

# STATE-OF-PRACTICE OF WATER DELIVERY SYSTEMS (SPRINKLERS) USED IN THE WILDLAND-URBAN INTERFACE

*COMPENDIUM*

FPInnovations

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April 2019

This compendium is not restricted.

This is a compendium of reports published during the state-of-practice review of water delivery systems (sprinklers) in the wildland-urban interface (WUI). Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).

Sprinklers are used to protect structures from wildfire during wildland-urban interface (WUI) events across Canada. Traditionally, standard forestry equipment has been used in conjunction with impact sprinklers. FPInnovations is reviewing common practices and equipment used during sprinkler deployments, in Canada, to determine if they are the most appropriate for community structure protection, or if alternative approaches should be considered.

This compendium includes a literature review of the pathways to structure ignition, the results of a national survey on the use of sprinklers in Canada, a review of standards and codes specific to the WUI that relate to the use of sprinklers, the results of an equipment evaluation, a collection of WUI case studies and observations that describe actual sprinkler deployments, and a discussion on best practices and recommendations to enhance the effectiveness of sprinkler deployments.

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COMPENDIUM

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## FOREWARD

This *State-of-practice of water delivery systems (sprinklers) used in the wildland-urban interface*, is a compendium of nine individual reports that have been published independently, on the subject matter, by FPInnovations. The following reports have been incorporated into the compendium and can be found individually on the FPInnovations website at:

<http://wildfire.fpinnovations.ca/Research/SprinklerStateOfPractice/SprinklerStateOfPractice.aspx>

1. Ault, R. & Gardeski, C. (2019). *Executive Summary: State-of-practice of water delivery systems (sprinklers) used in the wildland-urban interface*. FPInnovations. Vancouver, B.C.
2. Melnik, O. & Gardeski C. (2019). *Literature Review – Pathways and mitigation of structure ignition in the wildland-urban interface*. FPInnovations. Vancouver, B.C.
3. Ault, R. (2019). *National survey on sprinkler use; a first step in determining how effective existing sprinkler equipment is and what technology gaps need to be addressed*. FPInnovations. Vancouver, B.C.
4. Ault, R. & Gardeski, C. (2019). *Sprinkler deployment key messages and best practices; as identified through interviews and observations*. FPInnovations. Vancouver, B.C.
5. Refai, R. (2019). *Evaluating commercially available pumps for use in the wildland-urban interface; Mercedes Textiles' pumps – WICK 375, WICK 100G, and the WICK SI 300-10B*. FPInnovations. Vancouver, B.C.
6. Ault, R. & Hvenegaard, S. (2019). *Case study – Kenow fire, Alberta, 2017; structure protection in Waterton Lakes National Park*. FPInnovations. Vancouver, B.C.
7. Ault, R. (2019). *Case study – Elephant Hill fire, British Columbia, 2017; low-volume, low-pressure sprinkler deployment in the community of Skeetchestn*. FPInnovations. Vancouver, B.C.
8. Ault, R. (2019). *Case study – West Babine River fire, British Columbia, 2018; private citizens supporting the protection of their own infrastructure*. FPInnovations. Vancouver, B.C.
9. Ault, R. (2019). *Case study – Tolko Mill Yard, Heffley Creek, British Columbia; high-volume, high-pressure permanent sprinkler system*. FPInnovations. Vancouver, B.C.

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# 1. INTRODUCTION

Across Canada, sprinklers are used to protect structures from wildfire during wildland-urban interface (WUI) events. This project found that Canadian Wildfire agencies deploy more sprinklers during wildfire events than any other country in the world. In Canada, sprinkler deployments have traditionally been the responsibility of wildfire agencies. Over the past few years, this responsibility has shifted in many jurisdictions to be the responsibility of the Office of the Fire Commissioner (OFC). Traditionally, standard wildfire equipment has been used in conjunction with impact sprinklers to wet fuels and structures in advance, and during the impingement, of a wildfire. Agencies are looking to determine if the standard wildfire practices and equipment used in wildfire suppression operations are the most effective for community structure protection.

FPIInnovations was contracted by the Forest Resource Improvement Association of Alberta (FRIAA) to conduct a state-of-practice of water delivery systems (sprinklers) used in the WUI. The objectives of this project included:

- a) conducting a literature review of the pathways to structure ignition and sprinkler use,
- b) development and analyzing the results of a national survey on the use of sprinklers in Canada, and conducting interviews with known contractors and other relevant agencies,
- c) reviewing standards and codes, specific to the WUI, that relate to the use of sprinklers,
- d) evaluating equipment – Mercedes Textiles wildfire pumps,
- e) developing WUI case studies and recording observations to document the findings from actual sprinkler deployments,
- f) identifying opportunities for innovation and process improvement, and
- g) identifying best practices and providing recommendations that can enhance the effectiveness of sprinkler deployments.

# 2. LITERATURE REVIEW

In order to evaluate the effectiveness of current sprinkler technologies, it is important to understand how wildfire spreads within a community and how structures are ignited. A comprehensive review was completed that included obtaining data from various data bases, reviewing related on-line articles, published studies and other forms of documentation regarding the current understanding of structure ignition and structure protection. The most comprehensive document we found on this subject was the *Review of Pathways for Building Fire Spread in the Wildland Urban Interface, Part 1: Exposure Conditions* (Caton, S., and Hakes, R., and Gorham, D. and Zhou, A., and Gollner, M. 2017), and *Part 2: Response of Components and Systems and Mitigation Strategies in the United States* (Hakes, R., and Caton, S., and Gorham, D., and Gollner, M. 2017). This document incorporates the findings from many of the individual

documents that were reviewed, and comprehensively explains the current issues related to structure protection within the WUI.

The consensus within the wildfire research community points toward windblown firebrands as the primary source of structure ignition in the WUI. The pathway of structure ignition is often described as a process where receptive fuels adjacent to a structure are ignited by firebrands. These small fires continue to consume combustible materials, grow in intensity, and eventually cause the ignition of structural materials through a combination of radiant heat transfer, or direct flame contact. This process occurs in the “Structure Ignition Zone” which is a term identified in NFPA 1144 standard (NFPA, 2018). For the purpose of this report, the Structure Ignition Zone will include the area adjacent to buildings where the management or removal of combustible materials, and the application of water through the use of sprinklers, can have a significant effect on the survival of a structure during a wildfire event.

Management or removal of combustible material from the Structure Ignition Zone is a fundamental goal of the FireSmart program in Canada and the Firewise program in the United States. The FireSmart program defines the area up to 1.5 m from the structure as Priority Zone 1a (FireSmart Canada, 2018) and recommends that this zone contain only non-combustible materials to interfere with the pathway of structure ignition.

Of all the documents and international standards and codes FPIInnovations reviewed, only 4 documents and 2 standards mentioned the use of sprinklers for structure protection. Not one of these documents made direct linkages between the Structure Ignition Zone and effective sprinkler use. The most comprehensive document reviewed was a report from the Ham Lake fire in Minnesota, USA. The report provided useful information on permanent sprinkler systems that were used to protect cottages and residences in Minnesota lake country. One Australian study described a unique misting system that was attached to structures. In Canada, FPIInnovations has studied the use of sprinklers for structure protection during experimental crown fires in the Northwest Territories (Walkinshaw and Ault, 2008 and 2009).

The complete literature review can be found in Appendix A: *Literature Review – Pathways and mitigation of structure ignition in the wildland-urban interface*.

### 3. NATIONAL SURVEY ON SPRINKLER USE

Determining what equipment is currently being used during sprinkler deployments is an important first step to determining how effective current equipment is and what technology gaps need to be addressed. FPIInnovations developed a survey to help identify the equipment that is currently used for structure protection in Canada. The survey was distributed to the 13 wildfire agencies (including Parks Canada and all provinces and territories except Nunavut) that are members with the Canadian Interagency Forest Fire Centre (CIFFC). All agencies indicated that they are using or have used sprinklers as a primary tool for structure protection. All

provinces have sprinkler kits, and many are adopting sprinkler trailers as a way of organizing for structure protection assignments.

Not surprising, wildfire agencies favour forestry-type pumps and hose, which are the mainstay of the equipment complement. Common equipment includes Waterax Mark III and BB4 pumps, portable water tanks, 38-mm (1.5-in.) and 16-mm (5/8-in.) hose, and impact sprinklers. All survey respondents who have used sprinklers for structure protection found them to be a valuable tool.

The responsibility for structure protection varies by agency. Generally, wildfire agencies are responsible for deploying sprinklers for structure protection within and outside of the WUI. In British Columbia, Alberta, and Manitoba, the OFC has the leading role for structure protection; however, wildfire agencies continue to support sprinkler deployments.

The survey was not distributed to the OFC. Through discussions with the OFC, the Alberta Emergency Management Agency (AEMA), and the Alberta Fire Chiefs Association (AFCA), it became clear that municipal fire departments are purchasing sprinkler equipment and building structure protection trailer units similar to those used by wildfire agencies, which may not be ideally suited for structure protection efforts in the WUI.

Further discussions with the OFC revealed that British Columbia's (B.C.) OFC is expected to have six Type 1 trailers in place for the 2019 fire season, along with a Type 2 WASP urban trailer, and four FireBozz sprinkler kits. The development of B.C. inter-agency operational procedures and reimbursement rates for structure protection equipment (B.C. Interagency Working Group, 2018) has encouraged municipalities and wildfire contractors to develop structure protection trailer units, built to OFC standards. For the 2018 fire season, the B.C. OFC had standing offers with 15 contractors or municipalities for Type 2 trailers. An increase in the number of structure protection trailers in any jurisdiction increases the potential for resource sharing and interagency cooperation.

In addition, BC Wildfire is beginning to evaluate the benefits and costs of mass water delivery systems.

The results of the national survey can be found in Appendix B: *National survey on sprinkler use; a first step in determining how effective existing sprinkler equipment is and what technology gaps need to be addressed.*

## 4. INTERVIEWS AND OBSERVATIONS

In order to better understand the extent of equipment usage and some of the challenges associated with sprinkler deployments, FPInnovations interviewed fire managers after wildfire events, during active wildfires or WUI deployments, and during deployment exercises. In addition, we reached out to various Alberta water delivery contractors to understand some of



the larger equipment being used in the WUI. These interviews contributed to the conclusions and key messages in this report.

#### **4.1 Nordegg, Alberta – Wildland-urban interface fire 2013**

In May 2013, the hamlet of Nordegg was evacuated due to a wildfire that threatened the community. Alberta Agriculture and Forestry (AAF) and the Clearwater Regional Fire and Rescue Services (CRFRS) conducted several desktop emergency planning exercises in preparation for this type of event. As a result of these efforts, individual agencies were clear about their responsibilities for community protection, and resources were able to be deployed efficiently. The CRFRS used AAF sprinkler trailers and a contract water delivery service provider to deploy sprinklers to protect residential structures, community buildings, and the historic coal mine site. Effective communications between the two agencies and pre-planning significantly contributed to a successful deployment, which included the installation of 76 sprinklers that were supplied using a combination of high-volume and standard forestry equipment (20-mm to 100-mm hoses). Water sources included community hydrants, above ground community water tanks, water supplied using Mark III and BB4 forestry pumps, and water stored in portable water bladders.

**Key message:** The annual emergency planning exercises that were conducted in preparation for a wildfire event in Clearwater County contributed to the rapid deployment and success of this operation.

#### **4.2 Tallcree First Nation, Alberta – deployment 2015**

The structure protection specialist for the 2015 deployment at Tallcree First Nation provided notes and, in an interview, explained the assessment process used to determine which structures needed sprinklers and how water supply lines and pumps were organized during the deployment. The use of a 38-mm (1.5-in.) main line may not have been sufficient to supply adequate volume to protect all the structures in the community. The fire did not impinge the community. After the deployment, a formal community protection plan was developed based on the learnings from the deployment and called for the use of larger 65-mm (2.5-in.) supply lines to improve the water volume supply in the event of a future deployment.

**Key message:** After-action reviews of community protection plans are important for identifying opportunities for improvement.

#### **4.3 Robb, Alberta - deployment 2018**

In July 2018, the community of Robb, was placed under an evacuation alert, but sprinklers were never deployed. Structure protection crews on site conducted a pre-deployment assessment. A sprinkler deployment plan was developed several years earlier, and a deployment exercise was never conducted to validate the effectiveness of the plan. During the assessment, it was determined that it would be advantageous to stage water-holding tanks around the community to supply enough volume to support the perimeter sprinklers due to the topographical differences from the main water supply (the creek) to the top of town. The assessment also

revealed the advantages of using a 65-mm (2.5-in.) supply inch line rather than a 38-mm (1.5-in.) supply line to allow for more volume flow.

**Key message:** Plans need to be regularly updated to reflect current technologies and best practices. Plans benefit from test deployments.

#### **4.4 Smithers Landing, British Columbia – deployment 2018**

In August 2018, the lakeside unincorporated community of Smithers Landing was threatened by wildfire. Several residents used personal pumps and sprinklers to prepare their homes in the event of an evacuation. These simple private sprinkler systems relied on small pumps, garden hoses, and a variety of different sprinklers. Two of the cabins used the Bear Cat FP2126 fire pump kits. Some of these systems were in place and operational before wildfire and Structure Protection crews arrived. With an ample water supply, and the application of FireSmart guidelines, these structures were well protected.

**Key message:** The actions taken by residents to protect their personal property reduced the strain on limited agency resources.

#### **4.5 Jasper National Park, Alberta – deployment plan review 2018**

FPIInnovations met with the Jasper Fire Department to discuss their Community Wildfire Protection Plan, which called for the use of perimeter sprinklers and structural apparatus (fire engines) within the interior of the community. A number of years ago, the town changed its source of community water from the Athabasca River to a well system located above town. Based on concerns regarding available volume and pressure from the well system, the fire department recognized that it could still tap into the old infrastructure and use water from the Athabasca River to boost the system's volume and pressure. Communities all have unique challenges that require different solutions. In this case, re-assessing the deployment plan identified a need for more volume, and a solution was developed in advance of an actual wildfire event.

**Key message:** Each community has different water supply challenges that require unique solutions. It is critical that those challenges are identified and addressed in sprinkler deployment plans.

#### **4.6 Town of Canmore, Alberta – deployment exercise 2018**

In September 2018, the town of Canmore conducted a sprinkler deployment exercise to validate the assumptions in the deployment plan. The exercise allowed the municipal fire department to set up planned perimeter lines to get a sense of the logistics behind the deployment and to ensure that any challenges could be addressed before an actual event. The exercise identified equipment and logistic challenges associated with using the municipal hydrants to provide enough water to supply the system, using a 38-mm (1.5-in.) supply line. Re-deployment of a 68-mm (2.5-in.) supply line provided the necessary volume for the system.

**Key message:** Deployment exercises give communities an opportunity to validate and improve their community protection plan.

#### 4.7 Contractor interviews

FPIInnovations was able to interview six of the ten Alberta contract companies that AAF identified as having equipment that could be used for structure protection. These companies do not necessarily work on wildfires every summer. Only two of the companies are focused on providing specific wildfire services. The availability of high-volume water pumps was the focus of the interviews. Four contractors can supply high-volume pumps with capacities exceeding 750 gallons per minute (gpm) that can accommodate 100-mm (4-in.) water supply lines. One contractor commented that Alberta oil field water supply service providers could supply 70-75 water delivery systems that are capable of delivering between 750 and 1800 gpm.

Finally, FPIInnovations interviewed a duty officer with Wildfire Defence Systems in Bozeman, Montana. Wildfire Defence Systems is a contractor that supplies structure protection crews for Chubb insurance in 21 states. They have the largest private fleet of wildfire engines in the United States and a large inventory of wildfire suppression and structure protection equipment. Wildfire Defence Systems indicated that using sprinklers for structure protection in Montana is common and that deployment is often completed by private contractors. Wildfire Defence Systems uses water enhancing gel products with a gel induction system for ground based applications.

**Key message:** A small number of private companies are capable of providing specialized water delivery equipment. Many private companies that have the capacity to provide these services do not have the opportunity to remain current with structure protection tactics; thus they are able to reliably provide this service to the agencies.

A comprehensive list of key messages and best practices can be found in Appendix C: *Sprinkler deployment key messages and best practices; as identified through interviews and observations.*

## 5. STANDARDS AND CODES

FPIInnovations identified and reviewed the following international standards and codes related to the Wildland-urban interface, to determine if there were any standards specific to sprinkler use that would be beneficial to Canadian agencies. The following is a list of the more relevant documents:

- International Wildland-Urban Interface Code – The objective of this code is to establish minimum regulations for safeguarding life and property from the fire intrusion due to wildland fire exposures and fire exposures from adjacent structures. The code is to be adopted and used supplemental to the adopted building and fire codes for a jurisdiction.

- California Fire Code (Chapter 49: Requirements for Wildland-Urban Interface Fire Areas (California) – This code provides minimum standards for increasing the ability of a building to resist the intrusion of flame or burning firebrands projected by a vegetation fire, and it contributes to a systematic reduction in conflagration losses through the use of performance and prescriptive requirements.
- Australia AS 5414 – 2012 Bushfire Water Spray Systems – This is a standard for the installation of permanent sprinkler systems on homes. The standard calls for a minimum reservoir of 22 000 L (4830 imperial gallons) and a 30-minute to 2-hour continuous run time for the pump.
- Canada, National Research Council – Wildland Urban Interface Fires: regulations and guidelines - A national wildland urban interface guide for Canada was under development in May 2018.

The following National Fire Protection Association (NFPA) standards guide operations in the WUI:

- NFPA 1141: Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas
- NFPA 1142: Standard on Water Supplies for Suburban and Rural Fire Fighting
- NFPA 1143: Standard for Wildland Fire Management
- NFPA 1144: Standard for Reducing Structure Ignition Hazards from Wildland Fire

Most available standards focus on mitigation practices in the WUI. No standards were identified that were applicable to sprinkler deployments from a Canadian perspective. If standards for sprinkler use in the WUI are to be developed a logical, structured approach is required that needs to be supported by science.

## 6. EQUIPMENT EVALUATION AND INNOVATION

The state-of-practice review indicated that there is no national approach to developing or evaluating wildfire equipment or techniques for the WUI in Canada. The United States Forest Service Technology and Development Centers in Missoula and San Dimas evaluate fire chemicals and some fireline equipment, including pumps and wildland engines.

FPIInnovations believes that the lack of a process or organization to help foster and evaluate products, in Canada, limits the development and implementation of new technologies and information sharing between agencies. FPIInnovations examined the feasibility of conducting these evaluations on wildfire pumps.

### 6.1 Equipment evaluation

There are several commercially available pumps for use in wildfire suppression and community protection operations in the WUI. The Waterax Mark-3 pump is the most widely used pump for wildfire operations in Canada. Other pumps are commercially available to wildfire and municipal

firefighting agencies. Knowledge of the strengths and weaknesses of different pumps is critical to make informed investment and tactical decisions.

A standardized testing methodology was developed to evaluate five key metrics of a pump used to supply water to sprinklers: pressure, flow rate, sprinkler casting distance, fuel consumption and number of sprinklers supported without significant loss of head pressure. This testing method can be used to validate pump manufacturers' claims. Results can be used to run head-to-head comparisons between different manufacturers. Three portable fire pumps were tested using both a closed-loop and a dead-headed system: Mercedes Textiles' WICK 375 (comparable to the Mark-3), WICK 100G (comparable to the Striker), and WICK Si 300-10B (similar to the BB4). The performance was documented and will be the subject of an independent report that will be published in 2019. Figure 1 and 2 show the difference in casting distance and number of sprinklers a single WICK 375 pump can support using both a closed-loop (equal volume) and a dead-headed (declining volume) system.

In the closed-loop system, each time an additional sprinkler is opened the casting distance is affected equally throughout the system, as this system is intended to equalize volume and pressure throughout. Once all 15 sprinklers were open, the casting distance of each sprinkler in the system was 8.6 m.

Comparatively speaking, only five out of the 15 sprinklers were able to achieve a casting distance of at least 8.6 m in the dead-headed system. This system does not equalize volume or pressure, and exhibits a significant reduction in casting distance due to the lower volume and pressure available to sprinklers further away from the pump.

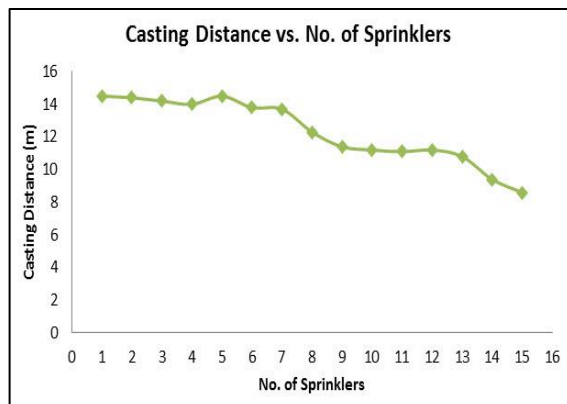


Figure 1. Casting distance vs. number of sprinklers in a closed-loop system

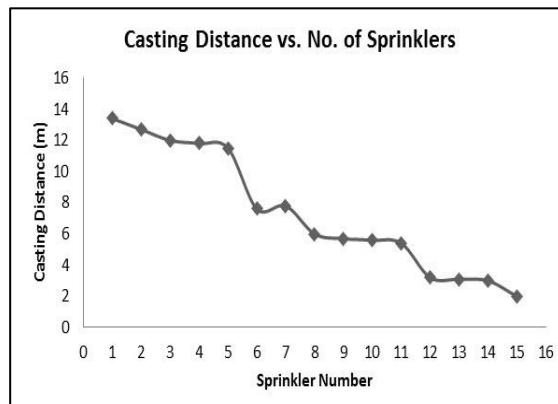


Figure 2. Casting distance vs. number of sprinklers in a dead-headed system

Evaluations of this kind provide data that practitioners can use to help make informed decisions based on defined metrics that can include but are not limited to; desired casting distances, available volume, and system pressure.

Future evaluations can be designed to examine any key metrics that are important to an agency. Equipment evaluations are not limited to pumps and can be applied to different sprinklers and other wildfire- or WUI-specific equipment.

The comprehensive equipment evaluation report can be found in Appendix D: *Evaluating commercially available pumps for use in the wildland-urban interface; Mercedes Textiles' pumps – WICK 375, WICK 100G, and the WICK SI 300-10B.*

## **6.2 Innovations in technology or approach**

Through the interviews with water delivery services providers, it became clear that entrepreneurs want to help solve the WUI problem. Challenges in the WUI are evolving. Science needs to support agencies in identifying emerging WUI needs and guide relevant solutions. Agencies, research organizations, and innovators can collaborate to provide equipment, technology, or service solutions.

In the case of structure protection and sprinklers, there are other industries and communities of practice such as irrigation systems manufacturers and professional engineers that could bring a different perspective to wildfire or WUI issues. A path to a broader level of engagement and collaboration is needed to solve WUI challenges.

## **6.3 An example of an innovative approach**

FPIInnovations was asked to observe the demonstration of a high-volume, high-pressure system that used up to 254-mm (10-in.) industrial hose to push water vertically to an irrigation sprinkler head approximately 15 m (50 ft.) above the ground in order to apply water over a mature forest. This innovative approach to water delivery was intended to be used in a wildfire situation. Several logistical challenges were identified that would need to be refined before this system could be used in a wildfire environment, including the deployment time, the use of heavy equipment in operations with poor access, and the environmental impact of drawing huge quantities of water that the system requires. Based on this feedback, the innovator is re-thinking the deployment logistics and size of the system, along with the intended use. This type of high-volume, high-pressure system could have applications for permanent infrastructure protection or deployment in highly accessible areas where high volumes of water or large casting distances are required. However, as the system existed at the time of observation, it would be of limited use in remote wildfire operations.

# **7. CASE STUDY SUMMARIES**

Little documented evidence was found regarding the conditions that make sprinklers effective based on observed fire behaviour, suppression actions taken, or other strategies and tactics. This lack of information makes it difficult to improve or develop more effective tools to enhance community protection efforts. There are only a few published case studies related to structure protection in North America. Five excellent examples were identified from the United States: four written by the National Institute of Standards and Technology (NIST) and one by

Minnesota's Department of Natural Resources. One of the five case studies discusses an Australian concept implemented in the US. Two of the five case studies relate to sprinklers and four of the five case studies relate to structure ignition. The differences in fuel types encountered in these case studies, limited their relevance from a Canadian fuels perspective.

Based on the limited relevant case studies available, FPInnovations examined four western Canadian WUI events and will publish four case studies that examine recent WUI incidents in Alberta and British Columbia, and document examples of successful sprinkler use. Three of the case studies relate to wildfire events, and one is an example of a permanent water delivery system used to protect industrial infrastructure. Building a case study after an event requires significant collaboration with people from the Incident's Management Team, in order to re-create and understand the events that contributed to successful sprinkler deployments or that resulted in structure loss. Gathering this information during a WUI event provides critical data collection and real-time observations that is not available after the event. Real-time data collection provides better insights and stronger conclusions to support future deployments and enhance protection efforts.

The case study events are summarized below.

### **7.1 Kenow fire – Alberta, 2017**

The community of Waterton experienced a major wildfire in September 2017. Structure protection initiatives involving wildfire and municipal crews protected more than 400 structures in Waterton Lakes National Park. The structure protection assignments included protecting remote back-country structures and the community itself. Strategies and tactics differed between the two assignments. Wildfire equipment was used in the back-country and along the WUI perimeter. Sprinkler lines were supported by volume pumps and 100-mm (4-in.) supply lines. Structure protection resources within the townsite included a combination of structural apparatus (fire engines) and sprinklers for specific values. Implementing the structure protection plan that was in place took eight days. Members of the Values Protection Branch said that the high-volume pumps were essential in providing an adequate water supply for the Waterton townsite structure protection efforts.

