggesting a common regional source.

Wildfire-influenced data were excluded from the calculation of air zone management levels. Excluded data are as summarized in Appendix II.

Appendix II – Wildfire-influenced Data in the Lower Fraser Valley Air Zone (2016-2018)

Ozone and $PM_{2.5}$ data from 2016-2018 for the Lower Fraser Valley Air Zone were evaluated based on the criteria set out in Appendix I for TF/EE influences. Various pieces of evidence were used to support identification of wildfire-influenced periods. These included the following:

- Wildfires of note – either due to size or proximity to populated areas – were identified by the BC Wildfire Service (see: https://www2.gov.bc.ca/gov/content/safety/wildfire-status/about-bcws/wildfire-history/wildfire-season-summary).
    - 2016 was below-average in terms of the amount of land burned (0.10 million hectares), with the greatest activity occurring in the spring in the Peace Region of the province.
    - In contrast, 2017 (1.22 million hectares) and 2018 (1.35 million hectares ha) were record-breaking years in terms of area of land burned.
    - Wildfires of note in proximity to the Lower Fraser Valley Air Zone included the East Harrison Lake fire in 2017 and the Mount Hicks fire in 2018 (see Table II-1).
    - Of additional local interest was a bog fire in Richmond on Jul. 27, 2018 that burned up to five days.
- Smoke events during the summers of 2017 and 2018 were a result of local and more distant wildfires from elsewhere in B.C., Alberta, Washington and beyond.
- Days flagged as potentially wildfire-influenced generally coincided with or preceded smoke-related advisories issued by Metro Vancouver (see Table II-2 for ozone and Tables II-3 and II-4 for $PM_{2.5}$).
- While not all ozone events during the summer of 2017 and 2018 were determined to be a direct result of wildfire influence, all $PM_{2.5}$ events coincided with periods of wildfire-smoke-related air quality advisories and as a result were considered to be wildfire-influenced.
- Satellite images during these periods provide additional supporting information on the spatial extent of wildfire smoke over the province, including the Lower Fraser Valley Air Zone, in 2017 and 2018. See Figures II-1 and II-2 for examples.
- Wildfire influences on specific ozone events are described further in Appendix III.

Table II-1. Summary of notable wildfires in the Lower Fraser Valley Air Zone between 2016-2018.[9]

Date Discovered	Size (ha)	Geographic Location	Description
2017-07-01	202	Harrison Lake East	30 km north of Harrison Hot Springs near the mouth of Big Silver Creek; Prompted evacuation alerts
2018-08-08	427	Mount Hicks	Located between Hope and Agassiz adjacent to Hwy 7

Table II-2. Days on which the 8-hour ozone concentrations exceeded the CAAQS level of 63 ppb (2016-2018) in the LFV Air Zone. Wildfire-influenced concentrations are highlighted in red. Rolling 8-hour average values are based on 1-hour concentrations rounded to the nearest integer.

Date	Hope			Mission			AQ Advisory in Effect
	8-Hr Daily Max O_3 (ppb)	24-hr $PM_{2.5}$ (µg/m³)	Max T (°C)	8-Hr Daily Max O_3 (ppb)	24-hr $PM_{2.5}$ (µg/m³)	Max T (°C)	
2017-07-05	67.5	8.3	29.3	60.9	10.1	28.2	None
2017-07-06	66.7	9.7	29.4	57.2	9.0	28.4	Yes (due to O_3)
2017-08-03	78.3	89.3	31.5	61.1	69.9	31.1	Yes (due to $PM_{2.5}$ from interior fires)
2017-08-07	72.0	73.9	29.3	70.5*	50.8	28.6	
2017-08-10	78.7	58.5	31.4	79.8*	52.7	30.4	Yes (due to $PM_{2.5}$ from interior fires + O_3)
2017-08-11	68.7	41.6	30.3	58.5	33.8	29.2	
2017-08-29	75.9	28.5	32.1	74.9*	23.7	31.3	
2018-07-16	71.3	11.5	31.6	57.3	9.7	31	None
2018-07-25	69.7	9.7	30.5	63.1	11.4	30.7	None
2018-07-26	69.8	13.5	30.5	63.0	10.0	30.4	None
2018-07-27	71.5	16.8	29.8	68.0	17.1	29.3	None
2018-07-28	70.9	14.6	30.1	57.9	11.4	29.0	O_3 advisory
2018-07-29	72.6	16.1	32.6	79.3	17.3	32.5	O_3 advisory
2018-07-30	78.0	18.4	34.2	81.5	23.1	33.8	$PM_{2.5}$ and O_3 advisory
2018-08-07	66.6	9.7	31.1	66.1	9.1	30.8	No advisory
2018-08-08	70.5	18.4	34.2	76.7	15.1	33.7	O_3 advisory in FVRD
2018-08-09	65.6	25.3	33.2	77.1	11.5	n/a	PM and O_3 advisory in FVRD
2018-08-21	62.6	82.1	30.8	67.4	83.7	31.2	PM and O_3 advisory
2018-08-22	68.8	151.5	27.1	76.8	111	27.6	PM and O_3 advisory

*Note: As the 4th highest daily 8-hour maximum O_3 concentration at Mission in 2017 was less than the standard level of 63 ppb, 2017 O_3 values from Mission were not evaluated for wildfire influence. However, given elevated O_3 and $PM_{2.5}$ levels at both Mission and Hope on these days, it is likely that the Mission O_3 measurements were also influenced by wildfire smoke.

[9] https://www2.gov.bc.ca/gov/content/safety/wildfire-status/about-bcws/wildfire-history/wildfire-season-summary

Table II-3. Wildfire-influenced $PM_{2.5}$ data from 2017.

Location	Date	Daily Mean (μg/m³)
Agassiz	2017-08-01	38.5
Chilliwack	2017-08-01	30.3
Hope	2017-08-01	62.6
Abbotsford-Airport	2017-08-02	48.5
Abbotsford-Mill Lake	2017-08-02	57.8
Agassiz	2017-08-02	98.6
Burnaby South	2017-08-02	54.4
Burnaby-Kensington	2017-08-02	56.3
Chilliwack	2017-08-02	88.2
Hope	2017-08-02	97.5
Horseshoe Bay	2017-08-02	53.3
Langley	2017-08-02	37.9
Mission	2017-08-02	68.1
N. Vancouver-2nd Narrows	2017-08-02	45.9
N. Vancouver-Mahon Park	2017-08-02	41
New Westminster	2017-08-02	44.4
North Delta	2017-08-02	37.1
Pitt Meadows	2017-08-02	41.4
Vancouver Clark Drive	2017-08-02	39.6
Abbotsford-Airport	2017-08-03	65.6
Abbotsford-Mill Lake	2017-08-03	55.5
Agassiz	2017-08-03	78.8
Burnaby South	2017-08-03	47.5
Burnaby-Kensington	2017-08-03	67.9
Chilliwack	2017-08-03	74.1
Hope	2017-08-03	89.3
Horseshoe Bay	2017-08-03	70.4
Langley	2017-08-03	49.3
Mission	2017-08-03	69.9
N. Vancouver-2nd Narrows	2017-08-03	70.2
N. Vancouver-Mahon Park	2017-08-03	66.1
New Westminster	2017-08-03	52.6
North Delta	2017-08-03	45.5
Pitt Meadows	2017-08-03	58.8
Port Moody	2017-08-03	74.7
Vancouver Clark Drive	2017-08-03	38.3
Abbotsford-Airport	2017-08-04	34.2
Abbotsford-Mill Lake	2017-08-04	40.5
Agassiz	2017-08-04	72
Burnaby South	2017-08-04	29.1
Burnaby-Kensington	2017-08-04	46.1
Chilliwack	2017-08-04	62.7
Hope	2017-08-04	79.4
Horseshoe Bay	2017-08-04	37.6
Langley	2017-08-04	31.9
Mission	2017-08-04	46.7
N. Vancouver-2nd Narrows	2017-08-04	43.1
N. Vancouver-Mahon Park	2017-08-04	48.5
New Westminster	2017-08-04	30.2
North Delta	2017-08-04	30.4
Pitt Meadows	2017-08-04	39.3
Port Moody	2017-08-04	46.3
Vancouver Clark Drive	2017-08-04	31.2
Agassiz	2017-08-05	58.1
Burnaby-Kensington	2017-08-05	45.6
Chilliwack	2017-08-05	37.7
Hope	2017-08-05	80.1
Horseshoe Bay	2017-08-05	36.9
Mission	2017-08-05	32.4
N. Vancouver-2nd Narrows	2017-08-05	51.9
N. Vancouver-Mahon Park	2017-08-05	48.4
New Westminster	2017-08-05	32.1
Port Moody	2017-08-05	38
Abbotsford-Mill Lake	2017-08-06	30.9
Agassiz	2017-08-06	58.1
Burnaby South	2017-08-06	31.6
Burnaby-Kensington	2017-08-06	51.2
Chilliwack	2017-08-06	47.7
Hope	2017-08-06	86
Horseshoe Bay	2017-08-06	39.3
Langley	2017-08-06	29.8
Mission	2017-08-06	38.9
N. Vancouver-2nd Narrows	2017-08-06	47
N. Vancouver-Mahon Park	2017-08-06	47.2
New Westminster	2017-08-06	35.4
Pitt Meadows	2017-08-06	33.8
Port Moody	2017-08-06	46.8
Vancouver Clark Drive	2017-08-06	37.4
Abbotsford-Airport	2017-08-07	32
Abbotsford-Mill Lake	2017-08-07	37.3
Agassiz	2017-08-07	64.4
Burnaby South	2017-08-07	37.6
Burnaby-Kensington	2017-08-07	50
Chilliwack	2017-08-07	56.8
Hope	2017-08-07	73.9
Horseshoe Bay	2017-08-07	44.8
Langley	2017-08-07	37.1
Mission	2017-08-07	50.8
N. Vancouver-2nd Narrows	2017-08-07	53.1

