Wildfire Water Pumping and Sprinkler System Handbook

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Foreword

This handbook is intended to provide information to wilderness property owners who are interested in building wildfire pumping and sprinkler systems. It is not intended to be a replacement for any other publication, guidance, or information about safety, government regulations, local bylaws, insurance, or anything else. Safety, prevention, and preparation activities are very well-documented through established programs such as FireSmart, Firewise, and other initiatives led by provincial and national organizations. Visit https://www.firesmartcanada.ca or contact your local community representative for more information on community fire prevention and preparation for wildfires.

The style that I am aiming for with this handbook is to clearly explain details of wildfire water pumping systems in practical, everyday language, and to help guide interested people towards choosing the right equipment for building a pumping system. I tried to write the technical information in plain terms as if we were having a conversation, and not like a textbook or technical report. There are several things about wildfire pumping systems that it's important to get right in order to build a quality system that will be easy to operate and maintain and will stand up well over time. This handbook is intended to be an evergreen work, and so it will be updated as required. As it is important to include and collect all lessons learned from practical experience, any reader with questions or comments is encouraged to contact me and contribute to the work. I can be contacted at jason.gogal@gmail.com.

Graphics and pictures used in this handbook are taken from public domain sources, used with permission, or prepared by the author. The author is a professional engineer, and hopes that you don't hold that against him.

Glossary

The terms **wildfire** and **wildfires** will be considered equivalent to "forest fire" and "forest fires."

The terms **protection** and **values protection** refer to fire water pumping systems protecting structures.

The term **deadhead** means to operate a pump against a closed valve with no flow.

The term **runout** means to operate a pump at full throttle with nothing restricting the discharge.

The term **wildfire water pumping system** refers to a protective sprinkler system.

Other terms are explained within wherever they are used.

Units and Unit Definition

Pump system parameters are commonly measured in a mixture of Imperial and SI units at this time, with Imperial units being more common in everyday conversation. The following units will be used throughout:

Unit	Definition
cc	cubic centimeter
C	Celsius
F	Fahrenheit
ft	foot
gal	US gallon. 1 US gallon = 3.78 liters
GPM or gpm	gallons per minute.
h	hour
HP or hp	horsepower. 1 hp = 746 W
head	Pressure equal to a standing water column of a certain height. 2.31 feet of head = 1 psi.
L	litre
m	metre. 1 m = 3.28 ft.
min	minute
psi	pounds per square inch
s	second

Introduction

Wildfires are a fundamental part of natural forest behavior in Canada and the USA. Most wildfire activity occurs in sparsely populated areas, and does not cause much community value damage. However, wildfires can quickly become an acute risk with significant consequences. Homes, cabins, and entire communities can suddenly be faced with serious situations when wildfires are nearby. At these times, wildfire water pumping systems can become a crucial deciding factor. You can go a long way towards making sure your property stays standing if you build your own wildfire water pumping system and regularly practice using it. Passive protection strategies such as FireSmart can go hand-in-hand with a sprinkler system, and more examples of the combination of active (sprinkler) and passive (FireSmart) risk reduction systems are appearing as property owners become more knowledgeable and motivated.

The number of serious wildfire events appears to be increasing in recent years, in both in the frequency as well as the severity of events that impact populated areas. Responses to wildfire events can include a number of different techniques, depending on the location and the availability of equipment and resources. There are many examples of wilderness properties that have been spared from wildfires by the

operation of sprinkler systems. Sprinklers simply work. Property owners, however, should not depend on government wildfire crews or anyone else protecting their property or placing their property at a high priority for protection during a wildfire event. The most sure way to protect a property from an approaching wildfire is through planning and working ahead, and having a pumping system that is well-constructed and is easy to operate and maintain. Fire is opportunistic. A wildfire that arrives at a soaking wet property with no dry fuel around it cannot and will not ignite structures. A very strong strategy involves a combination of removing problem fuel sources close to your structures (FireSmart), adding protection by building a sprinkler system, and operating it for as long as is reasonably possible prior to the wildfire arriving at a property.

Wildfire is the biggest and highest-consequence risk that faces most wilderness properties. A sprinkler system is, in my opinion, an essential feature to any wilderness property – just as essential as plumbing, lighting, heat, or any other utility. You might say, “But I have insurance!” Well, among other things, insurance can’t replace the sentimental value of your home or prized possessions, and it can’t possibly offer the tangible safety features that a wildfire pumping and sprinkler system does. Insurance claims take time to process, and it can take several years to rebuild. Also, consider that the insurance industry is currently being bombarded with increasing numbers of claims for wildfire damage. Insurers cannot and will not indiscriminately pay out increasing numbers of claims without adapting their policies. Working, good quality sprinkler systems are becoming more common as a prerequisite for insurance coverage. Having a wildfire sprinkler system can in some cases reduce your premium costs.

In the past, sprinkler systems have often been ignored in wilderness property construction, or have been treated as an afterthought or a last-minute thing or a nuisance expense. Take a tour around any typical wilderness community and you will see many things like boats, ATVs, campers, and so on. Well, all of these things cost money, but unfortunately, they are all virtually useless in wildfire situations. The tools and equipment that matter the most during wildfire events are actually simple things: fire pumps, hoses, fittings, sprinklers, and nozzles. I know from experience that there is nothing that replaces the physical reality of having a reliable source of high-pressure, high-volume water available to distribute on your property with sprinklers and fire hoses. No amount of cleverness or handiwork can ever be on par with a wildfire pumping and sprinkler system. They work. I hope to see wildfire sprinkler systems become more normal and common now that information about their benefits is more available, and given that wildfire events and insurance policies are evolving.

A sprinkler system offers a number of benefits beyond fire protection. Wildfire pump systems can be used for local structural fires, and for mutual community protection. I have first-hand examples of events such as private wildfire systems being used to put out a structural fire that was not responded to by any nearby fire department, and could not be actioned by wildfire personnel. These events could have easily put the communities at significant risk, but the fires were actioned thanks to private sprinkler systems. Preparedness likely saved multiple structures and the larger community from significant losses. Once you have a sprinkler system set up, operating it is as simple as running your pump. Again, there is nothing that really replaces the physical reality of having a wildfire pumping system to deliver high pressure, high volume water on and around your property.

Wildfire sprinkler systems are usually operated periodically when wildfire risk is high, and for long periods if a wildfire is closing in. Last-minute, emergency situation operation should be carefully planned out in advance, and should be conducted in cooperation with your local community and local authority as required. Your safety and the safety of others are more important than the safety of your property, so use common sense, good judgement, and caution if you are considering running your sprinkler system before a wildfire impacts your property.

That said, if you and your neighbors and community members do intend to operate sprinklers before a wildfire event (as many do), there are some important timing things to consider. 2 hours of sprinkler system operation before a fire passes the property is the bare minimum time recommended. Longer and more regular operation times are usually better, because more water creates more cooling and more microclimate effects. 24 hours of system operation before a wildfire impact is not uncommon. During high risk periods, operators will typically run their systems daily or periodically in order to continually maintain some moisture around their properties and saturate the area. I know from experience that in high-risk wildfire conditions, any standing water disappears very quickly, because the relative humidity is extremely low. Have your system ready to go, and use good judgement of how frequently to operate it.

It is possible to build remotely activated water or gel foam fire protection systems at a cost, and they can be effective. However, a very effective wildfire water pumping system can be built on your property for a fraction of the cost of a commercial installation, using common supplies and tools. The do-it-yourself approach will be the focus of this handbook. Links to some irrigation and pumping system equipment suppliers are provided in the Appendix. Interested readers are also welcome to contact me for any type of consulting or assistance in building sprinkler systems.

Wildfire water pumping systems at remote wilderness properties are often constructed quickly, sometimes using improvised or exotic materials and methods. These materials and methods can and do work – anything that gets water on the ground, by definition, “works.” However, there are tradeoffs to consider when using improvised materials. A last-minute setup and operation with untested equipment will be difficult to perform under stress. A strung-together system also may not perform as well or as reliably as a system that has been put together with some design thinking and targeted effort. I believe that a good approach is to build and maintain a well thought-out, properly specified system that is regularly tested and operated. You’ll spend less money and time this way, and you won’t have to keep changing and rebuilding things.

Practice drills and community training days can also be helpful in building a *community of practice* around wildfire sprinkler operation. Practice and training is a core feature of any emergency response team, and again, the “muscle memory” built up by doing things a few times can be handy in times of stress. Getting used to something seasonal and unusual like running a wildfire sprinkler system will help you concentrate on things that are important when you need to do the task under stress, instead of figuring things out as you go and multitasking. I find that you can learn and discover important things through practice, which can help you troubleshoot and optimize a system. It’s a good idea to work with neighbors or neighboring communities and cooperate on pumping system operation. Show each other your systems, so that more people know how to operate your system if you are not there when it is needed. Practice makes perfect.

The community of practice that is created from this can be very handy. It's also valuable to develop a "muscle memory" of how to operate the system so that you don't have to think much about it. You may choose to use your wildfire pump for irrigation and domestic water needs (as some do, including myself). This gets you some valuable practice and learning while taking care of an everyday basic need for domestic water.

By employing design thinking and selecting the right materials and features, a wildfire sprinkler system can be made to be robust, powerful, reliable, and long-lasting. There are a few things that can make it easy for wildfire agency values protection crews to connect their equipment to your system if they come to your property to help. If you have a working and properly constructed sprinkler system, and it is possible for a values protection crew to operate or tie into it, you are more likely to get their help and have their help be effective in saving your property. Wildfire values protection crews will usually prioritize properties where it is evident that steps have been taken to protect the property. A well-maintained property with a working sprinkler system is a better priority than an abandoned, grown-in property. But again, you cannot assume that anyone will come and take responsibility for saving your property from a wildfire. You also cannot assume that someone will use a home-made system; I have seen examples where homemade systems were ignored or bypassed, because the components were incompatible or inoperable with what values protection crews were doing. It is, in my view, primarily the responsibility of the wilderness property owner to prepare and operate some type of sprinkler system as part of an overall fire prevention and protection strategy. Wildfire sprinklers should be more of a normal, essential feature, and should be incorporated into any wilderness home or cabin type of structure. The alternative is that you will have to evacuate and be unable to do anything but hope for the best and lobby for assistance, but if you're reading this book, you're probably interested in doing things right, so let's focus on how to do that.

Wildfire Behavior Effects on Pumping Systems

I am not an authority or expert on wildfire management or wildfire behaviour. The reader is encouraged to consult a local, national, or other regional wildfire agency and talk to an expert in this area for more information and advice on wildfire behavior and wildfire management. However, with that said, some well-known wildfire behaviors influence the design of wildfire pumping systems. Some important considerations of the effects of wildfire on pumping systems are as follows:

- Wildfires can smolder across and underneath areas of dry ground or muskeg for long periods of time. Any vegetation on the ground can burn. Trail duff, moss, plants, almost anything. A slow smoldering fire is called a *ground fire*, and small flare-ups of twigs and plants are called *surface fire*.
- Surface fire can ignite larger and taller bushes, branches, mosses, and any other fuel, which are called *ladder fuels*, and move up into tall trees.
- A stand of coniferous trees in the right conditions can burn very hot and and move with considerable speed, like a giant pack of matches burning at once. This is called a *crowning fire* and this type of fire is what most people associate with forest fires from seeing them in the media.

