Alberta Infrastructure

Guideline for Wildfire Protection of Institutional Buildings in Forested Regions in Alberta

March 2013

Preface

Use of the Guideline

This document will be used as a resource during planning and designing of new buildings or upgrades to existing institutional buildings that may be exposed to the threat of a wildfire.

Owners of institutional buildings shall comply with all applicable legislation. This guideline is intended to supplement, not replace existing codes and regulations. In addition, it can be used as a reference and guide to best practices when designing or upgrading institutional buildings located within forested regions of Alberta. The guideline will assist in evaluating whether the design of existing buildings or facilities presents an unacceptable risk, or may result in an increased risk in the event of a wildfire. The evaluation of the design must consider various risk factors in determining whether an existing institutional building or facility should undertake improvement in order to conform to the guideline criteria. The risk assessment factors must cover, but may not be limited to, the following areas:

- Building Construction (roof, walls, openings)
- Building Services (utilities, HVAC Isolation)
- Topography (slope, evacuation routes)
- Passive Exposure (tree line distance, other buildings, barriers, ground cover)
- Water Supply (fire suppression water)
- Active Suppression (sprinklers)

To determine the requirement for fire protection mitigation, a scoring table has been developed and presented in Appendix A. This table can be used to evaluate the fire protection mitigation requirement of the building in question and, as a result, guide in the building design decision making process or evaluation of existing buildings.

Relation to Codes and Regulations

In preparing this document, Alberta Infrastructure recognizes that viable alternative solutions may exist and they may be equivalent to or exceed the fire protection measures contained within this guideline.

It must be noted that this guideline is a "starting point" for the evaluation of wildfire protection of institutional buildings in forested regions of Alberta. There is currently no single document that provides specific recommendations for wildfire protection design for buildings located in wildfire prone areas. The Environmental and Sustainable Resources Development group in collaboration with Partners in Protection (referenced in this document) has provided programs (FireSmart) to assist building owners and communities in understanding and applying best practices in wildland-urban interface areas.

As noted above, this document is a guide to best practices and is not all encompassing. Wildfire protection of institutional buildings also requires a further understanding of building and fire codes, best practice measures, and documents produced by professional associations. It must be noted that every new building and its operation in Alberta must meet the minimum regulatory requirements of the Alberta Building Code, Fire Code and the related codes and standards.

Through the adoption of fire protection measures, adherence to regulatory requirements and installation of proper controls, the hazards associated with wildfires can be minimized and reduce the likelihood of the devastating impact of wildfires on life and property.

Commendations

In conjunction with various codes and standards a number of studies and programs have been utilized in the development of this document. The list of reference material is in Appendix C.

The authors of the guideline would like to acknowledge the individuals who assisted in the development of this guideline:

- Mr. Troy Holloway, *Senior Design Architect, Capital Projects, Alberta Infrastructure*
- Mr. Murray Johnson, *Planning Manager, Northern Region, Property Development, Alberta Infrastructure*
- Mr. Brian Oakley, *Director of Architecture, Capital Projects, Alberta Infrastructure*
- Mr. Brian Vance, *Chief Administrative Officer (CAO) Slave Lake*
- Mr. Trent West, *Alberta Fire Commissioner/Executive Director*
- Mr. Bruce Jackson, *Royal Canadian Mounted Police (RCMP) Arson investigator*
- Mr. Wendell Pozniak, *Environmental and Sustainable Resource Development (ESRD)*

Morrison Hershfield Team

This guideline was developed by a diverse team of expertise at Morrison Hershfield Limited

- Mr. Wayne Rose, *Project Manager, Senior Fire and Emergency Management Specialist*
- Mr. Barry Colledge, *Senior Fire Protection Engineer*
- Mr. Haris Wijayasiri, *Architect*
- Mr. Fred Johnsen, *Senior Fire Protection Specialist/Safety Codes Officer*
- Mr. Loyd Bacon, *Senior Fire Protection Specialist*
- Mr. Jamie Spence, *Fire Protection Engineer (former Helitack Team Leader, ESRD)*
- Mr. James Eduful, *Fire Protection E.I.T.*
- Mr. Mike Danilowich, *Senior Mechanical Engineer*
- Mr. Clarence Cormier, *Senior Electrical Engineer*
- Mr. Michael Ball, *Project Engineer/Building Envelope*
- Mr. Kalum Galle, *LEED® Project Manager/Sustainability*
- Ms. Cheryl Dorsey, *Executive Assistant*

GUIDELINE

For Wildfire Protection of Institutional Buildings in Forested Regions in Alberta

for

Alberta Infrastructure, Technical Services Branch, Capital Projects Division

Contents

1 Introduction

Wildfires are named as such for a reason; they are often uncontrollable. What *is* controllable is the preparation and planning taken to protect buildings from damage and loss when a wildfire occurs. Wildfires can be a devastating experience but are an essential part of the forest ecosystem for renewal[1]. Fire will recycle nutrients, help plants reproduce and create a diverse habitat that benefits a variety of wildlife. It has long been accepted that forests protected from fire are more ingrown and selective of the types of trees developing[2]. Undergrowth and decaying materials in these areas increase the likelihood and intensity of a fire when an ignition source is provided.

Figure 1.1 *Undergrowth fire igniting 'ladder fuels'*

The Government of Alberta owns and operates a large number of buildings that could be exposed to wildfires. Appendix E provides a list of current facilities considered under this guideline. In this case, *institutional* refers to all buildings operating government programs.

It is a necessity that some government buildings be located in forested areas in order to serve the citizens of Alberta. This guideline is developed to increase the survivability of buildings located within forested areas, to function during and after a wildfire. Occupied buildings shall have an emergency plan in place that includes evacuation or Shelter-in-Place with sufficient resources to survive for at least 3 days (72 Hours) as a minimum requirement following a disaster.

After the passing of a wildfire through an area, when a building survives, people describe these events using terms like luck, miracle, or divine will. These terms describe people's emotions of being powerless and unable to control the outcome. With proper planning and preventive measures the notion that all wildfires are uncontrollable and their damage unavoidable can be addressed and exposed as incorrect. There are numerous tested and proven methods available to reduce losses resulting from wildfires. Short of constructing an underground bunker or removing all of the trees, shrubbery and organic matter in the vicinity of a building, it is difficult to create a building that is 'guaranteed' to survive the worst wildfire scenario. The intent of this guideline is to enhance the survivability of a building exposed to wildfires by allowing informed decisions to be made on the value of building upgrades that will withstand the potential disasters of wildfire incidents.

1.1 Glossary

Appendix D provides a list of terms and acronyms used in this guideline.

1.2 Wildfire Prevalence

The total area burned by wildfires in Canada has increased steadily since the 1970s along with an increase in temperatures during the wildfire season[3]. Furthermore, it has been shown that there is a trend of decreasing relative humidity in the spring and autumn in Alberta producing an expansion of the fire seasons duration[4]. This is of particular note, as Alberta may develop a longer spring wildfire season. The recent devastating Slave Lake fire in 2011 occurred in the spring. Wind events are increasing in Alberta[4] and theoretical forest modeling indicates the Midwest boreal forests may be reaching a tipping point that is increasing the threat of wildfires[5]. The combination of the above with the expansion of rural communities and the continuing trend of our desire to live near forested areas means the prevalence and impact of wildfires will continue to increase in Alberta and across North America.

1.3 Building Ignition

The ignition and spread of fire is a simple combustion process. The requirements for combustion are fuel, heat, oxygen, and a chemical chain reaction (Figure 1.2). Fire spreads as a continuing ignition process either from the propagation of flames or from spot ignitions by fire brands. A fire will continue to spread as long as all four elements are present. Once ignited, removal of any one of the four elements will extinguish the fire.

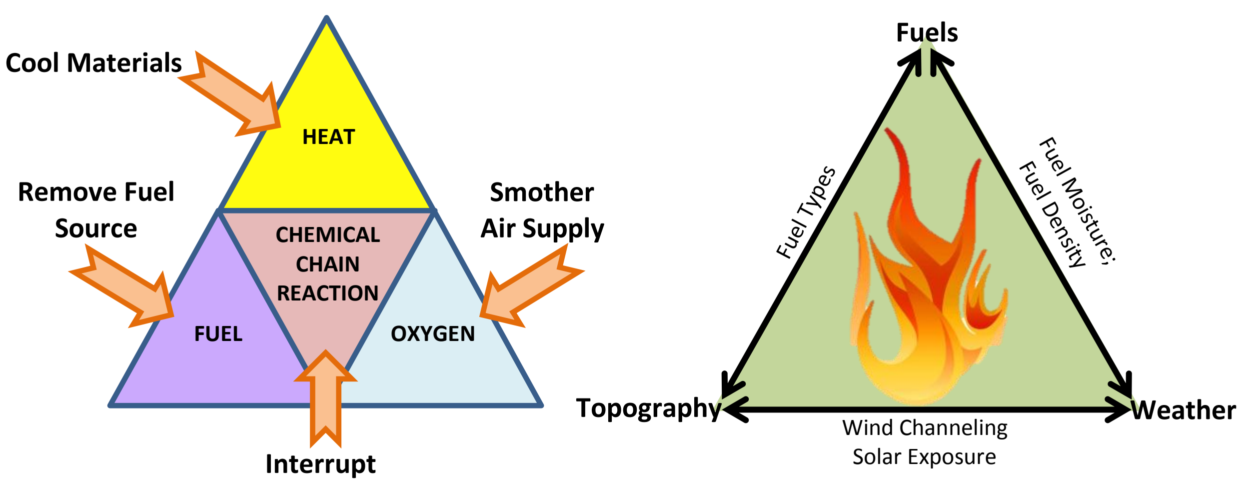


Figure 1.2 Fire Tetrahedron and Wildfire Triangle *- Fire ignition and burning process*

The fire triangle demonstrates other factors that impact risks addressed in this guideline.

Wildfires are detrimental to buildings in three ways:

- **Radiation: excessive quantities of heat will cause exposed building materials to fail, which may result in its collapse and/or failure of systems, even if they are not directly exposed to flames. It is also probable that a particular material is elevated to auto-ignition temperatures, causing spontaneous combustion.**
- **Direct flame impingement: results in collapse and/or failure of systems and will set ablaze any exposed combustible building material.**
- **Lofted fire brands: airborne burning embers and fire brands are carried on the updraft created by the concentrated heat of a forest fire. Low pressure and air drawn from around the fire can carry the burning brands significant distances. When embers encounter a low pressure stratum on a building they will settle on available surfaces as a result of gravity. One ember may not cause combustion but an accumulation of embers will ignite combustible material under the proper conditions.**

The best way to ensure a building's survival is to prevent ignition. Research and professional experience indicate that the main flame front passes through an area in as little time as 50-70 seconds[6]. Cohen concluded, based on model results of experimental burns of forest test plots and case studies, that radiant heat from an intense *crown fire* will not ignite wood panels greater than 40 metres from the flame front[6]. In a subsequent study the same author reduced this distance to 30 meters[7].

