A Review of the 2016 Horse River Wildfire

Alberta Agriculture and Forestry
Preparedness and Response

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EXECUTIVE SUMMARY

The Horse River wildfire (wildfire MWF-009) started on May 1, 2016 in a forested area seven kilometres outside Fort McMurray, Alberta. It quickly became the worst wildfire experienced in recent Canadian history. Within two days the wildfire entered Fort McMurray and went on to threaten nearby First Nations communities, oil sands camps and facilities, critical infrastructure and other important values.

The Insurance Bureau of Canada estimated insured losses at $3.7 billion and reports in the media indicate that the economic impacts on Canada's GDP are significant. The wildfire's impacts on families and the many first responders who worked hard to protect their homes and communities are beyond measure.

Alberta Agriculture and Forestry commissioned this review to consider the environmental conditions leading up to and during this extraordinary wildfire, to evaluate the readiness and level of preparedness prior to May 1, and to evaluate the response of the department. Reviews such as this are standard practice in Alberta after large or damaging wildfires. The premise is that situations like these challenge the wildfire management program to its limits, expose areas of deficiency and present opportunities to improve. This review is aimed at understanding what happened, evaluating the department's performance, and recommending possible improvements.

A review of historical data and trends indicates that the fire season in Alberta is becoming longer, is starting earlier and is featuring more frequent periods of extreme wildfire hazard. Historical data indicates that Alberta now experiences the most wildfires in May and more forest area is burned in May than any other month. Fire weather and wildfire hazard conditions throughout northern Alberta were severe in early 2016 owing to extremely dry conditions across Alberta in the previous year, low snow pack over the winter and hot and dry conditions in the spring. These conditions were evident in northeastern Alberta in the week leading up to May 1, 2016.

Alberta Agriculture and Forestry recognized that the early wildfire hazard was very high and took appropriate measures to be prepared earlier than usual. Airtanker and rotary wing aircraft contracts were moved ahead and initiated early, wildfire crew training was accelerated and many crews were commenced early, and resources were prepositioned according to the province's pre-suppression preparedness system. While the department responded to the early spring threat appropriately, the system is not intentionally designed for an early spring startup. Comments and recommendations to better address early spring wildfire hazards are made.

The fire weather forecasting and wildfire science capabilities of the department are strong and were available to support strategic and tactical decision-making and planning. Weather forecasts were accurate, the scientific understanding of the fuel characteristics and burning conditions was sound and fire behaviour modelling was insightful. Enhancements and improvements to how these capabilities can be better incorporated into the planning and operations functions of wildfire management are recommended.

As with all wildfires, the response to the Horse River wildfire in the first 36 hours was critical. The detection system performed within expectations and initial attack was immediate—both are critical factors in the wildfire suppression system. While it is not possible to determine whether any alternative decisions or actions in the first 36 hours would have resulted in a different outcome, it is possible to learn and improve from the experience by applying critical hindsight to the situation. In terms of the experience at the Wildland Urban Interface and with extended wildfire suppression operations, there are additional opportunities to learn and improve.

Recommendations and opportunities for improvement for the program have been identified as part of this review. Recommendations are presented as follows:

1. Continue Agriculture and Forestry's strategic direction to be fully prepared and ready to respond to wildfires the week after snow disappears or May 1 annually, whichever date is expected sooner. This may mean changes to the activation dates for aircraft and firefighting crews.
2. Improve fire weather forecast materials by extending the length of the forecast outlook period and by working closely with the Alberta Wildfire Coordination Centre, Planning Section to design products that directly link weather forecasts with predicted fire behaviour.
3. Enhance and expand the Planning Section in the Alberta Wildfire Coordination Centre to be operational March 1 annually, commencing in 2017, to provide daily fire behaviour and wildfire occurrence predictions to decision makers and to coordinate situation updates.
4. Establish a standard operating procedure across Agriculture and Forestry which requires, when a wildfire escapes from initial attack and interface risks are present, the immediate assignment of a senior Incident Commander to undertake tactical planning for wildfire containment and risk mitigation.
5. Develop an improved procedural model for airspace management where confined airspace over a community or airport is involved.
6. Continue to develop risk management frameworks as the foundation for wildfire management policy. This would include reviewing the list of five provincial priorities as the central policy and emphasizing a risk and consequence approach.
7. Direct agencies and services involved in wildfire suppression in relation to the Wildland Urban Interface to establish standard operating procedures for the implementation of an Incident Command System (ICS) and processes following the model provided by ICS Canada for future incidents like the Horse River wildfire.
8. Emphasize a long-term vision for FireSmart within the province that includes community responsibility, multi-agency collaboration and an outcome-based approach to implementing FireSmart projects. Ensure all seven disciplines of FireSmart are addressed.
9. Establish a joint Wildfire Planning Task Team comprised of senior Agriculture and Forestry staff and major industrial stakeholders (such as oil sands, energy, forestry, and utility companies) from across Alberta.
10. Complete and implement a unique and tailored Landscape Wildfire Management Planning process for the northeast region of Alberta.

1. APPROACH AND SCOPE OF THE REVIEW

1.1 Approach to the Horse River Wildfire Review

Agriculture and Forestry (AF) commissioned this review to learn what can be done better the next time a challenging wildfire occurs. The review was undertaken by a team of individuals who each have substantial background and expertise in wildfire management or program review methodology. The core Review Team includes:

- Todd Nash, Partner, MNP LLP, Edmonton, AB: Project Manager
- Lee St Arnaud, Manager, MNP LLP, Calgary, AB: Consultant
- Al Tithecott, Wildfire Management Specialist, Sault Ste. Marie, ON: Lead Reviewer
- Brian Simpson, Wildfire Management Specialist, Castlegar, BC: Lead Reviewer
- Brian Stocks, Wildfire Science Specialist, Sault Ste. Marie, ON: Lead Reviewer

In addition to the core team members, insight and advice was provided to the Review Team by Dr. Tom Zimmerman, President of the International Association of Wildland Fire, Boise, ID; Hugh Boyd, Wildfire Management Specialist, St. Albert, AB; and Gary Mandrusiak, Wildfire Management Specialist, Rocky Mountain House, AB.

The Review Team examined data provided by AF including records, logs, notes and pertinent data covering the time period preceding and during the Horse River wildfire. Review Team members also interviewed 90 individuals who were involved in efforts to prepare for Alberta's 2016 fire season, respond to the Horse River wildfire or who were in some other way involved in the events. This included key personnel from AF, Regional Municipality of Wood Buffalo (RMWB), local Indigenous communities, and relevant stakeholder groups.

All data and input was reviewed to describe the conditions, outline the sequence of events, assess the response, identify opportunities for improvement and make recommendations. A list of references used to support the review and the groups of individuals interviewed is provided in Appendix C.

It is important to note that in approaching its work the Review Team was mindful that it had the benefit of hindsight and took care not to let this unfairly colour its thinking. In difficult and stressful situations, individuals are called upon to make decisions in real time, with only the information they have at hand. This is particularly true during an active and quickly changing wildfire event. Faced with the same circumstances and with the same information, different people can make different decisions that are rational, justifiable and understandable on their own. Good decisions and hard work are not always rewarded with good outcomes given the complexity of wildfires in these conditions.

The Review Team focused on how decisions were made; whether the right information was being collected and examined; whether the systems and procedures supported the people at critical times; whether necessary information was getting to the people who needed it; whether policies and best practices were followed when decisions were made; and whether training and experience was appropriate for individuals in key roles.

Recommendations from a review such as this are just a beginning. Some recommendations are directed at partners, communities, and broader government and are not completely within AF's control or responsibility. The preparation for, and response to, an event like the Horse River wildfire is a joint

responsibility among governments, agencies, communities, businesses and homeowners. Implementation of these recommendations is at the discretion of government and should be integrated into AF's continuous improvement program.

Above all, the Review Team approached the review with the goal of learning lessons from this wildfire event. Ideally, these lessons can help Alberta improve its systems and processes around wildfire management so that the province is better positioned when this kind of event happens again. The Review Team recognizes that some of the recommendations will require time and resources to implement. Recommendations may be refined over time based on new information or technology.

1.2 Scope of the Review

This review addresses the preparation and response of AF to the wildfire, including an assessment of the weather and fuel conditions that led to the early spring fire season and how that relates to preparation and operations. More specifically, the scope of the review includes:

- Agriculture and Forestry's preparation and readiness, provincially, up to May 31, 2016, with consideration of the following:
    - Wildfire environment conditions;
    - Fire behaviour;
    - Wildfire management decision support tools and models; and
    - Wildfire preparation, training, readiness and operations.
- Agriculture and Forestry's response to the Horse River wildfire with consideration of the following:
    - Forest fuels;
    - Fuel management work;
    - Fire behaviour and conditions;
    - Wildfire preparation, readiness, and operations; and
    - Wildfires and wildfire operations in the Fort McMurray Forest Area.

The following chapters describe the key factors contributing to the wildfire event, how AF prepared for and responded to the wildfire, and what can be learned from the experience. A separate review, initiated by the Alberta Emergency Management Agency (AEMA), investigates the impact of the wildfire on the residents and businesses of the Regional Municipality of Wood Buffalo (RMWB) and the coordinated emergency response that ensued.

2. AN OVERVIEW OF THE HORSE RIVER WILDFIRE

The onset of spring in 2016 throughout northeastern Alberta created conditions for extreme fire behaviour in the widespread boreal forest that surrounds Fort McMurray. In the week leading up to the Horse River wildfire, temperatures in the Fort McMurray area rose steadily, relative humidity levels decreased, and wind speeds were sustained in the 15-20 kilometres per hour range from the southeast to southwest. The weather forecast issued on April 30 called for the establishment of a strong upper level ridge over the province on May 1. This ridge would dictate weather conditions in the Fort McMurray area for several days before breaking down with a cold front passage expected on May 4. During this period, severe burning conditions were expected as temperatures were forecast to rise to 30 degrees C while relative humidity levels dropped to 15 percent and winds approached 25 kilometres per hour.

Exhibit 1 outlines the dramatic changes in fire weather conditions and the progression of the wildfire on May 1, the day it started and was actioned. The chart highlights a few of the key factors that made this wildfire extreme and particularly difficult to contain in the first burning period[1]:

- The relative humidity in the area was decreasing rapidly in the morning, dropping from 30 percent to less than 20 percent in less than an hour at 10:00h.
- The temperature was rising throughout the day to exceed 25 degrees C and to exceed the relative humidity value from 11:00h to 18:00h, creating what is referred to by wildfire personnel as “crossover” conditions[2].
- Higher than normal winds and gusts were occurring midday, intensifying the extreme burning conditions.

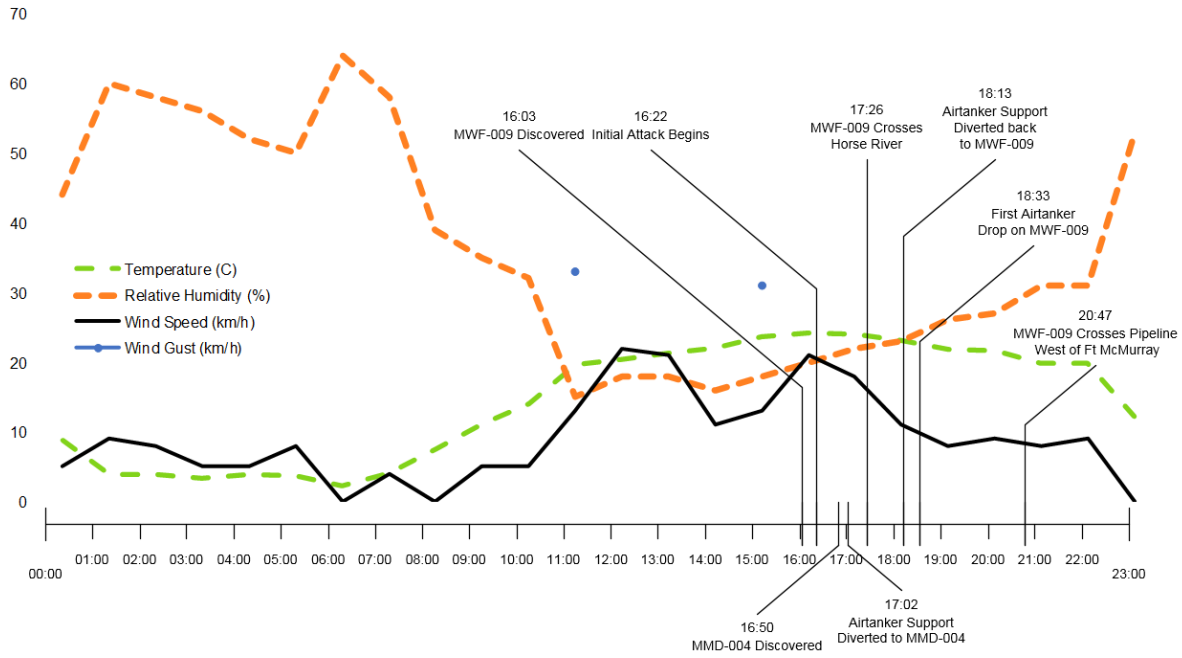
The Horse River wildfire was first detected on May 1 at 16:03h by an AF initial attack crew patrolling the area for wildfires in a helicopter. At the time it was found, the wildfire was approximately two hectares in size and approximately seven kilometres southwest of the ‘Urban Service Area[3] of Fort McMurray’ (Fort McMurray). Exhibit 2 presents a map and aerial photo views of the wildfire shortly after the time of discovery.

[1] The first burning period is the period of time from detection to 10:00h the next day.

[2] Crossover conditions exist when the value of the ambient temperature, expressed in degrees C, exceeds the value of the relative humidity, expressed as a percent.

[3] An Order-in-Council defines the Urban Service Area surrounding the developed portion of Fort McMurray. RMWB has responsibilities inside the Urban Service Area and the Rural Service Area outside is controlled largely by the province. This means the RMWB is responsible for all fire response inside the Urban Service Area, and AF is responsible for wildfire response outside the Urban Service Area.

Exhibit 1: Fire Weather Conditions and Wildfire Timeline for May 1, 2016

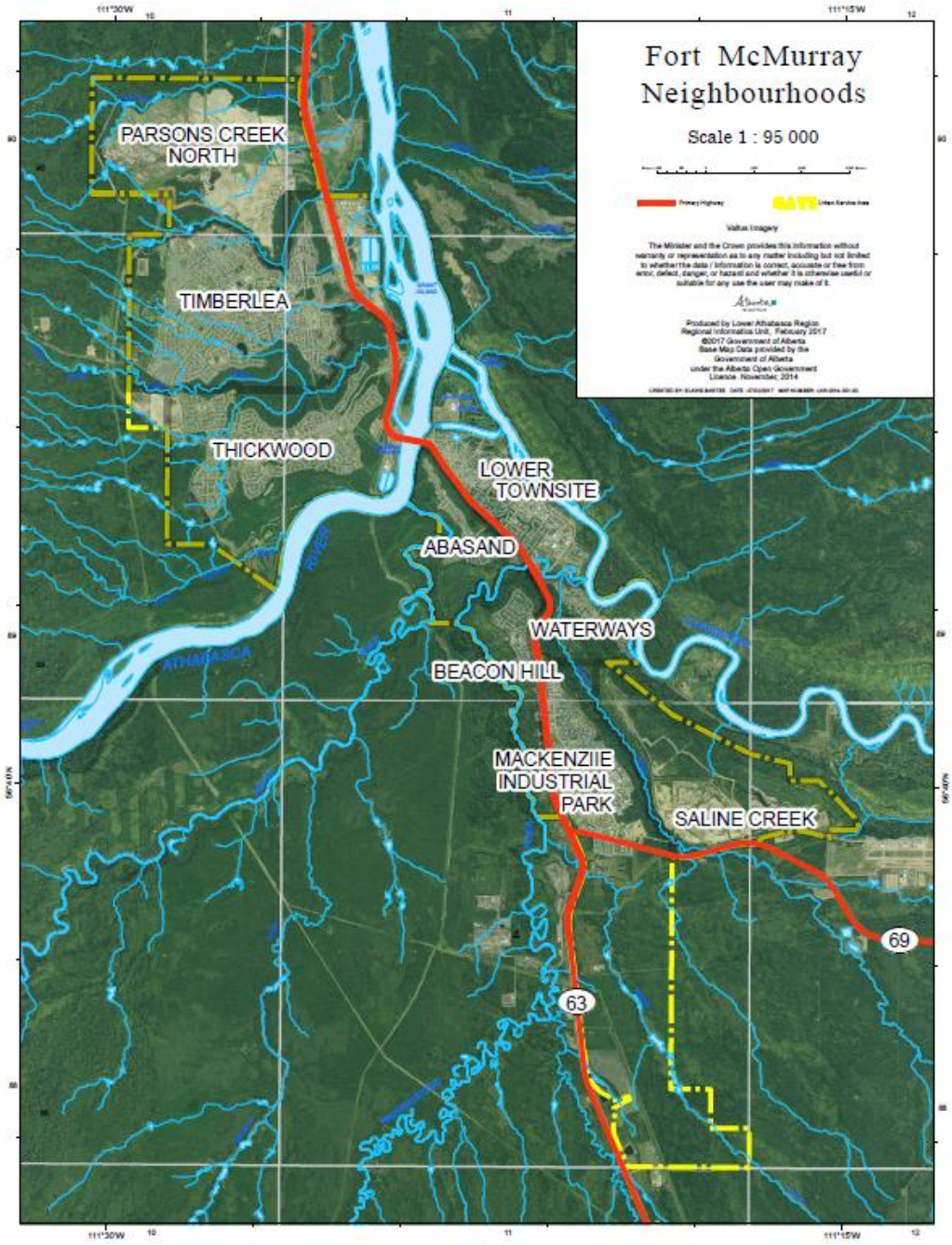


*Fire weather conditions collected from Environment Canada Weather Station at the Fort McMurray International Airport

Exhibit 2: Map and Aerial View of Horse River Wildfire Origin, May 1 at 16:51h

After escaping initial control efforts, the wildfire, pushed along by dry, windy conditions and hot temperatures, continued to grow to the east toward the Beacon Hill, Prairie Creek, and MacKenzie Industrial Park areas of Fort McMurray. On May 2, winds turned from the east and pushed the wildfire west, toward the Athabasca River. By the end of the day, the wildfire spanned an area of approximately 2,600 hectares. Exhibit 3 presents a map of the Fort McMurray area and its neighbourhoods.

Exhibit 3: Fort McMurray Urban Service Area



On the morning of May 3, the combination of extremely dry fuel conditions and a forecast of severe fire weather prompted AF forecasters to issue a Fire Weather Advisory warning of extreme burning conditions and extreme fire behaviour. Later that day, southwest winds pushed the Horse River wildfire into Fort McMurray. The subdivisions of Beacon Hill, Abasand and the MacKenzie Industrial Park were impacted first. While some residents had already evacuated, a mandatory evacuation order was issued by the Regional Municipality for all of Fort McMurray at 16:20h. Later in the evening, the wildfire entered the subdivisions of Thickwood and Waterways.

On May 4, the wildfire continued to burn within Fort McMurray and began to threaten the area surrounding the Fort McMurray International Airport. By the end of the day, the wildfire was approximately 12 kilometres from Anzac and the Fort McMurray First Nation.

On May 5, the wildfire continued to threaten the communities of Anzac and the Fort McMurray First Nation. These communities did not sustain major damage, largely due to indirect attack efforts undertaken by AF, including the use of aerial ignition, fireguard and airtanker support. The Fort McMurray First Nation supported these efforts through the construction of a fireguard around their community and structural protection activities in the community.

Over the next two weeks, hot, dry and windy conditions persisted and the wildfire continued to grow. Suppression efforts focused on setting priorities and protecting high priority values. On May 16, the wildfire moved north of Fort McMurray, where it threatened work camps and oil sands operations.

On May 16, the wildfire escaped control efforts to the west of Fort McMurray and destroyed the Blacksand Lodge. Wildfire growth on the northeast perimeter intensified concerns about encroachment on the oil sands operations. Exhibit 4 shows the estimated boundary of the Horse River wildfire in relation to Fort McMurray, the surrounding communities and oil sands operations. Exhibit 5 illustrates the growth of the wildfire by showing map views for May 2, 3, 5 and 17.

After mid-May, conditions improved somewhat. While the wildfire continued to grow sporadically, the risk to communities and other values were greatly reduced. On July 4, the Horse River wildfire was declared under control and a final size of 589,552 hectares was estimated. A detailed timeline of the wildfire event is provided in Appendix A.

Exhibit 4: Horse River Wildfire Boundary (Red Outline) and Oil Sands Operations

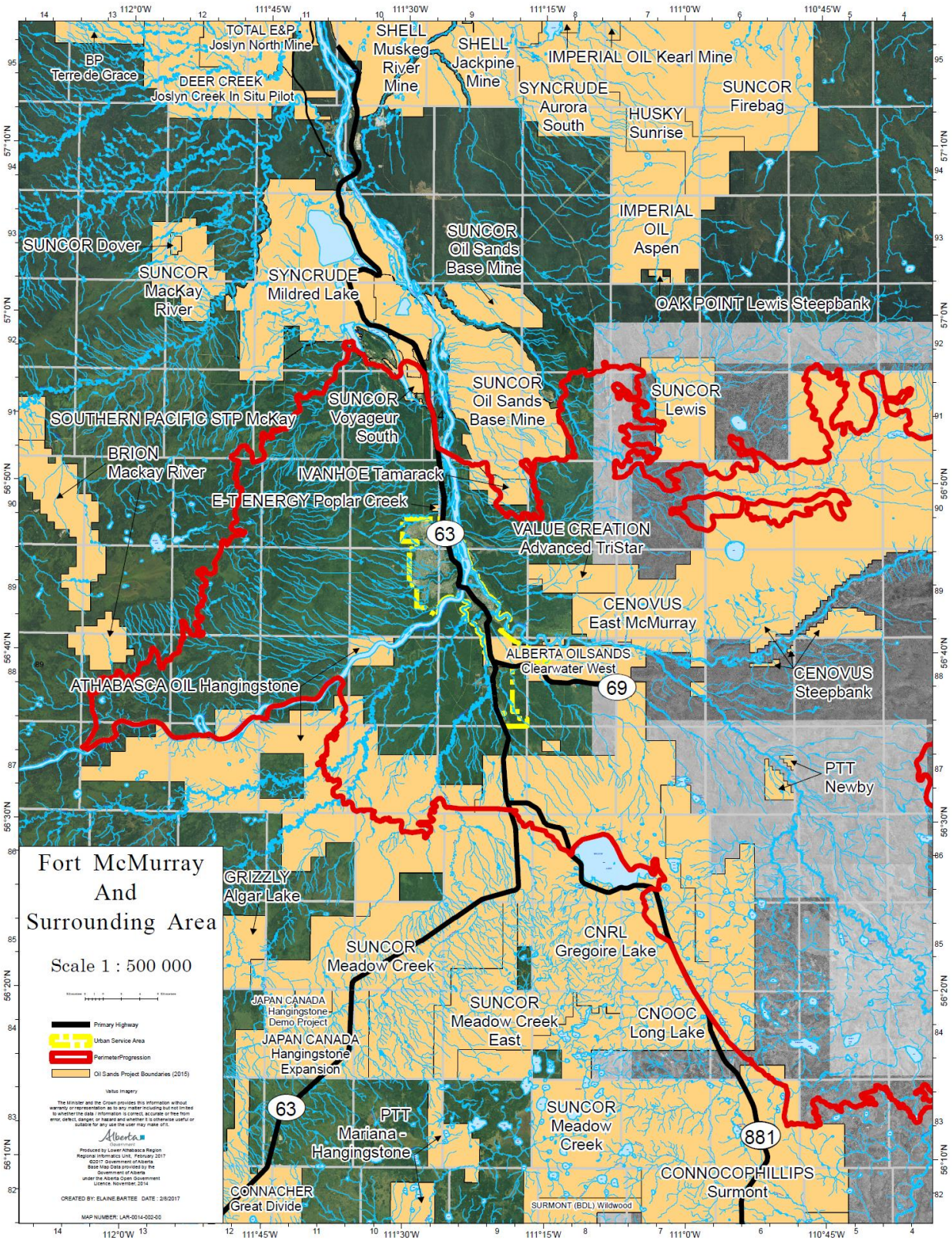
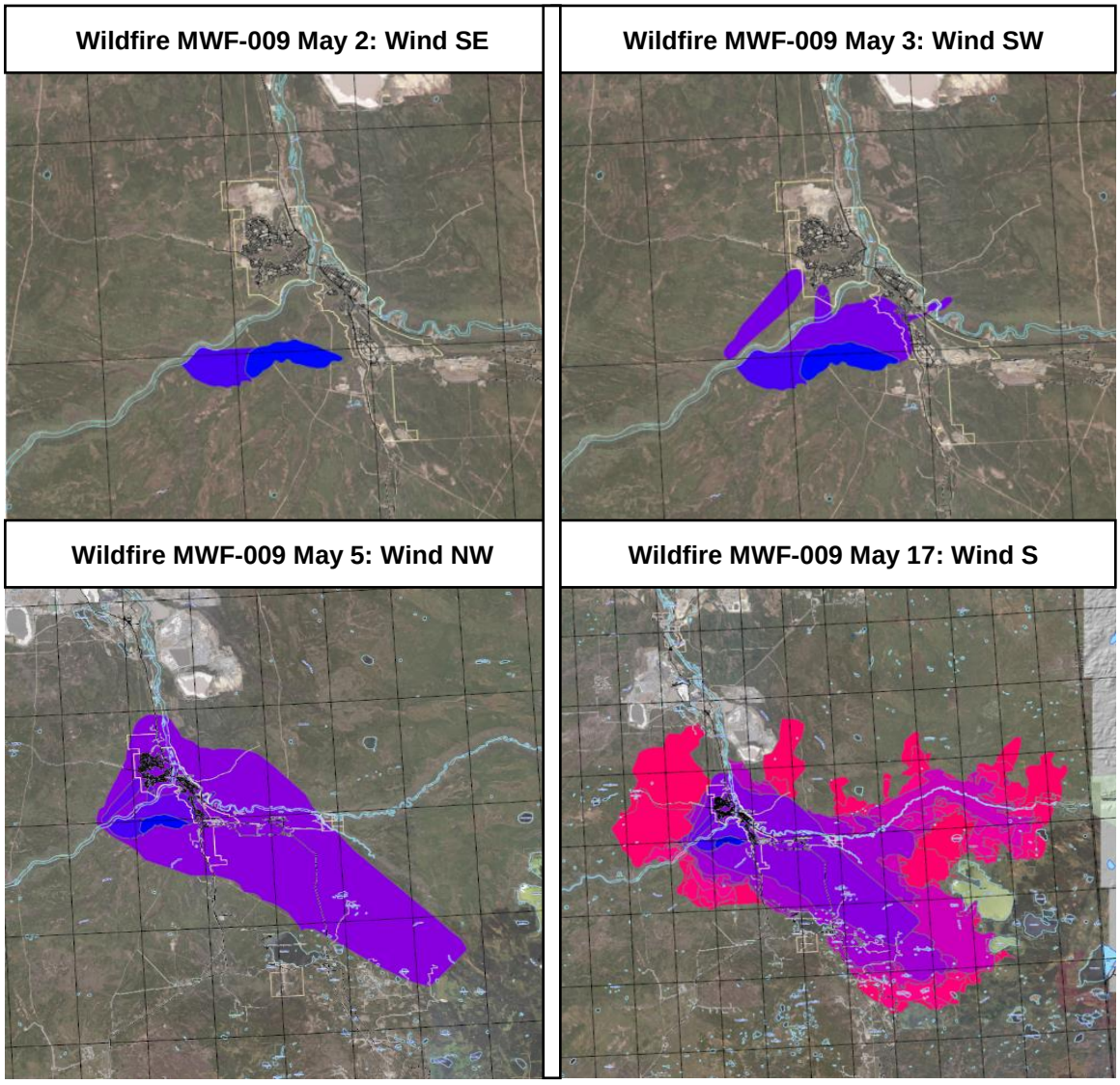


Exhibit 5: Horse River Wildfire Locations on May 2, 3, 5 and 17



AF leveraged significant suppression resources to combat the wildfire. As the wildfire perimeter expanded, the number of personnel and assets grew accordingly. The number of firefighting resources peaked on June 3, with total personnel of 2,197 (wildland and municipal firefighters plus support personnel), 77 helicopters, up to nine airtanker groups and 269 pieces of heavy equipment working to suppress the wildfire. Exhibit 6 outlines the deployment of resources over the timeline of the wildfire. Exhibit 7 summarizes the peak resource deployment.

Exhibit 6: Resource Deployment Over the Horse River Wildfire Timeline

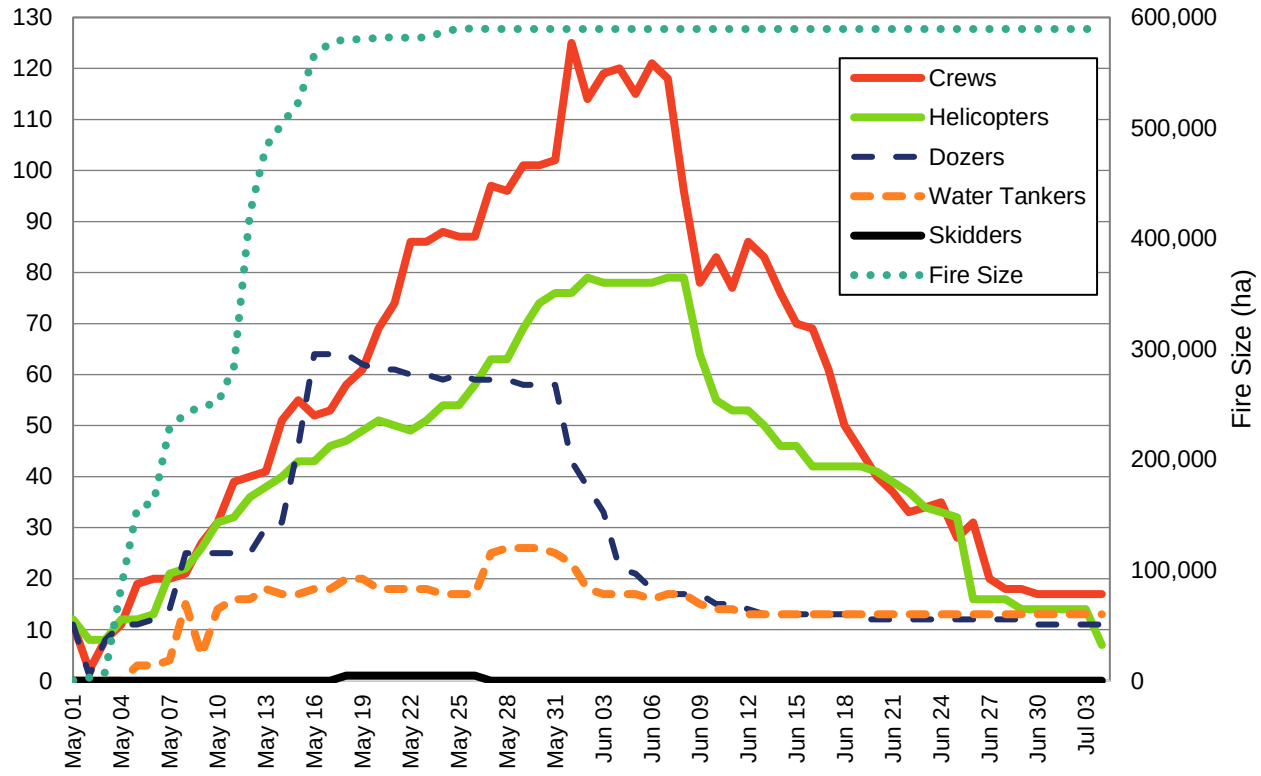


Exhibit 7: Peak Resource Deployment

Resource	Peak Deployment
Crews	126
Total Personnel	2,197
Helicopters	77
Airtankers	9 groups/18 airtankers
Dozers/Heavy Equipment	269

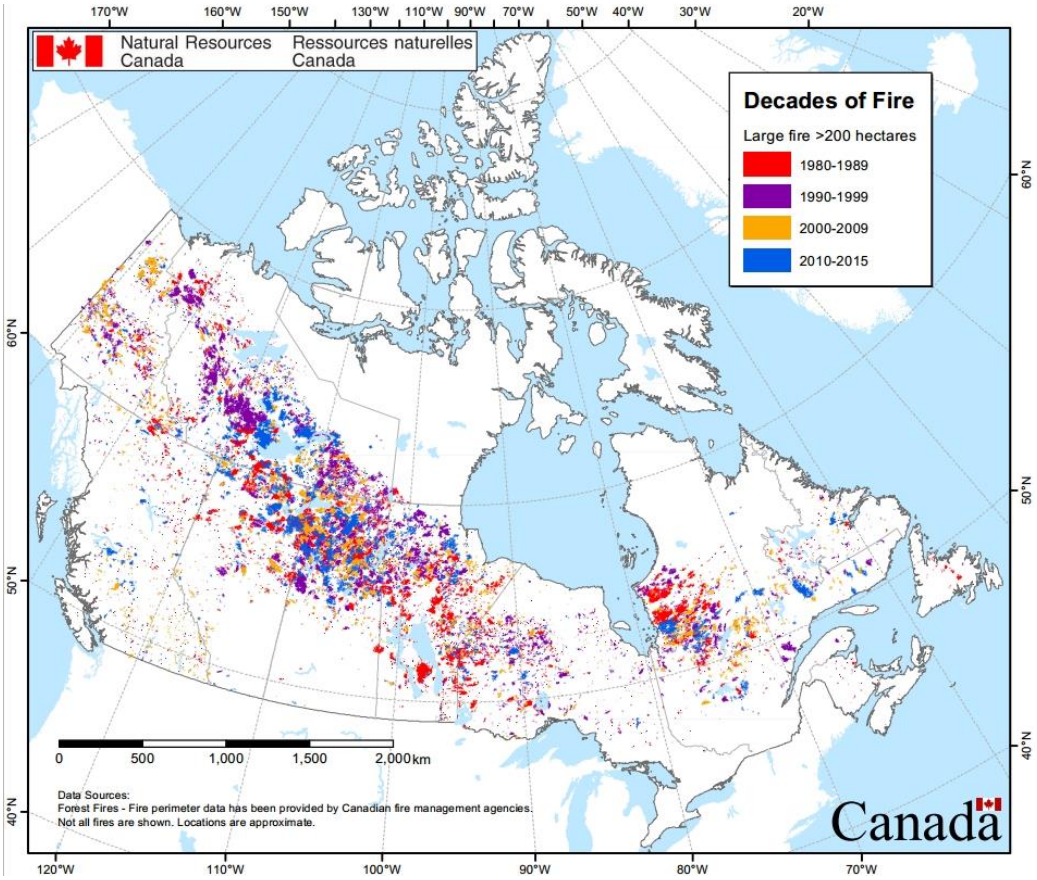
3. SETTING THE STAGE: THE 2016 FIRE SEASON

3.1 Wildfires: A Reality in Alberta

Intense wildfires, such as the Horse River wildfire, are inevitable and are becoming increasingly more likely. A major determinant of this lies in the nature of the boreal forest and its climate.