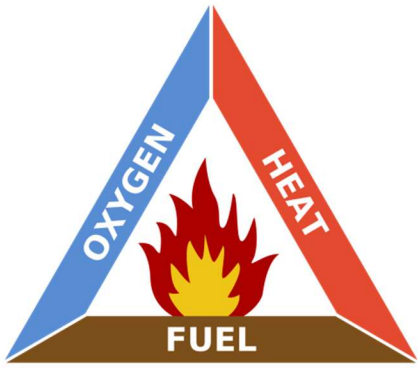
Although these fires are very hot, they move fast, and so they can go past a property area fairly quickly. This is an important consideration.

- Burning trees can throw off live embers called *firebrands* which can be carried for long distances by winds. Firebrands are a very common source of ignition for structures. The percentage of structural fires started by firebrands is most likely between 50%-90%.
- Partially burned tree bark, branches, needles, twigs, acorns, insects, and other debris can be carried quite far away from an active fire by wind and waves. Large amounts of this debris can collect on the shores of water sources and can foul (clog) pumping systems and sprinkler nozzles.
- A pump or part of a pumping system located in a forested area may be exposed to wildfire. Any gas or diesel operated pump located in a forest also has the potential to start a new fire. Spark arrestors and pump placement are important considerations. Stationing a fire extinguisher near your pump is recommended. Wherever possible, run hoses down a well-groomed trail.

In order to have the best possible chance at a property being protected from a wildfire, a fire water pumping system should be constructed in such a way that it is resistant to the effects of wildfires described above. Strategies for building such a system are covered in detail below.

Fire Fundamentals

Fires require three main ingredients to be together at the same time in order to burn: fuel, oxygen, and heat. This is often shown as a *fire triangle*.



Fire triangle.

Removing any one of the three ingredients of the fire triangle will stop a fire. Removing heat is often the easiest and fastest thing to do in a wildfire situation, and this is done by applying water to a fire or fuel source. Water absorbs a lot of heat as it heats and boils, and this rapidly cools down a wood fire's fuel source. This weakens both the heat and fuel sides of the triangle and stops a wood fire. Water vapour also increases the ability of air to carry heat, which adds to the heat removed by heating and boiling the water, and this removes the heat side of the fire triangle. A foam system can go one step further by isolating the supply of oxygen, which removes the oxygen side of the fire triangle.

Running a fire water pumping system several hours or days ahead of a wildfire's arrival can offer a very high chance of a property surviving a wildfire intact. A wildfire can then pass over and around a property without any of the buildings starting on fire. Nothing is ever 100% guaranteed, but experience shows that sprinkler systems can offer around a 90% or better chance of a property surviving a wildfire intact, especially as part of an overall fire prevention program. Take note of this statistic. Doing nothing and then relying on someone else to save your property will definitely not offer the same odds of a successful outcome.

There are many things that can be done to passively protect properties, such as removing fuels and preparing structures along the lines of FireSmart, but sprinkler systems stand alone as a powerful line of defence in a wildfire situation. However, the construction of a sprinkler system involves some important details, and it's important to get these details right so that you have the best user experience and the best odds of success. To get water from its source to a sprinkler system, we need to construct a special type of water pumping system. A wildfire sprinkler pumping system is different than a pumping system that just moves water over into a cistern or tank. A wildfire sprinkler pumping system operates best at pressures and flows that are higher than what most general purpose water pumps can deliver, and this includes some pumps that are called "pressure pumps" or "fire pumps" by unscrupulous or unknowledgeable vendors. A wildfire pump also may have to run for longer periods of time than is normal for other types of pumps. The higher performance demands of a sprinkler system mean that the best results and most economical service life will be obtained by choosing good materials and taking some important details into account during design.

Water Supply

Most wildfire sprinkler systems draw water from a lake or river. If your property is near a lake or a river, it is best to use the lake or river as the water source, and pump that straight to your sprinklers. Water is very heavy and awkward to move with a vehicle. Relying on a vehicle to move your fire water from a source to a tank or pump might seem fine for a practice exercise or occasional domestic needs, but it will become impractical or impossible in a real wildfire situation. You need a lot of water to effectively run a wildfire sprinkler system or to do substantial hose attack work, and you need it at a high pressure.

But what is "a lot" of water? Is it 1,000 gallons, or 2,000 gallons, or 50,000 gallons? A fire water pumping system with just three sprinklers can easily use more than 45,000 gallons a day. Five sprinklers can use up to 72,000 gallons per day, and so on. If you try and use some sort of tank for a fire water supply, even if the tank seems "big," it can drain very fast when supplying a wildfire water pumping system, and leave you in a difficult situation. This means a lot of trips if you are trying to haul water, and a lot of extra work and fueling if you are trying to use one pump to relay water into a tank and another pump pumping from the tank to sprinklers. Hauling water for a fire pump is not a job you want to be trying to do under stress.

Tankage can offer a benefit of having water close at hand for sudden, small demands, but the extra steps of keeping the tank full and using the water effectively can create unnecessary challenges and distractions in a real world wildfire situation. Tankage is just not robust in real-world settings, and tanks are seldom used in wildfire situations. It is better to have a good quality, proper fire pump system, and to use the

pump system as the main water supply. But you might ask, what if the pump fails? Reliability and availability concerns, depending on the situation, are usually addressed in industrial settings by having two pumps – one operating and one standby. If you build a hybrid pump-tank system to try and accomplish the same type of reliability goal for sprinklers, you just won't really get anywhere. Things will get more complicated than with a single pump. Most good fire pumps are actually very easy to start and run. Some aren't, and we'll get to that later.

Having your fire pump draw water directly out of a lake or river gives you a virtually unlimited source of water. This means that you will never have the difficulty of filling or hauling a tank, or having to run two pumps to do one job, and you can concentrate on sprinkling and protection. It will be generally assumed here that your wildfire pumping system draws water directly from a lake or stream. Most wilderness properties are close enough to a lake that pump discharge hose can be run from the water source to your property. Unless you are located very far from a water source, say more than 1 km or so, you should plan on running your sprinklers directly from the nearest convenient natural water source. Most municipal supplies have far too little volume or pressure available to be useful sources of water for wildfire sprinkler systems, and cannot be relied upon in emergency situations where electrical power may be unavailable. In general, any municipal or domestic water supply line is not suitable, and will not be discussed or considered here. You really need to be near a body of water for wildfire sprinkling to be effective.

Mobile fire trailers or skid units can be very effective in fighting spot fires and putting out hotspots, or in community structural fire situations. However, there is a limit to how big the water tank can be in order to be practically moved by equipment such as ATVs or trucks, and there is a limit to how much attack work that a mobile tank can accomplish. A mobile tank isn't ideal for a sprinkler system, due to the constant hauling and extra work involved, and the vulnerability of most tanks to fire. Mobile fire trailers are sometimes set up for foam dispensing and carrying fire equipment such as hoses, fittings, gas, and tools. Mobile fire trailers therefore have a role to play at the community level, and I have seen some great examples of them, but trailer systems are not the main focus of this handbook. Municipal structural firefighting also is not the focus of this handbook. Although I have almost 10 years of firefighting training and emergency response service, I will definitely leave municipal structural firefighting up to the folks who do it for a living and have that experience. The focus this handbook on pumping and water handling applications that I have decades of experience with.

Pump System Basics

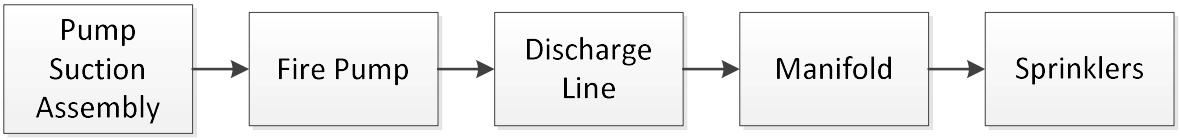
There are five key parts to a wildfire water pumping system:

1. **Pump Suction Assembly.** This is a strainer and foot valve assembly on the end of a special type of hose that is placed in a water source.
2. **Fire Pump.** This pump has a special, niche job. This pump needs to produce higher pressures and volumes than are possible with typical off-the-shelf utility pumps, and run for longer continuous periods than utility pumps. It has a long *duty cycle*, it must run for long periods. The ability of a fire pump to produce higher pressures is very important, and most utility pumps lack this ability.

Fire pumps are also constructed to smaller machining tolerances and have different qualities than utility pumps. Some people attempt to use utility pumps for fire sprinkler system service, but this is not recommended as anything other than a last minute reactive strategy. If you are planning ahead and can choose the best pump for the job, a fire pump will perform far better than a utility pump. Later on, I will specify pump models that I believe are ideal for most wilderness property owners. I will also indicate which types and models of pumps are not recommended, and for what reasons.

3. **Discharge Line.** This is a special hose or pipe that brings water from the pump to the place where the water will be used. Sometimes this line must be very long, and sometimes it needs to operate at higher pressures, which require higher quality materials.
4. **Manifold.** A manifold is any type of fitting that takes water from an incoming supply and delivers it to more than one part of a water system. Wildfire crews often use water thief fittings and Y (wye) fittings instead of hard piped manifolds, because water thieves are light and portable. However, a single hard piped manifold can do the job of many water thieves and wyes, and lets you easily set up and control a whole pumping system from one spot. I have built several types of manifolds, and after using various types, I prefer the hard piped style.
5. **Sprinklers.** The sprinklers used for wildfire systems are often the same type of impact sprinklers that are used in golf courses, farms, or parks. Garden sprinklers are sometimes used for wetting down the sides of buildings, outbuildings, or dry spots. Rocking sprinklers can be used to wet down the sides of buildings and under eaves or decks. If you see dry spots next to your buildings after test running your system, consider adding rocking sprinklers or any other type of garden or landscape sprinkler to wet down the dry spots. However, impact sprinklers are the standard type of sprinkler for wildfire sprinkler systems.

Most wildfire pumping systems will be set up in the same basic way. A simplified block diagram of a typical wildfire pumping system is shown below.



Pumping System Simplified Diagram

1. Pump Suction Assembly

When constructing a pump suction assembly, it is important to consider the following:

1. The suction hose should be rated for suction use. The best type of suction hose is made from EPDM rubber, and is usually ribbed or corrugated in appearance. These corrugations are there to support the hose walls against a vacuum. If you use any other type of pipe or hose for a suction hose, there is a chance that it could suck itself flat, which will stop your sprinklers and cause

damage to your pump. Avoid using PVC suction hose. It is better to use EPDM hose, as it has much better weather resistance to UV damage and abrasion.

