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Use of high-volume water delivery systems in peat fires

A case study in Central Alberta

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A human-caused wildfire was started on May 6, 2021 in Parkland County, Alberta near the rural community of Tomahawk. Among several Alberta Wildfire resources deployed to the wildfire, one particular resource was high-volume water delivery systems provided by Fire & Flood Emergency Service Ltd.

Alberta Wildfire asked FPInnovations to document the implementation of high-volume water delivery systems in actioning a peatland wildfire as a case study.

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BACKGROUND

A human-caused wildfire was started on May 6, 2021 in Parkland County, Alberta near the rural community of Tomahawk, in the area of Township Road 514 and Range Road 63. By the afternoon of May 7, 2021, the fire had grown to around 2,200 hectares, trending primarily in the north-west direction (fire perimeter shown in Figure 1). Mandatory evacuation orders issued for the immediate surrounding area. The wildfire predominantly impacted private land. On May 19, 2021, Parkland County announced that the wildfire was 100% contained, with crews still working on hotspots.

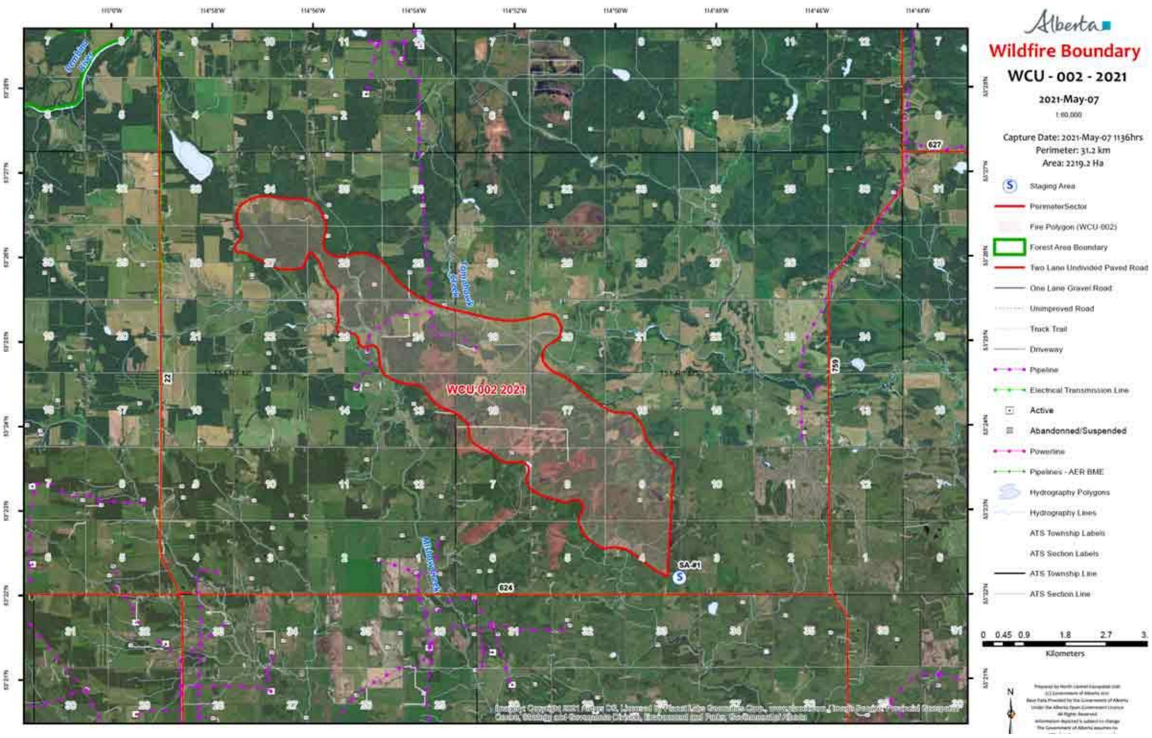

Figure 1. Fire perimeter on May 7, 2021. Source: Parklandcounty.com

As part of a mutual aid agreement between Parkland County and Whitecourt Wildfire Management Area (Alberta Wildfire), resources from Whitecourt were deployed to Parkland County in an effort to action the wildfire. Among several Alberta Wildfire resources deployed to the wildfire, one particular resource was high-volume water delivery systems provided by Fire & Flood Emergency Service Ltd. (hereafter known as 'vendor').