Table II-3 (continued)

Location	Date	Daily Mean (μg/m³)
N. Vancouver-Mahon Park	2017-08-07	53.2
New Westminster	2017-08-07	39.6
North Delta	2017-08-07	35.8
Pitt Meadows	2017-08-07	41
Port Moody	2017-08-07	52.4
Richmond South	2017-08-07	31.8
Richmond-Airport	2017-08-07	29.2
Tsawwassen	2017-08-07	29.3
Vancouver Clark Drive	2017-08-07	41.5
Abbotsford-Airport	2017-08-08	44
Abbotsford-Mill Lake	2017-08-08	48.4
Agassiz	2017-08-08	55.9
Burnaby South	2017-08-08	42.7
Burnaby-Kensington	2017-08-08	54.4
Chilliwack	2017-08-08	54
Hope	2017-08-08	55
Horseshoe Bay	2017-08-08	42.1
Langley	2017-08-08	43.2
Mission	2017-08-08	53
N. Vancouver-2nd Narrows	2017-08-08	55.7
N. Vancouver-Mahon Park	2017-08-08	58.4
New Westminster	2017-08-08	49
North Delta	2017-08-08	42.4
Pitt Meadows	2017-08-08	45.3
Port Moody	2017-08-08	56.2
Richmond South	2017-08-08	29.8
Tsawwassen	2017-08-08	29
Vancouver Clark Drive	2017-08-08	50.2
Abbotsford-Airport	2017-08-09	41.4
Abbotsford-Mill Lake	2017-08-09	45.8
Burnaby South	2017-08-09	44.8
Burnaby-Kensington	2017-08-09	56.3
Chilliwack	2017-08-09	51.9
Hope	2017-08-09	56
Horseshoe Bay	2017-08-09	50.7
Langley	2017-08-09	46.4
Mission	2017-08-09	57
N. Vancouver-2nd Narrows	2017-08-09	60
N. Vancouver-Mahon Park	2017-08-09	59.3
North Delta	2017-08-09	40.2
Pitt Meadows	2017-08-09	47.5
Port Moody	2017-08-09	57.8
Richmond South	2017-08-09	36.7
Richmond-Airport	2017-08-09	36.8
Tsawwassen	2017-08-09	33.6
Vancouver Clark Drive	2017-08-09	51.3

Location	Date	Daily Mean (μg/m³)
Abbotsford-Airport	2017-08-10	38.2
Abbotsford-Mill Lake	2017-08-10	42.1
Burnaby South	2017-08-10	41.6
Burnaby-Kensington	2017-08-10	51.5
Chilliwack	2017-08-10	48.8
Hope	2017-08-10	58.5
Horseshoe Bay	2017-08-10	45.5
Langley	2017-08-10	42.3
Mission	2017-08-10	52.7
N. Vancouver-2nd Narrows	2017-08-10	57.4
N. Vancouver-Mahon Park	2017-08-10	56.3
New Westminster	2017-08-10	43.3
North Delta	2017-08-10	39.8
Pitt Meadows	2017-08-10	46.8
Port Moody	2017-08-10	54.9
Richmond South	2017-08-10	32.7
Richmond-Airport	2017-08-10	33.7
Tsawwassen	2017-08-10	29.7
Vancouver Clark Drive	2017-08-10	49.3
Agassiz	2017-08-11	46.3
Burnaby-Kensington	2017-08-11	29.9
Chilliwack	2017-08-11	31.3
Hope	2017-08-11	41.6
Horseshoe Bay	2017-08-11	29.2
Mission	2017-08-11	33.8
N. Vancouver-2nd Narrows	2017-08-11	37.1
N. Vancouver-Mahon Park	2017-08-11	32
Pitt Meadows	2017-08-11	29.7
Port Moody	2017-08-11	36.6
Agassiz	2017-08-29	31
Chilliwack	2017-08-29	28.2
Hope	2017-08-29	28.5
Hope	2017-09-04	29.3
Abbotsford-Airport	2017-09-05	33.1
Abbotsford-Mill Lake	2017-09-05	31.3
Agassiz	2017-09-05	41
Burnaby South	2017-09-05	29.2
Burnaby-Kensington	2017-09-05	35.7
Chilliwack	2017-09-05	40
Hope	2017-09-05	46.2
Mission	2017-09-05	34.3
N. Vancouver-2nd Narrows	2017-09-05	33.2
N. Vancouver-Mahon Park	2017-09-05	41.6
New Westminster	2017-09-05	30.3
North Delta	2017-09-05	29.7

Table II-3 (continued)

Location	Date	Daily Mean (μg/m³)
Pitt Meadows	2017-09-05	32.1
Port Moody	2017-09-05	33
Vancouver Clark Drive	2017-09-05	30.2
Abbotsford-Airport	2017-09-06	32.4
Abbotsford-Mill Lake	2017-09-06	37
Agassiz	2017-09-06	56.9
Burnaby South	2017-09-06	31.1
Burnaby-Kensington	2017-09-06	44.3
Chilliwack	2017-09-06	57.4
Hope	2017-09-06	87.7
Horseshoe Bay	2017-09-06	43.9
Langley	2017-09-06	33.3
Mission	2017-09-06	47
N. Vancouver-2nd Narrows	2017-09-06	51
N. Vancouver-Mahon Park	2017-09-06	62
New Westminster	2017-09-06	43.6
North Delta	2017-09-06	34.4
Pitt Meadows	2017-09-06	40.2
Port Moody	2017-09-06	45.1
Surrey	2017-09-06	31.8
Vancouver Clark Drive	2017-09-06	37.5
Abbotsford-Mill Lake	2017-09-07	28.8
Agassiz	2017-09-07	46.6
Burnaby South	2017-09-07	31.9
Burnaby-Kensington	2017-09-07	39.4
Chilliwack	2017-09-07	42.8
Hope	2017-09-07	56.6
Horseshoe Bay	2017-09-07	39.5
Mission	2017-09-07	37.9
N. Vancouver-2nd Narrows	2017-09-07	42.3
N. Vancouver-Mahon Park	2017-09-07	41.9
New Westminster	2017-09-07	38.2
North Delta	2017-09-07	31.9
Pitt Meadows	2017-09-07	35.4
Port Moody	2017-09-07	41.5
Richmond-Airport	2017-09-07	28.6
Surrey	2017-09-07	29.1
Vancouver Clark Drive	2017-09-07	36.8

Table II-4. Wildfire-influenced $PM_{2.5}$ data from 2018.