Substantial sections of the northern half of Alberta are situated in boreal forests, which have been naturally shaped by wildfires for millennia.[4] Wildfire is a natural process in Canada's forested landscapes and has been a necessary renewal agent to ensure maintenance of ecological structure. In the Fort McMurray Forest Area, the forest has a predominance of black spruce, a species highly susceptible to wildfires. Exhibit 8 outlines the incidence of major wildfires in Canada's boreal forest over the past 35 years.

Exhibit 8: Forest Fires in Canada 1980-2015: Source – John Little, Natural Resources Canada

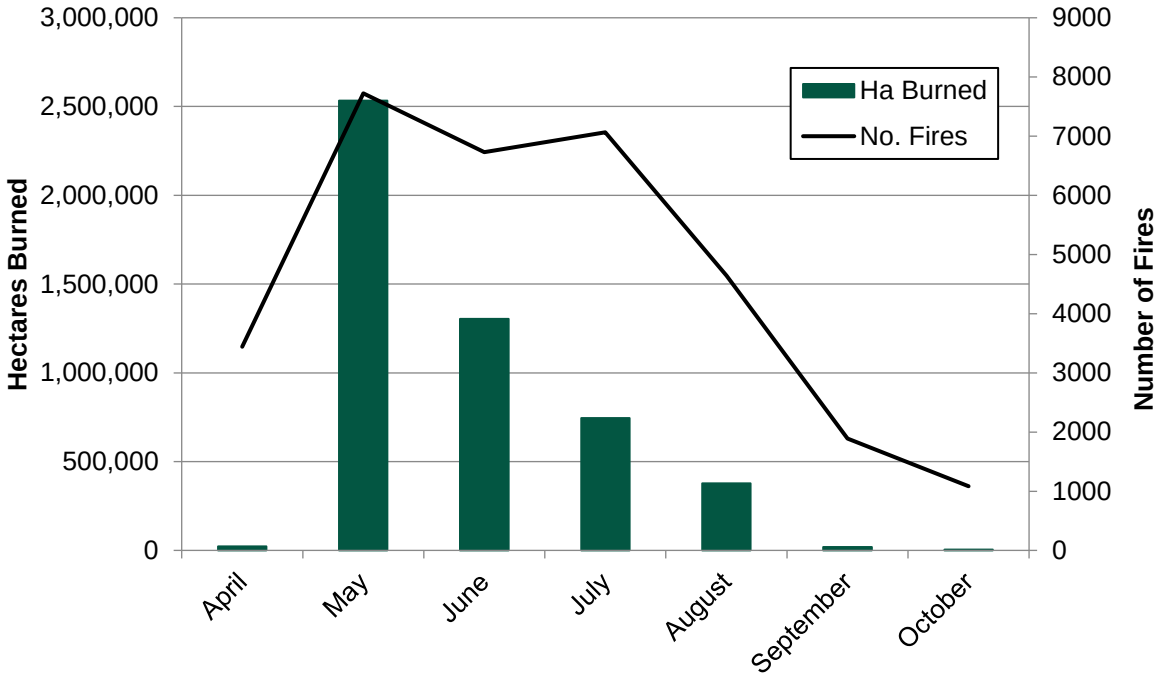


The majority of large wildfires in Alberta are now occurring during the spring. Since 1994, 23 percent of Alberta wildfires have started in May; however, these wildfires have contributed to approximately 50 percent of the area burned in the province. The risks of wildfire are particularly high during this period as it occurs between the melting of overwinter snow cover and the flushing (greening-up) of grasses and deciduous vegetation. During this time, fine fuels are exceptionally dry and extreme fire behaviour is commonly driven by low relative humidity and strong winds, caused by the intrusion of dry arctic air

[4] Stocks, 1991; Kurz et al.

masses into northern Alberta. Longer day lengths at this time of year at northern latitudes also serve to extend burning periods. Exhibit 9 outlines the average number of wildfires and area burned in Alberta by month over the past 22 years.

Exhibit 9: Number of Wildfires and Hectares Burned by Month: Alberta 1994-2016



We can expect this trend to continue, as climate change is expected to contribute to increased incidence of wildfire. Canadian studies of the effects of climate change on wildfire activity in Canada forecast greater climatic variability, more severe weather events, longer fire seasons, increases in both lightning-caused and human-caused wildfire occurrence, greater areas burned and larger, more intense wildfires. These studies also state that the effects of climate change and the associated risks from wildfire impacts will become even more apparent in the northern boreal forests of western Canada.[5]

Compounding the challenge for Alberta is the significant level of community and industrial values found throughout the forested landscape that require protection. Numerous communities are located throughout the northern half of Alberta, often surrounded by forested lands susceptible to wildfire. These include smaller remote communities as well as more populated communities that are home to thousands of people (Peace River, Hinton, High Level, Whitecourt, Canmore, Slave Lake and Fort McMurray, among others). Key infrastructure and industrial related values are common in many wildland areas, and include electricity transmission lines and stations, telecommunication sites, pipeline related infrastructure, resource extraction facilities and industrial camps or lodges hosting hundreds or thousands of workers.

Large and destructive spring wildfires in the wildland urban interface (WUI)[6] are not uncommon in northern Alberta. Most notable recent examples are the Virginia Hills and Mitsue wildfires of 1998, the Chisholm wildfire of 2001, and the Flat Top Complex wildfires of 2011, described in Exhibit 10. Two of

[5] Flannigan et. al. 2005; Weber and Flannigan IP 1997: CC 2014.
[6] The Wildland Urban Interface (WUI) is where populated communities and wildlands meet and intermix.

the three wildfires in the Flat Top Complex led to evacuations in and around the Town of Slave Lake, and resulted in the destruction of many homes and businesses with an insurable loss of over $700 million. The 2015 fire season was notable for both a busy spring and escalated lightning caused wildfire activity throughout the summer. In 2016, similar spring conditions led to the Horse River wildfire.

Exhibit 10: Summary of Previous Spring Wildfires and Events

Year	Wildfire/Event	Comments
2015	**2015 Fire Season**	Early spring fire season. One of the highest number of wildfires on record. Evacuations in Northwestern Alberta.
2011	**Flat Top Wildfire Complex**	Early spring fire season. Town of Slave Lake partly destroyed. Over 500 homes and non-residential building destroyed. Estimated insurable losses of over $700 million.
2001	**Chisholm Wildfire**	Spring fire season. One of the most intense wildfires recorded world-wide, in terms of energy release. Up to 75 structures lost, including 21 homes.
1998	**1998 Fire Season, Virginia Hills and Mitsue Wildfires**	Early spring fire season experienced, similar to the 2015 fire season. Extensive loss of productive forest and oil/gas production. Evacuations in central Alberta.

The wildfire itself was not an anomaly, and though extreme, the fire behaviour exhibited was predictable. It is also possible for it to happen under summer conditions and south of the boreal forest. The goal of this review is to assist AF to be better positioned to confront such a situation.

3.2 Overwinter and the Onset of Spring

Understanding the 2016 fire season begins by reviewing the conditions at the completion of the 2015 wildfire season – a season considered to be one of the busiest and costliest in recent history.

During the 2015 fire season, a total of 1,786 wildfires burned 492,400 hectares – well above the five-year average of 911 wildfires and 260,323 hectares burned. Sixty-four of these wildfires were over 200 hectares in size, compared to a five-year average of 19 wildfires in that size class.

At the end of the 2015 fire season, the northeast part of the province, including the Fort McMurray area, was experiencing moderate to severe drought conditions. This lack of moisture was exacerbated by the 2015-2016 winter, which was very mild and dry relative to other winters. Between October 2015 and April 2016, monthly precipitation in the Fort McMurray area was only 42.4 percent of the historical normal and monthly temperatures were consistently above normal.[7] The precipitation and temperature records for the Fort McMurray area are presented in Exhibits 11 and 12.

[7] A discussion of the 2015-2016 overwinter and 2016 spring conditions is in Appendix B.

Exhibit 11: 2015/2016 Precipitation Anomalies at Fort McMurray

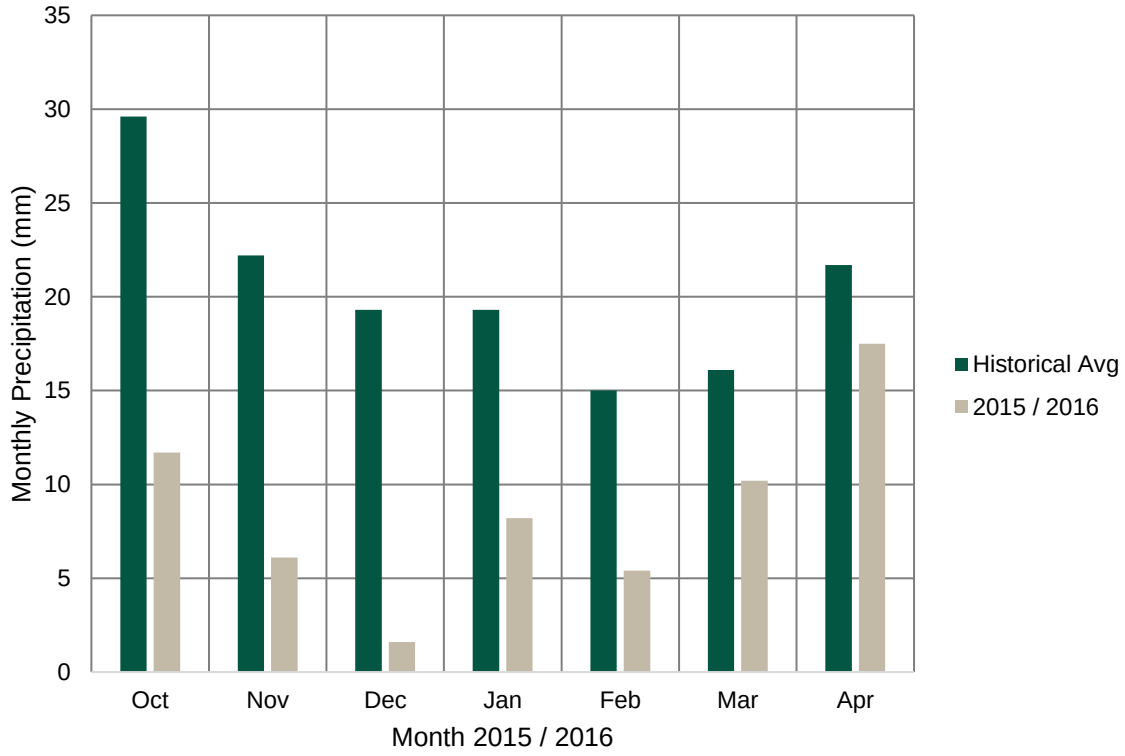
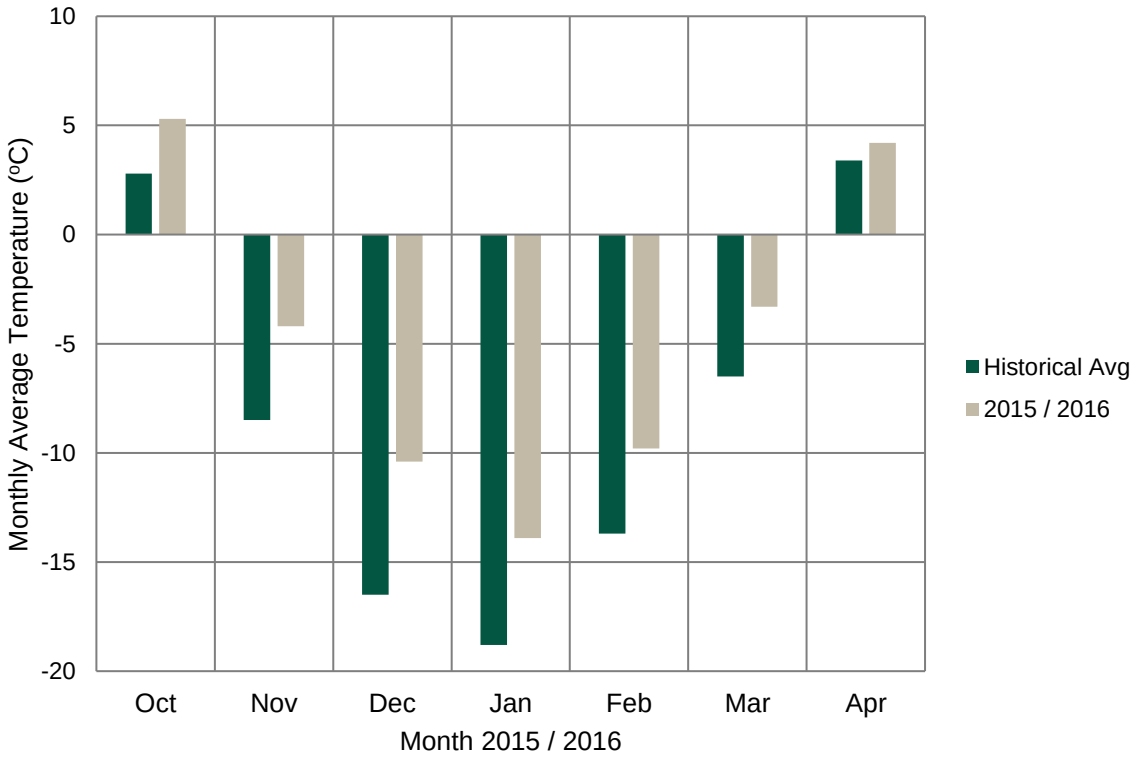
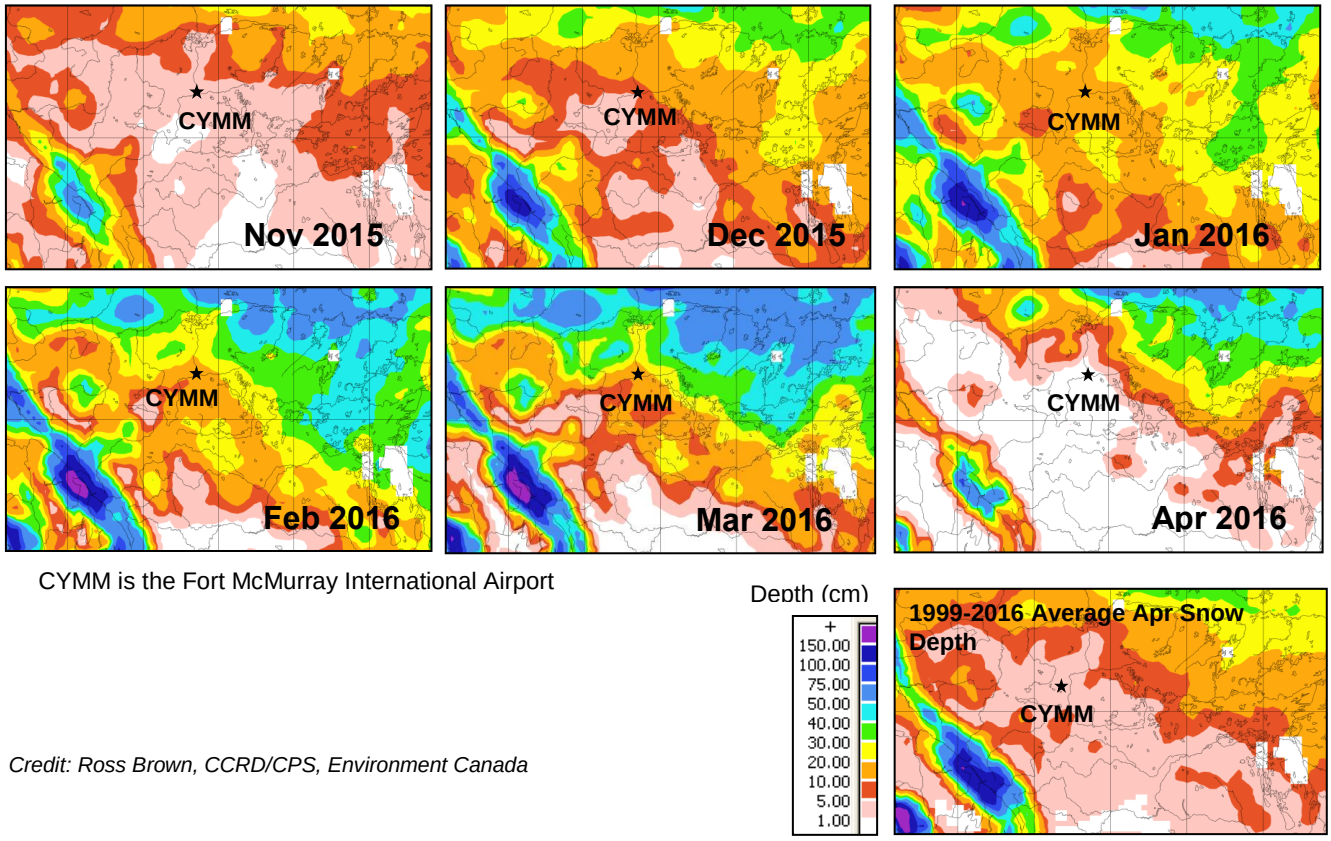


Exhibit 12: 2015/2016 Monthly Temperature Anomalies at Fort McMurray



These unusually warm and dry conditions generally led to a reduced snowpack in northeast Alberta, and in particular, the Fort McMurray area. By the end of March 2016, most of the snowpack around Fort McMurray had melted, accelerated by a four-day stretch during March that featured unseasonably high temperatures and low relative humidity. By the middle of April 2016, snow had essentially disappeared in the area – at least two weeks earlier than normal. Exhibit 13 illustrates the snow pack by month for the Fort McMurray area. The net result was that in early spring 2016 the ground fuels in the Fort McMurray area were very dry, and late spring was projected to continue to be warm and dry.

Exhibit 13: 2015/2016 Monthly Average Snow Depths in Northeast Alberta



CYMM is the Fort McMurray International Airport

Credit: Ross Brown, CCRD/CPS, Environment Canada

3.3 Preparing for the 2016 Fire Season

AF wildfire managers were aware of the potential for severe conditions and recognized that the 2016 fire season could begin very early with extreme conditions from the onset. Resources for the season were readied with these pre-season conditions in mind. Contract airtankers were activated for the season on April 14, which was earlier than in past years. Wildland firefighters were also hired earlier than normal in anticipation of early season needs. While some staff were in training at the time of the Horse River wildfire, there were numerous trained wildland firefighters available. The Fort McMurray Forest Area commenced crews and helicopters three weeks earlier than what was considered normal. On May 1, AF had airtankers based at Lac La Biche, Slave Lake, and Peace River providing coverage for northern Alberta. Exhibit 14 outlines the state of readiness in Fort McMurray and two adjacent Forest Areas in terms of spring 2016 resource start up dates.

Exhibit 14: Resource Commencement Timing in Late April and Early May[8]

		To 24 Apr	25 Apr	26 Apr	27 Apr	28 Apr	29 Apr	30 Apr	1 May	2 May	3 May	4 May
New Wildfires	Fort McMurray	7	0	0	1	0	0	0	2	0	1	2
	Lac La Biche	47	1	1	0	4	4	2	8	1	2	2
	Slave Lake	23	0	1	2	3	0	2	4	0	3	7
	Alberta	210	2	4	5	13	11	9	17	8	21	25
Airtankers Groups	Fort McMurray		0	0	0	0	0	0	0	2	2	0
	Lac La Biche		0	0	0	0	0	1	1	1	1	2
	Slave Lake		2	2	2	2	2	1	1	2	2	2
	Alberta		5	5	5	5	5	5	5	8	8	9
Wildfire Crews	Fort McMurray		4	9	9	9	9	9	9	8	9	8
	Lac La Biche		5	10	11	10	12	10	10	13	15	14
	Slave Lake		9	12	13	12	10	10	14	18	17	18
Helicopters	Fort McMurray		2	2	2	2	2	4	4	10	10	12
	Lac La Biche		0	0	1	2	5	5	8	10	12	14
	Slave Lake		2	3	3	6	7	7	12	19	14	17

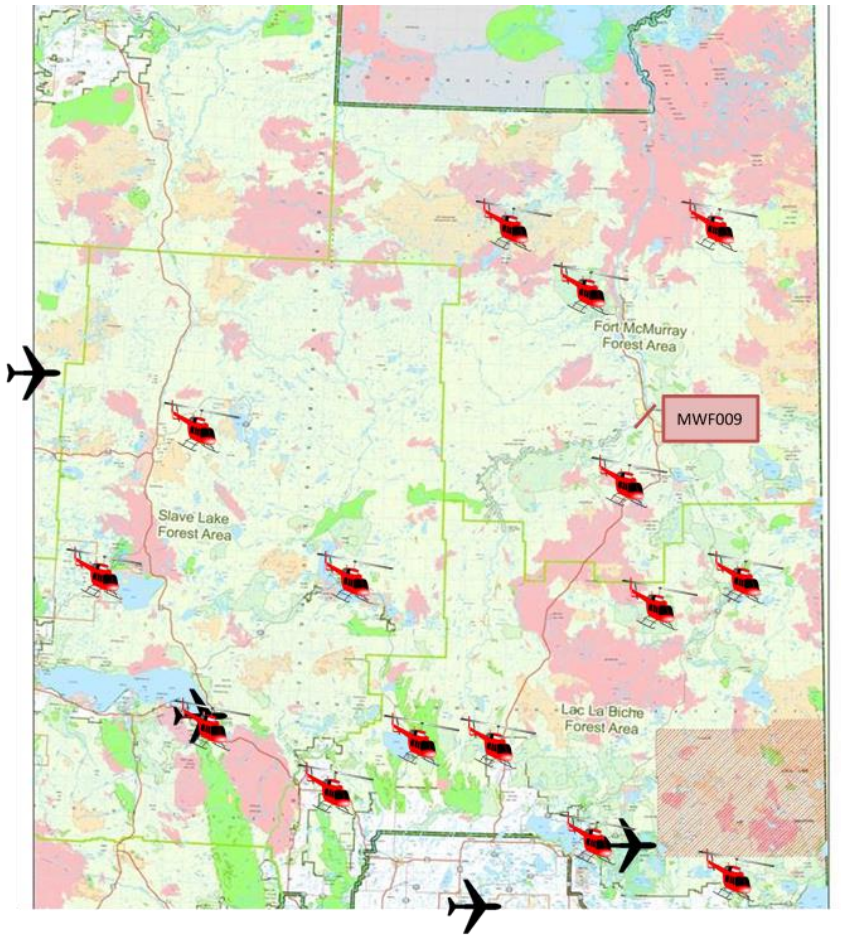
In addition to resource start-up, the deployment of these resources is an important factor in determining readiness and the ability to be effective. Exhibit 15 illustrates the general deployment of resources in northern Alberta in late April. Wildfire crews were at each of the helicopter locations. Additional wildfire crews were at other locations with trucks.

While resource levels were being planned in a manner consistent with an early spring wildfire hazard, there are some ways in which preparedness could have been enhanced. As a general observation, some resources remained in a “spring start-up” mindset leading up to May 1, which means the focus was on getting organized and undergoing training, and anticipating that serious wildfire activity was still some time in the future.

As an example, infrared perimeter mapping services were not available when requested, which prevented the use of this tool in the first few days when smoke was a major issue in determining the location of the wildfire perimeter. AF approached vendors to see if they could provide this service immediately, however, none were ready or able to deliver on short notice. This speaks to the need to make these arrangements sooner or in advance of the fire season whenever possible. Though it would not likely have changed the outcome of the wildfire, having infrared services available earlier would have assisted responders in their work.

[8] Included are AF wildfires. Municipal areas would have additional wildfires, for which AF may have provided wildfire assistance. Crews vary in size (4-20 people) and make-up, particularly in the spring when staff are arriving by experience level and new staff remain in training. Starting on May 2, Lac La Biche and Slave Lake Forest Areas took over the initial attack for the Fort McMurray Forest Area so that they could focus on the Horse River wildfire.

Exhibit 15: Locations of Aircraft Resources Leading up to May 1, 2016



As indicated earlier, the month of May is Alberta's most critical month from a wildfire preparedness perspective. Given this reality, it should be one of the primary goals of the organization to ensure most resources are available for deployment, fully trained and ready to respond by May 1 each year. During the Horse River wildfire, there were several instances where people were placed in a new role to gain operational experience or to cover off for others who were in recertification training or otherwise not available. This early season approach is a typical strategy used by all wildfire management organizations to give people experience or to provide organizations the flexibility to get fully prepared. This approach, however, needs to be better aligned with forecasted fire behaviour conditions, recognizing that winter conditions can quickly transition into a severe situation in Alberta during this time of year.

Like all wildfire management organizations in Canada, Alberta's organization may find adjusting to an earlier start-up problematic for many reasons. Most Canadian wildfire management organizations use student workforces as part of wildfire crews and many students are still at school in the period of time leading up to May 1. There are also highly variable conditions from year to year that, because of late snow or other weather impediments, can cause delays in some areas. Despite these challenges, encouraging the organization to be at its highest state of readiness by May 1 is critical and reinforcing this concept in all aspects of its business is essential.

Recommendation #1

Continue Agriculture and Forestry's strategic direction to be fully prepared and ready to respond to wildfires the week after snow disappears or May 1 annually, whichever date is expected sooner. This may mean changes to the activation dates for aircraft and firefighting crews.

Expected Outcomes:

- Improved capacity and response during Alberta's most critical month of the fire season; and
- Enhanced ability to meet future wildfire conditions predicted to occur because of climate change.

Opportunities for Improvement:

1. The process for accessing infrared technology should be streamlined to ensure it is readily available for operations by May 1 annually. This should include the following being in place:
   - Long term contracts;
   - Standards for products; and
   - Explicit procedures for requesting the resource and deployment onto incidents when requested.

4. EXAMINING THE SCIENCE BEHIND THE WILDFIRE

The growth and intensity of the Horse River wildfire was driven by the nature of the vegetation present, the lack of moisture during the preceding winter and early spring weather conditions that were windy and unusually dry and warm. The fire behaviour prediction tools available accurately predicted the behaviour of the Horse River wildfire.

Understanding the science behind the Horse River wildfire can help AF better prepare for future wildfire events.

4.1 Fire Weather Forecasting

Weather forecasting is a key activity that supports decision-making in advance of and during the fire season. Together with fire behaviour analysis, forecasting informs the overall picture of wildfire risks. This helps AF determine how to best deploy wildfire management resources throughout the province so that wildfires can be detected and managed as efficiently as possible. Fire weather forecasting is also crucial for helping predict fire behaviour, particularly spread direction and distance, when a wildfire occurs. Some ways in which the fire weather forecasting process in AF could be improved to better assist decision makers have been identified.

The winter-to-spring transition is critical for wildfire management agencies. Daily changes in snowpack, fuel moisture levels, temperatures and winds can have dramatic impacts on wildfire risk levels. A network of weather stations is required to provide a good spatial understanding of the evolving risk. During early season start up, when only a few stations are being used, there is a risk that data from a single sample point may not reflect conditions for a larger area. In the middle of the season, the availability of many stations reduces the dependence on any one station and provides corroboration of weather indices. Adding to the complexity in the spring, it is necessary to adjust the Spatial Fire Management System (SFMS) hazard maps to account for northern areas which have few weather stations. This is particularly important during the winter-to-spring transition.

In addition to carefully analyzing the winter-to-spring transition period, the use of upper air profiles is an important consideration. Upper air profiles were not used in forecasting winds on May 3 and May 16 when afternoon and evening gusts were a factor contributing to spread of the wildfire. Soundings from Environment Canada stations in Fort Smith on May 3 and Stony Mountain on May 16 showed the presence of strong low-level jets in the lower atmosphere. These stronger winds aloft were brought to the surface due to the mixing/turbulence caused by increasing wildfire intensity and rapid convection column development. This resulted in stronger and gustier surface winds than forecasted. This information would have been valuable to the Incident Management Team trying to predict fire behaviour on those days.

There are opportunities to make provincial fire weather forecasts more informative and definitive. Currently, the forecast products provided to staff includes twice daily live weather briefing to the Forest Areas and a one page summary of the forecast. While the one page document makes the forecast readily digestible, it does not allow for the inclusion of more detailed information or additional context. In addition, the forecast contains weather variables for the next burning period and a brief description of the outlook for the following two days. The forecast is rather short relative to standard forecasts in the public domain and those produced by other Canadian wildfire management organizations, which extend up to five days. A more detailed five-day forecast would support an enhanced degree of

planning necessary to pre-position resources, address longer-term resource requirements, or direct tactics on the fireline.

When longer forecasts are used, the reliance on a single forecast model may be a concern. In recent years, ensemble[9] forecasts have become increasingly accurate indicators of patterns and trends for up to 10 days, have reduced concerns around uncertainty and are in common use by Canadian wildfire management agencies.

AF forecasts provide some key 'shorthand' indicators, such as "Large Fire Potential", "Blow-up Fire Potential", and Fire Weather Advisories in the form of "Low", "Medium" or "High". This approach fails to tell the whole story and does not allow for a description of how various factors are interacting with each other. The criteria and timing for issuing Fire Weather Advisories or setting Blow-up Fire Potential to High is unclear; there is a risk that readers will not be adequately informed. For example, in the 15:00h forecasts for the Fort McMurray area on May 3 and May 4, the forecast values for "Blow-up Fire Potential" indicated "Low-Medium" and "Medium", respectively. This greatly underestimated the subsequent high-intensity fire behaviour on those days, when convection column heights topped 12 kilometres indicating "High Blow-up Fire Potential".

Similarly, the forecast and conversations among staff currently use short-cut terms such as "crossover" and "RH recovery" for the relationship of temperature and relative humidity, presenting them as simple indicators of conditions on the ground. This binary presentation overly simplifies what are complex situations, making it difficult for decision makers to assess the actual conditions. The Fire Weather System codes and indices and other products of the Canadian Forest Fire Danger Rating System (CFFDRS) provide accurate estimates of fuel moisture and fire behaviour. Staff, when properly trained, can use the CFFDRS to interpret fire behaviour information more quickly and accurately. Shortcuts which simplify information should not be used when more meaningful information is available.

Going forward, opportunities to improve the fire weather forecast should be addressed. Ideally, the provincial fire weather forecast should be a tool that draws on as much useful data as possible to provide the most thorough and comprehensive forecast possible to wildfire managers. Ensuring that common training standards are in place relative to the fire weather system being used is important. This ensures that all wildfire management staff have a basic level of training, which will help decision makers and operations personnel better understand what is being presented to them.

Recommendation #2

Improve fire weather forecast materials by extending the length of the forecast outlook period and working closely with the Alberta Wildfire Coordination Centre, Planning Section to design products that directly link weather forecasts with predicted fire behaviour.

The redesign should consider:

- Providing forecast products for five days and longer using ensemble forecasts;
- Supporting three to five-day fire behaviour projections for all briefings and planning meetings;

[9] Ensemble forecasting uses two or more models and synthesises possible outcomes using more than one set of assumptions or modelling methods. This is useful to provide users with a "most likely" prediction of future weather, particularly several days (3 to 10) days ahead of the prediction.

- Improving connections between weather forecasting and fire behaviour analysts to support wildfire operations staff;
- Including observations from Environment Canada weather stations where they can augment a sparse network;
- Monitoring Environment Canada stations providing upper air soundings and providing indicators of upper air influences on fire behaviour;
- Re-evaluating the benefit of the Fire Weather Advisory; and
- Removing the “Trend” and “Blow-up Fire Potential” elements from the forecast product.

