Introduction

This is the second annual air quality report for the Southern Interior 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

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 Southern Interior 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.

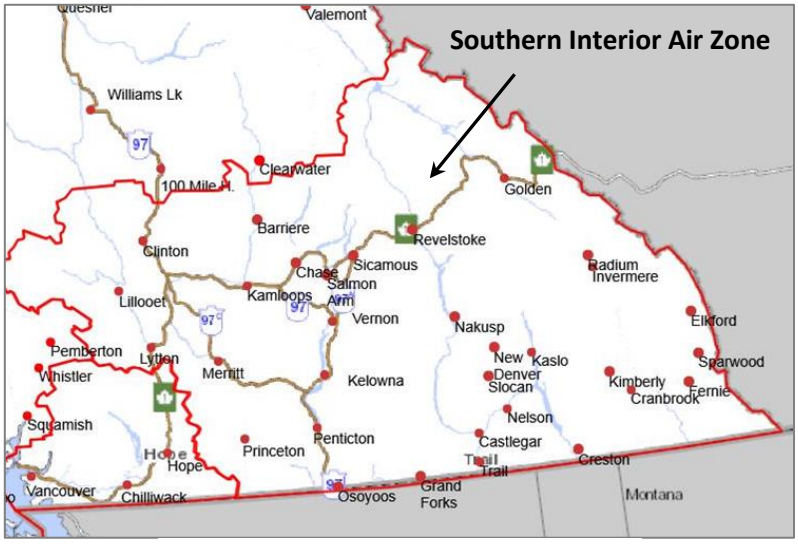

Figure 1. Southern Interior Air Zone.

Table 1. Air zone management framework for ground-level ozone and $PM_{2.5}$. The CAAQS define the upper threshold, separating the "red" and "orange" management levels.

Management Level	O_3 (ppb)		$PM_{2.5}$ – Annual ($\mu g/m^3$)		$PM_{2.5}$ - 24h ($\mu g/m^3$)	
	2015	**2020**	**2015**	**2020**	**2015**	**2020**
Red	Actions for Achieving Air Zone CAAQS					
Threshold (CAAQS)	63	62	10	8.8	28	27
Orange	Actions for Preventing CAAQS Exceedance					
Threshold	56		6.4		19	
Yellow	Actions for Preventing Air Quality Deterioration					
Threshold	50		4		10	
Green	Actions for Keeping Clean Areas Clean					

Ozone Levels

Ozone measurements in the Southern Interior Air Zone are summarized in Figure 2. Concentrations ranged from 48 ppb in Nelson to 59 ppb in Kelowna.[1] All sites were below the national standard of 63 ppb.

Trends in ozone levels are shown in Figure 3.[2] Concentrations have generally remained below the level of the national standard throughout this period. An exception is Kelowna in 2012, when Siberian wildfire smoke contributed to higher ozone concentrations in the Southern Interior.[3]

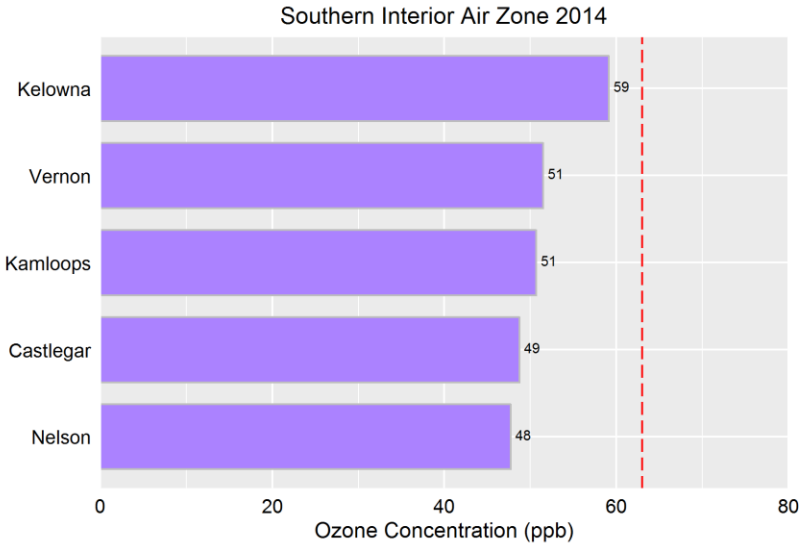

Figure 2. Ozone concentrations in the Southern Interior Air Zone, based on annual 4th highest daily 8-hour maxima, averaged over 2012-2014. Red dashed line identifies the CAAQS of 63 ppb.

