Fort McMurray Reentry

PRELIMINARY AIR QUALITY DATA

Alberta Government

About this document:

This technical document was prepared to provide information on particulate matter impacts on air quality during re-entry into an urban area after it was severely impacted by wildfire. The information provided in this report is preliminary; it does not provide a comprehensive assessment of all airborne contaminants, a neighborhood scale assessment, nor information about long-term livability of the impacted urban area.

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Statement of Availability:

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Introduction

Alberta Health (AH) retained Treissman Environmental Consulting Inc. and Millennium EMS Solutions Ltd. (MEMS) to support in their effort to assess the potential risk to human health associated with the Horse River Wildfire.

The purposes of this memo are to review particulate concentrations during specific episodes in the May 30 to June 8, 2016 period and to examine data from the AEP mobile air monitoring lab (MAML) and nearby fixed monitoring stations to determine if any changes in particulate ($PM_{2.5}$) concentrations resulted due to the reentry of people into Fort McMurray after the fire.

Staged re-entry

Staged re-entry took place in Fort McMurray as follows after the wildfire (zones are indicated in Figure 1):

- Zone 1 – June 1, 2016;

- Zone 2 – June 2, 2016;

- Zone 3 and Zone 4a – June 3, 2016; and

- Zone 4b – June 4, 2016.

An air quality advisory was in place for Fort McMurray and surrounding areas during this time, and re-entry was voluntary.

Episodes exceeding the ambient air quality guideline

$PM_{2.5}$ episodes above the 80 µg/m^3 Alberta Ambient Air Quality Guideline (AAQG) for the time period between May 30 to June 9, 2016, coinciding with the reentry of Fort McMurray residents, were examined. $PM_{2.5}$ data were evaluated for the following air monitoring stations (station locations are indicated in Figure 1):

- $PM_{2.5}$ E-BAM Stations: Courthouse and Keyano College/REOC;

- Wood Buffalo Environmental Association (WBEA) Permanent stations: Patricia McInnes (AMS06) and Athabasca Valley (AMS07); and

- MAML (Mobile) Labs: All MAML locations are combined in each figure into single data series labelled MAML. Lab locations plotted are Karl A Clark Elementary, Ecole McTavish, Parsons Creek Access, Thickwood, Wood Buffalo Community, Beacon Hill, Abasand, Waterways Community, and Gregoire.

The $PM_{2.5}$ data indicate that a number of episodes occurred in the period between May 30 to June 9, 2016 (Figure 4); and most frequently at AMS06 (Patricia McInnes Air Monitoring Station). High $PM_{2.5}$ concentrations were observed on June 1, 2, and 8 at AMS06, occurring shortly after midnight. An episode was also observed at Keyano College and AMSO7 (Athabasca Valley Air Monitoring Station) between June 8 and June 9, 2016.

Episode May 31 - June 1

High $PM_{2.5}$ was measured at midnight at AMS06. No other stations recorded values above the AAQG. The 5-minute data indicate a large spike in concentration about an hour before midnight. Winds for a few hours were relatively steady from the S and SSW and light and support a hotspot fire source. A smaller broader peak was noted at AMS07 and the MAML site at Karl Clark School in the lower townsite.

No smoke was noted during this episode and the information available does not identify where smaller controlled fires or smoldering occurred, to correlate PM with a smoke source.

Episode June 2

Two distinct $PM_{2.5}$ maxima were observed at AMS06 just after midnight, associated with two distinct wind direction shifts and two distinct periods of light winds. High concentrations were not observed at other stations. Because of the wind direction shifts, we don't know precisely the source direction. One possibility is that it was associated with a source S to SE of the station. The other is a source W-NW of the station. However, the light winds would be subject to terrain effects and flows along valleys, making interpretation of a source location difficult without a more detailed assessment.

During the June 2 event, smoke smell was noted by WBEA staff and the observation was associated with a temperature inversion and fog. The fog would have formed around the smoke particles in the air. The measurement technology heats the air before particulate mass is weighed so the values in the figure are "true" particulate, not water plus particulate.

Episode June 8

On June 8 just after midnight, high PM$_{2.5}$ at AMS06 was also observed with relatively high values of ammonia, THC and NMHC (N.B., ammonia, THC and NMHC are not shown in Figure 2). Winds were light from the NNW shifting to NW after the episode so it is possible that the first peak was associated with smoldering fires travelling from the north along the Athabasca Valley (although if that is the case, high concentrations should also have been observed at AMS07). It is also possible that higher concentrations could be associated with oil sands plant start-up; however, high concentrations of other gases were also present in higher concentration during the main fire event in May so the presence of these constituents in air does not imply an industrial source.

A second set of high concentrations were observed late evening on June 8 first at AMS06 and AMS07, with AMS07 peaks above the AAQG, and simultaneously at the Courthouse and Keyano College. Wind directions during this period were from the north (NNW-NNE) and speeds were moderate; a source north of the city is very likely, possibly associated with smoldering fires or plant start-up.