Location	Date	Daily Mean (μg/m³)
Hope	2018-08-10	49.4
New Westminster	2018-08-10	31.6
Abbotsford-Airport	2018-08-13	29.3
Abbotsford-Mill Lake	2018-08-13	31
Agassiz	2018-08-13	54.4
Burnaby South	2018-08-13	40.8
Burnaby-Kensington	2018-08-13	44.1
Chilliwack	2018-08-13	52.1
Hope	2018-08-13	63.8
Horseshoe Bay	2018-08-13	41
Mission	2018-08-13	38.1
N. Vancouver-2nd Narrows	2018-08-13	38.3
N. Vancouver-Mahon Park	2018-08-13	40.3
New Westminster	2018-08-13	35.7
North Delta	2018-08-13	33.9
Pitt Meadows	2018-08-13	31.4
Port Moody	2018-08-13	38.6
Richmond South	2018-08-13	32.7
Richmond-Airport	2018-08-13	32.2
Surrey	2018-08-13	37.1
Tsawwassen	2018-08-13	30.3
Vancouver Clark Drive	2018-08-13	38.5
Abbotsford-Airport	2018-08-14	46.9
Abbotsford-Mill Lake	2018-08-14	46.2
Agassiz	2018-08-14	66.1
Burnaby South	2018-08-14	54.7
Burnaby-Kensington	2018-08-14	65.6
Chilliwack	2018-08-14	60.3
Hope	2018-08-14	65.3
Horseshoe Bay	2018-08-14	59.7
Langley	2018-08-14	44.4
Mission	2018-08-14	57.6
N. Vancouver-2nd Narrows	2018-08-14	65.9
N. Vancouver-Mahon Park	2018-08-14	63.8
New Westminster	2018-08-14	57
North Delta	2018-08-14	52.2
Pitt Meadows	2018-08-14	51.1
Port Moody	2018-08-14	69.6
Richmond South	2018-08-14	46.8
Richmond-Airport	2018-08-14	44.9
Surrey	2018-08-14	48.6
Tsawwassen	2018-08-14	34.5
Vancouver Clark Drive	2018-08-14	57.4
Abbotsford-Airport	2018-08-15	36.2
Abbotsford-Mill Lake	2018-08-15	35.3
Agassiz	2018-08-15	57.6
Burnaby South	2018-08-15	32.4
Burnaby-Kensington	2018-08-15	40.8
Chilliwack	2018-08-15	50.3
Hope	2018-08-15	71.2
Horseshoe Bay	2018-08-15	42.2
Langley	2018-08-15	33
Mission	2018-08-15	45
N. Vancouver-2nd Narrows	2018-08-15	46.1
N. Vancouver-Mahon Park	2018-08-15	44
New Westminster	2018-08-15	40.2
North Delta	2018-08-15	36.3
Pitt Meadows	2018-08-15	37.8
Port Moody	2018-08-15	42.1
Surrey	2018-08-15	36.2
Vancouver Clark Drive	2018-08-15	39.4
Hope	2018-08-16	28.5
N. Vancouver-2nd Narrows	2018-08-16	28.9
Hope	2018-08-18	44
Abbotsford-Airport	2018-08-19	30.4
Abbotsford-Mill Lake	2018-08-19	39.3
Agassiz	2018-08-19	89.7
Burnaby-Kensington	2018-08-19	34.5
Chilliwack	2018-08-19	59.1
Hope	2018-08-19	240.8
Horseshoe Bay	2018-08-19	30.9
Mission	2018-08-19	43.9
N. Vancouver-2nd Narrows	2018-08-19	28.2
N. Vancouver-Mahon Park	2018-08-19	36.1
Pitt Meadows	2018-08-19	36.5
Port Moody	2018-08-19	32.4
Richmond South	2018-08-19	31.4
Richmond-Airport	2018-08-19	28.7
Tsawwassen	2018-08-19	28.3
Abbotsford-Airport	2018-08-20	76.9
Abbotsford-Mill Lake	2018-08-20	65.6
Burnaby South	2018-08-20	72.6
Burnaby-Kensington	2018-08-20	87
Chilliwack	2018-08-20	68
Hope	2018-08-20	70.5
Horseshoe Bay	2018-08-20	76
Langley	2018-08-20	59.3
Mission	2018-08-20	51
N. Vancouver-2nd Narrows	2018-08-20	101.6
N. Vancouver-Mahon Park	2018-08-20	94.7
New Westminster	2018-08-20	70.9
North Delta	2018-08-20	78.1
Pitt Meadows	2018-08-20	65.1
Port Moody	2018-08-20	84.6
Richmond South	2018-08-20	96.8
Richmond-Airport	2018-08-20	89.1
Surrey	2018-08-20	60.3
Tsawwassen	2018-08-20	92.4
Vancouver Clark Drive	2018-08-20	80.2
Abbotsford-Airport	2018-08-21	99.9
Abbotsford-Mill Lake	2018-08-21	90.7
Burnaby South	2018-08-21	74.5
Burnaby-Kensington	2018-08-21	59.6
Chilliwack	2018-08-21	78.6

Table II-4 (continued)

Location	Date	Daily Mean (µg/m³)
Hope	2018-08-21	82.1
Horseshoe Bay	2018-08-21	55.4
Langley	2018-08-21	89.7
Mission	2018-08-21	83.7
N. Vancouver-2nd Narrows	2018-08-21	60.2
N. Vancouver-Mahon Park	2018-08-21	61.1
New Westminster	2018-08-21	75.7
North Delta	2018-08-21	91
Pitt Meadows	2018-08-21	69.4
Port Moody	2018-08-21	52.3
Richmond South	2018-08-21	99.3
Richmond-Airport	2018-08-21	91.5
Surrey	2018-08-21	100.8
Tsawwassen	2018-08-21	92.3
Vancouver Clark Drive	2018-08-21	74.8
Abbotsford-Airport	2018-08-22	126.5
Abbotsford-Mill Lake	2018-08-22	118.7
Agassiz	2018-08-22	117.4
Burnaby South	2018-08-22	112
Burnaby-Kensington	2018-08-22	98.9
Chilliwack	2018-08-22	118.7
Hope	2018-08-22	151.5
Horseshoe Bay	2018-08-22	96.2
Langley	2018-08-22	114.1
Mission	2018-08-22	111
N. Vancouver-2nd Narrows	2018-08-22	83.3
N. Vancouver-Mahon Park	2018-08-22	90
New Westminster	2018-08-22	128.1
North Delta	2018-08-22	125.4
Pitt Meadows	2018-08-22	106
Port Moody	2018-08-22	96.1
Richmond South	2018-08-22	123.1

Location	Date	Daily Mean (µg/m³)
Richmond-Airport	2018-08-22	122.3
Surrey	2018-08-22	126
Tsawwassen	2018-08-22	124.7
Vancouver Clark Drive	2018-08-22	116.7
Abbotsford-Airport	2018-08-23	39.9
Abbotsford-Mill Lake	2018-08-23	46.3
Agassiz	2018-08-23	68.5
Burnaby South	2018-08-23	39.8
Burnaby-Kensington	2018-08-23	43.7
Hope	2018-08-23	82.7
Horseshoe Bay	2018-08-23	52.5
Langley	2018-08-23	33.3
Mission	2018-08-23	50.2
N. Vancouver-2nd Narrows	2018-08-23	50.2
N. Vancouver-Mahon Park	2018-08-23	49.6
New Westminster	2018-08-23	41.7
North Delta	2018-08-23	43.9
Pitt Meadows	2018-08-23	47.2
Port Moody	2018-08-23	49.6
Chilliwack	2018-08-23	59.7
Richmond South	2018-08-23	32.5
Richmond-Airport	2018-08-23	33.3
Surrey	2018-08-23	34.9
Tsawwassen	2018-08-23	34.3
Vancouver Clark Drive	2018-08-23	48.2
Chilliwack	2018-08-25	28.2
Langley	2018-08-25	30.5
Mission	2018-08-25	32.7
New Westminster	2018-08-25	28.6
Surrey	2018-08-25	29.8
Agassiz	2018-09-06	32.5
Hope	2018-09-06	37.1

a. NASA Worldview, Aug. 3, 2017

b. NASA Worldview, Aug. 7, 2017

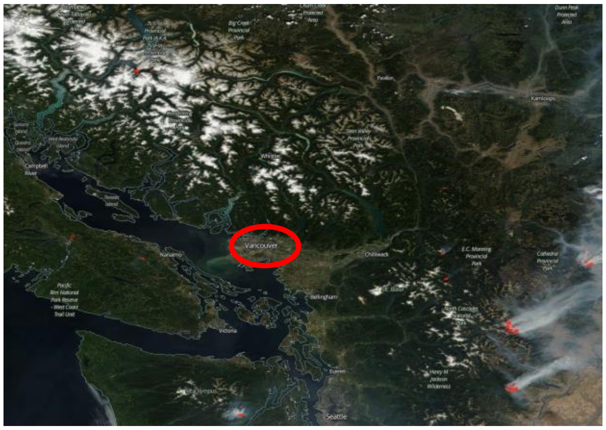
c. NASA Worldview, Aug. 10, 2017

d. NASA Worldview, Aug. 29, 2017

e. NASA Worldview, Jul. 26, 2018

f. NASA Worldview, Jul. 30, 2018

Figure II-1. Satellite images covering Aug. 3, 7, 10 and 29, 2017 and Jul. 26 and 30, 2018, showing wildfire smoke (grey plumes) over the southwest coast, including the LFV Air Zone. Red dots indicate fires and thermal anomalies. Large red circle in Figure II-1(a) identifies Vancouver on map. Source of images: NASA Worldview Snapshots at: https://worldview.earthdata.nasa.gov/.

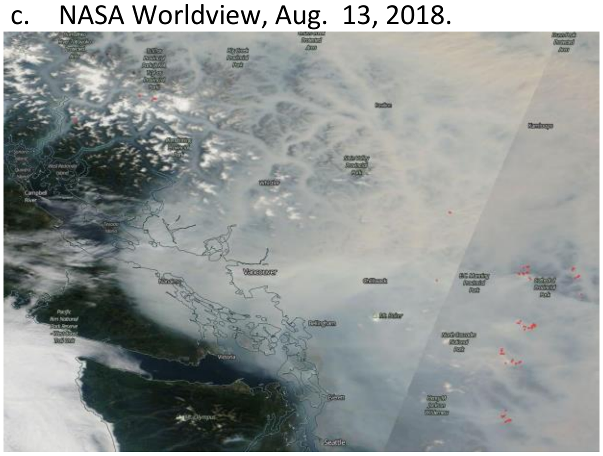


a. NASA Worldview, Aug. 8, 2018

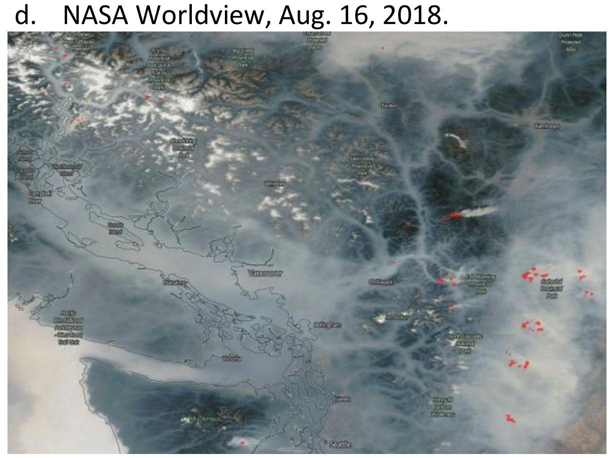
b. NASA Worldview, Aug. 9, 2018

c. NASA Worldview, Aug. 13, 2018.

d. NASA Worldview, Aug. 16, 2018.



e. NASA Worldview, Aug. 18, 2018.



f. NASA Worldview, Aug. 22, 2018.