Currently, the use of high-volume water delivery systems in wildfire applications is not well documented. To address this, Alberta Wildfire asked FPInnovations to document the implementation of high-volume water delivery systems in actioning a peatland wildfire as a case study. Both the vendor and FPInnovations researchers were informed of their deployment on May 15, 2021 and were requested to be present at site on May 16, 2021 for the morning briefing at the incident command post. Documentation of the high-volume water delivery systems spanned a total of 3 days.

USE OF HIGH-VOLUME WATER DELIVERY SYSTEMS IN PEAT FIRES

Equipment requests from Deputy Operations Chief

The high-volume water delivery systems vendor had a variety of available systems to offer – ranging from 4-inch systems to 12-inch systems, with system inter-mixing capability (i.e., option to mix and match different systems). The initial request made by the Deputy Operations Chief was to use a 4-inch system for this peat fire.

Day 1 involved the exclusive use of 4-inch water delivery systems. With consultation from the vendor and having a better understanding of the water volume requirements for the task at hand at the end of Day 1, the Deputy Operations Chief requested that a 6-inch system be used for assignments provided. The 6-inch system was therefore brought in a day after the 4-inch system was setup and in use. A mixed system (Figure 2) was used wherein the 6-inch hose served as the main line with multiple 4-inch hose off-shoots. The two systems – 4-inch system, and 6- and 4-inch combination system functioned simultaneously on Days 2 and 3.

Figure 2. Mixed system with a 6-inch main line and 4-inch off-shoots.

Assignment provided to vendor

The water delivery systems were tasked with putting out hotspots on the south side of the wildfire. The assignment involved targeting hotspots at a peat farm off Highway 624, at the end of Range Road 65. Figure 3 presents a map sub-section that shows the proximity of Range Road 65, the staging area, the peat farm, and the water source in spatial relation to each other. Hotspot locations were pre-identified via night-time infrared scanning. Specific hotspot locations were provided to the vendor prior to the morning briefing on May 16, 2021 to facilitate planning. Figure 4 presents the location of 5 hotspots, in order of priority, that were part of the assignment provided.

Figure 3. Proximity of Range Road 65, the staging area, the peat farm, and water source for this assignment.

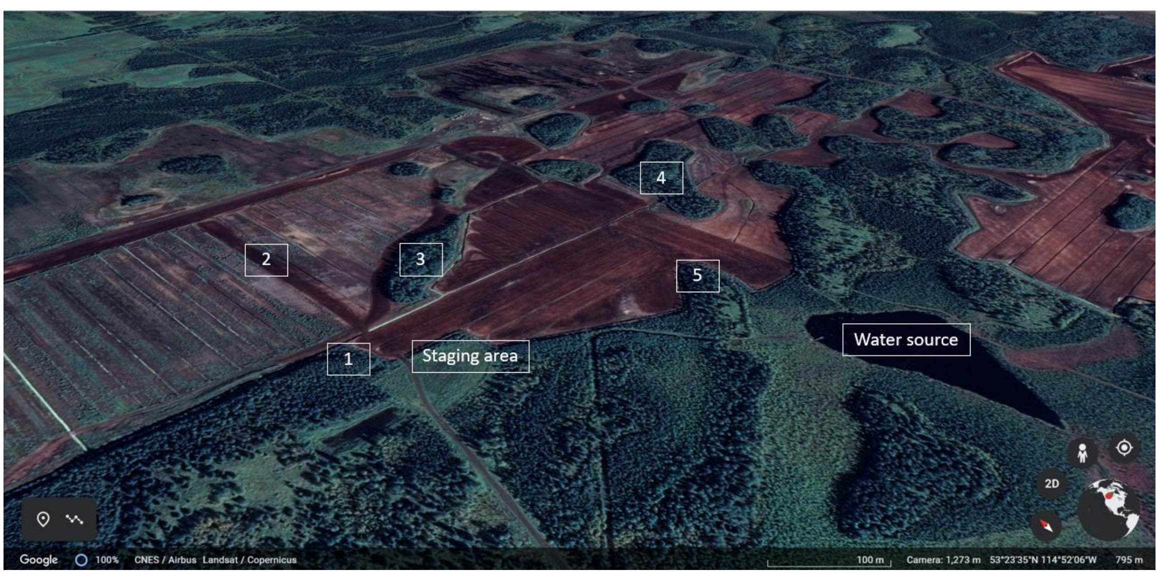

Figure 4. Hotspots, labelled in order of priority, served as the assignment for the water delivery systems.