Expected Outcomes:

- Improved weather forecasts;
- Better anticipation of events;
- Increased understanding of resources needed to meet wildfire suppression workload demand; and
- Improved safety for wildfire crews in wildfire response.

4.2 Fire Behaviour Analysis

Fire behaviour analysis is an essential tool to help decision makers make more informed judgements about how to deploy personnel and equipment and what tactics to use when responding to wildfires. Done well, it can predict how an expected or active wildfire will evolve in terms of its spread, direction, and response to suppression efforts.

Alberta has full access to current wildfire science information, tools and skilled staff able to apply information and tools to decision-making. AF has been a leader in investing in a world-class model for wildfire growth (known as “Prometheus”). These tools were applied during the Horse River wildfire; however, gaps and inefficiencies in situational awareness and decision-making that could be filled by better integration of wildfire science in decision-making were identified.

Currently, the fire behaviour analyst (FBAN) function is provided at the Alberta Wildfire Coordination Centre (AWCC) and is available once a wildfire situation has started. Wildfire Science Specialists are available at the Forest Area to assist with wildfire behaviour analysis, and typically are utilized once a wildfire has started. At the time the Horse River wildfire started, the Fort McMurray Forest Area was largely working from fire weather forecasts for setting alerts and planning for wildfire response. While this approach may have been sufficient in the past, more integrated use of fire behaviour projections may lead to more proactive strategies to respond to Alberta’s longer and more severe fire seasons. An effective approach would be for AF to enhance the FBAN function within the AWCC, so that it can support presuppression preparedness decisions in Forest Areas on an ongoing basis.

On May 3, AF wildfire managers were attempting to confirm wildfire escape predictions at the same time things were quickly changing in the field. Although there was information available in the system (e.g., observations from wildfires, discussions among FBANs, model projections, etc.), that information was not completely available to all decision-makers. In some cases, people at a distance (in Edmonton, for example), were asked to confirm a wildfire growth projection, but those staff struggled to obtain the latest information adjustments that were being made elsewhere such as the wildfire perimeter, fuel type and condition, and other data. In some cases, maps and updates flowed through email or telephone conversations to senior managers, and the staff working on forecasts did not have the latest situation update. Although a strategic planning unit was ultimately created, it took valuable time to establish the situational context and information flow throughout the organization.

Preferably, the system should be in place to facilitate necessary recordkeeping and the seamless escalation of information flow in advance of any wildfire situation becoming complex. Having such a system in place early would not only help facilitate informed decision-making, it would also support the transition of personnel who come from other areas to assist in responding to the wildfires as they occur.

When a wildfire escapes initial attack, staff from across Alberta (and potentially from other jurisdictions) will converge on the Forest Area experiencing the wildfire. Each person carries their own experiences and expectations from their home area, which has its own conditions to which they are accustomed. It takes these staff some time to adjust to the realities of a different location. Ideally, staff should be provided with a multi-day fire behaviour briefing while they are en route, so that they have an opportunity to understand the conditions they will encounter upon arrival. This would shorten their transition times and improve their situational awareness upon arrival.

There is a community of wildfire specialists and analysts within AF who are able to engage with wildfire managers and help inform decision-making with supportive science. There is an opportunity to make better use of their skills during periods of high hazard and high wildfire activity.

Throughout the wildfire event, wildfire specialists and analysts within AF were using the Prometheus wildfire growth simulation model to help inform AF wildfire managers. Using the same data that was available to these people at the time of the Horse River wildfire, the Review Team undertook growth simulations of the wildfire using the Prometheus tool. The simulations closely matched the actual wildfire spread, as illustrated in Exhibits 16 and 17. This confirms the predictive tools available to AF worked well.

Exhibit 16: Prometheus Wildfire Growth Simulation for May 3, 2016 (Prometheus Model Assumes No Suppression Action)

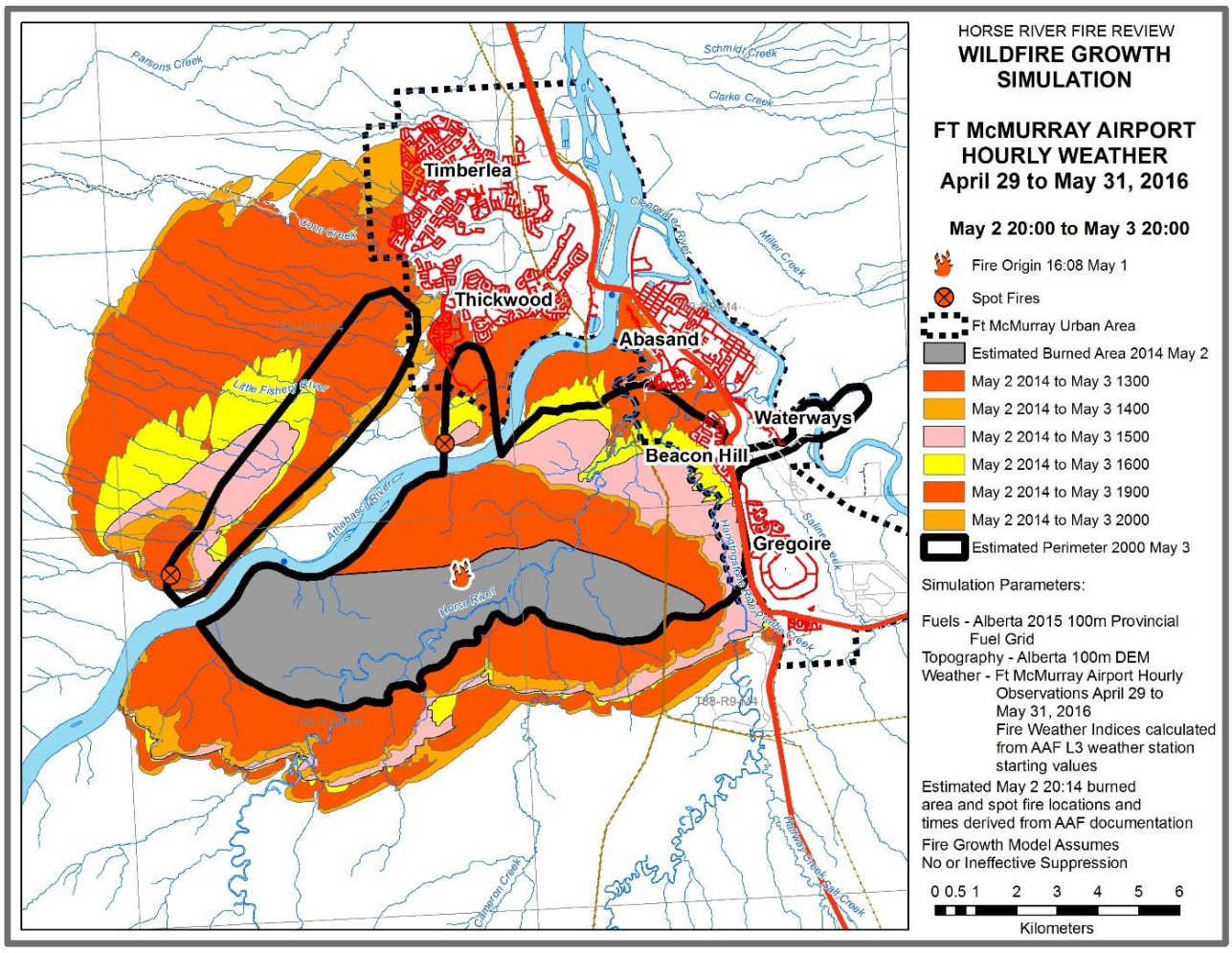
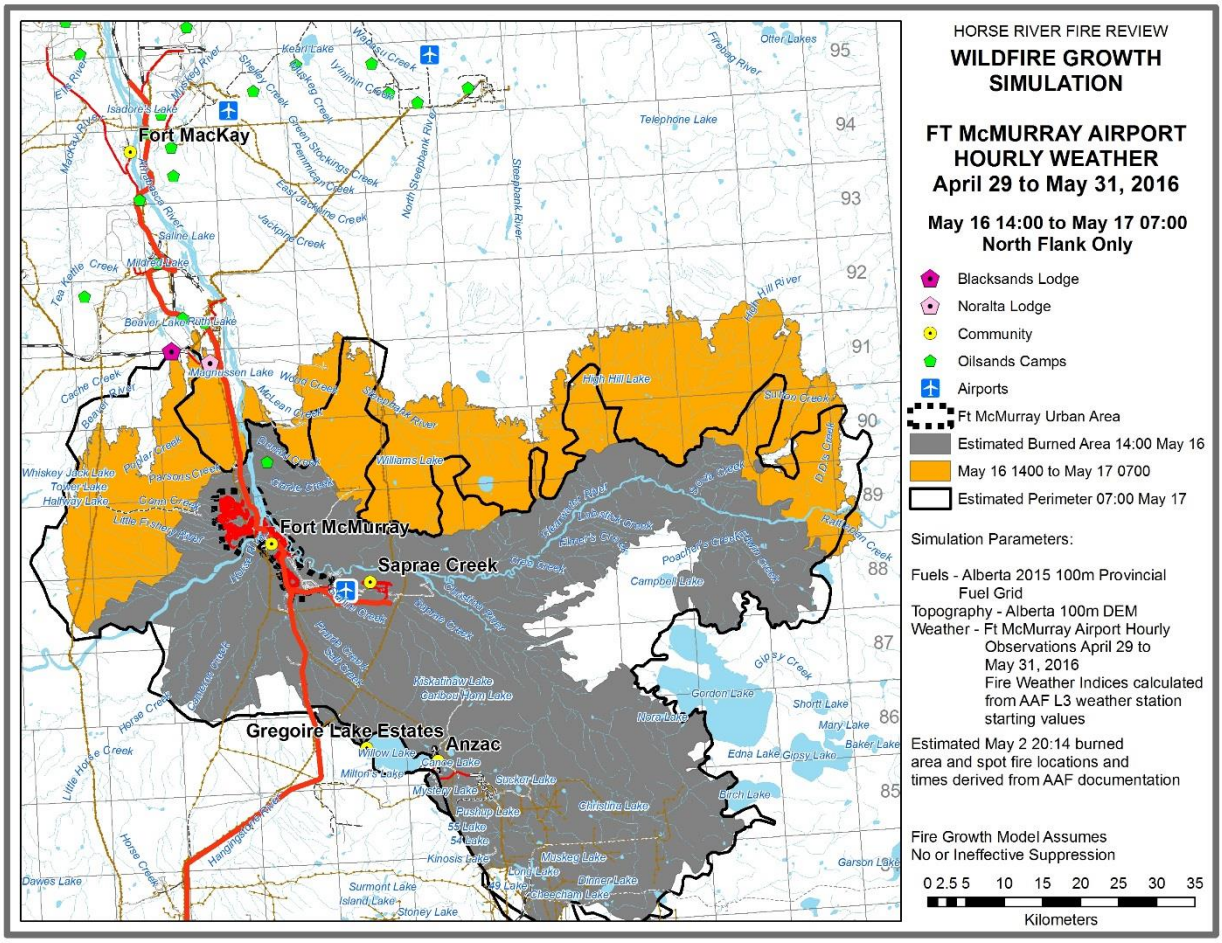


Exhibit 17: Prometheus Wildfire Growth Simulation for May 16-17, 2016 (Prometheus model assumes no suppression action)



A greater use of specialized tools and skills may enhance situational awareness and operational planning. During a rapidly evolving and complex wildfire situation, AF operational staff often rely primarily on their experience, training and observations to quickly identify a course of action to respond to wildfire situations. This is consistent with Recognition Primed Decision Making[10] and requires a high degree of experience to be effective. Having a more prominent role for wildfire science is necessary where decision makers are less experienced. An enhanced role for wildfire science would also help improve operational tactics, contingency planning, long range projections, and provincial scale strategic planning, particularly during transitions in season and as burning conditions change through the day.

The AWCC implemented a provincial strategic planning process in 2015, which was used again during the Horse River wildfire and continues to evolve. This process is currently being utilized; however, it can be expanded to enhance proactive planning, improve information flow and effectively integrate fire behaviour analysis into the decision-making process earlier.

[10] Zimmerman, 2012; Wildland Fire Management Decision Making, in Journal of Agricultural Science and Technology.

Recommendation #3

Enhance and expand the Planning Section in the Alberta Wildfire Coordination Centre to be operational March 1 annually, commencing in 2017, to provide daily fire behaviour and wildfire occurrence predictions to decision makers and to coordinate situation updates.

The Alberta Wildfire Coordination Centre, Planning Section should:

- Provide daily five-day fire behaviour forecasts/analysis products and briefings to support daily preparedness plans, strategic decision-making processes, risk assessments and risk management strategies;
- Adjust briefings according to the Alberta Wildfire Coordination Centre escalation protocol to support transitions (when snow recedes, for example) and expansions of the Section to address strategic planning;
- Provide briefings on current and forecasted conditions with respect to wildfire workload, wildfire intensity/difficulty of control, and resource needs;
- Coordinate access to remote sensing data and technology;
- Interact with Wildfire Specialists at the Forest Areas and act as a coordinating resource centre for the projection and evaluation of seasonal transitions (e.g., spring conditions, onset of lightning wildfire outbreaks, end of season planning);
- Establish and maintain (or modify) an electronic file sharing system for the distribution of situation and planning information, including all weather forecasting and fire behaviour analysis products and briefing materials;
- Encourage and empower staff working in Forest Areas and on wildfires to share and post information they have about fire behaviour (observations, maps, projections); and
- Expand and demobilize in anticipation of changes in the wildfire situation according to the principles of the Incident Command System, adding unit leaders and strategic planners as required to support strategic wildfire priority setting processes.

Expected Outcomes:

- Focus is shifted to a multi-day fire behaviour forecast;
- Preparedness is improved and seamless, quicker transitions in the use of fire behaviour science in decision-making is enhanced as a situation evolves;
- Observed and known information about wildfires is quickly shared among all levels of the organization, reducing the need for email traffic;
- Fire Behaviour Analysts are better informed and able to support each other;
- Wildfire Specialists are engaged and empowered before situations evolve; and
- Strategic planning to support complex wildfire situations and priority setting is transitioned and mobilized more efficiently.

5. RESPONDING TO THE HORSE RIVER WILDFIRE

A combination of factors made the Horse River wildfire challenging to suppress, including:

- Pre-existing forest conditions, which were highly susceptible to wildfire;
- Reduced overwinter snowpack, rapid snow melt in early spring, and an absence of rain during the last week of April and first week of May; and
- Very dry early spring conditions, with daily weather that was hot, dry and windy.

It is uncertain whether any action or group of actions during the wildfire response would have resulted in a better outcome. However, a number of opportunities are identified to improve responses to events like the Horse River wildfire, from both the wildland and the Wildland Urban Interface perspectives.

5.1 Preparedness

The success of a wildfire response depends on the preparedness and deployment of firefighting resources before the wildfire starts. This context is critical to any analysis of the detection and initial attack response.

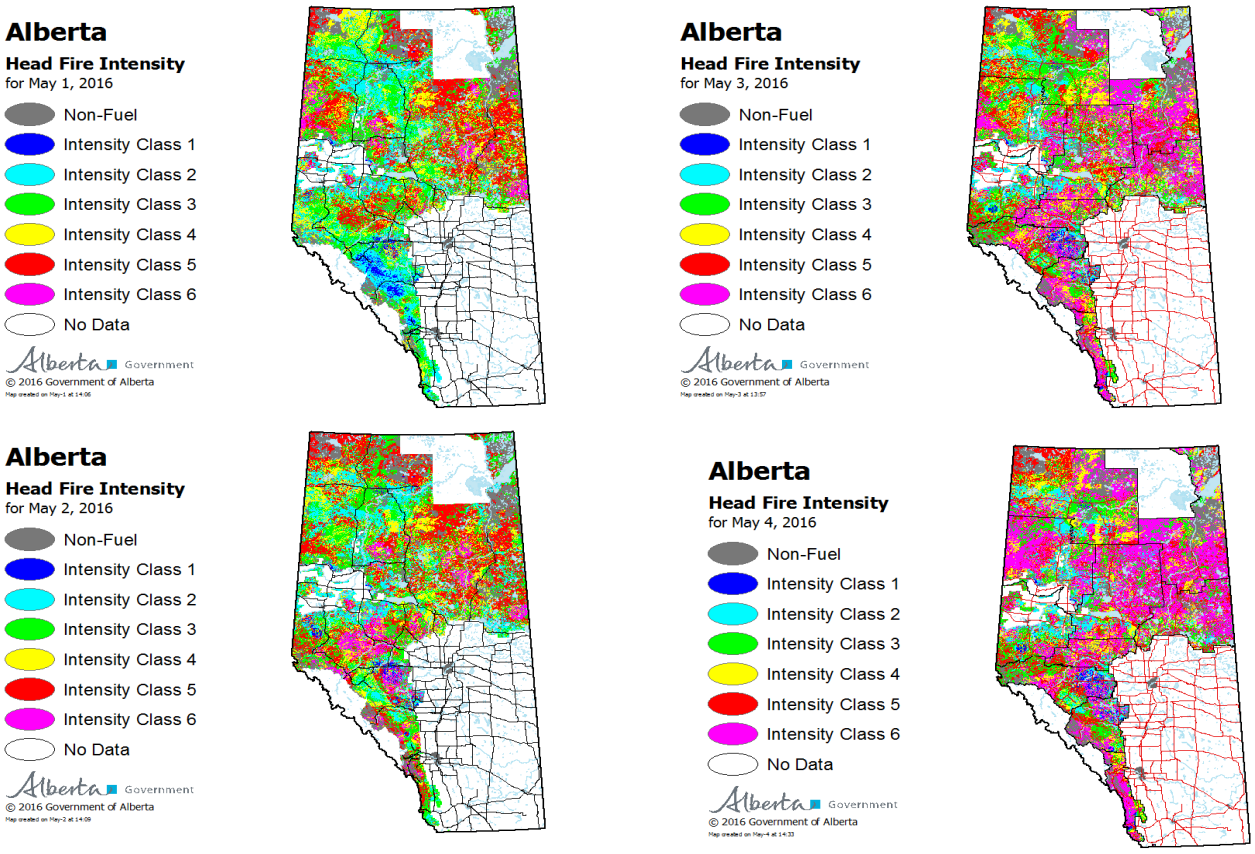
As is typical in the spring, the wildfires that occurred in spring 2016 were human-caused. Many spring wildfires are clustered around communities and are typically extinguished quickly. Spring can also lead to surprisingly quick transitions in wildfire conditions, changing from damp or cold situations to dry and warm conditions accompanied by wind. In spring 2016, Forest Areas across Alberta were active, with over 200 wildfires fought before the last week of April. The Fort McMurray Forest Area had the fewest wildfires and area burnt before April 30, though the conditions for challenging fire behaviour were present. Exhibit 18 presents the Provincial wildfire situation on May 1.

Exhibit 18: Provincial Wildfire Situation on May 1, 2016 at 10:00h

New Wildfires in the Last 24 Hours					Total Number of Wildfires and Hectares (ha) Burnt to Date							
Wildfire Management Area	Lightning	Human	Under Invest.	Total Fires	Out of Control	Being Held	Under Control	Turned Over	Active Files	Exting-uished	Total Fires	Area Burnt (ha)
Calgary	**0**	0	0	**0**	0	0	0	0	**0**	18	**18**	34.54
Edson	**0**	1	0	**1**	0	0	0	2	**2**	27	**29**	10.87
Fort McMurray	**0**	0	0	**0**	0	0	0	0	**0**	8	**8**	2.13
Grande Prairie	**0**	1	1	**2**	0	1	2	2	**5**	26	**31**	124.65
High Level	**0**	0	0	**0**	0	0	0	0	**0**	26	**26**	34.64
Lac La Biche	**0**	2	0	**2**	0	0	1	1	**2**	57	**59**	92.4
Peace River	**0**	0	1	**1**	1	0	2	4	**7**	17	**24**	235.53
Rocky Mtn House	**0**	0	1	**1**	0	0	2	0	**2**	35	**37**	70.77
Slave Lake	**0**	1	2	**3**	1	0	1	2	**4**	28	**32**	229.55
Whitecourt	**0**	2	0	**2**	0	0	1	3	**4**	13	**17**	8.78
Total	**0**	**7**	**5**	**12**	**2**	**1**	**9**	**14**	**26**	**255**	**281**	**843.86**

In the days leading up to the Horse River wildfire, the weather across a large part of the province was such that wildfire risks were rising in many areas. As can be seen in Exhibit 19, showing provincial maps of Head Fire Intensity,[11] this risk picture worsened during the early days of the Horse River wildfire.

Exhibit 19: Provincial Recordings of Head Fire Intensity May 1 to May 4



Provincially, AF officials were challenged to optimally deploy available resources across a large geographic area that had the potential for new wildfires. No areas were without some level of hazard and resources. Primarily, wildfire activity was concentrated from west to east across the centre of the province. In advance of the Horse River wildfire, AF took a logical approach to pre-positioning its resources, taking into account forecasted weather conditions, current and expected wildfire workload and other factors that are a part of the presuppression preparedness system.

Significant to the response to the Horse River wildfire is the preparedness in the weeks and days preceding the wildfire, and the plan for wildfire response that set the stage for action on May 1.

In the Fort McMurray Forest Area, staff were gearing up and responding to a few wildfires. Of note, wildfire MMD-002 occurred inside the Urban Service Area of Fort McMurray near Parson's Creek on

[11] Head fire intensity is a measure of the predicted intensity or energy output of the wildfire at the front or head of the wildfire.

April 29, challenging the combined municipal and AF resources. The wildfire was controlled within the first burning period, and was a clear indicator of the fire behaviour potential present in the area around Fort McMurray. The observed fire behaviour fit with anticipatory discussions across AF of the potential for a serious wildfire in spring conditions.

Exhibit 20: MMD-002 on April 29 – Near Parson's Creek

On May 1, AF had airtankers on alert in Lac La Biche, Slave Lake, Whitecourt, Edson and Peace River, providing coverage for the province. There were no airtankers positioned in Fort McMurray, which is not unusual for that time of year. The airtanker base at Fort McMurray was fully operational and ready with fuel and retardant. Many wildfire crews were on alert in the Fort McMurray and neighbouring Forest Areas. Helicopters were also brought on contract early, and others hired on a short term basis according to provincial preparedness guidelines. Although crews may have been comprised of senior staff (while new staff were being hired on or undergoing training), there is no evidence these “spring start-up” activities impaired the availability of trained wildland firefighters on May 1.

5.2 The Wildfire Response

The First 36 Hours

The detection and initial attack phases of the Horse River wildfire were examined in detail by the Review Team. Although there were some delays in the phases, none of these could be considered unreasonable given the circumstances and were consistent with AF standard operating procedures and performance of other wildfire management agencies. AF had deployed appropriate resources in the field and all indications were they were taking immediate and appropriate action.

As with any wildfire, some time passed after the Horse River wildfire started before it was detected (See Appendix A). While the exact time of ignition is not known, the time lag is not believed to be inordinately long as the wildfire was detected at a size of less than 2.0 hectares – within expectations set for the detection program. AF had initial attack resources with helicopters in the field serving detection functions ("loaded patrols") to complement the function of lookout towers. With an elevated hazard across a large geographic area and the expectation of human-caused wildfires, there is no certainty where or when a wildfire might occur. On a warm spring Sunday in early May, people will be active around communities, roads and trails in Alberta. The challenge for AF is to search for wildfires and to rely on prompt public reporting. On the afternoon of May 1, a helitack crew in a helicopter was on a patrol looking for wildfires at the peak of the burning period and, detected the Horse River wildfire. This indicates the system deployed that day was working.

Once the Horse River wildfire was detected by the helitack crew, they immediately responded and support from large airtankers was requested. The airtanker group arrived in just over 30 minutes, which was within standards and criteria. Having the benefit of hindsight, positioning an airtanker group at the Fort McMurray airport would have allowed air attack operations more quickly; however, there is no evidence the plan for the day was unreasonable given the known variables. Once the wildfire was detected, the initial attack system responded appropriately.

Complicating the situation was another wildfire that was reported almost simultaneously with the Horse River wildfire. This wildfire (known as wildfire MMD-004) was located immediately inside the boundary of Fort McMurray, and was in similar forest and weather conditions as the Horse River wildfire. Both wildfires received ground wildland firefighting crews. When airtankers arrived, AF officials were forced to choose between the Horse River wildfire and MMD-004 for initial air attack. Exhibit 21 presents a photograph of both the Horse River wildfire and wildfire MMD-004 on May 1, at 18:35h.

Exhibit 21: Photo Showing the Horse River Wildfire (right) and Wildfire MMD-004 on May 1, 2016

At the time, wildfire MMD-004 was in closer proximity to structures in the community than the Horse River wildfire and thus posed the greater immediate risk. It was also evident to the first air attack officer that applying air attack on wildfire MMD-004 was more likely to yield a successful result (a decision balancing risk and probability of success). With the exhibited fire behaviour and the time that had passed for the wildfire to gain some momentum, the Horse River wildfire was likely to outpace the actions of the dispatched airtanker groups. Crews on the ground could begin to fight the Horse River wildfire near the origin, but neither ground or air attack would be successful directly on the head of the wildfire. In the end, this judgement proved correct, and wildfire MMD-004 was successfully suppressed without damage to the surrounding values. The consequence was a further delay in the use of air attack to slow or redirect the Horse River wildfire.

Within the first hour of commencing suppression activities on the Horse River wildfire, it became clear that initial attack efforts would not be successful in containing the wildfire. This awareness required another transition in the thinking of AF and RMWB. Operational personnel would continue to attack the wildfire, but the plan needed to shift to the requirement for expanded operations.

Once it became clear that the Horse River wildfire was beyond initial attack, it was important for personnel to adjust their plan to deal with the large wildfire close to the community. While some good efforts were made to adjust to this transition, the review of actions taken found some areas where AF and RMWB staff could improve in the future:

- The primary suppression strategy implemented in the first 2 days was focused on direct attack measures and heavy use of airtankers. Because of the proximity to the community and the expected fire behaviour, there was a reluctance to use ignition tactics as part of initial suppression efforts. Later in the overall response, when direct attack failed, more indirect strategies were implemented with the use of ignition. A notable success was the protection of

the Hamlet of Anzac, Gregoire Lake Estates and the Fort McMurray First Nation. Ignition can be a high risk/high reward technique. Ignition tactics were used sparingly due to safety concerns in the early days of the wildfire. Given the time of year, the fuel types involved, the burning conditions and the sheer size of the wildfire perimeter, ignition tactics may have been employed earlier with some success.

- Use of heavy equipment for wildfire suppression is common and expected in Alberta. Over the duration of the Horse River wildfire heavy equipment was used extensively. No heavy equipment action was initiated on May 1 and night operations were not considered for heavy equipment on the first evening of the wildfire. The first heavy equipment arrived at a staging area near the landfill on May 2 between 06:00h and 07:00h and wasn't deployed on the ground until between 13:00h-14:00h with guard construction commencing from 14:00h-15:00h. This represents a significant delay (almost 24 hours from the start of the wildfire). The equipment initiated access to the wildfire from the east, but it encountered a major pipeline corridor that ran between the wildfire and the community. Almost all of May 2 was spent trying to cross the pipeline corridor resulting in only minor guard construction completed by day's end. Given the predicted fire behaviour and burning conditions, direct attack with heavy equipment was not likely to meet with success and a more indirect attack approach may have been warranted. The wildfire's behaviour forced the tactical withdrawal of all the heavy equipment on May 3, for reassignment the following day.
- From May 2 onward, there were many days when personnel had difficulty identifying the perimeter of the wildfire due to smoke-obscured visibility. There are indications that remote sensing technology (such as satellite imagery or high elevation infrared scanning) was not available to assist personnel in this regard, or was inconsistently used or shared. Further, it appears that these technologies are not always used by some AF personnel.

Wildfires that have the potential to spread into a WUI zone present a higher level of priority, complexity and challenge to firefighters. To be successful in containing such wildfires, the secondary response is critical. Unless the wildfire is immediately involving structures at initial attack, the time required to make decisions and implement contingency plans is compressed into the first 36 hours of the wildfire, often before the first Incident Management Team (IMT) can arrive on scene, take over operations, and be "up and running". The first 36 hours required a critical transition on the Horse River wildfire - actions taken during this transition period can make a difference in the ensuing events after initial attack efforts have failed.

The transition from initial attack to deal with an escaped wildfire requires wildfire staff to develop and implement simultaneous direct attack and indirect attack contingency plans. This is difficult at the best of times, and even more so when there are WUI values at risk. The complexities involved in implementing a multi-pronged approach during the first 36 hours demand skills and experience levels not normally present among initial attack crews or first responders. These individuals are most familiar with direct attack on small wildfires and are more likely to be drawn into a singular focus on a direct attack approach. They are less likely to recognize the need to "step back" and plan contingencies with more complex indirect containment strategies including the use of ignition aimed at preventing the wildfire from entering the community or giving the suppression organization a place to defend from.

Based on what happened on the Horse River wildfire, it can be argued that different approaches could have been implemented. The following observations were noted and should be considered when wildfires like this occur:

- Incident Commanders and operational leaders on scene during the first and second burning period (May 1 and early May 2) who were new to their roles were taxed with the complexity of the situation. The Operations Chief for the first Incident Management Team (IMT) arrived by noon on May 2 and assumed operational responsibilities sometime later that day. By the time he was in place, the wildfire was exhibiting extreme fire behaviour, requiring that he focus on safety and field operations – actions that were almost entirely reactive and appropriate to extreme fire behaviour.
- There was a considerable delay in mobilizing heavy equipment from the time the wildfire started on May 1. Opportunities to build contingency lines or control lines through the first 24 hours including night operations were not carried out. The direct attack strategy using heavy equipment was complicated and delayed by the need to cross a major pipeline. By the time dozer guard construction commenced it was the heat of the day on May 2. The pipeline corridor and fire behaviour limited what could be accomplished and equipment was pulled back on May 3 for safety concerns.
- Suppression efforts on May 1 and May 2 were very much focused on direct attack, which was not proving successful and ultimately failed. Adding to the complexity, the wind shifted direction several times over the first 72 hours. To some wildfire personnel, these wind changes appeared surprising, but they were well forecasted by AF. There is limited evidence that contingency plans were being developed and implemented during the first 36 hours aimed at providing opportunities to contain or minimize damage as the wildfire approached the community. Indirect attack alternatives were evaluated by AF officials and considered to pose unacceptable risks; opportunities to implement indirect attack strategies, such as aerial ignition, were therefore not pursued. The suppression organization maintained a singular focus on direct attack measures with a heavy reliance on aerial suppression using airtankers.
- Given the fluid nature of wildfire organizations, staff experience and the unpredictability of the workload, it is not always reasonable to have the expertise readily available everywhere when needed. However, AF should aim to put the most experienced command staff (i.e., Operations Chief or Incident Commander 3 or 2 qualified staff) available into managing the transition from initial attack until an Incident Management Team is fully functional especially when the wildfire has the added complexity and risk of WUI values.
- Rapid deployment of sprinkler systems is an effective tactic for reducing damage to buildings when a wildfire approaches. While not an AF responsibility, contingency plans and actions should include joint efforts of wildland and urban firefighters to deploy sprinklers to reduce ignitions from spotting ahead of the fire.
- The key is to recognize upfront that WUI wildfires such as the Horse River wildfire require more than a standard wildfire suppression approach because of the potential values at risk. Planning for the potential opportunities or contingencies requires an experienced Incident Commander and/or Operations Chief available to direct efforts and build plans during the first 36 hours of such a wildfire. While it is acknowledged that the ability to achieve this will vary depending on the location of a wildfire and where personnel are available at the time, it makes sense to formally establish this as a goal through training and standard procedures.

Recommendation #4

Establish a standard operating procedure across Agriculture and Forestry which requires, when a wildfire escapes from initial attack and interface risks are present, the immediate assignment of a senior Incident Commander to undertake tactical planning for wildfire containment and risk mitigation.

This procedure should consider:

- Initiating sustained attack actions and options, such as indirect attack and 24-hour suppression activities (including night operations) when achievable objectives exist;
- Emphasizing simultaneous direct and indirect attack tactics, including the implementation of contingency plans to protect the community at risk if direct attack fails;
- Preparing for a seamless transition of wildfire operations to the Incident Management Team as they arrive to take over the wildfire, including expected fire behaviour and clearly outlined risks and contingency plans; and
- Implementing unified command with the community fire department to ensure common situational awareness and operational plans.

Expected Outcomes

- Safety and support to initial attack personnel and response officers;
- Improved situational awareness, providing better anticipation of needs and suppression effectiveness;
- Provision of multiple defense opportunities where possible to mitigate community impacts; and
- Improved wildfire suppression success.

Opportunities for Improvement:

2. The Office of the Fire Commissioner, Agriculture and Forestry and municipalities should continue work to expand the use of sprinkler systems to protect buildings at the Wildland Urban Interface. This work includes investment in equipment, training, and procedures for unified operations among wildland and urban firefighters. Municipal fire departments should utilize specialized teams and equipment that can be deployed by the province to assist them in structural protection.