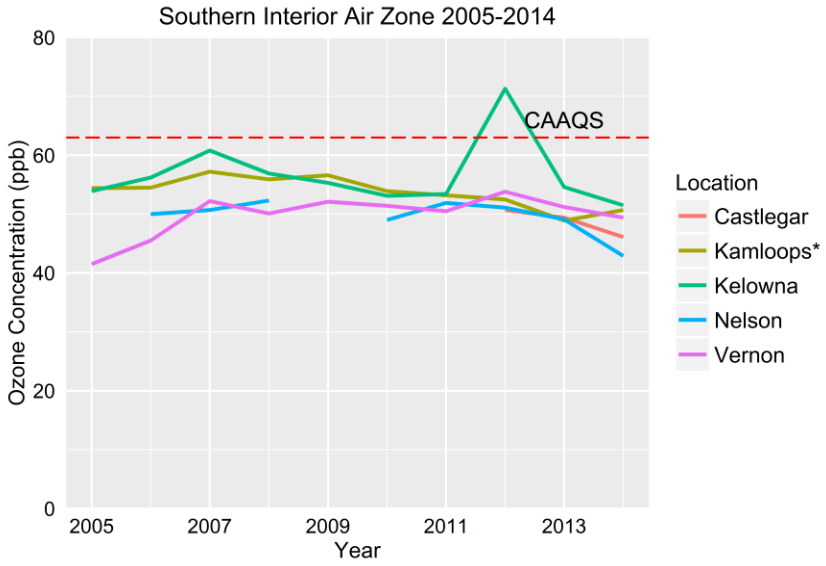

Figure 3. Trends in ozone concentrations (2005-2014), based on annual 4th highest daily 8-hour maxima for a single year. Red dashed line identifies CAAQS of 63 ppb. Asterisk (*) flags combined dataset from multiple sites in Kamloops.

[1] Concentrations based on 4th highest daily 8-hour maximum, averaged over three years (2012-2014).
[2] Concentrations based on 4th highest daily 8-hour maximum, averaged over a single year.
[3] Teakles, A.D., So, Rita, 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.

$PM_{2.5}$ Levels

$PM_{2.5}$ refers to inhalable particles up to 2.5 micrometres in diameter. $PM_{2.5}$ measurements are summarized in Figure 4. A distinction is made between data collected using the new Federal Equivalent Method (FEM) technology and the older TEOM instruments that are being phased out. The FEMs are the preferred instrument as they provide a more complete measure of $PM_{2.5}$ than the TEOMs.

Daily concentrations (upper plot) ranged from 12 to 23 µg/m^3.[4] All sites achieved the national standard of 28 µg/m^3. Annual concentrations (lower plot) ranged from 3.9 to 8.6 µg/m^3.[5] All monitoring sites achieved the national standard of 10 µg/m^3.

Trends in annual mean concentrations between 2005 and 2014 are shown in Figure 5 for a subset of these sites.[6] A shift to higher reported concentrations is seen with the change from TEOM to FEM instruments from about 2010 onward. However, all monitoring sites remained below the CAAQS level.