Figure II-2. Satellite images covering Aug. 8-9, 13, 16, 18 and 22, 2018, showing wildfire smoke (grey plumes) over the southwest coast, including the LFV Air Zone. Red dots indicate fires and thermal anomalies. Large red circle in Figure II-2(a) identifies Vancouver on map. Source of images: NASA Worldview Snapshots at: https://worldview.earthdata.nasa.gov/.

Appendix III – Supporting analysis of wildfire influences on ozone levels in the Lower Fraser Valley Air Zone (2016-2018)

This appendix provides additional supporting information on the identification of ozone events that were influenced by wildfire smoke. In this context, an ozone event is considered to be a day in which 8-hour daily maximum ozone concentrations exceeded the CAAQS level of 63 ppb.

Potential wildfire-influenced days were initially flagged on the basis of elevated ozone and $PM_{2.5}$ concentrations, the issuance of a wildfire-related air quality advisory and/or satellite images showing smoke in the region. This information was summarized in Table II-2.

While $PM_{2.5}$, concentrations are typically low during the summer months if not for the presence of wildfire smoke, ozone concentrations in the Lower Fraser Valley typically peak in the summer, during stagnant periods characterized by sunny conditions, high temperatures and light winds. To assess the likelihood that high ozone days were driven by the presence of wildfire smoke and not just the typical conditions conducive to ozone buildup, ozone and $PM_{2.5}$ concentrations for the day in question were compared against historical data for the months of June, July, August and September using an approach developed by Howe for the 2015-2017 Lower Fraser Valley Air Zone Report (see: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/air/reports-pub/air-zone-reports/2015-2017/lfv_air_zone_report_2015-2017.pdf).

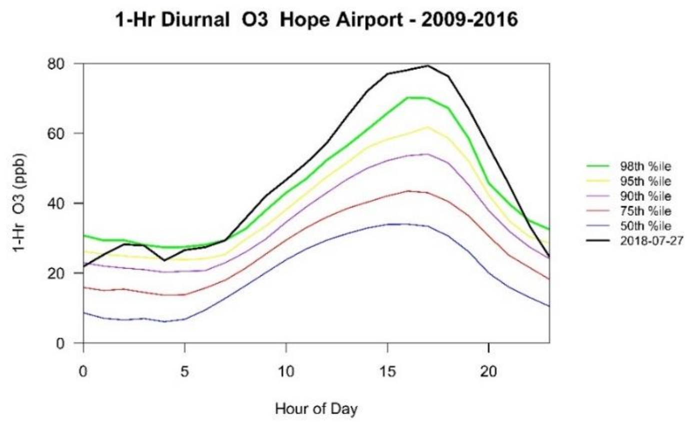
A series of percentile curves were constructed for ozone and $PM_{2.5}$ and compared to hourly concentrations for each day in question. A "percentile" refers to the value below which a given percentage of values are found. For example, the 50th percentile curve is created by finding the 50th percentile for each hour of the day during the summer months between 2009-2016.[10] Temperature data from the day in question are also presented, as temperature is a useful indicator of solar radiation (a key input for ozone production), with temperatures in excess of 31°C typically associated with ozone concentrations in excess of 75 ppb in the eastern LFV (Doerksen, pers. comm.).

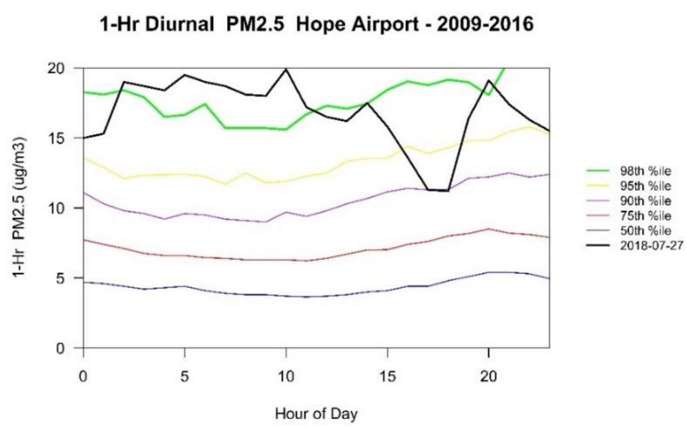
Information from these plots can be used to determine if ozone and $PM_{2.5}$ levels on the day in question were historically high (e.g. equal to or greater than 99% of measurements in previous years) compared to the past several years and/or showed a different diurnal profile than otherwise expected (such as peak ozone concentrations occurring earlier or later in the day than normally found).

For percentile plots compared to 2017 ozone events, the reader is referred to the 2015-2017 Lower Fraser Valley Air Zone Report. Percentile plots compared to 2018 ozone events are provided in Figures III-1 to III-7 for Hope and Figures III-8 to III-13 for Mission. In all examples, historical levels of ozone and $PM_{2.5}$ were reached for at least part of the day. In some cases, sharp peaks were observed in $PM_{2.5}$ levels that were not otherwise attributable to local activities, such as on July 27, 2018 in Mission (Figure III-8)

[10] Note: Howe (2019) constructed percentile curves using ozone data collected from 2009-2018. In the current report, data from the summers of 2017 are excluded as they were both considered extreme wildfire seasons.

and Aug. 22, 2018 in Hope (Figure III-7). On July 28, 2018, $PM_{2.5}$ levels at Hope monotonically increased throughout the day to reach 99th percentile levels in the late evening (Figure III-3), although these levels were not excessively high (i.e. did not exceed the CAAQS level of 28 $\mu g/m^3$). Satellite images during this period (e.g. Figures II-1(e) and (f)) showed a layer of light haze over the region. An ozone-related advisory in place during this time also referenced the presence of a layer of wildfire smoke over the south coast that had likely resulted from distant wildfires in Eurasia and Alaska, and a bog fire in Richmond. Although not as obvious as other examples, the ozone event from Jul. 27-30, 2018 and including Jul. 28, 2018 met the criteria for "wildfire-influenced" used in these analyses.





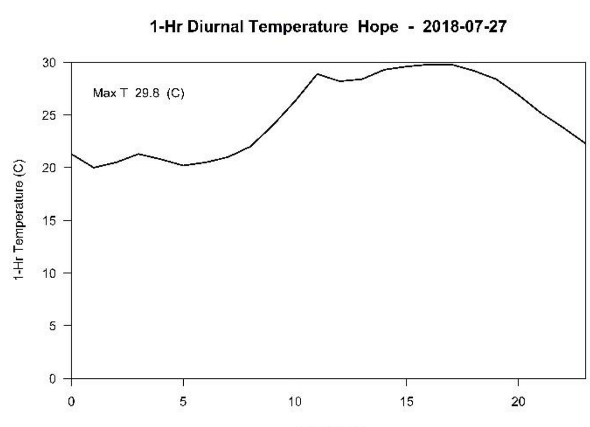


Figure III-1. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Hope Airport, July 27, 2018.