The first peak of the day at AMS06 was associated with higher concentrations than the second peak and could be the result of closer proximity to the source or the "concentrating" effect of lower wind speeds.

No smoke was noted during this episode and the information available at time of writing does not identify where smaller controlled fires or smoldering occurred, to correlate PM with a smoke source.

Local fire hotspots

A local fire map obtained from Natural Resources Canada (Figure 2) indicated fire hotspots remained unchanged between May 30 to June 9, 2016, with one active fire (>1000 ha) located approximately 10 km SW of the centre of Fort McMurray. During this time, firefighters were also working on smoldering fires north of the city but the locations were unknown (based on media reports).

Figure 3 from the US Forest Service shows an alternate hotspot image. The hotspots identified in Figure 3 are expected to be associated with industry start-up flaring.

Reentry comparisons

Reentry into Fort McMurray was staged (Figure 6). MAML measurements made during reentry are identified in Figure 7, along with measurements made at other fixed stations. Table 1 lists the specifics of MAML measurement times and locations and identifies the nearest fixed monitoring station for each reentry zone and time period. Figure 1 indicates where each location was for each timeframe.

Table 1 MAML Measurement Locations								
Period	Date	Start Time	End Time	Location	Lon.	Lat.	Reentry Zone	Closest E-BAM Stations
1	1-Jun-16	8:28	12:27	Karl A Clark Elementary	-111.358	56.71741	Zone 1	Athabasca Valley Courthouse
2	1-Jun-16	13:03	16:02	Ecole McTavish	-111.452	56.76155	Zone 2	Patricia McInnes
3	2-Jun-16	8:42	12:41	Parsons Creek Access	-111.45	56.77716	Zone 2	Patricia McInnes
4	2-Jun-16	13:14	16:13	Thickwood	-111.419	56.73149	Zone 3	Athabasca Valley Courthouse Patricia McInnes
5	3-Jun-16	8:36	11:35	Wood Buffalo Community	-111.464	56.72095	Zone 3	Patricia McInnes
6	3-Jun-16	12:22	14:21	Gregoire	-111.343	56.67465	Zone 4a	Keyano College
7	4-Jun-16	8:54	9:54	Beacon Hill	-111.363	56.69429	Zone 4b	Courthouse
7	4-Jun-16	11:20	12:20	Beacon Hill	-111.363	56.69429	Zone 4b	Keyano College
8	7-Jun-16	10:38	13:38	Abasand	-111.375	56.71029	Zone 4b	Athabasca Valley Courthouse
8	7-Jun-16	14:11	17:10	Waterways Community	-111.339	56.6985	Zone 4b	Athabasca Valley Courthouse

Tables 2 to 9 list PM$_{2.5}$ concentration measurements made at each reentry location by MAML and the corresponding measurements at fixed E-BAM stations. In making these comparisons, data from

EBAM stations have been adjusted from GMT to local time. Measurements from fixed stations nearest the MAML positions are highlighted in red text.

The tables also show the particulate 'loading" which has here been defined simply as the sum of the particulate measurements during the hours in which the MAML operated at each site. This was considered an appropriate approach compared to comparing hour by hour observations which could vary substantially during each period.

Of the 8 periods identified, MAML measurements were higher than the nearest fixed station measurements in 4 periods and lower than fixed measurements in 3 periods. In period 7, uncorrected E-BAM station measurements could not be used as determined by a relatively high proportion of negative values. On the basis of this simplified approach, it can't be said that concentrations measured by the MAML were definitively higher or lower than measurements at the nearest fixed stations, although 4 of 7 were higher.

If reentry activities had generated substantial additional dust in the PM$_{2.5}$ size range, and if the MAML lab was deployed to locations to capture that increased dust, then by ranking the measurements at all particulate stations, a pattern could emerge. The ranking results are shown in Table 10 for seven valid sets of measurements, with the highest concentration of all stations given a rank of 1. The average rank of 3.9 doesn't support an interpretation that substantial dust was generated by reentry, at least not in sufficient quantities to be observable in the MAML data. Reentry locations, based on MAML data, did not have higher PM$_{2.5}$ concentrations than other sites.

Additional interpretation could have been attempted, for example by examining observations at fixed stations before reentry began and by looking for a statistical increase in the measurements. This approach was not undertaken as it is not clear that substantial dust in the PM$_{2.5}$ size range would have been re-suspended by reentry activity. Smoulding fires are more likely to be the source of particulate matter.