**Key message:** Complex WUI events require the deployment of a variety of different systems. Pre-planning and training are critical, and deployment takes time.

The comprehensive case study can be found in Appendix E: *Case study – Kenow fire, Alberta, 2017; structure protection in Waterton Lakes National Park.*

### **7.2 Elephant Hill fire – British Columbia, 2017**

In August 2017, the Elephant Hill fire threatened the First Nation community of Skeetchestn. At the time of deployment, structure protection resources anticipated imminent fire impingement of the 300 person community. The OFC, using 20 structural and 3 wildfire firefighters, deployed WASP low-volume, low-pressure sprinklers on approximately 105 structures in 4.5 hours. The

WASP sprinklers were connected to 38-mm (1.5-in.) hose fed by community hydrants, or to the structures hose bibb. This was the first deployment where WASP technology was used as the primary sprinkler for structure protection. Ultimately, the fire did not reach the community. The deployment of low-volume (2.5-5.0 gpm) sprinklers, operating at less than 50 psi, can be important in communities that have deployment plans that call for the use of community hydrants as a primary water source, or in situations where water conservation is important.

**Key message:** Low-volume, low-pressure sprinklers are an effective tool that can be rapidly deployed and connected directly to a community water supply.

The comprehensive case study can be found in Appendix F: *Case study – Elephant Hill fire, British Columbia, 2017; low-volume, low-pressure sprinkler deployment in the community of Skeetchestn.*

### **7.3 West Babine River fire – British Columbia, 2018**

In August 2018, the West Babine River fire was within 2 km of a steelhead fishing lodge located along the Babine River. The lodge manager purchased Honda pressure pumps and sprinklers to protect the main lodge, cabins, and out buildings. The OFC developed a sprinkler plan, and the BC Wildfire Service (BCWS) provided assistance to the lodge owner during sprinkler set up. The lodge manager was evacuated once the sprinkler system was operational, and the BCWS crews committed to activating the pumps if the wildfire threatened the lodge. When residents take responsibility for structure protection on their private property by implementing FireSmart guidelines and pre-position pumps, hose, and sprinklers ahead of time, it not only increases the probability that their property will survive a wildfire but reduces the pressure on the limited number of firefighters involved in an incident.

**Key message:** Private citizens can be empowered and responsible for deploying their own sprinkler system. This takes pressure off limited agency resources. Tools to help build citizen's capacity in advance of a WUI event can be developed.

The comprehensive case study can be found in Appendix G: *Case study – West Babine River fire, British Columbia, 2018; private citizens supporting the protection of their own infrastructure.*

### **7.4 Tolko mill yard – Heffley Creek, British Columbia**

Tolko Forest Products has installed a permanent sprinkler system to help maintain wood quality at the Heffley Creek sawmill. The system also provides fire protection for the wood storage yard. Eighteen Big Gunn sprinklers connected to a 100-mm (4-in.) supply line are used to automatically wet the log yard based on predefined conditions. The sprinkler line is 2300 ft. long and the sprinkler radius is 120 ft. This type of system may be suitable for various industrial users or communities that require a permanent perimeter line.

**Key message:** This is an example of a permanent high-volume, high-pressure systems used for critical infrastructure protection.



The comprehensive case study can be found in Appendix H: *Case study – Tolko Mill Yard, Heffley Creek, British Columbia; high-volume, high-pressure permanent sprinkler system.*

## 8. CONCLUSIONS AND KEY MESSAGES

The literature suggests that the most common pathway to structure ignition is where receptive fuels adjacent to a structure are ignited by firebrands. These small fires continue to consume combustible materials, grow in intensity, and eventually cause the ignition of structural materials.

FPIInnovations believes that the deployment of sprinklers to wet combustible fuels in the structure ignition zone, and the development of sprinklers designed specifically for use in Priority Zone 1a (0-1.5 m from a structure), can have a significant effect and improve the outcomes in the WUI.

The spectrum of WUI structure protection efforts in Canada is wide and ranges from the protection of lake-side cottages to cities imbedded in the boreal forest. We tend to use the same sprinkler deployment strategies under very different scenarios therefore; our efforts may not be as effective as they could be if the strategies were adjusted across this spectrum.

Depending on the time available for deployment, and on the fuel characteristics, fire behavior, and available water supply, different sprinkler system designs could be required for successful structure protection. Protecting structures in lake country with an ample water supply is much different from protecting structures in the WUI in a community such as Canmore or Whitecourt, with a limited water supply. The use of high-volume, high-pressure systems may be required for perimeter lines adjacent to standing timber to effectively reduce radiant heat transfer and direct flame contact with a structure. Conversely, low-volume, low-pressure systems may be effective at applying an appropriate amount of water to prevent firebrands from igniting fine fuels in the Structure Ignition Zone. However the current practice in Canada is to use the same wildfire equipment for almost every situation.

The evidence is clear: sprinklers can be effective in protecting structures from wildfire, and the current configuration of wildfire equipment has been effective, especially in areas where there is ample water supply and the number of structures to protect is limited. However, the development of equipment and technology specific to the WUI, in areas where water is limited or the number of structures is considerable could provide firefighters with an enhanced set of tools and deployment options.

### 8.1 Conclusions

Based on the current equipment and technology available, agencies are doing an excellent job of protecting seasonal cottages and lakeside communities. Although the reporting of results of structure protection actions tends to be anecdotal with very few published documents or after-

action reviews, fire managers across the country seem to agree that sprinklers are an effective tool for structure protection.

Agencies are also doing a good job of protecting rural residential structures when adequate water is available. If limited water is available or numerous structures exist in remote settings, the task becomes logistically more difficult. Rural residential deployments in areas with limited water supply tend to be labour-intensive and can create potential firefighter safety issues in terms of egress and available survival zones. For remote or isolated structures, the use of gels, foams, and retardants is an option that needs to be further developed to provide clear benefits to firefighters and agencies.

Smaller communities, such as Nordegg and Tallcree First Nation, on the edge of the forest or grasslands can have a heightened fire risk. These communities are more difficult to protect because potential head fire intensity resulting from wind-driven forest fires results in longer spotting distances and an increase in radiant and convective heating in close proximity to residential structures. There is potential for high intensity ignition when structures are located less than 30 m from standing timber. In these cases, communities can benefit from the use of high-volume, high-pressure systems that can move greater volumes of water than traditional forestry equipment.

Protecting a community with 200–400 structures becomes a major logistical challenge. In the case of the Kenow fire, eight days were required to prepare for the wildfire event, even when the community had an existing plan. In Alberta, existing structure protection equipment, adequate for protecting larger communities like Banff and Canmore, is likely not available on short notice. Using wildfire equipment during large-scale WUI events and outfitting every residence with a sprinkler system is not practical and it is likely not necessary if more WUI-specific equipment can be developed. The development of rapid deploy or permanent sprinkler systems capable of wetting the first 100 m from the WUI perimeter could help resolve some of these logistical challenges.

Communities that are supported by forest fuel treatments may benefit from the addition of a permanent sprinkler system, similar to the one installed by Tolko. Fuel treatments reinforced with high-volume, high-pressure sprinklers may enable a “stay and defend” strategy for structure protection crews. Permanent high-volume, high-pressure sprinkler systems are also an option for protecting industrial facilities and other critical values at risk outside the WUI. The use of permanent sprinkler lines will be especially valuable in the early spring when wind-driven fires can occur simultaneously at multiple locations, which stretches response resource availability.

As demonstrated in the Skeetchestn case study, the use of community water supplied to a rapidly deployed low-volume, low-pressure sprinkler system is an option that is currently available. The WASP sprinkler is available to residents through retailers such as Canadian Tire, and it provides a casting pattern that is similar (different distance) to that of other impact

sprinklers. The benefits of the low-volume, low-pressure sprinklers need to be further explored to determine if current designs and installation practices provide adequate coverage for Priority Zone 1a.

In communities where water reservoir capacity is limited or unreliable, fire managers will be reluctant to support any external use of community water for fear of having insufficient water when it is needed for conventional structural fire containment. In all cases, structure protection becomes a water supply and water management issue. Water management technologies that control water flow and can be remotely controlled are already available. However, these technologies have not yet been well adapted for use in the WUI. These technologies can help ensure that adequate water is delivered while conserving the available supply. Ensuring that enough water is available needs to be considered during the residential planning phase and should be considered as an infrastructure upgrade for existing communities.

Finally, the case studies, observations and interviews showcase the benefits of having a wildfire structure protection and sprinkler deployment plan for forested communities. The required water supply should be determined by reverse engineering the system, starting with the number and size of sprinklers that will be deployed. An assessment of the water needed, compared to the community water available will dictate the need to leverage nearby non-community water sources such as creeks or lakes, or the need to bring in portable water or install additional permanent water storage tanks. Sprinkler deployment plans need to be validated through training and deployment exercises to ensure that they will be effective prior to a wildfire event.

## **8.2 Key messages**

1. Sprinkler deployment plans need to be well aligned with existing FireSmart guidelines and fuel management treatments. Deployment plans should be developed using a decision tree approach. A standardized sprinkler plan template and support tools that can help practitioners design appropriate deployment plans that address the water supply challenges, should be developed.
2. Reliable water supply and delivery is essential for sprinklers to be effective. The required water supply should be determined by reverse engineering the system, starting with the number and size of sprinklers that will be deployed.
3. Wildfire equipment is commonly used in the WUI, although there is very little science to support equipment choices. In most cases, a “one size fits all” approach is being applied by structure protection specialists. New equipment that can support WUI protection efforts is emerging. This equipment should be evaluated so that agencies can make informed purchase, strategic, and tactical decisions. In addition, knowledge exchange between agencies needs to be enhanced to facilitate information sharing on what is effective and what is not. The following are some opportunities for enhancing the use of wildfire equipment within the WUI, as extracted from the case studies, observations, and interviews:
  - Classify commercially available pumps based on the number of sprinklers that they can support.

- Improve the frequency of use of relay tanks to support sprinkler deployments.
- Stock a variety of sprinklers (low, medium, and high-flow) in each trailer and ensure resources know how and where to effectively deploy each type.
- Stock 30 m (100 ft.) and 15 m (50 ft.) hose lengths to accommodate sprinklers with shorter casting distances.
- Evaluate the implementation of a version of the Ontario quick deploy sprinkler attachment.

Opportunities for innovation include:

- a. working with manufacturers to reduce friction loss from water thieves, through enhanced equipment design
  - b. developing compact, lightweight, easy-to-transport relay tanks
  - c. designing an affordable quick-deploy sprinkler package for residents that includes a pump, sprinkler, and a portable tank. Newly designed systems should incorporate automated and remote water management technologies
4. Community hydrants and reservoirs need to be assessed to determine the extent to which they can support sprinkler deployments. In communities where the water supply is limited, the use of low-volume, low-pressure sprinklers should be considered to conserve water.

Currently, the WASP system is the only low-volume, low-pressure system that is commercially available. Innovation opportunities to make low-volume, low-pressure systems more relevant in the WUI are thought to include:

- development and testing a ground-based, ultra-low-volume, low-pressure, resident-installed system that can be used in conjunction with a portable pump, a well pump, or be installed on a structure's hose bibb. Design criteria for such a systems should include:
    - a. sprinklers that operate at less than 25 psi and use less than 3 gpm
    - b. quick deployment by the resident (less than 30 minutes per system)
    - c. water management features such as automation, remote operation, and watering time control
    - d. affordability
5. High-volume, high-pressure systems are becoming increasingly common. The effectiveness and efficiency of these systems is not well understood by agencies or the system manufacturers. The benefits of these systems as portable or permanent water delivery systems for protecting communities or other critical infrastructure needs to be evaluated. These systems are commonly used in the oil and gas industry to move large quantities of water. Innovation opportunities to make these systems relevant in the WUI are thought to include:
- weight reduction to alleviate some of the remote access concerns
  - development of rapid deployment systems

- Inclusion of water management features such as automation, remote operation, and watering time control to reduce the number of people required to operate these large-scale systems
6. Determine the feasibility of using water enhancing gels for protecting remote structures.

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# APPENDIX A: LITERATURE REVIEW – PATHWAYS AND MITIGATION OF STRUCTURE IGNITION IN THE WILDLAND- URBAN INTERFACE

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This report is not restricted.

This literature review contributes to the state-of-practice review of water delivery systems (sprinklers) in the Wildland-Urban Interface (WUI). Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).

Sprinklers are used to protect structures from wildfire during wildland-urban interface (WUI) events across Canada. Traditionally, standard forestry equipment has been used in conjunction with impact sprinklers. FPInnovations is reviewing common practices and equipment used during sprinkler deployments, in Canada, to determine if they are the most appropriate for community structure protection, or if alternative approaches should be considered.

This literature review is meant to provide a consolidated understanding of the pathways to structure ignition in the wildland-urban interface. This understanding can guide mitigation strategies including the use of sprinklers.

#### 301012735: FRIAA SPRINKLER PROJECT

#### LITERATURE REVIEW

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# 1. INTRODUCTION

Wildfire events that affect the wildland-urban interface are becoming increasingly common. Between 2000 and 2012, more than 38 000 homes were lost during wildland-urban interface fires in the United States. On average, 2970 homes were lost per year during this period, which is more than a three-fold increase compared with 932 per year on average between 1990 and 1999 (IAWF 2013). Alberta has sustained significant structure loss from wildfires that affected the communities of Slave Lake in 2011 and Fort McMurray in 2016. In order for wildland and municipal firefighting agencies to develop or select appropriate policies, approaches, techniques, and equipment to effectively protect structures from wildfires it is critical to understand the mechanisms or “pathways” of structure ignition. This review is a synthesis of information from 33 documents and 8 international standards and codes that discuss structure ignition during wildfire events in the wildland-urban interface.

# 2. STRUCTURE IGNITION PATHWAYS

According to Cohen (2008), “wildland-urban interface fire disasters depend on homes igniting during wildfires”. Furthermore, Cohen states that “if homes are sufficiently resistant to ignition and do not ignite during the extreme wildfire exposure, then the homes survive without firefighter protection: we have an extreme wildfire but not a [wildland-urban interface] fire disaster. Thus, [wildland-urban interface] fire disasters principally depend on home ignition potential”. Based on this view, we may conclude that managing the susceptibility of a home to an ignition source is a necessary prerequisite for reducing loss. The literature review suggests that structure loss from a wildfire is rarely the result of the ignition of building materials that are directly exposed to a high-intensity wildfire flame-front. The consensus within the wildfire research community points toward windblown firebrands (embers) as a primary source of structure ignition in the wildland-urban interface (Cohen & Stratton 2008).

The pathway of structure ignition is often described as a process where receptive building materials (e.g., non-class A rated roofs) or fuels adjacent to a structure are ignited by firebrands. In the case of firebrands igniting combustible fuels adjacent to a structure; these new small, low-intensity fires, ahead of the fire-front, continue to consume combustible materials, grow in intensity, and eventually ignite adjacent structural materials. This process occurs in the Structure Ignition Zone which is defined as “the area around a specific structure and associated accessory structures, including all vegetation that contains potential ignition sources and fuels” (NFPA 2018a). Combustible materials can include, but are not limited to: vegetation, landscaping materials, construction materials, firewood, and yard debris.

Calkin et al. (2014) discuss the disaster sequence in the wildland-urban interface and conclude that “if the problem is identified as home ignition, mitigation of the [Structure Ignition Zone] is the most cost-effective investment for reducing home destruction, and this can be augmented with other investments”.

Other investments can include fuel management treatments as proposed by FireSmart Canada. Fuel management treatments can reduce the intensity of a fire before it impinges a community and can provide a defensive position for firefighting resources and for the establishment of a wet line. During extreme events, these treatments may not be large enough to prevent the deposition of firebrands, which can originate from several kilometers away, into the structural ignition zone. Therefore removing or managing the combustible materials within this zone is also critical to disrupt the ignition pathway and reduce structure loss during a wildland-urban interface event.

The literature suggests that the probability of structure ignition during an extreme wildfire event is determined, not only by the fire resistance of the structure itself (e.g., building materials, design, and condition), but also by the amount, and susceptibility, of the fuels within the Structure Ignition Zone (i.e., the fuels moisture content, horizontal and vertical continuity, and connectivity to a structure).

### 3. STRUCTURE EXPOSURE

There are three potential sources of exposure that can result in the ignition of structures in the wildland-urban interface. Gollner et al. (2015) and Caton et al. (2017) identify radiation, direct flame contact, and firebrands as heat transfer mechanisms that can lead to the ignition of a structure.

#### 3.1 Exposure to radiant heat

Radiative heat transfer occurs when a structure is exposed to the radiant heat from a wildfire flame-front, from burning fuels within the Structure Ignition Zone, or from burning neighbouring structures, without direct flame contact. Radiant heat exposure significantly decreases as the distance to the flame increases. Calculations made using the Structure Ignition Assessment Model (SIAM) indicate that the exterior wood walls of a structure cannot be ignited by the radiant heat from a crown fire flame-front if the distance between the flame-front and the structure is greater than 40 m (Cohen 1999). However, radiant exposure did not cause instrumented panels to ignite when the distance from a high-intensity wildfire flame-front was greater than 10 m during experimental fires (Cohen 2004). During a post-fire evaluation of the 2016 Horse River wildland-urban interface fire, Westhaver (2016) determined that, even with a high intensity fire-front the “forest [to] home clearances [along] perimeter areas of Fort McMurray were sufficient to [limit] structural ignition from flames and radiant heat of the forest fire”.

The evidence collected from the Structure Ignition Assessment Model, experimental fires, and post-fire evaluations suggests that radiant heat transfer from a wildfire flame-front may not be the primary cause of structure ignition during wildland-urban interface events.

### **3.2 Exposure to direct flame contact (combined radiant and convective heat)**

A combination of radiative and convective heat transfer occurs when flames come in direct contact with a structure. During wildland-urban interface events, flames from a wildfire, a burning neighbouring building, or burning fuels within the Structure Ignition Zone may come into direct contact with a structure.

Combined radiant and convective heat transferred from a wildfire flame-front to a structure can be significantly different than the heat transferred during a structure-to-structure fire based on a number of factors including, but not limited to; the distance of the heat and flame to the structure, the intensity of the flame front, and the duration of exposure.

Cohen (2008) concludes that “the large flames of burning shrubs and tree canopies (crown fires) must be within one hundred feet [30 m] to ignite a home’s wood exterior.” Recommendations in the FireSmart and Firewise programs attempt to reduce the potential for direct flame contact from a wildfire flame-front by removing or mitigating flammable fuels in priority zones that surround a home. When these recommendations are followed, the probability of a structure being exposed to direct flame contact from a wildfire flame-front is reduced.

In contrast, full-scale laboratory experiments at the National Institute of Standards and Technology (NIST) showed that high-intensity flame exposure from a burning building is able to ignite a neighboring structure at a distance of 1.8 m (Maranghides & Johnsson 2008). Therefore, when the density of structures is high, the probability of structure-to-structure ignition by direct flame contact increases during a wildland-urban interface event. However, if structure ignitions can be eliminated altogether, then the potential for structure-to-structure fire spread is eliminated.

A more likely source of exposure from direct flame contact occurs when smaller, lower intensity, flames from fuels ignited within the Structure Ignition Zone come in direct contact with a structure. These ignitions are usually the result of firebrands, transported from the approaching flame-front or from a burning neighbouring building, igniting the fuels (e.g., smaller vegetation, cured grass, dry foliage, mulch, firewood piles, boards/logs, or other flammable materials) within the Structure Ignition Zone. These smaller flames consume other fuels within the Structure Ignition Zone, grow in intensity, come in contact with a structure, and ignite it.

Literature suggests that direct flame contact is a significant source of structure ignition. Ignition of flammable fuels within the Structure Ignition Zone, that have an uninterrupted pathway to a structure, have been identified as a primary source of loss during wildland-urban interface fires.

### 3.3 Physical exposure to firebrands

“Burning [firebrands] are the most important cause of home ignitions. When they land near or on a building they can ignite near-by vegetation or accumulated debris on the roof or in the gutter, or enter the building through openings (an open window or vent for example) and ignite furnishings in the building or debris in the attic” (Quarles 2012).

Firebrands can be a direct source of ignition, if they enter a house through eaves, vents, or other exposed openings, or if they land on non-fire resistant building materials. Examples of vulnerable structural materials include, but are not limited to; non-class A rated roofs or highly flammable porches and decks. Firebrands can land on structural components in concentrations up to 700 firebrands per square metre (Rissel & Ridenour 2013; Westhaver 2017).

Maranghides & Mell (2009) discuss the fire behavior observed during the 2007 Guejito fire in California, in which firebrands travelled up to 9 km ahead of the fire front and were responsible for the ignition of three homes. During the California Grass Valley fire in 2007, 193 of 199 homes destroyed were thought to have been ignited by firebrands directly or indirectly by spot fires induced by firebrands in Structure Ignition Zone fuels (Cohen & Stratton 2008). During the Witch Creek and Guejito fires in California, firebrands and resulting convective (smaller flames) exposures were thought to be responsible for two-thirds of the structure losses (Maranghides & Mell 2013). Most of the homes along the perimeter of Fort McMurray, that were lost during the 2016 Horse River fire, were exposed to convective heat transfer from Structure Ignition Zone fuels that were ignited by firebrands (Westhaver 2017).

Post-fire evaluations and laboratory experiments strongly indicate that firebrands are a significant source of direct and indirect structure ignition. Understanding the mechanisms of ignition and fire spread from firebrand deposition can inform strategies and tactics that can interrupt the pathways to structure ignition.

## 4. STRUCTURE IGNITION ZONE FUELS

The primary sources of structure ignition in the wildland-urban interface, as reported in the literature, are direct flame contact and physical exposure to firebrands, such that: (1) firebrands ignite fuels in the Structure Ignition Zone and these smaller fires result in the ignition of a structure, or (2) firebrands directly ignite the building materials on, or attached to a structure. The probability of structure ignition resulting from these pathways in the wildland-urban interface depends on fire-weather conditions as well as the spatial arrangement and flammability of the fuels within the Structure Ignition Zone. The potential of these fuels to impact adjacent structures, once ignited by firebrands, depends on their amount, vertical and horizontal continuity, and the fuels connectivity to a structure.

## **4.1 THE INFLUENCE OF STRUCTURE IGNITION ZONE FUELS ON IGNITION PATHWAYS**

The ability to accurately predict fire behaviour in the wildland-urban interface depends on our understanding of the pathways of structure ignition. Identifying the most effective ways of interrupting these pathways can help homeowners prepare in advance, or help firefighting resources determine which fuels within the Structure Ignition Zone should be a priority for mitigation during an incident. This requires a better understanding of the flammability of the various fuels found within a Structure Ignition Zone. Literature suggests that the following fuels contribute significantly to the ignition of structures during wildland-urban interface events:

### **4.1.1 Fine fuels, vegetation, and landscaping materials**

Native and ornamental vegetation, cured grass, dry leaves, litter, combustible landscaping materials such as straw, mulch, wood chip or bark, and landscaping logs that are ignited by firebrands are a common cause of structure ignition by smaller flames (Quarles 2012; Zipperer et al. 2007; Westhaver 2017). If these burning fuels are connected to a structure, the risk of structure ignition through direct flame contact increases.

Removal of these fuels within 1.5 m of a structure should be a priority for homeowners or structure protection resources. Management of these fuels within the remainder of the structure ignition zone can help to interrupt the pathway for structure ignition. Management strategies can include but are not limited to; maintaining a healthy lawn, removal of cured grass and leaves, planting more fire-resistant vegetation and selecting fire-resistant landscaping materials.

### **4.1.2 Combustible fuels attached to a structure**

Combustible elements of the structure such as decks, porches, patios, and attached Structure Ignition Zone fuels, such as fences, are one of the most significant sources of structure ignition (Maranghides et al. 2013; Quarles et al. 2013) in the wildland-urban interface.

Using less flammable construction materials will help to interrupt the pathways of structure ignition. As an example, the use of fire-resistant materials could be considered for the section of the fence that is immediately adjacent to a house. In addition, the area under decks should be maintained and free of highly combustible yard debris or cured grass.

### **4.1.3 Miscellaneous combustibles**

Miscellaneous combustibles can include, but are not limited to; machinery, parked vehicles, liquid propane tanks, petroleum products, outbuildings, furniture, stored materials, firewood, and compost.

Best practices would suggest either removing these combustibles from the Structure Ignition Zone or storing them as far from the structure as possible.

## **4.2 THE INFLUENCE OF BUILDING MATERIALS AND DESIGN ON IGNITION PATHWAYS**

Building materials and building design can also influence the susceptibility of a home to ignition during a wildland-urban interface event. Firebrands can be a direct source of ignition if they land on non-fire resistant building materials, or if they enter a house through eaves, vents, or other exposed openings. Non-fire resistant materials used in building construction should be considered as available fuel for ignition pathways. Literature suggests that the following building components can be considered pathways to structure ignition if exposed to firebrand deposition:

### **4.2.1 Roof materials and design**

Roof materials and design can contribute to the susceptibility of a structure to ignition from firebrands. Wood shake and wood shingle roofs are more susceptible to ignitions from direct contact with firebrands compared to Class A-rated roofing materials (i.e., asphalt shingles). Class A-rated roof coverings are “considered the most effective against severe fire test exposures” (Hakes et al. 2016). Experiments, using a firebrand generator, ignited typical debris (e.g., pine needles) in the gutters attached to asphalt shingled roofs. The ignition of the debris caused the roofing material to melt but did not result in the ignition of, or fire spread along the roof surface (Manzello et al. 2008). In contrast, Quarles (2012) determined that debris ignited in gutters contributed to the ignition of, and fire spread along untreated wood shake roofs, and concluded that should debris in rain gutters be ignited, metal gutters stay in place, whereas vinyl gutters melt, become detached from the fascia, fall to the ground, and can contribute to the ignition of finer fuels adjacent to a structure.