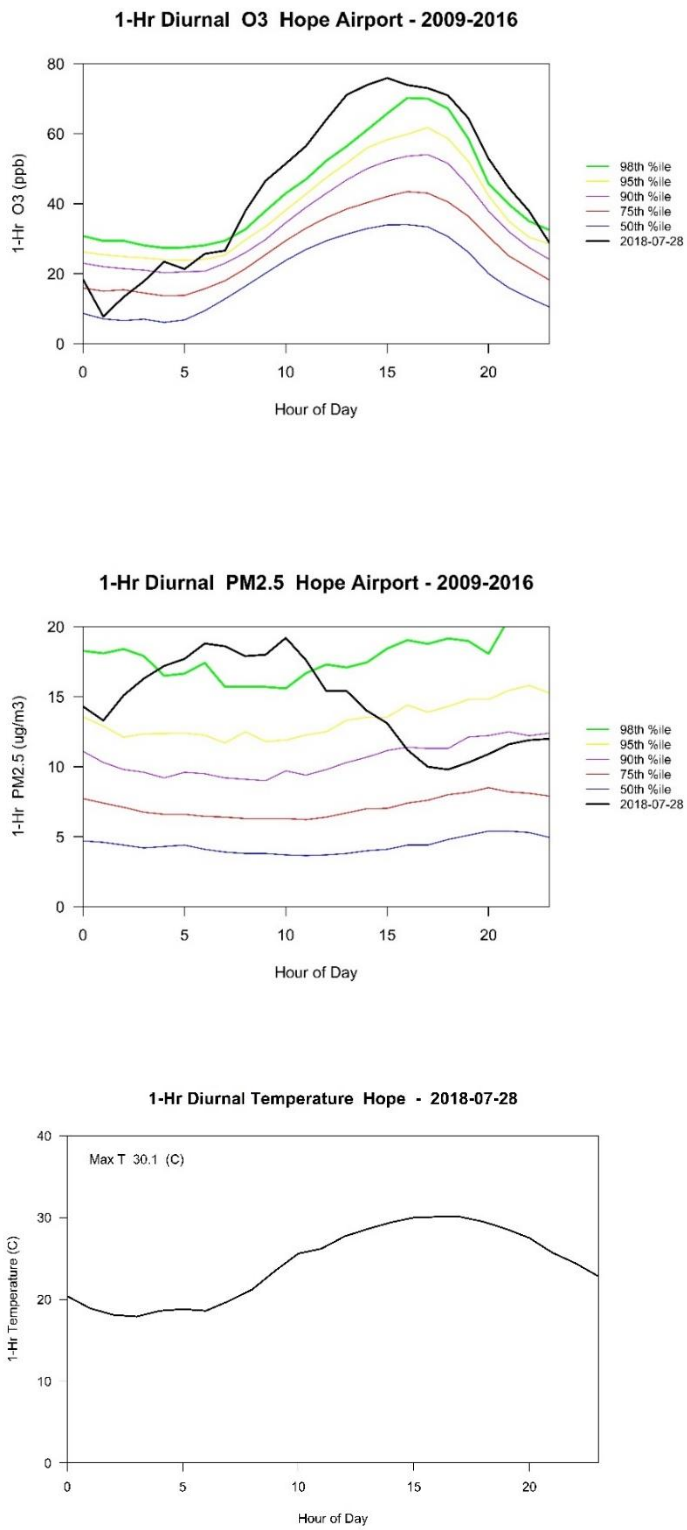
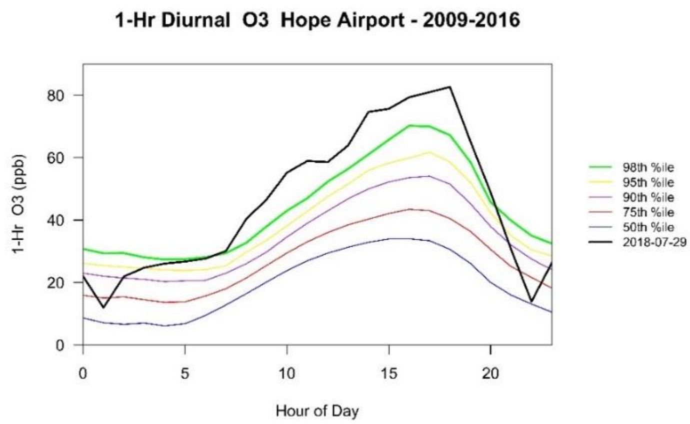
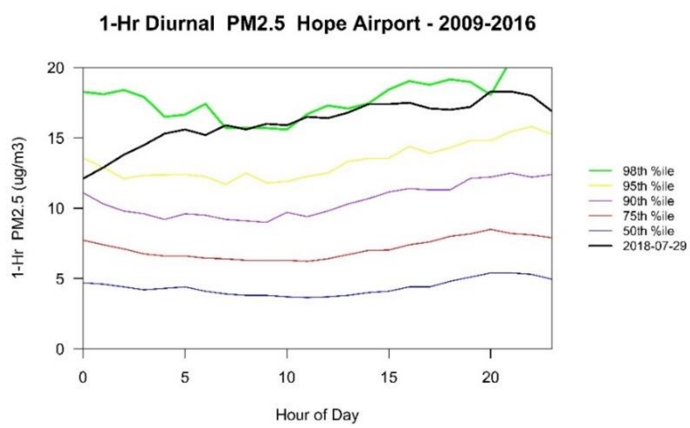


Figure III-2. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Hope Airport, July 28, 2018.





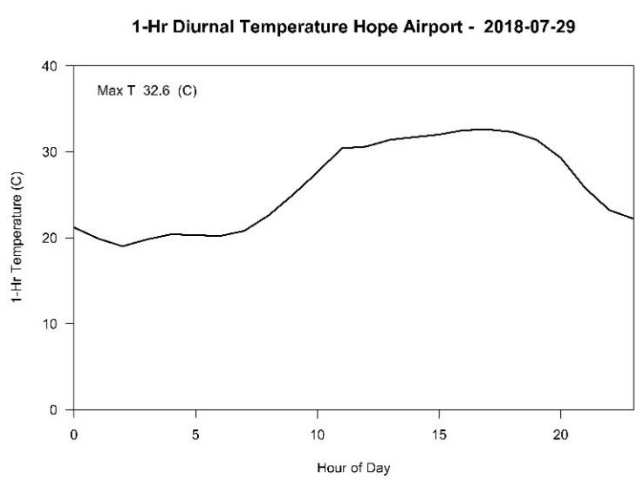
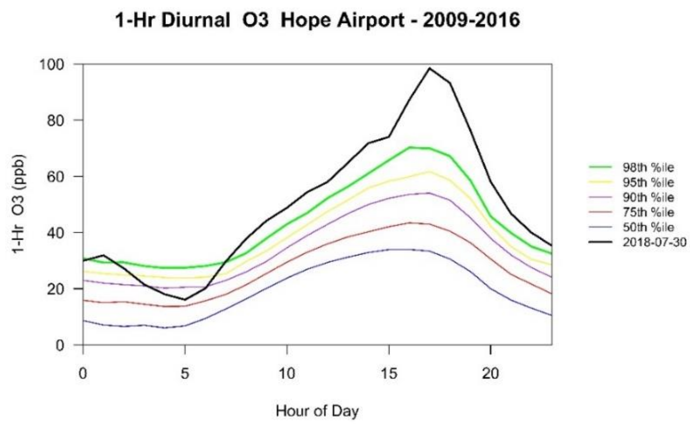
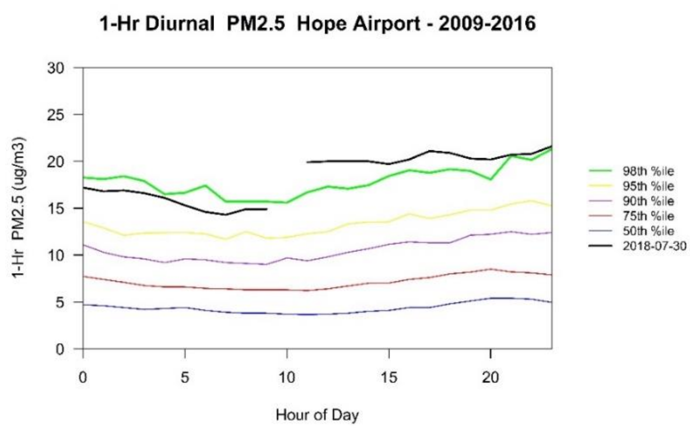


Figure III-3. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Hope Airport, July 29, 2018.





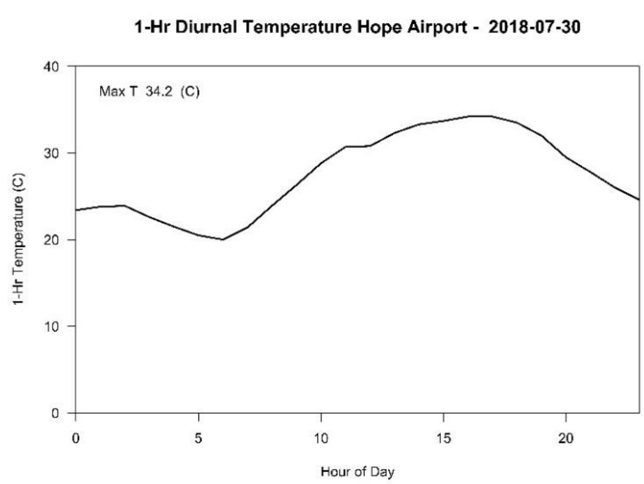
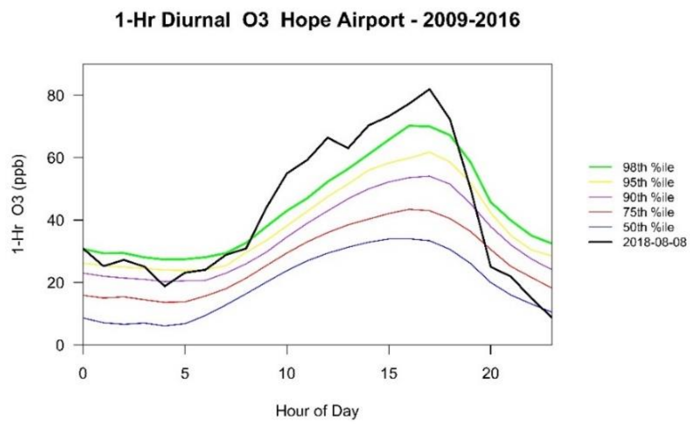
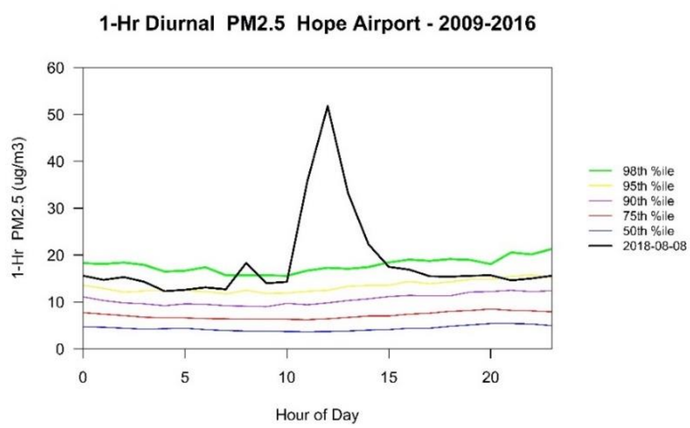


Figure III-4. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Hope Airport, July 30, 2018.