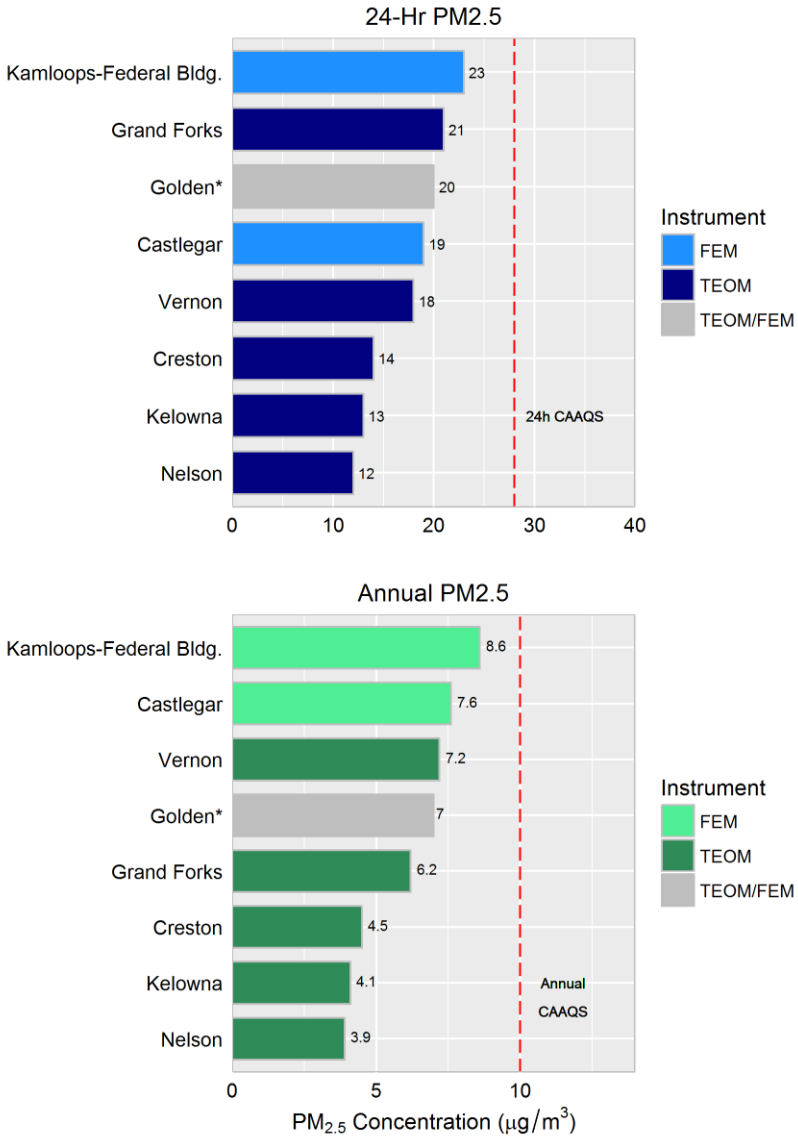

Figure 4. $PM_{2.5}$ concentrations in Southern Interior Air Zone. Upper plot based on 24-hour concentration (annual 98th percentile, averaged over 2012-2014). Lower plot based on annual mean concentration (averaged over 2012-2014). Red dashed lines identify CAAQS of 28 µg/m^3 (upper plot) and 10 µg/m^3 (lower plot). Asterisk (*) flags combined dataset from multiple sites in Golden.

[4] Concentrations based on the annual 98th percentile of 24-hour values, averaged over three years (2012-2014).
[5] Concentrations based on the annual average of 24-hour values, averaged over three years (2013-2015).
[6] Concentrations based on the annual 98th percentile of 24-hour values over a single year.

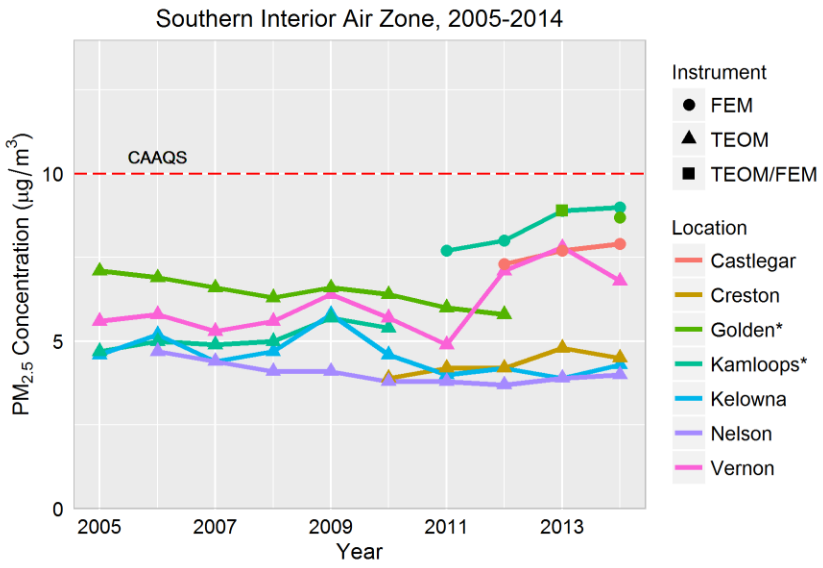

Figure 5. Trends in $PM_{2.5}$ concentrations (2005-2014), based on annual mean concentrations from a single year. The CAAQS value of 10 µg/m^3 is shown by the dashed line. $PM_{2.5}$ measurements prior to 2011 are reported at 25^{o}C and 1 atm. From 2011 onward, measurements are reported at local conditions.