Roof valleys, inside and re-entrant corners (an internal or inside corner; usually used to describe angles less than 90°), and intersections between a deck and an exterior wall (IBHS 2007; Manzello & Suzuki 2014) are areas where firebrands can accumulate in significant concentrations. These accumulations can and contribute to the ignition of flammable building materials.

Best practices suggest using roofing materials that provide resistance to fire (e.g., metal coverings, or asphalt shingles), using metal rain gutters, and keeping areas prone to firebrand accumulations free of flammable debris, in areas that are at risk from firebrand exposure.

### **4.2.2 Exposed openings and windows**

Eaves and vents are a potential pathway to structure ignition if these openings allow firebrands to enter the structure and ignite flammable materials (Manzello et al. 2012). The installation of screens over exposed openings can help reduce the size of firebrands that can enter the structure and thus could reduce the probability of ignition.

If glass windows break during flame impingement or if the window falls out due to framing material ignition, the window opening will provide another pathway to structure ignition. Double-paned windows are less vulnerable to flame impingement (Quarles 2012).

## 5. REDUCING THE RISK IN THE STRUCTURE IGNITION ZONE

At the community scale, the layout of structures and the characteristics of the spaces between them have been shown to be very important in mitigating wildfire risk. Structures on the perimeter of the community need more protection because they are more likely to be destroyed during a wildland-urban interface fire (Maranghides et al. 2013) and once ignited, these structures provide new pathways to structure ignition through additional firebrand generation and structure-to-structure fire spread (Quarles et al. 2013).

FireSmart Canada identifies seven disciplines that can help communities address the threat of wildfire including; Education, Vegetation management, Legislation and planning, development considerations, interagency cooperation, Emergency planning and cross training (Partners in Protection 2003).

At the local scale, creating defensible spaces by managing or removing fuels around homes can be effective in reducing exposure to radiant heat, direct flame contact, and firebrands. Management or removal of combustible material from the Structure Ignition Zone is a fundamental goal of the FireSmart program in Canada and the Firewise program in the United States.

FireSmart Canada has published the *“FireSmart Begins at Home”* manual, which is designed to inform home owners on steps that they can take in the Structure Ignition Zone to help reduce the risk of loss during a wildland-urban interface event. This manual identifies the following priority zones (Figure 1) and associated fuel management strategies:

- Priority Zone 1a (0-1.5 m from the structure): identified as the non-combustible zone or an area surrounding the building where all combustible materials should be removed.
- Priority Zone 1 (1.5–10 m from the structure): identified as a zone that should be fire resistant and suggests the removal of highly combustible fuels, and the presence of fire-resistant lawns and plants
- Priority Zone 2 (10–30 m from the structure): Identified as a zone where thinning and pruning of trees and the elimination of surface fuels should be carried out. The manual recommends a tree spacing (distance between the outer branches) of at least 3 m.
- Priority Zone 3 (30–100 m from the structure): identified as a zone that, if managed, can help to reduce the intensity and the rate of spread of a wildfire by increasing the spacing between trees and shrubs, pruning, and removing ladder and surface fuels.

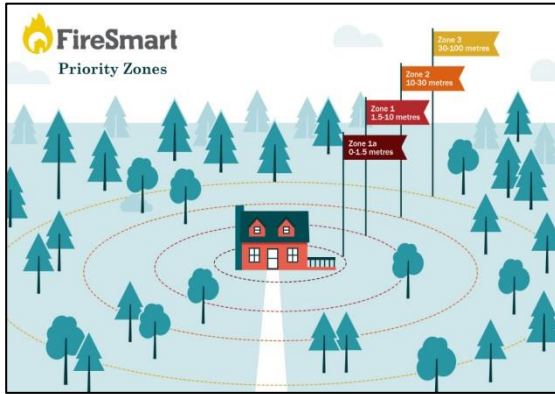


Figure 1. The FireSmart Canada Priority Zones.



Figure 2. The Firewise Home Ignition Zones (HIZ).

Similarly, Firewise USA uses the concept of the Home Ignition Zone and identifies three zones (Figure 2) surrounding a home that can be managed to reduce the effects of radiant heat from a wildfire (NFPA 2018b). These zones include the Immediate (0–5 ft.), Intermediate (5–30 ft.), and Extended Zone (30–100 ft.).

Other mitigation strategies found in the literature review that could help to reduce the risk of structure ignitions during wildland-urban interface events include, but are not limited to; the creation of defensible spaces, fire service intervention, engineered building solutions, and hardening of structures by applying wetting and covering agents, such as water enhancers and building wraps.

Hardening (reducing the flammability) of a structure by engineering them to resist wildfire exposure (Manzello et al. 2008) is a logical approach. Temporary hardening of structures can be achieved by applying wetting and covering agents: water, foams, gels, material coatings, and blanket materials (Glenn et al. 2012; Takahashi et al. 2013; Urbas 2013). While firebrands still remain a challenge and many design recommendations have been proposed to harden structures against firebrand exposure by using ignition-resistant building materials, the use of “temporary hardening” by wetting and external sprinkler systems should be considered one of the most effective ways to enhance the fire-resistance of structures and reduce the flammability or the receptivity of fuels, within the Structure Ignition Zone, during firebrand exposure.

## 6. EFFECTIVENESS OF SPRINKLER SYSTEMS

The ability of firebrands to initiate ignition strongly depends on fuel moisture content (Yin et al. 2012). This supports temporarily hardening a structure and Structure Ignition Zone fuels by wetting using external sprinkler systems. The literature review provided only a few documented examples of structure protection operations that used sprinklers.



Experimental crown fires were ignited at the Canadian Boreal Community FireSmart Site in the Northwest Territories, Canada in 2005, to evaluate the effectiveness of sprinklers and an aqueous gel product for structure protection. The experiment showed that “water application from sprinklers reduced the combustibility of the structural fuels and reduced the fire intensity in the wildland fuels immediately adjacent to the cabin. As a result, the structure survived and surface fuels were unburned for 2 m surrounding the cabin within the sprinkler arc” (Walkinshaw & Ault 2008). During a second experimental fire conducted the same year, “sprinklers were operated for 10 minutes prior to wildfire impingement...and continued to operate for an additional 6 minutes after the initial wildfire passage”. Again, the structure survived and “the post-fire investigation indicated that water application from the sprinklers reduced the combustibility of the structure and the wildland fuels immediately adjacent to the cabin” (Walkinshaw & Ault 2009).

During the 2007 Ham Lake fire in Minnesota, USA, 72% of the threatened structures that survived had working sprinklers (Johnson et al. 2008). The Ham Lake case study provides anecdotal evidence, during an actual wildland-urban interface event, of the effectiveness of sprinklers. The Wind-Enabled Ember Dousing System (WEEDS) has been used to extinguish firebrands deposited on a structure and to prevent burning firebrands from entering a structure through exposed openings. Although this system has been shown to be effective during the 2003 Cedar fire in California, USA (Mitchell 2006), its applicability during large-scale events and in different fire exposure conditions has yet to be investigated.

A scan of the following international standards and codes related to the Wildland-urban interface was conducted to determine if there were any standards specific to sprinkler use that would be beneficial to Canadian agencies:

- International Wildland-Urban Interface Code – The objective of this code is to establish minimum regulations for safeguarding life and property from the fire intrusion due to wildland fire exposures and fire exposures from adjacent structures. The code is to be adopted and used supplemental to the adopted building and fire codes for a jurisdiction.
- California Fire Code (Chapter 49: Requirements for Wildland-Urban Interface Fire Areas (California) – This code provides minimum standards for increasing the ability of a building to resist the intrusion of flame or burning firebrands projected by a vegetation fire, and it contributes to a systematic reduction in conflagration losses through the use of performance and prescriptive requirements.
- Australia AS 5414 – 2012 Bushfire Water Spray Systems – This is a standard for the installation of permanent sprinkler systems on homes. The standard calls for a minimum reservoir of 22 000 L (4830 imperial gallons) and a 30-minute to 2-hour continuous run time for the pump.
- Canada, National Research Council – Wildland Urban Interface Fires: regulations and guidelines - A national wildland urban interface guide for Canada was under development in May 2018.

The following National Fire Protection Association (NFPA) standards guide operations in the WUI:

- NFPA 1141: Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas
- NFPA 1142: Standard on Water Supplies for Suburban and Rural Fire Fighting
- NFPA 1143: Standard for Wildland Fire Management
- NFPA 1144: Standard for Reducing Structure Ignition Hazards from Wildland Fire

Most available standards focus on mitigation practices in the wildland-urban interface. No standards were identified that were applicable to sprinkler deployments from a Canadian perspective. If standards for sprinkler use in the wildland-urban interface are to be developed a logical, structured approach is required that needs to be supported by science.

## 7. SUMMARY

Significant progress has been made in understanding how structures ignite during wildland-urban interface events. The literature review suggests that interrupting the pathways to structure ignition is critical to prevent structure loss. This can be achieved through the removal and mitigation of flammable fuels as recommended in the FireSmart and Firewise programs, by planting less flammable vegetation, and by the use of landscaping and building materials that are resistant to ignition from firebrands. Explorations into structure ignition conditions and the relative flammability of different fuels that contribute to ignition pathways in the Structure Ignition Zone should continue.

Sprinklers can be an effective tool to wet vulnerable structural components and increase the moisture content of surrounding fuels to reduce their receptivity to ignition from firebrands. There are very few documented case studies regarding the effectiveness and best practices for the deployment of sprinklers during wildland-urban interface events. However, the case studies that are available show that sprinklers are effective in preventing structure loss. Further research into effective technologies and practices should include the evaluation of wildfire chemicals to determine if, or how, these can be incorporated into existing strategies and tactics to reduce loss.

Further study in these areas will enhance our understanding of how structure engineering, fuel management, and strategic application of water within the Structure Ignition Zone can increase the chances of structure survival during wildland-urban interface events.

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# APPENDIX B: NATIONAL SURVEY ON SPRINKLER USE

*A FIRST STEP IN DETERMINING HOW EFFECTIVE EXISTING  
SPRINKLER EQUIPMENT IS AND WHAT TECHNOLOGY GAPS  
NEED TO BE ADDRESSED.*

Ray Ault

April 2019

This survey report is not restricted.

This national survey contributes to the state-of-practice review of water delivery systems (sprinklers) in the wildland-urban interface (WUI). Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).

Sprinklers are used to protect structures from wildfire during wildland-urban interface (WUI) events across Canada. Traditionally, standard forestry equipment has been used in conjunction with impact sprinklers. FPIinnovations is reviewing common practices and equipment used during sprinkler deployments, in Canada, to determine if they are the most appropriate for community structure protection, or if alternative approaches should be considered.

This report documents the results of a survey developed and administered by FPIinnovations, to help identify the equipment that is currently used for structure protection in Canada. The survey was distributed to the 13 wildfire agencies (including Parks Canada and all provinces and territories except Nunavut) that are members with the Canadian Interagency Forest Fire Centre (CIFFC).

301012735: FRIAA SPRINKLER PROJECT

SURVEY REPORT

#### **ACKNOWLEDGEMENTS**

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# 1. SURVEY – EXECUTIVE SUMMARY

FPIInnovations contacted all the wildfire agencies that are members of the Canadian Interagency Forest Fire Centre (CIFFC) Fire Equipment Working Group. All 13 members completed the survey.

The results of the national survey indicated that all the agencies are or have been involved, at some point, in protecting structure from wildfire. While 31% of the agencies are not responsible for structure protection, 77% indicated that they may, depending on the situation, be involved in the deployment of sprinklers for structure protection. For those agencies that are not responsible for structure protection from wildfire, the responsibility rests with either the provincial Office of the Fire Commissioner or Fire Marshall, which may deploy sprinklers or coordinate structure protection response.

Clearly, the survey indicated that Canadian agencies are using sprinklers and that sprinklers are an important component in structure protection during wildfire events.

Respondents were asked about the usefulness of sprinklers for structure protection and wildfire containment lines. Responses were as follows:

Regarding structure protection:

Not very useful: 0%  
Useful: 15.4%  
Very useful: 30.8%  
Extremely useful: 30.8%  
I have no experience: 23.1%

Regarding wildfire containment:

Not very useful: 23.1%  
Useful: 8.0%  
Very useful: 30.8%  
Extremely useful: 0%  
I have no experience: 38.5%

Based on these answers, it would appear that agencies are more confident about the usefulness of sprinklers for structure protection than for wildfire containment.

Agencies were then asked about the estimated average number of annual sprinkler deployments in the Wildland–Urban Interface (WUI) over the past five years. Responses were divided into four categories (Saskatchewan did not provide a response):

0–5 deployments: P.E.I., N.S., Nfld., Que., B.C., Alta., N.B.

6–10 deployments: N.W.T., Y.T.

11–20 deployments: Man.

> 20 deployments: Ontario Ministry of Natural Resources and Forestry and Parks Canada

FPIInnovations then asked about the sprinkler kit inventory for the 2018 fire season and the numbers of sprinklers in each kit. The survey results indicated that the 2018 national inventory for sprinkler kits was 1878, which is approximately 11 320 sprinklers. Sixty-six percent of the kits had five sprinklers; the rest had eight sprinklers. The manufacturers of the sprinklers in the kits included Rain Bird, Royal Coachman, and Buckner. The development of structure protection

trailers also added to the inventory available for the WUI and structure protection, given that many of the agencies were using or developing trailers for rapid response and to have a more comprehensive inventory.

When asked about the sources for sprinkler information, 66% of respondents said they rely on internal documents. However, internal documents are not easily viewed by other agencies, which limits knowledge exchange. Thirty-three percent of respondents said that FPIInnovations and FireSmart were sources of sprinkler information, while 11% noted the National Fire Protection Association (NFPA) and the International Journal of Wildfire.

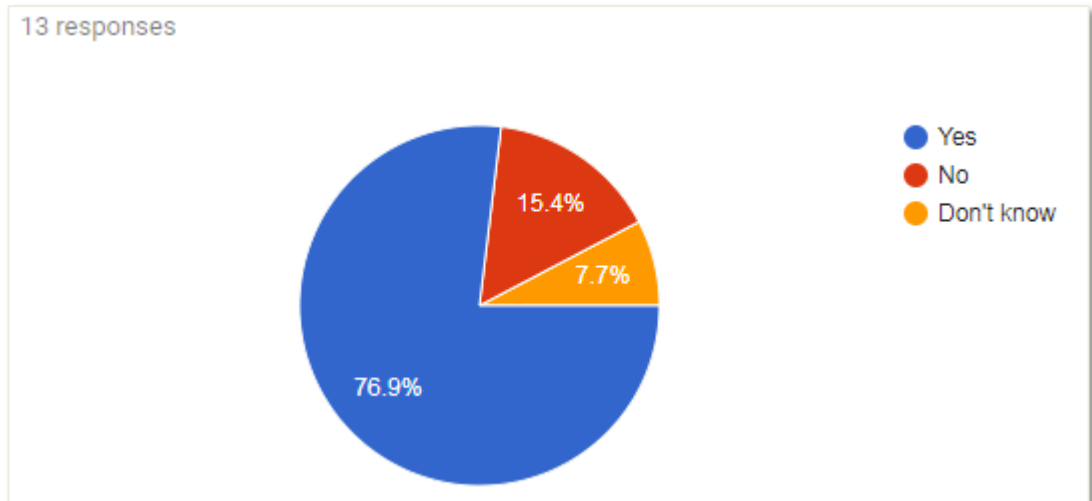
Agencies were also asked about future plans or changes needed regarding sprinklers. Modest additions to inventory were planned, but none of the agencies indicated that they were planning for a shift in equipment or dramatic change in sprinkler tactics.

This survey focused primarily on wildfire organizations because we could identify the individuals through membership in the Wildfire Equipment Working Group. Not included in the survey were the contractors and structural fire organizations that had Structure Protection Unit (SPU) trailers. For the 2018 fire season, the British Columbia Office of the Fire Commissioner (OFC) had 15 SPU type 2 trailers available through contractors or municipal fire departments. The British Columbia OFC also maintains type 1 and type 2 trailers. In Alberta, the OFC has one type 1 trailer and four type 2 trailers, and 15 County Fire Departments may be building sprinkler capacity for local emergency needs. Ontario has a 16 m (53 ft.) trailer operating as a mobile structure protection warehouse, and Manitoba is in the process of building a type 1 SPU trailer. All the structure protection equipment and sprinklers noted above are based on a wildfire model of pressure pumps, 38-mm hose, and impact sprinklers. None of the OFC or Fire Department sprinkler inventories or equipment were included in the national survey results.

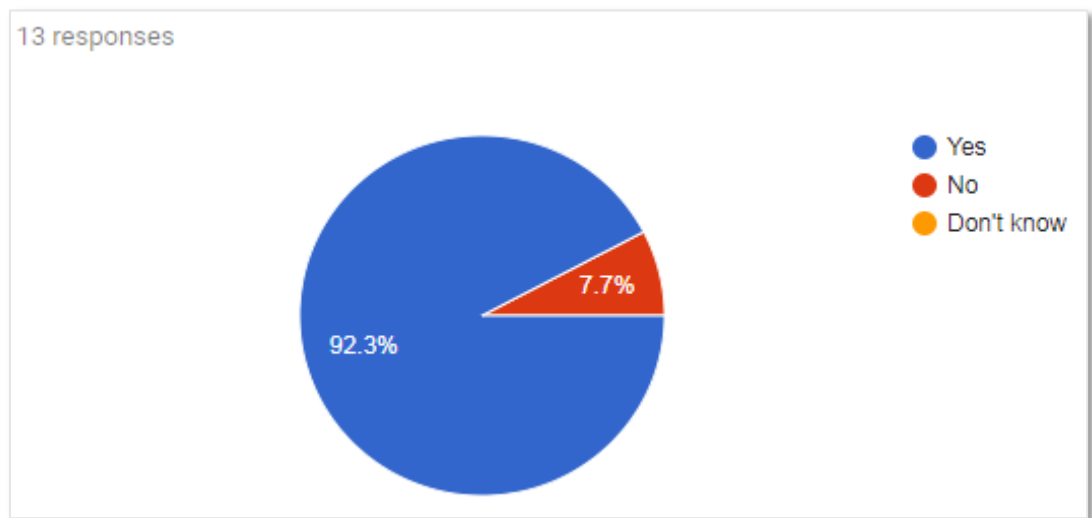
Agencies across Canada have adopted sprinklers as a tool for structure protection from wildfire in a substantial way, and the broad acceptance of, and commitment to using sprinklers has been further encouraged by the interprovincial exchange of fire crew and incident management teams. Many Canadian firefighters, regardless of jurisdiction, have been involved in values protection in some degree.

## 2. SURVEY RESULTS

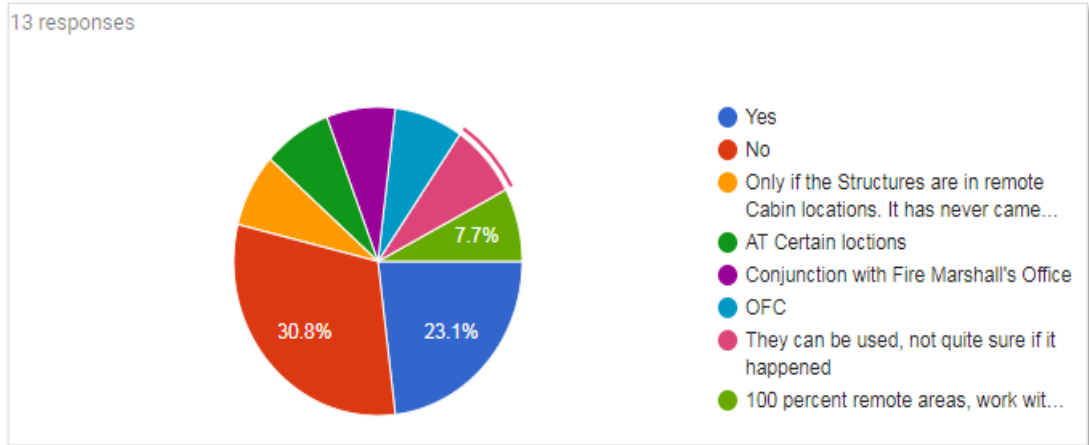
1. In your province, are sprinkler systems used in wildfire suppression operations for wildfire containment?



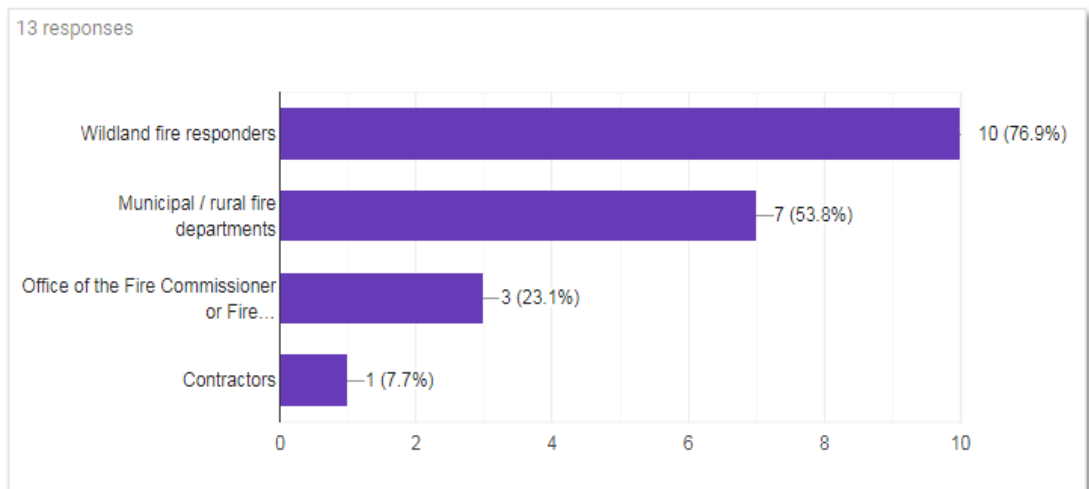
2. In your agency, are sprinklers used for structure protection?



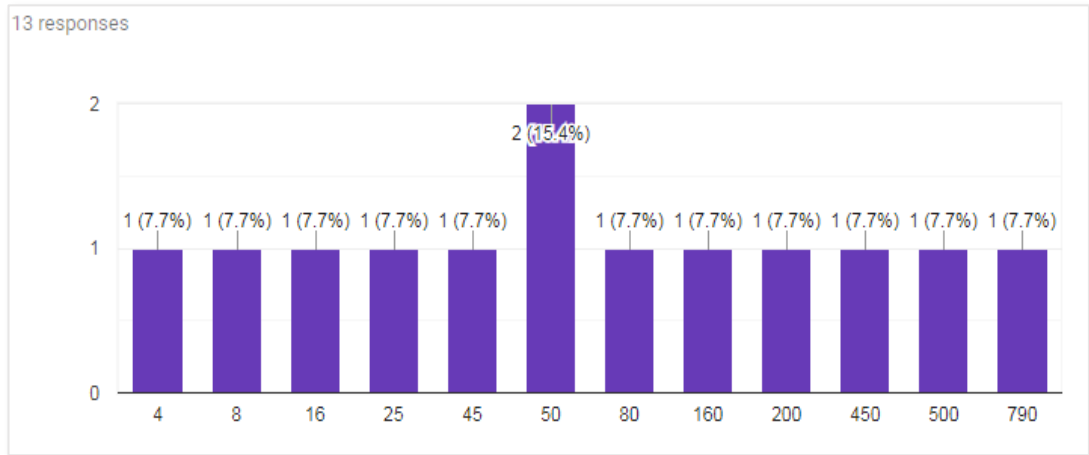
3. In your province, is your agency responsible for structure protection during wildland-urban interface events?



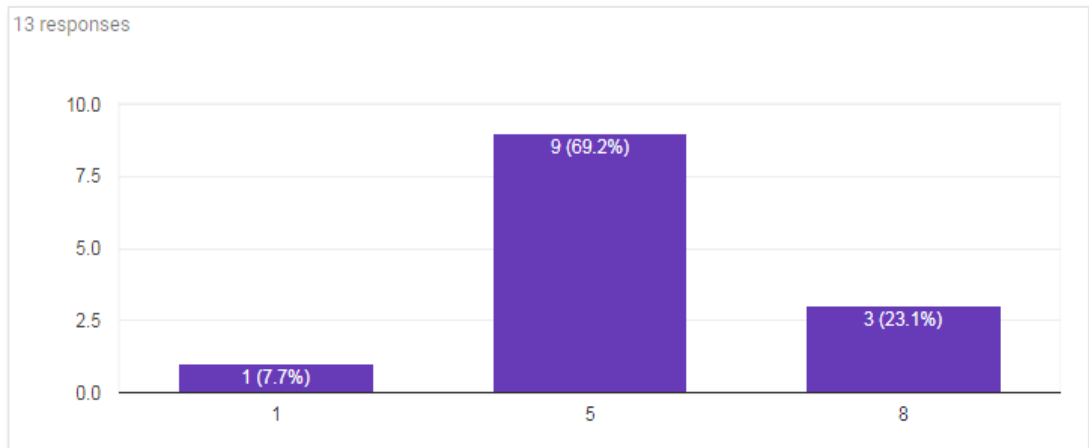
4. In your province, generally, who deploys sprinklers for structure protection or the protection of values at risk?