Extended Operations

By May 4, the potential fire behaviour and impact of Horse River wildfire was gone. Staff were faced with wildfire in the community and further challenges arose when both the AF Incident Management Team (IMT) and the Regional Emergency Operations Centre (REOC) had to relocate several times as the wildfire threatened their command locations. Operational communications were difficult as staff were in transit and scattered in different locations. At the same time, they were attempting to escalate the response to the wildfire. Despite these challenges there were several successes:

- Additional staff were brought in to assist the rapidly expanding organization.
- Initial attack on new wildfires in the Fort McMurray area were assigned to the Lac La Biche and Slave Lake Forest Areas. This freed up the Fort McMurray Forest Area to focus solely on the Horse River wildfire.
- A plan was put in place to relieve staff in the Fort McMurray Forest Area office. They had been working long hours under considerable stress and were living in the office, sleeping on the floor and eating poorly. When advised they would get days off, staff were initially reluctant and concerned about abandoning a situation they felt personally committed to. On reflection, they realized fatigue and prolonged focus on task would cause them to become less effective. They were able to reconnect with family who had been evacuated without them, helping them to understand the situation outside the Fort McMurray Forest Area office. The replacement staff came in with renewed energy that was essential to deal with the situation at hand.
- Phone systems were challenging, especially as the REOC and AF Incident Command Post (ICP) were forced to move locations. Several key staff indicated email became unusable because of volume. The cell phone system was reliable and continued throughout the event, which allowed communications to continue.
- On May 4 and 5, the wildfire continued to move to the southeast driven by high winds threatening Anzac, Gregoire Lake Estates, and the Fort McMurray First Nation. Again, a stressful, short-notice evacuation was required of residents and challenges with situational awareness and operational planning were evident. Despite these challenges, the suppression effort by AF, the local First Nation and community members was well executed and prevented damage to the communities. Suppression included a combination of heavy equipment, indirect attack, and air attack support.

While the wildfire spread on May 3 was most dramatic, because of the impact on Fort McMurray, the largest spread of the wildfire occurred in subsequent days. By the end of May 5, the wildfire was estimated at over 100,000 hectares in size and continued to spread to the south and east.

Once a wildfire has reached this large size, wildfire suppression can only occur strategically at points of priority where specific values are at risk. Organizing personnel and equipment to deal with the entire perimeter is not possible. There was no evidence that this large wildfire operation was without resources and the priority setting process was appropriate given the dynamic and fluid circumstances the firefighting organizations were dealing with. Resources from across Canada and around the world were provided over several weeks and were managed well by the IMT. At this stage of the wildfire the daily operational planning and implementation was both reasonable and effective, given the circumstances.

On May 8, strong winds from the west caused a significant eastward run of the wildfire and created a long and dangerous flank directly south of the oil sands operations. By midday on May 9, the wildfire had grown to 230,000 hectares in area. Priorities were set by the Incident Management Team and the

focus of suppression remained the southern perimeter of the wildfire. Concern arose quickly, however, with risks to oil sands operations (close to the wildfire's northern perimeter). Managing these concerns represent important lessons learned, which can be applied to similar wildfire events in the future:

- All indications are that AF took appropriate action on the wildfire and dealt with priorities at risk in the south and western parts of the wildfire. Projected fire behaviour following the events of May 8 did not, from the Incident Management Team perspective, place the northeast flank as a higher priority compared to the other priorities. As well, the northeastern flank was in difficult terrain and would require considerable time and effort to contain.
- The oil sands industry had considerable financial and economic value at stake and took the wildfire's threat on the northeast flank very seriously. They undertook independent planning and action to protect their oil sands operations. This included hiring independent experts to assist with implementation of existing FireSmart plans, to conduct fire behaviour assessments of risk, and to identify other measures to protect their operations and "infrastructure".
- The manner in which the risk assessment and operations on the northern flank occurred created several points of tension which can be avoided in the future by a few simple principles:
  - Significant stakeholders, such as the oil sands industry, forest industry and utilities industry, should have a formal connection to the operational Incident Command Post to share and gather information, conduct joint risk assessments, discuss the nature and magnitude of values at risk, and to share local knowledge about operations on the land (IMTs often come from other areas of Alberta or Canada – industry staff work in the area every day). Industry was directed to gain information at the REOC. If the wildfire had not involved the RMWB, the oil sands industry would have shared information and concerns at the Incident Command Post (ICP). That is where they should have connected to wildfire planning. The industry should have a presence at the REOC as well but for other reasons, such as managing the evacuation process.
  - The oil sands industry must ensure that wildfire is identified as a risk in their site emergency response plans, including plans to evacuate staff, protect operational assets, and communicate/interact with AF wildfire staff.
  - Industry relies on rigorous engineering, financial risk analysis and risk mitigation activities that require real time wildfire information and analysis. If they cannot readily gain access to the information they need in direct communications with those managing the wildfire, they are forced to gather the information on their own. This creates a situation where information is gathered twice and forecasts are developed independently. This leads to confusion and concerns over which forecast should be used.
  - The simple list of five provincial wildfire priorities (see page 37) should be expanded to deal with values at risk in the context of the wildfire and impact on the economy. Common understanding of the priorities for the wildfire should come from a risk assessment exercise that includes the affected communities and industry stakeholders. For example, the residents of the Firebag Lodge will be evacuated to save them from harm; however, the camp, operating with key staff in place, supports ongoing oil sand operations, including a pipeline that must stay operational. If that pipeline was to be shut down in haste, a very expensive asset could be lost as warmed bitumen solidified in the line. Oil sands representatives indicate that this could disrupt oil sand production for up to a year. In the priority setting process used on the

Horse River wildfire, it was not clear enough how the facility should be treated considering the significant economic impact to Alberta and Canada.

On May 16, containment efforts on the southwest corner of the wildfire were breached and the wildfire took major runs to the north. This further exacerbated the concerns of the oil sands industry. The northeast flank of the wildfire became the head and concerns increased about incursion on the Firebag facility. Of more direct impact, the wildfire ran towards Blacksand Lodge on the northwest corner of the wildfire and that facility was burnt over. Readily available and prudent FireSmart initiatives, such as clearing flammable debris near buildings and use of sprinklers can reduce the risk for industrial facilities and homeowners alike.

There are many examples of good work during the extended period of time of wildfire operations. Efforts to understand values at risk to the south of the wildfire, including the Cheechum tank farm and utility installations were effective and suppression efforts became more strategic to deal with both the ongoing fire behaviour and the size of the wildfire. As another example, before the wildfire eventually entered Saskatchewan, operations were integrated seamlessly with an Agency Representative from Saskatchewan joining the IMT in a well-coordinated fashion.

Many government departments pulled together and provided support to the wildfire response and the evacuation and support of residents. The Review Team heard a number of comments about challenges in dealing with such a complex situation involving several supporting departments in government. Any wildfire of this magnitude will have some of these issues. It is essential for the people involved to discuss what happened, and to identify what future support should look like.

A separate review is specifically looking at the issues and learnings that may have arisen in relation to the overall emergency response and recovery. There are a few items discussed in this review that leaders in other government departments should be aware of to determine the best way to respond in the future.

Airspace Management

The management of airspace during the Horse River wildfire presented some unique challenges and yielded some best practices that can be implemented in future wildfire situations. As the wildfire spread eastward through Fort McMurray it burned close to the Fort McMurray International Airport, an airport that is normally quite busy with scheduled domestic and chartered flights operating daily. Wildfire operations near the airport involved an Air Traffic Control Zone and aircraft operating through various areas of controlled airspace. Adding to the complexity of the situation was the use of the airport by airtankers and helicopters for reloads and refueling.

As the wildfire encroached on the community of Fort McMurray, dozens of aircraft were operating directly over the community, including heavy airtankers dropping loads in an urban setting. It is not typical for these types of wildfire operations to be conducted so close to an airport that features a high level of passenger travel. The number of aircraft in such a confined airspace presented complexity and significant safety concerns. Eventually the decision was made to divert normal air traffic and the controlled airspace over Fort McMurray was taken over completely by AF.

The initial days of the wildfire represented the most concerning period of time with respect to safety and orderly control of air traffic. While those aircraft under direct control and communication with AF were operating pursuant to the Notice to Airmen (NOTAM) issued by Transportation Canada (the regulator), it is noted that other aircraft were flying through the area without authorization from AF. Once AF was given expanded responsibility for the airspace to support the wildfire suppression efforts,

order was established and a local policy termed “clear air – clear objective” was implemented which greatly improved control and safety within the airspace.

Despite the complexity and need to assert expanded control over the airspace, air operations were managed very well. There were no significant accidents reported and indications are that the safety incidents were minimal given the extent of the aircraft operating in the area. Comments were received regarding safety concerns about refueling practices for rotary wing contract services. These had been identified and resolved during the wildfire operations. Overall, safe and effective air operations is a success which AF and the air operators share. It demonstrates the effectiveness of the existing wildfire air operations procedures being used and an ability to adapt to a unique situation to create a safe airspace.

It is foreseeable that a future wildfire may involve a similar set of airspace-related circumstances; the lessons of the Horse River wildfire should be leveraged to guide airspace management in such instances. Air operations staff and their key aviation partners should ensure that these lessons are well documented and forwarded to staff and pilots who may face similar situations in the future. These learnings and improved procedures should be distributed through the Canadian Interagency Forest Fire Centre to wildfire management agencies across Canada. A fact sheet for Nav Canada staff should be developed to help them understand this type of situation.

Recommendation #5

Develop an improved procedural model for airspace management where confined airspace over a community or airport is involved.

Expected Outcomes

- The unique lessons learned from the Horse River wildfire are leveraged;
- Improved aviation safety during wildfire responses;
- Better understanding and comfort among airport users, aviation operators, Nav Canada and Transport Canada;
- Safe operations in complex situations where a Notice to Airmen (NOTAM) is in place and many aircraft are involved;
- Involvement of key air operators who are partners and may have perspectives on how wildfire operations can be further improved; and
- Effective coordination of wildland and other aviation traffic in the area of a wildfire and a municipality.

Opportunities for Improvement:

3. Agriculture and Forestry should review its standards and procedures for contract aircraft fueling and ensure vendors comply.
4. Review and improve mapping processes and geographic description systems to better guide airtanker activity when working in close proximity to city limits.

Determining Wildfire Priorities

To help guide AF in its deployment of resources when responding to wildfires, the Government of Alberta has established five provincial wildfire priorities:

1. Human Life
2. Communities
3. Watersheds and Sensitive Soils
4. Natural Resources
5. Infrastructure (which has major impact on public safety or local economy)

The current priorities are characterized quite broadly. This can create interpretation challenges during active wildfire operations.

The priorities are intended to provide strategic direction, and there is evidence that wildfire operations staff applied this direction in responding to the Horse River wildfire. However, part way through the incident, further direction was provided to operational staff to increase their emphasis on oil sands infrastructure (priority #5) and industrial work camps. The rationale for this decision was the potential for significant economic impacts to the province if these assets were to sustain major damage. Such broad economic impact does not fit neatly within the current list of priorities and some people interpreted this new guidance as an arbitrary change creating associated concern and uncertainty. This uncertainty can be avoided in the future with less emphasis on a simple list of value categories and more clarity regarding priority in the context of a wildfire situation. This can be accomplished through the establishment of a risk management framework that provides guidance for decision making while taking into account a greater amount of information and context.

The direction provided to operations staff about the priority for industrial camps had merit. Industrial camps in the Fort McMurray region often contain thousands of residents and there is a compelling argument that these camps are more appropriately considered as communities rather than industrial infrastructure. Further, the value of the camps follows from the foundation they provide to business continuity and the economic impact caused when workers cannot support oil sands operations. The same argument can be used to suggest that more requirements should be imposed on the owners of these camps for preventive measures such as external sprinkler protection and FireSmart practices.

Identifying priorities on a large complex wildfire is a risk management exercise. Of course, protection of life will always rank first. Second, the relative value of the structures, facilities, or equipment needs to be collected from pre-existing inventories (Wildfire Management Plans currently under development by AF will be a useful place to gather and confirm the location and nature of values at risk). These items then need to be considered in the context of wildfire impact on human values, government or business continuity, and impact on the economy or other operations. They should then be placed in a risk assessment matrix demonstrating the probability of that impact, such that risk is a multidimensional space, not a simple list. What is at risk, why is it important, and what is the probability for the wildfire to cause an impact? This information can then be used to engage with community and stakeholder representatives to get current and nuanced information. Clearly, this discussion will require engaging both land and wildfire managers about the values in proximity to the wildfire. Setting priorities must be more of a process, not just reliance on a provincial list.

Recommendation #6

Continue to develop risk management frameworks as the foundation for wildfire management policy. This would include reviewing the list of five provincial priorities as the central policy and emphasizing a risk and consequence approach.

The results of this review should:

- Provide for additional clarity around the specific criteria to be considered when setting priorities;
- Identify where and how the consideration of economic impacts will be considered;
- Provide for industrial camps to be evaluated as communities; and
- Be communicated widely to internal and external audiences, allowing for interpretive and interactive discussions that reduce uncertainty as to how priorities effect decision making on a large wildfire.

Expected Outcomes:

- Clearer strategic direction for Agriculture and Forestry decision makers;
- Transparency is provided for the public and all stakeholders; and
- Opportunity for discussion and consensus about priorities on a wildfire and how they are to be interpreted.

In association with an approach built on a risk management framework, there are also opportunities to enhance inventories of values and assets in Alberta's wildland areas. In responding to the Horse River wildfire, operations personnel were at times challenged by a lack of precise information. Although an inventory of key values and assets in the Fort McMurray Forest Area had previously been compiled, this inventory lacked details about the level of their significance. As a result, operations personnel discovered information about certain assets 'on the fly' which forced them to reactively shift their tactics.

For example, during the incident it was learned that a known electricity asset in the area was a key substation for providing electricity to a significant geographic area. Similarly, it was learned that a pumping station near a known energy asset was most vital for the smooth operation of several pipelines and energy facilities. The true significance of these assets, once learned, put the vulnerabilities and risks associated with them in a new context and influenced decisions about the deployment of firefighting resources. Had the actual value of these assets been known in advance, operations personnel could have planned proactively and saved valuable time

5.3 The Wildland Urban Interface Response

Use of the Incident Command System

The most notable aspect of this wildfire was its impact on the community of Fort McMurray and surrounding areas. As with previous wildfires that threaten or impact urban areas, such as the 2011 Flat Top Wildfire Complex in the Slave Lake area, managing a wildfire in the Wildland Urban Interface (WUI) becomes much more complicated because of all the entities involved.

One of the key issues to overcome is effective coordination of plans and resources. Even if that coordination does not change the outcome of a wildfire in the community, the way the response is managed has a dramatic impact on the people involved. While AF is primarily responsible for addressing a wildfire in a wildland area, the municipal fire department is typically responsible for addressing all fires within their community. When a wildfire interfaces with a community, both organizations (i.e., AF and the local fire department) must be engaged, and both need to immediately work together in an integrated manner to be effective.

To facilitate such cooperation, the Incident Command System (ICS) was developed. ICS involves the use of a common organizational structure to manage people and resources that respond to a wildfire. ICS Canada is the standard in Canada for the design and use of incident command systems. It is critical for all provincial and municipal emergency agencies to use one system and not to modify or customize the organization or roles. This is particularly important in the realm of wildfire, where personnel are shared across Canada every year. ICS has three primary purposes:

- To provide for the orderly and predictable division of labour;
- To provide for the overall safety at the incident or event; and
- To ensure that the work at the incident or event is performed efficiently and effectively.[12]

Fundamental to ICS is the use of “unified command” when different organizations join together on an incident. It effectively means that a single chain of command is created, so that each individual involved in the response reports to only one supervisor or command structure. The use of unified command avoids the practical problems that can be encountered when multiple organizations with multiple hierarchical structures come together to work together (for example, the possibility of receiving conflicting instructions from a number of different supervisors). It also ensures a common understanding of the situation and common operating plan to deal with the incident and the safety of personnel involved.

Incident Command System

AF describes ICS as " a standardized on-scene emergency management system specifically designed to allow users to adopt and integrate an organization structure equal to the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries."

Alberta’s Office of the Fire Commissioner references ICS as a “system designed to enable effective, efficient management of an emergency by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure”.

As indicated by ICS Canada:

> “When incidents are of different types and/or do not have similar resource demands, they are usually handled as separate incidents or are coordinated through an Emergency Operations Centre (EOC) or Emergency Coordination Centre (ECC). If the incidents under the authority of the Area Command span multiple jurisdictions, a Unified Area Command should be established”.
>
> “This allows each jurisdiction to have appropriate representation in the Area Command. Area Command oversees management coordination of the incident(s), while the communications/dispatch centre or EOC/ECC, coordinates support.”

[12] ICS Canada. 2012. Incident Command System Operational Description.

In the response to the Horse River wildfire, senior personnel quickly realized that wildfire and municipal resources should be activated and organized for an effective, safe and efficient response.

In the case of a smaller wildfire within the Urban Service Area (wildfire MMD-004), this would have occurred a certain way. The Incident Commander of AF wildfire resources and the Battalion Chief of RMWB would have immediately established unified command at the operational level. Situational awareness, tactics, and longer range planning would have been understood and undertaken jointly, following the principles and organization of ICS. Adopting this structure ensures the most effective use of resources in a cohesive and integrated fashion, despite the fact the organizations typically work under two completely separate command structures. For the Horse River wildfire, however, the organization under ICS was undertaken differently. This appears to have happened due to the approach taken to get organized, as well as overarching provincial direction.

Once reported and actioned, the Horse River wildfire became an "incident" under the AF structure. Once the wildfire's threat to the community was identified on May 1, RMWB began treating the situation as an emergency management incident and, before it was directly involved in wildfire suppression, activated its Regional Emergency Operations Centre (REOC). Under provincial direction (through AEMA), the REOC became the Incident Command Post (ICP) for RMWB.

At this point a split began to emerge in the joint response to the Horse River wildfire. Operations for municipal/urban resources began reporting to the REOC. Some interviewees recalled that AF and RMWB were working "right alongside each other" from May 1, while others recalled that unified command was not organized until May 4. Still others suggested that resources did not function in a unified way for several days or at all for the duration of the wildfire. In the opinion of the Review Team, the connection between the AF organization and the municipal resources never achieved unified command as described by ICS Canada. Connections of AF within the REOC were informal adjustments of the system. The urban firefighting resources were not connected within the AF Incident Command organization. By May 6, some personnel considered the REOC to be the ICP, AF had also established an ICP with a Type 1 Incident Commander, and there was an "ICP" at MacDonald Island Park for urban resources. Various interviewees indicated that they "were at the ICP" or talking to the appropriate command structure but, in fact, they were in different locations talking to different people. Clearly, communications among these structures was difficult and added to the complexity of gaining one clear operational plan for dealing with the wildfire. This is one of the main challenges that the ICS structure was designed to overcome.

According to many interviewees, the structure that evolved in many ways served the necessary emergency management functions around the community. However, many interviewees who are familiar with large and complex incidents identified gaps in understanding of the situation and plans at all levels, and the lack of a common operating plan on the ground. Those involved in wildfire operations were obviously disconnected from each other in many circumstances. Things changed rapidly over the duration of the Horse River wildfire, and the organization struggled to keep pace with changing developments. It is clear that the REOC's role required it to deal with more than just the wildfire operations including the region's social wellbeing and order.

Complicating matters, both the REOC and the AF ICP had to relocate and re-organize several times because of the wildfire encroaching on their locations. AF and RMWB staff both reported that once a WUI Branch was established under the AF Incident Management Team, and AF firefighters started working alongside municipal firefighter's operations on the ground, operations were conducted more effectively. This integration of ground operations did not occur until after the first week of the wildfire. In

many respects, operational unified command with respect to the wildfire and the WUI was never fully achieved.

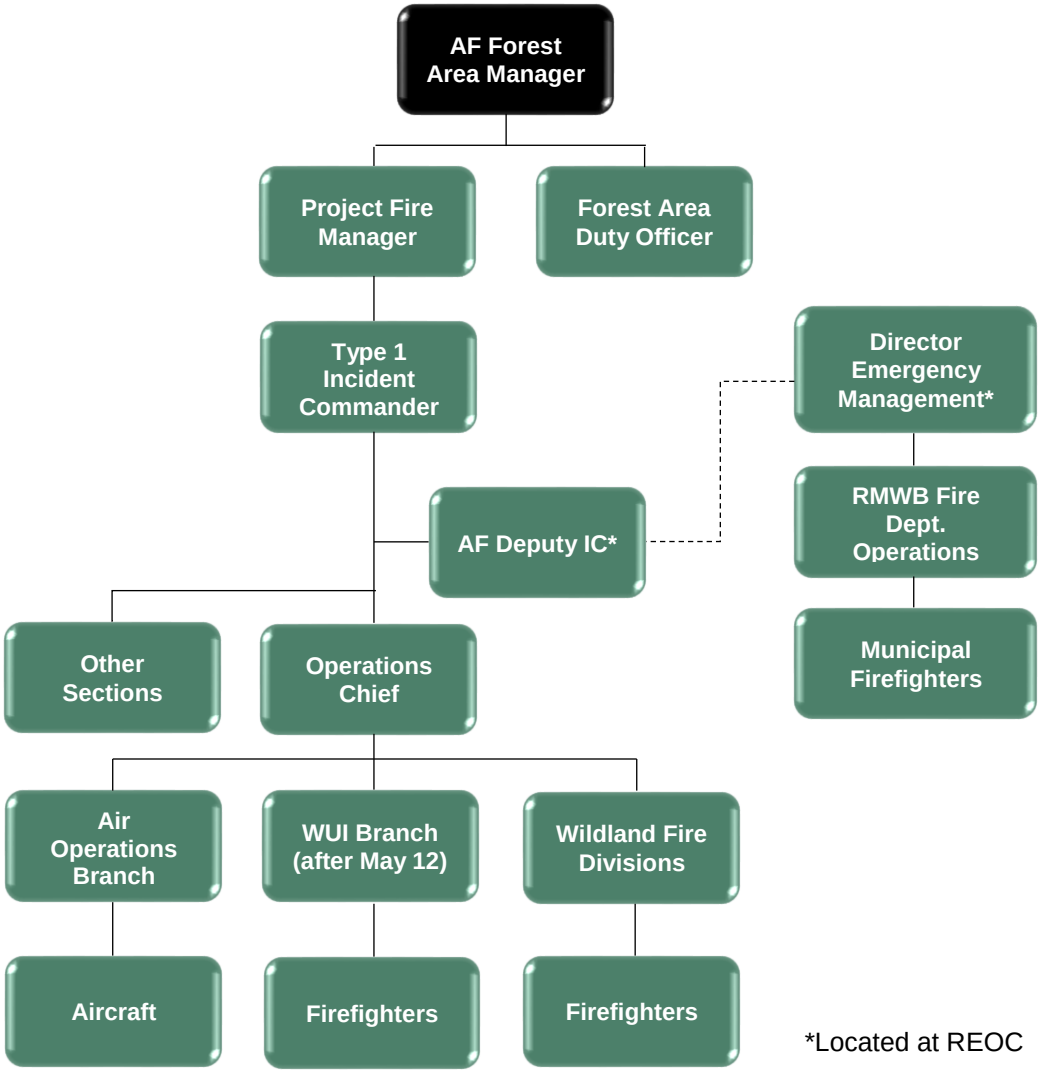
The best practice should be to quickly identify the scale of the incident, and create unified command of the wildfire operations – both wildfire and urban fire – at that scale. At the same time, the supporting organizations to the incident and associated emergency response should unify in coordinating and supportive roles, and leave wildfire operations to the unified Incident Management Team. Many partners should, and did, join together at the REOC, including law enforcement, health care, social services, and others; however, the operational command of wildfire and WUI operations needs to be unified in an ICP focused on the wildfire, resource needs, and implementing one integrated operations plan on the ground covering both the wildland and urban areas.

Although each part of the organization, and industry stakeholders, ultimately found ways to get information that they required, the situation was not unified and created unnecessary stress between the organizations. This stress about information flow went beyond the key responding agencies also affecting key partners and stakeholders (such as the oil sands industry) who needed to make plans to respond to the evolving situation. Inefficiencies and controls on communication of information created tensions and additional work among these partners.

As an example, both RMWB and the oil sands industry independently hired aircraft to gather intelligence about the wildfire's location and behaviour when AF was doing the same. For many reasons, and obviously for safety considerations, gathering of intelligence should have been conducted under one operation. AF was managing air operations and could safely coordinate helicopter flights; however, the lack of a common integrated operational plan and the lack of information sharing at the operational level created the need for independent flights from different players resulting in varying degrees of situational awareness and a potential safety concern. ICS is designed to smooth out these processes and improve information sharing. A simplified depiction of the Review Team's understanding of the actual organization in relation to the Horse River wildfire is shown in Exhibit 23.

The gap created by attempting to unify command at the REOC and not at the wildfire ICP was best demonstrated on May 3. By late morning on May 3, the AF Operations Chief realized the wildfire was beyond the ability of firefighting resources and would run into Fort McMurray that afternoon. On the municipal side of the incident, another Operations Chief was deployed to the REOC. Rather than learning about the wildfire's imminent incursion into Fort McMurray through the ICS structure, the RMWB Operations Chief discovered the wildfire was in the community through public reports over social media. As it turns out, the RMWB Operations Chief's connection to the wildfire operation was through the Deputy Duty Officer at the Fort McMurray Forest Area Office – two or three steps removed from the Operations Chief on the AF side of the incident. This is not consistent with the unified command structure under ICS, which calls for one Operations Chief or two Operations Chiefs working in unison.

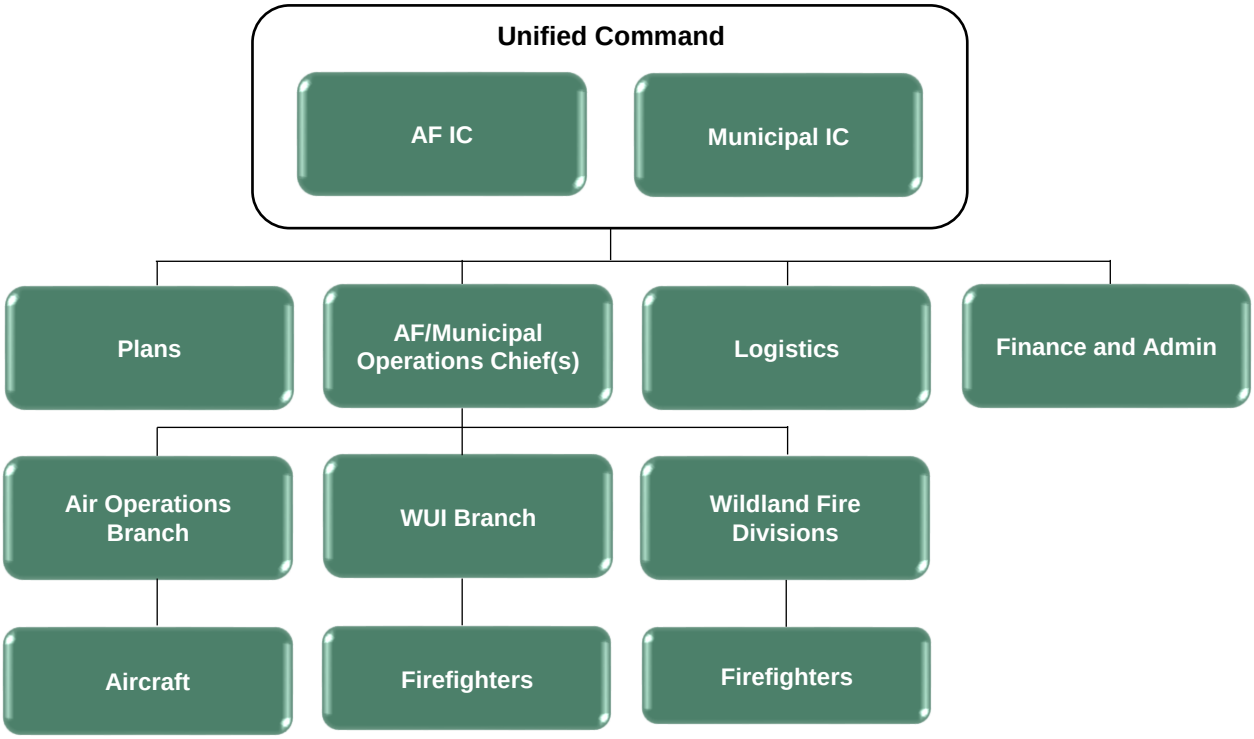
Exhibit 23: Simplified Depiction of the AF Organization During Wildfire MWF-009



Overall, the lack of proper unification, at the operations level, led to the two organizations often finding themselves 'chasing' the wildfire and reacting to its consequences and issues, rather than proactively getting ahead of potential issues.

As another example, when the wildfire ran to Anzac on May 5, a RMWB representative at the REOC was sent to engage residents in Anzac. Upon reaching the area, that representative realized evacuation was necessary and immediately undertook the required leadership role. Under better functioning unified incident command, situational awareness and the resulting wildfire suppression and evacuation needs would have been better coordinated through the AF ICP and REOC. A simplified depiction of a properly implemented ICS structure in this instance is presented in Exhibit 24.

Exhibit 24: The Review Team's Interpretation of Proper Design under ICS



Given that this was an interface wildfire and there was a strong possibility that the wildfire would move into Fort McMurray on May 3 or May 4, a WUI Branch should have been organized at an early stage.[13] Ideally, when the IMT was established on May 2, a WUI Branch should have also been formed with the goals of: coordinating wildland and urban resources; organizing a plan for protection of the community; and commencing planning for evacuation of at-risk areas. The review found no indications that such planning was undertaken.

It should also be noted that Alberta has a WUI Team in Slave Lake comprised of trained municipal firefighters and specialized equipment. This team was formed in response to the Flat Top Complex review. That team is prepared for and experienced in the kind of situation which occurred around the Horse River wildfire. The team was dispatched to assist in Fort McMurray and arrived informed and ready to take action. This was a great opportunity to build an effective WUI Branch on the wildfire. The WUI Team, however, was not integrated into operations upon its arrival and it left earlier than expected.

Finally, this review discovered the understandings among agencies about the best way to apply ICS during a critical event is different. AF is practiced in the application of ICS to wildfire incidents and the review heard compliments on the organization of AF on this wildfire. This experience is valuable to partner agencies, particularly ones who do not implement ICS frequently. Staff of the Office of the Fire Commissioner and other municipal fire departments who deal with wildfire on a regular basis would be valuable contributors to how ICS should be implemented when wildfires threaten the WUI. The people of Alberta depend on government agencies to pull together as efficiently as possible during large events. ICS as defined by ICS Canada is designed to provide that structure for fluid and complex

[13] A WUI Branch was ultimately formed, but this happened many days later.

incident management. Relationships and understanding of underlying management and leadership principles are key to success.

Recommendation #7

Direct agencies and services involved in wildfire suppression in relation to the Wildland Urban Interface to establish standard operating procedures for the implementation of an Incident Command System (ICS) and processes following the model provided by ICS Canada for future incidents like the Horse River wildfire.

In developing these principles and procedures, the following specific points should be considered:

- Unified Command must be established immediately at the operational Incident Command Post (ICP) close to the incident with the Incident Commander from the municipal fire department working in unison with the Agriculture and Forestry Incident Commander under one Incident Action Plan.
- Once a wildfire has come under control of a Type I or Type II Incident Management Team, and has Wildland Urban Interface (WUI) possibilities, a WUI Branch with joint Agriculture and Forestry and municipal fireline operations must be established such that community protection plans and activities are carried out jointly from the earliest effort on the wildfire.
- The Regional Emergency Operations Centre (REOC), Forest Area, Alberta Wildfire Coordination Centre and Provincial Operations Centre roles should be confirmed as supportive coordination centres overseeing all services such as supplying resources to the incident, evacuation, policing, health care, social services, and others. Wildfire and WUI operations on the ground will be directed by the Incident Command Post under the Unified Command structure and should remain separate from the REOC.
- One joint Incident Action Plan should be established daily for wildfire operations, and should be jointly approved and implemented at the incident level.
- Municipal firefighting resources should come under control of the Agriculture and Forestry WUI Branch Director. Under unified command, municipal fire departments should anticipate this process.
- Where a WUI Team is available, they should be integrated into the WUI Branch and given leadership roles commensurate with their qualifications (i.e., the Team Lead could be a branch director or co-director).
- ICS should provide for inclusion of both community and industry partners in the information flow of daily planning at the operational ICP, such that stakeholders and communities can access key information and maps without separate intelligence efforts or the need for separate flights or fire behaviour forecasting. Discussions at the ICP should include opportunities for industry and community partners to contribute to suppression of, and logistical support for, the wildfire.
- Community and industry partners may need to attend both the unified command ICP and the REOC during a complex incident to understand the wildfire situation and plan, and plans of the community related to evacuations, etc.
- Once the ICS direction is clarified, a table top exercise should be designed using the Horse River wildfire as the scenario for problem-based learning, to reinforce revised roles and responsibilities. Joint training exercises for Alberta Emergency Management Agency, Agriculture and Forestry and municipal staff should be held across the province.