2. Use one piece of good quality suction hose. If you try and splice extra pieces of hose or mix and match hose and pipes into your suction assembly, you increase the chances that you will suck air into the system or suck a hose flat, which could damage your system.
3. Suction intakes are the first (and usually the only) line of defence against pump damage and clogging caused by debris in the water source. Suction intakes should be protected with fine mesh screening in order to prevent debris from entering the pump system, but not so fine that they become clogged. Even improvising something like tying an old window screen or fresh conifer boughs around a suction strainer will be effective. There are also suction strainers available that are made of fine mesh metal screen material, and other plastic frame suction strainers wrapped in foam padding, and it's easy to DIY improving a suction strainer. One way or another, try to avoid getting debris into the water system, because it can damage your pump and clog sprinklers or hoses. And whatever method you choose, ensure that it is easy to clean. Small in-line filters or strainers may quickly foul, and this will reduce system performance.
4. Suction hose should be located securely and completely submerged in the water at all times. Any air entering the suction line could cause pump damage, system failure, or safety issues. Also, try to avoid having the suction strainer sitting on the bottom of the water source. Suspending it or securely propping it about 12 inches up off the bottom is best. An anchor and float will accomplish this, and there are other methods depending on what the water access is like at your locale.
5. All couplings should be tightly secured with good quality clamps. If you can find the right T-bolt clamps, these will be much better and stronger than worm gear clamps.
6. Locate the pump close to the water and secure it. Your pump should be anchored, tied, or chained to something solid so that it does not move around from vibration or waves, and for safety and security.
7. A foot valve connected to the suction strainer will make priming the pump much easier, and the pump can be started without having to prime it each time. Good pre-made suction strainer / foot valve assemblies are not easy or cheap to find as a consumer, but an excellent suction assembly can be built with easily accessible parts.
8. Pump suction lines often attach to pumps with NPSH thread, which don't quite match the common NPT. You may need specific nipples and adapters for connections to the strainer and pump.

2. Fire Pump

The pump is the most important part of the fire water pumping system. It's probably the most important thing to get right. It does all of the work, and without a reliable pump, you cannot have a reliable pumping system. To make things interesting, there are a huge variety of pumps available to the consumer, but unfortunately, most of them are not actually very powerful. Pumps differ in how much power they can develop, how they use their power, and what they are designed for. There are some very important differences in manufacturing details between a real wildfire pump and a general purpose off-the-shelf

pump. Although there are many types of water pumps available, only a small few specific types and models are really suitable for service in a wildfire pumping system.

Pumps also range in price. You can get a small general-purpose pump off the shelf for about $500, or a high-powered, high pressure wildfire pump for $5000 or more. There are many types of fire pumps in a range of prices and sizes in between and beyond, depending on their size. If you are considering buying a pump for a wildfire water pumping system, take the time to seriously research your purchase, and try to resist the urge to compromise on quality for price. I've seen many examples of folks having to redo things and keep spending time and money on fixing issues, versus simply doing it right in the first place and not ever having the issues. The type of pump that you choose to buy could make the difference between protecting or losing your property. If you cooperate with neighbors, you can also buy bigger and better pumps and protect more than just your own property. Below I recommend some pumps that I believe are ideal for most wilderness property situations based on my experience.

Pump Power

Water is a heavy material. It requires a lot of power to move water, just like it takes a lot of power to move a vehicle. Bigger vehicles need bigger engines to perform well. A fire water pumping system is like a big vehicle in that way. A fire pump has to push a large volume of water through a hose, uphill, and through sprinkler nozzles. If a pump is too small and can only deliver water at 20 psi to the sprinkler nozzles, you will get a smaller stream of water that just squirts and doesn't accomplish much, and your sprinklers might not work or rotate properly. If instead your pump can deliver 50 to 80 psi to the sprinklers, you will get two or more times as much water flow, the spray pattern will be much more effective, and the spray will cover a much larger area. Vehicles and boats often have engines that are rated at more than 200 hp in order to provide the required performance. Why then should any sprinkler system pump have an engine that is too small for the job? You can technically take a golf cart on a 500 km road trip, but it wouldn't be very effective or practical. Pump power is an important consideration in any wildfire pumping system, and is often overlooked and misunderstood. Pump power is also often deliberately misrepresented by low-end equipment manufacturers in order to make utility pumps seem more powerful than they really are. It's a market segment where there is a lot of gimmicks and junk being sold.

It is critical that a fire pump has enough power. If your property is located very close to a water source, then having higher pumping power is not as critical, and you can likely use something like a 6 hp pump running at full throttle to get the minimum 30 psi at your sprinklers. However, if your property is more than about 400 feet away from the water source, and the top of your buildings are more than about 25 feet above the water source, then chances are you will need a pump that has more power, from 8 to 11 hp or possibly higher. Again, the idea of "if it gets water on the ground, it works" applies here, but bare minimum doesn't always mean acceptable. Also, a lot of water is better than a little water in a wildfire situation, so pump power and quality are very important considerations. You don't need to get ridiculous on the power of your pump, and you should actually stay away from extremely powerful pumps, but your system will work best if you can provide water at the sprinkler at least in the middle of an impact sprinkler's operating pressure range, or 50 psi. Spray patterns and droplet sizes will be much more

effective at higher pressures. Sizing a pump will be discussed in detail below, as will my specific pump recommendations.

It is possible to "daisy chain" two pumps together in series (one pump's discharge feeds the next pump's suction) to get a higher pressure water supply, but this is not recommended, because more things can go wrong with this type of setup. It is better and cheaper to simply buy a stronger pump in the first place than it is to try and daisy chain two weaker pumps together. All pumps should be monitored while running, and a dual pump system is even more important to monitor closely. If one series pump runs out of gas or fails, the other pump can be severely damaged if left unattended for even a few minutes.

Pump Curves

Pump performance is often measured in units of pressure and flow. The pressure units are usually measured in feet or meters of *head*. Head is a term that means the pressure at the bottom of a water column of a certain height. There is 1 psi for every 2.31 feet of head. For example, if you see a pump that says "maximum 187 ft total head," what this means is that this pump can push water 187 vertical feet from a water source before the water will stop flowing from the top of the pipe. In other words, the pump will *deadhead* at 187/2.31 = 81 psi. *It will not be actually producing any flow!* This includes any height difference and pressure losses from the water source to the pump, so in this example, you will actually get a few psi less than 81 at the pump discharge. *And it will not be flowing!*

Flow is measured in units of volume per time. Flow is usually described in conversations in gallons per minute (GPM), but sometimes is shown in liters per second, liters per minute, or cubic meters per hour in manufacturer literature. Pumps are performance tested by manufacturers, and their performance is usually shown in a *pump curve.* It is important to understand how to read pump curves, and it's easy to do once you see it. Pump curves show you how much pressure the pump can produce as a discharge valve is moved from completely closed to completely open, going left to right across the graph. As the valve is opened, more and more water flows from the pump until it cannot move any more water. A pump will use more power as it moves more water, and the pressure it is able to produce usually decreases as the flow increases.

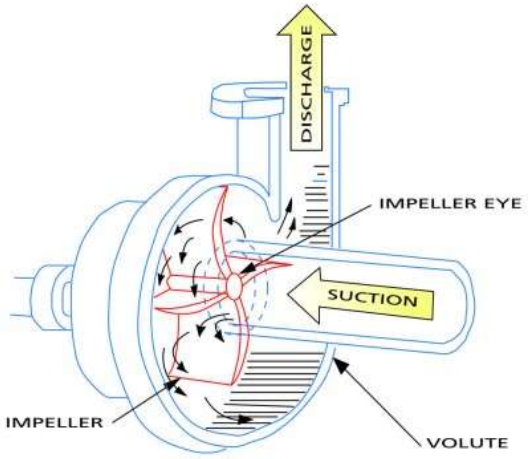
Many off-the-shelf pumps are advertised without a curve, but with two misleading numbers: a maximum pressure and a maximum flow. These do not tell you how the pump really works. How the pump really works is that the maximum pressure is always when the pump is at zero flow, and the maximum flow is achieved when the pump is in runout and delivering its lowest pressure. When a manufacturer gives both numbers, this creates the misleading impression that the pump can do both the pressure and the flow advertised, when it is actually the opposite! It can do the pressure at zero flow, and it can do the flow at near zero pressure! A centrifugal pump will never produce both its maximum pressure and maximum flow at the same time. Don't be fooled by some big numbers painted or stickered on to a pump cart or pump body, or in an advertisement. I see this all the time. The fact that these numbers are printed on there at all is actually a bad sign, and you should usually avoid this type of pump if you see it. Unfortunately, this type of stuff is all over the place, and many retailers are eager to sell you a generic pump that isn't really a good pump. A real wildfire pump will usually be painted plain red, with no numbers on it. It will be easy

and plain to determine the actual capabilities of a real wildfire pump made by a reputable manufacturer. If a manufacturer does not publish performance data, or provides the two numbers as discussed above, be very careful. You just might get what you pay for.

The Appendix section shows pump curves for a few pumps that are commonly used for wildfire and other pumping systems. The shapes are not exactly perfect to the manufacturer's published curves, but they are close enough to see the differences side by side, and will show how pumps have very different capabilities.

Pump Types

Most pumps used in wildfire water pumping systems, whether or not they are designed to be used in a wildfire environment, are centrifugal pumps. A drawing of a typical centrifugal pump is shown below.



Centrifugal Pump.

A centrifugal pump has an impeller which spins and sucks water into the pump suction port. The pump impeller then throws the water against the wall of the pump, which is called the *volute*. The water pressure rises as it hits the wall of the pump, and the pressurized water then exits through the discharge of the pump. Depending on the size of the impeller, the size of the casing, the shape of the impeller, and the number of impellers, this type of pump will usually be able to either gently push a lot of water (a "volume pump"), or strongly push a smaller flow of water (a "pressure pump"). Pumps that have more than one impeller next to each other along a shaft are called *multi-stage centrifugal pumps*, and this is the category of pump that we will focus on for wildfire sprinkler systems. Each main type of pump is explained below.

Volume Pumps

When you go to a local store or motorsports dealer and buy a pump off the shelf, you are usually buying a volume pump. Even if it is advertised as a "pressure pump," and even if the dealer tells you that is a fire pump, you are almost always really looking at a volume pump, sometimes called a transfer pump. These

pumps are designed to move a lot of water at a low pressure. Their deadhead (no flow) discharge pressure is usually about 30-70 psi. They usually have engines of about 5 to 6.5 hp, and 1 ½" or 2" discharge ports, although sometimes 3" or more. Volume pumps are commonly used by wilderness property owners to fill tanks or water yards. Volume pumps with plastic volutes and other inexpensive imported volume pumps are also commonly available. These in my opinion should be avoided for wildfire sprinkler pumping systems, because they just don't perform that well.

The wet ends of general purpose volume pumps are not usually built to a robust or high quality, and are usually not designed for the intense demands required for wildfire service. There are other drawbacks with these types of pumps that I cover in detail below. The customer is always right, but you also get what you pay for, so buyer beware if you choose to buy a volume pump and try to use it for a sprinkler system. You may be disappointed by its performance and reliability, and you may end up actually paying more in the long term when running a utility pump.