5. Within your agency, how many sprinkler kits will be available for use at the start of the 2018 fire season?

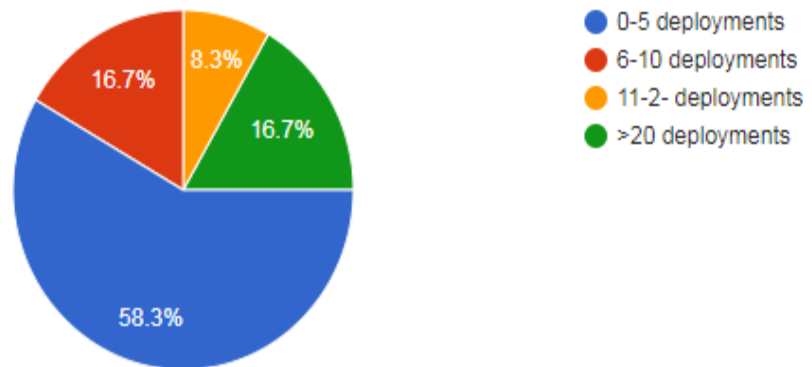


6. Based on a 2008 Canadian Interagency Forest Fire Centre national inventory of wildfire sprinkler kit contents, we understand the number of sprinklers in a kit varies by agency. How many sprinklers are currently in your agency's sprinkler kit?



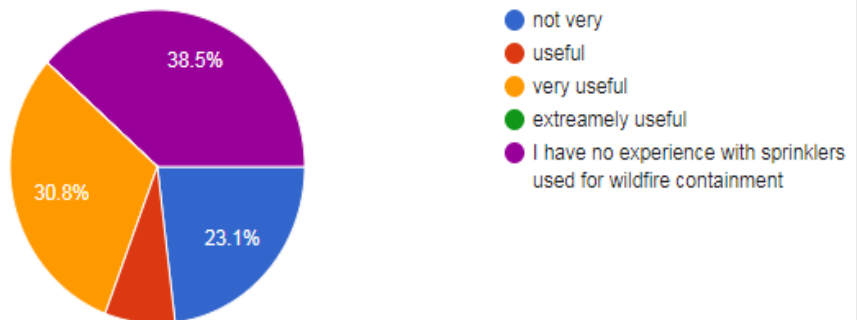
7. In the past five years, on average, what has been the annual frequency of sprinkler deployments in the wildland–urban interface “by your agency”?

12 responses

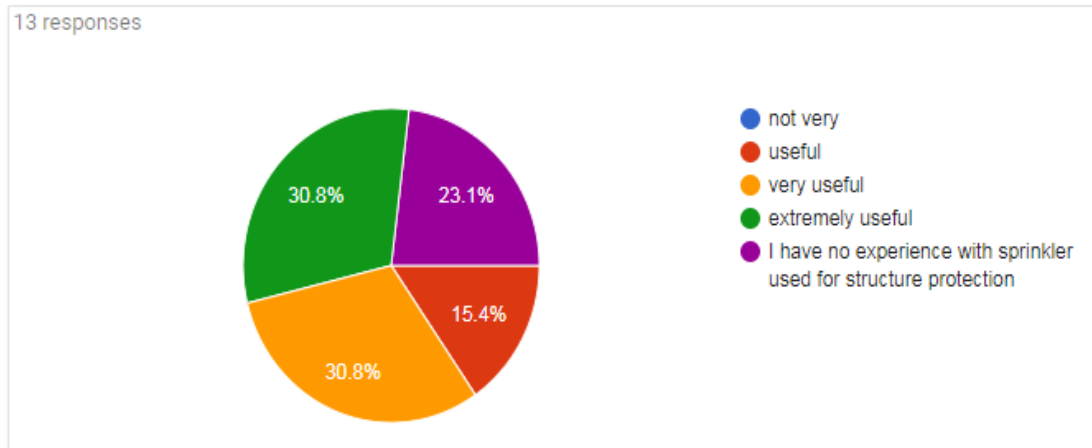


8. Based on your experience, how effective are sprinkler systems in wildfire containment?

13 responses



9. Based on your experience, how effective are sprinklers in structure protection?



10. What are some of the limitations you have experienced or might expect of the sprinkler systems in a structure protection context?

Responses included:

- Access to water source
- The reach would be some limitations, getting the water mist in hard-to-reach places, on top of roofs.
- We rarely use sprinklers in our agency, so our staff are not familiar with them.
- Volume of water needed for large setups
- Usually stored at warehouse, so timing with regard to deployment might be an issue
- Distance from water source fire smarting consideration
- Ladder training is required.
- Easiness of installation, equipment available on site (ladder)
- Operating time of pumps
- High roofs when personnel not permitted or trained to walk on the roof. Land/home owners don't let you set up the sprinklers for fear of water damage; sprinklers should be set up a number of hours prior to fire arrival in order for them to be most effective; some homes that are within the forest stand have no fuel buffer and this limits sprinkler effectiveness. The number of pumps within a sprinkler system greatly reduces or enhances the amount of water a sprinkler can distribute; the diameter of hose used in the setup can greatly reduce/improve the number of sprinkler heads a system can sustain; the amount of water available for a system (can you run the systems all day; do you have to alternate sections of the systems; are you waiting for water tenders to fill up reservoirs; are you waiting for water tributaries to fill ponds, small lakes; are your pumps taking out more water than the system is putting out?). The biggest limitation is resources. If you have multiple structures to protect, setting them up is only the first step; they still have

to be maintained. If you don't have the resources (crews to fix and service setups, helicopters/boats to give you access to refuel sites daily) to support them, they aren't good past day one.

- Difficulty in getting out to remote areas to start pumps with smoke conditions. Start in morning and pumps run about 8 hours. Went to 2.5-in. hose for long hose lay on the limestone plate where 2 or 3 mile is common. Use BB4 or Mark 75 pump for unique deployment. Sprinklers are equipped with three nozzle sizes and are interchangeable.

11. In advising other agencies, what would you suggest are key considerations in the successful use of sprinkler systems?

Responses included:

- Have a variety of sprinkler types/sizes. Various nozzle sizes. Will give you the right tool for the job and save water.
- Put the sprinklers out early and test the usefulness of them before the fire front comes through.
- Proper use of Incident Command System to incorporate structural protection resources into effective management of an incident
- Store a kit on an initial attack vehicle
- Proper deployment
- Creating a loop (closed water circuit) to increase water pressure in sprinklers
- Requires lots of sprinklers and pumps to meet the needs of multiple structures
- Continuous water source; avoid relay tanks if possible; coverage/protection of structures and hose lines; test system prior to use. Typical cause of failure is the knowledge of building the systems. Pumps can have volume and not much pressure or have pressure but not much volume—you need to be aware of what your water delivery method can do before setting up your system. Using smaller diameter hose can kill a system (1½ in. minimum as trunk lines; 2½ in. has a place in larger systems and use econo-flow sparingly—only from trunk line to sprinkler head if possible). Trying to stretch your water across too many sprinkler heads will make systems extremely ineffective—your water delivery system and hose diameter will determine number of heads.
- Staff training, rapid retrieval and repack for next fire

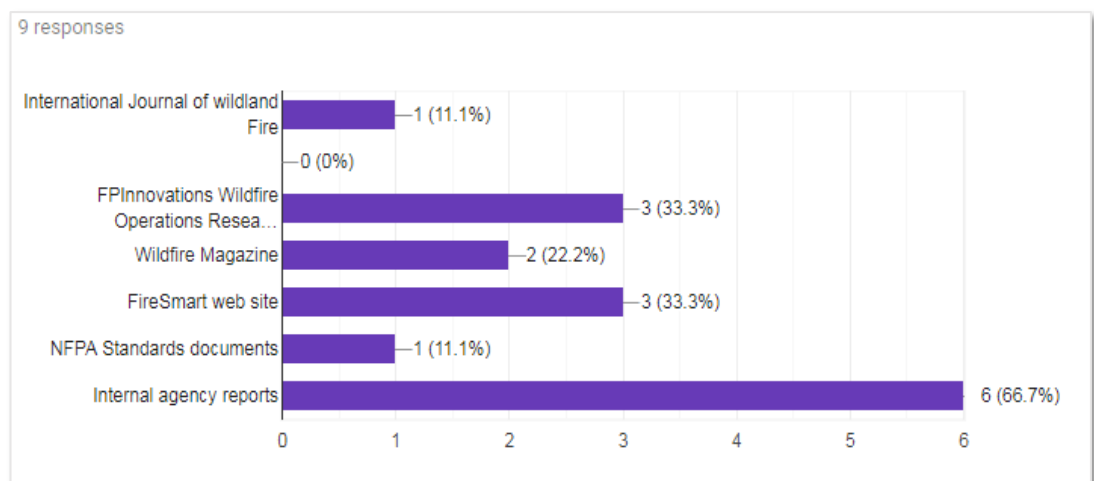


12. What are your agency's future plans or changing needs as they relate to sprinklers?

Responses included:

- We would like to add another Facility Protection Unit to our fleet.
- To continue using the sprinkler kits and do more training
- We have sprinklers to deploy for the protection of our structures and do not see any changing needs.
- Status quo
- Procuring a structural protection unit to protect 30 structures
- Always trying to improve our water distribution knowledge
- Converting 19-mm kits to 38 mm
- Kits were redesigned a few years back—this being said, always looking at/comparing other options
- Major growth in past five years. Three SPU trailers. OFC now has a 53-ft. sprinkler type 1 trailer. Moving away from 1-in. Rain Bird to Buckner because of weight for remote fly-in deployments.

13. What sources of sprinkler research do you access?



14. Within your province but outside of your agency is there any other organization you would recommend we contact in regard to wildfire sprinkler use?

Responses included:

- Fire and Emergency Services. Phone number 709-729-3703
- Office of the Fire Commissioner
- Alberta Fire Chiefs Association
- Not aware of any other than Waterax and Mercedes

# APPENDIX C: SPRINKLER DEPLOYMENT KEY MESSAGES AND BEST PRACTICES

*AS IDENTIFIED THROUGH INTERVIEWS AND OBSERVATIONS*

Ray Ault and Chad Gardeski

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April 2019

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This best practices document is not restricted.

This document contributes to the state-of-practice review of water delivery systems (sprinklers) in the wildland-urban interface (WUI). Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).

Sprinklers are used to protect structures from wildfire during wildland-urban interface events across Canada. Traditionally, standard forestry equipment has been used in conjunction with impact sprinklers. FPInnovations is reviewing common practices and equipment used during sprinkler deployments, in Canada, to determine if they are the most appropriate for community structure protection, or if alternative approaches should be considered.

In order to better understand the extent of equipment usage and some of the challenges associated with sprinkler deployments, FPInnovations interviewed fire managers after wildfire events, during active wildfires or wildland-urban interface deployments, and during deployment exercises. This report is a summary of the key messages and best practices identified by fire managers for the successful deployment of sprinklers.

#### 301012735: FRIAA SPRINKLER PROJECT

#### BEST PRACTICES

#### ACKNOWLEDGEMENTS

FPInnovations would like to acknowledge the Forest Resource Improvement Association of Alberta (FRIAA) for funding this project, and the following agencies and individuals for their support.

- The Alberta Office of the Fire Commissioner
- B.C. Wildfire Service
- Clearwater County, Alberta
- Tallcree First Nation, Alberta
- Murray Heinrich - Palisade Consulting Ltd.
- Town of Jasper, Alberta
- Town of Canmore, Alberta
- Stew Walkinshaw – Montane Forest Management Ltd.

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## INTERVIEWS

In order to better understand the extent of equipment usage and some of the challenges associated with sprinkler deployments, FPInnovations interviewed fire managers after wildfire events, during active wildfires or WUI deployments, and during deployment exercises. In addition, we reached out to various Alberta water delivery contractors to understand some of the larger equipment being used in the WUI. These interviews contributed to the conclusions and key messages identified in the executive summary. Fire Managers and water delivery contractors involved in the following wildfires, deployments, reviews, and deployment exercises were interviewed to identify some key messages and best practices for sprinkler deployments:

### **1. Nordegg, Alberta – Wildland-Urban Interface fire 2013**

In May 2013, the hamlet of Nordegg was evacuated due to a wildfire that threatened the community. Alberta Agriculture and Forestry (AAF) and the Clearwater Regional Fire and Rescue Services (CRFRS) conducted several desktop emergency planning exercises in preparation for this type of event. As a result of these efforts, individual agencies were clear about their responsibilities for community protection, and resources were able to be deployed efficiently. The CRFRS used AAF sprinkler trailers and a contract water delivery service provider to deploy sprinklers to protect residential structures, community buildings, and the historic coal mine site. Effective communications between the two agencies and pre-planning significantly contributed to a successful deployment, which included the installation of 76 sprinklers that were supplied using a combination of high-volume and standard forestry equipment (20-mm to 100-mm hoses). Water sources included community hydrants, above ground community water tanks, water supplied using Mark III and BB4 forestry pumps, and water stored in portable water bladders.

**Key message:** The annual emergency planning exercises that were conducted in preparation for a wildfire event contributed to the rapid deployment and success of this operation.

### **2. Tallcree First Nation, Alberta – deployment 2015**

The structure protection specialist for the 2015 deployment at Tallcree First Nation provided notes and, in an interview, explained the assessment process used to determine which structures needed sprinklers and how water supply lines and pumps were organized during the deployment. The use of a 38-mm (1.5-in.) main line may not have been sufficient to supply adequate volume to protect all the structures in the community. The fire did not impinge the community. After the deployment, a formal community protection plan was developed based on the learnings from the deployment and called for the use of larger 65-mm (2.5-in.) supply lines to improve the water volume supply in the event of a future deployment.

**Key message:** After-action reviews of community protection plans are important for identifying opportunities for improvement.

**3. Robb, Alberta – deployment 2018**

In July 2018, the community of Robb, was placed under an evacuation alert, but sprinklers were never deployed. Structure protection crews on site conducted a pre-deployment assessment. A sprinkler deployment plan was developed several years earlier, and a deployment exercise was never conducted to validate the effectiveness of the plan. During the assessment, it was determined that it would be advantageous to stage water-holding tanks around the community to supply enough volume to support the perimeter sprinklers due to the topographical differences from the main water supply (the creek) to the top of town. The assessment also revealed the advantages of using a 65-mm (2.5-in.) supply inch line rather than a 38-mm (1.5-in.) supply line to allow for more volume flow.

**Key message:** Plans need to be regularly updated to reflect current technologies and best practices. Plans benefit from test deployments.

**4. Smithers Landing, British Columbia – deployment 2018**

In August 2018, the lakeside unincorporated community of Smithers Landing was threatened by wildfire. Several residents used personal pumps and sprinklers to prepare their homes in the event of an evacuation. These simple private sprinkler systems relied on small pumps, garden hoses, and a variety of different sprinklers. Two of the cabins used the Bear Cat FP2126 fire pump kits. Some of these systems were in place and operational before wildfire and Structure Protection crews arrived. With an ample water supply, and the application of FireSmart guidelines, these structures were well protected.

**Key message:** The actions taken by residents to protect their personal property reduced the strain on limited agency resources.

**5. Jasper National Park, Alberta – deployment plan review**

FPIInnovations met with the Jasper Fire Department to discuss their Community Wildfire Protection Plan, which called for the use of perimeter sprinklers and structural apparatus (fire engines) within the interior of the community. A number of years ago, the town changed its source of community water from the Athabasca River to a well system located above town. Based on concerns regarding available volume and pressure from the well system, the fire department recognized that it could still tap into the old infrastructure and use water from the Athabasca River to boost the system's volume and pressure. Communities all have unique challenges that require different solutions.

In this case, re-assessing the deployment plan identified a need for more volume, and a solution was developed in advance of an actual wildfire event.

**Key message:** Each community has different water supply challenges that require unique solutions. It is critical that those challenges are identified and addressed in sprinkler deployment plans.

#### **6. Town of Canmore, Alberta – deployment exercise**

In September 2018, the town of Canmore conducted a sprinkler deployment exercise to validate the assumptions in the deployment plan. The exercise allowed the municipal fire department to set up planned perimeter lines to get a sense of the logistics behind the deployment and to ensure that any challenges could be addressed before an actual event. The exercise identified equipment and logistic challenges associated with using the municipal hydrants to provide enough water to supply the system, using a 38-mm (1.5-in.) supply line. Re-deployment of a 68-mm (2.5-in.) supply line provided the necessary volume for the system.

**Key message:** Deployment exercises give communities an opportunity to validate and improve their community protection plan.

#### **7. Contractor interviews**

FPIInnovations was able to interview six of the ten Alberta contract companies that AAF identified as having equipment that could be used for structure protection. These companies do not necessarily work on wildfires every summer. Only two of the companies are focused on providing specific wildfire services. The availability of high-volume water pumps was the focus of the interviews. Four contractors can supply high-volume pumps with capacities exceeding 750 gallons per minute (gpm) that can accommodate 100-mm (4-in.) water supply lines. One contractor commented that Alberta oil field water supply service providers could supply 70-75 water delivery systems that are capable of delivering between 750 and 1800 gpm.

Finally, FPIInnovations interviewed a duty officer with Wildfire Defence Systems in Bozeman, Montana. Wildfire Defence Systems is a contractor that supplies structure protection crews for Chubb insurance in 21 states. They have the largest private fleet of wildfire engines in the United States and a large inventory of wildfire suppression and structure protection equipment. Wildfire Defence Systems indicated that using sprinklers for structure protection in Montana is common and that deployment is often completed by private contractors. Wildfire Defence Systems uses water enhancing gel products with a gel induction system for ground based applications.

**Key message:** A small number of private companies are capable of providing specialized water delivery equipment. Many private companies that have the capacity to provide

these services do not have the opportunity to remain current with structure protection tactics; thus they are able to reliably provide this service to the agencies.

## BEST PRACTICES – PRE-DEPLOYMENT

The following best practices have been identified in terms of preparing for a sprinkler deployment:

1. Have a structure protection plan for the community, in a format that can be easily shared with other fire agencies and first responders. Practice the plan with other organizations as part of training.
2. In the planning phase, determine priorities for the first 12 hours, 24 hours, and 48 hours based on the wildfire location and expected fire behaviour.
3. Sprinkler deployment plans start first with the sprinkler and then are reverse engineered to the water source; this will determine flow, pressure, and needs for the system.
4. A Reliable water supply is essential. Consider backup power for community water systems.
5. Plan to have a representative from the power and water utility on site during operations.

## BEST PRACTICES - DEPLOYMENT

The following best practices have been identified during a sprinkler deployment:

1. Make the decision to request outside resources early. There is a lag in deployment because the dispatch and travel of fire crews can take several hours. Fire crews benefit from arriving at the incident and having time to become familiar with the situation.
2. The rapid return of firefighters once the wildfire has passed is critical. Structure protection using sprinklers relies on the follow-up of firefighters to suppress any spot fires ignited by firebrands or structural elements that might be burning.
3. The identification of safety zones for firefighters based on anticipated wildfire conditions, wind direction, crew experience, and training may need to be decided during the incident. A strategy of Prepare and Defend will rely on well-defined safety zones.
4. For responses in rural areas, accurate maps with structure locations are needed. County or regional district GIS departments often have the most up-to-date maps showing the location of critical infrastructure and residential dwellings. These maps can be important when vegetation obscures structure locations.
5. Once sprinklers are deployed, test the system and fine-tune the spray pattern of the sprinklers to ensure that:
  - a) the sprinklers are aimed to wet the Structure Ignition Zone (the area directly adjacent to the walls) and any decks or other attached structures; and

- b) the sprinklers will not cause water damage to the building. Avoid having sprinklers spray directly at windows and doorways. If sprinklers are located on the roof, cover vents and any other air circulation entry point where water and firebrands might access the attic.
- 6. Protect fire hose lines from catching fire by laying the hose on mineral soil and, where possible, configure the line so it stays wet during operation. When laying hose, stay close to the structure. Use percolating hose in situations where there is potential for more intense fire.
- 7. Tripods provide height to overcome vegetation and provide better casting distance than ground installed sprinklers.
- 8. Sprinklers do not need to be run for several hours in advance of the fire event. Activate the sprinklers a short time before the fire arrives (FPInnovations research has shown that as little as 10 minutes is needed). Sprinklers are most useful when applying water during fire impingement to keep combustible materials wet. It is critical that the water delivery system not run dry before fire arrival.
- 9. FPInnovations research has shown that operating sprinklers for long periods to produce a humidity bubble or humidity dome is ineffective during windy conditions. Water vapour is light and is easily transported downwind during wildfire events. Any water vapour (humidity) produced dissipates as it blows away.
- 10. Sprinklers need to be tested and adjusted to ensure that the Structure Ignition Zone will be wet. Once readied, the sprinklers do not need to be run for long periods.
- 11. When drawing water from a lake, pond, or relay tank, ensure that the end of the suction hose will not be clogged or plugged by debris. Two problems can be caused by conifer needles and other debris: (1) they can reduce pump suction when entering the foot valve, and (2) if they enter the hose, they can plug or constrict sprinkler nozzles. Sprinkler line patrols can help clean nozzles. Maintenance of sprinklers needs to be part of the operation.
- 12. Fire crews should determine what types of spare valves and connectors will be needed for their community. A box of adapters such as 7.6-cm (3-in.) camlocks for water tanks, swedges for 400 barrel tanks or other water storage tanks, and connectors with quick connect and municipal thread can be helpful.
- 13. Be prepared to deal with pets. Bring dog treats.
- 14. Recover equipment quickly and prepare for redeployment.



# APPENDIX D: EVALUATING COMMERCIALLY AVAILABLE PUMPS FOR USE IN THE WILDLAND-URBAN INTERFACE

*MERCEDES TEXTILES' PUMPS - WICK 375, WICK 100G, AND THE  
WICK SI 300-10B*

Razim Refai

April 2019

This report is not restricted.

This document contributes to the state-of-practice review of water delivery systems (sprinklers) in the wildland-urban interface (WUI). Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).

Several commercially available pumps for wildfire suppression are also used in sprinkler operations in wildland-urban interfaces (WUI). Given the variety of pumps on the market, a standard test methodology is needed to understand how different pumps perform against key metrics such as pressure, flow rate, casting distance, fuel economy, etc.

In this report, a standard test methodology was developed and used to evaluate three portable fire pumps: Mercedes Textiles' WICK 375, WICK 100G, and WICK Si 300-10B. Important data on key performance metrics were gathered and presented to help end users assess which pumps best suit their needs.

301012735: FRIAA SPRINKLER PROJECT

TECHNICAL REPORT

#### **ACKNOWLEDGEMENTS**

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## 1. INTRODUCTION

This project is supported by the Forest Research Improvement Association of Alberta (FRIAA). Through a state-of-practice review of water delivery systems (sprinklers) used in the Wildland-Urban Interface (WUI), FPInnovations confirmed that there is no national approach to developing or evaluating wildfire equipment or techniques for the WUI in Canada.

FPInnovations believes that the lack of a process or organization to help foster and evaluate products, in Canada, limits the development and implementation of new technologies and information sharing between agencies. FPInnovations examined the feasibility of conducting these evaluations on wildfire pumps.

There are several commercially available pumps for use in wildfire suppression and community protection operations in the WUI. The Waterax Mark-3 pump is the most widely used pump for wildfire operations in Canada. Other pumps are commercially available to wildfire and municipal firefighting agencies. Knowledge of the strengths and weaknesses of different pumps is critical to make informed investment and tactical decisions.

The purpose of this project is two-fold: First, develop a standard test methodology to evaluate how well commercially available portable low-volume, high-pressure pumps support sprinkler operations. Second, use the methodology to evaluate different pumps based on five key metrics: pressure, flow rate, sprinkler casting distance, fuel consumption, and number of sprinklers supported without significant loss of head pressure. Data from this test will form a benchmark from which comparative analyses of other commercially available pumps can be conducted under the same conditions. The learnings from this evaluation will also allow FPInnovations to refine the methodology and establish a framework for a larger equipment evaluation program that will help enable agencies to select appropriate equipment based on their specific needs.

This test methodology is not meant to replace the tests done by the US Forest Service but rather to supplement the information presented there. Their Qualified Product List (QPL) focuses on endurance testing, which is a key indicator of pump performance. The test conducted during this project did not include or attempt to replicate the endurance test.

Three portable fire pumps were tested: Mercedes Textiles' WICK 375, WICK 100G, and WICK Si 300-10B. Mercedes Textiles pumps are not widely used in Alberta; therefore, their operational performance has not been well documented.

## 2. PUMP PROFILES

The three pumps selected for this test, the WICK 375, WICK 100G and the WICK Si 300-10B are all commercially available portable pumps. A comparative profile has been included below in Table 1.



Figure 1(a). WICK 375.\*



Figure 1(b). WICK 100G.\*



Figure 1(c). WICK Si 300-10B.\*

Table 1. Pump profiles

Product	Engine	Pump	Dimensions	Weight (Dry)	Suction	Discharge	Max Pressure*	Cost**
WICK 375	10 HP, 2 stroke	4 stage	57.8 x 26.2 x 36.2 cm (22.7 x 10.3 x 14.2 in)	25.4 kg (56 lbs)	2" (50 mm)	1.5" (38 mm)	375 psi (2585 kPa)	4,500 CAD
WICK 100G	2.4 HP, 2 stroke	1 stage	33 x 28 x 29 cm (12.9 x 11.0 x 11.4 in)	7.9 kg (17.4 lbs)	1.5" (38 mm)	1.5" (38 mm)	100 psi (689 kPa)	1,675 CAD
WICK Si 300-10B	10 HP,	3 stage	55.9 x 47.6 x 46.4 cm	39.5 kg	2"	1.5"	275 psi	3,000 CAD

	4 stroke		(21.6 x 18.7 x 18.26 in)	(87 lbs)	(50 mm)	(38 mm)	(1896 kPa)	
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*\* Mercedes Textiles product flyers: WICK 375 (2018), WICK 100G (2018), and WICK Si 300-10B (2018).*

*\*\* Manufacturer quotes obtained in October 2018. Pricing provided for comparison only and do not reflect the market price for anytime other than the date the quotes were received.*

The WICK 375 (Figure 1[a]) strikes a good balance between portability (weight) and pressure (owing to the four-stage pump head). The WICK 100G (Figure 1[b]) is a highly portable, lightweight pump. The WICK Si 300-10B ((Figure 1[c]) theoretically offers more volumetric efficiency and a longer engine lifespan due to its four-stroke engine.