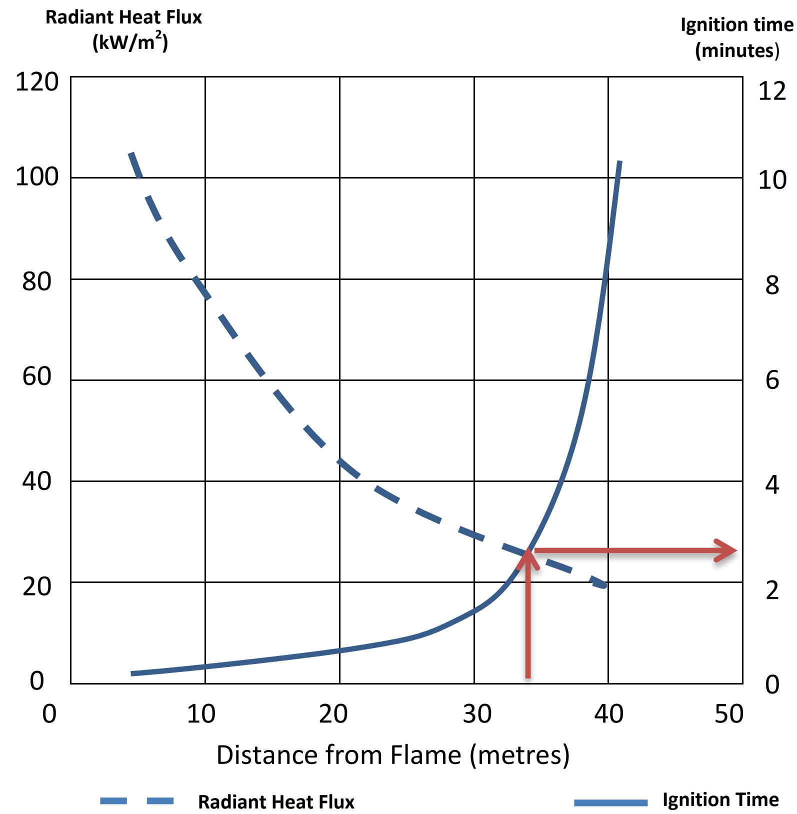


***Figure 1.3** - **Radiant Heat Flux** - The incident radiant heat flux is shown as a function of a wall's distance from a flame 20 meters high by 50 meters wide, uniform, constant, 1,200 K, black-body[6].*

Figure 1.3 demonstrates a correlation between radiant heat flux, ignition time, and distance from flame. Note that approximately 3 minutes is required for piloted wood located 30 metres from the flame front to ignite.

It has been proven statistically that the majority of buildings lost due to a wildfire are ignited by embers or fire brands that cause small fires on or around a building[8].

These small spot fires can ignite through contact directly with flames or due to radiant heat. If left unmitigated and with access to sufficient fuel, these fires will propagate into large fires that will significantly increase the likelihood of igniting surrounding buildings. Whether a building survives a wildfire disaster will initially depend on whether the building will ignite. Once ignited, as burning continues, the survivability of the building will depend on intervention with suppression efforts. Mitigating the fuel load and quantity of heat are also factors that will affect the combustibility of a building and significantly reduce the probability of ignition.

Figure 1.4 Fire Tornado *- Although a rare occurrence this photo demonstrates the exposure risk of a 'fire whirl' that would impact almost any building design.*

Heat reduction (siting), limiting combustibility (building construction) and fire suppression (building protection) are all addressed to mitigate the impact of fire, while allowing some flexibility in the final building design.

2 Site Planning

2.1 Building Location

Individual buildings located within a forest provide a challenge with respect to available resources that could improve survivability. In an urban setting the allocation of resources must also consider the neighborhood context. Each scenario has challenges and expectations which must be satisfied when developing the final building design in a location exposed to the potential risks of wildfires.

Defensible Zone (U.S. terminology) or Asset Protection Zone (Australian terminology) shall be provided. Defensible Space or Zone provides a break between the front of fire and the exposing building face being protected. This buffer space while distancing the fire, also allows access for emergency response and working space for the responders and their equipment. This zone also limits the likelihood of a building (which may have already ignited) to contain the fire. Asset Protection Zone is similar to the Defensible Zone but is defined as the highest level of strategic protection to human life, property and high value assets vulnerable to radiant heat or embers.

2.1.1 Urban or Rural

Many buildings are designed and constructed in rural areas in response to the desire to take advantage of the natural setting and aesthetics. Aesthetics must be weighed against the risks to the building imposed by its surroundings and available access of rescue services. Many rural locations also require the building to be self-sufficient for all or some of the utility services required to function.

Some regions, towns, and municipalities may provide planning for buffer zones using parks, golf courses, roadways and other open spaces around buildings to protect them from the risk of wildfires. They may also allow for community-based central services such as fire prevention services, quick action rescue services, utilities, and roads.

When a building is located within a municipal center amongst other buildings, its actual exposure may no longer be the forest but the surrounding buildings. The close proximity of buildings in an urban environment could spread the fire into the heart of that community, as demonstrated in Slave Lake. The exposure between buildings now becomes a primary concern that would go beyond the expectations as presented in ABC 3.2.3 (Alberta Building Code) due to involvement of multiple buildings ignited by the forest fire. Reduction in the occurrences of destructive fires is the intent of the building code. A wildfire is a conflagration, or extensive fire, that can threaten a municipal center. Irrespective of the location of the building, the intent of the ABC is to prevent the fire from spreading to neighbouring structures. There are no provisions under ABC to address wildfires. The International Code Council family of documents has been updated to include a new standard under the title ‘2012 International Wildland-Urban Interface Code’.

2.1.2 Access Routes

Infrastructure through planning and development provides roads which are navigable through all seasons and weather conditions. Some Alberta Infrastructure owned buildings are built deeper in the forest due to necessity. At such locations, while the threat of wildfires is increased, the quality and quantity of available access roads are diminished. It is advisable to have two accessible routes for evacuation and training protocols to simulate an evacuation.

2.1.3 Climate

The flow, speed and direction of prevailing winds have a significant impact on how a wildfire will travel. The wind also impacts the distance and direction of travel for fire brands. Wind-borne fire brands are one of the sources of ignition which propagate a wildfire.

The use of the *Prometheus*© software program will assist in the modeling of the winds and evaluation of the safe fuel load in proximity to the building analyzed. The program factors in the geographical location as well as the species of indigenous trees, providing a realistic view of the risks associated with the location of the buildings.

Rainfall levels and humidity also have a significant impact on the moisture content present in a forest and must be considered when the risk of a wildfire is assessed during building planning, or during annual forest fire risk assessments conducted by authorities with jurisdiction. These conditions are usually localized and analyzed when determining the likelihood of ignition and development of wildfires.

2.1.4 Topography

Topography of a building site or region has a significant impact on access routes for rescue or suppression, the speed of access, and the speed and intensity of the spread of the wildfire. A wildfire burning up a slope will progress more rapidly and with greater intensity than a wildfire on level terrain. Natural features such as valleys can channel and intensify the wildfire.

Figure 1.5 Fire travel - *Photo illustrates the fire progression climbing a hillside with an abundance of fuel.*

Different features can provide barriers to the propagation of *ground* or *surface fires*:

- **Natural barriers: rocky outcroppings, bodies of water, large expanses of barren land, etc.**
- **Constructed barriers: roads, paths, stone walls of sufficient height, etc.**

These features provide a point of defense and can reduce the quantity of resources needed to eliminate or divert the propagation of a fire.

2.1.5 Major Considerations

Siting of the building should be done with due consideration of available building protection methods and proposed construction materials. Use the best practices advice developed through the *FireSmart Program* and other standards and codes to assist in reducing the losses potentially sustained due to wildfires.

To minimize the risk of fire spread onto a building, the following site planning considerations must be made:

- **Use open spaces as barriers to fire spread. To reduce the probability of building ignition, provide open barriers at least 30 metres wide. When buildings are located near slopes (devoid of vegetation), allow up to 50 metres of clearance. (Note: clear area must be maintained through fire prevention practices).**
- **Consider the height of the surrounding trees when clearing so that the trees do not compromise the safety distance required.**

- **Provide access to property for emergency responders and provide evacuation routes for building occupants. Roads should be at least 6.1 m wide with turn-around space as required by the Alberta Building Code Division B, Part 3.3.2.5.6.**
- **Provide a fire resistance rating for the building exterior, commensurate with the risk. See section 5: Building Design and Utility Services.**
- **Provide a water supply that meets or exceeds the minimum requirements of the Alberta Building Code for the building design.**

2.2 Building Separation

Two basic scenarios must be considered for all buildings when discussing exposure to a fire. The impact of a wildfire on buildings and occupants is the primary concern of this study. The scenario of a fire starting in a structure and becoming the ignition source for a wildfire must also be considered when reviewing exposure.

2.2.1 Forest

It is impractical to turn all of Alberta forests into safely managed parks that limit the probability of uncontrolled wildfires. Many documents have been developed to address wildland-urban interface that can be applied to individual structures or entire communities. Alberta's Environmental and Sustainable Resource Development (ESRD) initiative has had the FireSmart Program available since 2000.

Depending on the size and type of trees (i.e. Aspen versus Black Spruce) the wildfire will burn very differently. The size of the tree, particularly the trunk circumference, will impact the rate of burning and quantity of heat released. The continual build-up of dead plant material on the forest floor provides fuel for a potentially intense fire which could be easily ignited and difficult to control. Undergrowth also provides small, easily ignitable fuel for a fire, while hindering emergency access. *Ground* and *surface fires* have a greater fuel load but a *crown fire* will travel much faster and respond more readily to wind conditions. However, selective removal of this 'accumulated fuel' is impractical and interferes with the natural forest lifecycle, which can impact the health of the forest and create a greater disaster when a fire does occur.

2.2.2 Exposures

Considering the number of variables involved, accurately defining and predicting the risk of exposure to a wildfire is a challenge. While constantly changing weather conditions provide many variables, the wind and moisture content are two significant variables that can impact the parameters of a fire and the area of probable impact of wind-borne embers. The amount and type of fuel will also impact the intensity and duration of exposure to the fire. Topography can impact the speed of fire spread and the intensity of radiated heat while limiting accessibility to escape routes.

- **Subsection 3.2.3 of the ABC provides spatial separation between buildings, limitations to the area of the exposed building face and the limitations to unprotected openings in that exposed building face.**
- **Increasing the defensible zone allows more leeway in building design but increases the impact on the existing forest.**
- **The architectural response for designing buildings located in forested areas is usually to design in harmony with nature and integrate the building with trees and natural features of the site. Although this approach is aesthetically desirable, it presents the greatest danger when dealing with wildfire risks. Mitigating the risk of fire to such structures is a combination of reducing the exposure to the fire while upgrading the building to withstand remaining exposure.**

2.2.3 High Intensity Residential Fires (HIRF)

In 2009, The Alberta Building Code was amended to address exposure fires in residential buildings. The amendments were applied to all buildings outside a 10 minute response capability of the local fire department. This level of protection has been applied to other occupancies threatened by increased exposure. The amendments address exposure by requiring application of at least one of three options:

- **Increase the distance between houses**
- **Provide a greater fire resistance rating for the building envelope**
- **Install sprinklers in the residences**

In the aftermath of the wildfire in Slave Lake, the municipality has initiated a policy that no emergency response to a building can guarantee fire department suppression in 10 minutes, requiring all new construction to meet the HIRF stipulations.

2.2.4 Parking

Parking lots provide wide open areas devoid of combustible materials, which can provide a buffer - until the lot is filled with vehicles. Vehicles located in parking lots can become hazards in an intense wildfire. The gasoline or other fuels in the vehicles and the combustible material content of the vehicles will provide increased risk to the buildings through explosions and production of toxic fumes created by intense combustion.

Ensuring a minimum 3 metre separation of vehicles from the building will reduce the threat to the building. Ensuring that vehicles in the parking lot are separated from the threat of wildfires to maintain any developed defensive zone shall be a primary consideration. Parking vehicles next to or near a building could compromise the safety distance.

2.2.5 Landscaping

The ESRD FireSmart Program for Landscaping provides guidance for preparing the defensive zone around a building. This document should be referenced by all personnel responsible for maintaining the landscaping for buildings in forested areas.

Ornamental trees, shrubs, mulch and peat moss can provide sources of heat and fire brands within the defensive zone, should they ignite. These materials provide less fuel than trees but are more easily ignited and can create fire brands close to the building. Other combustible material, outdoor furniture, and equipment within the defensive zone or attached to the building provides potential ignition points. Pergolas and breezeways, gazebos, wooden shutters and louvers, awnings, decking, combustible projections, park benches and picnic tables, BBQs, wood piles, etc. are materials and installations which are discouraged within the defensible zone or attached to the building.