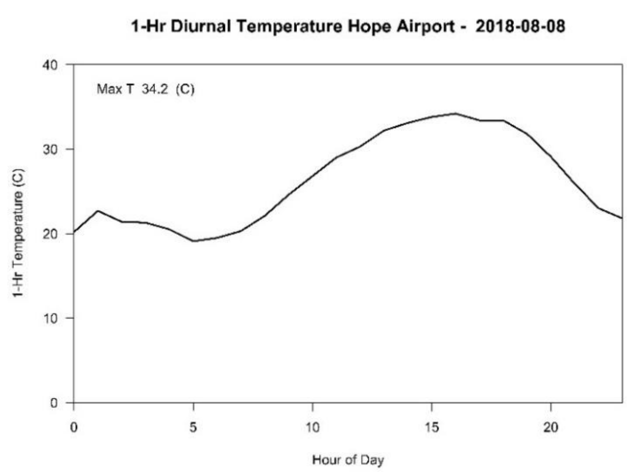
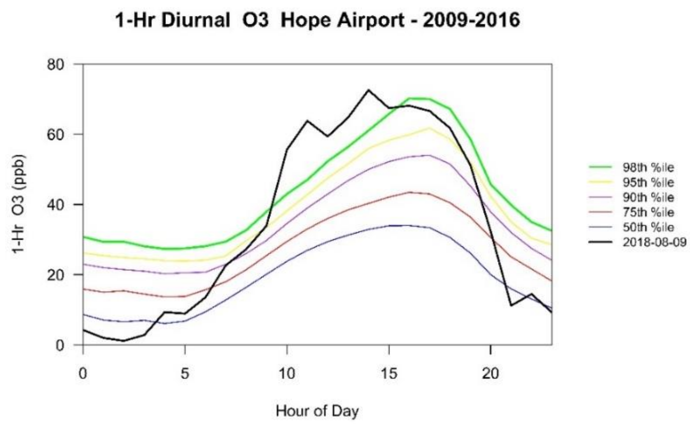
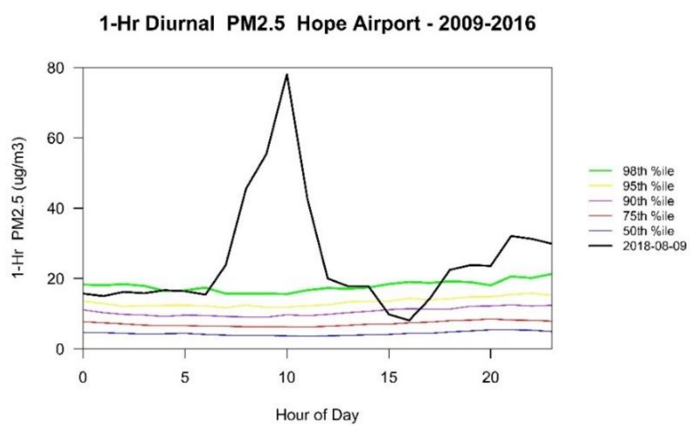


Figure III-5. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Hope Airport, August 8, 2018.





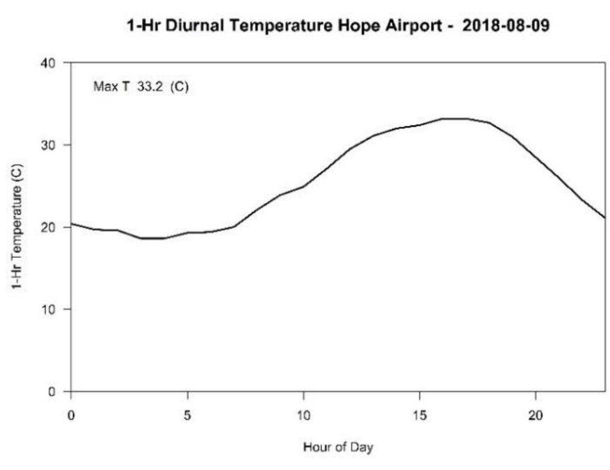
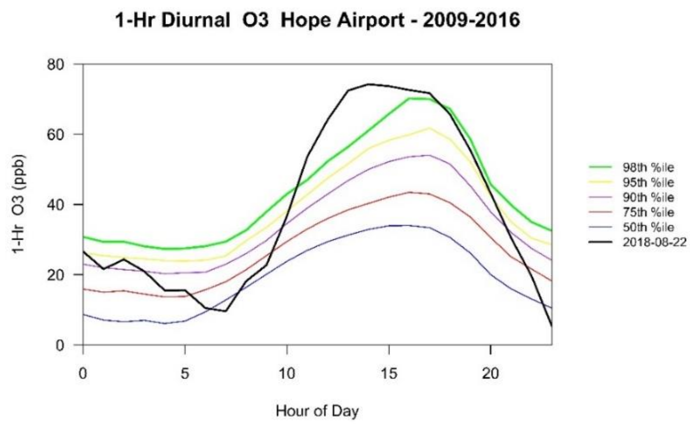
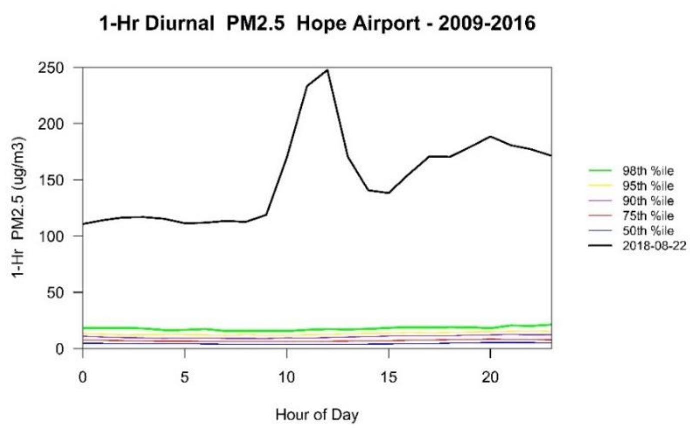


Figure III-6. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Hope Airport, August 9, 2018.





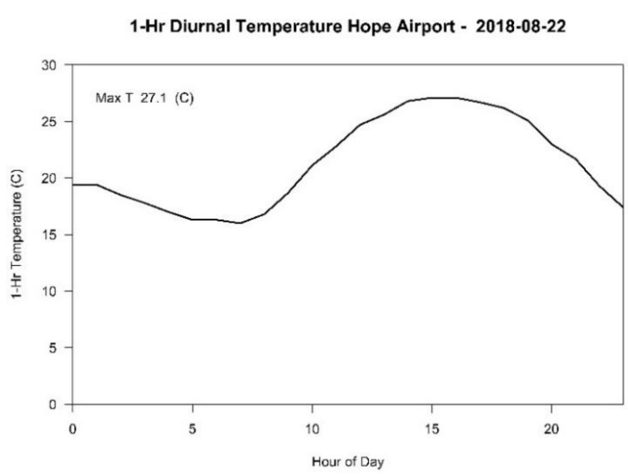
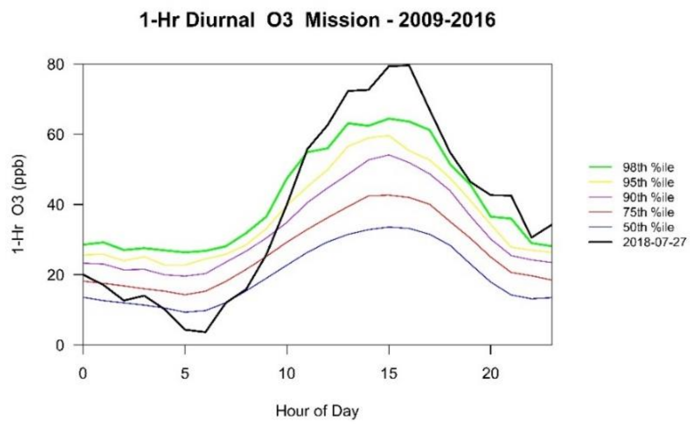
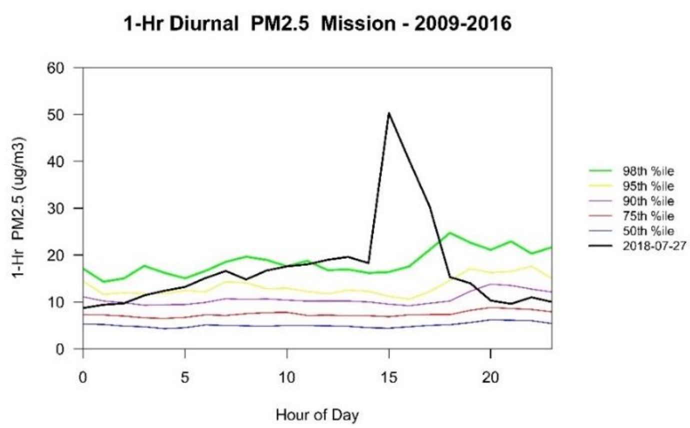


Figure III-7. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Hope Airport, August 22, 2018.