Compared to the most common pumps used across Canada, the WICK 375 is comparable to the Mark-3 (Waterax), the WICK 100G is similar to the Mini-Striker (Waterax), and the WICK Si 300-10B is an approximate equivalent to the BB4 (Waterax).

### 3. RESEARCH SITE

The research site selection criteria included relatively flat ground with sufficient open space, minimal elevation gain or drop, and a consistent and reliable water source nearby. Flat ground minimized the influence of elevation changes on pressure readings. The research site selected for this project was the Athabasca Riverfront Park in Hinton, Alberta (Figure 2).



Figure 2. Research site - Athabasca Riverfront Park (white box).

Site information is shown above in Table 2. Areas of high slope/elevation were avoided as much as possible during testing. Testing occurred on October 4, 2018. The temperature was -5°C at 9 a.m. and 8°C by 4 p.m. The research site was initially covered with 2-4 cm of snow. However, as the day progressed, most of the snow cover disappeared (Figures 3[a] and 3[b]). Minimal wind/gusting occurred throughout the day.



Table 2. Athabasca Riverfront Park – site information

Water source	Athabasca River
Research site area	8,670 m <sup>2</sup> (28,444 ft <sup>2</sup> )
Elevation gain/loss	0 – 2.3 m (0 - 7.6 ft.)
Max slope	10%
Average slope	2.8%



Figure 3(a). Research site: 9 a.m.



Figure 3(b). Research site: 4 p.m.

## 4. TEST ASSEMBLY AND METHODOLOGY

In order to evaluate the pumps, a closed loop sprinkler configuration was selected. A closed loop configuration facilitated equal pressure throughout the hose line, allowing all sprinklers to have approximately the same casting distance. Sprinklers with the same casting distance would be the ideal setup for wildland-urban interface (WUI) applications, since even coverage is achieved.

Figure 4 is a schematic of the equipment layout and water flow. Water from the Athabasca River was pumped by a Mark-3 pump to a 9463 L (2500 gallon) bladder (Figure 5[a]), which served as a relay tank. Each of the three pumps being evaluated drew their water from the bladder. During the test, each pump was connected to a flow meter (Figure 5 [b]) and a pressure gauge



with one 30 m (100 ft.) long, 38-mm (1.5-in.) diameter forestry hose. The flow meter and pressure gauge were connected in tandem using quarter-turn connections with no hose between them. The pressure gauge outlet was connected to a wye from which a closed loop system was formed.

Water flowed from the wye through the closed loop system consisting of 17 units of 38-mm (1.5-in.) hose generating a total system length of 518 m (1700 ft.). At each hose junction, a Rain Bird (70CH) sprinkler with an orifice of 6.4-mm (1/4-in.) was connected to the supply line using a 16-mm (5/8-in.) garden hose. A total of 15 sprinklers were used during the tests. A second pressure gauge was installed at the location farthest from the pump to assess pressure in the weakest section of the loop and ensure that pressure loss due to friction was minimal. Operational data showed a difference in pressure gauge readings of one to five psi, a negligible value.

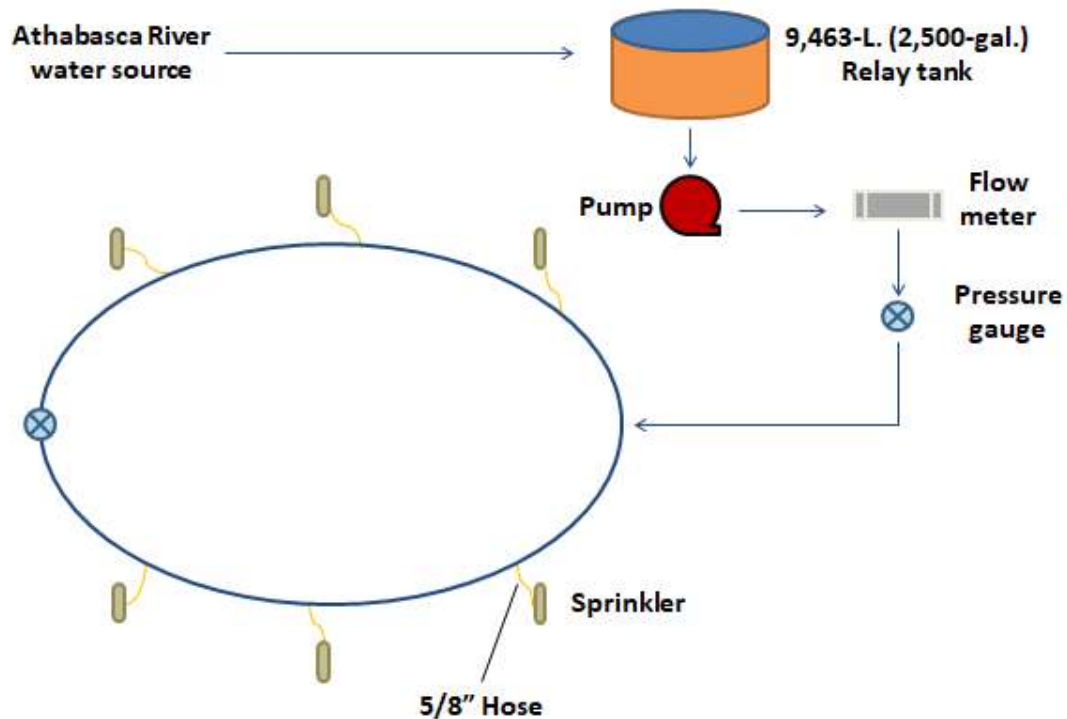


Figure 4. Equipment layout.

With the pump running and once the pressure gauges showed stable pressure, the sprinklers were opened one by one. Each time a sprinkler was opened, its pressure, flow rate, and casting distance were measured to help map pump curves and sprinkler coverage. The two pressure

gauges validated that the pressure was approximately equal along the closed loop system. Testing was stopped when any of the 15 sprinklers stopped rotating. When a sprinkler stops rotating, it is an indication of insufficient pressure in the system and hence was selected as the stopping point.



Figure 5(a). WICK 375 connected to a 9,463-L. (2,500-gallon) bladder.



Figure 5(b). Flow meter and pressure gauge 30-m. (100-ft.) from pump.

Fuel consumption was also calculated during each test and determined by measuring the amount of fuel before and after each test and comparing that to the pumps run-time. Fuel consumption was expressed in L/hr.

## 5. RESULTS

### WICK 375

#### PRESSURE VS. FLOW RATE

The maximum pressure observed when a single sprinkler was activated was 180 psi (1241 kPa). The flow rate was 30 gpm (6.8 m<sup>3</sup>/hr) and the casting distance was 14.5 m (47.5 ft). As sprinklers were sequentially activated, pressure in the loop decreased and flow increased. When all 15 sprinklers were activated, the pressure in the loop was 35 psi (241 kPa), the flow rate was 89 gpm (20.2 m<sup>3</sup>/hr) and the average casting distance was 8.6 m (28.2 ft).

The pump curve generated from the tests is shown in Figure 6 and is similar to the manufacturer-stated pump curve at higher flow rates. However, the pressure produced at lower flow rates (30-70 gpm or 6.8-15.9 m<sup>3</sup>/hr) is lower than what is stated in the manufacturer's pump curve. A comparison of Figures 6 and 7 (manufacturer's pump curve) at these flow rates illustrates this difference.

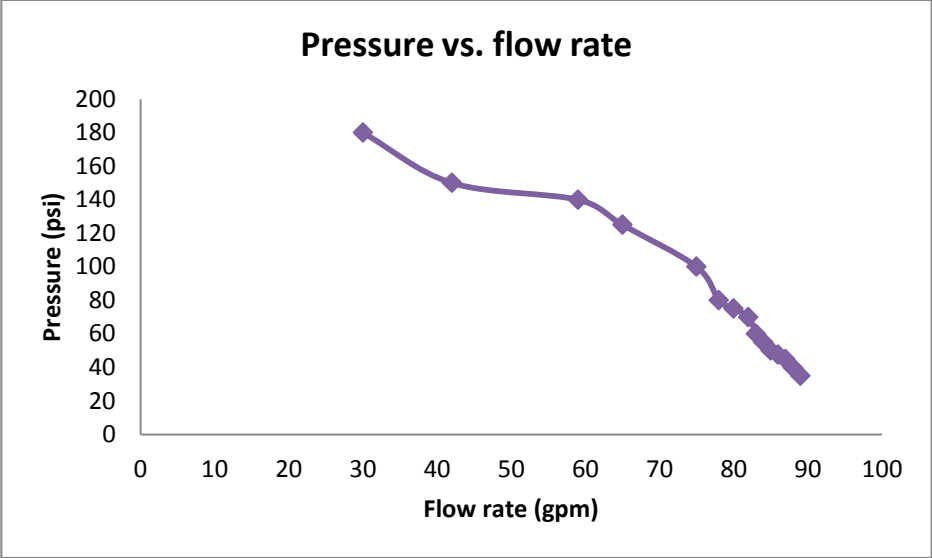


Figure 6. WICK 375 pressure vs. flow rate (pump curve from test).

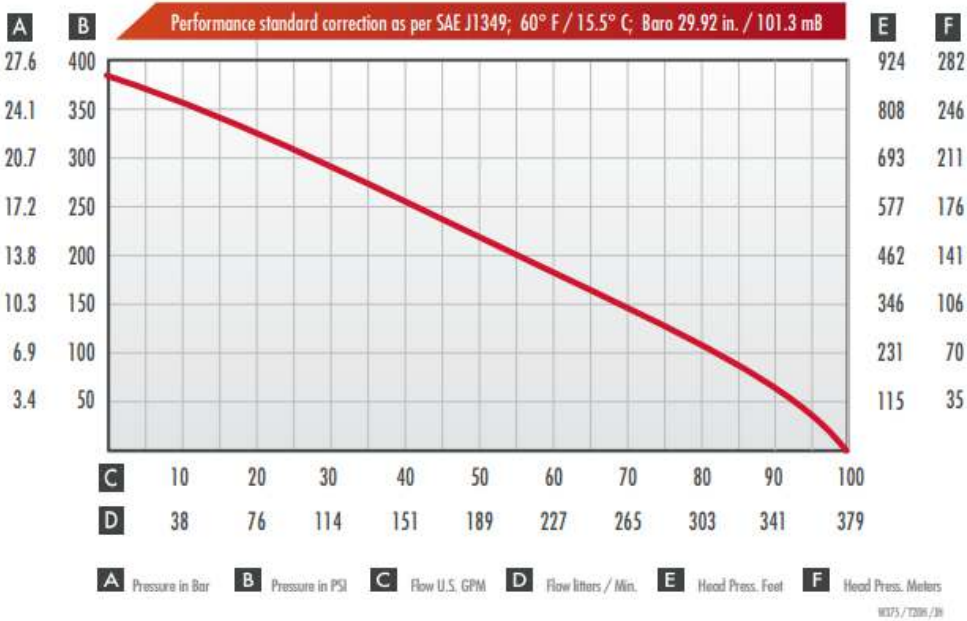


Figure 7. WICK 375 pressure vs. flow rate (pump curve from manufacturer - Mercedes Textiles Product Flyer: WICK 375 [2018]).

## PRESSURE REDUCTION IN LOOP

Pressure reduction in the loop as sprinklers were activated is presented in Figure 8. As each additional sprinkler was activated, the pressure in the loop decreased. Pressure in the loop with the WICK 375 started off at 180 psi (1241 kPa) with one sprinkler open and subsequently dropped to 35 psi (241 kPa) when all 15 sprinklers were open and still operational. Based on this information, users will be able to determine how many sprinklers they can activate based on desired or known system pressure.

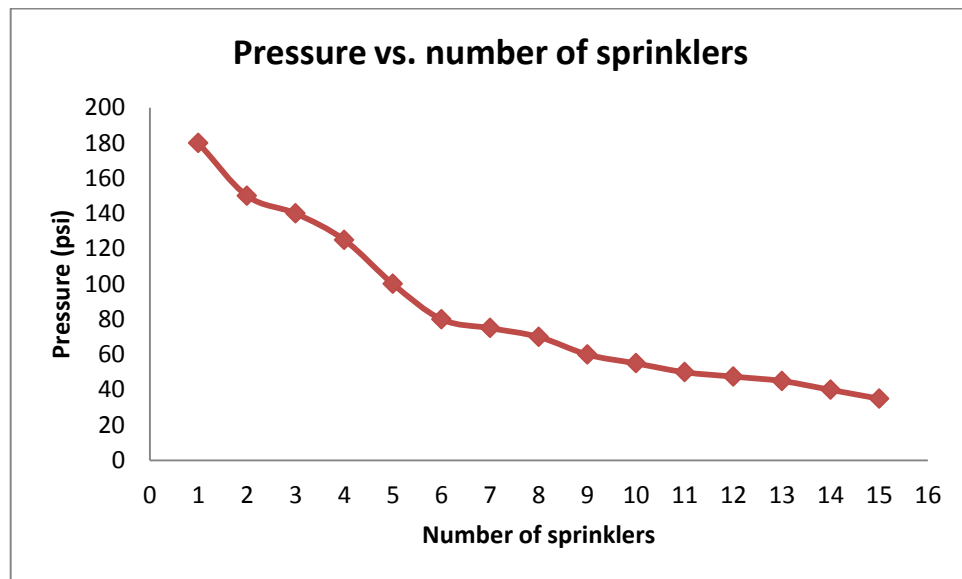


Figure 8. WICK 375 pressure vs. number of sprinklers.

## CASTING DISTANCE

The casting distance with the activation of additional sprinklers is showing in Figure 9. The maximum casting distance observed in the setup was 14.5 m (47.5 ft.) when just one sprinkler was open. As subsequent sprinklers were opened, the casting distance was reduced, reaching 8.6 m (28.2 ft.) when all 15 sprinklers were open. Based on the user's casting requirements in terms of area to be covered, sprinkler placement, and required overlap, the number of sprinklers required can be derived from this graph.

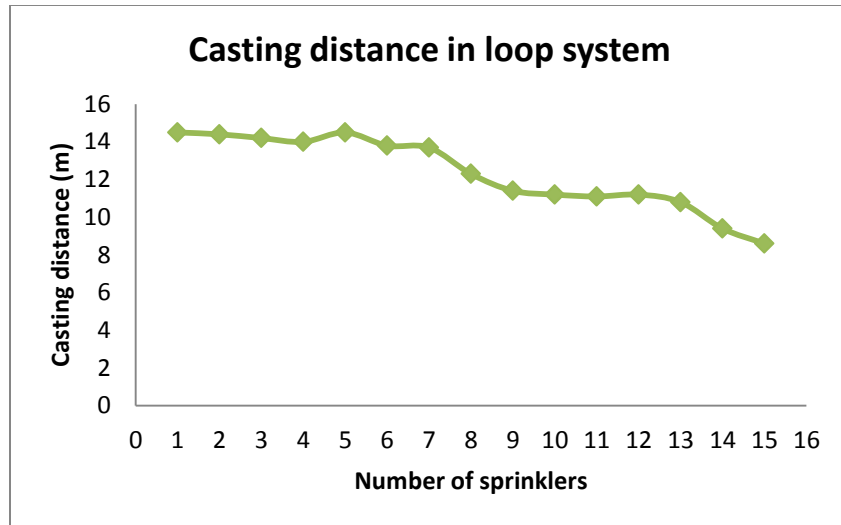


Figure 9. WICK 375 casting distance vs. number of sprinklers.

As a surplus data set, it was of interest to see the casting distance profile when the sprinklers were arranged in a linear configuration, i.e. dead end line, when all operational sprinklers in this setup are open. In the event a wet line needs to be created, this information would help to understand what casting distances can be expected when sprinklers are placed in a straight-line configuration using these pumps. A blank cap was installed on one outlet of the wye in order to switch the configuration from a loop setup to a straight-line setup. With 15 sprinklers open in a linear configuration, the casting distance was 14.5 m (47.5 ft.) at the first sprinkler and 2 m (6.5 ft.) at the fifteenth sprinkler (Figure 10). This shows us that only 5 sprinklers had a casting distance of above 8.6 m (28.2 ft.) in the straight line configuration whereas all 15 sprinklers had a casting distance of 8.6 m (28.2 ft.) in the loop configuration.

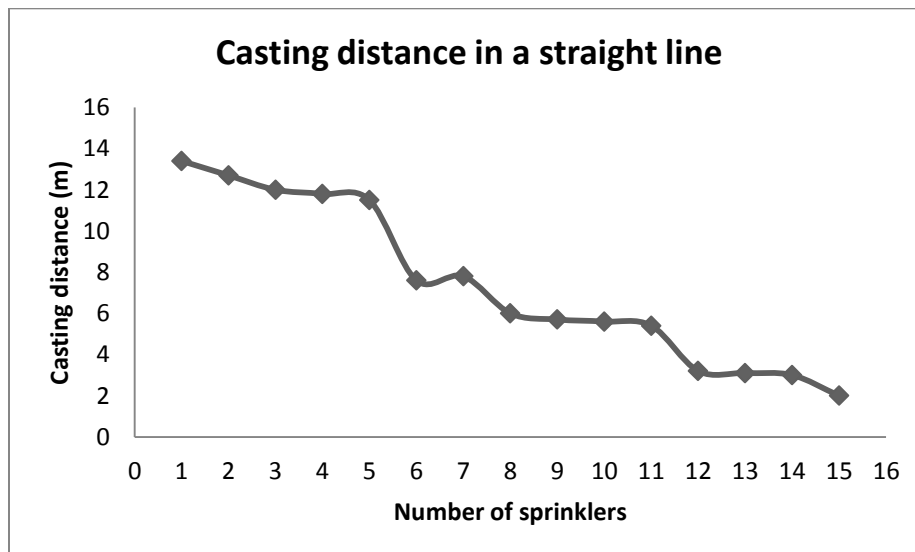


Figure 10. WICK 375 casting distance vs. number of sprinklers.

## FUEL CONSUMPTION

Based on the WICK 375's run time and the quantity of fuel used by the pump, the rate of fuel consumption was calculated to be 4.84 L/hr (1.06 gal/hr).

## WICK 100G

### PRESSURE VS. FLOW RATE

With a single activated sprinkler, pressure in the loop was 75 psi (517 kPa), with a flow rate of 15 gpm (3.4 m<sup>3</sup>/hr) and a casting distance of 15.2 m (49.8 ft.). As sprinklers were activated one by one, it was observed that when the twelfth sprinkler was activated, multiple sprinklers stopped rotating. Therefore, all results presented for the WICK 100G have data for 11 sprinklers only. With 11 sprinklers activate, the pressure in the loop was 30 psi (206 kPa), and the flow rate and casting distance were 50 gpm (11.3 m<sup>3</sup>/hr) and 4.7 m (15.4 ft.), respectively. It can be stated that the WICK 100G can support a maximum of 11 sprinklers in this specific sprinkler configuration before one or more sprinklers become non-operational. The generated pump curve is quantitatively similar to the pump curve provided by the manufacturer. A visual comparison of the test-generated pump curve and the manufacturer-stated pump curve is presented in Figures 11 and 12.

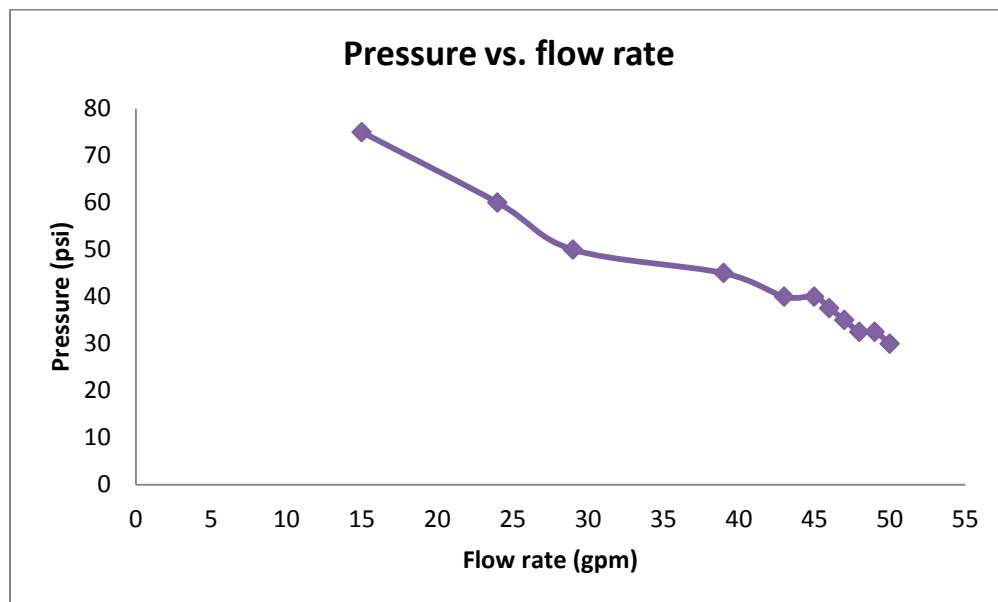


Figure 11. WICK 100G pressure vs. flow rate (pump curve from test).

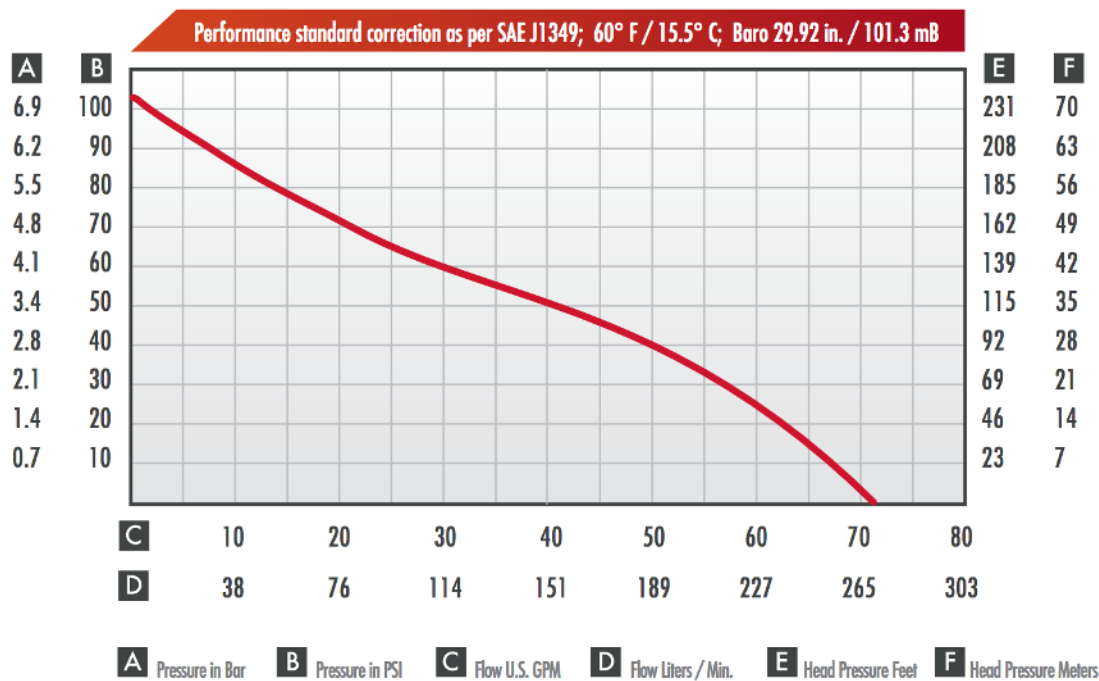


Figure 12. WICK 100G pressure vs. flow rate (pump curve from manufacturer - *Mercedes Textiles product flyer: WICK 100G [2018]*).

### PRESSURE REDUCTION IN LOOP

Pressure reduction in the loop as sprinklers were opened is presented in Figure 13. Pressure in the loop with the WICK 100G started off at 75 psi (517 kPa) when one sprinkler was activated and dropped to 30 psi (206 kPa) when 11 sprinklers were activated. As mentioned before, the activation of the twelfth sprinkler resulted in a further drop in pressure, i.e. below 30 psi (206 kPa). Multiple sprinklers in the system stopped rotating because of this drop in pressure and were deemed non-operational.

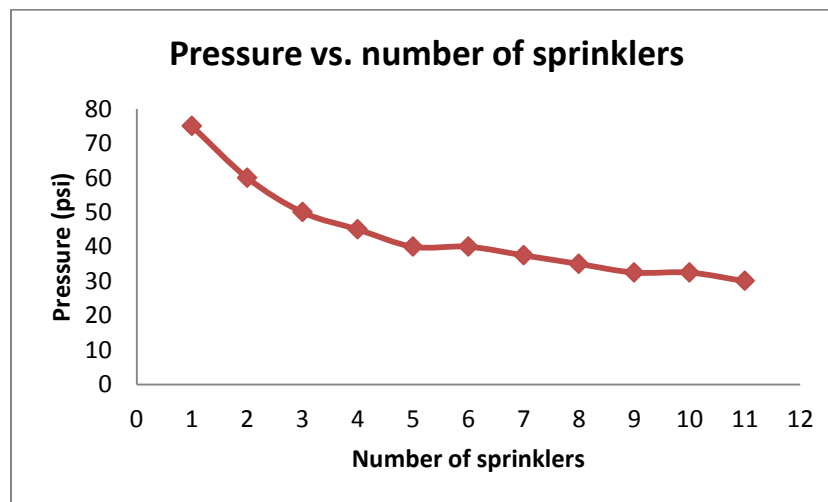


Figure 13. WICK 100G pressure vs. number of sprinklers.