Natural and constructed barriers such as fences (brick vs. wood) or natural formations (rock outcroppings) provide either a route for fire or a barrier (as discussed under 2.2.2 Exposures). Noncombustible landscaping elements in the form of fences, area demarcations, nodes, monuments, screens, etc. are encouraged to separate surrounding combustible plant material from the building envelope. Such construction shall not create ‘negative pressure areas’ where wind-borne fire brands and embers could settle and concentrate in intensity. Combustible landscaping elements shall not be attached to the buildings. Water features with independent reliable power sources that spray water into the air with a collection system, which then recirculates (i.e. pumps) through the system are encouraged.

2.2.6 Siting Criteria

Good landscaping practices can also provide water for firefighting. Drainage of rainwater to a basin or underground containment tank for future use in routine ground maintenance or emergency sprinkler application is one practice. As a benefit, this would qualify the building project for LEED® credit.

As discussed in this section, when reviewing a potential site the following factors must be considered:

- **Slope of site (a level site is preferable to locating on a slope or crown of a hill since a fire burns rapidly with greater intensity in sloped areas)**
- **Predominant prevailing winds for building location**
- **Fuel content in the form of combustible building and plant material**
- **Available access routes (multiple routes are preferable for evacuation or emergency response)**
- **Density of the forest and species of trees (this would determine the fuel supply that helps define the intensity and duration of a wildfire exposure)**
- **Available sources for water (consideration of volume, accessibility and reliability will allow more options in designing the building protection)**

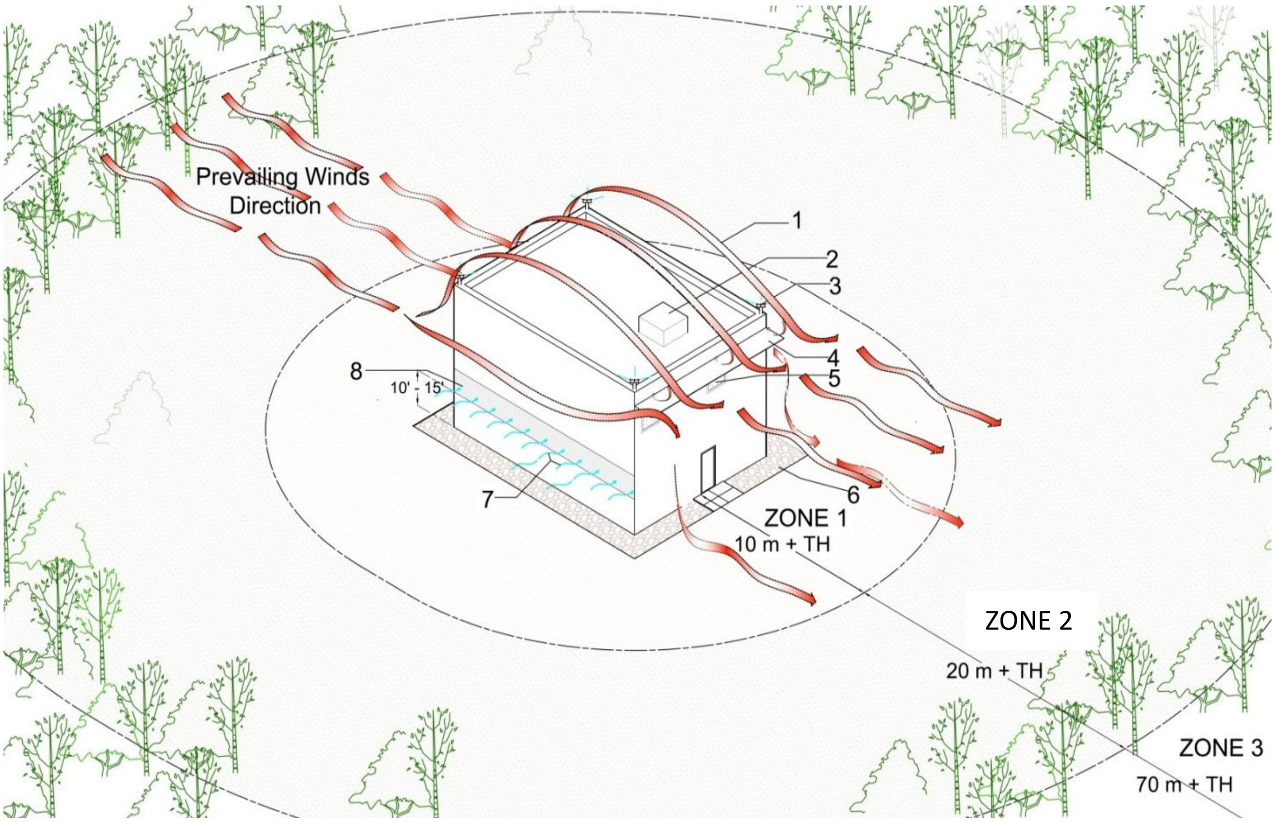


Figure 1.6 *Schematic sketches of site considerations*

Key

1 – Hot gases from wildfire
2 – HVAC roof to unit (protected)
3 – Exterior sprinklers
4 – Non-combustible solar shading
5 – Windows with non-combustible shutters
6 – Non-combustible semi-permeable material (e.g. gravel) for fire water re-circulation). *Refer to Section 5.4 for details*
7 – Air intake
8 – Air intake location with smoke detectors

TH: refers to anticipated tree height based on species type

Zone 1

Wildfires occurring within this zone will generate enough radiant energy to ignite most combustible materials through radiation. Exposed noncombustible structural assemblies are likely to lose their structural integrity.

Zone 2

Wildfire in this zone has the potential to generate enough heat flux to ignite combustible materials. Ignition and survivability will depend on the exterior materials, the design of the building, and amount of heat that impinges on the building's exposed elements.

Zone 3

Wildfires occurring in this zone will not directly ignite buildings located beyond 70m + TH through radiant exposure. Primarily building survivability concern will be to protect the building or area from spot ignition from lofted fire brands.

3 Local Resources

3.1 Communications

During any emergency, good communication is critical to ensure a timely, planned, and orderly response. A wildfire can cover a large area of land or region and move quickly under opportune conditions. Building operators should be familiar with local emergency procedures and the methods of communication to be utilized by the governing agency during an emergency. All communications equipment shall be connected to a reliable back-up power source. They shall have data connectivity independent of systems that could be interrupted due to a potential incident of a wildfire.

3.2 Emergency Response

The first responders to an emergency caused by a wildfire are firefighting personnel. In addition, many other organizations may get involved, including police, emergency medical services, search and rescue, and support organizations (e.g. Red Cross). Heavy equipment may also be employed to prevent the spread of a wildfire. This may include bulldozers, skidders, graders, and other support equipment for fire breaks and removal of fuel sources.

3.2.1 Alberta Environmental and Sustainable Resource Development (ESRD)

ESRD Forest Protection employs over 300 Type I wildland firefighters for initial deployment and has access to over 2,000 Type IF or Type II crews for sustained action. Cooperative agreements with other Canadian provinces and neighbouring states can allow for the deployment of additional wildland firefighters and equipment.

The firefighters on the ground are supported by air tankers, helicopters, dozers, skidders, water tenders, catering camps and a plethora of other heavy equipment used to assist in containing and extinguishing wildfires.

ESRD has developed mobile sprinkler trailers which are used during wildland urban interface events. These trailers consist of portable sprinklers, hose lines, pumps and water tanks which can be set up in a relatively short time period to protect buildings threatened by wildfire.

When a wildfire threatens a populated area, firefighters will evaluate and prioritize buildings that are defendable and those which likely cannot be saved.

Pre-fire planning will identify those buildings that require a higher level of protection.

3.2.2 Fire Department

The resources of the local fire department can vary widely in Alberta. In the areas exposed to the highest risk of wildfires, the primary fire department response team may only be staffed with volunteers or paid on-call firefighters and located a significant distance from the emergency. A local fire department’s wildfire fighting skills and their level of knowledge can also vary greatly through the province. All fire departments will have basic wildland firefighter training, but some fire departments will be well versed in wildland tactics and have an excellent working relationship with ESRD in their area, while some fire departments may only have limited experience with minor grass fires.

Allowing that these resources would be utilized at the front line of operations in an emergency situation, the designs based on this guideline have considered that the emergency response will be engaged elsewhere.

It is recommended that building operators liaise with the local fire department on a regular basis to ensure that the fire department is familiar with the building location, typical occupancy, fire protection measures in place, and any special needs required from within to help the firefighters to pre-plan for any potential incident.

3.3 Water Supply

3.3.1 Planning and Evaluation

Assessing the availability of a reliable supply of water for fire suppression is critical in planning for the potential risk of a wildfire. When the building location and its size is determined, the availability of a sustainable water supply for an emergency must be made.

In some locales, a municipal distribution network of water with hydrants may provide the necessary water flow for the building being designed or evaluated. Such a system is beyond the control of this guideline but the source and reliability of the water supplying this network should be considered during design.

In many isolated forested areas the water supply must be stored on site. Natural sources of water; such as lakes, rivers and streams, can provide the necessary water but must be evaluated for available quantity and accessibility during planning. Other sources could be a reservoir, well or storage tank with sufficient water to meet the calculated water flows. The final option is to supply the water using water tenders or tankers; in the event of a wildfire this source may quickly become unavailable.

To evaluate the available water supply the first step is to calculate the demand to meet either minimum code requirements, insurance recommended levels, or risk specific demands for the site. Meeting Building Code requirements is a simple calculation based on building volume, construction and exposure for a building without sprinklers as described in The Alberta Building Code, Division B, 2006 (ABC) 3.2.5.7. If the building has sprinklers, the calculation is based on NFPA 13 (2002) Table 11.2.3.1.1 and Figure 11.2.3.1.5. Insurance requirements are calculated using Water Supply for Public Fire Protection Fire Underwriters Survey (FUS), based on construction, area, contents, and exposures. It should be noted that these methods calculate the requirements to extinguish a fire occurring within the building and not from an exposure fire. Controlling an interior fire to avoid the building becoming the start of a wildfire is as important as protecting the building from exposure, so the requirement for the interior fire water supply is a necessary part of the evaluation. The final step is to protect the building from exposure in the event of a wildfire. Exposure can take the form of radiated heat, direct flame or fire brands. The size of the risk is determined by many factors covered elsewhere in this guideline and ranges from the distance of the forest fuel load to the materials of construction.

For calculating the required water supply, the method of protection should be the first data determined. A fixed external sprinkler system can easily be designed to operate on a given volume of water based on flow and duration. Manual firefighting is more difficult to determine, particularly for duration. The actual water demand for suppression is covered under the building design section.

3.3.2 Water Storage

Water supplied from hydrants, reservoirs and storage tanks is relatively constant once designed, provided the proper maintenance occurs to ensure reliability.

For natural sources of water, topography, vegetation and weather can impact availability. Obviously, the highest risk of a wildfire occurs during the high summer heat as well as the fall while a building fire can occur at any time. Hot summer weather can impact the water source by reducing the quantity of available water through absorption and evaporation. Wet weather can reduce the risk of wildfires but can also impact accessibility to the water source and response routes. Vegetation growth, both in the water and along the banks, can also negatively impact the availability of water. The final risk is ice formation (unless a viable means of accessing water under the ice has been developed). Improving accessibility can be accomplished with the installation of a dry hydrant adjacent to a developed access route suitable for a firefighting vehicle.