Then there are "trash pumps." These are basically a volume pump that is designed to be able to pump debris the size of pieces of gravel. Since you are not going to be pumping gravel into your sprinklers, you don't need a trash pump, and they should, like all other general purpose volume pumps, generally be avoided for wildfire sprinkler pumping service.

Pressure Pumps

Some off-the-shelf pumps advertised as "pressure pumps" will deadhead at 60 or even as high as 85 psi and move up to a maximum of about 100 GPM. These pumps move a little less water than a volume pump, but push it a little harder. This type of pump may work for a sprinkler system if your property is within about 400 feet of a lake and at a very low elevation compared to the lake. Their performance will not be very good if they have to lift water vertically more than about 25 feet or push it for more than about 400 feet. Also, as you add more sprinklers and allow the pump to produce more flow, the pressure can drop off dramatically with this type of pump. These pumps develop their highest pressures at low flows – at most, one or two sprinklers. They can work, and again, anything that gets water on the ground "works." However, the quality and endurance of these pumps is still not the same as with real fire pumps.

High Pressure – High Volume Pumps

High pressure – high volume (HPHV) pumps can create high pressures while also moving a lot of water. This is what you want. This is the category that most real fire pumps are in. These pumps usually have larger engines, more than one impeller, or turn fast. There are 2-stroke and 4-stroke engines. Maintenance is much more of an issue with 2-stroke engine pumps than 4-stroke engine pumps. 2-stroke pumps require more work with mixing fuel, changing spark plugs, changing wear parts, adjusting carburetors, and so on. 2-stroke engines can be very finicky and hard to start, and can require a lot of maintenance in order to keep in a good running condition for a few hours until the next time they need maintenance. 2-stroke engine pumps are extremely loud, run hard, and parts can wear out quickly during wildfire pumping service. This can be an important issue if it is left unaddressed. If you are considering getting a high pressure – high volume pump, it is a good choice to get one with a 4-stroke engine. They

are usually more user-friendly – and ultimately more reliable – than 2-stroke engine pumps. And they cost far less than 2-stroke pumps! I include recommendations for specific types of 4-stroke engine pumps below.

Multi-stage centrifugal pumps such as the popular Waterax Mark III ("Wajax") wildfire pump or a Wick 375 are capable of producing very high pressures approaching 400 psi at deadhead. This means that this type of pump can push water for very long distances down a discharge line and still maintain usable pressure. This excess pressure can compensate for long distances and design flaws in a sprinkler system. This type of pump requires special discharge line hose and pipe that are designed to run at high pressures. 4-stage pumps such as the Mark III, Wick 375, and other very high pressure pumps are not usually capable of moving both high volumes of water and producing high pressures *(and they are very expensive)*.

There is a trade-off between high pressure and high flow, and you can't really have both with the same engine size. While a typical volume pump can move well over 100 GPM without losing much of its deadhead pressure, a "Wajax" pump's discharge pressure will drop rapidly as the flow increases, and by the time it is producing about 90 GPM, the pump can only produce about 50 psi or less. This pump has enough power for many applications, and has some features that are desirable for wildfire crews in certain situations, but again, a 2-stroke engine requires more maintenance and is far more touchy than a 4-stroke engine. Most property owners would only be idling this pump while running a sprinkler system, and this can rapidly foul spark plugs and create issues with maintenance, downtime, reliability, and operating costs. Multi-stage pumps can be very powerful, but they must be used the right way for the best results. If you need more pressure or more flow, you usually simply need to get a 4-stroke pump with a bigger engine, which leads us to the next section…

Don't Get a "Wajax" Pump

I actually recommend that most people reading this book do not purchase and use a 2-stroke engine pump such as a Mark III ("Wajax") pumps or similar pumps such as the Wick 375. This question comes up often enough that the answer is worth its own specific section. I make this recommendation for the following reasons:

1. They are very expensive. You can get two or more excellent 4-stroke engine fire pumps for what a Mark III pump costs to the general public, and the 4-stroke engine pumps will probably work better for you.
2. They can be difficult and demanding to start, keep running, and maintain. They are high maintenance.
3. It can be difficult and expensive to get parts for them.
4. They are much too powerful for most wilderness property situations, and can create safety issues, or damage your system.
5. They are (like most pumps with 2-stroke engines) extremely loud, and will annoy your neighbors.
6. They run on a rich oil mix, and require a lot of fuel mixing (and operating cost for the oil).
7. The rich oil mix means that they can blow off a lot of smoke and fumes.

8. You probably don't need a light, highly portable and durable pump that can take a beating like a Mark III type of pump can. You probably don't need to carry them by helicopter, by plane, by backpack, or through muskeg and remote areas like wildfire crews do. They are a very sophisticated piece of technology, that are specifically designed for things that most property owners do not actually need.
9. Wildfire agencies do stock and maintain them, but do not use them in every situation.
10. Some see the Mark III as the "Cadillac" or ultimate pump due to their usage by wildfire agencies, but this is a misconception. They are an excellent pump, for sure…*for wildfire agencies, and for specific situations and needs that you probably don't actually have.* They are not a one-size-fits-all, and they are actually not the best type of pump for most property owners and communities.

Most people in home and cabin situations simply don't need them, and should avoid them.

Electric Powered Pumps

Electric powered pumps, submersible or not, are not recommended for use in wildfire pumping systems. Besides the fact that you cannot always rely on electric power being available, the common off-the-shelf types of electric pumps are usually much too low powered to be able to supply enough water at a high enough pressure to run a sprinkler system. An electric powered pump should not and cannot generally be used to power a sprinkler system, and electric pumps will not be discussed further.

Off Brand Pumps

The internet has made it possible to view classified ads and equipment vendor catalogues worldwide. Also, many retailers sell pumps. This is both a good thing and a bad thing. A few minutes of searching the internet or a visit to a retailer usually turns up these types of pumps:

1. Off-brand pumps.
2. Used pumps.
3. Pumps that are not fit for wildfire service advertised as "fire pumps."

The customer is always right, but I recommend to be very cautious about following up on these kinds of leads. Some of these pumps might work (for a while anyway), but some of the things that can go wrong in this area are:

1. Off-brand pumps may be of questionable quality.
2. Off-brand pumps may have hard to obtain, imported, off-brand parts and supplies, or be essentially disposable.
3. Maintenance of off-brand pumps can be exotic and difficult, and the product life cycle can be short by design. Who will fix or be able to fix these pumps if they need it?
4. Off-brand pumps may come and go and become obsolete at any time.
5. Off-brand pumps sometimes are copies of name brand pumps, but with flaws.
6. Used pumps may have hidden maintenance or operating issues.

7. Pumps that are not designed for fire service may not stand up well to the intense demands of wildfire sprinkler pumping systems.

Pump selection is the most important thing to get right in a wildfire sprinkler pumping system, so if at all possible, resist the urge to find an off-brand pump on the internet or at a store. Get the real deal. I've seen many examples of folks trying to find bargains on the Internet, and stringing together homemade materials, and then 10 years later, they're at it again, and discovering that their system's performance is actually really limited. All of this is easily avoided by getting a good quality pump to begin with.

Recommended Pumps

I recommend that most single property systems use a two-stage pump (two impellers; a multi-stage centrifugal pump), powered by a 4-stroke engine, ideally a Honda GX engine. The pump manufacturer that I recommend is a Canadian company called CET (see links in the Appendix), and the best pumps for most cabin or community situations are found in their High Pressure series. The specific models that I recommend are the PFP-9HPHND-M-TWIN (my #1 recommendation, and the pump that I most commonly use on projects) or the PFP-6HPHND-M-TWIN (if you specifically want something smaller). The 9 hp pump has enough pressure and volume for most sprinkler system applications, plus hose attack work. The models I have specified are manual start types in manual carry frames (which I have mounted to various carts), but they are also available in electric start and with skid mount frames. CET also makes larger HPHV pumps in 11, 14, 20, and 23HP sizes. These are good options for larger scales where the property is large, there is an irrigation demand, there is a high lift, or the volume is large due to neighbors sharing. Pumps any larger than 23hp become more cumbersome and heavy. A 23 hp pump can be carried by two people, or mounted to a wagon or quad trailer.

Other important manufacturers to look at are Waterax, Waterous, and Mercedes Textiles, but these pumps are usually much more expensive and somewhat harder to obtain, and may not actually be appropriate for what you need to do. And again, be cautious about going to a local hardware store, motorsports dealer, or water equipment supply house, as the quality and price of pumps found at these places can be less than ideal. If you're unsure of which pump is right for your application, contact me, and I will gladly help you choose the best pump for your situation and your budget. I also now can buy pumps at factory direct pricing, which can make a substantial difference to your budget.

CET 9 hp pump mounted on hand/hitch cart.

3. Discharge Line

A discharge line is required to bring water from the pump to your property. There are a lot of different types of pipes and hose that will do the job. You can get pipe made of many different kinds of metals or plastic, and many different kinds of hose as well. You can use just about anything that is round, and even things that are square if you want to. If it works, it works. But if you are building a semi-permanent wildfire water pumping system, why not use a discharge line that is going to be strong, easy to use, and robust? The cost of building a system with a good quality discharge line is not going to be all that much more than the cost of building a system with a lower quality discharge line. Also, for wildfire service, the discharge line size and material can be important, and can affect the safety and reliability of your system.

Plastic Pipe

Many wilderness properties already have permanent pumping systems which draw water from a lake for cisterns, storage tanks, domestic water systems, and irrigation. Probably the most common discharge line material that is used by most people for these applications is flexible black polyethylene plastic pipe, or

"poly." Poly pipe is inexpensive and is fairly durable for some purposes. However, poly line has some important disadvantages for a semi-permanent wildfire water pumping system:

1. It is often not designed for high pressures (over 100 psi) in 1 ½" and 2" sizes, which can create serviceability, safety, and reliability issues.
2. It can soften and melt when it is exposed to heat. This has caused a number of cases of system failures and property losses.
3. It will conform to ups and downs wherever it lays. This could lead to airlocking and freezing damage.
4. Coupling the ends of poly pipe can be cumbersome, as getting a grip on shanks is not guaranteed to handle high pressure. There are compression fittings available, and there are other ways to handle the ends such as flanges, but these are generally expensive and outside the realm of what most people can reasonably carry out.
5. It can take significant time and effort to properly repair poly pipe if it becomes damaged.
6. Any poly pipe, if used, should be set up so that it is always wet down by your sprinkler system. If you have the means to do so, burying plastic piping is one possible approach, but comes with a few provisos and risks that need to be taken into account.

Another material that is often used due to its "off the shelf" nature is PVC. I do not recommend using this either, because it can have poor weathering characteristics, and is prone to fracturing during temperature changes, as the material and things that it is attached to expand and contract and shift. It just will not have the same longevity and serviceability of better materials. I have seen numerous cases where PVC pipes fail and must be repaired on a seasonal basis.