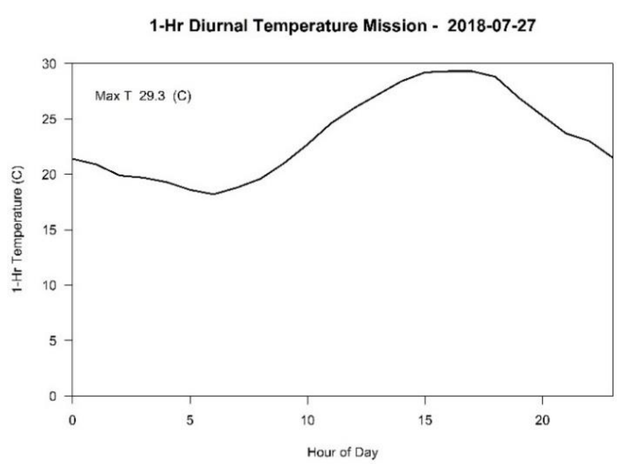
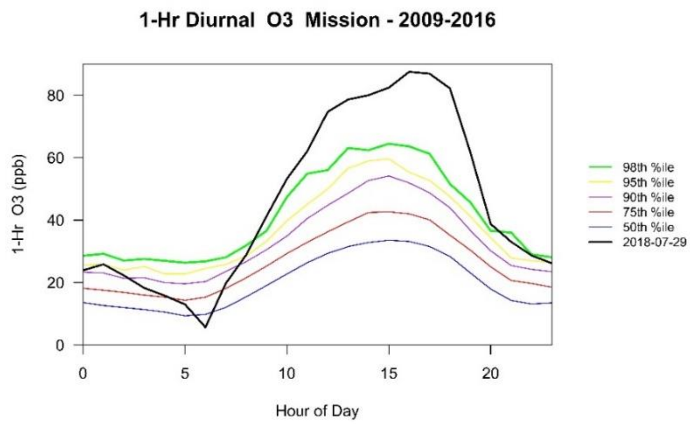
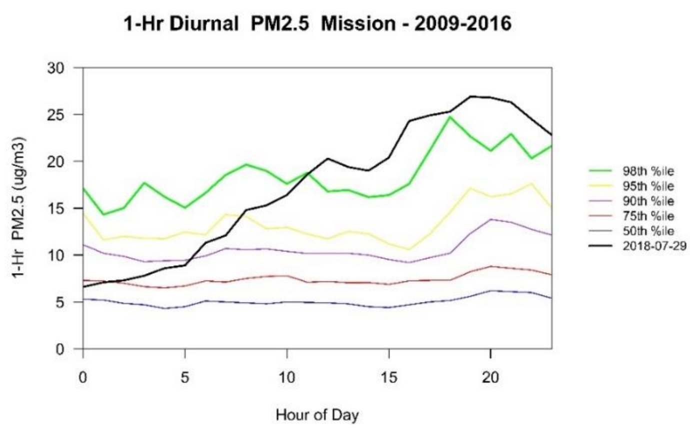


Figure III-8. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Mission Works Yard, July 27, 2018.





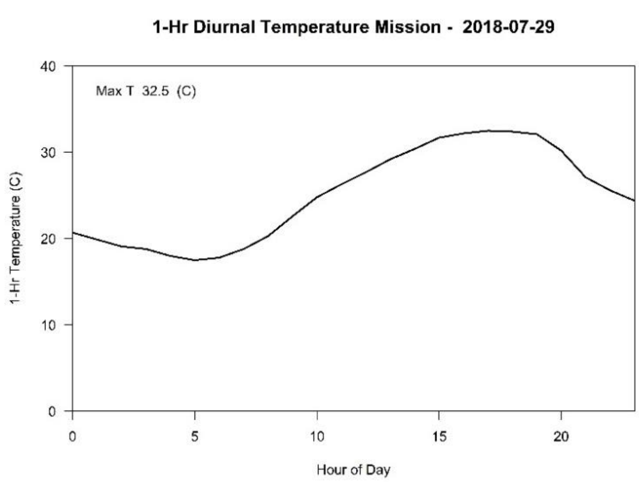


Figure III-9. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Mission Works Yard, July 29, 2018.

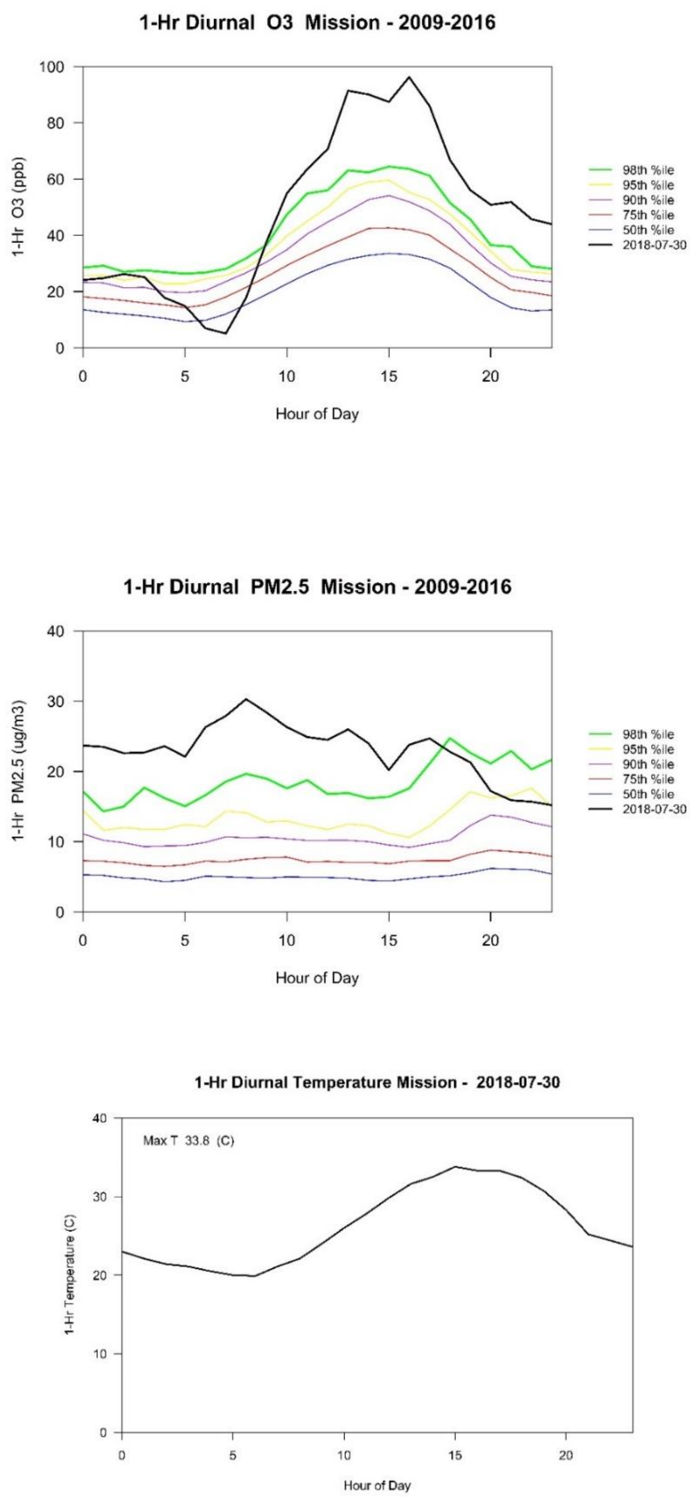
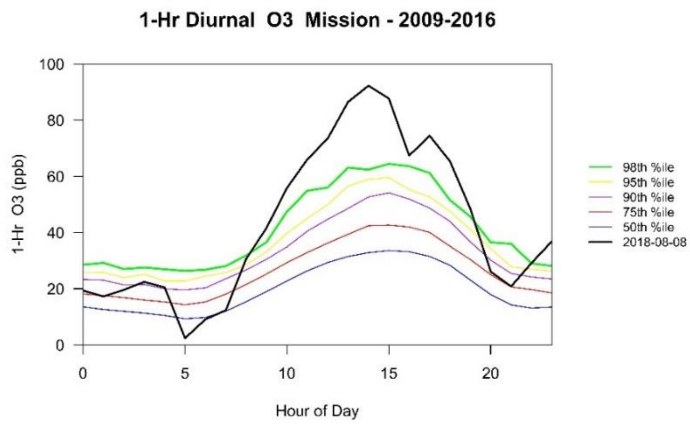
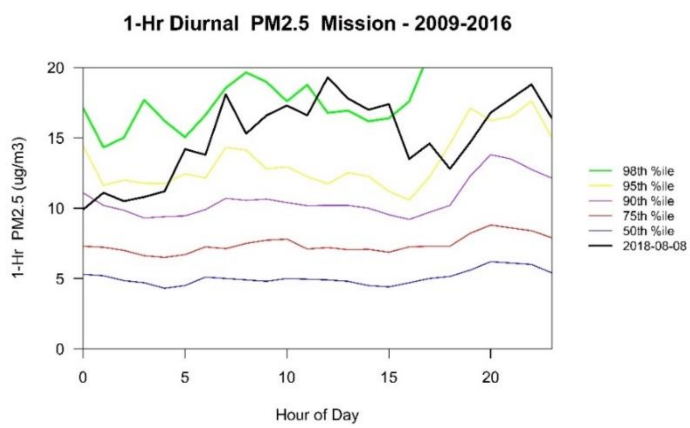