Recommendation #7

Expected Outcomes

- Safe coordination of ground forces, particularly when air attack is working the wildfire.
- Connected, effective, and efficient firefighting in the field;
- Best opportunity to reduce losses at the Wildland Urban Interface;
- Expertise in wildfire and urban fire suppression will be integrated for planning and executing community protection;
- When a wildfire is threatening a community, Agriculture and Forestry maintains the lead for the province and municipal firefighting resources will engage with the department through unified command;
- More efficient and effective establishment of situational awareness from field observations, science-focused briefings, daily planning;
- Seamless coordination of aircraft usage to assess the wildfire, make plans, and direct ground forces;
- Development, from the early moments of the wildfire's escape of Initial Attack, of a community protection strategy using the joint capacity of wildland and urban firefighting skills and resources; and
- Effective coordination of wildland and urban resources which arrive from outside the area/municipality.

Opportunities for Improvement:

5. Leverage the experience gained from the Horse River wildfire and the 2011 Flat Top Complex wildfires by having Agriculture and Forestry and Alberta Emergency Management Agency jointly lead the development and delivery of a comprehensive exercise involving all the major players in Alberta that have responsibilities during a Wildland Urban Interface event. This exercise should be delivered across Alberta to test their respective organizations and systems to help inform communities who haven't had the experience firsthand. At the same time this exercise would provide for continuous improvement and practice of current protocols and systems in place.
6. Recent reorganizations across government have seen the centralization of administrative support to Agriculture and Forestry. The 2016 wildfire season tested this new structure and some key learnings have been identified. A review of this form of service delivery with emphasis on ensuring established commitment levels of service should be carried out.
7. The provincial 310-FIRE reporting line was overwhelmed by the call volume due to the Horse River wildfire. The reporting line's capacity, technology and systems should be reviewed in light of this incident to look at specific areas for improvement.
8. To prepare for the future, incident leadership should exercise scenarios where the team is required to move and rely on transient communications and alternative means of communications.
9. After Action Reviews should be carried out at the local level immediately after operations and after staff have had time to decompress from their experiences. For example, initial attack crews

Opportunities for Improvement:

first on the scene, duty room staff, or those involved in observations from the scene carry a sense of responsibility for outcomes when they leave the workplace. There are two primary objectives for these After Action Reviews and debriefings. First, capture the learnings from the experience for future improvements and team-building at the local level. Second, assist staff to make sense of what they have experienced, their role in making a difference, and to heal where events have been traumatic.

10. Agriculture and Forestry should position itself to take full advantage of existing and emerging technology to help with situational awareness especially during times when smoke is a major issue. Agriculture and Forestry should explore measures to encourage prompt and increased use of technologies such as satellite and high level infrared scanning. This should include a coordinated pre-organized contracting approach to streamline access at the operational levels.

Radio Communications Among Personnel

During suppression efforts, firefighters on the ground and in the air need to be able to quickly and clearly communicate by radio. This is essential from both safety and efficiency perspectives:

- The wildfire operating environment is spatially complex and risk laden. Wildfires move quickly across the landscape, and firefighters need to stay connected so they do not become separated from their crew or risk being burnt over.
- Smoke can obscure the visibility of crews around the wildfire, both to other crews and to aircraft.
- Experienced wildfire suppression staff are often in aircraft overhead, helping direct and support the movement of ground forces.
- Airtankers arrive overhead to drop heavy loads of fire retardant. Communication with firefighters on the ground is critical for them to ensure it is safe to make their drops and help provide them guidance on more precise targets.

During the Horse River wildfire, municipal firefighters were operating on a radio frequency different from AF firefighting personnel. Consequently, at critical times when municipal and wildland firefighters were not physically working together on the ground, they could not directly communicate by radio to identify priorities or support each other.

This was particularly problematic when it came to air attack. AF aircraft had no way to forward a direct message to municipal firefighters. Likewise, municipal firefighters had no way of asking for support or directing airtanker drops; in some instances, they resorted to physical signals that the aircraft could see.

In the future, firefighting crews should be comprised of both AF and municipal firefighters who can share communications in real time. Those crews should operate under one line of command to the Operations Chief (through a WUI Branch Director), and they should be able to communicate through one channel.

In large and complex incidents such as the Horse River wildfire, municipal and private sector firefighters will often arrive under mutual aid arrangements. In this case, firefighters came from municipalities across the province, including the large cities. They all arrived with their own personal

and vehicle radios, operating at different frequencies. Being able to communicate while in transit is essential to optimal deployment. Arriving firefighters need to gain situational awareness and direction on positioning and task assignments. On a wildfire, experienced leadership is likely overhead in an aircraft or at a distance from crews working on the ground so direct communications are essential. The integration of operational activities effectively and safely demands a common radio frequency. The radios and frequency are available to all municipalities and it is important for those that are at risk of wildfire to acquire and use these tools.

Opportunities for Improvement:

11. Provide for a common radio frequency to be installed in all Agriculture and Forestry and local fire department radios for exclusive use across Alberta for wildfire operations and in response to wildland urban interface wildfires.

6. PROTECTING WHAT WE VALUE

As mentioned earlier in this report, the threat of wildfire only stands to grow in Alberta's forested areas. This is particularly challenging for Alberta, since there are a multitude of values in areas that are put at high risk – including industrial assets and communities. Doing everything reasonably possible to protect or mitigate future damage to these values is not an option, but an imperative.

Steps can be taken long before future wildfire situations occur to best mitigate potential damages and set responding organizations up for success.

6.1 Applying the FireSmart Disciplines

As development has increasingly reached into forested areas, it has become more commonplace to talk about the WUI. There are many WUI areas throughout the forested areas of Alberta and especially in the Fort McMurray area.

Arising out of growing concern about the threat posed by wildfires to the WUI, the FireSmart program was developed. Alberta has been a leader in the development and application of FireSmart principles since the early 1980s. FireSmart includes a collection of strategies aimed at helping communities guard against the risk of wildfire. FireSmart is recognized across Canada and is considered to be best practices for communities, homeowners, and businesses to better prepare for wildfire.

There may be a view among some that if more "FireSmart work" or vegetation management had been done, the Horse River wildfire could have been stopped. This is not the case; there are two problems with this view.

Firstly, it ignores that the Horse River wildfire exhibited Intensity Class 5 and Intensity Class 6 wildfire behaviour[14]. The reality is that vegetation management alone will not stop a wildfire of this intensity. Although there are some examples where vegetation management reduced the spread of the Horse River wildfire, it is unlikely that the overall outcome of the wildfire would have been different if additional vegetation management work, at the scale of current FireSmart projects, had been done.

> "…FireSmart is not just **Vegetation Management**, and is not just the responsibility of wildland fire managers, but requires a larger perspective that encompasses the other six FireSmart Disciplines:
>
> **Development** – educating and empowering land use planners to create appropriately planned communities where access, egress, structure density, set-backs and other issues are addressed
>
> **Public Education** – engaging and empowering community leaders and the public to take action on their private lands through the FireSmart Community Recognition Program
>
> **Legislation** – strengthening of building code and other local government regulations that require the inclusion of FireSmart best practices
>
> **Interagency Cooperation** – the cooperation between all land management (and) emergency response agencies to ensure a comprehensive and collaborative approach to addressing the complex WUI challenge
>
> **Cross Training** – training of land management and emergency response staff at all levels of government to increase the effectiveness of cross-jurisdictional mitigation and emergency response efforts
>
> **Emergency Planning** – interagency and inter-jurisdictional plan mitigation and emergency planning focused on community fire adaptation and resiliency"
>
> *Reference:*
>
> *Johnston, Kelly. 2016. Comprehensive FireSmart® Implementation: More than Just Forest Fuel Management. Canadian Wildland Fire & Smoke Newsletter. Fall 2016. Western Partnership for Wildland Fire Science. Pp 16-17.*

Secondly, this view is rooted in a common misconception that FireSmart is solely about clearing trees and other vegetation around a community to deprive wildfires of fuel. While vegetation management is

[14] Intensity Class 5 fire behaviour describes an organized crown fire front with spotting. Intensity Class 6 is an organized crown fire with moderate to long range spotting.

an essential component of FireSmart, there are six other essential disciplines. All seven FireSmart disciplines need to be comprehensively pursued for a community to guard against the risk of wildfire.

Managing vegetation as a fuel over an extensive area poses some challenges. Vegetation management can conflict with other valid policy interests that aim to minimize industrial footprints, limit linear disturbances and protect biodiversity. It can also be expensive, which is difficult with limited fiscal resources available for communities. In addition, it is a discipline that requires ongoing commitment as vegetation management is useful only if maintained.

Further limiting the use of vegetation management to reduce fuels near communities are public acceptance challenges. In some cases, the public opposes vegetation management near homes and communities because they value the scenery, natural atmosphere and lifestyle that is associated with living in or near the forest and they feel that vegetation management detracts from these values. Perceptions that vegetation management negatively affects their lifestyle and property values is rooted in a misunderstanding of the risks associated with wildfire in the WUI.

The review of vegetation management emphasizes the importance of pursuing all seven disciplines of FireSmart, especially in an area such as RMWB where there are many locations where wildland is immediately adjacent to homes and business assets that are vital for the provincial and national economies. A comprehensive prevention strategy including vegetation management should be pursued by industrial operators and communities in the region.

It is worth noting that evidence shows the use of many small-scale, cost-effective strategies can make a significant difference in guarding against wildfire. An investigative study prepared for the Institute for Catastrophic Loss Reduction found homes in Fort McMurray that were rated “low” to “moderate” hazard using FireSmart criteria survived much more frequently than homes that had higher hazard ratings. In side-by-side comparisons conducted by the study (wherein one home survived while the other did not), it was found that 89 percent of the time the surviving home had a substantially lower risk using FireSmart criteria.[15] FireSmart is clearly a useful guide for homeowners and communities. While it is by no means a guarantee of protection, it definitely helps improve a community’s resilience.

There is evidence of the application of aspects of FireSmart in RMWB, but not in a way that is particularly robust. For example, RMWB requires FireSmart planning as part of its land use permitting process. However, the implementation of these plans is not mandatory, so the extent to which the activities in the plans are actually implemented is uncertain. This review noted that previously made plans were hastily implemented once the Horse River wildfire occurred. Implementation of plans is best completed and maintained proactively.

There are two key disciplines of FireSmart that should be highlighted for improved focus by communities and provincial agencies when looking to the future: interagency cooperation and emergency planning aimed at wildfire adaptation and resiliency.

[15] Westhaver, A. 2016.

Recommendation #8

Emphasize a long-term vision for FireSmart within the province that includes community responsibility, multi-agency collaboration and an outcome-based approach to implementing FireSmart projects. Ensure all seven disciplines of FireSmart are addressed.

Expected Outcomes:

- Increased awareness of interagency cooperation and emergency planning disciplines by community members and leaders, including large industrial partners;
- More effective implementation of FireSmart principles in and near communities;
- An improved ability of wildfire managers to take advantage of FireSmart work when developing suppression strategies; and
- Reduced losses at the Wildland Urban Interface.

6.2 Interagency Cooperation

The FireSmart program includes guidelines for the development of interagency cooperation. The Review Team has concluded there is more work to be done in the RMWB on this front, and that lessons should be shared among all communities and Forest Areas in the province.

Interagency cooperation and effective working relationships are fundamental to protecting communities from wildfire. Cooperation must be built from the ground up, among firefighting organizations and individuals who work together when wildfire threatens communities. This is not just the responsibility of AF, as the provincial partner, to develop. Communities in Alberta share a significant portion of the responsibilities for both wildfire response and community protection from wildfire.

In the case of the Fort McMurray area, there is also a need to work with the oil sands industry to develop plans and identify key priorities to help guide the response. Oil sands operators not only have significant assets and business operations on the landscape, but also play leadership roles in the area. This principle applies to all industries province-wide.

Energy operations in Fort McMurray area are extensive in terms of size and value, and they have significant impact on the provincial and national economies. As was found during the Horse River wildfire, these operations present some unique challenges during a wildfire event. For example:

- A bitumen line takes a great deal of time to shut down. If done too quickly, the product in the line will solidify and render the asset useless, resulting in huge replacement costs and significant production delays.
- Oil sands facilities require many workers who are sometimes located at work camps situated in high-risk wildland areas. Evacuating the work camp can deprive the facility of the people that are crucial to its safe operation or safe shut down and the loss of these camps present major job and economic loss.

- The shutdown of certain industrial facilities (pipelines and tank farms, for example) or utilities has disproportionately large financial implications for other business continuity, government operations and for the local, provincial and national economies.
- Industry has the potential to contribute valuable local knowledge, resources and assets to assist AF in suppression efforts when required.

It is therefore important that AF and industry develop and sustain interagency cooperation to support wildfire preparedness and suppression.

Historically, industry has been closely linked with the command structure of Incident Management during wildfire events. This has provided for unimpeded communication and information flow, enabling industry to make informed and timely decisions about their operations and where they can support AF in the suppression effort. On the Horse River wildfire, industry was directed to source its required information through the organizational structure that was established to deal with the impact on the community (the REOC). This structure did not provide the information flow to industry that they expected, primarily because the REOC had substantially higher priorities to deal with (especially in the early days of the wildfire).

The lack of real time intelligence on the wildfire situation was a concern to industry, given the critical decisions they faced in respect of shutdown and evacuations and the associated financial implications. Consequently, industry members proceeded to hire their own team of wildfire management experts to fill the information gap and inform their own decision-making processes. This organization of 'shadow experts' produced information which did not always align with information provided by AF experts. This in turn created issues and questions. The situation remained problematic until almost two weeks into the wildfire, when it was determined that an industry liaison should be formally included in the AF IMT structure. After that point, the situation improved.

During the first two weeks of the wildfire, the lack of information flow not only impeded industry's decision-making, but it also detracted from discussion about industry's ability to contribute to the suppression effort. With better information flow, operational staff could have had access to knowledge regarding various factors (vulnerable and critical assets; heavy equipment; or camp assets close to the fireline) which would have better supported suppression activities.

This point bears emphasizing. When a wildfire stands to impact local industry, its members are not only stakeholders but also valuable potential partners in suppressing the wildfire. Industry often has substantial resources, local knowledge and expertise in areas such as the use of heavy equipment, which could be invaluable for AF to readily access during wildfire events. These industry partners will also be key partners in gaining access to the wildfire in a landscape busy with pipelines and utility corridors. Several companies in northeast Alberta have work camps and airport assets, some of which were used by AF in suppression operations. Having a more complete inventory of these assets could help increase the level of cooperation and resource sharing between AF and industry to support presuppression preparedness and suppression activities.

Wildfire events such as the Horse River wildfire are predicted to become even more commonplace, and the makeup of Alberta's economy is such that these events are likely to have potential impacts for industry. The Horse River wildfire and other recent wildfire situations has drawn attention of industry to wildfire risks. Participation in proactive discussions may be more engaged than following quiet wildfire seasons. Developing and maintaining a strong relationship with industry, and capitalizing on the expertise and resources industry can provide, would be a major asset for AF going forward. Having

such a strong partnership would also be helpful to the province in mitigating the economic impact of future events.

Recommendation #9

Establish a joint Wildfire Planning Task Team comprised of senior Agriculture and Forestry staff and major industrial stakeholders (such as oil sands, energy, forestry, and utility companies) from across Alberta.

The objective of this task team should be to:

- Confirm communication protocols and procedures to be followed that will ensure effective two-way communication of information in preparation for and during wildfire management events, to help facilitate decision-making processes for both Agriculture and Forestry and industry;
- Identify opportunities to formalize agreements to enhance response capabilities by exploring available industry capacity, technology, and expertise in areas such as heavy equipment use, managing pipeline crossings, logistical resources and local environmental and geographic knowledge;
- Provide for a more comprehensive and current inventory of assets that are considered vulnerable to wildfires, with due consideration to confidentiality and security issues; and
- Encourage participation in annual pre-organization meetings to sustain relationships and exchange information around expected conditions, resources, and changes to policies or protocols.

Expected Outcomes:

- Improved response capacity and effectiveness;
- Better utilization of industry assets and expertise; and
- Improved information exchange to support critical decision-making needs.

6.3 Landscape Wildfire Management Planning

Currently, AF is undertaking a wildfire management planning initiative across the province. This approach to managing wildfire and mitigating losses from a landscape perspective has great opportunity. The northeast region of Alberta has been recognized as a priority for this initiative. Some site-specific work within the Fort McMurray area has already been done, but it is highly variable and is mostly focused on small-scale fuel modification or general FireSmart planning. In most cases, plans have not been implemented and efforts have not been maintained.

Compared to other areas of Alberta, the Fort McMurray Forest Area is unmatched in terms of the scale of industrial presence on the landscape coupled with an historical, predictable, and increasing wildfire risk. These circumstances demand a different approach than what might be used elsewhere. Both a long-term commitment and a paradigm shift are required, infused with a sense of urgency that reflects the growing threat posed by wildfire in the province. Wildfire is dominating these landscapes because it has the potential to change a whole landscape in one season. No other factor has this kind of potential impact on such a broad scale. Given this reality, wildfire needs to be considered as the key driver for

landscape-level planning and approval processes. Measures to protect assets in northeastern Alberta need to be mandatory and should embrace all seven disciplines of FireSmart.

Ultimately, the goal for landscape planning should be to create more wildfire-resilient landscapes and to situate and develop sites with better intrinsic protection for values and assets. More wildfire resilient landscapes would provide AF a greater opportunity to steer large wildfires away from these assets. This would also translate into increased protection for the population in the area, especially given the prediction of more frequent and potentially more serious wildfires. In the wake of the Horse River wildfire, stakeholders are motivated to undertake efforts to guard against future wildfire threats. This environment should be leveraged to enhance wildfire preparedness, prevention and planning in the region.

Recommendation #10

Complete and implement a unique and tailored Landscape Wildfire Management Planning process for the northeast region of Alberta.

This planning process should be made a high priority and should:

- Establish wildfire as the key driver in all land management considerations and approval processes that involve the placement of vulnerable assets or the modification of natural landscapes in the area;
- Account for the area's significant industry presence and substantial economic impact provincially and nationally;
- Undertake risk assessment that considers the area's anticipated future given climate change, investments in resource development, and the inherent natural wildfire risks on these landscapes;
- Use the planning process to gather and update data sets on location and key information related to values at risk, fuel complexes, and other factors;
- Establish landscape-level wildfire management objectives that are aimed at creating a more wildfire-resilient landscape over time;
- Outline explicit and mandatory actions aimed at reducing or mitigating impacts from future wildfire events; and
- Enlist industry and government cooperation, including a commitment for resources and financial support to implement measures in as short a timespan as possible.

Expected Outcomes:

- Reduced risk to human life and communities;
- More wildfire-resilient landscapes;
- Reduced costs for suppression;
- Reduced economic impacts; and
- Reduced impacts to public, industry and government assets and natural resources vulnerable to wildfire.

7. CONCLUSION AND ACKNOWLEDGEMENTS

For most people, what will be remembered about the Horse River wildfire that burned into Fort McMurray on May 3, 2016 are the graphic and frightening images of people fleeing the flames. The destructive power of a large wildfire is, for many, incomprehensible. What is rarely understood, except by the people and agencies responsible for managing these events, is that once a large conflagration wildfire gets established gaining momentum under the right fuel and weather conditions, any response organization is limited in what it can do to stop the wildfire. The focus must shift to protecting human life and mitigating damage until the conditions change and give the organization an opportunity to take control. This is precisely what the wildfire suppression and emergency management agencies and the people in the area faced in the spring of 2016 around Fort McMurray.

This review considered the inner workings of AF's response to the Horse River wildfire. Certain experiences and lessons should be valuable to leaders of governments and industry and with members of the general public following such an experience. Not only do we need to be world class at wildfire suppression, but we must manage our communities and our landscapes to become more wildfire resilient or we can expect similar or worse outcomes on a more frequent basis. This is not just an Alberta problem, but one that is well documented around the globe. The public and their leaders should no longer expect wildfire management agencies to manage the problem alone. Preparing for wildfire in the boreal forest, preventing wildfires, and mitigating damage requires the collective will and long-term commitment by all parties, from the homeowner to industry and through all levels of government.

AF should be commended for commissioning this review and seeking to understand the issues and opportunities where things could have been handled differently. The Review Team has made recommendations based on the circumstances of the Horse River wildfire that, if implemented in the future, will make a difference during similar circumstances. It is also important to keep in mind that reviews have the benefit of hindsight and time to thoroughly examine details and rationalize options, before deciding what to recommend. This benefit was not afforded to the men and women who were thrust into this situation and forced to make decisions quickly, and under some of the most stressful circumstances imaginable. From the multitude of interviews, analysis of the science, and hundreds of documents reviewed by the Review Team, there is ample evidence that suggests that good and hard effort by the people involved was overwhelmed by the behaviour of the wildfire. The responding agencies and their people should be praised for their response and the obvious sacrifice they made to limit the damage and human toll.

While this review has identified opportunities to improve aspects of wildfire management in Alberta, it is necessary to emphasize the level of success that was realized during the Horse River wildfire. Despite the need to manage around challenging weather conditions, a complex and value-laden landscape, and a massive evacuation effort, public safety was protected.

The Horse River wildfire was unique in many ways. At the same time, it was a typical high-intensity wildfire that is occasionally experienced in boreal forests – it is both natural and essential in the boreal forest ecosystem. It cannot be stressed enough that the threat of wildfires in Alberta only stands to grow, driven in part by a changing climate and increasingly mature forest complexes. As more human economic development occurs in wildland areas, more numerous and diverse values on the landscape will be placed at risk of wildfire. It will take vision and a long-term commitment by all decision-makers, along with strong relationships between governments, communities and industries to protect these

values and guard against future wildfire threats. There is an urgency to address the recommendations presented in this review and to support the ongoing effort to implement improvements from past reviews.

The Review Team wishes to thank more than 90 individuals who took time to share their experiences and provide their perspectives. We would also like to thank the numerous people who provided a multitude of compiled notes, documents, and maps for this review, in a timely fashion upon our request.

Specific recognition must go to the people of Fort McMurray and the surrounding communities who faced the terrifying circumstances of the wildfire in a most caring, unselfish and supportive manner. While the rest of us can move on, these people continue to live with their memories and work to rebuild their communities and their lives.

We especially want to acknowledge those people who had the unbelievable task of responding to this wildfire event. Many of these first responders did this while their own homes were burning and their families evacuated without them. There will always be things that can and should be done better, but these people deserve the real thanks for managing the event in the best possible way they could at the time. We have been honoured to have met some of these people and to understand their personal, unfiltered view of what they experienced.

APPENDIX A: CHRONOLOGY / TIMELINE / WILDFIRE PROGRESSION

Horse River Fire Behaviour/Growth Chronology May 1-31, 2016

May 1, 2016

The Horse River wildfire (wildfire MWF-009) was detected by helicopter patrol shortly after 16:00h MDT on May 1, burning in grass fuels along a utility corridor approximately seven kilometres southwest of downtown Fort McMurray. The wildfire was visible to satellite instruments shortly afterward (Exhibits A-1 and A-2). At that time the wildfire was estimated to be less than two hectares in size, and was exhibiting Intensity Class 4 fire behaviour (surface wildfire with organized flame front). The wildfire spread quickly into the surrounding vegetation, spreading eastward at an estimated rate of spread (ROS) of 10 m/min. At this time hourly weather observations at the Environment Canada (EC) station at the Fort McMurray airport (Exhibit A-3) showed westerly winds of 10-20 kilometres per hour, temperatures of 22-24 degrees C, and relative humidity levels of 20-25 percent. Canadian Forest Fire Weather Index (FWI) System FWI outputs indicated a Fine Fuel Moisture Code (FFMC) of 92, a Buildup Index (BUI) of 70, an Initial Spread Index (ISI) of 10, and a FWI of 25. FWI System codes and indices for the month of May are shown in Exhibit A-4.

The wildfire jumped the Horse River around 17:26h, still spreading to the east at greater than 10 metres per minute and now categorized as Intensity Class 5 (organized crown fire front with spotting). By 18:05h the wildfire was estimated at 60 hectares in size, growing to 120 hectares by 19:05h (Exhibit A-5), and reaching the pipeline on the west side of Fort McMurray by 19:30h. Over the late afternoon and early evening the wildfire spread east 5.2 kilometres in three hours (an average spread ROS of 29 metres per minute), and continued burning through the night despite reduced winds and rising RH values. At that time, the east front of the wildfire was approximately 1.5 kilometres west of the MacKenzie Industrial Park. Satellite imagery[16] shown in Exhibit A-6 illustrates the position and extent of wildfire MWF-009 overnight. Weather conditions on May 1 were as forecast, and fire behaviour was generally consistent with predictions using the Canadian Forest Fire Behaviour Prediction (FBP) System.

[16] Satellite images are not available in real time and are not generally used to support ongoing suppression activities; rather they are available for single points in time and are useful for strategy and planning.

Exhibit A-1: National Oceanic and Atmospheric Administration (NOAA) Geospatial Operational Environmental Satellite (GOES) Image of Horse River Wildfire Hotspot at 16:30h MDT May 1, 2016

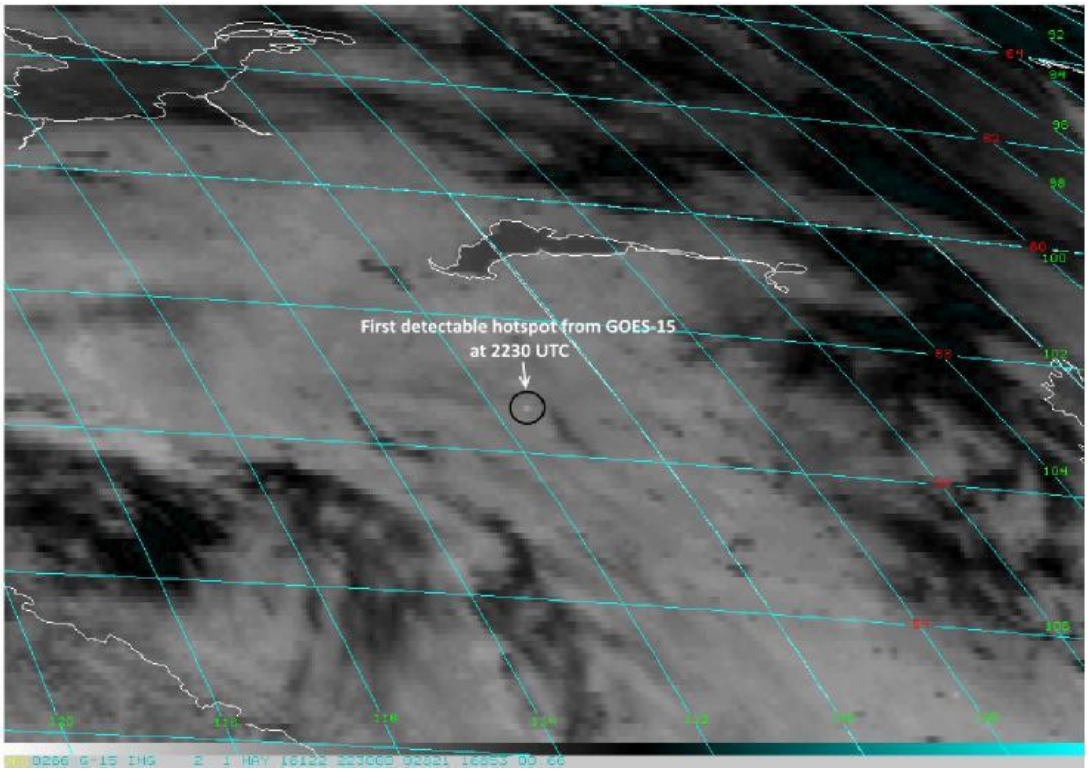


Exhibit A-2: NOAA Advanced Very High Resolution Radiometer (AVHRR) Image of Wildfire MWF-009 at 16:46h MDT on May 1, 2016

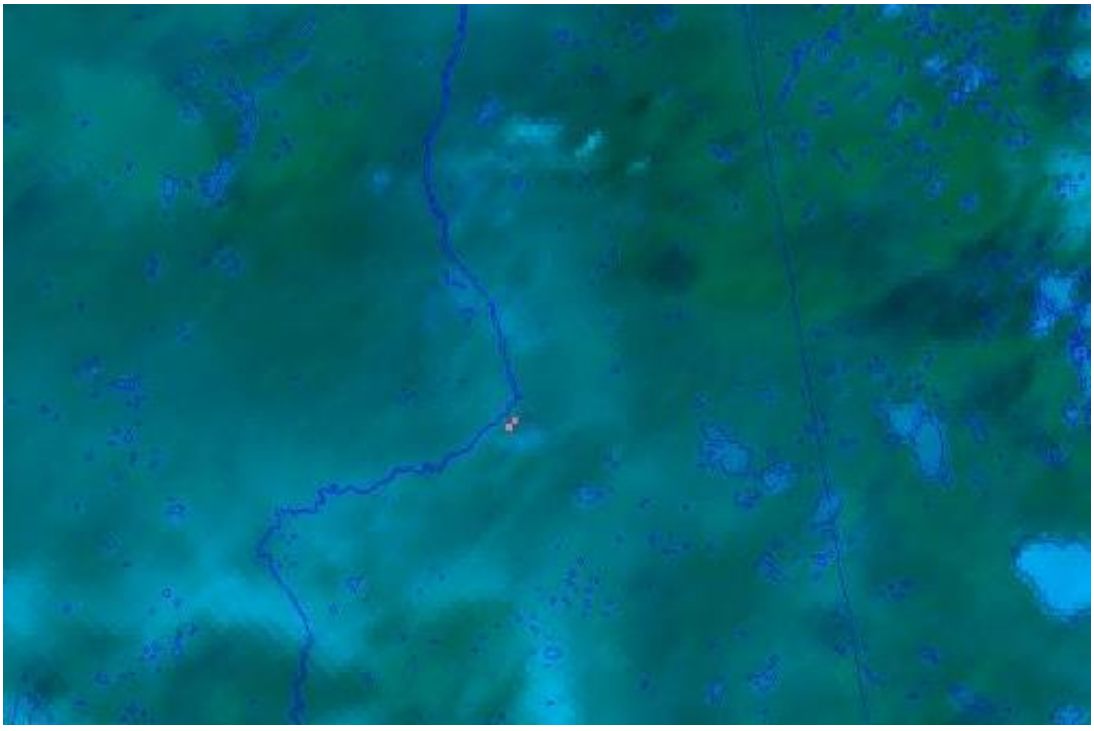


Exhibit A-3: Diurnal Trends in Temperature, Relative Humidity and Wind Speed on May 1, 2016 from Environment Canada Weather Station at Fort McMurray Airport

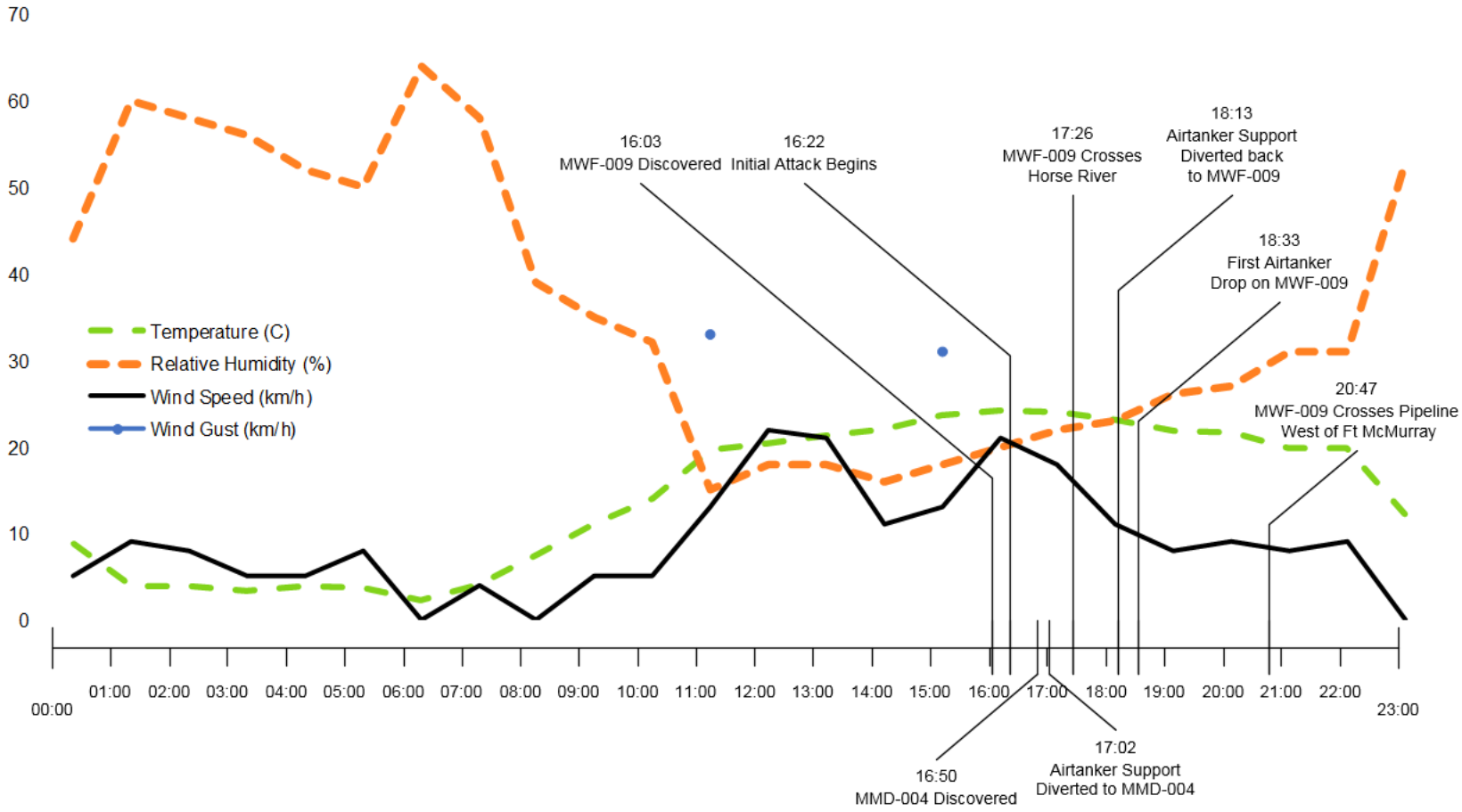


Exhibit A-4: Daily FWI System Codes and Indices April 16-May 31, 2016 from Environment Canada Weather Station at Fort McMurray Airport (Key Burning Periods are Highlighted)