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. This is done so that long-term management strategies are not developed on the basis of events that are beyond local or provincial control.

In the Southern Interior Air Zone, 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. The summer of 2012 was considered to be below average from a B.C. wildfire perspective, but smoke from Siberian wildfires had significant impacts on local air quality.[3] The summer of 2014 was characterized by hot, dry conditions and an above-average number of hectares burned within the province These fires created smoky conditions and periods of elevated $PM_{2.5}$ concentrations in several communities across B.C.

Table 2 summarizes the as-measured concentrations for ground-level ozone and the management levels after consideration of any TF/EE influences. As described in Appendix II, modelling and trajectory analyses indicate that Kelowna ozone measurements were likely affected by wildfire smoke during the summer of 2012. After exclusion of this data, the Southern Interior Air Zone is assigned a “yellow” management level on the basis of ozone concentrations in Kelowna. This indicates that ozone-related actions should focus on preventing further air quality deterioration.

Table 2. Summary of ozone concentrations as measured and air zone management levels for the Southern Interior Air Zone (based on 2012-2014 data).

Location	No. Valid Years	4th Highest Daily 8-hour Maxima		Air Zone Management Level
		As Measured	TF/EE Influences Removed	
Castlegar	2	49	49	Goal: Preventing Further Deterioration
Kamloops	2	51	51	
Kelowna	3	59	54	
Nelson	2	48	48	
Vernon	3	51	51	

Table 3 summarizes $PM_{2.5}$ concentrations as measured and with TF/EE influences removed for each monitoring site. The impact of removing wildfire influences was generally small, but did result in Golden being assigned a "yellow" management level for daily mean concentrations, rather than "orange". Overall, the air zone continues to be assigned an "orange" management level, indicating that $PM_{2.5}$-related activities may be prudent to prevent future CAAQS exceedances.

Table 3. Summary of $PM_{2.5}$ concentrations as measured and air zone management levels for the Southern Interior Air Zone (based on 2012-2014 data). Asterisk (*) flags combined dataset from multiple sites in Golden.

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	
Castlegar	FEM	3	19	19	7.6	7.5	Goal: Preventing CAAQS Exceedance
Creston	TEOM	3	14	13	4.5	4.4	
Golden*	TEOM/ FEM	3	20	19	7	6.9	
Grand Forks	TEOM	3	21	20	6.2	6.1	
Kamloops	FEM	3	23	22	8.6	8.5	
Kelowna	TEOM	3	13	12	4.1	4.1	
Nelson	TEOM	3	12	12	3.9	3.9	
Vernon	TEOM	3	18	17	7.2	7.2	

Actions to Protect Air Quality

The reduction of smoke-related $PM_{2.5}$ emissions has been a priority in a number of communities across the Southern Interior Air Zone for several years. Strategies and actions to reduce $PM_{2.5}$ emissions have been documented in local airshed plans that have been developed and implemented for the Central Okanagan Regional District,[7] City of Kamloops,[8] the Boundary airshed,[9] and Merritt.[10] Golden is host to an active air quality committee.[11]

Between 2012-2014, wood stove change-out programs were supported in the Regional Districts of Kootenay-Boundary, Central Kootenay and Okanagan-Similkameen as well as in Kimberly, Cranbrook, Golden and the Nicola Valley to encourage residents to change out their older, smoky wood stoves for low-emission appliances.