### CASTING DISTANCE

The variation in casting distance in the test involving the WICK 100G is presented in Figure 14. Casting distance decreased from 15.2 m (49.8 ft.) when one sprinkler was activated to 4.7 m (15.4 ft.) when 11 sprinklers were activated. It is important to note that while 11 sprinklers were still rotating and active, having a casting distance as low as 4.7 m (15.4 ft.) may not be beneficial in WUI applications.

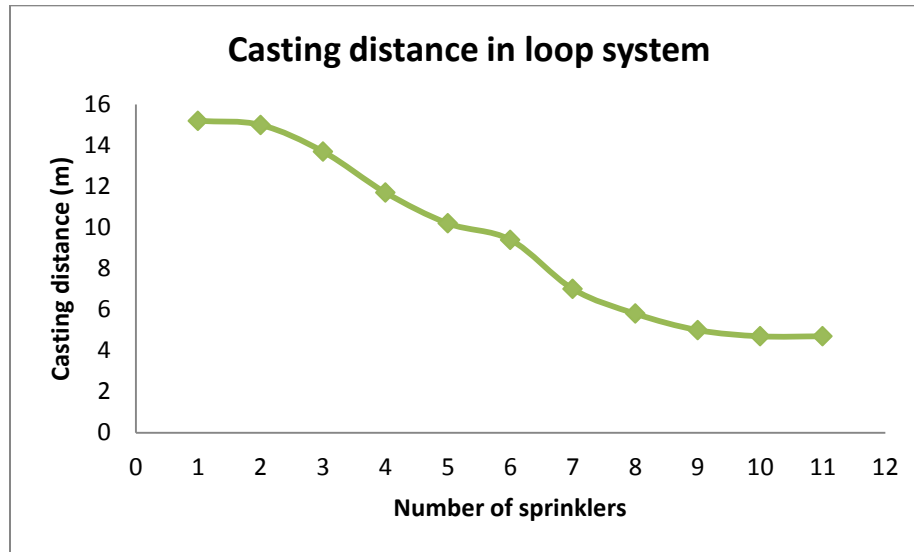


Figure 14. WICK 100G casting distance vs. number of sprinklers.

With 11 sprinklers open in a linear configuration, the casting distance was 8.4 m (27.5 ft.) at the first sprinkler and 4.4 m (14.4 ft.) at the eleventh sprinkler (Figure 15). The value of the loop configuration is highlighted again, where a total 15 sprinklers had a casting distance of 4.7 m (15.4 ft.) each whereas the straight line configuration had only 7 sprinklers with casting distances above 4.7 m (15.4 ft.).



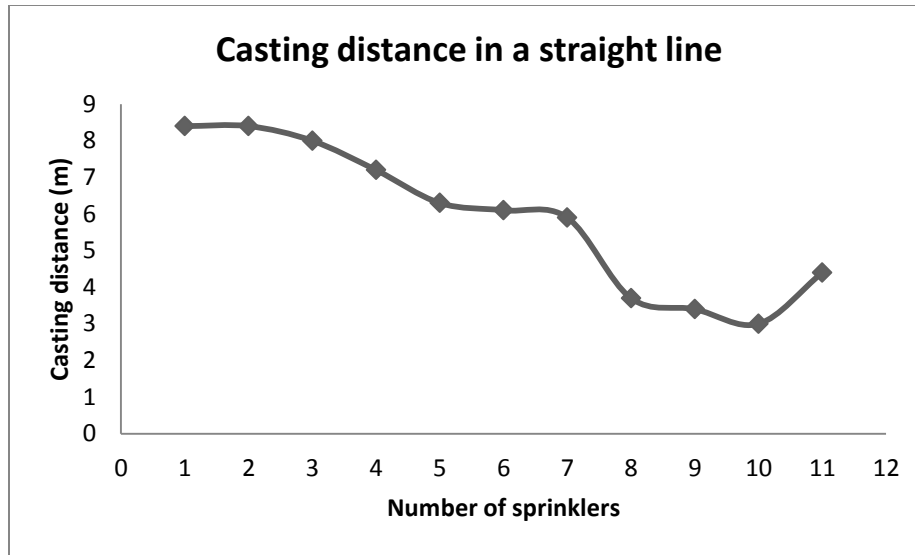


Figure 15. WICK 100G casting distance vs. number of sprinklers.

## FUEL CONSUMPTION

Based on the WICK 100G's run time and the quantity of fuel used by the pump, the rate of fuel consumption was calculated to be 1.14 L/hr (0.25 gal/hr).

## WICK Si 300-10B

### PRESSURE VS. FLOW RATE

The pump curve generated from the WICK Si 300-10B tests is presented in Figure 16. Pressure in the loop was 195 psi (1344 kPa) when one sprinkler was activated and decreased to 47.5 psi (327.5 kPa) when all 15 sprinklers were activated, with respective flow rates of 24 gpm (5.4 m<sup>3</sup>/hr) and 88 gpm (19.98 m<sup>3</sup>/hr), and casting distances of 26 m (85.3 ft) and 10.1 m (33.1 ft). The pump curve generated from the tests is quantitatively similar to the pump curve provided by the manufacturer, as seen in Figures 16 and 17.

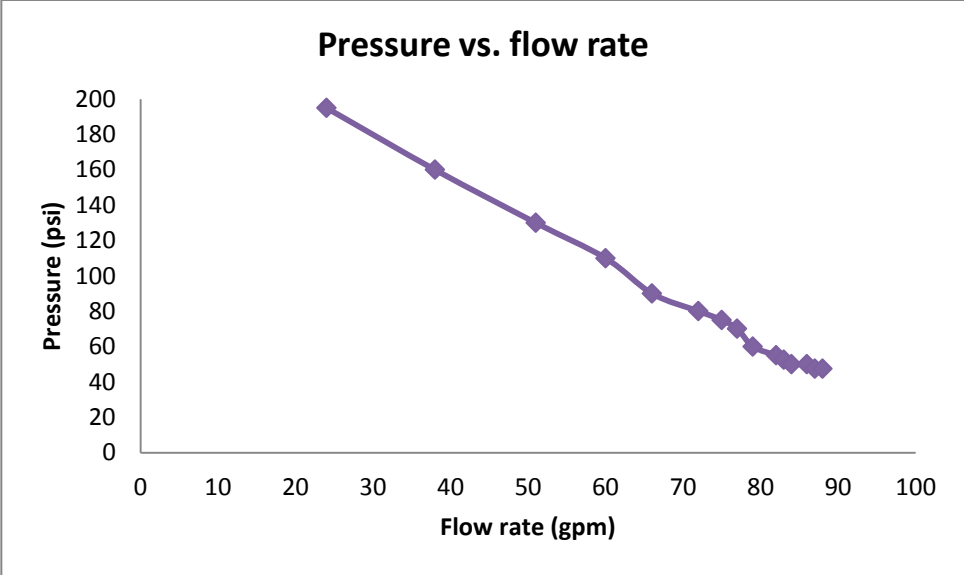


Figure 16. WICK Si 300-10B pressure vs. flow rate (pump curve from test).

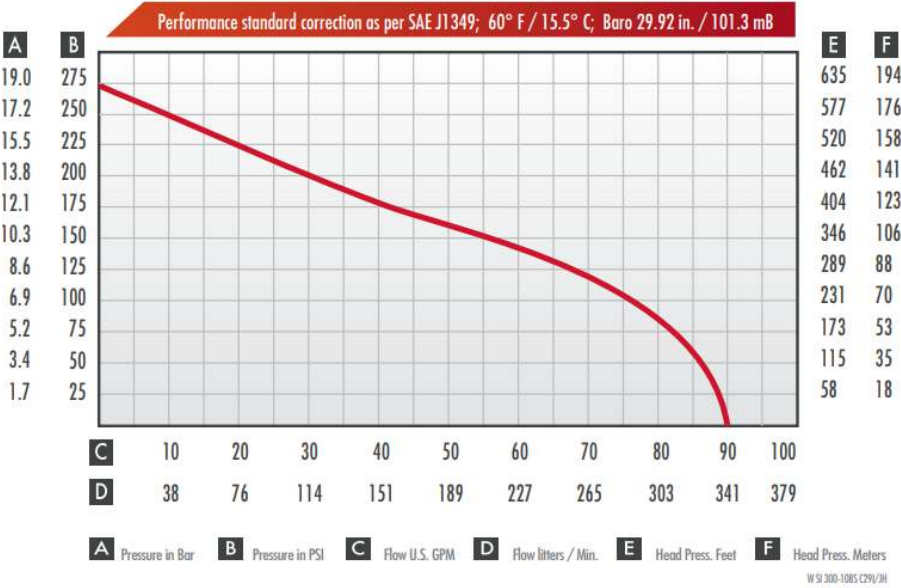


Figure 17. WICK Si 300-10B pressure vs. flow rate (pump curve from manufacturer - Mercedes Textiles product flyer: WICK Si 300-10B [2018]).

### PRESSURE REDUCTION IN LOOP

The pressure in the loop with the WICK Si 300-10B was 195 psi (1344 kPa) when a single sprinkler was activate and subsequently fell to 47.5 psi (327.5 kPa) when all 15 sprinklers were active and still operational.

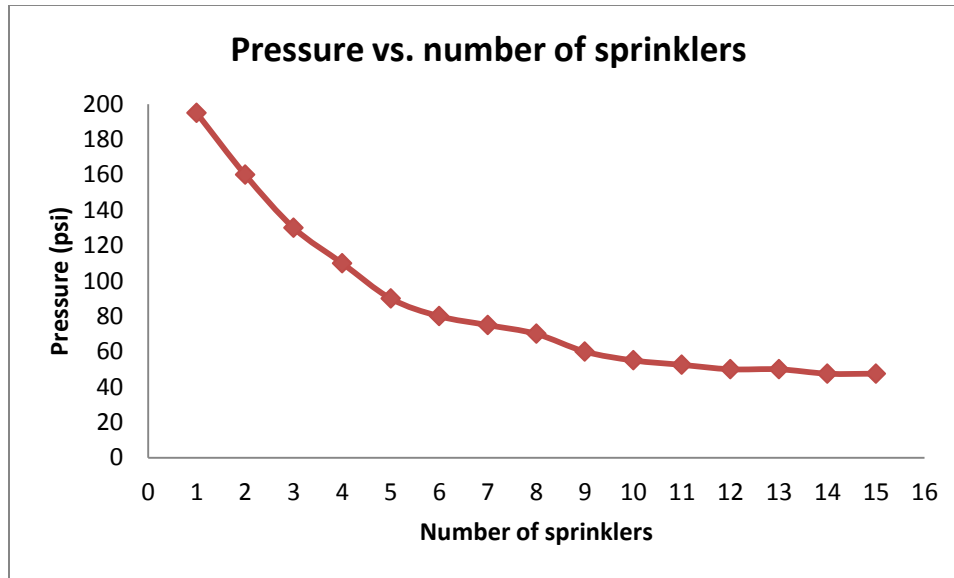


Figure 18. WICK Si 300-10B pressure vs. number of sprinklers.

### CASTING DISTANCE

The casting distance in the system decreased from 26 m (85.3 ft.) when one sprinkler was activated to 10.1 m (33.1 ft.) when all 15 sprinklers were activated, as shown in Figure 19. It should be noted that there was significant misting for the first six sprinklers when the WICK Si 300-10B was used. Misting makes it difficult to measure casting distances and therefore must be taken into consideration when assessing data from Figure 19. An increase in casting distance was observed in sprinkler 15. This was caused by elevation changes.

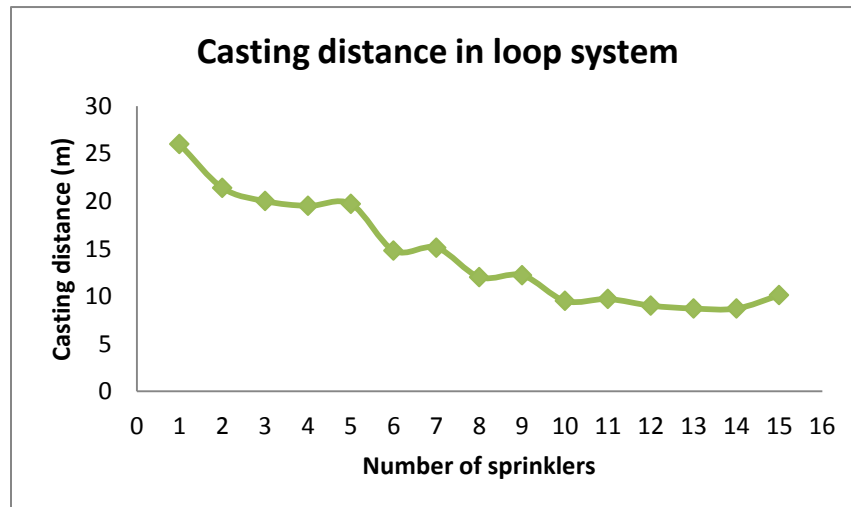


Figure 19. WICK Si 300-10B casting distance vs. number of sprinklers.

With 15 sprinklers open in a linear configuration, the casting distance was 15.2 m (49.8 ft.) at the first sprinkler and 2.6 m (8.5 ft.) at the fifteenth sprinkler (Figure 20). Once again, the loop configuration was able to sustain more sprinklers at a higher casting distance i.e. 15 sprinklers above 8.7 m (28.5 ft.) whereas the straight line configuration was able to sustain only 6 sprinklers above 8.7 m (28.5 ft.).

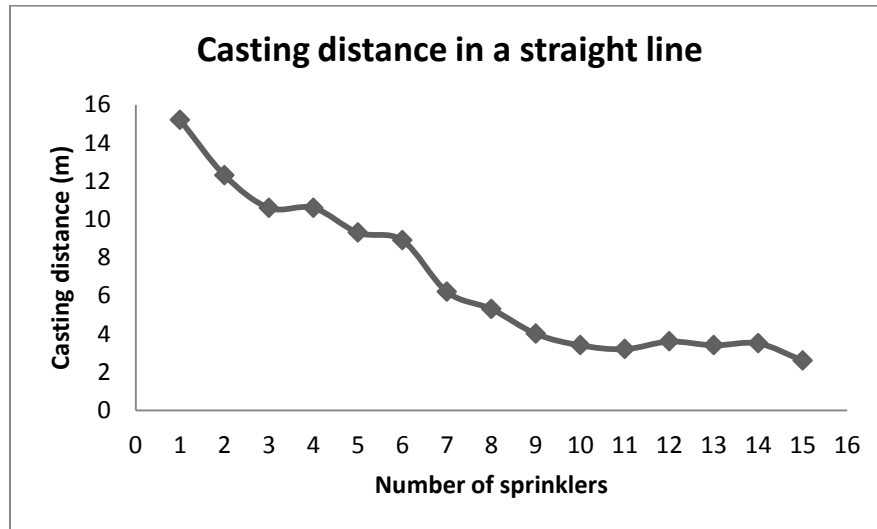


Figure 20. WICK Si 300-10B casting distance vs. number of sprinklers.

## FUEL CONSUMPTION

Based on the WICK Si 300-10B's run time and the quantity of fuel used by the pump, the rate of fuel consumption was calculated to be 3.72 L/hr (0.82 gal/hr).

## 6. DISCUSSION

**Test:** The pressure and flow rate presented in this report represent what can be considered ideal logistic conditions for a sprinkler setup. In practice, variability in terrain, water source, environmental conditions, etc. will have to be taken into consideration. This test methodology does, however, provide a way to evaluate different pumps under the same conditions, allowing for new pumps to be evaluated against existing pumps under the same conditions.

**Pump curves:** The pump curves generated in this report are similar to, but not exactly the same as, the manufacturer-stated pump curves. These differences are to be expected and can be attributed to several factors, including, but not limited to, environmental factors such as pressure and temperature of surroundings and working fluids. (Manufacturer-stated pump curves are corrected as per SAE J1349, which standardizes the performance curve for a specific temperature and pressure [15.5°C (59.9 F); 101.3 mB (75.9 mm of Hg)].) Minor differences in pumps were due to tolerances in the manufacturing process, system pipe friction, operational error, user error, etc. also contribute to any deviations from the manufacturers' pump curve.

**Coverage area:** The establishment of the termination point of the sprinkler configuration was when one or more sprinklers were deemed non-operational. However, in practical sprinkler applications, the overlap of coverage area must be considered. If hoses are laid out to cover maximum ground, the minimum criteria for overlapping sprinklers are estimated to be ~14-15 m (~45.9-49.2 ft.) of casting distance. (The length between two sprinklers is approximately 30 m (100 ft.). Approximation here is a result of forestry hose not always being exactly 30 m (100 ft.) long. Based on the above criteria, the WICK 375 and Si 300-10B would be able to sustain seven sprinklers, while the WICK 100G would be able to sustain two or three sprinklers for optimum overlapping conditions, as seen in Figures 9, 13, and 16.

**Nozzle size:** The number of sprinklers that a pump can support is also dependant on the type of sprinkler used. Changing the nozzle size (orifice size) on a sprinkler changes its flow rate, which can result in a difference in establishing how many sprinklers can be supported on a specific pump for optimum overlapping conditions.

## 7. CONCLUSIONS

A standard test methodology was developed to evaluate different commercially available pumps for use in sprinkler operations in a WUI environment. Three portable fire pumps – Mercedes Textiles’ WICK 375, WICK 100G, and WICK Si 300-10B – were tested in a closed loop system with 15 Rain Bird sprinklers. Pressure, flow rate, casting distance, and fuel consumption data were successfully gathered for all three pumps. Data from the tests were processed and presented so that end users can select pumps based on their desired use. The test methodology also allows for new pumps on the market to be tested and compared to existing pumps under the same conditions.

## 8. REFERENCES

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Mercedes Textiles Website – WICK 100G Product Specification Sheet - [http://www.mercedestextiles.com/media/ecommerce\\_product.pdfFlyer/en-CA/Wick%20100G.pdf](http://www.mercedestextiles.com/media/ecommerce_product.pdfFlyer/en-CA/Wick%20100G.pdf), Accessed on 18<sup>th</sup> October 2018.

Mercedes Textiles Website – WICK Si 300-10B Product Specification Sheet - [http://www.mercedestextiles.com/media/ecommerce\\_product.pdfFlyer/en-CA/Wick%20Si%20300-10B.pdf](http://www.mercedestextiles.com/media/ecommerce_product.pdfFlyer/en-CA/Wick%20Si%20300-10B.pdf), Accessed on 18<sup>th</sup> October 2018.

# APPENDIX E: CASE STUDY – KENOW WILDFIRE – ALBERTA, 2017

## *STRUCTURE PROTECTION IN WATERTON LAKES NATIONAL PARK*

Ray Ault and Steve Hvenegaard

April 2019

This case study is not restricted.

This case study contributes to the state-of-practice review of water delivery systems (sprinklers) in the wildland-urban interface (WUI). Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).

Sprinklers are used to protect structures from wildfire during wildland-urban interface (WUI) events across Canada. Traditionally, standard forestry equipment has been used in conjunction with impact sprinklers. FPInnovations is reviewing common practices and equipment used during sprinkler deployments, in Canada, to determine if they are the most appropriate for community structure protection, or if alternative approaches should be considered.

This case study documents the complex protection efforts for more than 450 structures during the Kenow wildfire that occurred in Waterton Lakes National Park in September 2017.

#### 301012735: FRIAA SPRINKLER PROJECT

#### CASE STUDY

#### ACKNOWLEDGEMENTS

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- Parks Canada
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- Montane Forest Management Ltd.

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## 1. INTRODUCTION

The use of forestry equipment (hose and pressure pumps) to support sprinkler systems is a common approach to protecting values at risk from wildfire in Canada. This case study is one in a series that explores the viability of various types of sprinkler systems for protecting residential and commercial structures from wildfire.

The extensive structure protection measures used in Waterton Lakes National Park during the Kenow wildfire in 2017 included the deployment of high-volume pumps with large diameter hose and sprinkler systems, in addition to traditional forestry equipment. This case study documents the structure protection efforts of Parks Canada and their partners during the fire.

The objectives of this case study were to:

1. document the structure protection initiatives undertaken for the Waterton townsite during the fire, including timelines, resources, logistics, and operations;
2. examine the efforts taken to protect remote structures within Waterton Lakes National Park; and
3. summarize this information so that other communities can learn from it and use it to develop their own wildfire protection plans.

## 2. SITE DESCRIPTION

Waterton Lakes National Park is located approximately 45 km south of Pincher Creek, Alberta. This national park is bordered by Glacier National Park in Montana to the south, by British Columbia to the west, the Municipal District of Pincher Creek to the north, and Cardston County to the east and northeast. The Waterton townsite is situated on the north end of Waterton Lake, at the base of the Rocky Mountains.

There were 52 structures that were considered remote values at risk along the Akamina Parkway and the Red Rock Parkway. These structures were considered remote because of poor access with long and exposed evacuation routes that posed safety concerns to firefighting resources. Among these structures were two fly-in backcountry cabins.

Within the Waterton Valley, 421 structures were considered to be at risk from the Kenow wildfire, including 374 structures in the townsite, the Prince of Wales Hotel and visitor centre and their 14 associated buildings, and 31 administrative buildings and support facilities in the Parks Canada operations compound. The townsite's water supply consists of a 378 541-L (100 000 US Gallon) underground reservoir.

### 3. WILDFIRE THREAT

#### 3.1 Kenow wildfire overview

On August 30, 2017, a lightning strike ignited a fire on Kenow Mountain in southeast British Columbia, approximately 10 km from the western boundary of Waterton Lakes National Park. Exceptionally hot weather, strong winds, and extremely dry conditions fuelled the extreme behaviour of the Kenow wildfire. When Parks Canada wildfire staff discovered the fire on August 30, 2017, they immediately recognized the potential for it to impact the park. Parks Canada requested the aid of an Incident Management Team, a Structure Protection Specialist and additional fire crews on September 2<sup>nd</sup>. The team and the specialist arrived on September 3<sup>rd</sup> and began structure protection initiatives with the fire crews. Additional structural firefighting crews arrived on September 8<sup>th</sup> and a Superintendent's Closure Order was issued. Fire crews held the fire at the park boundary for eight days, but on September 11<sup>th</sup>, it entered the park and burned across to the eastern boundary (approximately 25 km) in less than six hours. Embers carried by strong winds contributed to the rapid spread of the fire.

The fire crossed Akamina Pass and moved into the Cameron Valley, where prevailing southwest winds caused it to accelerate rapidly, pushing it down the Akamina Parkway toward the Waterton Townsite. On the same day, the fire spotted into the Blakiston Valley, gained intensity and developed into a second fire front that threatened the Red Rock Parkway and rapidly spread to the northeast. Firefighters worked tirelessly throughout the night to protect the Waterton townsite and the Prince of Wales Hotel. As winds funnelled up Waterton Lake from the south, they carried embers to the northeast, ultimately pushing embers and the fire away from the townsite. These winds, however, directed the fire towards the Parks Canada operations compound, which received the full impact of the wildfire. Within hours the Kenow fire burned across the park and into neighbouring Cardston County and the Municipal District of Pincher Creek. The Kenow fire burned 38.6% (19 303 ha) of Waterton Lakes National Park.

Parks Canada worked closely with partner agencies and neighbouring jurisdictions to protect its critical infrastructure and other values at risk within the Waterton Valley and in more remote areas of the park. The complexity of the event required the strategic use of traditional forestry equipment (i.e., pumps, hoses and sprinklers), high-volume pumps and hoses, and structural firefighting apparatus. The existing fuel treatment along the west-perimeter of the townsite had been well maintained and was reinforced with a sprinkler line. Fire crews created fuelbreaks around individual structures by burning off or removing flammable surface fuels. Helicopters dropped water on hotspots while class A foam was sprayed on picnic shelters, washrooms, and other visitor facilities. These tactics, along with other extensive fire protection measures were effective in safeguarding most of the values at risk within the park.

## 3.2 Kenow wildfire chronology

- Aug. 30 The Kenow wildfire was discovered in British Columbia.
- Sept. 3 The Incident Management Team and Values Protection Branch Director arrived and began risk assessments and planning for the protection of remote values at risk. Wildfire crews began deploying sprinklers, removing brush, and conducting grass burns.
- Sept. 4 A crew from RapidFire & Rescue Inc. (RapidFire) arrived and began installing sprinkler lines around the Waterton townsite and the Parks Canada operations compound.
- Sept. 5 An evacuation alert was issued for the Waterton townsite.
- Sept. 6 A list of required firefighting apparatus (structural and wildland engines, water tenders and aerial trucks) was developed.
- Sept. 7 The list of firefighting apparatus was submitted to the Incident Commander and the Operation Section Chief. Structure protection and site preparation on critical infrastructure within the townsite and Parks operations compound began. A high-volume pump was installed to supply the sprinkler line that was deployed along the west-perimeter of the townsite to reinforce the existing fuel treatment.
- Sept. 8 A Superintendent's Closure order was issued for the Waterton townsite. A closure order for the front-country and the back-country had been issued earlier. The Deputy Fire Chief from Cardston arrived at the incident and was assigned the position of Deputy Values Branch Director. Municipal structural crews arrived and the installation of a high-volume water supply line to the Prince of Wales Hotel began. A flow test of the sprinkler systems along the Red Rock Parkway was conducted and foam was applied to the values at risk in this area.
- Sept. 9 The Values Protection Branch was organized into two divisions:
1. Townsite Division: provided crew orientations and conducted structure and site preparation activities
  2. Prince of Wales Division: provided crew orientations and established the water supply from Emerald Bay to the hotel

Within the Values Protection Branch two groups were established:

1. Remote Values Group: set up sprinklers and applied foam on values along the Red Rock Parkway and the Akamina Parkway, assisted the Townsite and the Prince of Wales Divisions with structure and site preparation activities
2. Water Supply Group: deployed a high-volume water line to the Prince of Wales Hotel, operated the perimeter sprinkler line around the townsite perimeter, and applied foam to values at risk along the Red Rock Parkway

Sept. 10 The Values Protection Branch director ordered and received additional resources to replace Parks Canada wildland crews that were being reassigned to protect remote structures.