Figure 1.7 Dry Hydrant - *An example of a dry hydrant installed on a pond with gravel surface off main road for access. See detailed example in Appendix F*

3.3.3 Volume of Water

The actual volume of water required to effectively fight a fire is based on the required water flow and the duration that the supply must last. A forested area has a finite amount of heat to release when burned. The quantity of heat potentially released is dependent on the volume of fuel and types of wood present on the site. The exposure, however, can be short and intense or an extended release at a lower rate. The amount of water needed will be relatively similar for both scenarios but the rate of application could change significantly based on the fire's heat release rate. Although the local conditions may provide some factors in determining a suitable amount of water storage, calculations for the actual required water supply must consider both extremes.

Since it is not easy to adjust the water flow for fire suppression systems during an emergency, the most successful approach would be to provide a flow of water that matches the worst-case scenario for a duration that would equal the expected exposure time of a slow burning fire. This approach could result in a significant volume of water, depending on the existing fuels within a risk area, and is not always practical.

By recirculating the water used for firefighting or for sprinklers, better use of the suppressant could be achieved. Designing the facility to collect the water after usage in a reservoir for quick filtration and recirculation as a suppressant should be considered, where feasible. It is normal that some of the water would evaporate or be absorbed during use.

Water Demand Example

A single-storey, public service building having an area of 600 square metres (6,460 sq. ft.) and of combustible construction can be designed to meet the risks from a wildfire. Assuming the building is 3 metre (10 ft.) high, it would require 72,900 liters (19,260 usg) of water delivered at a rate of 45 L/s (713 gpm) to meet the Alberta Building Code if it has no sprinklers. If interior sprinkler protection is provided as a low hazard occupancy, the building would require 12.5 liters per second (200 gpm) for a period of 30 minutes or 22,500 liters (5,945 gpm) of water to meet the ABC requirements.

The same building, using Fire Underwriters Survey (FUS), would require 188.3 liters per second (2,985 gpm) if without sprinklers, and 121.3 liters per second (1,923 gpm) if protected with interior sprinklers.

NFPA 13 11.2.3.7 provides basic requirements for exposure requiring the minimum pressure to be 48.3 kPa (7 psi), which would equate to a flow of 0.95 liters per second (15 gpm) when the sprinkler constant is 8.14 (metric) or 5.65 (imperial).

3.3.4 Delivery of Water

Water can be delivered to the area requiring protection by three methods: fixed systems, semi-fixed systems, or manual discharge of water as suppressant but each requires sufficient water pressure to operate the system of delivery.

Fixed systems are already in place and capable of immediate operation upon receiving the activation. Semi-fixed systems require personnel to position and/or activate the suppression. After activation these systems are typically able to operate independently. Manual suppression requires active firefighting by the local fire department or Alberta Sustainable Resources to actively suppress the threat using hose streams, monitors or other available resources. It also requires personnel to be at the boundary of the fire.

Water pressure can be provided from a site remote from the building through a municipal distribution system or local pump installed as part of the building. The alternative source of pressure comes from the fire engine or other portable pump used by the responding emergency team.

Should the system be designed to pressurize with an on-site pump, a power supply with a reliable back-up power source shall be provided to operate the pump.

3.3.5 Water Criteria in Summary

1. **Determine the demand based on building size, construction and usage**
2. **Determine the application rate based on the type of mitigation**
3. **Determine the preferred local water supply based on the demand, rate, accessibility, reliability, and cost**
   Note: There may be co-operative reasons for water storage in community, site, and building design. Stormwater management, LEED, thermal exchange, and aesthetics are a few examples.

4 Building Usage

The Alberta Building Code provides direction on the minimum standard for construction based on the building size, usage and accessibility under ABC Subsection 3.2.2. Before upgrade of existing or design of a new building is undertaken, the proposed occupancy and use, from routine to post-disaster requirements, must be considered. Once the occupancy and use have been determined, the building can be designed to meet that level of construction. Alternative usage should not be considered without a full evaluation considering the same risk factors for a building renovation.

The combination of occupancy, occupant load and usage (category) of the building will determine the level of safety necessary based on the need for survival.

4.1 Occupancy

Occupancy is defined in ABC Table 3.1.2.1 under six major classifications ranging from Assembly (A) to Industrial (F). This occupancy will determine the minimum code compliance for building design. It should be noted that minimum code design is based on assumptions as listed in the Alberta Building Code, Division B, Appendix A. Designers are familiar with the code requirements but this guideline does address areas where the minimum standard is considered insufficient to address the expected risk from a wildfire.

4.2 Building Use (Category)

Building type will have to consider high occupancy loads such as hospitals, schools, and nursing homes. This includes buildings identified in the Alberta Building Code Importance Category of High, which could be used as *post disaster* shelters, or classified as *post disaster* buildings. These structures require special design and spatial separation considerations to ensure their survivability from a wildfire threat. Buildings identified as having a high occupancy load, particularly hospitals and nursing homes, will add considerable logistics to already overtaxed emergency resources if evacuation is required during a wildfire event.

Not all buildings or functions are critical. Financial loss must be considered, yet when it costs more to protect an asset than the value of the asset, the priority has not been met. For this guideline, three levels of building importance have been considered to guide judgment of value.

4.2.1 Low

Low Importance buildings represent a low direct or indirect hazard to human life in the event of failure, which include minor storage buildings and low occupancy buildings. Siting consideration must be given to these structures to ensure they do not contribute to the fire load or fire spread during a wildfire event.

4.2.2 Normal

Loss of these buildings would impact routine operations, however, the contents can be replaced and temporary arrangements made during replacement if necessary. Most buildings would be considered Normal Importance for design purposes.

4.2.3 High

High Importance is given to buildings where the functions or contents cannot be lost or interrupted. An additional category are those buildings that present an unacceptable threat, such as manufacturing and storage facilities containing toxic substances, explosives or other substances in sufficient quantities to be dangerous to the public if released. Post-disaster buildings as listed below are prime examples of High Importance for maintaining operations during and after an emergency. Other examples are museums, schools, cultural resources (ie. Historic churches) community centres or buildings designated as shelters during an emergency.

4.2.3.1 Shelter-in-Place Facilities

Sheltering in place may be an option to consider for high occupancy facilities as long as the building has all the required protection systems in place, including: fire resistive exterior walls/roof, spatial separations, protected window openings, ventilation systems that control smoke entry into building, emergency backup utilities, water supply, washroom facilities etc.

The Alberta Building Code High Importance category includes buildings that are likely to be used as shelters, including those where the primary use is:

- **An elementary, middle or secondary school**
- **A community centre**
- **Similar public facilities**

4.2.3.2 Post Disaster Buildings

The 2006 Alberta Building Code defines a Post-Disaster Building as a building that is essential to the provision of services in the event of a disaster, and includes:

- **Hospitals, emergency treatment facilities and blood banks**
- **Telephone exchanges**
- **Power generating stations and electrical substations**
- **Control centers for land transportation**
- **Public water treatment and storage facilities**
- **Water and sewage pumping stations**
- **Emergency response facilities**
- **Fire, rescue and police stations**
- **Storage facilities for vehicles or boats used for fire, rescue and police purposes**
- **Communications facilities, including radio and television stations**

Buildings that are classified as either High Importance or Post-Disaster are required to meet more stringent Alberta Building Code design requirements than buildings classified under Normal or Low Importance. Part 5 of this guideline is considered a vital addition to the Building Code requirements in developing designs for High Importance buildings.

5 Building Design and Utility Services

The survivability of a building subjected to the threat of fire from the interior or exterior depends on two primary factors: the performance of the building envelope and the structure of the building. In addition, the failure of any one of the utility services could impact the efforts to suppress the fire and will make the building uninhabitable during the event. The performance of the building envelope and its resistance to temperature increase and ignition are important factors in the performance of the building structure. Building design decisions such as choice of building form, size and massing, envelope, material, and fire protection principles and techniques, determine the performance of the building when exposed to a wildfire.

In the wake of the 2011 Slave Lake fire, Alberta Infrastructure intends to upgrade existing facilities (which are vulnerable to wildfire) for their continued operation where warranted and economically justifiable.

Upgrades to existing buildings would require the evaluation of the building and its utility services for necessary redress and the improvement of its preparedness for a wildfire incident. The aspects and elements that can be modified during the redesign can be affected and completed using the same methodology used to design a new building. The only criteria which could not be redressed is the siting of the building, however, changing the characteristics of the site to improve its survivability should be examined. A sample case study for the Slave Lake Warehouse can be found in Appendix J.

In a building categorized as High Importance, it would be necessary to evaluate the utility services to maintain a minimum level of health and safety needs for the occupants (in addition to resisting fire). This would include identifying any other persons who need to be added to the occupant load from designated neighbouring buildings. The air quality and temperature within the building must remain within tolerable limits while the power and water services continue to flow (uninterrupted) to protect occupants' safety and health.

Building designers must consider a design that takes into consideration the following:

- **Preventing ignition of the building and any items or fuel within close proximity of the building (defensible zone)**
- **Provision of fire suppression systems to the building beyond code requirements**
- **Providing adequate Fire Resistant Rating (FRR) to building assemblies**
- **Reduction of radiated heat flux impact on exposed building envelope**

5.1 Building Form

The form and orientation of a building to the wildfire have major impacts on its survivability. The choice of building may create spaces that are likely to trap the fire's heat and also create undesirable areas of negative pressure. Concentration of heat is not desirable as it may raise and exceed the temperatures of the building material causing them to melt, ignite or lose structural integrity. Some building materials, once heated to a vaporized or molten state, would require only a source of ignition to initiate the process of combustion. Areas with negative pressure promote the accumulation of embers and fire brands. Where the material in contact with this accumulation is combustible, it will start the ignition and initiate the combustion process. Example of elements that can create heat traps include: areas of negative pressure on the leeward side of parapet walls, solar collectors mounted on buildings, roof/wall intersections, roof valleys, and decks. The designer should take the utmost care to ensure that the abrupt transition of wall and roof planes is minimized. Computer programs are available to model and address these conditions.

Although the direction of a fire is difficult to predict, one could presume that it would most likely be determined by the prevailing wind direction of the site and probable location of fuel in the form of plant matter. The resulting exposure (mitigated by landscaping) will then dictate the construction requirements for the building to meet a predetermined risk level based on the building category. Appendix A provides a calculation sheet to determine the comparative level of safety.

5.1.1 Size and Massing

Small and slender exposed building elements of combustible construction can be the weakest element of a building in a wildfire. Smaller combustible elements that are exposed are often easy to ignite due to size. Unprotected slender non-combustible elements may also be susceptible to the exposed radiant heat energy due to their low thermal mass.

In general terms, compact buildings with simple forms are comparatively easy to defend when located in an area or region prone to wildfires. Under 2006 ABC 3.2.3 the exposure risk is determined by several factors beyond the building material. The width and height of the building face, as well as the ratio of those two dimensions, are combined with the total percentage of unprotected openings and wall fire resistance ratings to determine exposure. The measurement for spatial separation must also begin at the farthest projection of the wall, thus, a smooth face would require the least separation.