If you are designing a semi-permanent wildfire water pumping system, plastic piping is not in my opinion the best material to use. Use plastic pipe at your own discretion. As with anything else, use common sense and consider the pros and cons if you do decide to use plastic pipe. If you are going to the effort of creating a wildfire sprinkler system, every component should be well suited to the job. If any one component fails, the whole system fails.

Metal Pipe

Metal pipe is very strong and durable, and would be an excellent material for a discharge line, but it is expensive, heavy, and takes a long time to put together. It also gets a little complicated with pressure ratings and connections. It is therefore not very practical for a sprinkler system discharge line, especially in a remote area where materials must be brought in by boat or snowmobile. If you can find some 2" pipe and Victaulic couplings, and if you can put it together yourself and protect it from freezing damage, then by all means use metal pipe. If it works, it works. Victaulic coupled steel pipe is, after all, used for fire water systems in many large buildings. Likewise, if you can find some irrigation pipe, it may work for a sprinkler system. However, since metal pipe is not practical for most remote wilderness property areas, it will not be considered as a generally recommended material to use for a main discharge line.

Hose

In my opinion, usually the best choice for a semi-permanent system is forestry hose. Forestry hose is usually 1 ½" in diameter and comes in 50 or 100 foot lengths. Since it rolls up flat, it is in the category of what is called *lay-flat hose*. There are many different manufacturers and different types of hose. Some are single layer, some have multiple layers, some are fabric, some are plastic, and some are designed to sweat water, or *percolate.* Percolating hose is worth considering when a hose is run along a trail or through areas where there is shrub or bush. Since any plants and leaves can burn in a wildfire, a percolating hose will tend to protect itself from fire. This could be the deciding factor on whether you are able to protect your property from a wildfire. While any pipe or hose will tend to be cooled by the water flowing inside it, a percolating hose will be more resistant to ground or surface fire activity, and will likely stay intact as a fire burns around it. It is a bit heavier and more expensive than other fire hoses, but not by much.

Forestry hose can easily be set up, moved, adjusted, replaced, and disassembled when needed. Wildfire agency values protection crews almost always use forestry hoses to construct sprinkler systems. Forestry hose is available from several industrial suppliers, as well as wildfire equipment suppliers. It comes in many different types, so shop around and inquire with people who sell hose to find good quality and good prices on forestry hose. The best types that I use for projects have a urethane inner tube, and a polyester jacket with UV resistant coating. You may also find used hose on the Internet or a classified ad service, if you choose to purchase materials that way.

Forestry hose piled up waiting for collection after successfully protecting properties.

As with anything else, you get what you pay for. Single layer lay-flat hose is inexpensive, but can be easily damaged by abrasion. Rubber-coated or synthetic fiber lay-flat hose offers better protection, but can have poor weather resistance depending on the coating material. The higher end types are usually designed to be very light, but they are very expensive and are harder to find. The prosumer grade types are usually the best to use. These will have a 300 psi service pressure rating, UV resistant synthetic coating, and a urethane inner tube. Any lay-flat hose will require special couplings to connect; forestry quick couplings

are the standard, and are easy to use. Definitely avoid using camlock fittings for discharge line if you are using non-forestry lay-flat hose, since these couplings can create problems on discharge lines. For a semi-permanent wildfire water pumping system, forestry hose with quick couplings is in my opinion one of the best types to use. Some of the issues that you may run into when using forestry hose are failure and misplacement of the coupling gaskets, and interferences from manufacturing tolerances that make it difficult to connect the couplings together. Stocking a few extra gaskets and a couple of metal files in your toolkit will usually quickly resolve these issues.

Forestry quick coupling. Easy to assemble and disassemble by hand or with wrenches if required.

4. Manifold

A discharge line will bring water to your property. The water then needs to be directed to sprinklers; it needs a manifold of some sort. This can be done many different ways, and as always, "if it works, it works." Water thief fittings and 5/8" or 3/4" hoses are sometimes used as manifolds to branch off from discharge lines to sprinklers. However, this is not necessarily cost-effective, convenient, robust, or nice to look at for a semi-permanent system. A semi-permanent sprinkler system should, in my opinion, have a permanent manifold attached to or mounted near the main building that is being protected, or in some strategic or convenient spot. Even better is to have hard piped sprinkler connections inside the building, and sprinklers permanently mounted on roofs. This would be a good thing to consider for a new building.

There are many possible ways to construct a dedicated manifold. A straight manifold can be as simple as a quick connect coupling threaded into a line of piping tees with ¾" nipples and valves. Another possibility is a ring-style manifold as shown in the picture below. Water pressure in this type of pressure balanced manifold will be close to equal for every branch of the pumping system, and the manifold is smaller than a straight manifold. Manifolds can easily be constructed from common pipe fittings available at industrial pipe and fitting suppliers. If you know a plumber, welder, or pipe fitter, they may be able to offer advice or help you construct a manifold. I have built enough of them that I have developed some good details.

Here are some tips and ideas on manifold construction:

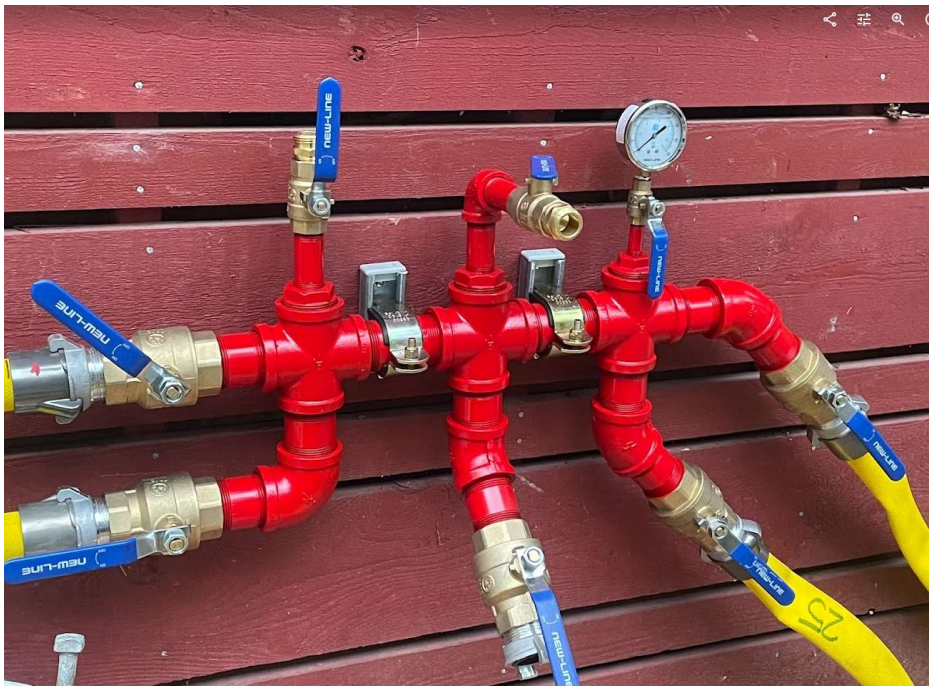
1. Use good quality materials. Black iron fittings are very strong, and will last for a long time, especially if painted with an anti-rust primer and paint. Galvanized are good too. Black iron or galvanized fittings can be sourced from industrial suppliers much cheaper than at hardware

stores. Use good thread sealant – use both tape and dope – and tighten the fittings enough to make them secure, but not so hard that you strip threads or risk hurting yourself.

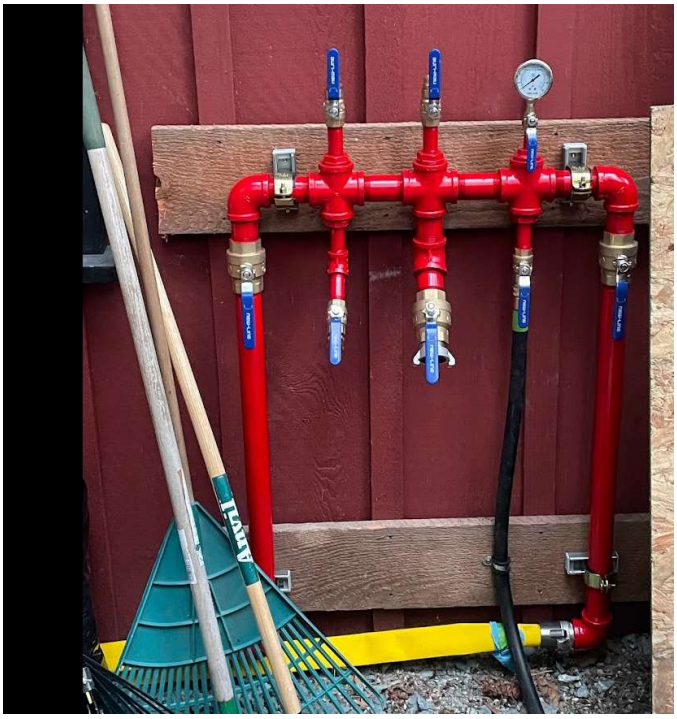
2. It is good to add a couple extra supply and takeoff ports to the manifold. It won't cost much more, and it will add some extra options to your system. For example, if you have extra 1 ½" forestry quick coupling connections, you can use the manifold to quickly hook up a fire hose. Values protection crews can also then easily connect to your manifold with their own pumps or as a *Siamese* (twin) connection to your pump. Also, if you have extra takeoffs, you have the option of using other sprinklers to wet down areas that are not wetted well enough by the main sprinklers.
3. Be careful about what valves you use in a manifold. Ball valves work very well, but if using ball valves, try and get *full port* ball valves. A reduced port ball valve will waste pump pressure. Sometimes water thieves are purposely built with reduced port ball valves in case the hose is damaged, so that that portion of the line will not rob pressure and flow from other sprinklers on the same line. In a manifold, the same logic could apply, but if you are using good quality hose between your manifold and sprinklers, or hard piped connections to your sprinklers, it shouldn't be an issue, and the full port ball valve will be superior.
4. Gate valves or globe valves also work well for some specific things, but are usually more expensive. Butterfly valves do not work well in my experience, and should, in my opinion, always be avoided. The discs in butterfly valves are located in the middle of the water flow. The discs therefore often collect debris and plug. These valves can also slam themselves shut under flow, which can damage a pumping system.
5. Be careful when connecting different types of metals at a manifold. Connecting two different metals such as copper and iron can cause the iron to rust. Ask a plumber or do some research on what metals don't mix well if you plan on using dissimilar metals in a manifold.
6. You may want to consider connecting a piece of zinc to a manifold to act as a *sacrificial anode.* This will cause the zinc to rust before the iron does. Small threaded 3/8" NPT sacrificial anodes are easily available online, and can be added into a manifold in order to improve its corrosion resistance and extend its lifespan.
7. As with all piping, make sure that there is a way to drain everything before winter so it doesn't freeze and ruin all of your hard work. Be sure it's drained, and then be sure again.
8. Be careful about using plastic fittings or valves for a manifold; they are not much different from metal fittings in price, and the plastic is far less robust.
9. For that matter, be careful about building any part of your system using plastic materials, since the strength of these materials and joints is far below that of metal fittings. Plastic also tends to degrade with time and sun exposure, and crack during seasonal temperature swings. You don't want your system blowing apart under service. If you're going to go to the effort of building a pumping system, use quality materials and metal fittings wherever you can.
10. My experience has led me to avoid using small inline hose strainers, piping strainers, or valve strainers. Be careful about trying to use any of these. Straining is best at the pump suction.
11. Securely mount the manifold in an easy to access spot. Consider adding a removable cover to protect the manifold from weather.