For this case study, the scope of documenting the use of high-volume water delivery systems involved only Hotspots 1, 2, and 3. Hotspots 4 and 5 were similar to Hotspot 3 in terms of area, fuel type, suppression tactics, and water delivery systems used, and therefore was deemed duplicative. The following are brief descriptions of the three hotspots.

Hotspot 1

Hotspot 1 covered an area of 1.3 ha in size. The fuel was predominantly composed of peat with a slash pile to one side (Figures 5 and 6). At the time of arrival on site, the peat was smouldering deep beneath the surface. The slash pile was also smouldering, with occasional flare ups when the wind speed increased (Figure 7). A unit crew had been working on this hotspot for three full days with limited success due to the depth beneath the surface at which the peat was smouldering.

Note that Figure 4 shows that Hotspot 1 is located in a treed stand. It is likely that the satellite imagery for this hotspot section is outdated.

Figure 5. Hotspot 1 - 1.3 ha area of predominantly peat.

Figure 6. Hotspot 1 - slash piles to one side of the 1.3 ha hotspot of interest.

Figure 7. Hotspot 1 - slash pile flaring up when wind speeds increased.

Hotspot 2

Hotspot 2 covered an area of 0.1 ha. The fuel comprised exclusively of peat that smouldered beneath the surface (Figure 8 and 9). No prior suppression activity had been done on this hotspot.

Figure 8. Hotspot 2 covered an area of 0.1 ha.

Figure 9. Hotspot 2 - peat smouldering beneath the surface.

Hotspot 3

Hotspot 3 was an island of mixed-wood trees (Figure 10) atop of smouldering peat. The size of Hotspot 3 was 1.4 ha in area. The wildfire had consumed majority of the trees, with approximately 25% of trees unburned (Figures 11 and 12). The smouldering peat continued to burn under the surface, causing damage to tree roots (Figure 13).

Figure 10. Hotspot 3 - an island of mixed-wood trees with peat smouldering beneath.

Figure 11. North side of the island of trees. Majority of the trees consumed by the wildfire.

Figure 12. South side of the island of trees, looking east. Few trees left unburned.

Figure 13. Smouldering peat beneath the mixed-wood stand causing damage to tree roots.

Execution of assignment

Day 1

Key tasks completed:

- Equipment transport to site
- Equipment setup – 4-inch system to target Hotspot 1
- Water cannon operations - 4-inch system on Hotspot 1

Equipment transport

Two semi-trucks with flat-beds were used exclusively to transport the equipment necessary for the 4-inch systems. Immediately upon unloading the equipment, the semi-trucks departed from site. In addition to the two-semi-trucks, one pickup truck with a flat-bed trailer was also used to transport equipment.

The list of equipment transported to site on Day 1 is presented in Table 1.

Table 1. Equipment transported to site on Day 1.

Equipment	Quantity	Figure No.
Skid steers	2	14
Pumps (Pioneer PP86C17, 335 HP)	2	15
Suction hose, 6-inch	4	16
Hose, 4-inch – spooled, 0.5 km length	5	17
Hose, 4-inch – boxed, 0.5 km length	1	-
Manifolds, 4-inch	20	-
Water cannons with various nozzle size	16	18
Compressor	1	19
UTV	1	-

A total of 6 pickup trucks were used to transport 6 personnel to site and were parked at the stage area for the duration of operations.

Figure 14. Two skid steers were used to move majority of the equipment at site.

Figure 15. Two 335 HP pumps were used for water delivery operations. Only one pump was used on Day 1.

Figure 16. Suction hose being transported to the water source.

Figure 17. Spools on 4-inch hose, each 0.5 km in length. Total length of 2.5 km.

Figure 18. Water cannons used in water delivery operations.