The Remote Values Group moved from the Values Protection Branch to the Wildfire Branch for the Sept. 11<sup>th</sup> operational period. This allowed the Values Protection Branch to focus on protecting values at risk in the Waterton Valley and the Wildfire Branch to focus on protecting remote values at risk, and containing the wildfire.

Sept. 11 Structural protection objectives were achieved. Sprinklers were set up for priority infrastructure, structure and site preparations were complete, and the establishment of the water supply line to the Prince of Wales Hotel was completed.

At 1830 hours, the Operations Section Chief requested that the Values Protection Branch activate the sprinklers in preparation for impingement. By 1915 hours, all sprinklers were active and propane tanks were shut off in the Townsite Division. At 2000 hours, the Operations Section Chief reported that the fire has stalled at Lineham Creek and the high-volume water supply line to the Prince of Wales Hotel was turned off. However, at 2115 hours the fire began to progress again down the Akamina Valley and the high-volume water supply line to the Prince of Wales Hotel was restarted. At 2215 hours, the fire was located just above the townsite and the Townsite Division began to apply foam to combustible roofs.

Sept. 12 Replacement crews were requested for the Values Protection Branch at 0000 hours.

The Prince of Wales Hotel, the Parks Canada operations compound, the golf course, and the stables are surrounded by fire; the visitor centre and the Prince of Wales wood shop were lost at 0100 hours. By 0400 hours, the intensity of the fire behaviour decreased and replacement crews arrived at 0800 hours.

## 4. DATA COLLECTION

FPIInnovations interviewed members of the Kenow wildfire Incident Management Team as well as the operational personnel who were responsible for developing and implementing the structure protection initiatives. Our interviews focused on:

- processes for dispatching structural protection resources
- strategies and tactics
- prioritization of critical infrastructure
- resource requirements and availability
- deployment timelines and time constraints
- equipment configuration
- types and number of equipment deployed
- results of the protection efforts

## 5. FINDINGS

### 5.1 Structure Protection

Within Waterton Lakes National Park there were 473 structures at risk, so structure protection was separated into three main areas: the Akamina Parkway, the Red Rock Parkway, and the Waterton Valley. A values protection summary is included as Appendix 1 that identifies the values at risk, total resources committed over the duration of the incident, number of structures, strategic actions and tactics, as well as the structure protection outcomes.

#### 5.1.1 Akamina Parkway

The strategy for the Akamina Parkway was prep-and-go: prepare structures for wildfire and evacuate the area before the fire arrives. The remoteness of the structures along this parkway, the long, exposed evacuation route, and the potential for reduced visibility from smoke meant that firefighters could not safely stay and defend. No one was in the area when these structures were challenged by wildfire.

The crews that worked on preparations along the Akamina Parkway included two Parks Canada crews (WLNP-4, LMNP-4) and one wildfire crew from Ontario Ministry of Natural Resources (Ontario-4).

There were 14 structures along the Akamina Parkway. This included 10 buildings at Cameron Lake, an Alpine Club of Canada hut and outbuilding, and a ski shelter with an adjacent outbuilding at Little Prairie. Sprinkler systems were installed on all 14 buildings. These systems consisted of Waterax Mark-3 pressure pumps and impact sprinklers. The sprinklers were attached to the gable ends of the structures, and water was pulled from natural sources (creeks and lakes).

When the fire burned into the Akamina Parkway, it flanked the 10 buildings at Cameron Lake. These buildings survived. It is believed that the reduced fire intensity and the fire-resistant cladding used on these newly constructed buildings contributed to their survival.

The fire burned right up to the sprinkler lines at the Alpine Club of Canada hut and outbuilding, and both buildings survived. The ski shelter at Little Prairie received fire damage, and the outbuilding was destroyed.

### 5.1.2 Red Rock Parkway

The strategy for the Red Rock Parkway was also prep-and-go for the same reasons as the Akamina Parkway. The crews that worked on preparations along the Red Rock Parkway included two Parks Canada crews (WLNP-4, LMNP-4), one crew from Ontario Ministry of Natural Resources (Ontario-4), and eight firefighters from RapidFire.

There were 38 structures at risk along the Red Rock Parkway. Protection preparations were conducted on 29 of these structures. Preparations included the installation of sprinklers, fuel removal with chainsaws and drip torches, and application of Class A foam. Foam was applied using two RapidFire Type 3 wildland engines supported by a water tender (Figure 1).



Figure 1. A wildland engine applying foam.  
(Courtesy: RapidFire & Rescue Inc.)



Figure 2. The perimeter sprinkler lines reinforcing the forest fuel treatment.  
(Courtesy: RapidFire & Rescue Inc.)

The following five structures at three day-use areas were prepared for wildfire:

- Red Rock Canyon day-use building
- Lost Horse Creek day-use site with two buildings
- Coppermine Creek day-use site with two buildings

Preparations for these structures included fuel removal and application of Class A foam. Two of these structures survived, one received fire damage, and two were destroyed.

There were 12 structures at the Crandell Mountain campground. Sprinklers were installed on 3 of these including the entry kiosk, the generator shed, and the interpretive theater. The sprinkler system for the entry kiosk and the generator shed consisted of one Mark-3 pump

(pulling water from Blakiston Creek) and several impact sprinklers. The sprinkler system for the theatre consisted of three 9463-L (2500 US gal.) relay tanks, three Mark-3 pumps, and several orbital rooftop sprinklers. Two structures survived with no damage and one sustained damage. The nine unprotected structures were destroyed.

West of the Crandell Mountain campground was the Canyon Church Camp. Sprinklers were installed on the main lodge and 14 adjacent cabins. Two Mark-3 pumps ran in parallel to supply a 65-mm (2.5-in.) line to the camp. A 38-mm (1.5-in.) line ran through the camp to several impact and orbital sprinklers. The main lodge and six of the cabins survived; eight were destroyed.

Sprinklers were installed on two fly-in backcountry cabins; Snowshoe Cabin and Lone Lake Cabin, and their associated outbuildings. The fire stopped short of these sites and all six structures survived with no damage.

### **5.1.3 Waterton Valley**

The Waterton Valley included the (1) townsite, (2) Prince of Wales Hotel and visitor centre, and (3) Parks Canada operations compound. The strategy for the Waterton Valley was prep-and-defend, where crews and apparatus remained on-site during impingement.

On September 11<sup>th</sup>, there were 78 personnel in the Values Protection Branch assigned to protecting values at risk in the Waterton Valley. This included municipal firefighters, the RapidFire crew, the personnel required to attend to the Self Contained Breather Apparatus (SCBA) Cascade trailer and the Alberta First Responders' Radio Communications System (AFRRCS), and two Parks Canada public works staff to monitor the town's water system.

Equipment committed to values protection included four values-protection trailers, eight high-volume pumps and hose, six 9464-L (2500-US gal.) relay tanks, one SCBA trailer and one AFRRCS mobile communications unit. RapidFire provided two Type 4 wildland engines, an 11 356-L (3000-US gal.) tactical tender with BB4 pump and flex tank, and a flat deck rear-mounted crane truck to carry volume pumps.

#### **5.1.3.1 Townsite**

The townsite had a community wildfire protection plan<sup>1</sup> that was used to identify values at risk and determine values-protection strategies and tactics. The townsite consisted of 374 commercial and residential buildings. The structural protection tactics used for the townsite included:

- removing combustibles around structures, cleaning roofs and gutters, moving propane tanks and firewood, and blocking openings to flying embers;

---

<sup>1</sup> Waterton Valley Wildfire Suppression Plan (draft) March 29, 2012. Randall Schwanke, Fire Management Officer. Note: This is a comprehensive suppression plan for the townsite and backcountry.

- installing perimeter sprinkler lines to reinforce forest fuel treatments and protect structures;
- installing sprinklers on critical buildings using portable pumps to draw water from natural sources and from fire hydrants;
- establishing fire engine refill stations for bump-and-run operations; and
- ensuring that fire hydrant reservoir water levels were maintained.

Through mutual-aid and other agreements, a total of 19 firefighting apparatus were on-site when the fire passed through the townsite. This included five structural fire engines, eight wildland fire engines, two municipal aerial trucks, and four water tenders.

Eight members from RapidFire set up the perimeter sprinkler lines. The perimeter sprinkler lines were set up within a forest fuel treatment adjacent to the buildings on the west side of town (Figure 2). There were four lines, each requiring four hours to set up. The entire perimeter sprinkler system took two days to complete. The RapidFire team deployed two high-volume pumps (4543-L/min. (1200 US gal./min.): one at Cameron Bay pumping water north to Cameron Falls and another pumping water south from Emerald Bay to Cameron Falls. The 100-mm (4-in.) main supply line was 1600 m long and was connected to 65-mm (2.5-in.) branch lines that fed 38-mm (1.5-in.) parallel sprinkler lines. The sprinkler lines had approximately 25 sprinklers spaced 30 m (100 ft.) apart. One-inch (2.5-cm) head Rain Bird 70 CH sprinklers were used with various nozzle sizes. The sprinklers were attached to ground-level step spikes or 1 m tall portable stands.

In addition to the perimeter sprinkler lines, sprinklers were installed on six structures. Water for these sprinklers was supplied by Mark-3 pumps pulling water from either Waterton Lake or fire hydrants. A crew from Parks Canada set up these sprinklers. Class A foam was applied, by municipal fire engine crews, to approximately 30 structures that had combustible roofs.

Municipal engine crews patrolled the townsite for spot fires and suppressed any ignitions inside the sprinkler line. Four engine-refill sites were set up throughout the community to facilitate a bump-and-run strategy for the engines, which allowed them to extinguish spot fire ignitions as quickly as possible. The mobility of engines and crews was highlighted as a key component in the structure protection plan. One of these re-fill stations was located at the town boat launch, and included a high-volume pump and 100-mm (4-in.) hose line that was provided by the Lethbridge Fire Department.

The townsite's 378 541-L (100 000 US gal.) underground water reservoir gravity-feeds the fire hydrant system. Two water system attendants remained on-site as the wildfire passed through the townsite to ensure the system continued to provide water to structural crews.

#### **5.1.3.2 Prince of Wales Hotel and visitor centre**

The area surrounding the Prince of Wales Hotel and visitor centre included a total of 16 buildings. For the hotel, the RapidFire crew deployed two high-volume pumps (5110 L/min.



[1350 US gal. per min.]) at Emerald Bay (Figure 3) to supply water to two parallel 152-mm (6-in.) main lines to two City of Calgary aerial trucks. Both main supply lines had a boost pump midslope. No inline holding tanks were needed because each line had three inline pumps. Sprinklers were put in place along the main supply lines to prevent embers from igniting the grass and willow. The aerial trucks provided a steady stream of water and foam to the roof, decks, and walls of the hotel as the wildfire passed through the area (Figure 4).



Figure 3. High-volume pumps supporting the aerial trucks at the Prince of Wales Hotel. (Courtesy: RapidFire & Rescue)



Figure 4. Aerial trucks spraying the Prince of Wales Hotel. (Photo: Unknown source)

Impact sprinklers were installed to protect the staff accommodation buildings between the lake and the hotel. A structural engine crew patrolled the staff accommodations and extinguished spot fires.

The visitor centre was assessed as having a non-combustible roof and had a parking lot, green lawns, and a road surrounding it on three sides. No sprinklers were installed on the visitor centre. A patrolling structural engine crew came upon the visitor centre after it had ignited and attempted to suppress the fire from the outside, but the building was soon totally engulfed in flame.

The hotel, the staff accommodations, and many of the ancillary buildings survived the fire, but the hotel wood shop and the visitor centre were both destroyed.

#### **5.1.3.3 Parks Canada operations compound**

The operations compound consisted of 31 administrative buildings and support facilities, requiring that 250 m of perimeter sprinkler line be installed to the south. A Waterax BB4 (high-volume) pump supplied water to the sprinkler line from Waterton Lake across the highway from the compound. Eight structures had sprinklers mounted on their roofs. Water for these sprinklers was supplied by fire hydrants, two 9464-L (2500 US gal.) relay tanks (Figure 5), and portable pumps.

A 2460 L/min. (650 US gal./min.) trans-loading pump was also set up on the lake to support bump-and-run operations for water tenders.

The operations compound received the full onslaught of the wildfire, but 29 structures sustained no damage and only 2 outbuildings were destroyed. All wheeled heavy equipment had been removed from this area during the evacuation alert, which limited losses.



Figure 5. Relay tanks at the Parks Canada operations compound (Courtesy: Parks Canada).

## 6. DISCUSSION

A number of different agencies and resources were required to work together to implement the community wildfire protection plan. Many of the resources that were needed had to be requested through the Alberta Emergency Management Agency and the Office of the Fire Commissioner. It took time to dispatch the various resources and for those resources to travel, receive an orientation and briefing, and commence operations. The structure protection strategies and tactics used in Waterton Lakes National Park were fully implemented in eight days, which may not have been possible without an existing wildfire suppression plan. Without advanced planning, community protection strategies and tactics would have taken longer to develop and implement, and the structure loss may have been significantly higher.

The unified command decision, to implement a prep-and-defend strategy, was made possible by the identification and implementation of critical elements within the Waterton Valley Wildfire Suppression plan. This plan called for the establishment and maintenance of forest fuel treatments around the perimeter of the townsite, identified safety zones, and included protection plans for the numerous values at risk. The prep-and-defend strategy called for firefighters to remain onsite, as the fire impinged the community, to ensure sprinklers and other structure protection measures were not compromised. Without the existing forest fuel treatments, the risk of wildfire breaching the sprinkler lines would have been higher.

Members of the Values Protection Branch indicated that high-volume water delivery contractors were essential in providing an adequate water supply to a significant number of sprinklers, which resulted in the successful protection of many structures. However, a survey of contractors working in the wildland-urban interface, in Alberta, revealed that only a limited number of contractors have experience with both wildfire operations and high-volume pumps with large-diameter hose. The Lethbridge Fire Department provided a mobile high-volume pump with hose; however, few municipal fire departments have this capability. These could be limiting factors for future wildfire events if more than one Alberta community is at risk at a given time.

Tasks were assigned to firefighting crews based on their experience and strengths. Experienced contract structure protection crews were tasked with setting up water delivery equipment including pumps, water distribution lines, and relay tanks. Wildfire crews focused on forest fuel modifications using chainsaws, completing burnout operations and were essential to the rapid implementation of a variety of tactical plans. Municipal structural firefighting crews focused on installing sprinklers on structures.

Trigger points, conditions that would initiate a full evacuation of firefighting personnel, were established and communicated to all resources on the incident. If the water supply failed, if the fire within the wildland-urban interface exceeded the ability of the existing resources to prevent multiple structure ignitions, or if hazardous smoke conditions occurred, firefighting resources would retreat using pre-planned escape routes and safety zones.

Class A foam was applied on a number of remote structures. Research on the properties and operational effectiveness of water-enhancing gels is being undertaken to verify if these products provide longer-lasting protection. Depending on the results of this research, using gel products on structures could be considered where time or water supply is limited.

## 7. CONCLUSION

Complex wildland-urban interface events require the implementation of carefully designed structure protection strategies and tactics that include the deployment of a variety of different sprinkler systems. Pre-planning and training are critical, and deployment takes time.

The combined effort made in Waterton Lakes National Park during the Kenow fire is an excellent example of the successful execution of a community wildfire protection plan. The plan was executed without injury to the public, firefighters, or support staff. There were 473 structures threatened by the Kenow wildfire and 446 of those were protected because of the efforts of multiple agencies working through a unified command.

## APPENDIX 1

### 2017 Kenow Wildfire – Waterton Lakes National Park values protection summary

Value Name	Resources	No. of Structures	Strategic action	Tactic(s)	Structure protection outcomes		
					No damage	Damaged	Destroyed
<b>Akamina Parkway</b>		<b>14</b>	<b>Prep-and-go</b>				
Cameron Lake Day Use	▪ 2 - PC <sup>a</sup> crews	10		10 structures with sprinkler	10		
ACC Cabin	▪ OMNR <sup>b</sup> crew	2		2 structures with sprinklers	2		
Ski Shelter	▪ OMNR crew	2		2 structures with Sprinklers		1	1
<b>RED ROCK PARKWAY</b>		<b>38</b>	<b>Prep-and-go</b>				
Lone Lake warden cabin	▪ OMNR crew	3		3 structures with sprinklers	3		
Snowshoe warden cabin	▪ OMNR crew	3		3 structures with sprinklers	3		
Red Rock Canyon Day Use	▪ 2 - PC crews ▪ RapidFire crew	1		1- Burnout and apply Foam to structures	1		

Value Name	Resources	No. of Structures	Strategic action	Tactic(s)	Structure protection outcomes		
					No damage	Damaged	Destroyed
Lost Horse Cr Day Use	<ul style="list-style-type: none"> <li>2 - PC crews</li> <li>RapidFire crew</li> </ul>	2		2 – Burnout and apply Foam to structures	1	1	
Coppermine Cr Day Use	<ul style="list-style-type: none"> <li>2 - PC crews</li> <li>RapidFire crew</li> </ul>	2		2 – Burnout and apply Foam to structures			2
Canyon Camp	<ul style="list-style-type: none"> <li>PC crew</li> <li>OMNR crew</li> </ul>	15		15 structures with sprinklers	7		8
Crandell Mtn. Campground	<ul style="list-style-type: none"> <li>PC crew</li> <li>OMNR crew</li> </ul>	12		3 structures with sprinklers  9 structures received no protection	2	1	9

Value Name	Resources	No. of Structures	Strategic action	Tactic(s)	Structure protection outcomes		
					No damage	Damaged	Destroyed
<b>WATERTON VALLEY</b>		<b>421</b>	<b>Prep-and-defend</b>				
Townsite	<ul style="list-style-type: none"> <li>▪ RapidFire crew</li> <li>▪ Municipal fire crews</li> <li>▪ 2 - PC crews</li> <li>▪ OMNR crew</li> </ul>	374		1600 m – Perimeter sprinkler line  6 structures with sprinklers  Bump & Run with Engines	374		
Prince of Wales Hotel/visitor centre	<ul style="list-style-type: none"> <li>▪ Municipal fire crews</li> <li>▪ RapidFire crew</li> <li>▪ PC crew</li> <li>▪ OMNR crew</li> </ul>	16		Anchor & Hold with 2 – Aerial Apparatus  Bump & Run with Engines	14		2
Parks Canada operations compound	<ul style="list-style-type: none"> <li>▪ RapidFire crew</li> <li>▪ PC crew</li> <li>▪ OMNR crew</li> </ul>	31		250m – Perimeter sprinkler line 8 structures with sprinklers Bump & Run with Engines	29		2
<b>Total:</b>		<b>473</b>			<b>446</b>	<b>3</b>	<b>24</b>

<sup>a</sup> PC: Parks Canada

<sup>b</sup> OMNR: Ontario Ministry of Natural Resources

**Additional tactics conducted in all areas:**

- Cut and remove intermediate fuels (e.g., brush, grass etc.) surrounding structures – 10 sites
- Move firewood/deck furniture/propane tanks from structures – 25+ values
- Block openings (e.g., attic vents, eaves etc.) in structures to prevent embers from blowing inside the structure – 4 sites
- Establish five apparatus water- supply stations in the Waterton townsite. Relay tanks and high volume pumps and hose were installed at strategic locations to allow apparatus to refill their booster tanks quickly.

# APPENDIX F: CASE STUDY – ELEPHANT HILL FIRE, BRITISH COLUMBIA, 2017

*LOW-VOLUME, LOW-PRESSURE SPRINKLER DEPLOYMENT IN  
THE COMMUNITY OF SKEETCHESTN*

Ray Ault

April 2019

This case study is not restricted.

This case study contributes to the state-of-practice review of water delivery systems (sprinklers) in the wildland-urban interface. Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).



Sprinklers are used to protect structures from wildfire during wildland-urban interface events across Canada. Traditionally, standard forestry equipment has been used in conjunction with impact sprinklers. FPIinnovations is reviewing common practices and equipment used during sprinkler deployments, in Canada, to determine if they are the most appropriate for community structure protection, or if alternative approaches should be considered.

This case study documents the deployment of low-volume, low-pressure sprinklers in the First Nations community of Skeetchestn when threatened by the Elephant Hill fire in August, 2017.

#### 301012735: FRIAA SPRINKLER PROJECT

#### CASE STUDY

#### ACKNOWLEDGEMENTS

FPIinnovations would like to acknowledge the Forest Resource Improvement Association of Alberta (FRIAA) for funding this project, and the following agencies for their collaboration during the case study:

- British Columbia Office of the Fire Commissioner
- Skeetchestn First Nations
- Nelson Irrigation Corporation
- WASP Manufacturing Ltd.
- British Columbia Wildfire Service
- First Nations Emergency Services Society of British Columbia

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# 1. INTRODUCTION

The use of forestry equipment (hose and pressure pumps) to support sprinkler systems is a common approach to protecting values at risk from wildfire in Canada. This case study is one in a series that explores the viability of various types of sprinkler systems for protecting residential and commercial structures from wildfire.

Common forestry equipment used, by wildfire agencies, during sprinkler deployments includes Waterax Mark-3 and BB4 pumps, portable water tanks, 38-mm (1.5-in.) and 16-mm (5/8-in.) hose, and impact sprinklers. An impact sprinkler is a type of irrigation sprinkler in which the sprinkler head is driven in a circle by the force of the water (Figure 1). These sprinkler systems can use almost any water source. Depending on the distance of the nearest water source, these systems can require many sections of hose and multiple pumps.

There has been very little innovation in equipment that could make sprinkler deployments more effective in the wildland-urban interface. WASP Manufacturing Ltd. in Port Coquitlam, British Columbia (B.C.) has adapted low-volume, low-pressure irrigation sprinklers (Figure 2) for the WUI. WASP is the first company in Canada to promote the use of low-volume, low-pressure sprinklers for structure protection during a wildfire. The sprinkler system is ideally used with a community's or homeowner's particulate-free, water supply system. Because these systems require less water (compared to systems comprised of common forestry equipment) and can be connected to a community's water supply system, the time to deploy them is greatly reduced. This case study examines the use of the WASP system in the small B.C. community of Skeetchestn during the 2017 wildfire season.



Figure 1. An example of an impact sprinkler



Figure 2. The WASP patented rain gutter mount sprinkler with a high-flow nozzle

## 2. SITE DESCRIPTION

### Community of Skeetchestn

The community of Skeetchestn (Figure 3) is approximately 60 km west of Kamloops, B.C., in the Deadman River valley. The community is home to 300 people and consists of two settled areas that are 5 km apart: the village and the benchlands. There were approximately 45 structures in the village, 45 structures in the benchlands, and 15 structures between the two areas, for a total of 105 structures.

Skeetchestn's water supply consists of two reservoirs: one at the village (546 000 L or 144 230 U.S. gal.) and one at the bench lands (227 000 L or 60 000 U.S. gal.)<sup>1</sup>. Water for each reservoir is drawn from a well using an electric pump.



Figure 3. The Community of Skeetchstn looking west towards Elephant Hill

## 3. WILDFIRE THREAT

### Elephant Hill fire

The Elephant Hill fire started on July 6, 2017 and burned throughout the summer. It consumed 191 000 ha of forest and affected several communities within the Thompson-Nicola Regional District. On August 4<sup>th</sup>, changing winds put the First Nations community of Skeetchestn under imminent threat. However, by August 6<sup>th</sup>, the fire had moved to the north and missed the community; therefore, the sprinkler system was not tested against the wildfire.

## 4. DATA COLLECTION

FPInnovations conducted interviews over the phone and in person with key individuals involved in the deployment of the WASP sprinkler system at Skeetchestn in the summer of 2017. We visited Skeetchestn in July 2018, but because the sprinkler system was no longer in place, we were unable to evaluate it. However, we gathered data on the sprinklers used in Skeetchestn from specifications published by Nelson Irrigation. We used a Google satellite image to determine distance between the two main areas of the community and the number of structures.

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<sup>1</sup> Skeetchestn Water Technician, personal communications, November 28, 2018.

## 5. FINDINGS

### 5.1 Deployment logistics

During the 2017 fire season, Emergency Management BC – Office of the Fire Commissioner (OFC) was responsible for providing structure protection in British Columbia. The Emergency Operations Centre (EOC) in Kamloops coordinated the dispatch of resources for the province. On August 1, 2017, the EOC identified Skeetchestn as a community that was potentially needing structure protection based on the threat from the Elephant Hill fire. The EOC dispatched a member of the First Nations Emergency Services Society (FNESS) to work with community representatives in Skeetchestn. Together, they identified critical infrastructure and assessed resource needs. On August 4<sup>th</sup>, the OFC dispatched a Structure Protection Specialist, five engine crews (20 firefighters), and a three-person wildfire crew to install sprinklers in Skeetchestn. The FNESS member informed the community administration about what to expect and explained the deployment process to the crews. Sprinkler systems were installed on approximately 105 structures in 4.5 hours.