Pressure Balancing

When taking water off of a supply line, it can be important to consider pressure losses from takeoffs. Have you ever had someone flush a toilet or run a faucet when you are in the shower, and the water temperature suddenly changes? This is because the water supply pressure changes when the faucet or toilet starts drawing water from same line that is feeding your shower. This change in pressure immediately changes the flow of hot or cold water to the shower. This same thing can happen with sprinkler systems, and becomes more important as the number of sprinklers in the system increases. A pressure balanced loop manifold solves this. Wherever possible, it is best practice to construct a pressure balanced loop manifold or join two manifolds in a ring arrangement. A ring manifold will accomplish pressure balancing under load. So will joining the two downstream ends of a wye into a ring, or joining the ends of a straight manifold with a length of hose. Avoid making a line of takeoffs into a dead end. The last sprinkler in the line can have far less pressure and far less flow than the first. Try to give each sprinkler the same access to pressure and flow.



Manifold part of a multiple-manifold, loop connected sprinkler/irrigation system.



Another manifold as part of a loop-connected sprinkler/irrigation system.

Primary manifold with ergonomic entry/exit to secondary manifold (not shown).

5. Sprinklers

Sprinkler placement is probably the single most important and worthwhile thing that homeowners can do to work in conjunction with wildfire crews. Wildfire crews are not allowed to climb on roofs, and often improvise sprinkler stands from trees or lumber. These stands can only reach a certain height, and building them can take a lot of precious time. However, the ridge cap or end gable of any given building is usually a good high point from which to attach a sprinkler, and this is an excellent way for you to prepare your property. A sprinkler on both ends of a ridge cap will usually protect a whole building with a good radius around it, and especially at the perimeter.

Sprinklers used in wildfire systems are usually rotating impact sprinklers like you would see at a golf course, farm, or park. The better types are usually made from bronze or brass, and there are different types of mounts available. You can purchase (and pay a lot for) special ridge cap mounts, gable mounts, lumber mounts, fascia mounts, and gutter mounts, and by all means, do this if you choose. However, you can usually build something superior yourself if you are so inclined.

There are many possible ways to set up sprinklers, but the overall goal is to wet down roofs and areas next to buildings. Some tips and ideas for sprinklers are as follows:

1. Consider building permanent hard-piped sprinkler connections into a pipe chase inside a new property, or concealing hard pipe connections somewhere inside your existing property. Hard pipe can be copper, galvanized, black iron, PVC, etc, if it is indoors – sunlight can degrade some types of plastic piping, so use plastic piping outdoors with caution.
2. For any permanent pipe, ensure that horizontal runs have at least ¼" per foot slope and that the pipe can be totally drained and capped in the fall. Hard piped sprinkler connections are probably the best and most robust way to feed sprinklers from a manifold.
3. Sprinklers with two nozzles will offer more flow and better area coverage than single nozzle types. However, single nozzle sprinklers can be more resistant to clogging. Single nozzle sprinklers will tend to create unbalanced forces, and can stress and destroy mounts, so better mounts may be required for single nozzle sprinklers.
4. Tall sprinkler mounts can sway and bend from the force of sprinkling, and can wear themselves apart. If you construct a tall homemade sprinkler mount, try to make it able to handle the repeated stress and motion that will come from sprinkling. If your building's ridge cap(s) are high enough, you probably don't need a tall mount, and can even try and incorporate a hard piped mount as shown below.
5. Larger sprinklers will require more flow and can require the entire system to be constructed from better and larger materials.
6. Regardless of mounting style, once you have built and tested the system and you are happy with the coverage of water, secure the sprinklers well. It could get very windy if a wildfire approaches your property, and the sprinklers could be pulled out of place if not secured.
7. If using hose to connect your manifold to your sprinklers, it is better to use good quality, internally reinforced rubber hose. Plastic hose, like poly pipe, can swell and melt when heated. Quality

rubber hose costs a bit more than plastic hose, but is very durable and will perform better and longer than cheap hose. Cheap hose may be degraded by weather exposure. Lay-flat fabric forestry hose will also work, but is usually not as durable or long lasting as rubber hose.

8. Try to use ¾" diameter hose (or pipe) for each sprinkler. See the Appendix for hose pressure loss charts. A 5/8" diameter hose can lose up to 30 psi per 100 feet at 10 GPM. This wastes precious pumping power. A ¾" hose in the same conditions would only lose 14 psi.
9. Keep all hose runs as straight and smooth as you can, and neatly coil any excess hose in a safe spot. Avoid kinking or twisting hoses.
10. For connecting the hose to ¾" NPT manifold nipples, and to the sprinklers on the other end, it is important to use garden hose thread (GHT) x NPT adapter fittings, since NPT and GHT are not exactly the same and do not fit together perfectly. These adapter fittings come with male or female NPT or GHT threads on each end. To connect a supply hose to a manifold, you will usually need a FNPT x MGHT adapter fitting. For connecting a hose to a sprinkler head, you need a FGHT x MNPT adapter fitting and a ¾" coupling.
11. Don't assume or forget to make sure that all the threaded parts of your system actually fit together. Put it together and test it.
12. Impact sprinklers are usually come with a ¾" MNPT connection, and you need a standard NPT coupling to connect them as described above. There will not be enough room to put the sprinkler heads straight into an adapter fitting, and they won't fit a hose end. The bottom of the sprinkler is a rotating bearing, and it needs to be free to rotate.

Concealed hard pipe sprinkler connection and permanent roof mount. These are excellent examples of permanent construction. Photo credit: onestopfire.com

Designing Your System and Putting It All Together

Now that we have gone over the details of the main parts of wildfire sprinkler systems, we can plan your system out step by step. The list of basic steps below should help you plan out and construct your system. Following these steps will help you first to see how much flow you need then and to select the correct pump for your application. Selecting the correct pump is the most important part of building your system. Once you have your pump selected, it is a matter of putting everything together and running it. If you are located close to a neighbor, you may be able to work with your neighbor and pool your resources to buy a pump or pumps that will serve both of your properties. Pooling resources in this way can be beneficial in a number of ways.

Pooling resources with a neighbor will reduce the costs for both of you, and by working together, you can put the system together at least twice as fast as each of you building your own system. The more neighbors that pitch in, the cheaper and better it becomes for everyone – but the system might get a little more complicated if it has to serve more than two or three properties. It won't be rocket science to put a bigger system together, and it is worth discussing a bigger system with members of your community, but you will need to plan a little more carefully with a bigger and more complicated system, and they can be much more cumbersome to operate. It preferable in my experience to have multiple smaller system based on smaller pumps. Also, any big and fancy system becomes a one-of-a-kind thing that will start to not match up with what your local wildfire agency and neighboring communities are doing. See the Fire Pump section for more information on what I believe are the best types of pumps to use for most situations.

I've already recommended pumps that I believe are ideal for most situations, but if you want to calculate things from scratch, I've included some material to help you do that. The simplified steps to follow to design a pumping system are as follows. A Pump Selection Worksheet is also provided in the Appendix. You can use the worksheet to calculate and record numbers.

1. Plan out how you want to run your hose from the lake to your property. Pick a good, short path and make sure the hose will be safe from vehicles or other damage. Measure the distance, and get enough discharge line to cover this distance. Round up to the nearest 100 feet. Let's work through an example. Say your property is 550 feet up a path from a lake. Here you would buy at least eight 100 foot lengths of hose, keep two as spares, and your hose lay would be **600 feet** long. Write this number down.
2. Plan out how many sprinklers you need. Start with the assumption that each sprinkler will use 10 GPM. Use two sprinklers for your main structure (or more, depending how big it is and how it is laid out), and one for smaller structures. Try to get up to at least 50 GPM in total for your property for the best chance of success. For an example, let's say you decide to use five ¾" sprinklers. This means you will assume that you need **50 GPM.** Write this number down and circle it.
3. Once you know how much flow you need, use a hose pressure loss chart (or pipe pressure loss chart if using pipe) like the chart in the Appendix to figure out how much pressure you will lose between your pump and your manifold at your design flow. In our example, we need 50 GPM in 600 feet of hose. The hose pressure loss chart shows that there would be 9 psi of pressure loss

per 100 feet of 1 ½" hose. You are using 6 lengths of hose in this example. So, 6 x 9 = **54 psi** hose pressure loss. Write this number down.

4. Estimate how far you have to lift water to your sprinklers from the lake, in feet. Divide this by 2.3 to get your elevation pressure loss. Let's assume this is 34 feet = **15 psi.** Write this number down.
5. Estimate pressure loss from your manifold to your sprinklers by using the chart below. Let's assume a sprinkler is connected to your manifold by 50 feet of ¾" hose. The pressure loss at 10 GPM is 15 psi per 100 ft x (50ft/100ft) = 7.5 psi, round up to **8 psi.** Write this number down. The pressure loss from the manifold to the sprinklers will actually decrease as you run multiple sprinklers from a manifold, but we will ignore that for this calculation, mostly to err on the side of caution, and also because it is a small difference.
6. Decide how much pressure you want to give your sprinklers. Their usual operating pressure range is 30 to 80 psi. **50 psi** is a good recommended starting point. Write this number down.
7. Add the pressures from steps 3, 4, 5, and 6. In this example, it is 54 + 15 + 8 + 50 psi = 127 psi, round up to the nearest 5 psi = **130 psi.** Write this number down and circle it.
8. You have now calculated your *pump operating point*. It is **50 GPM at 130 psi** in this example. You need to find a pump that can provide this operating point or better. Go through pump specs or ask someone who knows about fire pumps to help you pick a pump that will perform the way you need it to. It's that simple. This same basic process applies, no matter how many sprinklers you need or how far you are from the nearest water source (within reason). The pressure required gets higher the farther you have to move the water, but that is easily solved by selecting a stronger pump. Most typical cabins will need a pump that can deliver between 50 and 200 psi. Try to avoid compromising on pump capability or buying a cheaper pump. The pump is the most critical part of the system. Over-designing your pump a little is going to be far less of a problem than under-designing your pump. Searching the internet for "forest fire pump Canada" will bring up a list of manufacturers and retailers. Some manufacturers and retailers are also listed in the Appendix.