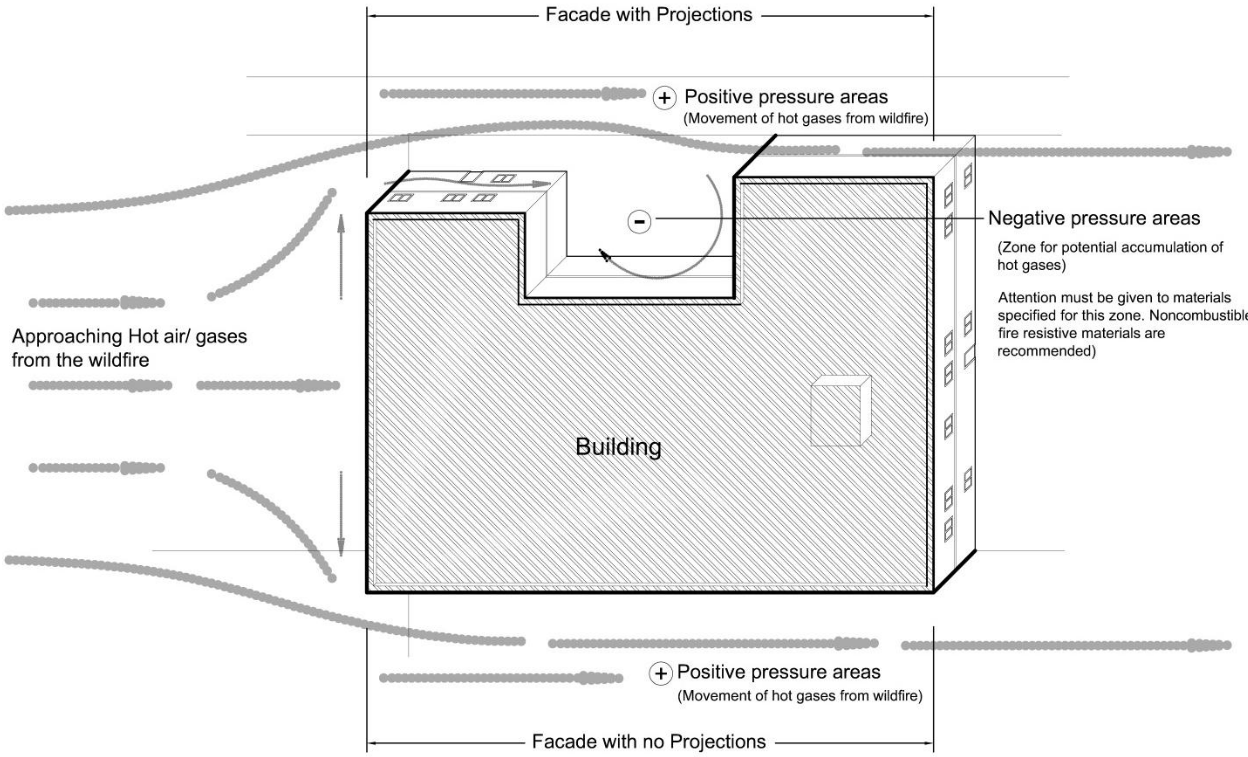


Figure 1.8 Building Forms *– illustration demonstrates the impact of wildfire on buildings with and without projections*

Generally, any projection from the building envelope would provide opportunity for embers to collect or hot eddies to be created, increasing the risk of fire. Where feasible, such conditions should be avoided or close attention paid to the detailing of such projections mitigate risks. A couple of embers landing on a building may self-extinguish. However, a large accumulation of embers would increase the temperature and most likely start a fire.

Fire brands would accumulate within negative pressure 'voids' and increase the probability of starting a fire. Observations from the Slave Lake fire support this fact.

Figure 1.9 Residential building in Helsinki - *Although the aesthetics are pleasing and it is blended into the environment; the building is at extreme risk for fire damage and potential loss.*

5.2 Building Envelope

The probability of the building catching fire from an external source is directly proportional to the amount of combustible building envelope that is exposed to the fire. Hence, all attempts should be made to minimize the combustible proportion of the building envelope. The survivability of a building, when subjected to the forces of a wildfire, is primarily dependent upon its ability to maintain the integrity of the envelope throughout the event. Should the building envelope fail even partially, the resulting ingress may compromise the structure to the point of collapse. It is also important to have uninterrupted utility services to activate and maintain the building's fire suppression and smoke control systems in order to maintain the health and safety of its occupants. Fire Protection Engineering defines failure under three themes:

1. **Integrity Failure (cracks, fissures, etc. as a result of the fire that allows fire or fire gases to penetrate an assembly)**
2. **Insulation Failure (increase in temperature on the unexposed side of an assembly, usually an average temperature of 140^{o}C and no more than 180^{o}C in any one location on the unexposed side.)**
3. **Structural failure (loss of load carrying capacity of a structural element exposed to fire). Often the critical factor is the temperature at which the yield stress has been reduced to about 50-60%**

For a building to survive fire exposure from the outside, the building envelope or exposed structural assemblies must be able to perform in all the three areas described above. For instance, if the integrity of the building fails, smoke may enter and affect residents (for Shelter-in-Place facilities). Fire can also travel through cracks to ignite the inside of a building.

If the insulation in an assembly fails, the increased temperature on the unexposed side of the assembly can ignite objects inside of the building in direct contact with the assembly (e.g. wall).

Structural collapse occurs when the structural supports give way due to fire exposure. Survivability of the structure of a building is important as failure may result in total investment loss as well as injury or loss of life of occupants (and rescue personnel).

5.2.1 Exterior Walls

Exterior walls receive most of the thermal impact from wildfires as they receive direct exposure to the fire and its resultant radiant energy.

Design recommendations:

- **Where possible do not use synthetic materials on exterior building walls, doors, and windows (polycarbonates, methacrylate, PVC, etc.)**
- **Materials used for exterior cladding should be fire resistant e.g. stucco, masonry, cement shingles, concrete, stone, etc. (FireSmart recommends a minimum of 12 mm thickness for exterior fire resistant or non-combustible siding materials to protect interior). An exterior wall assembly with sufficient thickness and material properties reduces heat transfer through the material or assembly into the interior space.**
- **Do not use vinyl siding, foam filled material, Aluminum Composite Material (ACM) panels, etc. that can ignite or melt, exposing interior combustible elements or openings**
- **Design the building envelope as a fire separation with a minimum of a 2 hour fire resistance rating.**
- **Avoid designing buildings without defined exterior corners as these areas if not prominent, are prone to accumulating debris and act as a trap for fire brands (refer to Section 5.1)**

5.2.2 Fenestration

5.2.2.1 Windows and Glazing

In the event of a fire, windows and glazed façades become one of the easiest points through which the fire may reach the interior. Glass will crack when exposed to fire or as a result of temperature differences between the exposed and unexposed side. A splash of water across a heated pane of glass may cause it to fail. Window size, frame type, glass thickness, glass defects, glazing methods, and vertical temperature gradient all have an effect on the likelihood of failure. Glazing may also be penetrated by projectiles from the fire or by direct impact from any tall falling trees or structures.

Design recommendations:

- **Clear vegetation and fuel within 10 m of glazed openings and/or provide rated shutters.**
- **Use tempered or preferably Fire Resistance Rated (FRR) insulated glazing (limiting the pane area as much as possible). There are UL listed FRR glass assemblies that can resist fire exposure for 60 – 120 minutes based on the testing protocol. These FRR glass assemblies have specific construction details: thickness (19mm to 60mm), maximum exposed dimension (2.4m to 2.8m), and maximum areas (2.4m^2 to 2.9m^2).**
- **Use non-combustible shutters or metal fire screens with corrosion-resistant mesh coarse enough to prevent fire brands from accumulating on the window sill. (The NFPA 1144 suggests using mesh coarser than 6.3mm whereas FireSmart suggests 3 mm).**
- **All exterior glazing, windows, glazed doors, and skylights should be considered for protection. If not protected by shutters, utilize tempered glass, multilayered glazed panels, or glass block in accordance with NFPA 1144. The Building Importance classification should dictate the FRR based on the building design evaluation chart in Appendix A. Buildings or structures of High Importance (such as Shelter-in-Place) may require a higher FRR.**

5.2.2.2 Doors, Openings and Vents

Openings for vents, crawl spaces, attic spaces, roof cavities, fans, mechanical equipment, etc. often provide the means of access for fire and smoke to reach the interior spaces of buildings. Exterior doors may also provide access for wildfires if in an opened position or if not of sufficient fire resistance to maintain its integrity throughout the exposure period.

Design recommendations:

- **Vent openings should be made of non-combustible materials and screened with a wire mesh that is sufficiently fine to prevent the passage of sparks and flames. [The NFPA 1144 suggests using mesh with openings not to exceed 6.35mm].**
- **Openings for air intakes should be protected with smoke sensor activated dampers or smoke filters as appropriate**

- **All exterior doors, frames, and hardware should be metal UL/ULC labelled fire rated assemblies**

5.2.3 Roofs

Although flat roofs are not directly exposed to the fire front, they present challenges from air borne fire brands. Pitched roofs stand exposed to the fire front and are more challenging than the vertical façade of a building to protect.

Large wildfires often produce fire brands and air borne embers that are lofted by the prevailing winds over great distances. The fire brands may ignite spot fires in other areas or within built up areas. Fires can be started as a result of fire brands landing and accumulating on combustible roofs. According to the FireSmart manual, roofs that catch fire are the main cause of building losses in wildland and urban interface areas. Fire brands or embers which get lofted and wind borne are relatively small and may be extinguished when they land on a negative pressure area of a roof. However, accumulation of fire brands or embers creates dangerous conditions when such accumulation takes place on a combustible building surface, like an asphaltic roof. Provided fire brands do not accumulate in concentration, a flat, fire rated roof would perform better, when compared to a pitched roof due to its reduced exposure to the heat flux.

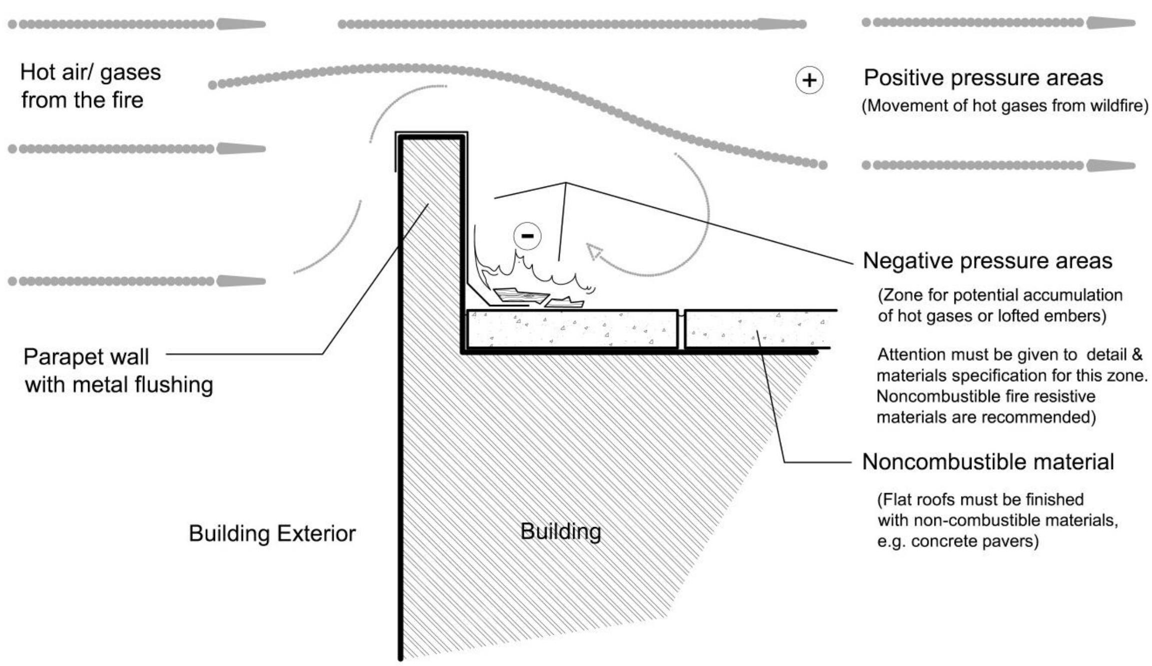


***Figure 1.10 Accumulation of Fire Brands -** Illustration shows considerations in the design of a flat roof*

Design recommendations:

- **Use only FRR roof of A, B, or C based on the risk assessment matrix to determine rating requirements. The Class A classification may be restricted with roof slope and its use should be verified with the manufacturer.**
- **Always use a classified roof assembly. Non-combustible materials (such as metal roofs, concrete shingles and tile, slate shingles, clay tiles, etc.) are recommended because they often provide a stand-alone Class A covering rating. However, most metal sheet roofs (such as aluminum, which has a low melting point) must be installed with additional materials under the roof covering to receive Class A (by assembly) rating.**
- **Some wood shakes treated with specialized pressure-impregnated, fire-retardant chemicals can achieve a Class A assembly rating. It must be noted that these roof assemblies must be tested in accordance with ASTM E-108 standards and given a fire-resistant rating. In addition, other combustible roof covering materials (such as membrane roofs) can be applied over a gypsum underlayment to attain a Class A assembly rating.**
- **Use fire resistant materials to construct penthouses on roof tops.**
- **Avoid creating roof forms or shapes where air borne embers could accumulate.**
- **Application of pea gravel is not recommended for standard SBS membranes. This would require embedment into a hot asphalt flood coat (or cold applied mastic) to prevent wind scour and erosion, particularly at corners and low-parapet perimeters. Application of pea gravel to a modified bitumen membrane surface would add extra weight, capital cost and extra costs in the future for repairs, additions, or recovery options.**
- **For asphaltic roof surfaces where risk assessment requires greater protection; protect the roof with concrete pavers or loose gravel with grain size of 40mm to 75mm, provide newer high performance roofing systems intended for embedded pea gravel application or consider an inverted roof assembly of 2ply SBS.**
- **Protect areas prone to the accumulation of embers (negative pressure areas) with concrete pavers.**
- **Green roofs may provide additional risk to structure loss in the event of a wildfire unless carefully designed and maintained. Appropriate fire protection mitigation/suppression measures shall be provided to mitigate the risk. In critical areas requiring burning ember protection, install non-combustible roof coverings as “fire breaks” near roof perimeters, roof/wall junctions, and roof penetrations (i.e. concrete pavers, loose gravel with grain size of 40mm to 75mm).**

Material recommendations:

- **It is a misconception that a metal roof covering will eliminate the risk of a fire start on a roof. Always use a classified roof assembly.**
- **A vegetated roof covering per LEED® must be designed and maintained to provide protection in a wildfire scenario. Avoid combustible vegetative matter and soils containing peat moss, and combustible composted plant matter on roof.**
- **Green roof growing medium composition may be considered an alternative roof covering for fire protection. Newer green roof soil standards suggest selecting low organic compositions with high ratio of non-combustible aggregate materials. Plant selection such as using only succulents (sedums) can slow down ignition and have shown to survive better with low maintenance than other plant types on rooftops. Avoid grasses and woody herbaceous plants on roof tops.**

5.2.3.1 Parapet Details and Metal Flashings

- **Plywood facings on parapets as a nailable support is essential for most roof membrane applications. The roof membrane, electrical appurtenances, and metal flashings rely on wood blocking and wood sheathing for effective attachment on vertical surfaces.**
- **Metal flashings (base and cap) covering parapets are a Building Code requirement for buildings classified for non-combustible construction when wood sheathing is used in the parapet construction. Non-combustible gypsum roof boards (coated glass-faced, acrylic gypsum core) as a substrate for membrane flashings can act as a fire separation over top of combustible plywood facings.**
- **Some membrane manufacturers may void warranties if there are mechanical fasteners going through the membrane when installing metal flashings.**
- **The bottom edges of metal base flashings are not to be in contact with the roof membrane to avoid puncture and tears. The metal base flashing terminated at roof level must be 1 to 2 inches above the roof surface. This may defeat the protection from burning embers collecting in these areas. Use concrete pavers and extend the metal base flashing with a horizontal leg on top of the paver as shown in the first roofing graphic. Where loose gravel is used, it should cover the horizontal leg of the base flashing.**

5.2.3.2 Skylight

Skylights may provide an entry point for fires and should be avoided. When light is to be introduced through the roof, vertical clerestory glazing is preferred over sloped glazing. If, after considering the risks and alternatives, designers still opt for skylights and clients accept the risks associated, the following recommendations will reduce the risk of skylights providing an entry point for fires:

- **Skylights must be designed with fire protection shutters that can be closed with minimal risk to residents in the event of a wildfire**
- **The design must consider configurations that will prevent accumulation of airborne fire embers or hot wildfire gases on the roof. Slender projections should be avoided.**
- **The use of fire resistant glazing is recommended (Refer to 5.2.2.1)**

5.2.4 Eaves and Projections

As fire approaches a building, hot gases are often deflected by the exterior wall up into the eaves. Open and combustible materials may be prone to ignition. Furthermore, the modifying effects on the stream of hot air caused by the ‘air dams’ may create heat concentrations and settlement of fire brands on undesirable surfaces and locations.

Architectural design recommendations:

- **Avoid overhangs where practical. Solar shading could be achieved with metal louvers.**
- **Cover eaves with a fire rated or non-combustible soffit. Eaves must be covered creating sloping soffits or cavities which may trap the heat. Flat soffits may help deflect the impinging hot gases on the building outwards. NFPA 1144 recommends boxing eaves with 15.8mm nominal sheathing or non-combustible material.**

- **The NFPA 1144 recommends the use of heavy timber, a 1 hour FRR assembly, or noncombustible material for all overhanging projections**
- **Avoid placing combustible content where there is a probability of fire brand accumulation**
- **Avoid open roof vents underneath soffits that are likely to encounter rising hot fire gases from the exterior wall (see Figure 1.11 and 1.12)**

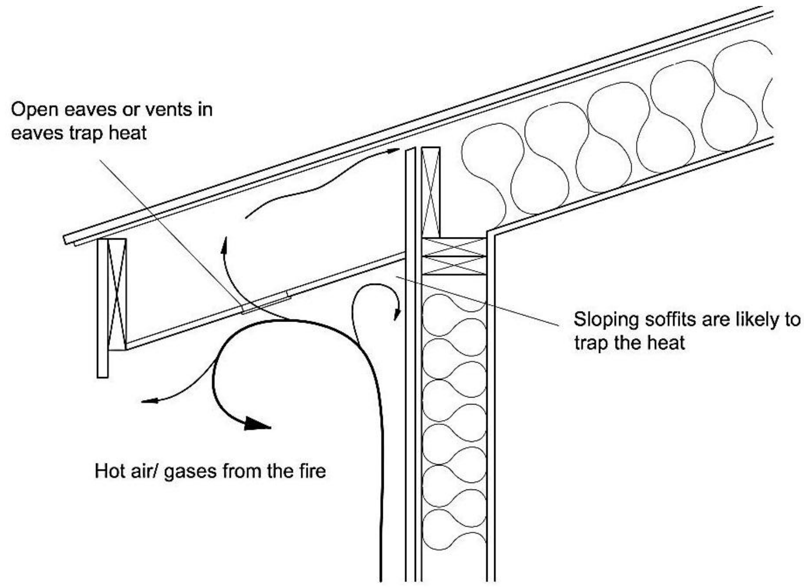


Figure 1.11 Closed eave with flat soffit

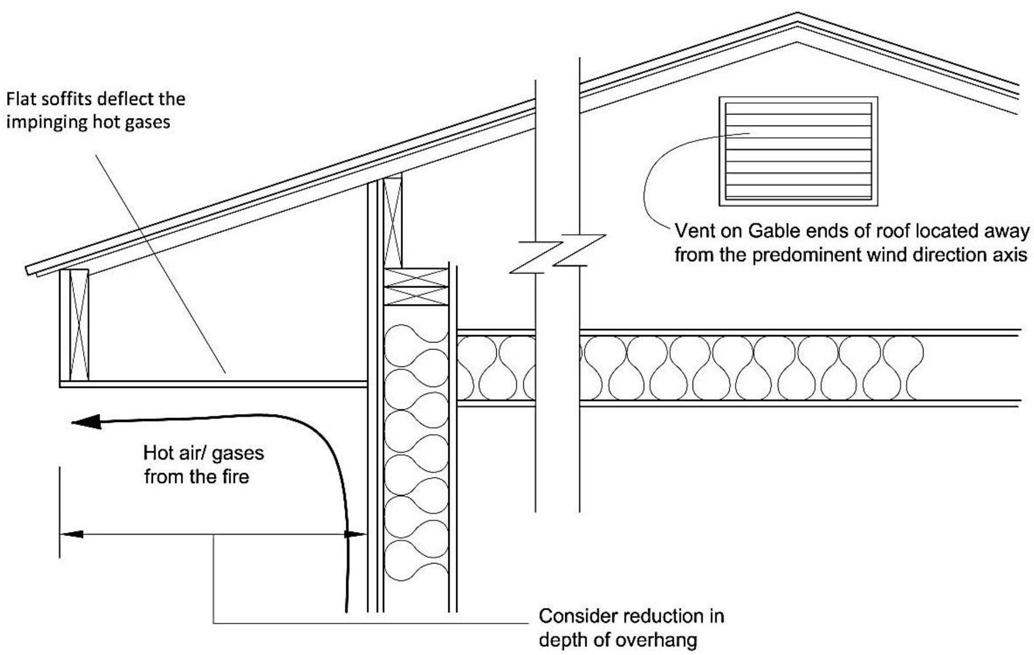


Figure 1.12 Open eave with sloping soffit

5.2.5 Combustible Projections and Additions

Many additions can be added to a building for decorative or functional purposes: canopies, brise soleil, porte-cochere, porches, decks, and balconies are some examples.

The shape and design of these projections often create heat traps for hot air from an approaching fire front. If the projection is made out of combustible materials the fire hazard becomes amplified when it comes in contact with fire brands and super-heated air causing the material in contact to reach ignition temperatures. Projections also provide shelves that collect fire brands and embers, eventually setting the projections on fire along with any adjacent combustible material on the building envelope.

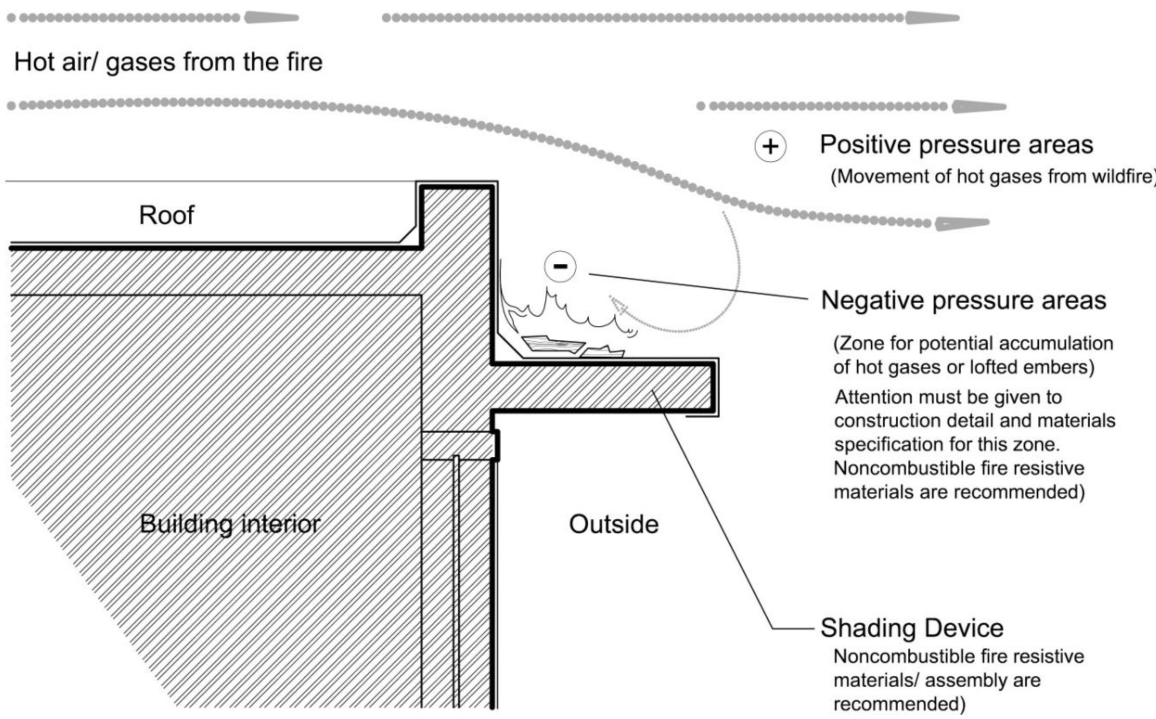


Figure 1.13 Solar shading

Design recommendations:

- **Avoid using combustible material for their construction when these projections are a necessity**
- **Do not use combustible railing or stilts with non-combustible materials to provide a fire resistance**
- **Eliminate heat traps at the underside of decks**
- **Enclose the underside of decks to reduce the risk of ignition, while providing access to clean out debris from underneath decks on a regular basis**
- **Avoid landscape 'structures' and their connectivity to a building**

5.2.5.1 Gazebos and Canopies

Gazebos and canopies promote outdoor living and allow enjoyment of favourable weather during the warmer seasons. However, in urban and wildland interface regions it also means an increased risk of wildfires, especially when they are located within 3 meters of a building. Combustible components of gazebos, when ignited near a building will generate enough radiant energy to shatter unprotected glass openings or ignite other exposed and unprotected combustible components in buildings.