Table 2 Period 1 measurements							
	MAML	E-BAM Stations				WBEA Permanent Stations	
	Karl A Clark Elementary	Courthouse	First Nations Health Centre	Keyano College/REOC	YMM Airport	Patricia McInnes (AMS06)	Athabasca Valley (AMS07)
6/1/2016 8:00	33.6	28	10	14	41	2.5	23.21
6/1/2016 9:00	25.4	23	5	10	16	3.08	21.51
6/1/2016 10:00	14.3	26	5	13	15	4.44	27.19
6/1/2016 11:00	6.0	18	3	8	9	3.86	22.54
"Loading"	79.3	95.0	23.0	45.0	81.0	13.9	94.5

Red text indicates closest fixed station to the MAML lab

Table 3 Period 2 Measurements							
	MAML	E-BAM Stations				WBEA Permanent Stations	
	Karl A Clark Elementary	Courthouse	First Nations Health Centre	Keyano College/REOC	YMM Airport	Patricia McInnes (AMS06)	Athabasca Valley (AMS07)
6/1/2016 13:00	3.7	-4	1	-2	9	2.52	2.72
6/1/2016 14:00	3.5	13	8	23	20	2.41	2.4
6/1/2016 15:00	3.3	16	2	-5	-3	2.17	2.22
"Loading"	10.5	25.0	11.0	16.0	26.0	7.1	7.3

Red text indicates closest fixed station to the MAML lab

Table 4 Period 3 Measurements							
	MAML	E-BAM Stations				WBEA Permanent Stations	
	Parsons Creek Access	Courthouse	First Nations Health Centre	Keyano College/REOC	YMM Airport	Patricia McInnes (AMS06)	Athabasca Valley (AMS07)
6/2/2016 9:00	12.2	15	6	12	6	2.44	11.22
6/2/2016 10:00	7.0	3	4	11	12	1.73	
6/2/2016 11:00		3	1	0	1	1.2	
6/2/2016 12:00	2.5	14	9	3	2	0.85	
"Loading"	21.7	32.0	19.0	26.0	20.0	5.0	

Red text indicates closest fixed station to the MAML lab

Table 5 Period 4 Measurements							
	MAML	E-BAM Stations				WBEA Permanent Stations	
	Thickwood	Courthouse	First Nations Health Centre	Keyano College/REOC	YMM Airport	Patricia McInnes (AMS06)	Athabasca Valley (AMS07)
6/2/2016 13:00	3.0	8	0	1	9	1.19	1.21
6/2/2016 14:00	3.6	3	6	9	4	1.13	0.5
6/2/2016 15:00	3.8	9	7	13	5	1.12	0.12
"Loading"	10.4	20.0	13.0	23.0	18.0	3.4	1.8

Red text indicates closest fixed station to the MAML lab

Table 6 Period 5 Measurements							
	MAML	E-BAM Stations				WBEA Permanent Stations	
	Wood Buffalo Community	Courthouse	First Nations Health Centre	Keyano College/REOC	YMM Airport	Patricia McInnes (AMS06)	Athabasca Valley (AMS07)
6/3/2016 9:00	5.0	3	1	5	0	1.7	3.3
6/3/2016 10:00	3.8	7	-4	6	2	0.9	2.3
6/3/2016 11:00	2.8	0	-3	-5	-2	1.0	1.4
"Loading"	11.6	10.0	-6.0	6.0	0.0	3.6	7.0

Red text indicates closest fixed station to the MAML lab

Table 7 Period 6 Measurements

	MAML	E-BAM Stations				WBEA Permanent Stations	
	Gregoire	Courthouse	First Nations Health Centre	Keyano College/REOC	YMM Airport	Patricia McInnes (AMS06)	Athabasca Valley (AMS07)
6/3/2016 12:00	2.2	0.0	6.0	3.0	1.0	1.4	0.3
6/3/2016 13:00	1.7	-3.0	-1.0	9.0	2.0	1.6	0.0
"Loading"	3.9	-3.0	5.0	12.0	3.0	3.0	0.3

Red text indicates closest fixed station to the MAML lab

Table 8 Period 7 Measurements

	MAML	E-BAM Stations				WBEA Permanent Stations	
	Beacon Hill	Courthouse	First Nations Health Centre	Keyano College/REOC	YMM Airport	Patricia McInnes (AMS06)	Athabasca Valley (AMS07)
6/4/2016 9:00	3.5	1.0	-1.0	-1.0	10.0	4.2	4.2
6/4/2016 10:00		4.0	2.0	7.0	1.0	2.4	3.8
6/4/2016 11:00	11.5	-1.0	4.0	-5.0	12.0	1.6	2.4
"Loading"	15.0	0.0	3.0	-6.0	22.0	5.7	6.6

Table 9 Period 8 Measurements

	MAML	E-BAM Stations				WBEA Permanent Stations	
	Ababsand/ Waterways Community	Courthouse	First Nations Health Centre	Keyano College/REOC	YMM Airport	Patricia McInnes (AMS06)	Athabasca Valley (AMS07)
6/7/2016 11:00	5.7	9	9	2	4	6.6	6.4
6/7/2016 12:00	4.2	8	4	26	10	8.7	4.7
6/7/2016 13:00	8.2	21	5	-1	2	6.5	6.3
6/7/2016 14:00	9.1	-1	6	26	23	7.9	13.8
6/7/2016 15:00	5.9	16	8	16	17	7.4	9.3
6/7/2016 16:00	11.8	9	13	2	4	5.9	8.3
"Loading"	44.8	62.0	45.0	71.0	60.0	43.1	48.8

Red text indicates closest fixed station to the MAML lab

Table 10 MAML "Loading" Comparison Ranking

Period	1	2	3	4	5	6	8	MAML Average
MAML Rank	4	5	3	5	1	3	6	3.9

MAML measurement comment

$PM_{2.5}$ data from 6 fixed location stations were available and have been reviewed since the main fire event: two WBEA stations in Fort McMurray, three E-BAM sites operated by AEMERA in the community and one E_BAM at the Fort McMurray airport. Data from these sites were analyzed beginning late April.