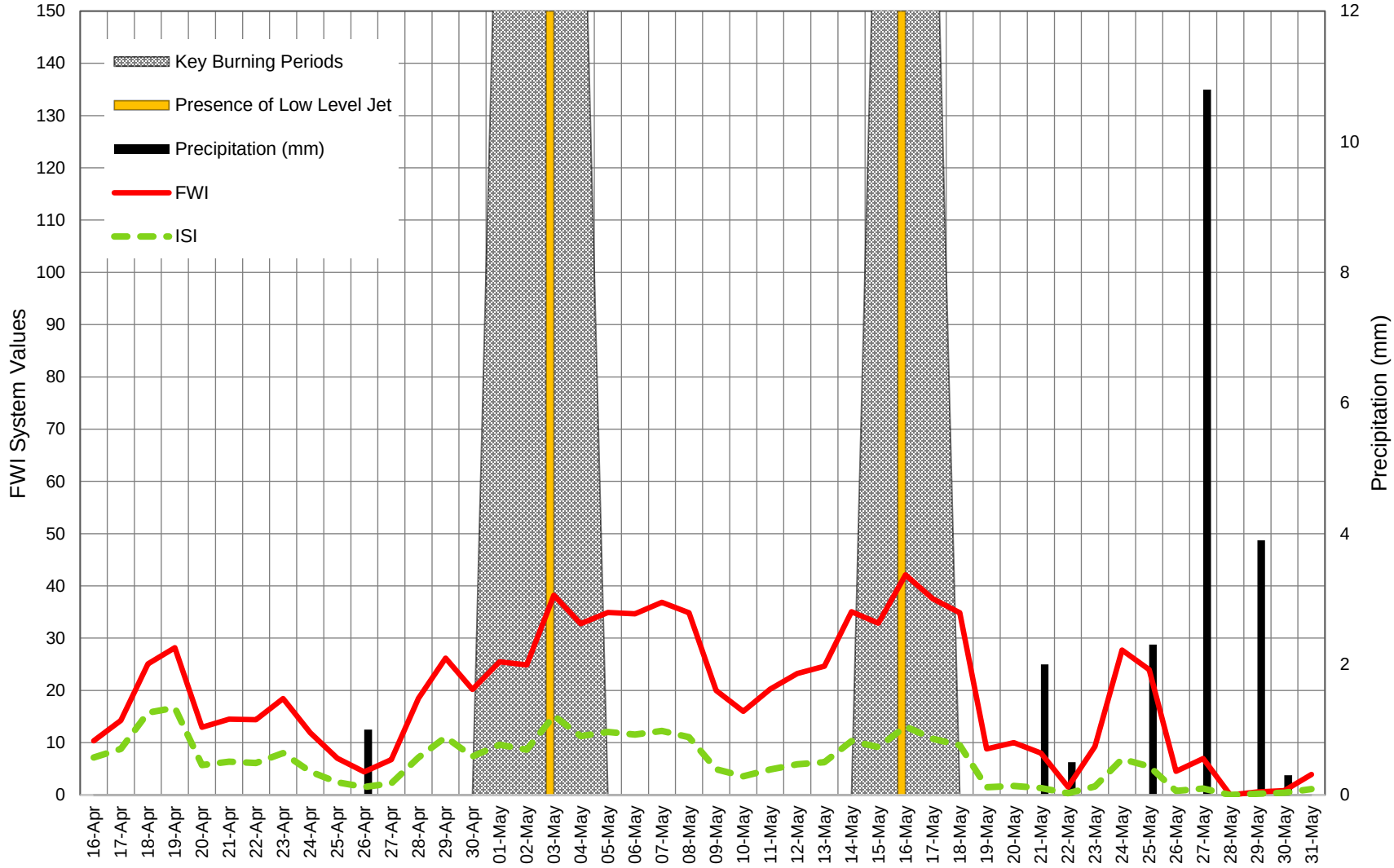


Exhibit A-5: NOAA AVHRR Image of Wildfire MWF-009 at 18:25h MDT May 1, 2016

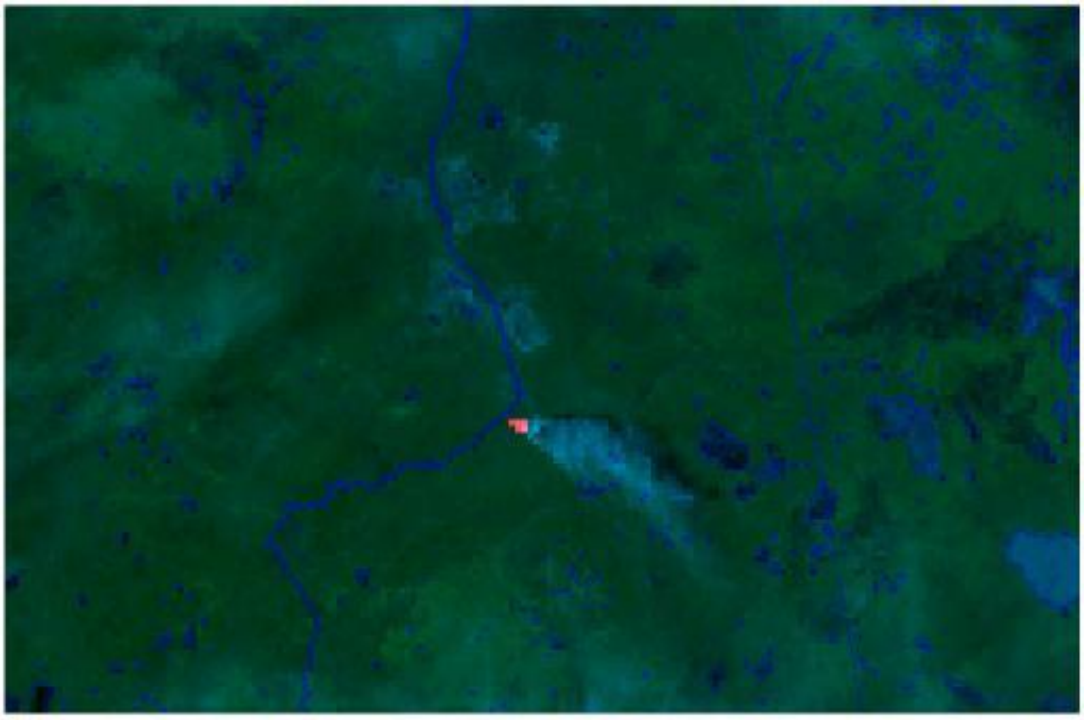
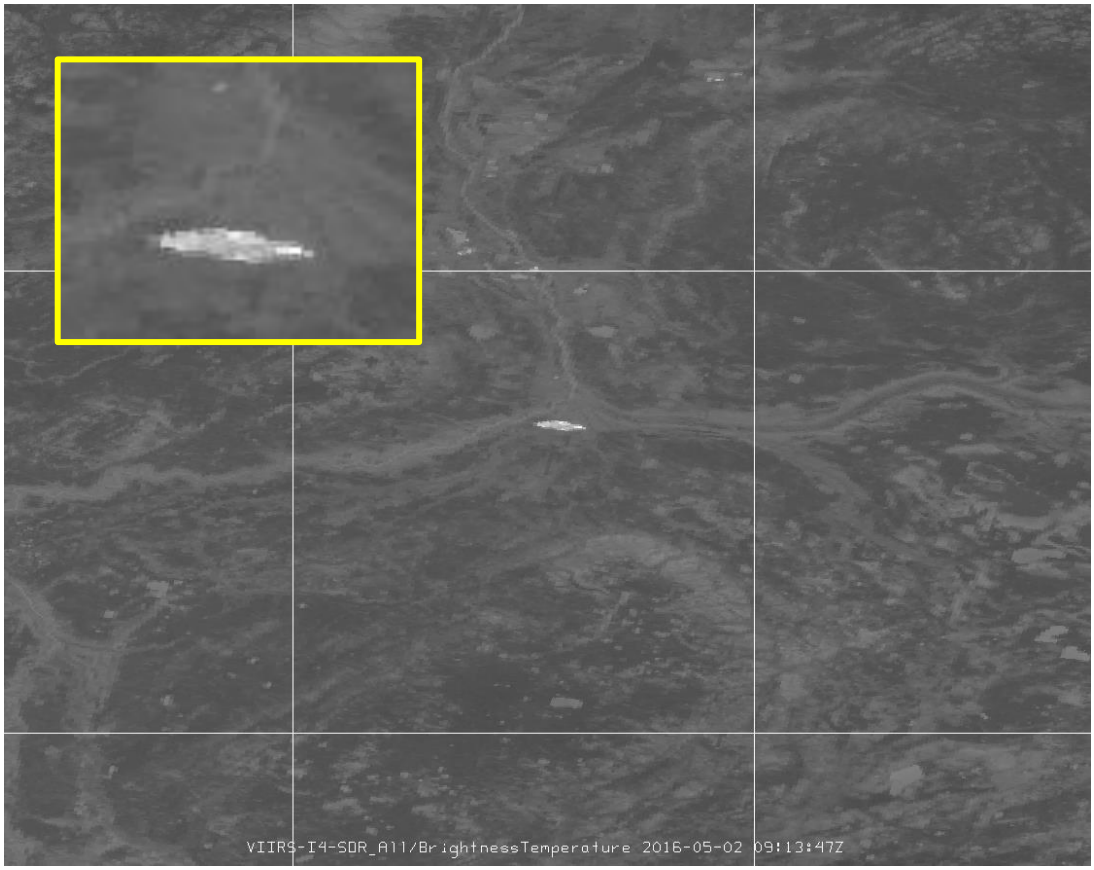


Exhibit A-6: NOAA Suomi Visible Infrared Imaging Radiometer Suite (VIIRS) Image 03:13h MDT May 2, 2016



May 2, 2016

At 10:00h on the morning of May 2 wildfire MWF-009 was mapped at 818 hectares. By 11:00h it had grown to 1,285 hectares. Cool temperatures, lighter winds and higher RH values limited wildfire growth in the morning, but throughout the afternoon winds were primarily from the east and moderate (5-10 kilometres per hour) while RH values fell to 20-30 percent, and temperatures were 24-27 degrees C. (Exhibit A-7). FWI System components were slightly higher than the previous day. Within the next few hours the wildfire moved quickly westward, burning to the Athabasca River by 20:00h and covering 2,655 hectares. Overnight the western most end of the wildfire spotted across the Athabasca River (Exhibit A-8). Weather on May 2 was as forecast, and fire behaviour was consistent with the FBP System outputs.

Exhibit A-7: Diurnal Trends in Temperature, Relative Humidity and Wind Speed on May 2, 2016 from Environment Canada Weather Station at Fort McMurray Airport

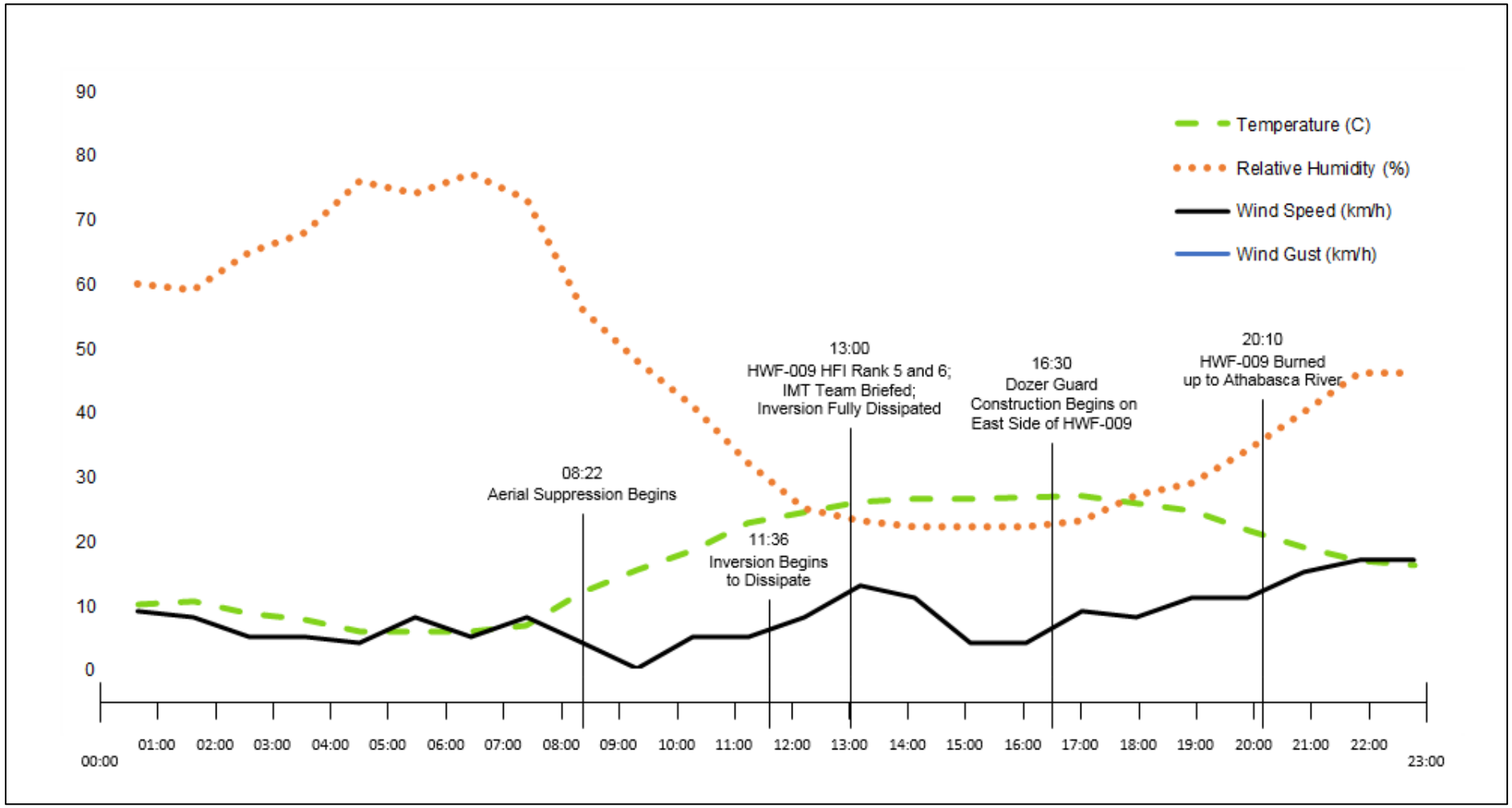
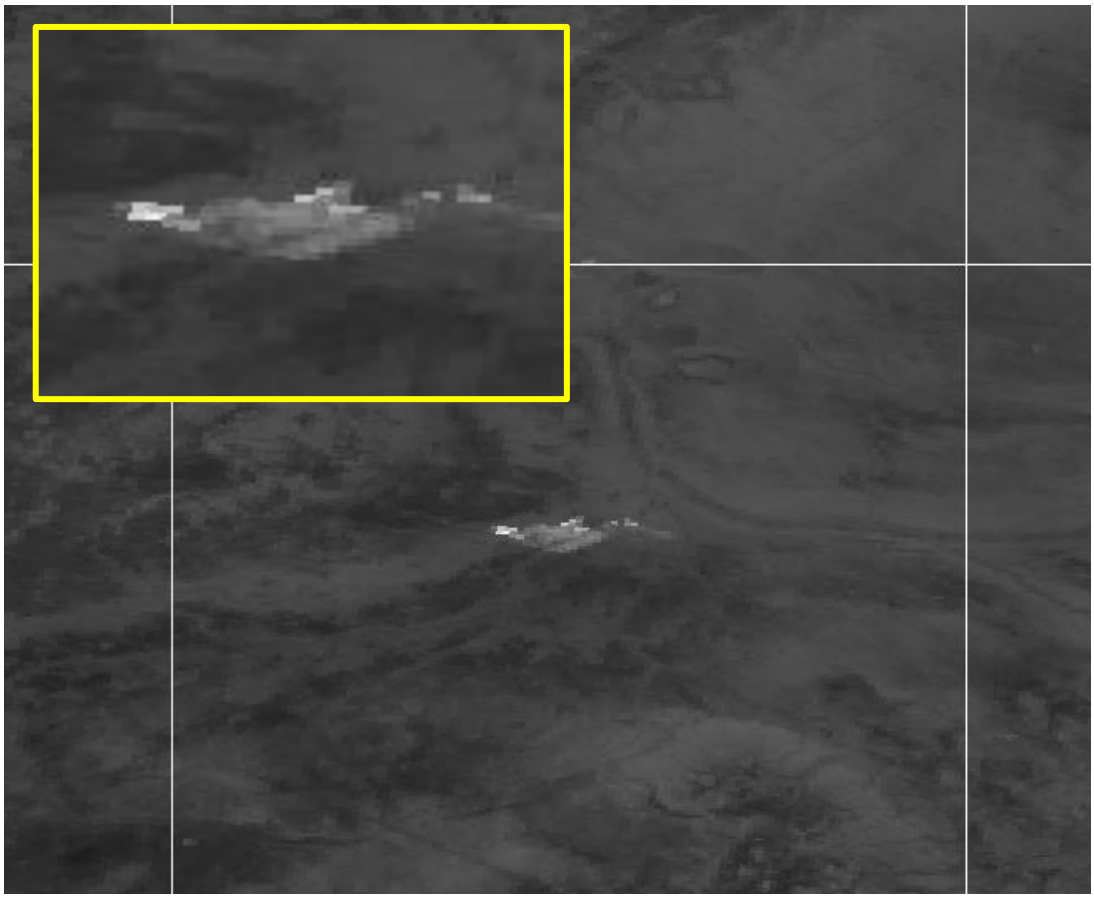


Exhibit A-8: NOAA Suomi VIIRS Image 02:54h MDT May 3, 2016



May 3, 2016

Dense smoke blanketed the wildfire on the morning of May 3, due to a strong inversion in the lower atmosphere. This inversion burned off in late morning, fire behaviour intensified as temperatures rose to above 30 degrees C and RH levels dropped to 15 percent by mid-afternoon (see Exhibit A-9). Ahead of an approaching cold front, winds shifted from southeast to southwest around 14:00h and increased to 20-25 kilometres per hour with gusts reaching 30-40 kilometres per hour throughout the afternoon and evening. The spot wildfire from the previous evening north of the Athabasca River was 10 hectares at 13:04h, but was quite active at the time of a satellite overpass at 14:26h (Exhibit A-10). Another spot wildfire occurred north of the river (directly south of Thickwood) at 14:52h. At the same time the east end of the wildfire south of the river was pushed rapidly east towards the southern Fort McMurray subdivisions of Abasand Heights, Beacon Hill, and MacKenzie Industrial Park.

Spotting into Beacon Hill began at 14:31h, with the wildfire alongside the MacKenzie Industrial Park at 15:05h. Structures were reported burning in Abasand Heights at 16:09h. The western spot wildfire was estimated to be 2.5 kilometres from Thickwood/Timberlea at 16:22h, burning as Intensity Class 6 (organized crown fire with moderate to long range spotting) and entered Thickwood at 19:30h. This translates to an average spread rate of approximately 28 metres per minute or 1.7 kilometres per hour. At 20:00h the wildfire was mapped at 18,678 hectares. A wildfire growth simulation model (Prometheus) was used in this analysis to project the wildfire's ROS throughout the afternoon, and the results were consistent with the times the wildfire reached the communities of Beacon Hill, Abasand, and

Thickwood/Timberlea (see Exhibit A-11). The wildfire continued to burn well into the night, spreading to the east of Beacon Hill and Abasand (Exhibit A-12). The wildfire MWF-009 convection column reached an altitude of 12 kilometres during the late afternoon on May 3 (Exhibit A-13). Temperature and RH values were as forecast but afternoon winds were higher than forecasted that morning as a low-level jet brought winds aloft to the surface causing strong wind gusts. FWI System components rose dramatically on May 3, with FFMC, BUI, ISI, and FWI values reaching 96, 85, 16 and 38 respectively, indicating severe and extreme burning conditions. Fire behaviour was generally consistent with the FBP System, as illustrated in the Prometheus model outputs.

Exhibit A-9: Diurnal Trends in Temperature, Relative Humidity, and Wind Speed on May 3, 2016 from Environment Canada Weather Station at Fort McMurray International Airport

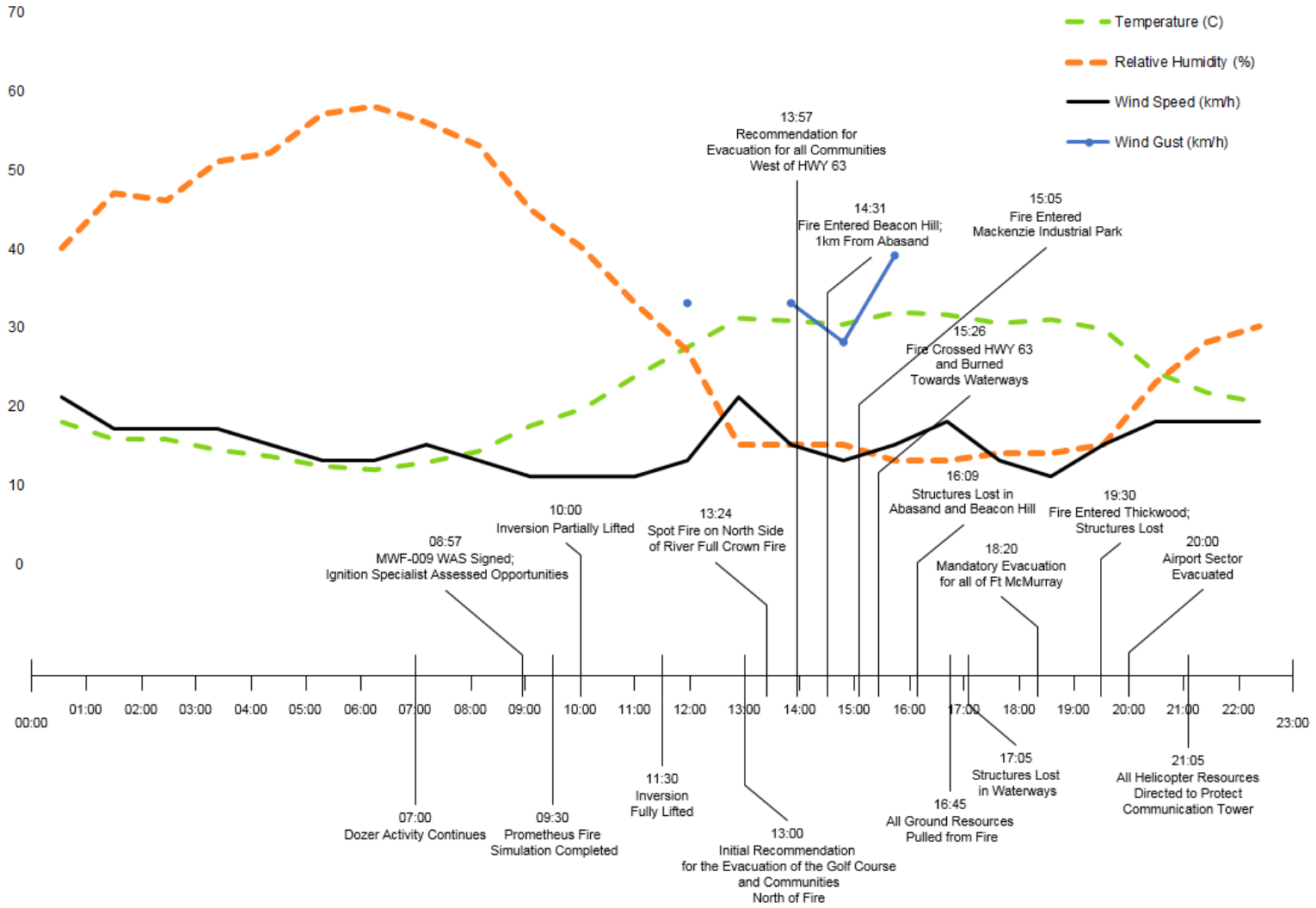


Exhibit A-10: NOAA Suomi VIIRS Image 14:26h MDT May 3, 2016

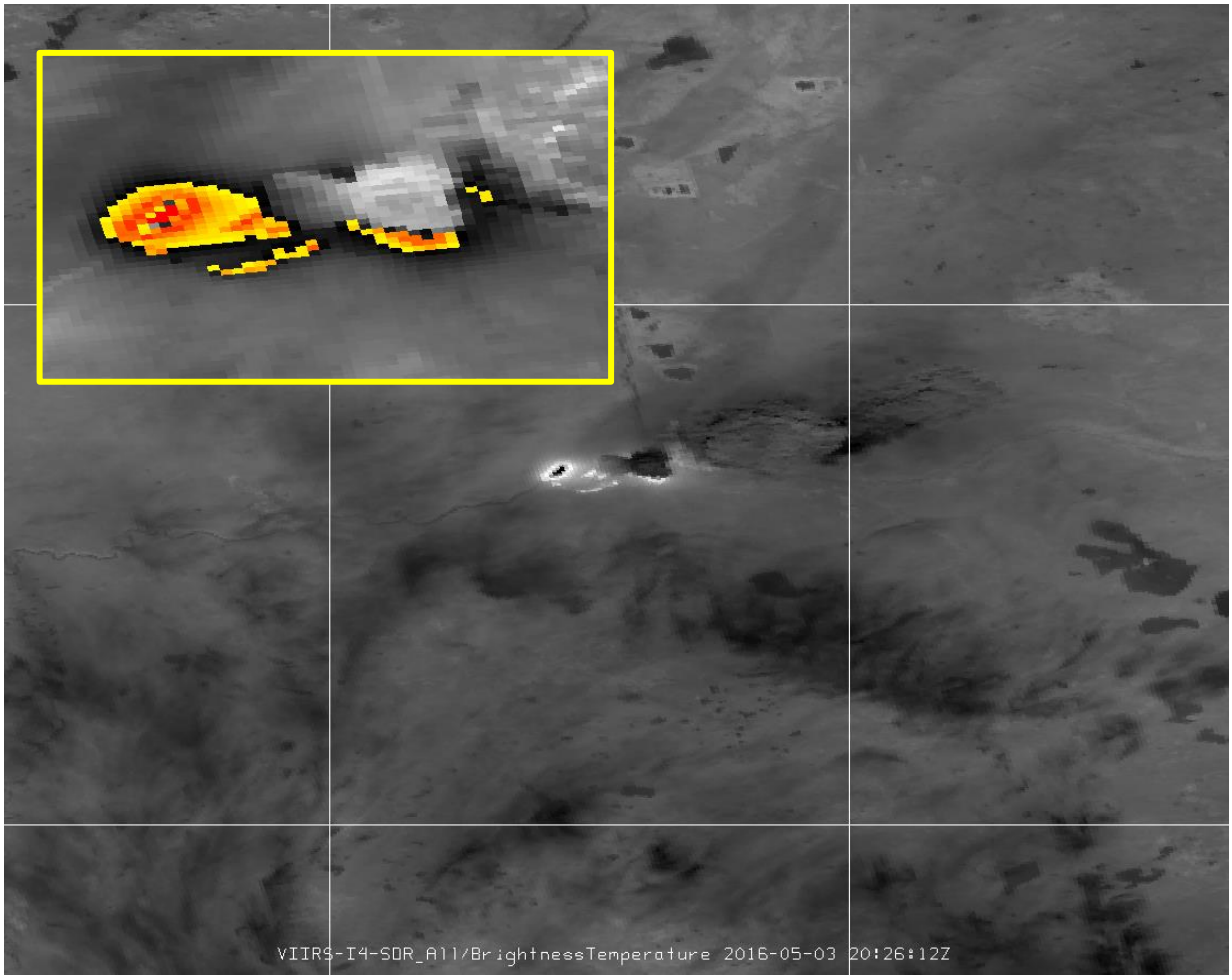


Exhibit A-11: Prometheus Wildfire Growth Simulation for May 3, 2016 (Prometheus Model Assumes No Suppression Action)