Figure 19. Compressor being off-loaded from the flat-bed. The compressor was not used since temperatures did not fall below~~fore~~ 0 degrees Celsius.

Equipment setup – 4-inch systems to target Hotspot 1

After unloading the equipment that was transported to site, the 4-inch system equipment setup commenced. The key activities involved transportation of pumps to the water source and 4-inch hose lay from the water source to Hotspot 1. During the setup process, two main challenges were faced by the crew during the equipment setup process.

Challenges during equipment setup

1. The terrain leading up to the water source was a cleared path whose surface comprised of muskeg – wet, soft ground (Figures 20 and 21). This posed a challenge for the transportation and placement of the pumps. In addition, the use of skid steers to transport the required equipment to the water source became progressively more challenging due to the tracks impacting the ground (Figure 22). The solution used to manage soft ground was the use of rig-mats that had to be externally ordered for this task (Figure 23). A total of 60 rig mats were ordered and used on the soft ground to provide a stable surface to traverse on (Figure 24).

Figure 20. Cleared path leading to water source. Challenging terrain to move heavy machinery.

Figure 21. Area immediately surrounding the water source was wet, soft ground.

Figure 22. Skid steers moving up and down the cleared path caused the surface to progressively get worse for equipment transport.

Figure 23. Externally procured rig mats were used to manage wet, soft ground.

Figure 24. A total of 60 rig mats was used to ensure secure passage from the peat farm to the water source for equipment transport.

2. The peat farm where the hotspots were located in had several drainage channels or trenches, ranging from 1.5-3 meters wide (Figure 25). This posed challenges for machinery to move around. To address this, more rig mats were used as a bridge across these drainage channels (Figure 26). Due to the frequency of these drainage channels in the working area, several of these bridges had to be made.

Figure 25. Instance of drainage channel in the peat farm that limited the movement of heavy machinery.

Figure 26. Rig mats used as a temporary bridge across drainage channels.

Additional equipment used

The following additional equipment was used to expedite equipment setup:

1. **Excavator** – An excavator contracted by Parkland County was re-assigned to work with the high-volume water delivery systems. While equipment could still have been setup without

the excavator, it was deemed beneficial both by the Deputy Operations Chief as well as the vendor that its use could expedite equipment setup as well as assist in operations. Figure 27 presents once instance where the excavator was used to build a dirt bridge for the vendor's skid steers to traverse over a drainage channel. Another instance of the excavator assisting in 4-inch hose lay is presented in Figure 28.

Figure 27. A Parkland County contracted excavator was used to expedite equipment setup. In this instance, the excavator was used to build a dirt bridge.

Figure 28. An instance of the excavator assisting in deploying the 4-inch hose around Hotspot 1.

2. **Rig mats** – After assessing the terrain, the vendor deemed that rig mats were required to be setup in the path leading up to the water source. Rig mats were not a part of the 4-inch system equipment transported to site. Therefore, rig mats had to be sourced from an external vendor. This procurement resulted in slowing down the equipment setup process. However, to minimize terrain damage and to protect assets (e.g., pumps), the use of rig mats was deemed necessary. A total of 60 rig mats were procured across two deliveries from external vendors.

Time for equipment setup

The total time for setting up the 4-inch system was 6.5 hours. This included the following:

- Set up of two pumps
- Two 500-meter main lines of 4-inch hose
- An additional 500-meter 4-inch hose wherein water cannons were connected
- 8 water cannons in total, 4 stemmed from each main line
- Procurement of 60 rig mats across two deliveries from external vendors
- Placement of 60 rig mats

It is likely that the time required for setting up may have been quicker if the rig mats were not externally procured.

Water cannon operations – 4-inch system on Hotspot 1

On Day 1, water cannons were run continuously for a period of 4.5 hours, until 9 PM. Nighttime operations were not permitted by the Deputy Operations Chief and therefore, the water cannons had to be shut down at the end of the day.

A total of 8 water cannons were used on Hotspot 1. 4 cannons stemmed off from each 4-inch main line in a dead-end configuration to cover the perimeter of the hotspot with overlapping side-to-side coverage. The locations of the water cannons occasionally had to be adjusted to ensure the central areas of the hotspot received water. Figure 29 shows the water cannons being operationally active. The pressure at source was 115 psi while the pressure at the water cannons was 80 psi.