MAML lab data are available beginning about May 16 and numerous locations in the city and locale have now been sampled, including during reentry. Nonetheless, the value in the $PM_{2.5}$ data is limited because the longest monitoring duration at any one location is about 3-4 hours. As a result the MAML data have not resolved any peaks in concentration compared to the fixed monitors in the area which already provide reasonable spatial coverage. While "snapshots' of data at a specific location provide an indication of concentrations during very short periods, MAML measurements have not clearly provided additional information that could not have been derived from fixed stations.

In addition, the information, at time of writing, was not sufficient to determine whether reentry caused increased dust levels. That question cannot be answered by a comparison of MAML and fixed stations measurements. To make a more definitive statement, the following information would be required:

- Location of fire hotspots, smolders, and firefighting activity in the area, to identify the extent to which peaks are fire-caused
- Location of any smolders in the community
- Location, timing and level of vehicle/pedestrian activities associated with all re-entries into the various zones

Finally, a change in the mode of operation of MAML should be considered. Given that the MAML measures a range of air constituents similar to the WBEA stations, and that coverage of $PM_{2.5}$ is good around the community, the value may be in other measurements taken by the MAML. It is suggested that the MAML be deployed at locations relatively far from the two WBEA stations and their locations be fixed for several days at a time. For a start, measurements at Saprae Creek, well east of the city centre, should be conducted.
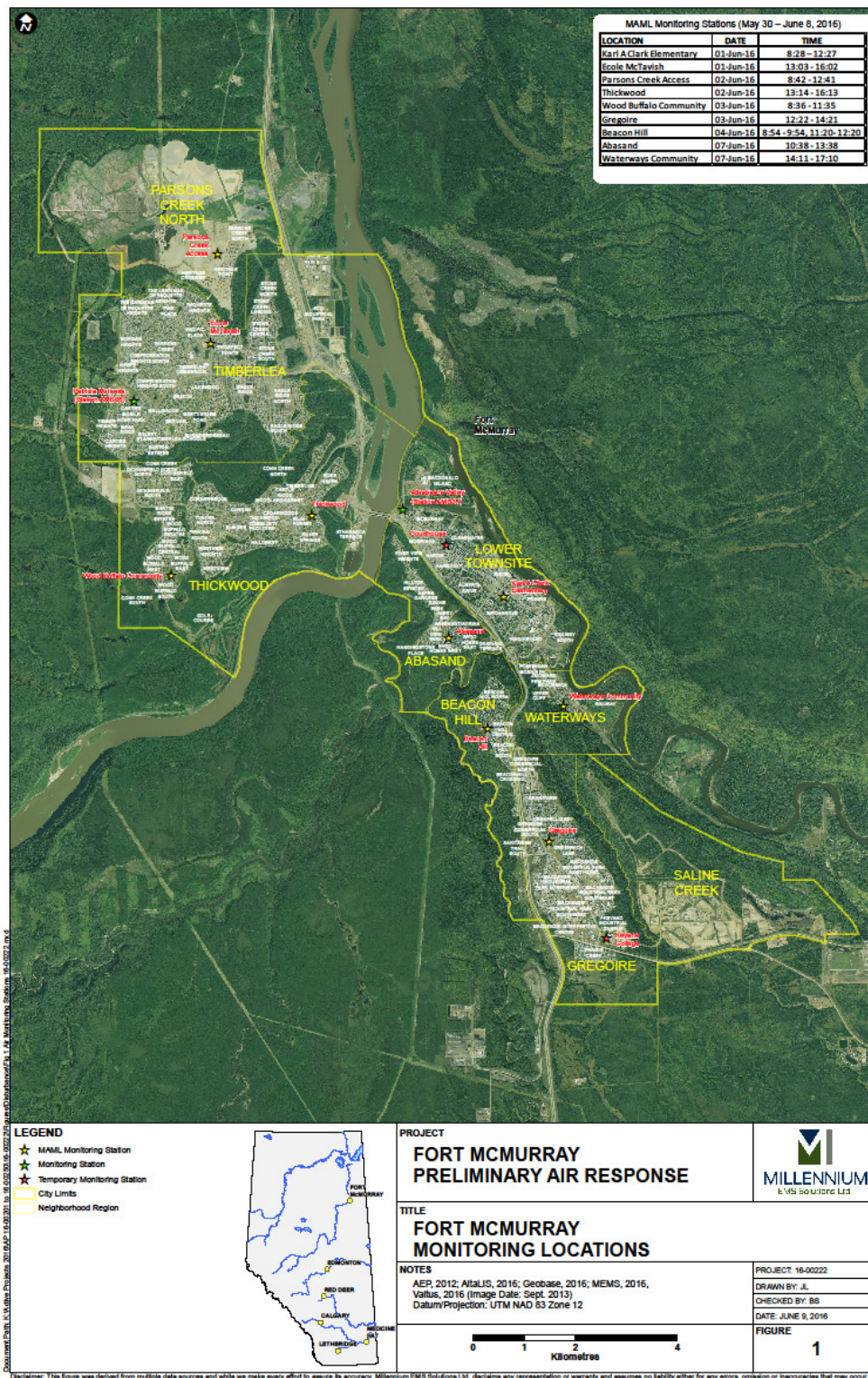
Figure 1: Measurement locations