Design Recommendations:

- **Avoid direct attachment of combustible components of gazebos or canopies onto buildings**
- **Avoid locating a gazebo close to unprotected combustible building components or in areas of unprotected openings**

5.3 Building Materials

5.3.1 Stone, Masonry, and Concrete

Stone, masonry, and concrete are three building material groups which can resist fire effectively, especially wildfires, as they usually extinguish once the fuel for the fire is consumed. As materials for building envelopes, stone, masonry and concrete have traditionally been used successfully and have proven durable while requiring very little maintenance.

Design Recommendations:

- **Stone, Masonry and Concrete, alone or in combination, would be ideal for protecting the building envelope from the forces of a wildfire.**
- **Stone, Masonry and Concrete, alone or in combination, would be ideal in the construction of a one storey building**

5.3.2 Structural Steel and Metals

Steel will lose its load-carrying capacity in fire when it reaches its *critical temperature* (i.e. the temperature at which it cannot safely support its load). The critical temperature is often considered as the temperature at which the steel's yield stress has been reduced to about 60%. The time it takes for an exposed steel element to reach this critical temperature depends on several factors including: fire exposure, structural element type, configuration and moment of inertia of section to height of member ratio (slenderness ratio), and orientation. It must be noted that the time to reach the critical temperature of an exposed non-combustible element (e.g. steel) is a function of the sectional properties of the member. This is because smaller sections tend to heat up faster than larger sections.

Fireproofing sprayed on coatings and intumescent paints are two methods of coating steel so it will withstand temperature increases due to fire. Wrapping steel components with UL/ULC rated cementitious assemblies or encasing the steel in masonry or concrete are other methods to achieve fireproofing.

Usually steel is used to fabricate the structure of a building and would be located in the interior of the building. When steel is subjected to the stress of temperature increase due to fire, the probability is that the fire has penetrated the building envelope. In this case, the furniture inside the building would provide more fuel than the surrounding forest. Unless the fire could be suppressed with a sprinkler system, one could assume that inevitably the building would sustain extensive damage.

Aluminum is another material used in building construction to fabricate non-structural components, such as window frames. Aluminum has a very low melting point compared to steel, quickly losing any structural properties when exposed to heat, and would not withstand the forces of a wildfire. Use of an aluminum curtain wall is discouraged. Galvanized steel performs better than aluminum when exposed to heat.

5.3.3 Heavy Timber Construction

As stated by the Canadian Wood Council, large dimension wood sections have an inherent resistance to fire. Wood burns slowly at approximately 0.6mm/minute. The char created on the wood surface as it burns helps protect and insulate unburned wood below the charred layer. The unburned portion of a thick member retains 85 –90% of its strength. Hence, a wood member with a large cross-section can burn for a significant amount of time before its size is reduced to the point where it can no longer carry its assigned loads.

Where combustible materials cannot be avoided, heavy timber construction in conformance with sections 3.1.4.5 to 3.1.4.6 of the ABC could be considered to fabricate the structure of a building. Exposed surfaces should minimize thin sections and sharp projections that would increase burn rates. Heavy timber construction can provide a 45 minute fire resistance rating as per ABC Article 3.4.1.5 and, when combined with an operational suppression system, can be expected to maintain its integrity for longer periods.

Fire tests have shown that glulam members exposed to fires behave in the same way as solid sawn-timber members of the same cross section. Advancement in fire performance of wood products research has proven that glulam beams and columns can be designed to provide up to one hour fire resistant rating. The 2009 International Building Code (IBC), Section 721.6 provides a methodology for calculating the ability of glulam beams or columns to resist fire up to one hour.

5.4 Fire Protection

General building code requires larger buildings to have sprinklers to prevent an interior fire from developing before evacuation and emergency response can be completed. No such requirement exists for preventing an exterior fire from entering the building. In the National Building Code and Alberta Building Code, this risk is addressed by spatial separation. As previously mentioned, spatial separation when faced with a wildfire is often not sufficient. The values for spatial separation between buildings as per ABC 3.2.3 calculations should be doubled for protection due to the increased risk from radiated heat of a wildfire unless exterior sprinklers are provided.

Another consideration for fire protection is that a building fire should not present a risk which would result in a wildfire that threatens nearby structures and the forest. The provision of sprinkler systems in the building should be considered in the risk evaluation during design.

Exterior sprinklers have proven successful when used in combination with a basic defensive zone. In California, it is recommended that exterior sprinklers be designed for a minimum 10.2 L/min/m^2 of flow for wood construction and 4.1 L/min/m^2 for steel construction. Wetting the exterior of the building provides protection from burning fire brands carried by the wind and direct heat from the fire. These systems require a pump with a reliable power supply and a water source sufficient to meet the demand throughout the event. When the system is an integral part of the building it can be activated with short notice, while a portable system requires time to position the nozzles and piping, activate the water source and initiate the wetting of the building envelope. This requires sufficient notification or results in personnel working under significantly adverse and hazardous conditions.

Failure of any water supply components due to susceptibility to heat would render any sprinkler system inoperable. Those components (power, pump, water tank, etc.) must be protected from the fire during the emergency.

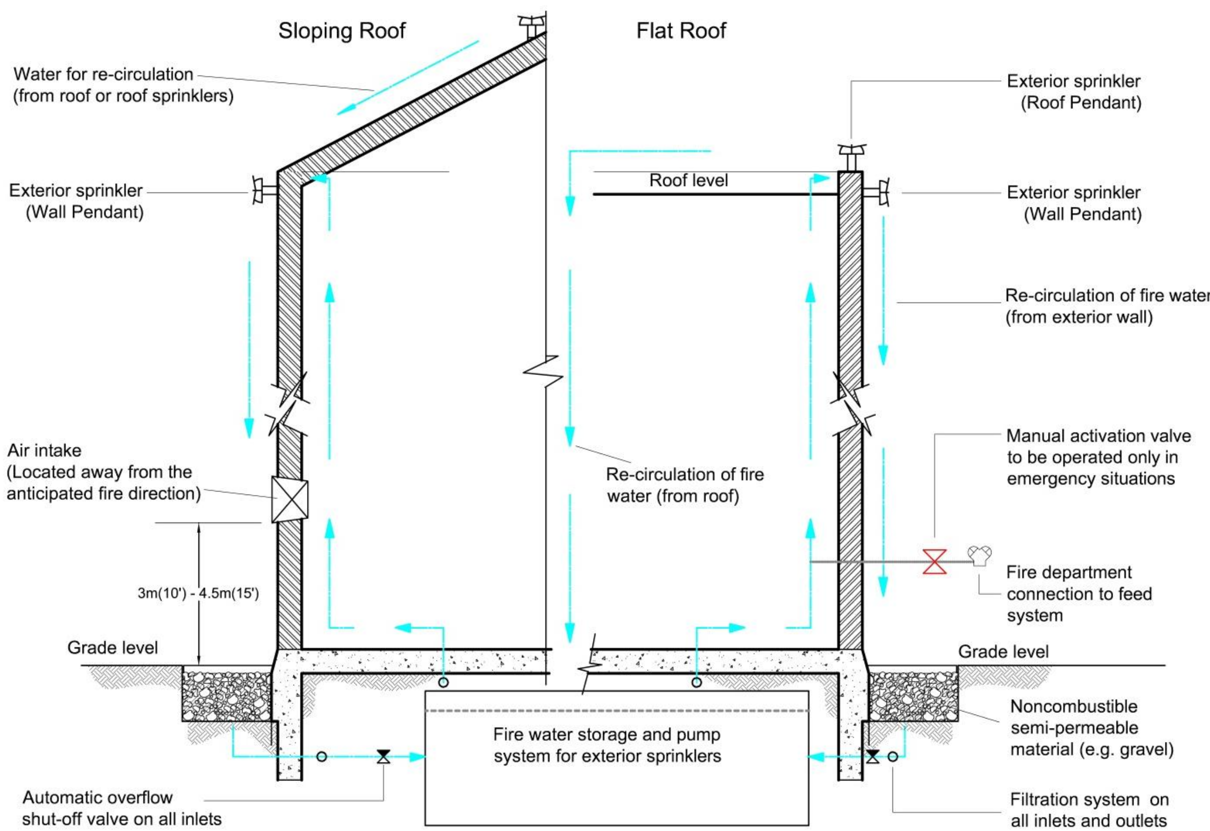


***Figure 1.14 Shelter-in-place wildfire protection measures**. Note: Refer to Section 2.1 for site planning overview*

5.5 Building Utilities

Building utilities, power, fuel, water and air treatment are essential to the operation of any facility. These components can also have a negative impact on emergency operations and building survival if damaged. Danger from downed power lines, exploding fuel tanks or the inhalation of smoke are obvious risks. Damage to generators, pumps or piping can also reduce or eliminate vital resources essential in an emergency.

Utilities include:

- Power
- Fuel
- Water
- Communications

The risks and requirements for each element; natural gas connections, location of regulators, overhead power versus buried power lines, water (potable and firefighting), transformers and their location are covered in this guideline, as are recommendations for upgrades in protection of services or backup facilities in the event of failure.

5.5.1 HVAC

Building ventilation systems require fresh air to ensure occupant health as mandated by the building code. Isolation or shut down of ventilation systems to avoid intake of contaminated air from the exterior of the building is important to minimize or reduce smoke ingress, to ensure occupant health, and to protect from property damage. This is particularly important for a building which is designated as a Shelter-in-Place. When used as a Shelter-in-Place, the number of occupants and duration of emergency must be evaluated against the amount of air and the ability to maintain an acceptable level of air quality.

HVAC smoke detection:

- **Must be provided in all outside air intakes and at individual return air intakes of all air-handling systems to initiate automatic fire mode operation**
- **Must operate at an obscuration level less than 0.5% per metre with compensation for external airborne contamination as necessary**
- **Systems must be located at all air intakes, return, and relief air openings associated with the building air-handling systems, and should be:**

  (a) of the sampling type system, or, duct detector,

  (b) of the point type optical smoke detection system.