Hotspot 1 was found to be burning deep beneath the surface. To ensure water cannon operations were effectively putting out the hotspot, the excavator worked actively in conjunction with the water cannons. The excavator was used to dig 4-5 feet beneath the surface, overturning soil to expose burning organic matter beneath the surface. An instance of this is presented in Figure 30.

Figure 29. 4-inch systems with water cannons working on Hotspot 1.

Figure 30. The excavator working in conjunction with the water cannons to put out Hotspot 1.

Day 2

Key tasks completed:

- 4-inch system water cannon operations on Hotspot 1
- 6-inch system transport and setup
- 6- and 4-inch combination system setup for Hotspot 3
- 6- and 4-inch combination system water cannon operations for Hotspot 3
- 4-inch system setup for Hotspot 2
- 4-inch system water cannon operations for Hotspot 2

With majority of the equipment setup completed on Day 1, Day 2 mostly involved continuing action on Hotspot 1 as well as moving and/or setting up new hose lays to target Hotspots 2 and 3. Several tasks occurred simultaneously with varying resources distributed. This made tracking the time and resources taken for a single task challenging to document.

4-inch system water cannon operations on Hotspot 1

The 4-inch system setup the previous day resumed operations on Day 2 (Figure 31). Water cannons were run for 5 hours on Day 2, resulting in a total run time of 9.5 hours for the 4-inch system operations on Hotspot 1. To ensure the hotspot was effectively put out, the excavator helped overturn soil, checking for deeper burning organic matter. Figure 32 presents the aftermath of 9.5 hours of water cannon operations on Hotspot 1. At the end of the 5-hour run time on Day 2, one main line of the 4-inch system was routed to hotspot 2.

Figure 31. Water cannon operations on Hotspot 1 continued on Day 2.

Figure 32. Hotspot 1 after 9.5 hours of water cannon activity.

6-inch system transport and setup

Equipment for a 6-inch system arrived on the morning of Day 2 after it was deemed advantageous to have greater volume throughput following operations on Day 1 with exclusively 4-inch systems. The list of equipment brought to site on Day 2 is presented in Table 2. This equipment for the 6-inch system was setup simultaneously as the 4-inch system worked on Hotspot 1.

Table 2. Equipment transported to site on Day 2.

Equipment	Quantity	Figure No.
6-inch hose, spooled – 0.4 km	5	33
6-inch manifolds	5	34
8-inch suction hose	2	-
Knuckle boom articulating crane	1	35

The 6-inch system was intended to be used as a high-volume main line which would feed multiple 4-inch lines to target Hotspot 3 (Figure 34). The 6-inch system main line setup therefore involved:

- Adding an 8-inch suction hose to the second pump
- Laying a 400-meter 6-inch main line (Figure 33) from water source to peat farm
- Adding manifolds for reducing the 6-inch main line to 4-inch offshoots (Figure 34).
- Adding rig mats to draining channels to create bridges.

The time taken to setup exclusively the 6-inch system with the aforementioned particulars was approximately 2 hours with periods of reduced activity involved due to other pending tasks.

Figure 33. 6-inch hose being unspooled on rig mats.

Figure 34. Manifold reducing 6-inch line main line (black hose) to 4-inch off-shoots (white hose).

Figure 35. A knuckle boom articulating crane was brought to site on Day 2. It was not used in any operations.

Figure 36. 6 water cannons working on Hotspot 3.

6- and 4-inch combination system setup for Hotspot 3

With the 6-inch main line installed, the 4-inch off-shoots had to be setup to form the 6- and 4-inch combination system. Upon extinguishing Hotspot 1, equipment resources from Hotspot 1 - namely, 4-inch hose, manifolds, and water cannons were re-allocated to Hotspot 3.

Two 4-inch lines were setup to target the south side of Hotspot 3, as shown in Figure 34. One line ran along the south boundary of Hotspot 3 heading west (Figure 37), while the other line ran along the south boundary of Hotspot 3, heading east (Figure 38). The west-bound line was 250-meters long and contained 4 water cannons while the east-bound line was 120-meters long and contained 2 water cannons. The time documented for adding the 4-inch lines to create the 6- and 4-inch combination system was 4 hours. Note that this 4-hour time period included:

- Demobilization of equipment from Hotspot 1,
- Mobilization and equipment setup at Hotspot 3, and
- Resource mobilization to work on Hotspot 2.