The Skeetchestn water system staff conducted a 1-hr flow test of the community system with the sprinklers activated, which resulted in a 25% drawdown of the reservoir. We have assumed that 95 sprinklers were deployed in the village, and the average flow per sprinkler is advertised to be 23.8 L/min. (6.3 gpm). Based on those results, the water system manager planned to stay and manually operate the hydrant zone valves so the water could be directed to the areas of highest need in order to conserve water and give the reservoir time to recharge.

Because of the potential to lose power during the wildfire, two 25 kWh power plants mounted on separate trailers were brought in to provide backup power for the reservoirs pumps.

### 5.2 Sprinkler deployment

The structure protection crew arrived on August 4<sup>th</sup>, with enough WASP sprinklers equipment to outfit 105 structures. WASP sprinkler systems use either a Nelson Irrigation R2000LP or R10T sprinkler. The operating pressure for these sprinklers is between 207 and 414 kPa (30 and 60 psi), and the spray radius is between 10 and 12.8 m (33 and 42 ft.). At 344 kPa (50 psi), a R2000LP sprinkler can move 18.9 L/min. (5 gpm) and a R10T sprinkler can move 9.4 L/min. (2.5 gpm). A sprinkler specification comparison is provided in Table 1. WASP also has a patent for a rain gutter mount that can be used to quickly and safely place the sprinklers on the roof (Figure 2).

For structures that were close to a hydrant, a 38-mm (1½-in.) mainline was established from the nearest hydrant to the building. A water thief was installed to connect the main line to a 16-mm (5/8-in.) hose that then carried water to two R2000LP sprinklers. Smaller R10T sprinklers were

connected directly to the hose bibb<sup>2</sup> of a residence, using 16-mm (5/8-in.) hose, if it was deemed impractical to run a fire hose from a hydrant to the structure.

The WASP system was deployed on all the structures in the community and in the benchlands. Two sprinklers were placed on each structure; therefore, each water reservoir supported 90–100 sprinklers. In addition, an existing irrigation system was modified to provide water to the church and community centre; however, the details of this configuration could not be obtained. Finally, a fourth configuration using Mark-3 pumps and 38-mm (1.5-in.) hose was used to supply river water to impact sprinklers for 15 structures between the community and the benchlands.

## 6. DISCUSSION

The sprinkler deployment at Skeetchestn was the first time the OFC had used a WASP sprinkler system as the primary system for structure protection. Only a few firefighters were familiar with the system. Nevertheless, the system was deployed quickly. The rain gutter mount was not widely used at Skeetchestn because few buildings had rain gutters, but this quick deploy feature would further reduce set-up time by eliminating the need to nail the sprinklers to the roof. The quick deployment of the WASP system was also possible because of the scouting and liaison work carried out by FNESS before the Structure Protection Unit arrived.

Low-volume, low-pressure sprinklers use less water, than other commonly available impact sprinklers but are considered to be just as effective at protecting structures. Table 1 compares WASP sprinklers (Nelson R10T and R200LP) with other commonly used impact sprinklers.

**Table 1. Comparison of the various sprinklers used in the wildland-urban interface**

SPRINKLER	Nozzle		Cast Distance		Pressure		Volume		90 Sprinklers		Water source connection
	mm	in.	m	ft.	kPa	psi	L/min.	gpm	L/min.	gpm	
<b>Nelson R10T</b>	#102 Yellow		10.0	33	344	50	8.0	2.1	726	192	hose bibb
<b>Nelson R200LP</b>	#20 DK Brown		12.8	42	344	50	18.9	5.0	1703	450	hydrant or pump
<b>Rain Bird 20JH 13mm (½-in.)</b>	3.6	9/64	12.2	40	344	50	15.3	4.1	1380	365	pressure pump
<b>Rain Bird 30H 19-mm (¾-in.)</b>	4.7	3/16	15.3	50	344	50	27.3	7.2	2453	648	pressure pump
<b>Rain Bird 70CH 25-mm (1-in.)</b>	5.6	7/32	18	59	344	50	34.5	9.9	3373	891	pressure pump

<sup>2</sup> A hose bib is the spigot, or faucet, on a building's exterior. It is also referred to as a garden hose spigot.

The second-to-last column shows the volume of water moved by 90 sprinklers (arbitrary example) and the water savings that can be achieved by using low-volume, low-pressure sprinklers. A pressure of 344 kPa (50 psi) was used for all the sprinklers in the table. However, 344 kPa (50 psi) is the upper operating range for Nelson rotator sprinklers; these sprinklers could effectively operate at lower pressures with lower flow rates.

The community of Skeetchestn was fortunate that it had time to source backup generators for its reservoir pumps and already had the necessary switches and wiring installed. Maintaining power to the water supply would have been of critical importance had the fire moved through the community.

Skeetchestn has a supervisory control and data acquisition (SCADA) water system, which allows staff to monitor the pressure and volume in both reservoirs using a smart phone or computer. However, several of the Structure Protection Specialists we interviewed believed that having a water manager on-site to monitor pressures and manage the reservoir is essential in these situations to prevent serious damage to the reservoir and contamination of the community water supply.

One concern voiced by our interviewees was the potential for the small sprinkler nozzles to become plugged if they are used with a natural, unfiltered water source. However, this potential is very low when a community water supply is used.

Another concern was that volumes and recharge rates of community water reservoirs can vary considerably, which could affect the system's ability to provide an adequate amount of water during times of peak need. Although the OFC coordinated this deployment with structural firefighters from other B.C. communities, local fire departments could be trained to carry out this role. This would reduce the demand on provincial structure protection resources during critical times and enable the community to be prepared and self-sufficient.

## 7. CONCLUSION

A low-volume, low-pressure system connected to a community water supply appears to be a viable option for protecting community infrastructure. These systems can be quickly connected to a community water supply, and because they use less water than the traditional forestry set-up, they can operate longer. Future evaluations of low-volume, low-pressure systems should include investigating the effect of wind on the systems performance. Wind will affect the sprinkler radius due to the steep trajectory of the sprinklers' water stream. A reduced radius could produce dry areas near the structure.

# APPENDIX G: CASE STUDY – WEST BABINE RIVER FIRE, BRITISH COLUMBIA, 2018

*PRIVATE CITIZENS SUPPORTING THE PROTECTION OF THEIR  
OWN INFRASTRUCTURE*

Ray Ault

April 2019

This case study is not restricted.

This case study contributes to the state-of-practice review of water delivery systems (sprinklers) in the wildland-urban interface. Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).



Sprinklers are used to protect structures from wildfire during wildland-urban interface events across Canada. Traditionally, standard forestry equipment has been used in conjunction with impact sprinklers. FPInnovations is reviewing common practices and equipment used during sprinkler deployments, in Canada, to determine if they are the most appropriate for community structure protection, or if alternative approaches should be considered.

This case study documents the steps a lodge owner took to protect his structure and how private citizens, wildfire, and municipal fire agencies worked collaboratively during the West Babine River fire that occurred in August 2018.

#### 301012735: FRIAA SPRINKLER PROJECT

#### CASE STUDY

#### ACKNOWLEDGEMENTS

FPInnovations would like to acknowledge the Forest Resource Improvement Association of Alberta (FRIAA) for funding this project, and the following agencies for their collaboration during the case study:

- Office of the Fire Commissioner
- British Columbia Wildfire Service
- Delta Irrigation, Kamloops

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## 1. INTRODUCTION

The use of forestry equipment (hose and pressure pumps) to support sprinkler systems is a common approach to protecting values at risk from wildfire in Canada. This case study is one in a series that explores the viability of various types of sprinkler systems for protecting residential and commercial structures from wildfire.

Wildfire agencies are often called upon to protect remote structures from wildfire. The priority for fire crew deployment is first and foremost to protect life, followed by other values at risk. Private and commercial sporting lodges located in forested areas are at risk from wildfire, and protection of these structures can be difficult when multiple fires are threatening numerous locations. Owners of remote structures are advised to be prepared and have the necessary on-site equipment to protect their property.

This case study examines the deployment of equipment purchased locally, by a remote commercial fishing lodge that is not accessible by road, in order to protect its assets from wildfire.

## 2. SITE DESCRIPTION

### **Commercial fishing lodge**

The fishing lodge was surrounded by small stands of coniferous timber to the east and west, the Babine River to the South, and an airstrip to the North that provided a fuel break between the buildings and the forest (Figure 1). All the structures had tin roofs. The lodge, four cabins, generator building, and carpenter shop were clustered together between the airstrip and the Babine River. Drums of fuel and propane were located at the east end of the buildings. The area surrounding the buildings was clean of debris, as outlined in the FireSmart Canada guidelines for Priority Zone 1.

## 3. WILDFIRE THREAT

### **West Babine River fire**

The West Babine River fire (R41913) was 1 of 11 active fires burning in the Bulkley Fire Zone on August 13, 2018. The fire burned on both sides of the Babine River inside the Babine River Corridor Provincial Park. The fire was situated 45 km northwest of Fort Babine, British Columbia (B.C.) and 45 km northeast of Hazelton, B.C.

The fire was expected to threaten the fishing lodge from the north on August 14th. By August 15th the West Babine Fire was estimated to have burned 7400 ha and was less the 3 km from the fishing lodge.

## 4. DATA COLLECTION

Notes of the sprinkler deployment were made while assisting in the placement of equipment and testing of the water delivery system. Data on equipment specification was collected from manufacturer websites and telephone calls with equipment retailers.

## 5. FINDINGS

### 5.1 Deployment logistics

On August 13<sup>th</sup> the Bulkley Zone Wildfire Coordination Officer determined that the West Babine River fire was a threat to the lodge and that structure protection was required. A morning meeting was held with the lodge representative. It was agreed that the lodge owner would source the fire equipment and that a Structure Protection Specialist (SPS) would be assigned to develop a sprinkler deployment plan (Figure 2).



Figure 1. Google aerial map of the lodge buildings, airstrip and the Babine River.

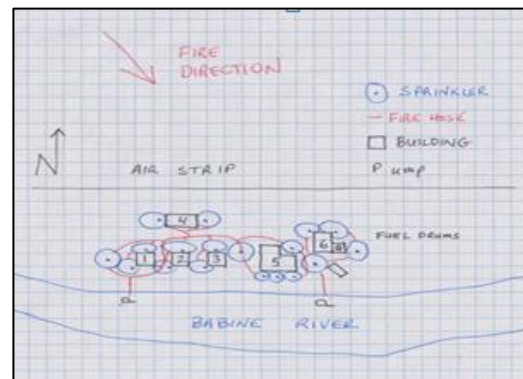


Figure 2. Sprinkler Deployment Plan.

The lodge owner purchased two Honda WH20XTC pressure pumps (Figure 3) from a local forestry equipment dealer. Both pumps were fitted with a 65-mm (2-in.) suction hose, foot valve, and 38-mm (1.5-in.) quick connect discharge hose fitting. Standard forestry hose, 38-mm (1.5-in.), was not available from local retailers, so it was provided, on loan, by the B.C. Wildfire Service. Eight lengths of 38-mm (1.5-in.) forestry hose and 20 lengths of 16-mm (5/8-in.) econo flow hose were provided. Fifteen 16-mm (5/8-in.) water thief valves and five 38-mm (1.5 in.) wye valves were required along with a 38-mm (1.5 in.) end cap. Fuel for the pumps was provided by the lodge.

A search for sprinklers in the community was unsuccessful. The lodge owner found that all the retailers were sold out of sprinklers. The lodge ordered sprinklers from an irrigation supplier in another community and arranged for pick up. Impact sprinklers with a 4-mm (5/32-in.) nozzle were purchased from an irrigation supplier. The sprinklers were “part circle type” and were capable of supplying 13.25 L/min. (3.5 gpm) at 310 kPa (45 psi) and 16.7 L/min. (4.4 gpm) at 276

kPa (40 psi). For this deployment, 19 sprinklers were used, and the pressure was calculated at 40 psi flowing a total of approximately 66 gpm.<sup>1</sup>

In the afternoon, a Structure Protection Specialist from the Office of the Fire Commissioner, a B.C. Wildfire Service representative, and a lodge representative completed a site assessment and developed the sprinkler deployment plan.



Figure 3. Honda WH20XTC pressure pump.

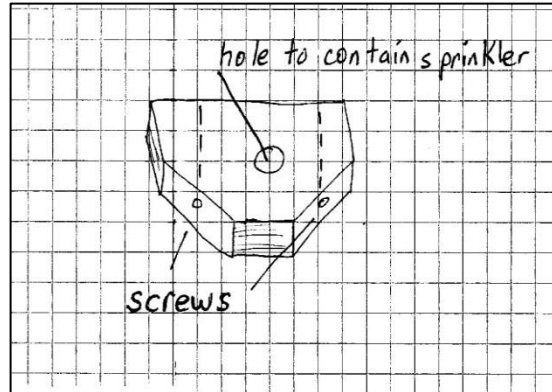


Figure 4. Carpenter designed wood sprinkler cradles for attachment to the roof eaves.

## 5.2 Sprinkler deployment

On August 14<sup>th</sup>, multiple fires and the potential for structure loss resulted in a Structure Protection Specialist and a Structure Protection Crew being assigned to deploy sprinklers on various lodges along the Babine River.

A B.C. Wildfire Service supervisor and initial attack crew were tasked with deploying sprinklers for at the fishing lodge. The team drove to the closest road accessible point to the lodge. A helicopter working on a nearby fire was diverted and assigned to transport the team and equipment from this point to the remote fishing lodge.

The crew was met on-site by the lodge manager, guide, and helper around 12:00 to begin deploying the sprinkler system. The lodge manager, who was also a carpenter, pre-built wooden cradles (Figure 4) to attach the sprinklers to the roof eaves in preparation for the wildfire event. The sprinklers were installed in a way that would minimize damage to the buildings. In total, seven people were on-site for the sprinkler installation.

Sprinklers on the front of cabins 1, 2, and 3 were adjusted to spray over the deck and between the cabins using a 270° casting pattern (Figure 5). Of the 19 sprinklers deployed, 14 were attached to the roofline, 3 were mounted on tripods (Figure 6), and 2 covered the main lodge

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<sup>1</sup> The pump curve for a similar sized Honda pump (WH20xtf) was used. Using this curve, at 42 psi, the flow is 66 gpm.

deck (Figure 7). The sprinklers were generally allowed to spray in a full circle pattern. The deployment was completed within 2.5 hours.



Figure 5. Sprinklers set to 270-degree arc at the front of the cabins.



Figure 6. Firefighter testing a tripod mounted sprinkler.

The system was tested and the Structure Protection Specialist determined that one pump was sufficient to supply the 14 sprinklers for the lodge and cabins. The lodge manager was concerned about the potential for water damage on the front of the main lodge building, so the number of sprinklers on the deck was reduced from three to two (Figure 7) and the plan was to activate the

deck sprinklers only if the main lodge was under imminent wildfire threat. The second pump was reconfigured to supply five sprinklers on an additional hose line that provided protection for the generator, fuel shed, and fuel drums. The re-deployment, fine tuning of the sprinklers spray patterns, and re-configuration of the pumps was completed by 15:00.



Figure 7. Sprinklers on the main lodge deck before reconfiguration.

## 6. DISCUSSION

During an exceptionally busy fire season, it is difficult for the Province to have sufficient equipment to adequately protect all structures on the forested landbase. When private citizens are able to provide for their individual structure protection needs, it lessens the load on the Province in terms of equipment and number of resources required for protection.

The purchase of structure protection equipment tends to be event driven. In this case, the lodge owner decided to purchase equipment in response to an active and threatening wildfire but had



challenges sourcing the equipment required. Private citizens should be encouraged to source equipment well in advance of a wildland-urban interface event and familiarize themselves with how to deploy and operate it. Tools that recommend appropriate equipment that is easy to install and can be effectively managed by agency resources are available.<sup>2</sup> If these resources are deemed appropriate, they can be provided to help build citizen's capacity in advance of a wildland-urban interface event. If not appropriate, specific resources can be developed.

In cases where the owners are under evacuation order, activation of the sprinkler system needs to be completed by the agencies responsible for structure protection. Incorporating remote operation technologies into water delivery systems would reduce the agency resources required to test and activate these systems.

Clear trigger points for sprinkler system activation should be included in the Incident Action Plan (IAP) or other planning documents. These documents should be distributed to the relevant resources to ensure that the activation process is clearly understood. The IAP or other planning documents also inform replacement resources during transitions.

Further research needs to be done to explore and evaluate smaller four stroke engine alternatives to the standard Waterax Mark-3 wildfire pressure pump. The option to use smaller pumps in situations where fewer than 10 sprinklers are deployed can conserve the Mark-3 fire pumps for more appropriate fireline assignments. Smaller pumps, similar to the WH20XTC Honda pump, do not have the fuel capacity of the Mark-3. This needs to be taken into account during deployments.

## 7. CONCLUSION

When residents take responsibility for structure protection on their private property by implementing FireSmart guidelines and pre-positioning pumps, hose, and sprinklers ahead of a wildland-urban interface event, it not only increases the probability that their property will survive a wildfire but reduces the pressure on the limited number of firefighters involved in an incident.

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<sup>2</sup> Gogal, J. (2018). *Wildfire water pumping and sprinkler system handbook* (4th ed.).

# APPENDIX H: CASE STUDY – TOLKO MILL YARD, HEFFLEY CREEK, BRITISH COLUMBIA

*HIGH-VOLUME, HIGH-PRESSURE PERMANENT SPRINKLER  
SYSTEM*

Ray Ault

April 2019

This case study is not restricted.

This case study contributes to the state-of-practice review of water delivery systems (sprinklers) in the wildland-urban interface. Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).



Sprinklers are used to protect structures from wildfire during wildland-urban interface events across Canada. Traditionally, standard forestry equipment has been used in conjunction with impact sprinklers. FPInnovations is reviewing common practices and equipment used during sprinkler deployments, in Canada, to determine if they are the most appropriate for community structure protection, or if alternative approaches should be considered.

This case study documents the use of a high-volume, high-pressure permanent sprinkler system that is installed in Tolko's millyard at Heffley Creek, British Columbia to maintain wood quality and protect the company's assets. Permanent high-volume, high-pressure systems may present a viable option for protecting community and other critical infrastructure.

**301012735: FRIAA SPRINKLER PROJECT  
CASE STUDY**

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- Highlands Irrigation Services – Kamloops, British Columbia
- Tolko Industries – Heffley Creek, British Columbia
- Nelson Irrigation – Walla Walla, Washington

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## 1. INTRODUCTION

The use of forestry equipment (hose and pressure pumps) to support sprinkler systems is a common approach to protecting values at risk from wildfire in Canada. This case study is one in a series that explores the viability of various types of sprinkler systems for protecting residential and commercial structures from wildfire.

The use of high-volume pressure pumps to run a sprinkler system has long been identified as a potential approach to protect industrial assets that are at risk from wildfire. Understanding whether a high-volume, high-pressure sprinkler system is a viable option for protecting infrastructure and industrial assets is a priority for many provincial fire managers.

Tolko Industries Ltd. is a privately owned forest products company based in Vernon, British Columbia (B.C.). The company has installed a permanent industrial sprinkler system at their Heffley Creek, B.C. sawmill. The primary purpose of this system is to wet the logs in the millyard to maintain wood quality during storage. This high-volume, high-pressure sprinkler system also provides protection from wildfire as an ancillary benefit.

FPIInnovations examined this high-volume, high-pressure system to determine if, or how, a similar system could be used to protect a community from wildfire. The objectives of this case study were to:

1. investigate and document the sprinkler system used by Tolko at its Heffley Creek sawmill; and
2. determine if a permanent sprinkler system similar to the one used by Tolko is a viable option for protecting a community from wildfire.

## 2. DATA COLLECTION

FPIInnovations obtained approval from Tolko Industries Ltd. to collect information on its millyard sprinkler system. We conducted a telephone interview with the system designer and equipment supplier, Highland Irrigation,<sup>1</sup> and conducted a site visit at the mill.

A representative from Highland Irrigation provided an overview of the high-volume, high-pressure system, and specifics on system pressures, volumes, and type of sprinklers used. The site visit to the mill provided an opportunity to observe and document the system during operation.

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<sup>1</sup> Highland Irrigation Inc. 782D Tagish St., Kamloops, B.C.

### 3. FINDINGS

Tolko's sprinkler system consists of 18 Nelson SR100 Big Gun sprinklers<sup>2</sup> with a 12.7-mm (1/2-in.) orifice (Figure 1). Water for the system is supplied by a water reservoir located approximately 36.6 m (120 ft.) above the millyard. Gravity provides 552 kPa (80 psi) of pressure head for the system. A 15-hp electric motor boosts the water pressure to 793 kPa (115 psi) and delivers approximately 655 kPa (95 psi) at the sprinkler head. The supply line is a 100-mm (4-in.) high-density polyethylene water pipe that runs 274 m (900 ft.) to the north from the pump station and 427 m (1400 ft.) to the south, for a total length of 701 m (2300 ft.). The supply line runs above ground where there is little elevation gain. The sprinklers are fixed to a tripod with a 65-mm (2-in.) water supply line (Figures 2 and 3). A TWIG TD200 Controller runs the system, and the wireless TWIG decoders are mounted on the risers next to the valves in order to activate the valves wirelessly.



Figure 1. The Big Gun SR100 sprinkler with a TWIG wireless decoder box.



Figure 2. A Big Gun sprinkler riser fixed to a sturdy tripod.

The Big Gun sprinkler can deliver 454 L (120 gal.) of water per minute over a radius of 37 m (120 ft.). The arc and trajectory can be adjusted to achieve specific spray patterns. Most of the sprinklers in the Tolko system are set to a spray pattern of 180° (Figure 4).

The system's manufacturer indicates that optimal performance occurs when 3 of the 18 sprinklers are activated at one time.<sup>3</sup> Optimal performance is achieved by optimizing pipe size and pump capacity. During the site visit, up to five sprinklers were operating at the same time for approximately 3 minutes each. The total time for all the sprinklers together was 12 minutes, during which approximately 20 441 L (5 400 gal.) of water were applied. Once the 12-minute sprinkler cycle is complete, the sprinklers are idle until the next programmed application. The Tolko sprinklers were programmed to activate two or three times each day depending on the

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<sup>2</sup> <http://www.nelsonirrigation.com/products/family/big-gun-sprinklers/100-series-big-gun>

<sup>3</sup> Personal communication with Highland Irrigation

weather conditions. The sprinklers are arranged to provide an overlap of 50% to ensure complete coverage.



Figure 3. The connection from the high-density polyethylene supply line to the sprinkler.



Figure 4. The Big Gun sprinkler in operation at the Tolko millyard at the Heffley Creek saw mill. Spray distance is approximately 30-61 m (100–120 ft.).

The estimated equipment cost for this permanently mounted high-volume, high-pressure system (18 sprinklers with a TWIG controller) is between \$40 000 and \$50 000 Canadian dollars. The water supply line and installation of the system were both provided by Tolko, but these costs were not available. According to Highland Irrigation, once ordered, the sprinkler equipment can be delivered in 2–3 weeks.

## 4. DISCUSSION

### 4.1 System type

Tolko's sprinkler system is a permanent, above-ground system. All the components are easily accessible, which makes operation and maintenance straightforward. Tolko drains the supply line in the fall and recharges it in the spring.

An advantage of a permanent system for infrastructure protection is its immediate readiness in the event of a wildfire. A system set up in the spring could be activated remotely as needed to provide protection throughout the summer. The remote activation and automated capabilities of the Nelson Irrigation controller would provide a high degree of safety by eliminating the need for an operator to access a site that is threatened by wildfire.

A disadvantage of a permanent system is the risk of theft and vandalism. The Tolko millyard is a 24-hour industrial operation, so this risk is low. However, a community would need to take precautions to protect its system from theft and vandalism.

Tolko uses an electric pump to drive its system. Power outages are likely during a wildfire event, so a community would need to plan for an alternative or backup power source.

Nelson Irrigation has developed a mobile sprinkler attachment for the Big Gun sprinkler.<sup>4</sup> But a difficulty with the short-term use of a high-volume sprinkler is the need to couple it with an adequate water supply, pump, and hose. The manufacture advised that riser stability is very important in the Big Gun sprinkler system design.

Irrigation equipment manufacturers, suppliers, designers, and installers are all very familiar with the various applications of sprinkler systems and the unique challenges of each application. These professionals would be a valuable resource when it comes to planning and developing a high-volume, high-pressure sprinkler system at the community level.

## **4.2 System operation**

The Big Gun sprinkler can spray water up to 37 m (120 ft.). Multiple Big Gun sprinklers require a significant water source, properly sized pump, and carefully planned plumbing to provide sufficient and reliable water volume, and pressure for the system. The desired number of sprinklers activated at one time dictates the diameter requirements of the supply line and the size of the pump required.

The 100-mm (4-in.) supply line that Tolko uses, limits the volume of water that can flow to the sprinklers at one time. A larger diameter supply line matched with a more powerful pump would allow more sprinklers to operate at the same time. If using a similar system for wildfire protection, limiting the number of sprinklers operating at one time because of volume restrictions may compromise structure protection.

The force at which the spray hits the ground was not measured. Diffusers and various adjustments that can alter the trajectory of the water spray and reduce the impact force are available for the Big Gun sprinkler. Further investigation into the impact force of these systems would be prudent to ensure that the risks to infrastructure are well understood.

## **5. CONCLUSION**

The strategic placement of a high-volume, high-pressure system to protect critical infrastructure adjacent to forested lands would be a proactive way to prepare for wildfire. These large-scale systems would not necessarily stop fire spread, but they could protect structures by immediately applying water when needed.

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<sup>4</sup> <http://www.youtube.com/embed/gzMaO8-XNJQ?controls=0&autoplay=1&rel=0>



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