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.regionaldistrict.com/media/217275/RDCO_2015_Clean_Air_Strategy_Final_DRAFT_2015_02_03_final.pdf

[8] http://www.kamloops.ca/environment/pdfs/13-05-AirshedManagementPlan.pdf

[9] http://www.grandforks.ca/air/aqmplans/GrandForksAQMP-Oct22.pdf

[10] http://www.env.gov.bc.ca/epd/bcairquality/reports/pdfs/merritt_aqmp.pdf

[11] http://www.goldenairquality.ca/

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 are emitted from wildfires, including $PM_{2.5}$ and gases such as nitrogen oxides and volatile organic compounds (VOCs) 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 $PM_{2.5}$ levels. Criteria used to flag and evaluate wildfire-influenced data included the following:

- 24-hour $PM_{2.5}$ concentrations exceeded the CAAQS level of 28 $\mu g/m^3$ or 8-hour daily maximum ozone concentrations exceeded the CAAQS level of 63 ppb between May and September, and
- Wildfires of interest were identified based on data from B.C. Wildfire Management Branch,
- Wildfire smoke advisories had been issued by the Ministry of Environment & Climate Change Strategy during the period of interest,
- MODIS satellite images indicated smoke impacts over the region,
- Back-trajectory analyses indicate that air parcel over area may have passed over wildfires,
- Multiple monitoring sites in the area of concern exhibited similar air quality characteristics, suggesting a common source or contributing source, and/or
- Modelling studies identify ozone enhancements due to wildfire smoke.

Wildfire-influenced data were excluded from the calculation of air zone management levels. A description of the affected data is provided in Appendix II.

Appendix II – Wildfire-influenced data in the Southern Interior Air Zone

Ozone and $PM_{2.5}$ data from 2012-2014 for the Southern Interior Air Zone were evaluated based on the criteria set out in Appendix I for TF/EE influences.

Wildfire influences on ozone concentrations at Kelowna were flagged on the following basis:

- Elevated ozone and $PM_{2.5}$ levels on July 10-12 and August 13-14, 2012 (see Table II-1).
- Modelling study by Teakles et al. (2017) that tracked a wildfire plume from Siberia to the Pacific Northwest on July 6-10, 2012, and estimated an resultant enhancement of ozone levels in the Southern Interior by about 15 ppbv between July 6-9, 2012.
- Back-trajectory analyses by Environment and Climate Change Canada (see Figure II-1) that suggest that air arriving over the Kelowna area on August 13, 2012 could have originated in eastern Siberia.

Table II-1. Highest daily 8-hour maximum ozone concentrations in Kelowna from 2012 and associated $PM_{2.5}$ concentrations.

Date	No. Hrs	Daily 8-hour Ozone (ppb)	1-hour $PM_{2.5}$ ($\mu g/m^3$)	24-hour $PM_{2.5}$ ($\mu g/m^3$)
2012-08-13	24	86.1	42	17
2012-08-14	24	84.2	25	11
2012-07-10	24	74.2	30	10
2012-07-12	24	71.3	17	11
2012-05-15	24	58.8	9	6
2012-07-11	24	58.2	29	9
2012-05-14	24	58.0	16	7
2012-08-19	24	57.3	14	8
2012-07-13	24	57.1	18	12
2012-08-17	24	56.8	15	7

Exclusion of wildfire-influenced ozone data from July 10 and 12 and August 13-14, 2012 yields an annual 4th highest ozone concentration of 57.3 ppb. For the 2012-2014 reporting period, the three-year average concentration is therefore adjusted 59 to 54 ppb for Kelowna and the site-specific management level changed from “orange” to “yellow”.

Wildfire-influenced $PM_{2.5}$ data are summarized in Table II-2. Affected days coincided with or immediately preceded periods during which a wildfire-related air quality advisory had been issued by the Ministry of Environment & Climate Change Strategy. This data was excluded from the calculation of air zone management levels for $PM_{2.5}$ and resulted in minor changes to the air zone management levels for individual sites, but did not affect the overall air zone management level.