General Notes and Summary

Some other general notes on sprinkler systems are either worth repeating or didn't fit well in other sections of the book, so I've collected them here. They are as follows:

- There's a saying that goes "there are no atheists in foxholes." When it's crunch time, things can become very different than what is usually considered normal. Tensions can flare. The need for something as simple as a fitting, a hose, a tool, a helping hand, or gasoline can become extremely magnified and intense. To help avoid this, plan your system out in advance while you have time and are not under stress. Stock up on key materials. Work ahead over time. Don't wait until the last minute and assume that you can throw it all together with no issues.
- Make note of any issues you encounter during routine testing and ensure that they are resolved, and test the system to make sure that the solution works.
- Get the best pump that you can. This is very important. I recommend the CET 9 hp Twin (2-stage) pumps for most situations, and other CET pumps with Honda engines for virtually any system from personal scale up to community scale.

- Test your system regularly and keep it in good working order. Forests and insects have a way of reclaiming space that can quickly degrade things. A pumping system should be tested at least twice a year and maintained in good condition. You don't want to be in a situation where you need to run the system and you find yourself trying to flush debris through a leaky hose and into a sprinkler nozzle that is plugged with insect nests or spiders.
- The ideal system should be "walk-away" for up to 24 hours so that it can stay running while you are in a safe place away from the wildfire. Some pumps come with fuel connections or can be modified to be able to be connected to portable boat fuel tanks or jerry cans, which means that the pump can run for a very long time without refueling.
- Any system should have one or two extra 1 ½" forestry quick coupling connections so that you, a neighbor, or a values protection crew can connect an extra pump and/or fire hose.
- The system should be protected from frost so that pipes or hose do not split from freezing. This may mean disconnecting and draining hoses or manifolds (especially ball valves), covering taps, and lightly taping over nozzles.
- Be careful of small in-line strainers. The more of these that you add to a system, the more things that can go wrong. Wildfires can carry an incredible amount of debris into a water source, and most lake shore areas have plenty of debris in the water that can clog any strainer or filter. In my experience it is best to have a large, robust suction filter screen to keep debris out of the system, instead of attempting to maintain a group of small strainers. Even with a suction filter screen, debris can enter pumping systems and will collect in any in-line strainers, which then require maintenance. Debris can sometimes plug nozzles, which will be revealed during system testing.
- For this reason, it's always good to flush a system for several minutes at high flow with a large valve or valves open to atmosphere at the manifold. This will clear debris from the lines.
- Gas powered fire pumps, like any other seasonal engine, should always be run with a fuel conditioner and stabilizer, so that the fuel system does not become clogged with stale gas varnish or absorb water. Avoid ethanol fuels, always use premium gasoline and stabilizer. I prefer the Yamaha fuel preservative, as it is alcohol free.
- Many people usually "know a guy" or are tempted by piecemeal "deals" or other shortcuts (and you will find that a lot of shortcuts are available!). If this is your cup of tea, by all means go ahead and do these kinds of things, if you are willing to take or ignore the risks involved. I suggest that it is better to go about building a pump system with a solid understanding of the whole thing from stem to stern, and with quality, common components all the way through.
- Components don't need to be gold plated, but there are a few key areas that it's important to get right. It's better to do it right once than to have to do it several times or waste time and money on excessive maintenance and rework. You don't want to be in the position of the guy I once saw at a retailer urgently asking for a very exotic type of compression fitting to repair his system. Or the guy stumbling around a rocky shoreline trying to prime a suction hose made from two damaged pieces of the wrong type of hose. The list goes on: expensive and wrong pumps, cheap pumps, mismatched piping, leaks, repairs, shaky mounts, patchwork fixes that fall apart after a short time. Seeing too many people in these kinds of predicaments and finding that folks were sometimes unwilling to talk or listen about what they were doing is a main reason I wrote this

handbook. I realized that most people in home and cabin situations don't pick apart details of system designs, parts, failures, serviceability, operability, costs, and reliability like I'm used to having to do in industrial settings. In industry, there are thousands of installed pump systems, and reams of books and knowledge about how to design, operate, and maintain them effectively. In this handbook I've tried to identify and provide solutions for most of the issues that I have seen people struggle with in wildfire pumping systems – issues that usually revolve around choices of materials and methods, often in an attempt to achieve the lowest possible costs, while disregarding almost everything else that is important in a wildfire pumping system. I've laid it all out, use it or ignore it as you see fit.

- When choosing pipe or hose sizes, it is usually better to have larger sizes. Larger diameter pipe or hose will allow more water flow and reduce pressure losses.
- You'll often see small aluminum spanner wrenches that are supposed to be used to break apart forestry quick couplings and hose connections. I find them to be difficult to use, and I've seen other people struggle with them. Since you don't need these tiny and light tools to fit in your pocket or be as light as possible in a helicopter or plane like a wildfire crew does, just get a couple of pipe wrenches as part of your toolkit. They are much easier and more effective to use.
- You lose 1 psi for every 2.31 feet that you lift water vertically. However, the water can wet down a larger area if the sprinkler is higher. But if a sprinkler is too high, wind can blow the water away from your property and make it difficult to get uniform water coverage (I've seen spray mostly miss a cabin where a sprinkler was mounted directly overtop of the cabin on an old radio antenna). Use common sense and test your system a few times to see how it works.
- Try to get all roofs and the whole perimeter around your buildings wet, and set things up so that you can get your main building totally wet using rocker sprinklers or garden sprinklers if you need to. If you have been keeping up on the FireSmart activities, you will have already reduced the risks immediately around your property, but it's still important to get everything wet.
- If a pump is rated for "25 feet suction lift," this means vertical feet. Your suction hose can be longer than this if required. Try and keep it as short as you can (20 feet is common), and try and keep the pump as close as you can to the water source. Pumps can lift water, but they don't usually perform very well if they have to do a high suction lift.
- The area around your cabin or home usually requires the most work to set up. This is a good place to start when you have all your materials and start to build your system. Running the discharge line hose and setting up a pump is the "easy" part, and can be done last, or someone else can do it while you are getting the property area sprinklers ready.
- Try to give yourself plenty of time to build, test, and optimize the system. If you work in a rush, you are more likely to make mistakes, break things, hurt yourself, or do something else unsafe. Safety should always be the top priority when building or operating a sprinkler system. This includes working at heights, working with tools and sharp objects, trips, slips, falls, etc. Even something as simple as a good pair of gloves goes a long way in preventing injury.
- Try and make sure your discharge line and distribution lines are wet and protected. There have been cases of systems failing due to discharge lines burning. Percolating hose is one possible solution, and trail maintenance is another.

- When starting your system from empty, take care to bleed the air from the lines safely. Compressed air can be very dangerous.
- Always open and close valves slowly to avoid suddenly starting or stopping water. Fast changes to water speed can cause *water hammer* and damage your system.
- Take care of your equipment, and it will take care of you. Maintaining and testing your equipment is very important. Carefully store seasonal items such as hose and pumps in the fall.
- There's always something new to learn, and you never know when you will learn something about sprinkler systems that could make a difference.
- A sprinkler system is not a magical safety blanket, and is not 100% guaranteed. It is best to look at your property in terms of an overall community fire prevention system such as FireSmart. Even remote properties with no nearby neighbors can use the principles of fire prevention systems. Between sprinklers and FireSmart, some think one is the ultimate, and some think the other. My vision is that sprinkler systems are totally complementary to FireSmart work, and can greatly improve the chances of a structure surviving a wildfire.
- Keep it simple. I've seen creative proposals for many different possible types of exotic water supply and pumping systems using all manner of equipment, from huge engines to irrigation equipment to scrapped municipal equipment to exotic power sources to weird parts, you name it, someone has probably brought it forward or tried to use it. But this stuff gets confusing and awkward in the real world. The things to ask about these, the things you need to answer about any of these are: who can operate it? Who can maintain it? What would it really cost in a couple years? Portable fire pumps, as outlined above, are based on familiar small gasoline engines. Portable fire pumps are easily operated and maintained by people of all ages and ability levels with very little in the way of specialized tools or training. Portable fire pump systems have very definite, well-established costs, and are built from common off-the-shelf items. It doesn't make much sense to try and build some kind of big, exotic, one-off system that very few people are capable of operating or maintaining, and which doesn't match any of the other systems that are normally used by almost everybody else. Keep it simple, keep it practical, you are just taking water from the lake and putting it on your cabin, you're not building a large town water system. Keep it simple.

Other Jurisdictions

Outside of North America, there are other jurisdictions impacted by wildfire, particularly Australia. The behavior of Australian wildfires is actually rather different than those in North America, in that there tends to be a hot and fast wind component, and water supplies are often limited. Australian systems frequently feature a specific type of building irrigation, designed to mitigate the specific conditions of Australian bushfires. Australia also often features remote start pumps via SMS technology, whereas remote start technology is more rare and more expensive in North America, and is not currently a retail item. There are microcontrollers that can be added to pumps for remote start, but they are not shelf items. It should not be assumed that international technology and materials are transferable to North American settings.