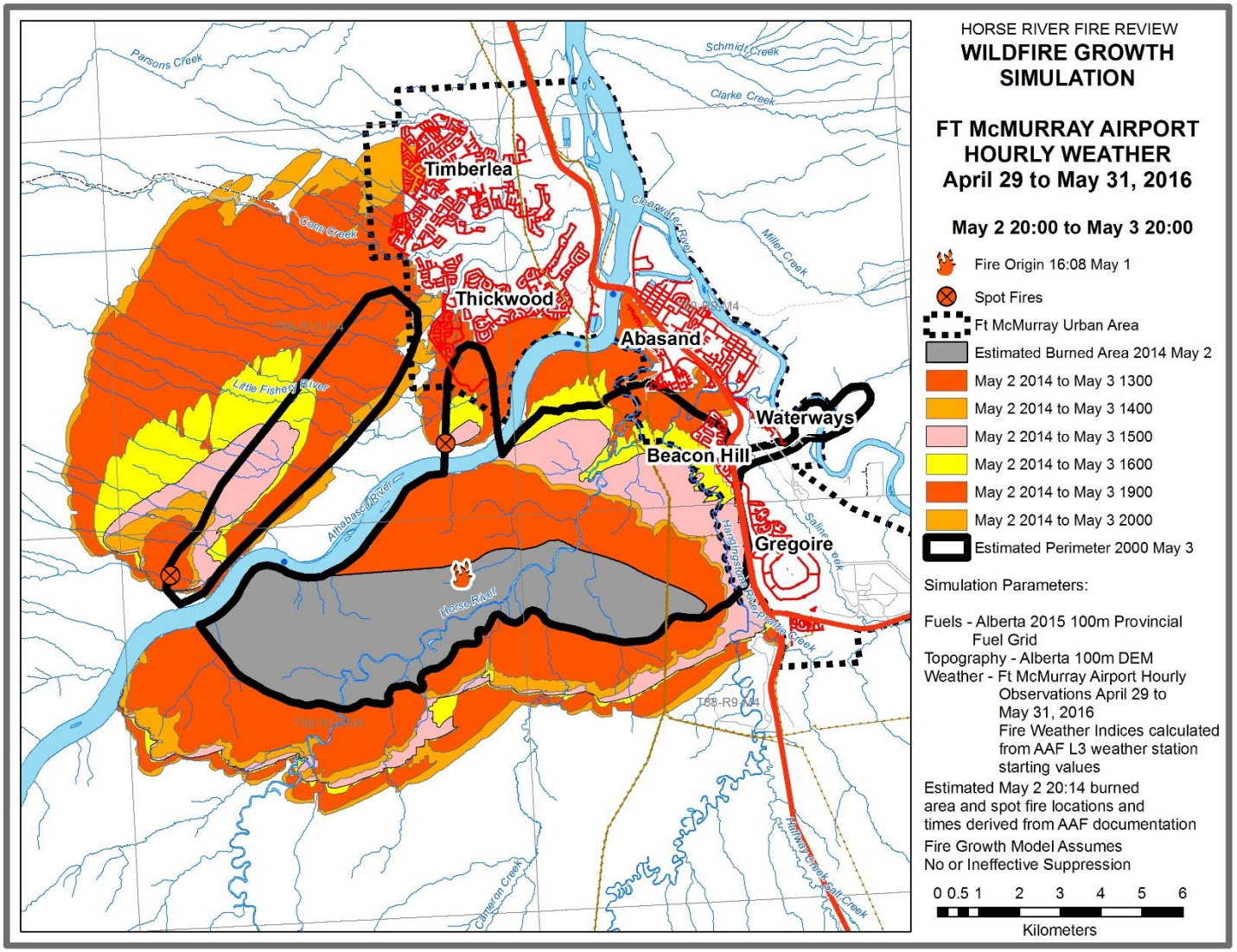


Exhibit A-12: NOAA Suomi VIIRS Image 04:16h MDT May 4, 2016

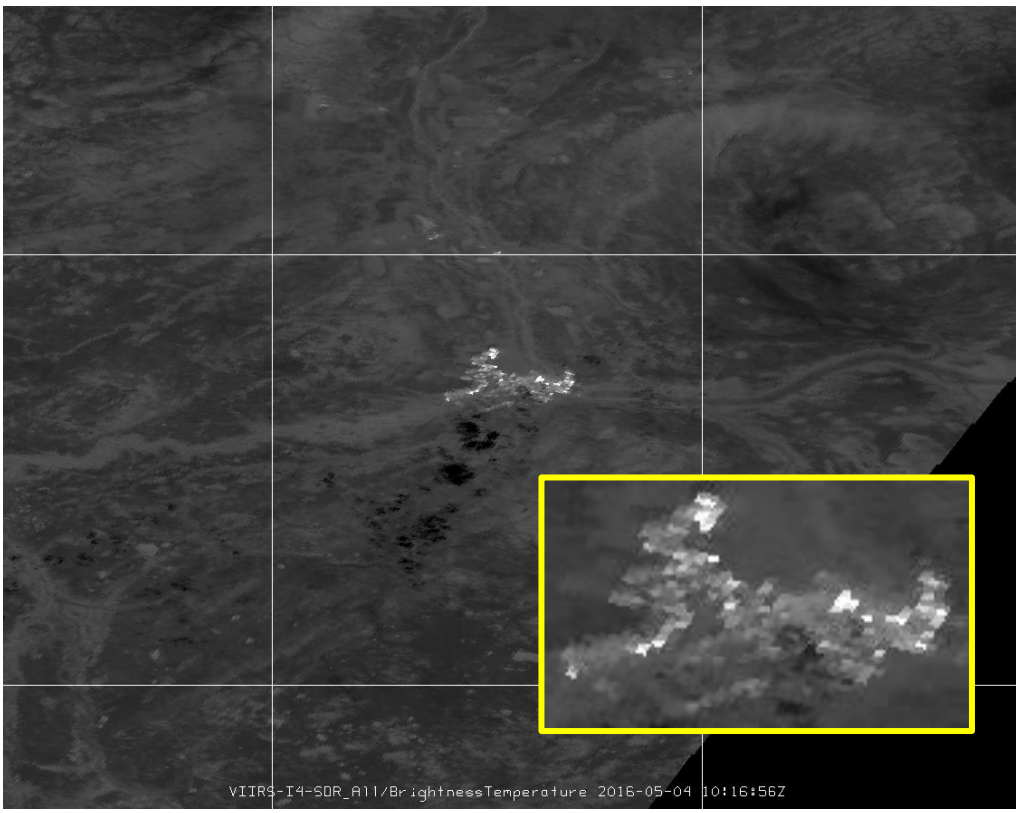
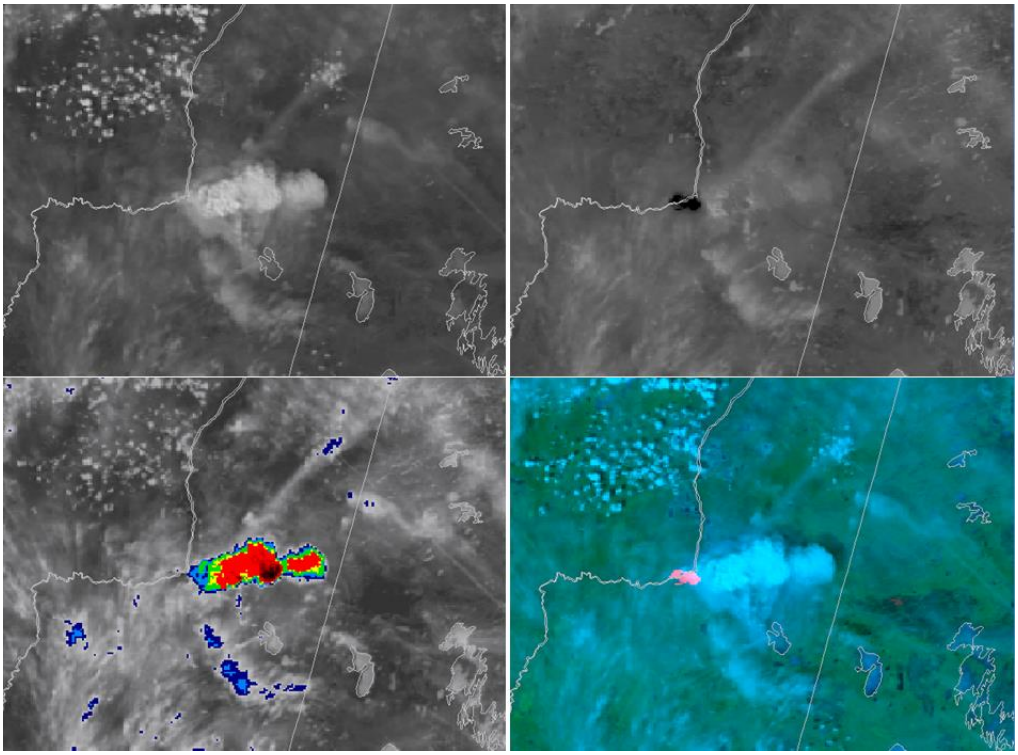


Exhibit A-13: NOAA AVHRR Image 15:04h MDT May 3, 2016



May 4, 2016

Extreme wildfire danger conditions persisted through May 4, with 30 degree C temperatures and RH levels dropping to below 15 percent throughout the afternoon. As the cold front approached, afternoon wind speeds reached 30-50 kilometres per hour with gusts as high as 65 kilometres per hour (Exhibit A-14). The Fort McMurray International Airport was threatened but the wildfire passed without damage in mid-afternoon. A satellite overpass at 14:07h showed an extremely active wildfire perimeter on all sides of wildfire MWF-009 (Exhibit A-15). With the passage of the cold front around 16:00h winds switched to the northwest and remained strong throughout the evening. The wildfire spread quickly to the southeast, and was estimated to be about 12 kilometres from Gregoire Lake Estates and Anzac at 21:34h. Wildfire MWF-009 continued to burn well into the night as winds remained strong and RH values low. The forecast weather for the afternoon of May 4 was accurate, and FWI System values moderated somewhat but were still extreme. Intensity Class 6 fire behaviour was consistent with FBP System outputs. High spread rates and downwind spotting drove the wildfire 40-45 kilometres to the southeast by the morning of May 5. Convection column heights on the afternoon of May 4 reached 12.5 kilometres and lightning from the pyrocumulonimbus cloud atop the column started a number of new wildfires up to 40 kilometres ahead of the main wildfire front (Exhibit A-16).

Exhibit A-14: Diurnal Trends in Temperature, Relative Humidity, and Wind Speed on May 4, 2016 from Environment Canada Weather Station at Fort McMurray International Airport

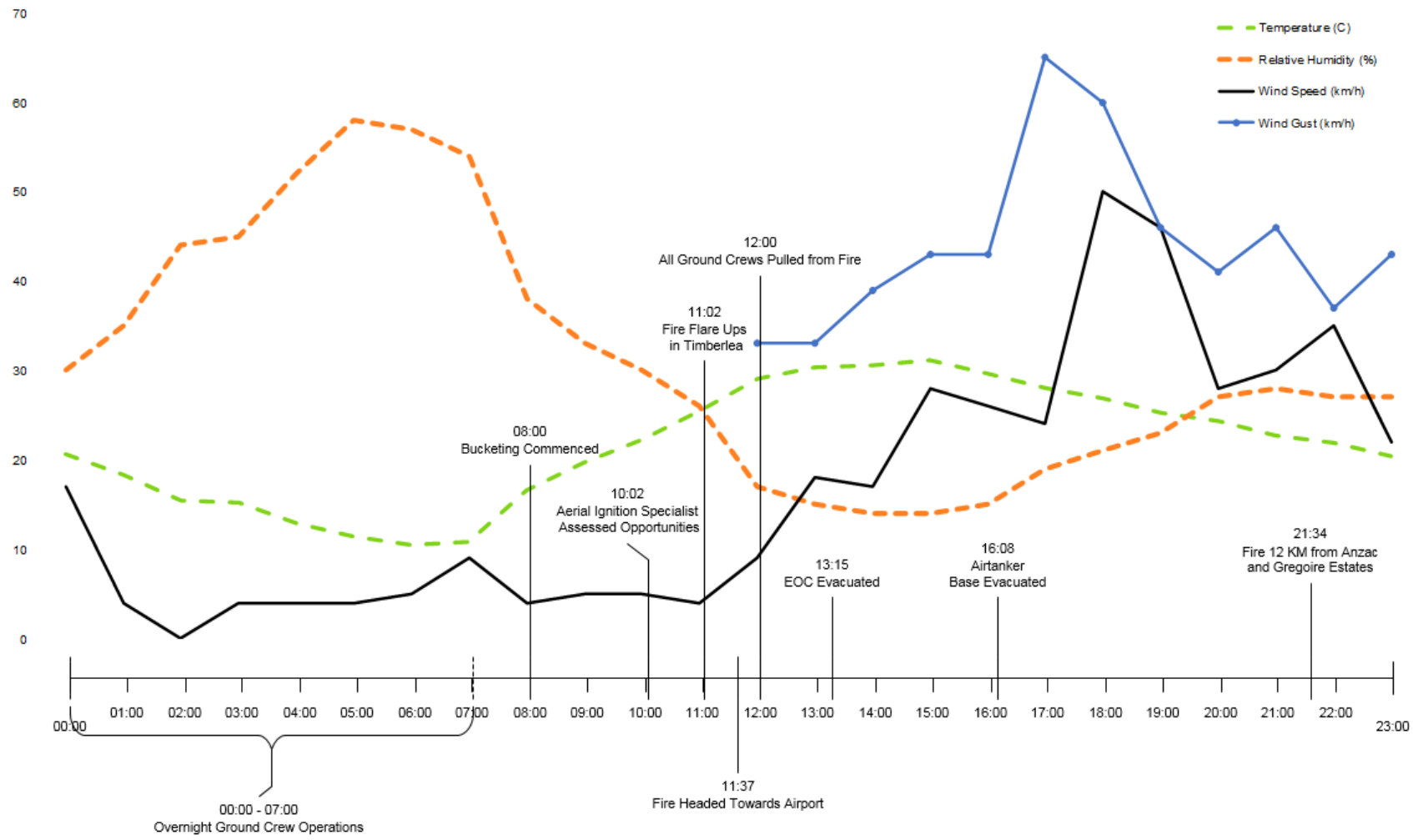


Exhibit A-15: NOAA Suomi VIIRS Image 14:07h MDT May 4, 2016

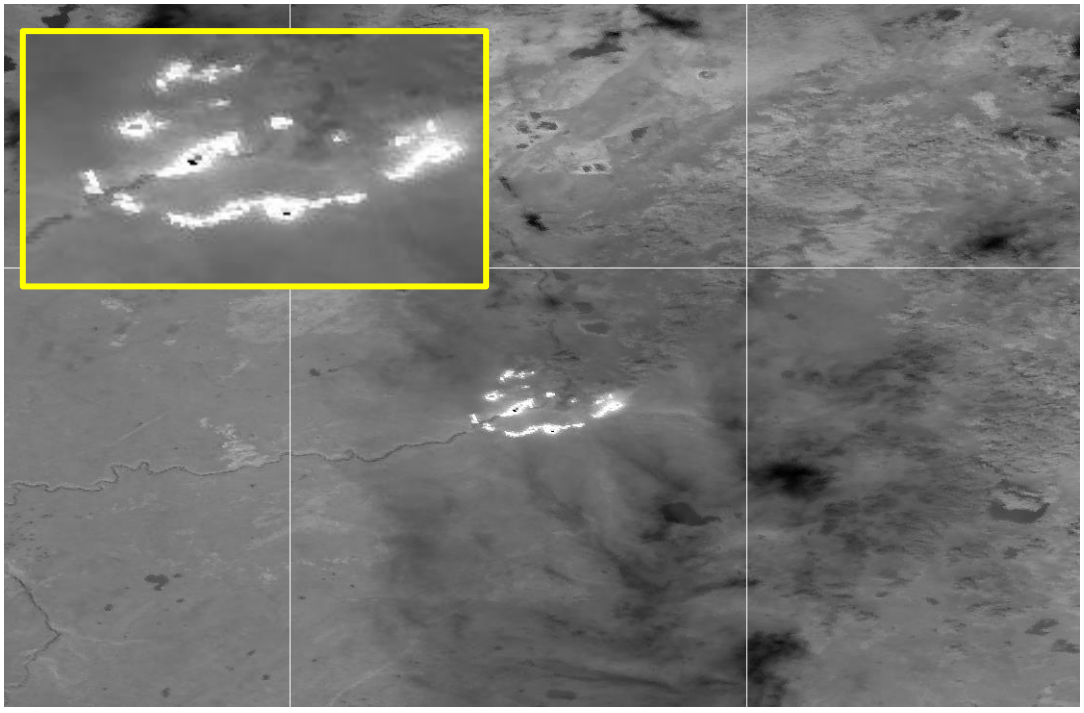
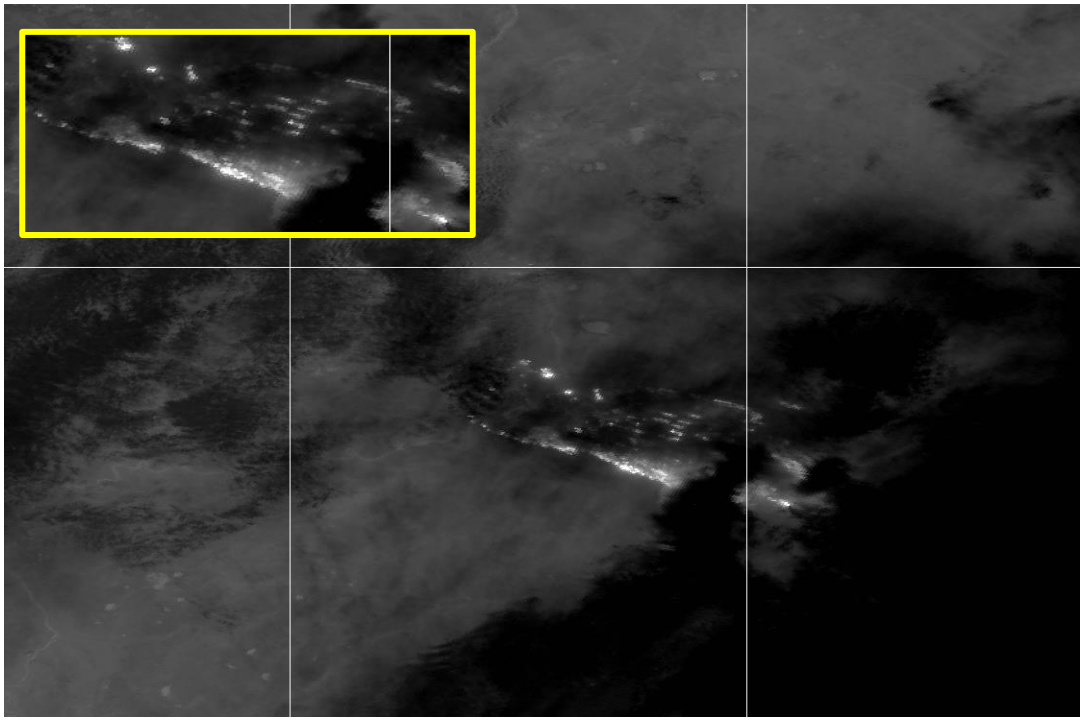


Exhibit A-16: NOAA Suomi VIIRS Image 03:58h MDT May 5, 2016



May 5-14, 2016

The cold front passage resulted in lower temperatures on May 5, but continued low afternoon RH values and strong winds (20-25 kilometres per hour) from the northwest (Exhibit A-17) continued to push the wildfire to the east and southeast. Fireguards protected the community of Anzac during this period, although a few structures were lost in the area. By 16:00h on May 5 the wildfire had burned 101,412 hectares (Exhibit A-18), and at 14:00h on May 6 it was mapped at 156,607 hectares. Over the next two days, the wildfire expanded slowly. Then on May 8 strong winds from the west pushed the southern and northeast (south of the oil sands operations) portions of the wildfire significantly eastward. By 13:30h on May 9 the wildfire was 229,078 hectares in area. Over the next week wildfire MWF-009 continued to expand slowly as cooler temperatures prevailed.

Exhibit A-17: Diurnal Trends in Temperature, Relative Humidity, and Wind Speed May 5, 2016 from Environment Canada Weather Station at Fort McMurray International Airport

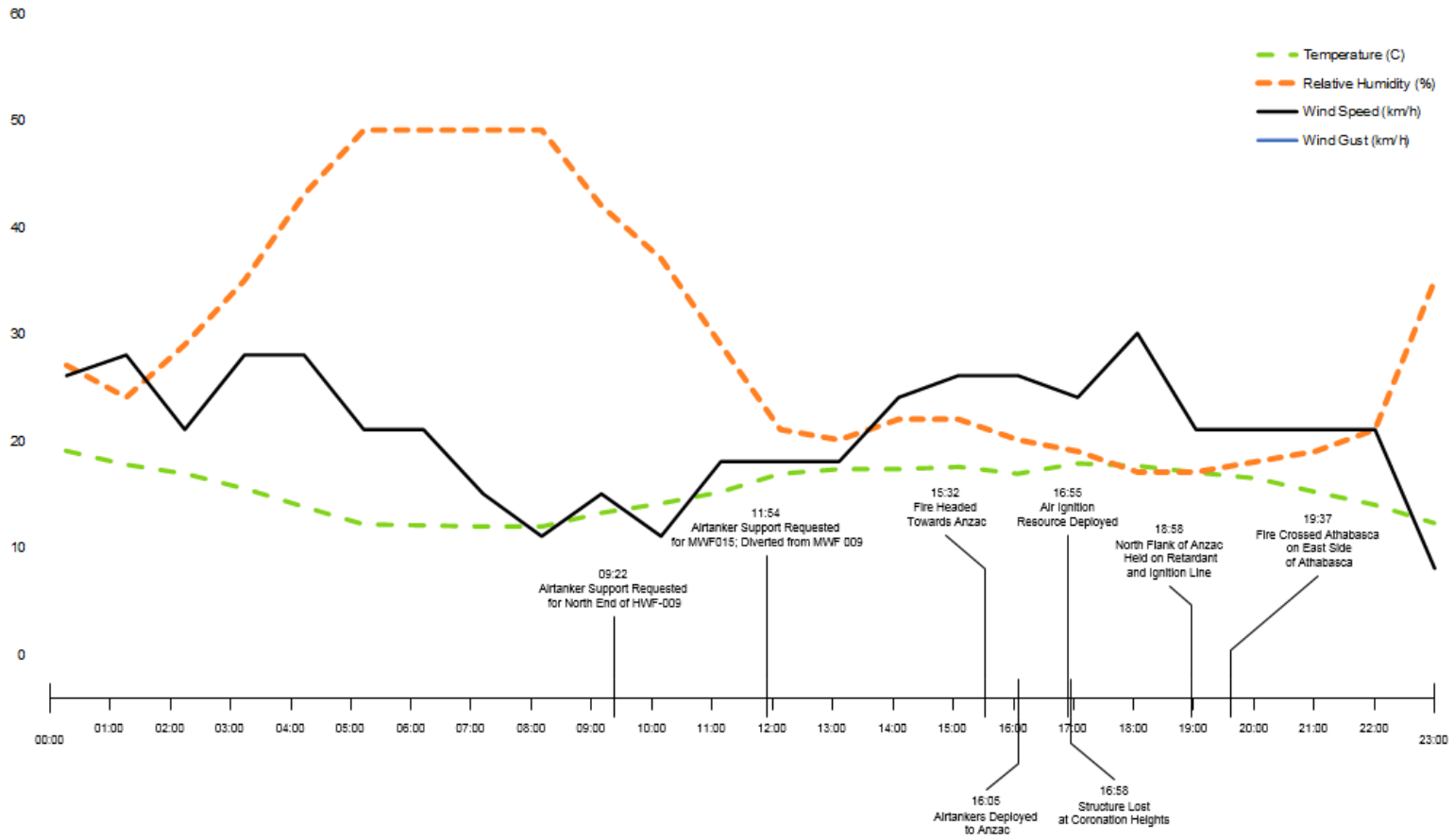
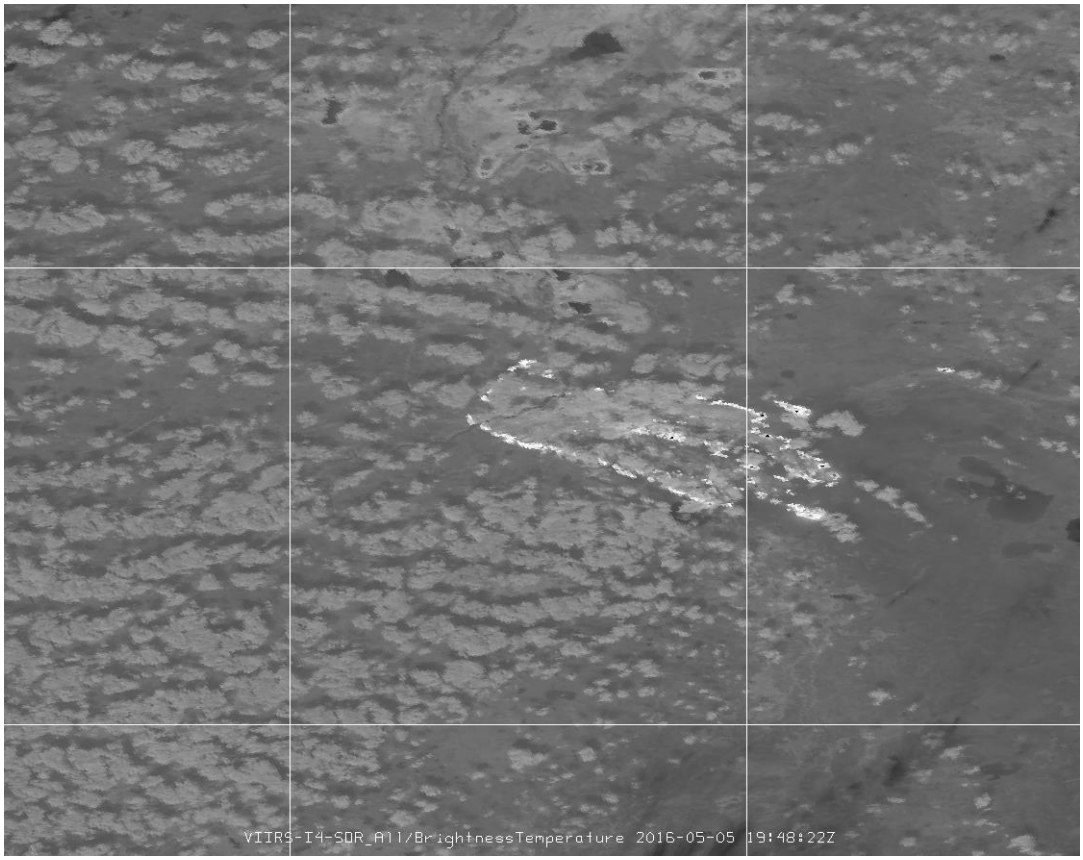


Exhibit A-18: NOAA Suomi VIIRS Image 13:48h MDT May 5, 2016



May 15-16, 2016

By the afternoon of May 15 warming temperatures and lower RH levels, along with moderate winds, caused the wildfire to behave more aggressively. The northeast flank began to expand northward, and the western flank moved further west. On the afternoon and evening of May 16 forecast strong southerly winds (20-33 kilometres per hour gusting to 45 kilometres per hour) combined with low RH values (15-17 percent) and warm temperatures (25 degrees C) (Exhibit A-19) pushed fingers of wildfire from these areas rapidly northward. FWI System codes and indices were extreme and Fire Behaviour Prediction (FBP) System outputs were accurate during this burning period. The wildfire burned well into the evening on May 16, with the northwest flank burning the Blacksand Lodge near Tar Island, while numerous fingers from the northeast flank now posed a significant threat to oil sands assets further east (Exhibit A-20). A Prometheus wildfire growth simulation (Exhibit A-21) showed the northwestern portion of the wildfire reaching Blacksand Lodge during this period. At 07:45h on May 16 the wildfire was mapped at 284,214 hectares. Continued good burning conditions on May 17 consolidated the fingers on the northeast flank, with the wildfire reaching 483,084 hectares by 19:08h on May 18.

After mid-May, the wildfire continued to expand sporadically, but the threat to oil sand assets was reduced though a combination of asset protection strategies by the oil companies, suppression and burnout operations, and more frequent precipitation events. Wildfire MWF-009 was declared Under Control (UC) on July 4, 2016 at a final size of 589,552 hectares.

Exhibit A-19: Diurnal Trends in Temperature, Relative Humidity, and Wind Speed May 16, 2016

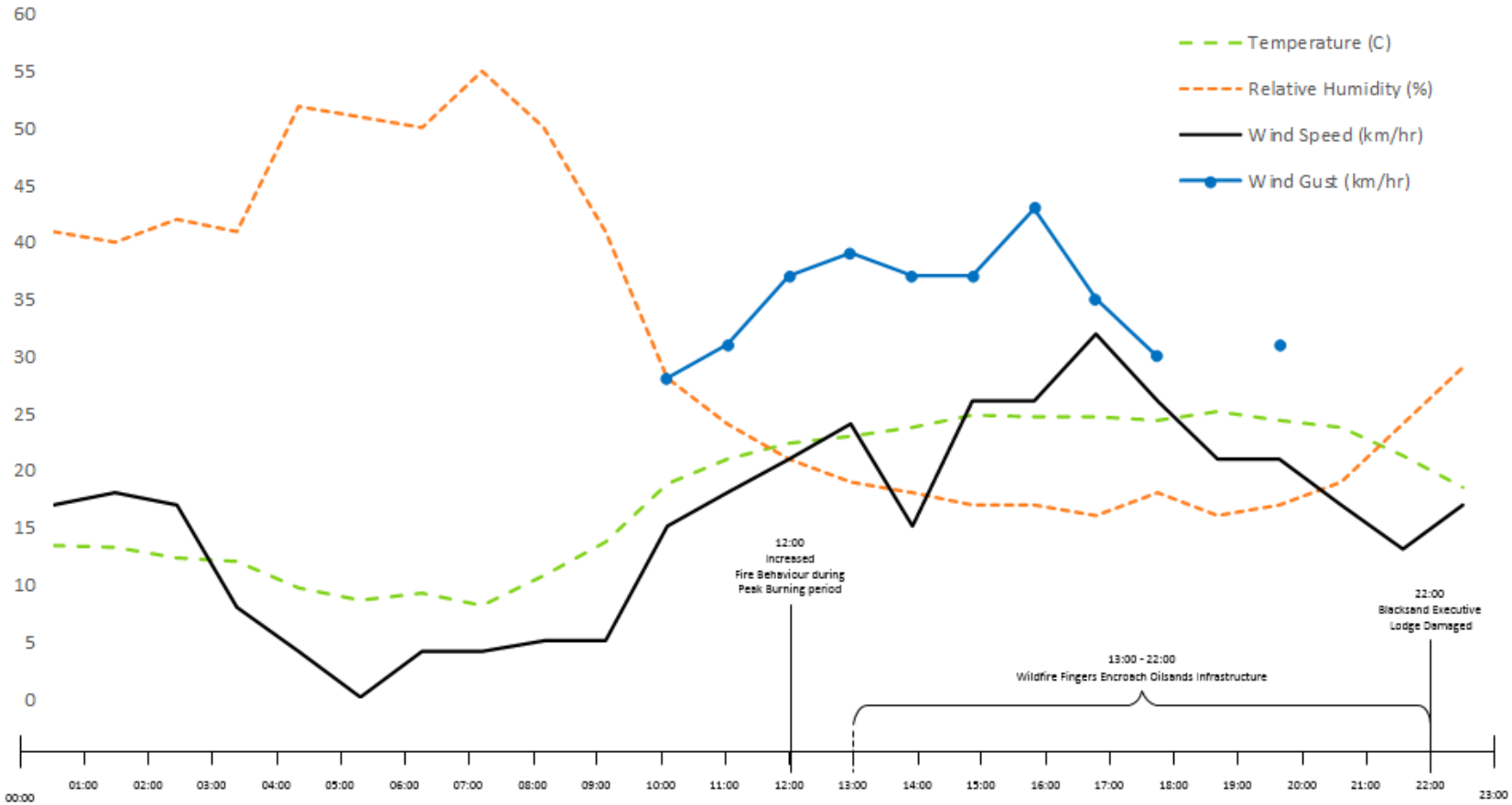
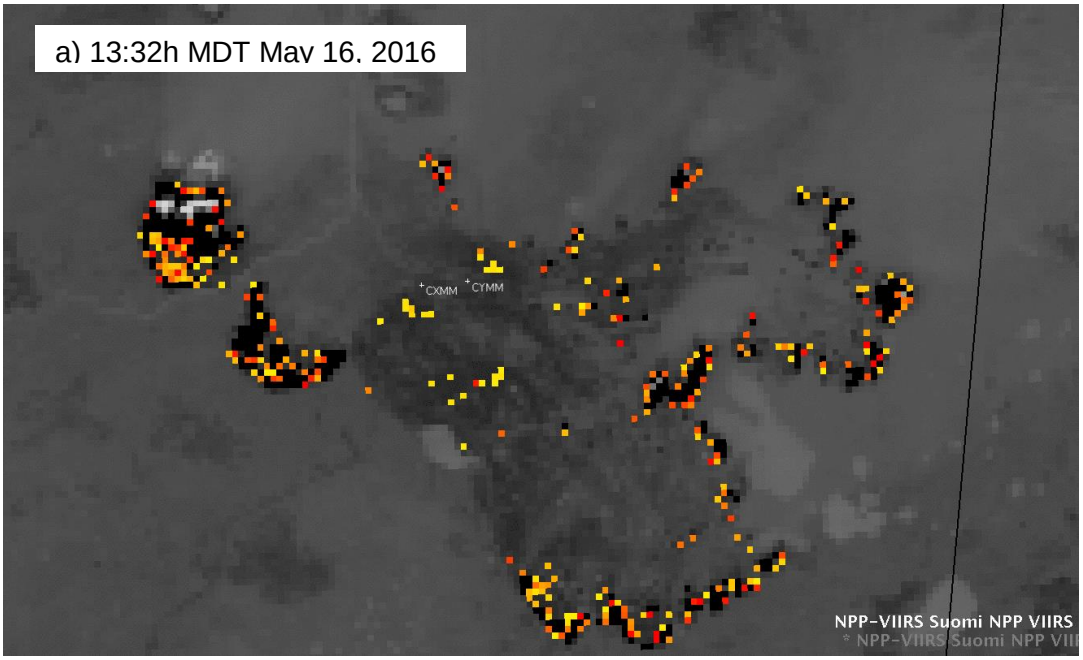