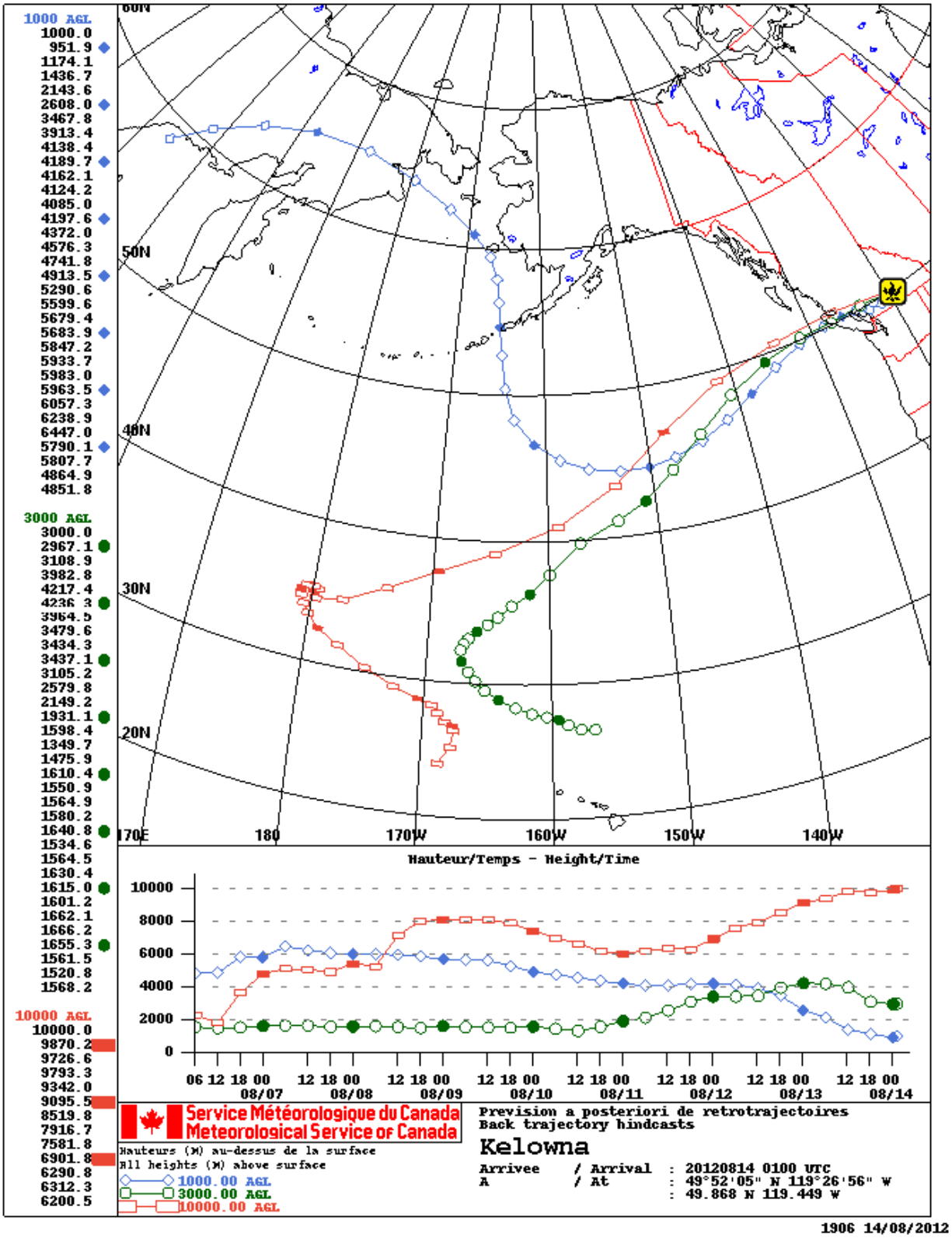

Figure II-1. Back-trajectory hindcasts for Kelowna, August 13, 2012 (August 14, 2012 UTC).

Table II-2. TF/EE-influenced $PM_{2.5}$ data.

Location	Date	24-Hour $PM_{2.5}$ ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?
Kamloops Federal Building	2012-07-07	32.6	Siberian smoke
Kamloops Federal Building	2014-07-16	61.4	Y
Vernon Science Centre	2014-07-16	37.7	Y
Kamloops Federal Building	2014-07-17	53.5	Y
Vernon Science Centre	2014-07-17	37.6	Y
Creston PC School	2014-07-18	39.8	Y
Castlegar Zinio Park	2014-07-19	34.4	Y
Creston PC School	2014-07-19	48.4	Y
Kamloops Federal Building	2014-08-06	28.2	Y
Castlegar Zinio Park	2014-08-07	34.5	
Castlegar Zinio Park	2014-08-08	29.6	Y
Grand Forks City Hall	2014-08-10	42	
Grand Forks City Hall	2014-08-11	33.8	Y
Grand Forks City Hall	2014-08-12	37.8	Y
Kelowna College	2014-08-12	32.2	Y
Vernon Science Centre	2014-08-12	29.5	Y