Figure 2: Local fire hotspot locations – May 30 to June 9 (unchanged); Natural Resources Canada (http://cwfis.cfs.nrcan.gc.ca/interactive-map)
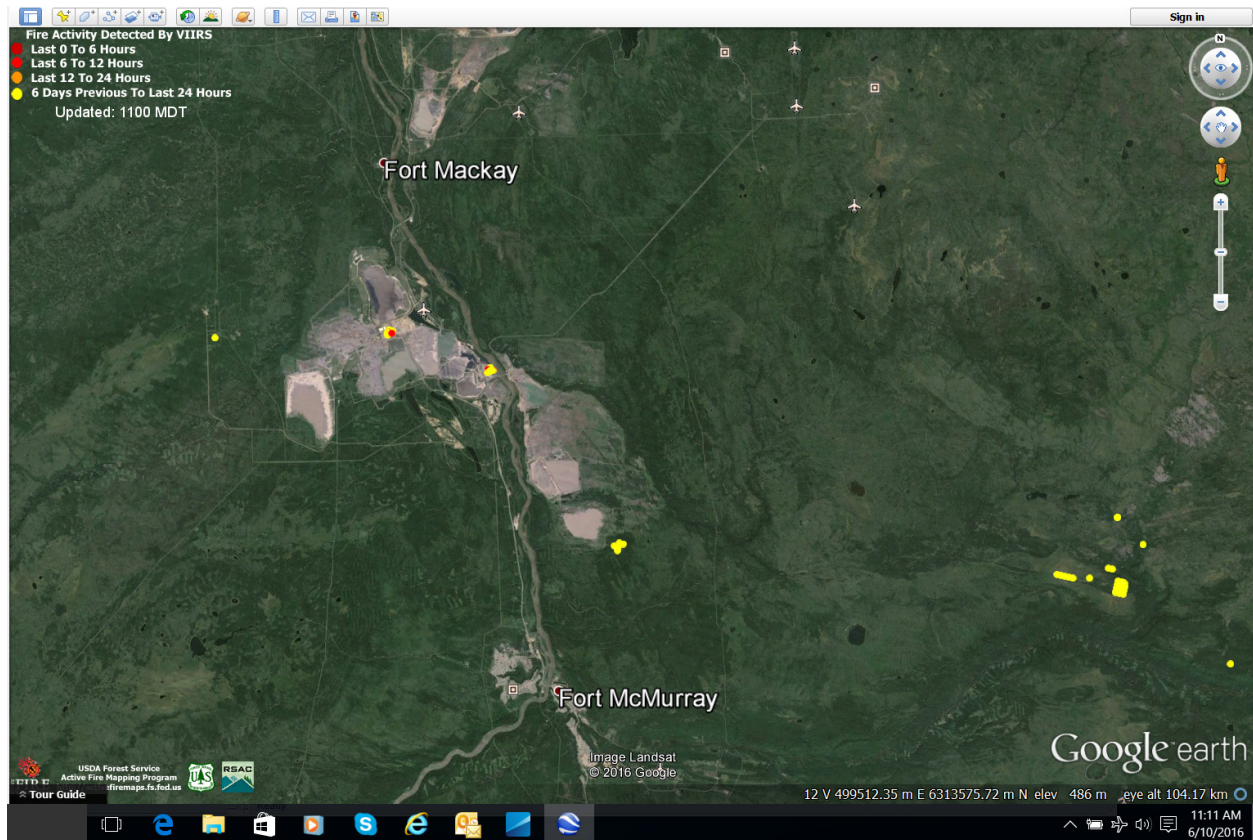
Figure 3: Hotspot locations 10 June 2016 (US Forest Services;
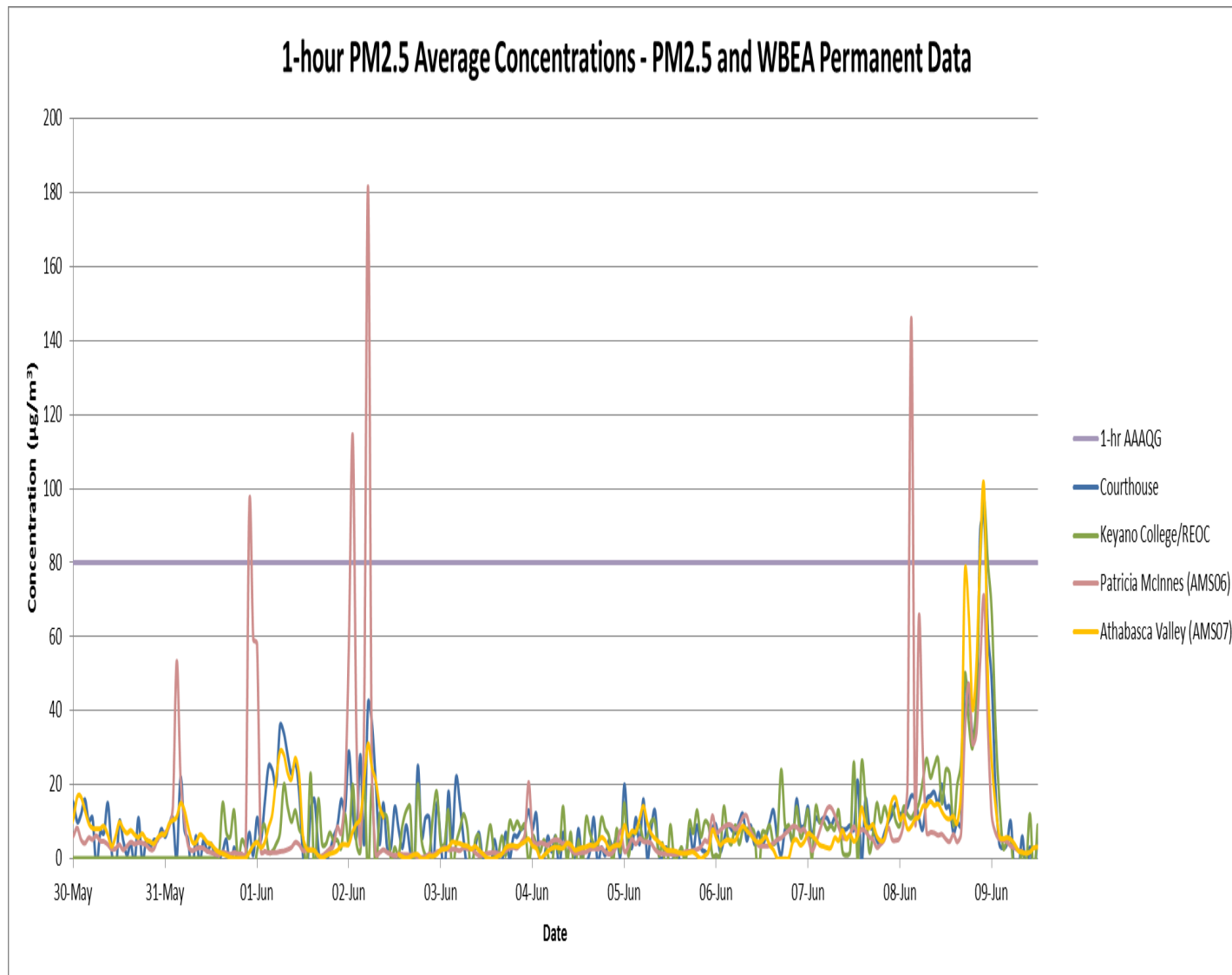http://activefiremaps.fs.fed.us/googleearth.php?sensor+viirs&extent=canada)