Exhibit A-20: NOAA Suomi VIIRS Images from May 16-17



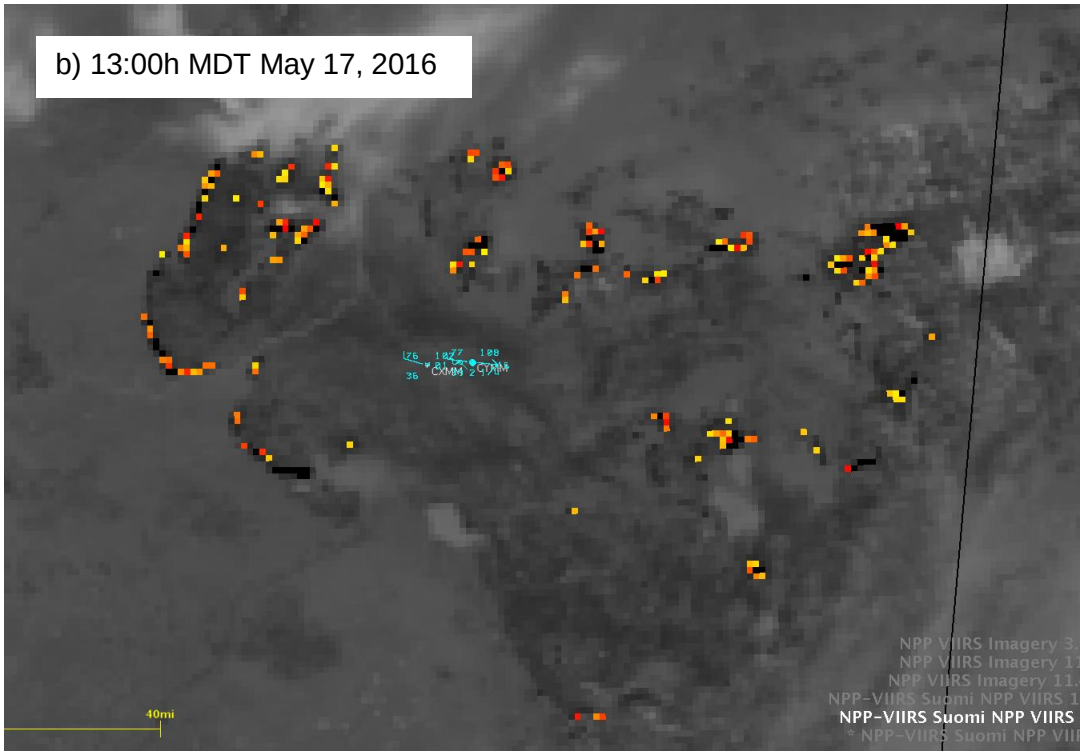
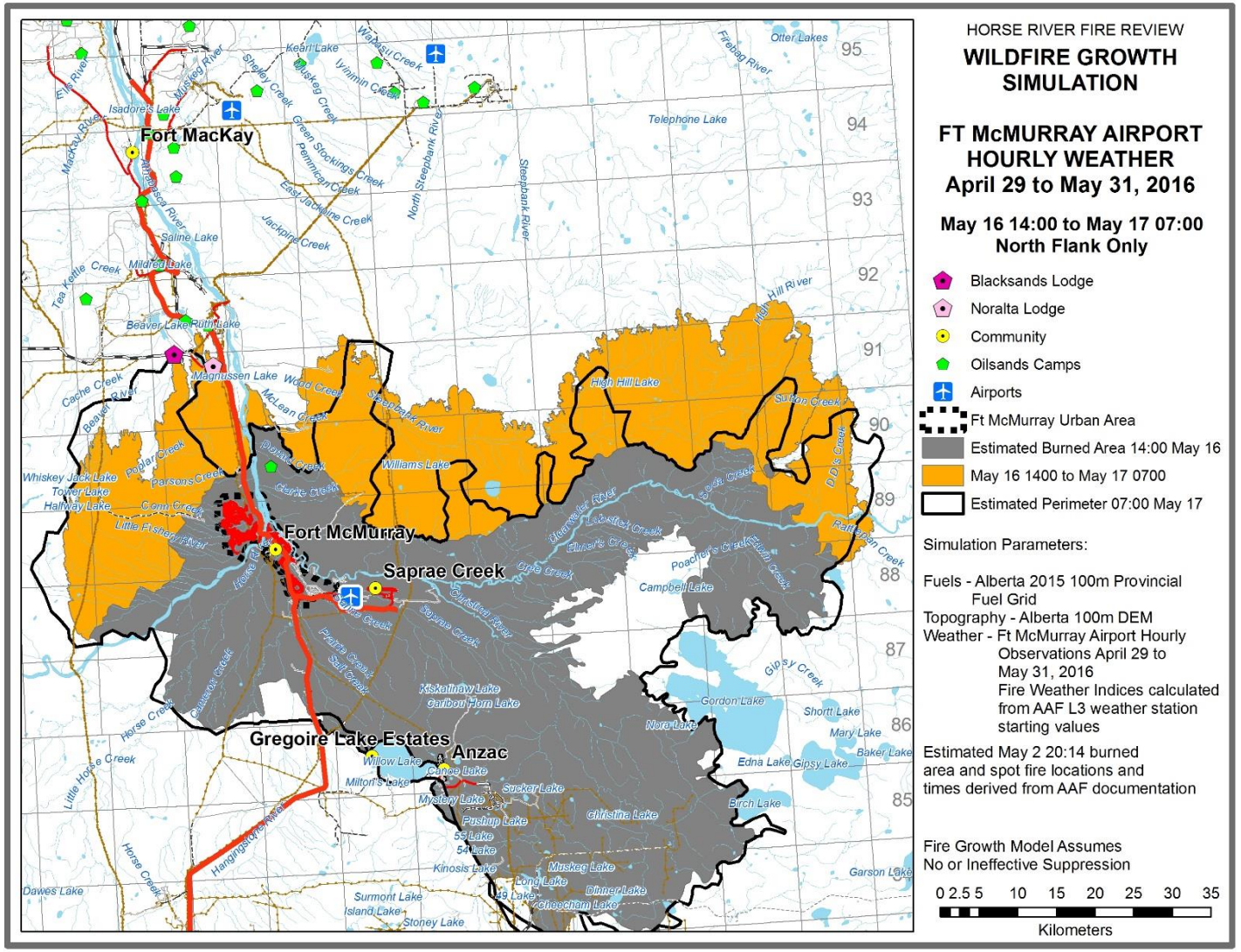


Exhibit A-21: Prometheus Wildfire Growth Simulation for May 16-17, 2016 (Prometheus Model Assumes No Suppression Action)



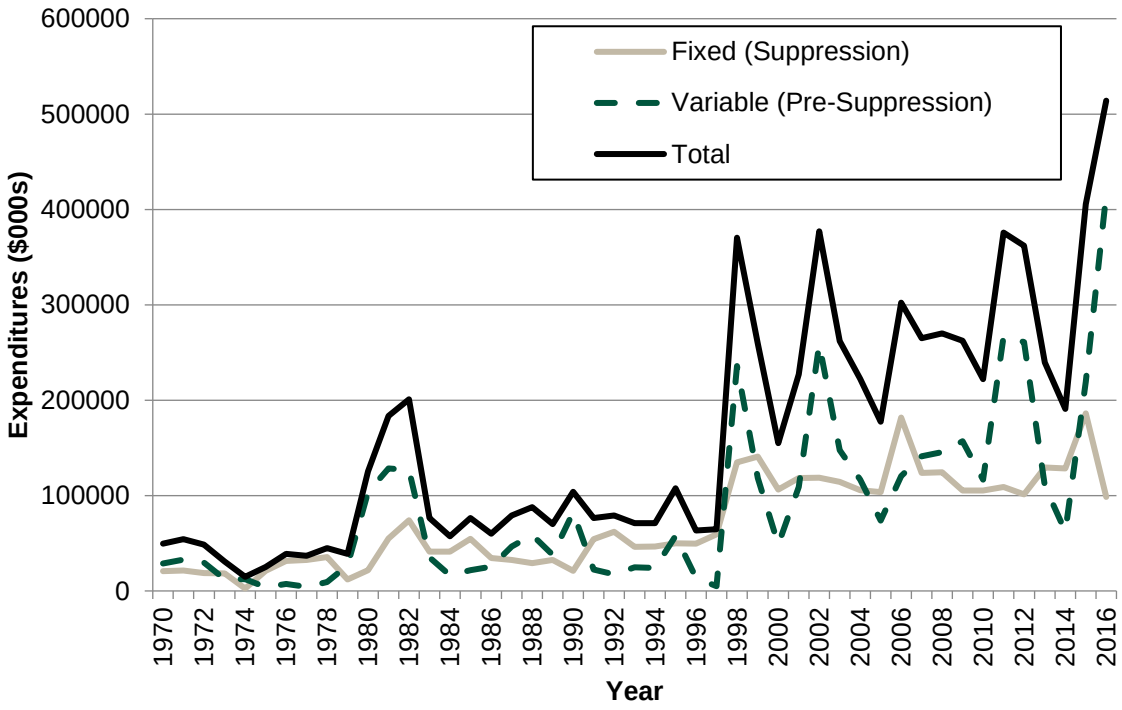
APPENDIX B: DISCUSSION OF OVERWINTER AND SPRING CONDITIONS

Background and Context on Boreal Wildfire in Alberta

Large wildfires have shaped the boreal forests of Alberta and Canada since the last Ice Age approximately 10,000 years ago. Wildfire is a natural ecosystem process and has been a required renewal agent in these forests to maintain ecological structure. Over the past century Canadian wildfires have frequently posed significant threats to public safety, property and natural resources, and Canadian wildfire management agencies have developed sophisticated, world-class programs aimed at protecting these values from unwanted wildfire, while balancing such losses with the ecological and necessary benefits of wildfires. This is an expensive undertaking, with Canadian agencies now spending close to $1 billion annually managing wildfires.

Wildfire management costs have risen steadily over the past 40-50 years, particularly over the last two decades, and a significant cause has been the steady expansion of human and industrial development into flammable forested and wildland landscapes. Both Alberta and British Columbia have experienced the most significant cost increases since the mid-1990s (see Exhibit B-1).[17]

Exhibit B-1: Wildfire Management Expenditures in Alberta 1970-2016 (CPI adjusted to 2016 dollars)



17 Adapted and updated from Stocks, B.J, and Martell, D.L. 2016. Forest fire management expenditures in Canada: 1970-2013. Forestry Chronicle 2(3): 298-306.

Over the past 2-3 decades, climate science has evolved to now show quite clearly that global warming is the direct result of human activity, and that major future impacts are imminent (or ongoing) and will be significant. The greatest warming is already occurring at northern latitudes. Canadian studies of the effects of climate change on wildfire activity in Canada forecast greater climatic variability, more severe weather events, longer wildfire seasons, increases in both lightning-caused and human-caused wildfire occurrence, greater area burned, and larger, more intense wildfires. These studies also state that these impacts will become apparent earliest in northern boreal forests.

Large and destructive spring wildfires have been relatively common in recent years in the boreal forest in Alberta. Most notable are the Vega wildfire of 1968, the Mitsue and Virginia Hills wildfires of 1998, the Chisholm wildfire of 2001, and the Flat Top Complex wildfires of 2011. The Vega, Mitsue and Chisholm wildfires (of 1968, 1988 and 1998 respectively) all burned towards the town of Slave Lake, with the Flat Top complex wildfires of 2011 making the threat a reality. Two of the three wildfires in the Flat Top Complex burned into the communities, including the town of Slave Lake. These spring wildfires occur when fine fuels are exceptionally dry, during the period between the melting of overwinter snow cover and the flushing (greening-up) of grasses and understory/overstory deciduous vegetation. Extreme fire behaviour is driven by low relative humidity (RH) values and strong winds, caused by the intrusion of dry arctic air masses into boreal regions of Alberta. Longer day lengths at this time of year at northern latitudes also extend burning periods.

2015/2016 Overwinter Precipitation, Temperature and Snowmelt Conditions

The 2015 fire season in Alberta was one of the busiest and most costly in recent memory. A total of 1,786 wildfires burned 492,400 hectares, in comparison to a 5-year average of 911 wildfires and 260,323 hectares burned.

When the 2015 wildfire season ended, abnormally dry/moderate drought conditions existed across northeastern boreal regions of Alberta. A very mild and dry winter and spring period followed, largely influenced by a very strong El Nino. The winter in this region began with a moisture deficit, and the 2015/2016 winter/spring period provided no relief, as precipitation levels remained well below normal with above normal temperatures (see Exhibits B-2 and B-3). In the Fort McMurray area, in the 7-month period between October 2015 and April 2016, monthly precipitation was only 42.4 percent of the historical normal (1971-2000). Clearly this was a very dry winter. Over the same 7-month period monthly temperatures were consistently above normal, reaching 4-6 degrees C above normal during the November through February period.

Exhibit B-2: 2015/2016 Precipitation Anomalies at Fort McMurray

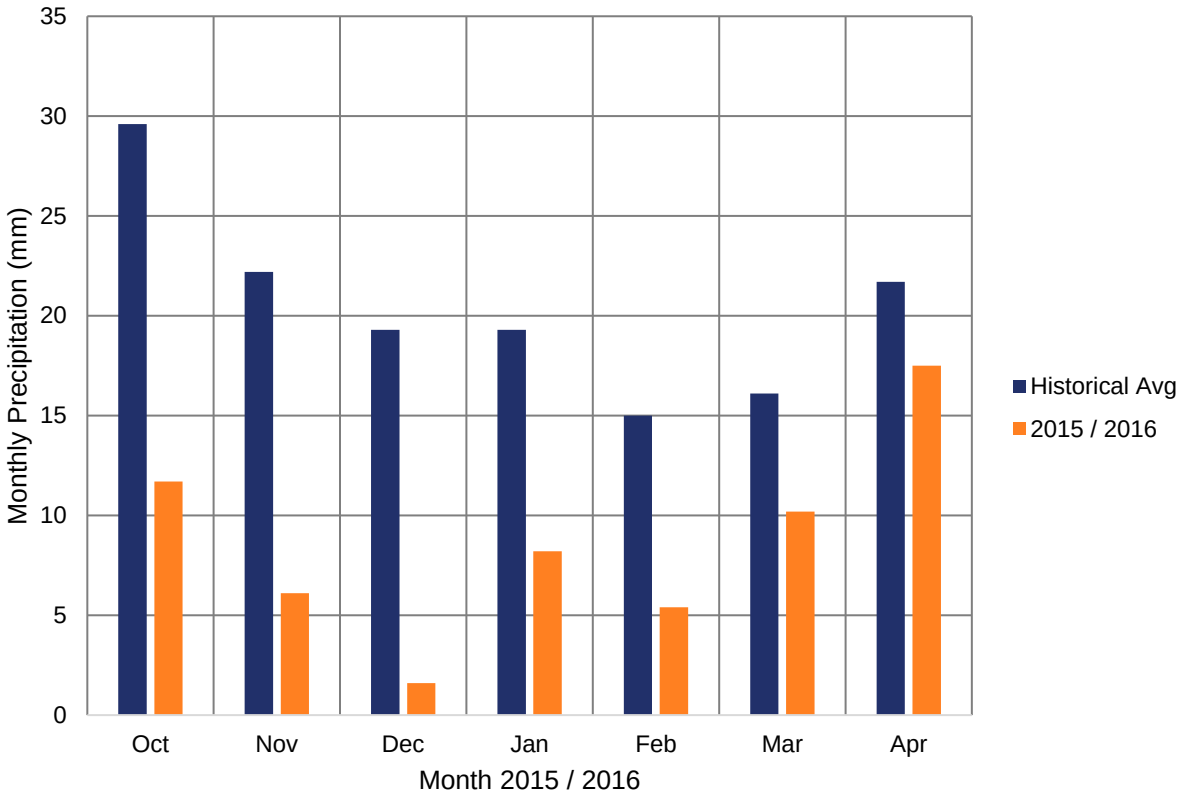
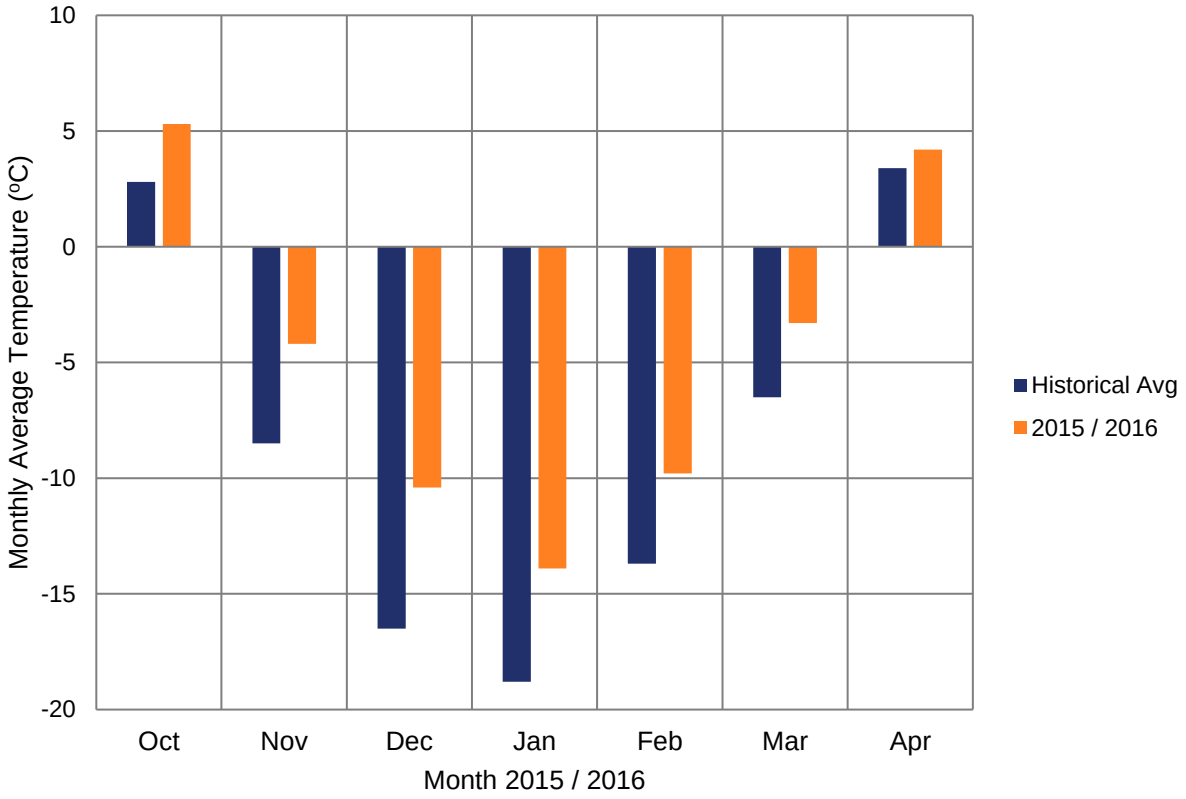


Exhibit B-3: 2015/2016 Monthly Temperature Anomalies at Fort McMurray



Low precipitation amounts combined with warmer temperatures resulted in a reduced overwinter snowpack in northeastern boreal regions of Alberta in general and the Fort McMurray area in particular. A few sustained warm periods in mid-winter also contributed to a reduced snow pack. The majority of the snowpack around Fort McMurray disappeared at the end of March during a 4-day period of high temperatures and low RHs (see Exhibit B-4). By mid-April satellite imagery shows snow has essentially disappeared in the Fort McMurray area, approximately two weeks earlier than normal (Exhibit B-5). Environment Canada monthly maps of snow depth confirm this (Exhibit B-6). This rapid snowmelt translated into a limited recharging of forest floor moisture levels. As a result, ground fuels were drier than usual in the spring of 2016, heading into a pre-green up period often characterized by warmer temperatures, lower RH values, and strong winds.

Exhibit B-4: Monthly Snow Cover Amounts at Fort McMurray, AB from 2005/2006 Through 2015/2016

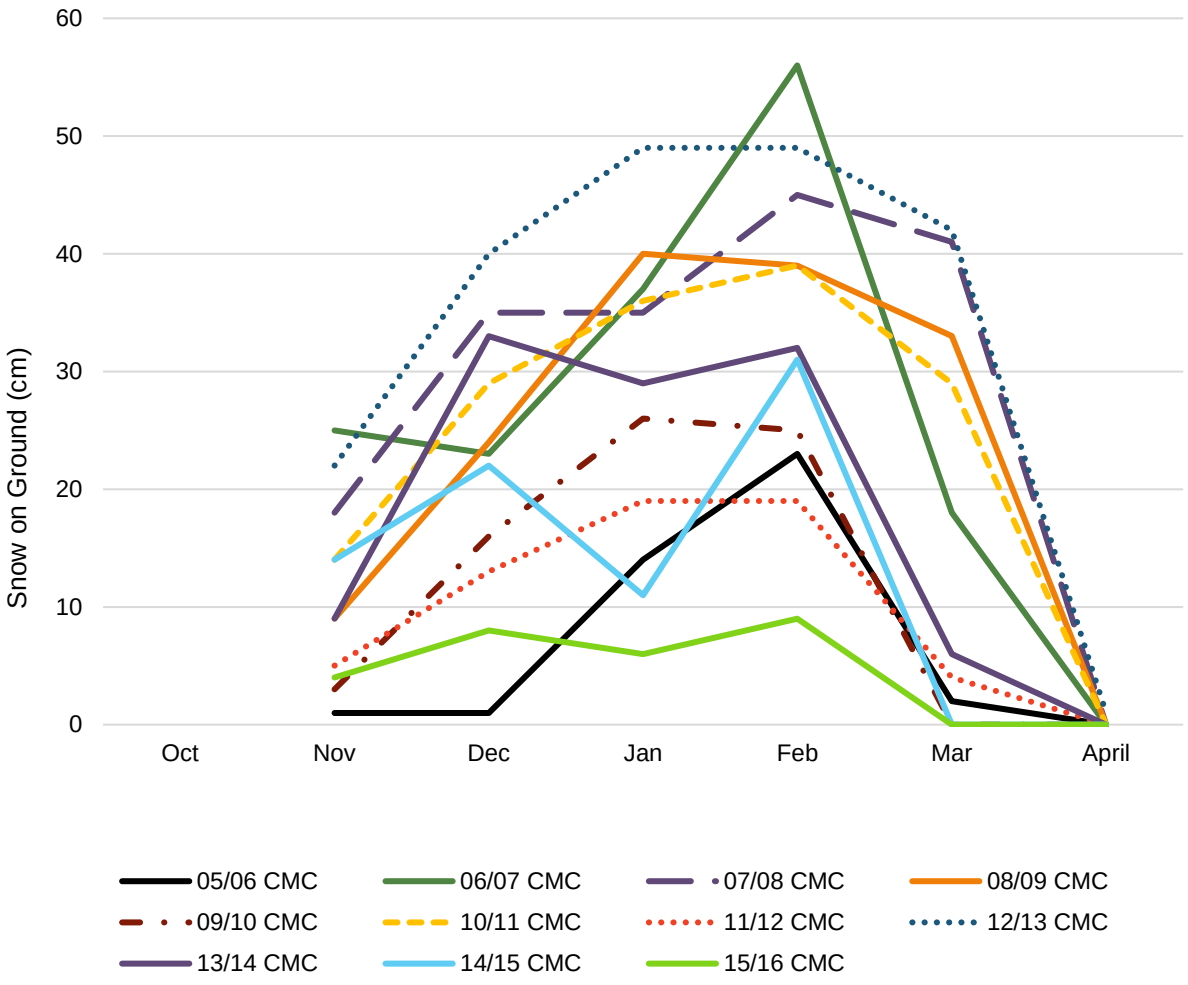


Exhibit B-5: MODIS Satellite Imagery of Mid-April 2016 Alberta Snow Cover

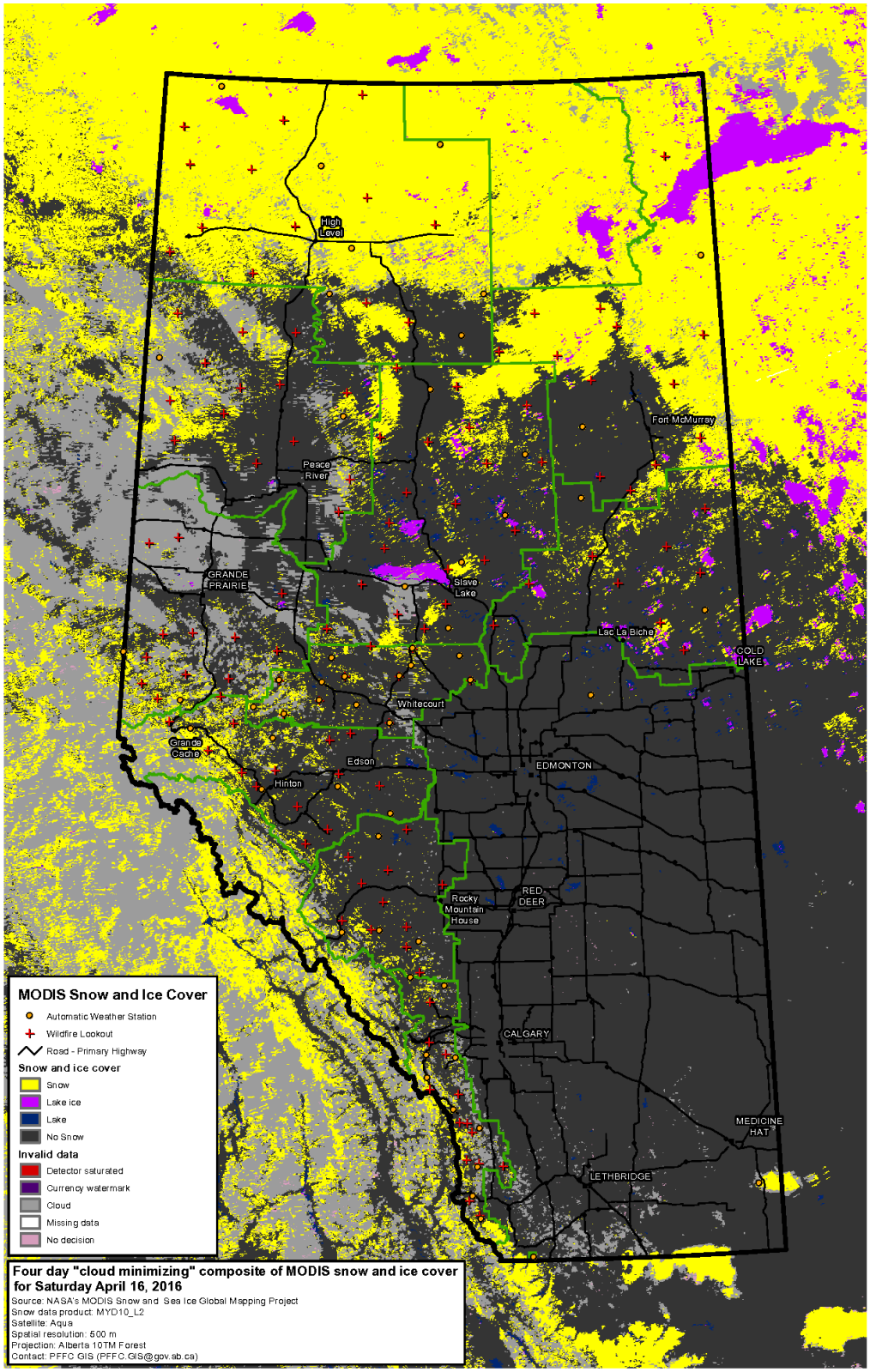
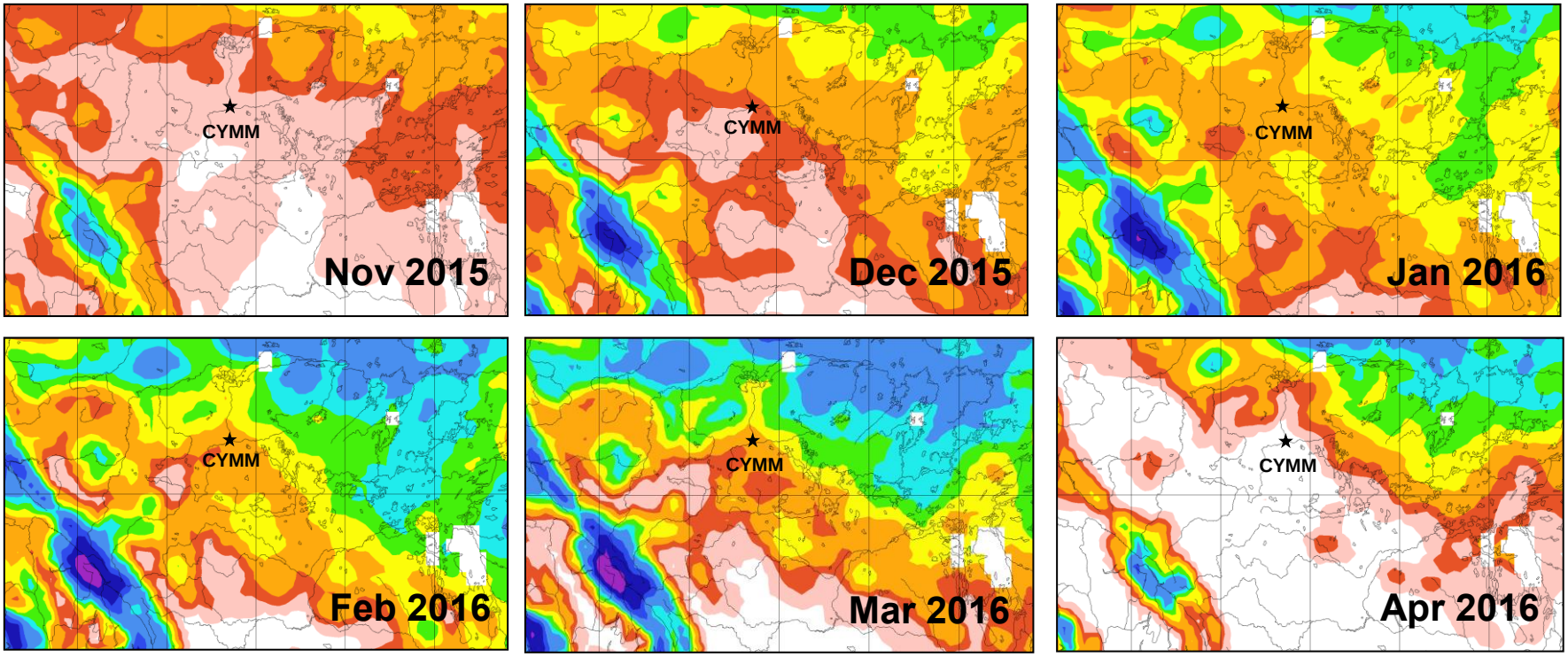
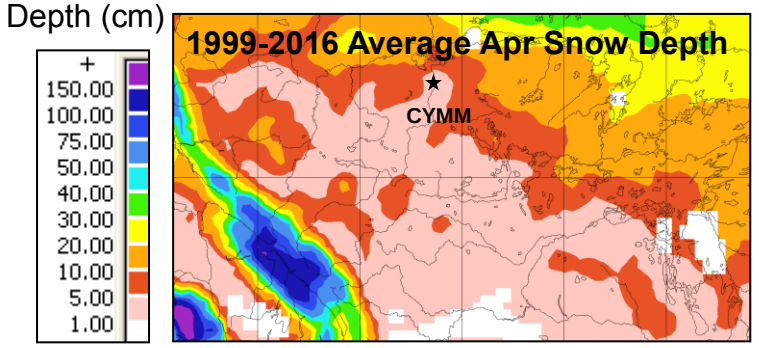


Exhibit B-6: 2015/2016 Monthly Average Snow Depths in Northeast Alberta



CYMM is the Fort McMurray International Airport



Credit: Ross Brown, CCRD/CPS, Environment Canada

The period between mid-April and the start of the Horse River wildfire on May 1 was characterized by air temperatures that were significantly above normal, coupled with a lack of precipitation. As a result, forest fuels were drying quickly. By May 1 the codes and indices of the Canadian Fire Weather Index (FWI) System were already at extreme levels in the Fort McMurray area. The Drought Code of the FWI System was adjusted throughout the winter, and start-up spring values indicated a fire season beginning under already moderately dry conditions in heavier ground fuels and deeper organic layers.

In general, upland boreal forests interspersed with wetlands are predominate in the Fort McMurray area. Pure aspen and mixedwood (aspen, poplar, balsam fir and white spruce) forests are most common, and pure black spruce stands are abundant. In addition, many of the aspen forests now have a very heavy white spruce understory, creating a more explosive fuel type than leafless aspen. With respect to the Fort McMurray area in late April, cured dry grass fuels are common at this time of year, and there are many regenerating cut blocks in the vicinity. In addition, conifer foliage is at its lowest moisture content levels during this period, and green-up of ground fuels and deciduous shrubs and trees has not started. Spruce budworm-killed fir and spruce was also present in this area, making more fuel available for combustion. The combination of all these factors would make high-intensity fire behaviour a certainty, given conducive wildfire hazard conditions.

Fire weather forecasts in the week leading up to the start of the Horse River wildfire on May 1, 2016, appear to be accurate for mid-afternoon conditions, as temperatures rose steadily, RH levels dropped, and wind speeds were generally 15-20 kilometres per hour from the southeast to southwest. At noon MDT on April 30 the temperature was 18.6 degrees C, the RH was 30 percent and winds were 22 kilometres per hour. The forecast issued on April 30 called for the establishment of a strong upper level ridge over the province on May 1 that would dictate weather conditions in the Fort McMurray area for the next few days before breaking down with a cold front passage on May 4. During this period, severe burning conditions were expected as temperatures were forecast to rise to 30 degrees C while RH levels dropped to 15 percent with winds approaching 25 kilometres per hour.

The combination of extremely dry fuel conditions and a forecast of severe fire weather prompted forecasters to issue a Fire Weather Advisory on the morning of May 3 warning of extremely favorable burning conditions and extreme fire behaviour.

APPENDIX C: ACKNOWLEDGEMENTS, REFERENCES AND INTERVIEWS

ACKNOWLEDGEMENTS

For provision and analysis of satellite imagery:

- René Servrankx, Environment Canada, Canadian Meteorological Service, Dorval, QC (retired)
- Dan Lindsey, NOAA Center for Satellite Applications and Research, Regional and Mesoscale Meteorology Branch – CIRA, Fort Collins, CO, 80523
- Scott Bachmeier, Cooperative Institute for Meteorological Satellite Studies, Space Science and Engineering Center, University of Wisconsin, Madison, WI, 53706

For provision and analysis of snow cover maps:

- Ross Brown, Climate Processes, Environment and Climate Change Canada, Montreal, QC

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- Weber, M.G., and Flannigan, M.D. 1997. Canadian boreal forest ecosystem and structure in a changing climate: impact on fire regimes. Environmental Reviews 5: 145-166.

INTERVIEWS

Over 90 individuals were interviewed within the following categories. To respect the confidential nature of specific observations, comments and input offered by individuals that were interviewed, names are not included.

- Agriculture and Forestry Alberta Wildfire Coordination Centre (AWCC) staff members
- Agriculture and Forestry Forest Area staff members
- Agriculture and Forestry leadership and management
- Agriculture and Forestry wildfire responders
- Regional Municipality of Wood Buffalo leadership and management
- Regional Municipality of Wood Buffalo emergency responders
- Regional Emergency Operations Centre and Provincial Operations Centre members
- Aviation contractors
- Oil sands industry representatives
- Forest industry representatives
- Emergency responders from outside the Regional Municipality of Wood Buffalo
- First Nations and Metis community representatives
- Independent wildfire scientists and specialists

MNP LLP