Some Final Notes

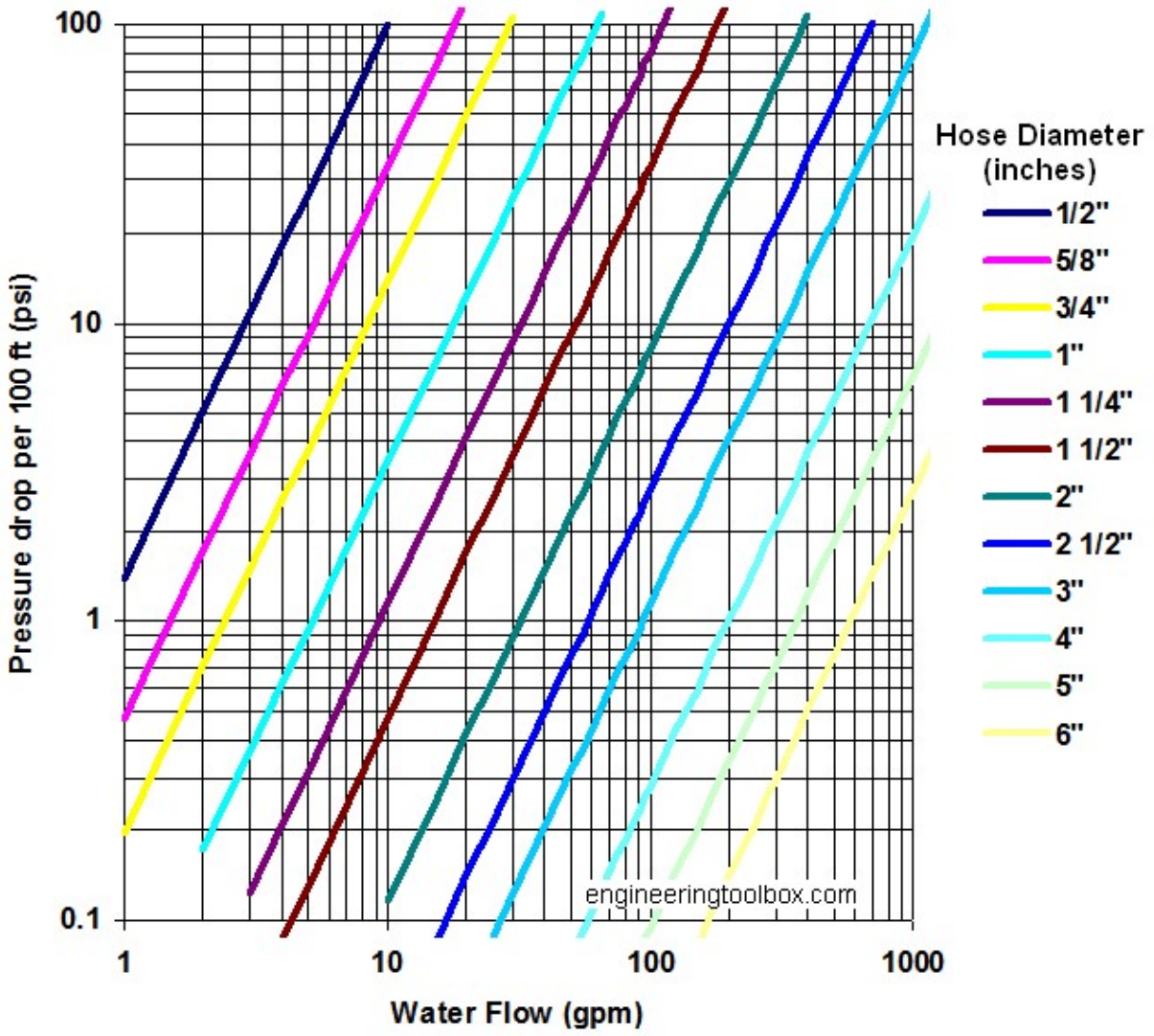
Fire seasons in Canada have become more and more intense. Having been in and near the thick of things and watching situations unfold in the La Ronge area in the 2015 season, I was motivated to try and help people understand how to build good-quality, long-lasting, semi-permanent pumping systems. You can easily build a system that costs far less and works far better than if you were to approach a vendor or water supply house to get a package system. I've seen the quotes, I've seen the receipts, there are outfits out there that are charging very high prices for equipment that isn't even always the right equipment. In 2016, Alberta experienced some devastating property damage from wildfires. In 2017, it was British Columbia and the Yukon. In 2018 it was BC and Alberta, with California again. This continued year after year. BC in 2022 and 2023. Jasper in 2024. Cities in Alberta in the middle of the day in mid-August looked like they were located on Mars. 2025 saw massive fires in Saskatchewan and Manitoba and many property losses in lakeside communities that lacked sprinkler systems. The trend of these events is likely to continue, and the costs and impact of these events to our society are in an increasing trend, like it or not. Thankfully, forward-looking provincial governments are doing more to mitigate wildfire risk. Hopefully resources go towards practical solutions and not into too much bureaucratic and academic activity. If this handbook can help even one more cabin or home survive a wildfire, it will be well worth the effort it took to write it. Be safe, and have fun.

Help With Your System

Over time, I received enough inquiries and demand that I started offering consulting and construction services for sprinkler systems. Whether you are looking at individual properties or community-scale systems, feel free to contact me at jason.gogal@gmail.com or view my website at aquaeus.ca. I have many years of hands-on experience with all aspects of pumping and wildfire pumping systems, from design and procurement all the way through to construction and operation, across Canada and the US. I also have partnerships with businesses and professionals in the community of practice across Canada that I can work with to help construct wildfire sprinkler systems. I work in an efficient, no-nonsense way, and I can help you build a system better and cheaper than anyone else.

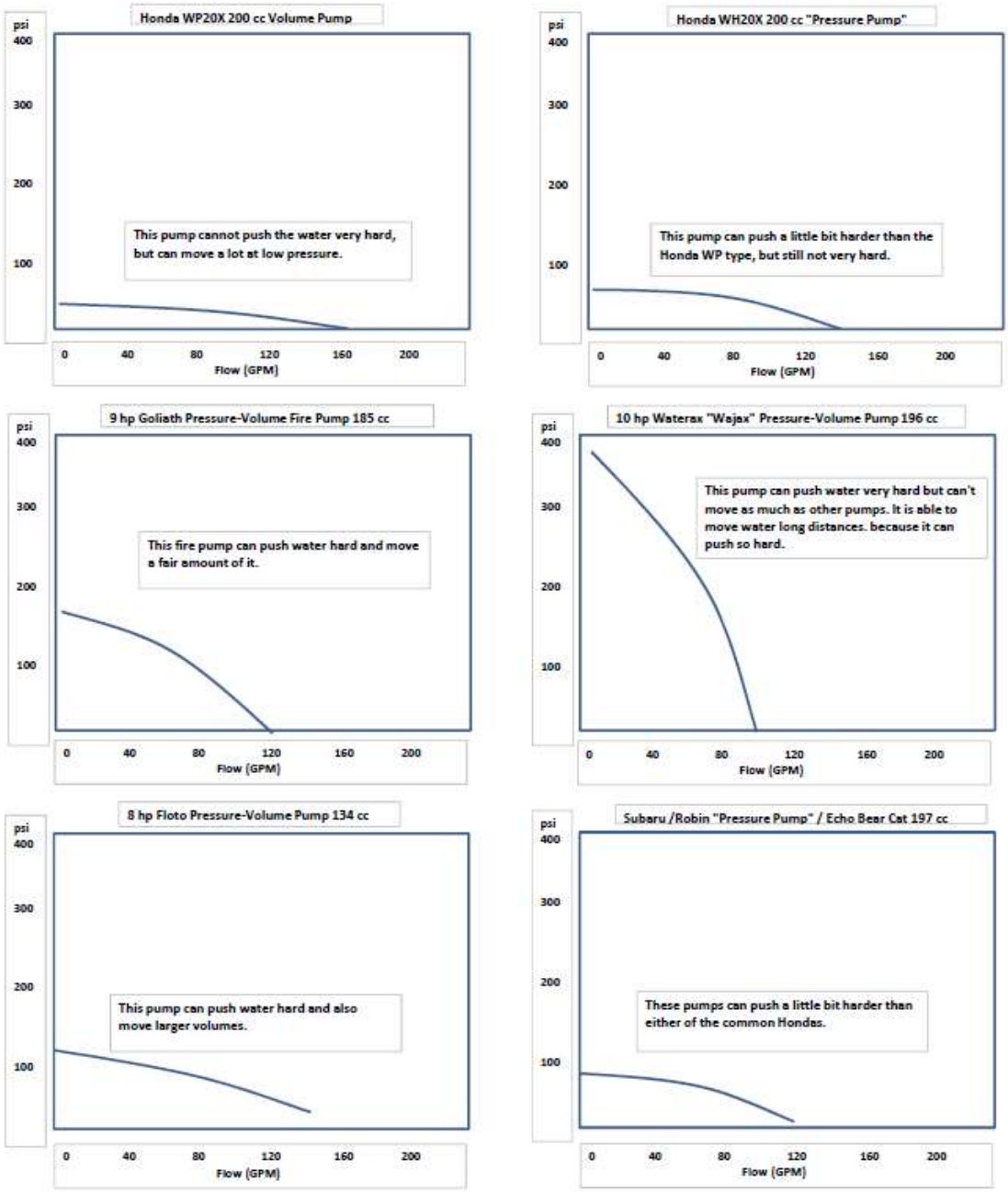
Appendix

Hose Pressure Loss Chart



Water pressure loss chart. For reference and design only. Actual system performance may vary by hose type, hose layout, and site conditions.

Pump Curves for Common Pumps



Comparison of curves for pumps that are commonly used to power sprinkler systems. The size of the area under the curve shows how much power the pump has, and the shape of the curve tells you how the pump uses its power. A low, flat curve means that the pump cannot push very hard. A steep curve means that the pump can push hard, but loses pressure as it moves more water. A diagonal curve means that a pump can both push hard and move a lot of water.

Links to Suppliers

These contacts are provided for the reader's reference only. If larger orders are placed with these companies, or you can find someone with an account at these companies, you may be able to get equipment at prices lower than retail list prices. If a reader has another company they know about, feel free to contact me to have the supplier added to this list. If anyone from these companies does not want their company listed here, contact me. I did not attempt to list every company that makes some unique widget or accessory. Generally the outfits listed below can help you get a whole system together.

Fire Pumps:

Aquaeus (pumps, accessories, and complete systems): aquaeus.ca

CET Fire Pumps MFG (a Canadian company): www.fire-pump.com

AJ Stone: www.ajstone.com

Wildfire (pump and hose retailer): www.wildfire-env.com

Vallfirest: www.vftnorthamerica.com

Forestry Hose, Hose, Pipe, and Accessories:

Aquaeus: aquaeus.ca

Green Line Hose and Fittings: www.greenlinehose.com

New Line Hose and Fittings: www.new-line.com

Nelson Irrigation (sprinklers): www.nelsonirrigation.com

Storm Buckner (sprinklers): www.bucknersuperior.com

Other References

There are many other sources of information on pumps, hose, sprinklers, pipe, wildfire prevention, and other subjects covered in this book. The internet or your local library or bookstore will provide many possible sources. The reader may also know plumbers, construction workers, farmers, or other people who are experienced with pumping and piping systems. The inclined reader is encouraged to consult any other source that they feel they need to in order to make well-informed decisions on system component selection and construction methods.

Safety

A final word about safety. Safety should be the number one consideration in everything you do when building and operating pumping and sprinkler system. Use common sense and safe work practices. Plan

your work out and avoid working in a rush or pushing yourself too hard. Consult online resources, a professional, or a local safety authority if you have any questions regarding working safely. And above all, always be safe as you work and as you play. Go home safely at the end of the day, every day.

Pump Selection Worksheet

Here is a sheet that you can use to determine your required pump operating point.

Number of Sprinklers x 10 GPM = F	_____ x 10 GPM = F =	_____ **GPM**
Property Distance from Water (ft) = D	_____ = D	
D rounded up to the nearest hundred and divided by 100 = L	_____ = L, and round up =	_____
Sprinkler Design Pressure = PS	_____ = PS =	_____ psi
Pressure Loss per 100 ft of 1 ½" hose at flow F (psi) = PL	_____ = PL =	_____ psi
Pressure Loss in Hose Run = L x PL = PLH	_____ x _____ = PLH =	_____ psi
Sprinkler Elevation Above Water Source Level (ft) = E	_____ = E	
Elevation Pressure Loss = E divided by 2.3 = PLE	_____ = PLE =	_____ psi
Sprinkler Hose Pressure Loss, one sprinkler @ 10 GPM = PLS	_____ = PLS =	_____ psi
Total Pressure Required at Pump = PS + PLH + PLE + PLS = PT	_____ = PT	_____**psi**

The top and bottom numbers are your required pump operating point = **_____ GPM at _____ psi**

Check your result to see if it makes sense. It should be somewhere between 50 and 200 psi for most systems within 3000 ft. of a water source.

Photo credit: Ontario Ministry of Natural Resources