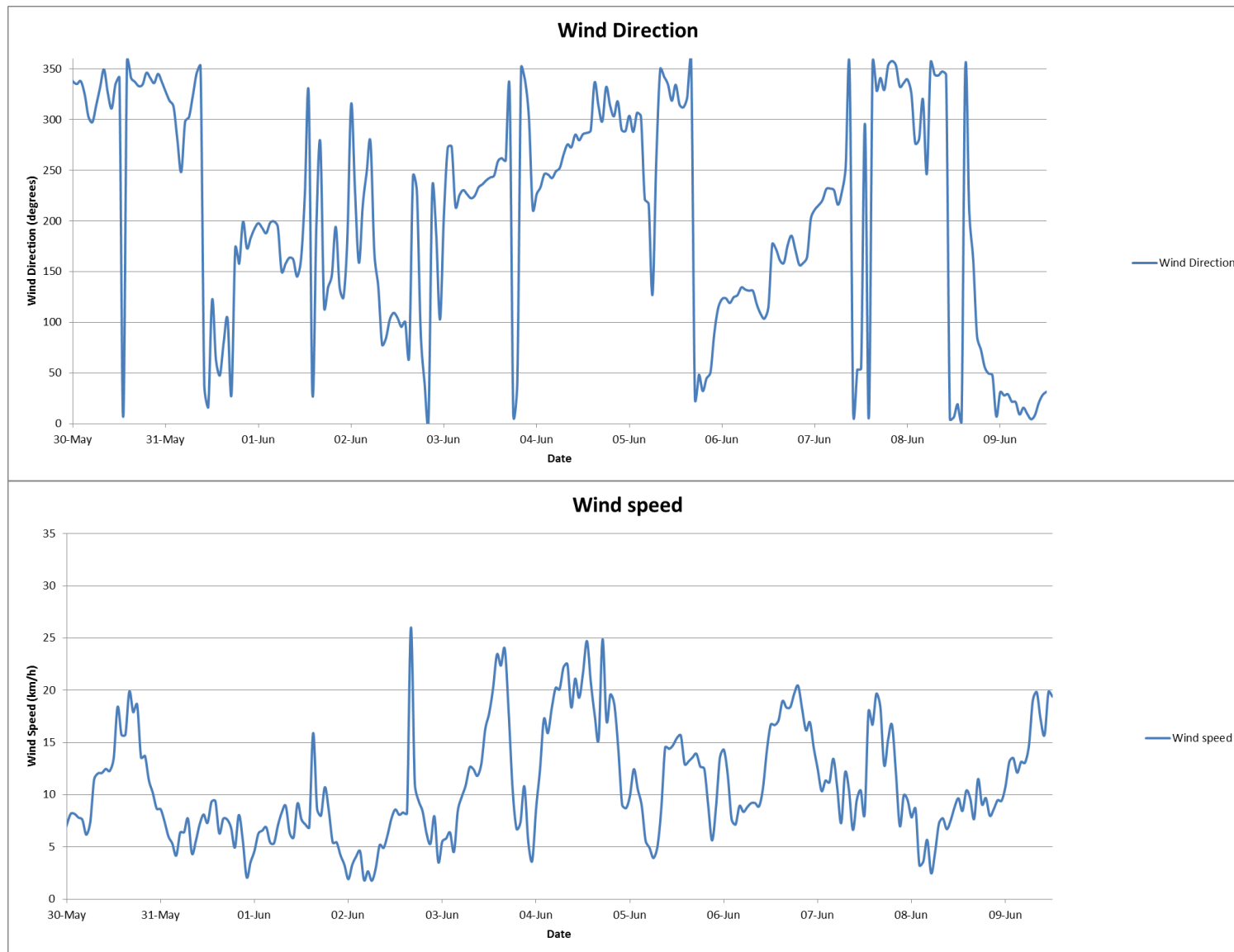Figure 4: Particulate measurements, 30 May to 8 June 2016