The total time taken to setup the entire 6- and 4-inch combination setup was 6 hours. This 6-hour time period included other activities that occurred in parallel and is therefore not a definite time needed for the setup of the 6- and 4-inch combination system.

Figure 37. West-bound 4-inch line, 250-meters in length, containing 4 water cannons.

Figure 38. East-bound 4-inch line, 120-meters in length, containing 2 water cannons.

6- and 4-inch combination system water cannon operations for Hotspot 3

The 6- and 4-inch combination system water cannon operations commenced at 4:30 PM on Day 2, running at 100 psi at the source and 80 psi at the water cannons. After receiving direction and approval from the Deputy Operations Chief for nighttime operations, the water cannons continued to work on the south side of Hotspot 3 for the remainder of the day. The excavator assisted in operations on the north side of Hotspot 3 by knocking down dead trees and pulling out smouldering roots.

4-inch system setup for Hotspot 2

The 4-inch system setup for Hotspot 2 was relatively minimal. Due to the proximity of Hotspot 2 to Hotspot 1, equipment – specifically, hose and water cannons, had to be redirected from Hotspot 1 to Hotspot 2. Working off of a pre-existing 500-meter hose lay from the water source to Hotspot 1, an additional 267-meter hose lay was required (Figure 39). This hose was extracted from the setup for Hotspot 1 and used for Hotspot 2. The time taken for this re-distribution was 30 minutes and include the installation of one water cannon.

4-inch system water cannon operations for Hotspot 2

Water cannon operations on Hotspot 2 was run from 2.45 PM for the remainder of the day and continued into the next day.

Figure 39. The additional 267-meter hose lay required for Hotspot 2 being setup.

Day 3

Key tasks completed:

- Demob 4-inch system on Hotspot 2
- Continue 6- and 4-inch combination system water cannon operations for Hotspot 3

Day 3 involved only a half day of documentation. At 11 AM, the site was hit with rain that sustained for the remainder of the day. The scope of the case study was limited to the first half of Day 3 since the forecast called for precipitation for the next several days, including periods of snow.

Demob of 4-inch systems on Hotspot 2

Water cannon operations on Hotspot 2 continued overnight until the next morning. The total run-time of water cannon operations on Hotspot 2 was 18 hours. The hotspot was confirmed to be extinguished with the help of an excavator that dug 4-5 feet beneath the surface to check for deeper lying smouldering organic matter. Upon extinguishing Hotspot 2, equipment was demobilized from its location. The demobilization task included spooling of hose and removal of a water cannon and lasted approximately 30 minutes. Figure 40 shows the aftermath of Hotspot 2 after 15 hours of water cannon operations.

Continue 6- and 4-inch combination system water cannon operations for Hotspot 3

Water cannon operations on Hotspot 3 continued overnight and through the next morning, running for 19 hours as 12 PM on Day 3. The excavator assisted with checking for hotspots beneath the surface, as shown in Figure 41.

Figure 40. Hotspot 2 after 18 hours of water cannon operations.

Figure 41. The excavator checking for hotspots beneath the surface where water cannon operations occurred on Hotspot 3.

DISCUSSION

1. **Use of high-volume water delivery systems in peat fires** – The use of mass water delivery systems in peat fires was found to be advantageous when compared to traditional water delivery practices used by fire crews. Peat fires can burn deep beneath the surface. Proper penetration of water below the surface is required to ensure saturation. To cover a large area (or volume) of peat, a significant quantity of water is needed, which reflects the value proposition of high-volume water delivery systems. As a quick comparison, Hotspot 1 was worked on by crews for three days without much progress whereas the use of high-volume water delivery systems proved to be more effective after 9.5 hours of water cannon operations.