Figure III-10. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Mission Works Yard, July 30, 2018.





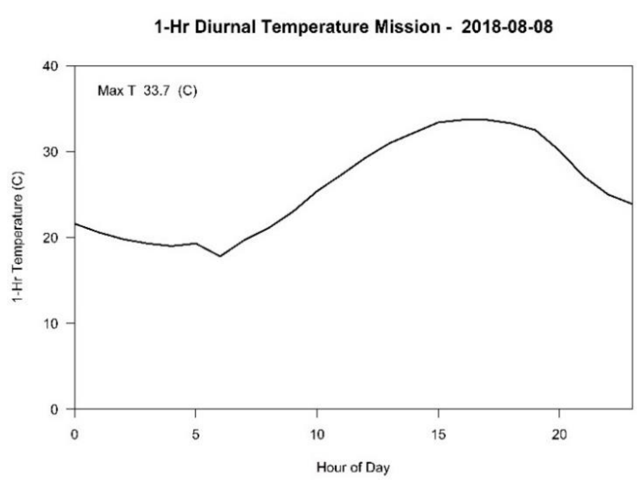
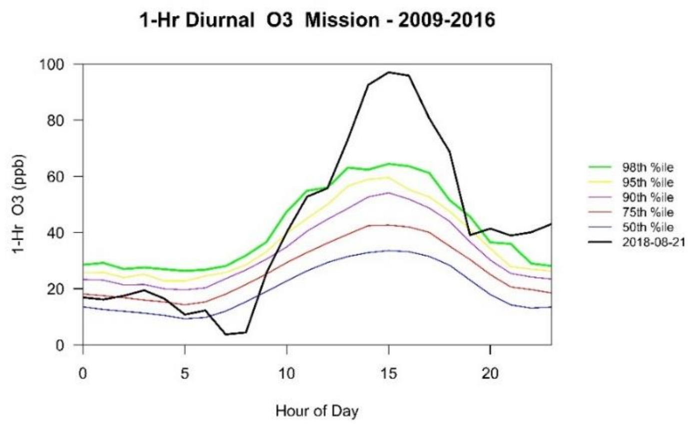
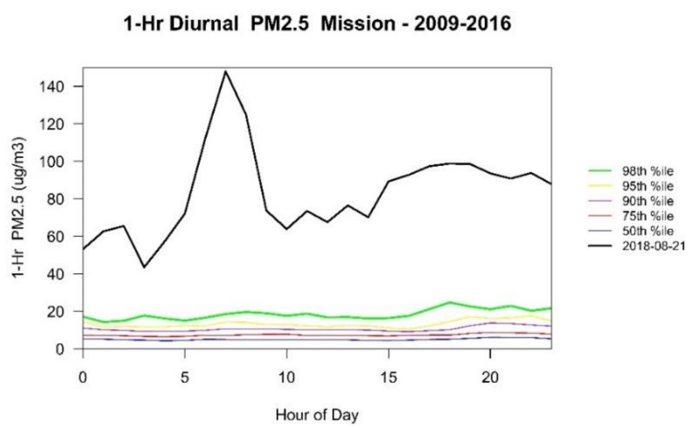


Figure III-11. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Mission Works Yard, August 8, 2018.





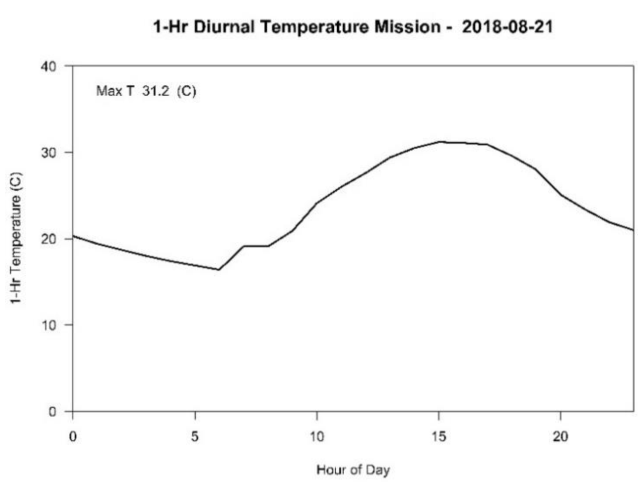
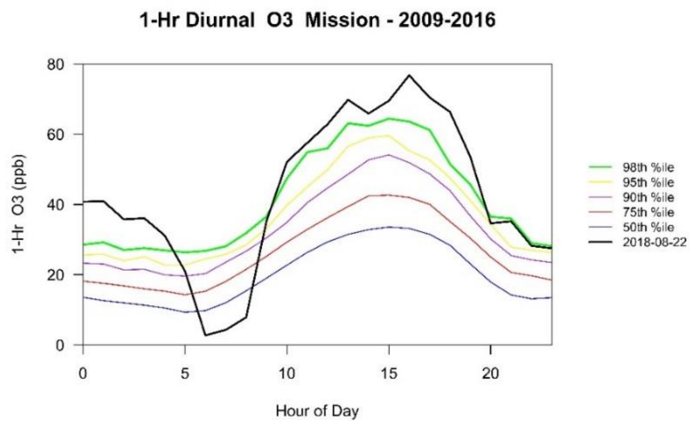
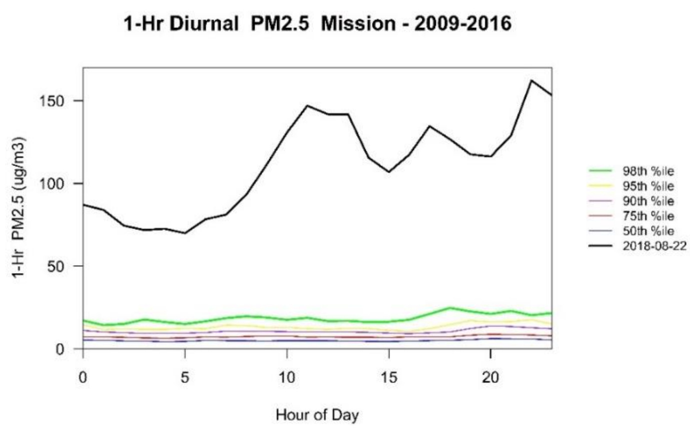


Figure III-12. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Mission Works Yard, August 21, 2018.





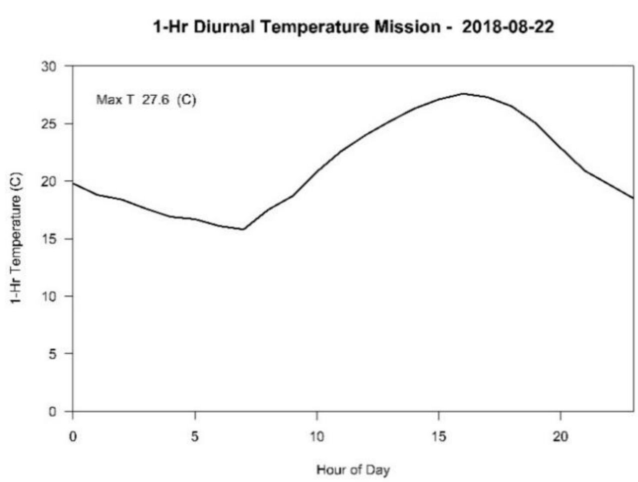


Figure III-13. Historical plots of ozone (upper) and $PM_{2.5}$ (middle) concentrations and plot of temperature (lower) at Mission Works Yard, August 22, 2018.