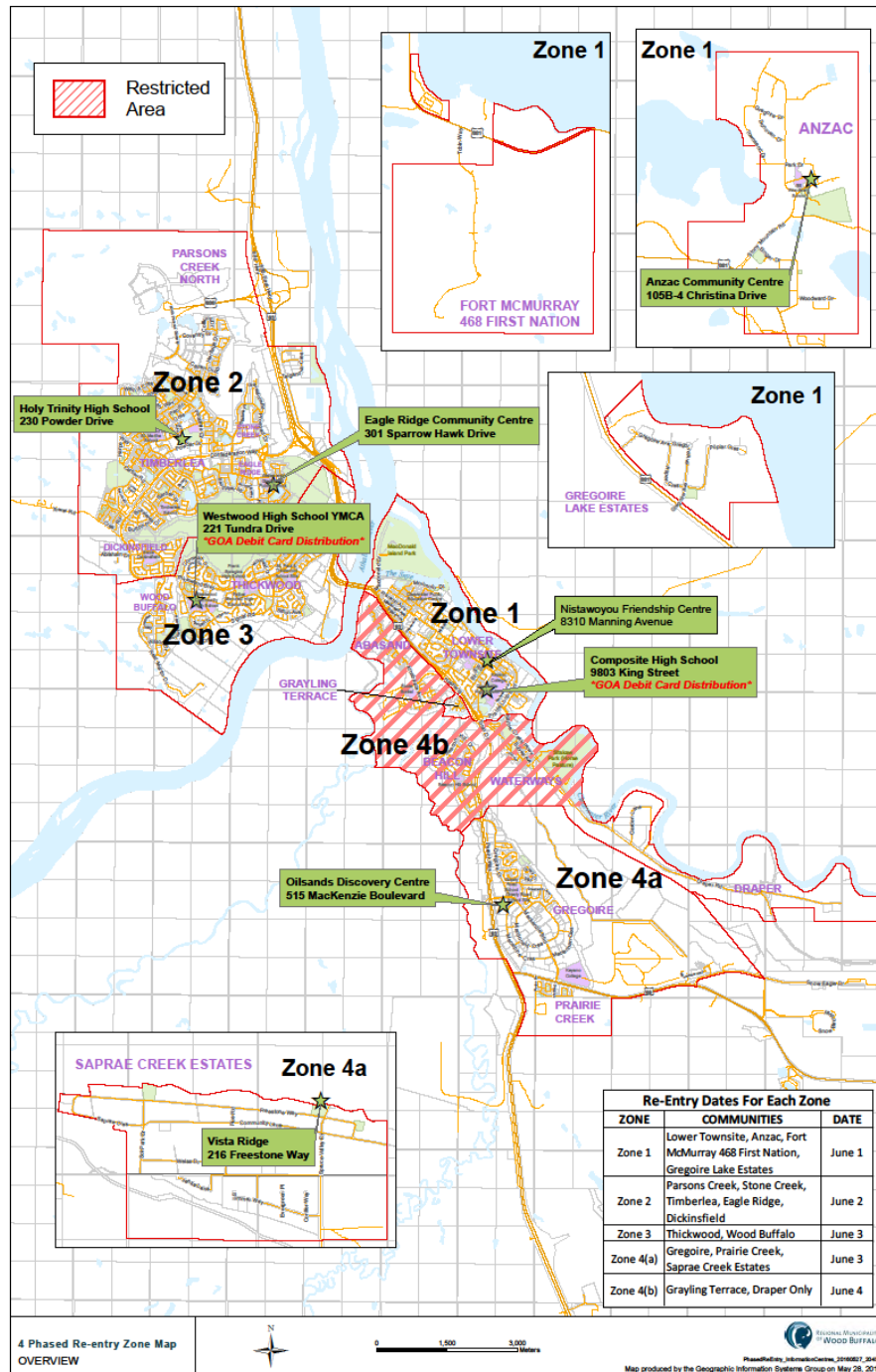Figure 5: Wind measurements in Fort McMurray, 30 May to 9 June 2016