2. **Operational run-time and effectiveness of water delivery systems** – While the high-volume water delivery systems were able to put out the hotspots, their operational run-time documented in this study may not reflect their effectiveness. In this study, water delivery systems were run passively, without active inspection of hotspots until sufficient time had passed. It is likely that hotspots may have been extinguished much sooner than what the operational run-times indicate. In addition, periods of rain on Day 2 as well as continuous rain on Day 3 of the study made it challenging to document the effectiveness of high-volume water delivery systems when rain was introduced as a variable in the study.

3. **Effectiveness of water delivery systems enhanced by excavator use** – High-volume water delivery systems, in the context of peat fires, may benefit from working in collaboration with fire crews and excavators. While the delivery of large volumes of water is certainly key to putting out peat fires, a means of checking beneath the surface for deeper burning organic matter is necessary. This can be done in collaboration with fire crews or excavators. In this study, the use of an excavator played an important role in turning peat, exposing more organic matter to water, and checking for deeper lying hotspots. The effectiveness of water delivery systems in this study was positively impacted by the use of an excavator. Therefore, 'effectiveness' of water delivery systems in this report specifically refers to the impact of water delivery systems as well as the excavator on the peat fire. It is likely that stand-alone water delivery systems may have taken longer to extinguish hotspots due to smouldering matter lying deep beneath the surface requiring time for saturation.

4. **Road access** – The use of high-volume water delivery systems in the configuration supplied by the vendor involves the use of semi-trucks for equipment transport to or near the site. The availability of road access plays a role in determining the ease at which equipment can be transported near where it is required. In the instance presented in the case study, reasonable road access was available. However, in the event road access is limited, it will likely require longer setup times and longer distances for hose lays, which impact timed-based deliverables (i.e., setup time) and system configurations (i.e., larger pump and hose for longer distances), respectively.

5. **Water access** – Similar to road access, the availability of water sources in proximity of where the water is needed impacts time-based deliverables and system configurations. In the instance presented in this case study, a water source was readily available. However, in the event a water source is not in close proximity, the use of high-volume water delivery systems may not be suitable.

6. **Terrain** – In this case study, it was observed that muskeg can prove to be challenging terrain for heavy machinery. This challenge was overcome by use of externally sourced rig mats. Given the abundance of muskeg in Alberta, it may be advisable to include rig mats are part of the high-volume water delivery system being delivered to site.

7. **Selecting appropriate water delivery system sizes** – In this case study, two systems were used – a 4-inch system and a 6- and 4-inch combination system. The decision to use a 6- and 4-inch combination system with the ability to transport larger volumes of water was made only after empirically seeing the limitations of the 4-inch system in the field. Currently, different water delivery systems are described by the vendor in technical language (e.g., X system can deliver Y cubes per minute). This technical language may not be understood by wildfire operations personnel who likely do not have training in water transport operations. It is suggested that the vendor provide information in the context of wildfire operations. A suggested statement can be as follows –

   '*A 6-inch system can be run 2 km from the water source, and support 8 water cannons. These 8 water cannons can cover 2 hectares in a loop configuration and can provide 5-mm of water every hour. It takes 3 hours to set up and can run indefinitely after that.*'

   Providing wildfire operations personnel with a list of options quantified in coverage area and coverage level may be beneficial.

8. **Crew safety** – Working around high-volume water delivery systems has inherent risks that crew members are likely unfamiliar with. It may be beneficial to acknowledge and discuss safe work practices around high-volume water delivery lines, which while not necessary under high pressure, do have substantially high-volume throughput than 1.5-inch hose.

CONCLUSION

The use of high-volume water delivery systems in a peat fire in Central Alberta was successfully documented as a case study. The high-volume water delivery systems were assigned to target three hotspots burning in a peat farm. FPInnovations researchers recorded details about logistics, equipment, timing, challenges, and qualitative effectiveness of two systems – one 4-inch system and another, a 6- and 4-inch combination system.

It was found that within the context of a peat fire, high-volume water delivery systems can be an effective tool due to the large and sustained water demands required for sufficient saturation of the smouldering fuels. The efficacy of high-volume water delivery systems can be improved when collaboratively used with certain resources like fire crews and excavators. Certain environmental particulars such as road access, water source availability, and terrain can play an important role in determining the suitability of high-volume water delivery systems for specific applications. These variables will have to be determined on a case-by-case basis.

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