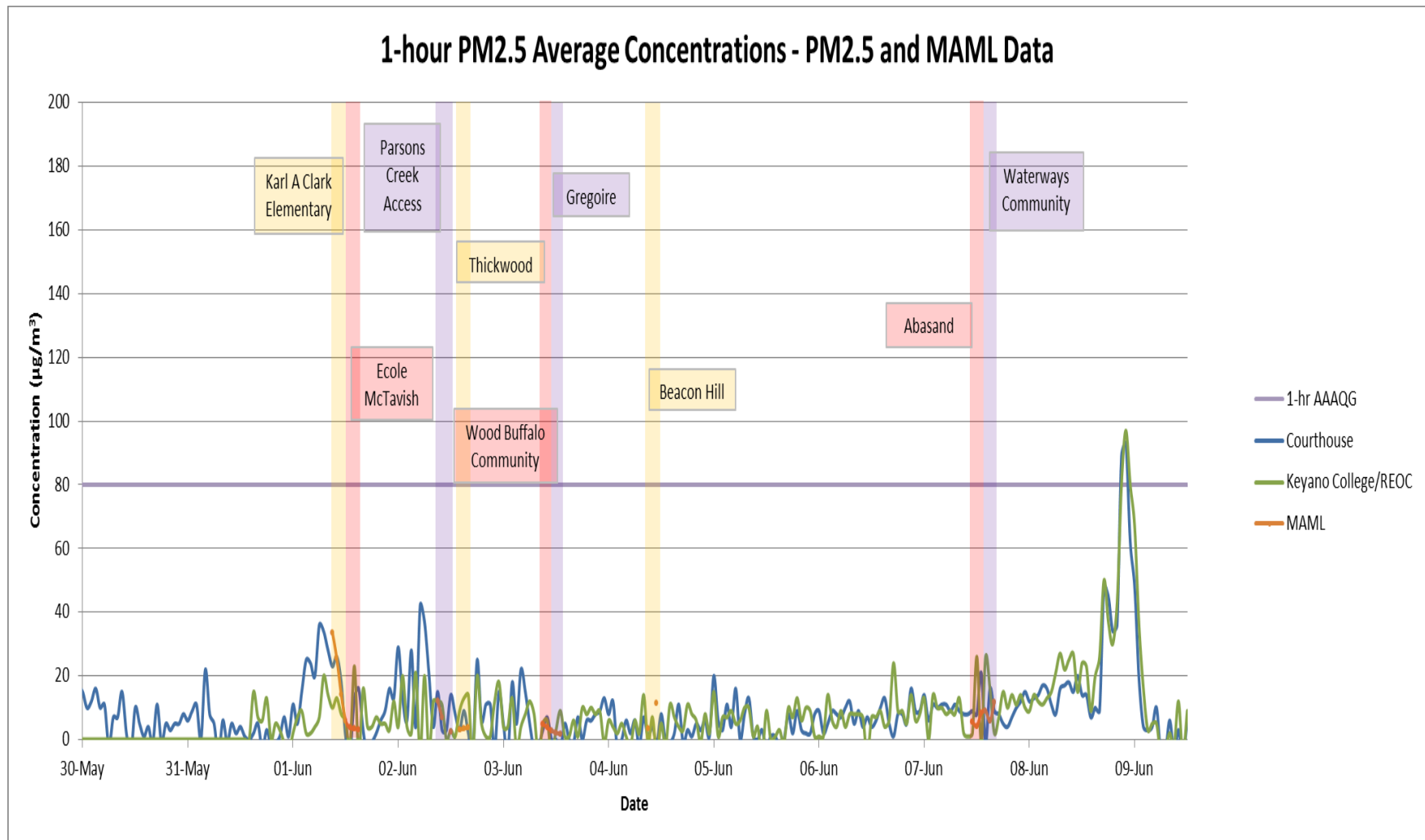
Figure 6: Reentry timeline

Figure 7: Annotated particulate concentration