The ventilation air system should include a carbon monoxide detector system. The detectors should be installed according to the ABC, with the installation of additional detectors at the fresh air intake openings. A suitable location would be on the inside of the louvers inside the intake, similar to the installation for the return openings. Design and install a strategically located alternate fresh air intake location where the probability of both locations being exposed to smoke would be low. Where feasible, install smoke filters and dampers to shut down any fresh air intake when smoke is encountered. It would be prudent to circulate air inside the building without contaminating it with smoke until the emergency has passed. The University of Lethbridge utilizes this type of intake louver system due to the large number of grass fires occurring in the surrounding area each year. Once smoke is detected, the intake louvers close and the HVAC system continues to circulate air within the building.

If the building is to be utilized for Post-Disaster or a longer term Shelter-in-Place (>12 hours, <72 hours) the design should incorporate a secondary air handling system (low level) with recommended installation at 3m (10 ft) to 4.5m (15 ft) above grade. The system would have to be installed with the intakes on an opposite side from the windward and leeward side, taking into consideration the topography and prevailing winds (see Site Planning in Section 2). This low level air handling system will require smoke and carbon monoxide detectors located at all air intake, return, and relief air openings associated with the building(s).

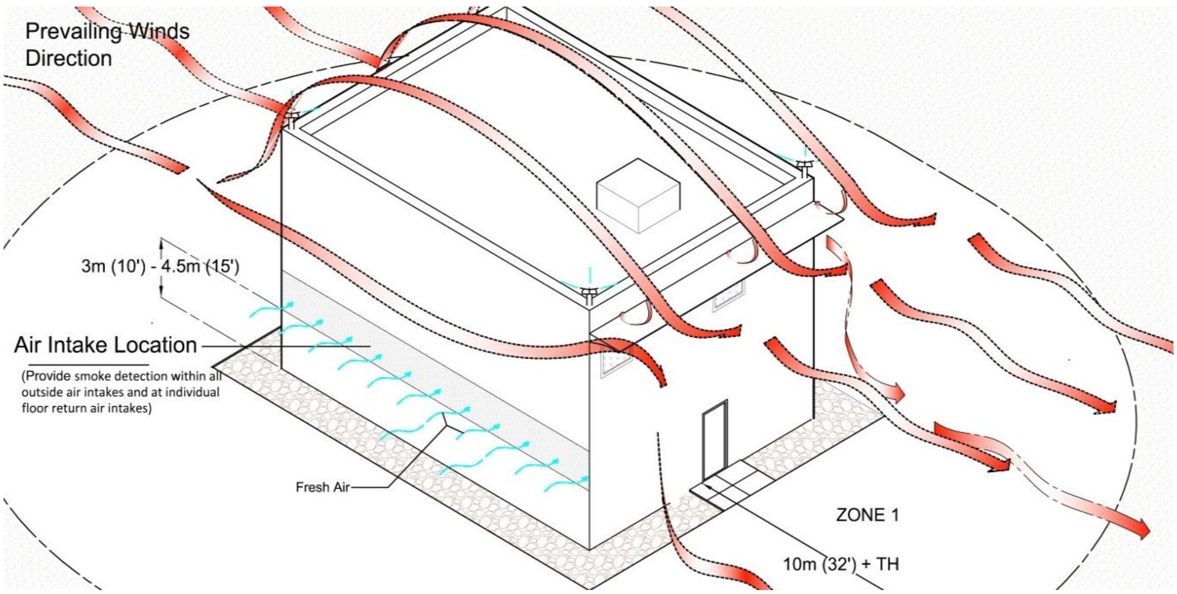


Figure 1.15 Close up of exterior vent/intake

5.5.1.1 Air quality

There are complex solutions around "scrubber" systems where compromises need to be made to achieve an optimum solution. Air scrubbers are used to remove contaminants when fresh air is at a premium. Engineered design applications of these systems would be an asset to the sustainability of the buildings. The ABC requires smoke exhaust fans as detailed below in the 'Exhaust' section.

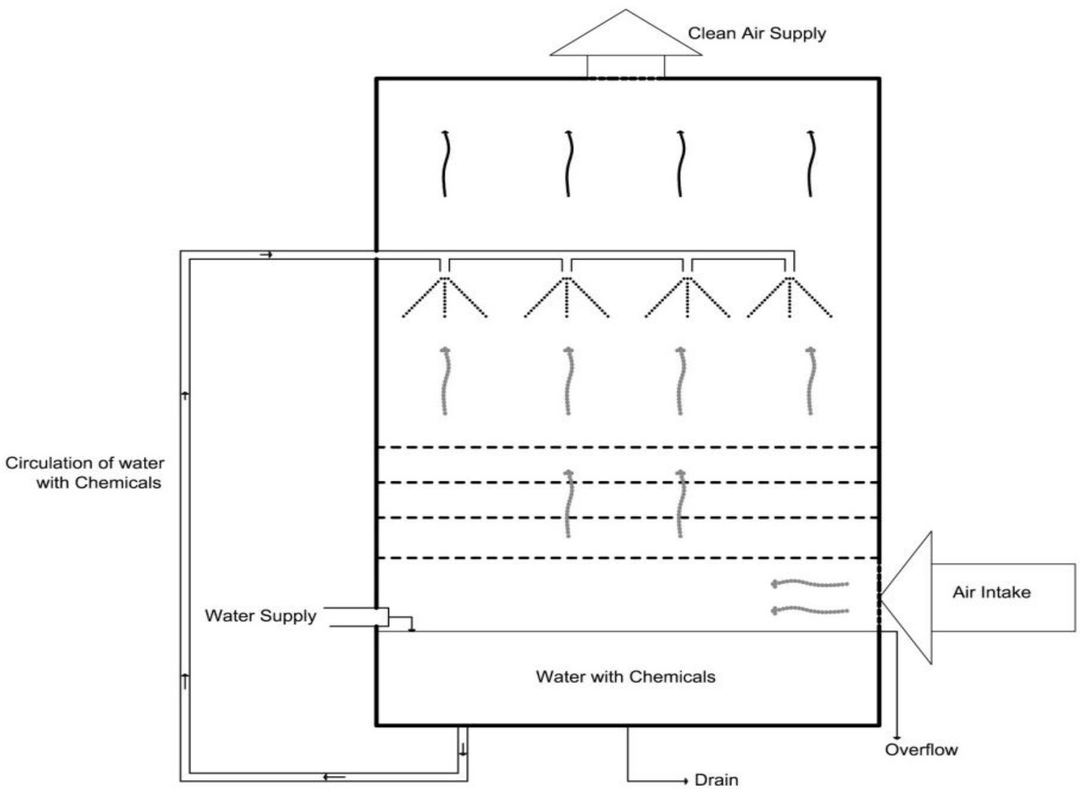


Figure 1.16 Example of a Scrubber system

5.5.1.2 Exhaust

- **Smoke exhaust should be provided using fans capable of continuous operation for a period of not less than 1 hour when handling exhaust gases at 200 degrees Celsius.**
- **All building entranceways should have air locks equipped with ventilation and exhaust fans. The air locks assist in preventing smoke from the exterior from entering the building.**

5.5.2 Plumbing System

Basic needs for a Shelter-in-Place or Post-Disaster building include shut-off valves with electronic and manual by-pass systems. Post disaster requirements include a stored supply of water to last a minimum of 72 hours duration. Elements of the plumbing systems can be augmented with the use of no-to-low-flow toilets and urinals, but potable water would still be required for hygiene purposes (washing and cleaning).

5.5.3 Utility Power

The primary transmission of power in Alberta is via overhead power lines, often strung on combustible poles. This configuration makes it highly susceptible to damage by a wildfire, and should be considered during the site planning.

5.5.4 Standby Power System

(a) A suitable alternative power supply must be provided to operate required life safety systems, including sprinkler systems, hydrant pumps, air handling systems, alarms, warning and communication systems, and emergency and exit lighting circuits.

(b) The alternative power supply must:

(i) be connected automatically if the normal power supply fails;

(ii) if located within the building, be separated from the remainder of the building by an enclosure with an FRR of at least 120;

(iii) be connected to the safety systems by means of cabling.

5.5.5 Alternate Power Sources

When the normal electrical power supply is lost because the poles and cables have succumbed to the wildfire, what power is available to support building functions, communications and fire protection features? Battery power or emergency generators could be a dedicated or a local shared resource. For a shared resource, the distribution system would need to be protected. These backup systems must also be maintained regularly and designed to last for the expected duration of the emergency. See Section 5.6 'Support Facilities' for additional information.

5.6 Support Facilities

When a building must accommodate a Post-Disaster function many requirements must be considered; foremost is the number of people in the area that would use the facility, and the length of time before those occupants would be relocated. For longer periods, food and shelter for an acceptable level of comfort becomes critical. Support facilities would be equivalent to that of an Emergency Operations Centre (EOC) which includes back up power, communications, rest areas, medical rooms and sustenance provision.

Electric-driven municipal fire pumps should be provided with an alternate power supply such as a diesel powered generator to ensure reliable pumping capabilities. Ensure that the fuel source(s) for the generator are protected and include automatic shut-off systems with adequate separation distance from the building(s), in compliance with code.

5.6.1 Fuel Supply and Storage

In more remote areas fuel is normally stored on site in atmospheric or pressurized tanks depending on the type of fuel. Any fuel tank located adjacent to a building provides an additional risk when exposed to the heat of a fire.

Barbeque fuel tanks or wood piles provide additional sources of fuel and routes to transfer flames closer to the building, increasing exposure. Pressurized cylinders provide an additional explosion risk that can cause severe damage to a building and associated systems.

Keep barbeques and open pit fires (which are not recommended in forested areas) outside the defensible space. Do not store propane canisters near buildings.

5.7 LEED® (Leadership in Energy and Environmental Design)

LEED® certification has become an essential component of sustainable design in the building and construction industry. It ensures that the building project is environmentally responsible, by introducing high-performance design and market leading construction and operation practice. Green building practices are primarily concerned with water efficiency, energy saving capability, indoor environmental quality, carbon dioxide emissions, and resource preservation. The LEED® rating system is considered during all building phases from design, construction, and operations, to tenant fit, maintenance, and significant retrofit.

Obtaining a LEED® certification is achievable when enough measures are incorporated across a spectrum of fire disciplines. The main credit categories are:

1. Sustainable sites that minimize impact on ecosystems and water resources.

   Choosing a site that has been previously developed is preferable over a greenfield site where trees may have to be removed. Wetlands, water bodies, and agricultural lands are to be avoided.

2. Water Efficiency credits promote smarter use of water, inside and out, to reduce potable water consumption.

   Normal building water usage can be developed to satisfy water reduction credits which meet LEED® and exterior fire protection may be possible in an eco-friendly manner using non-potable water. Such a design could gain credit through innovative use of water supplies for fixed fire suppression systems.

3. Energy and Atmosphere credits promote better building energy performance through design of high performance building envelopes and innovative strategies. (i.e. Low VOC, Durable Building, Measurement and Verification detectors)

   Constructing the building envelope of fire resistive materials does not conflict with the ideals of better energy performance and could provide credits for some solutions.

4. Materials and Resources credits encourage using sustainable building materials, locally sourced products and reducing waste. (i.e. sprinklered green roof or “living walls”).

   As for any building project, this credit can be applied through proper design and choice of materials. Adding a fire resistive component to the project does not negate its LEED® potential, although it may reduce the material choices available.

   Vegetated roofs, although available as a green technology, is discouraged when designing a building under the threat of wildfire (refer to landscaping section of this document).

5. Indoor Environmental Quality credits promote better indoor air quality and access to daylight and views.

   Developing an HVAC system with built-in redundancy and/or back-up power that can continue to operate successfully during a forest fire should enhance air quality and may provide innovative credits for the design. Providing additional natural lighting may be restricted to some degree but can be addressed under current fire resistive designs or alternative protection features such as suppression or shutters. Use of skylights would not be encouraged in a fire-safe design but larger windows with rated shutters could actually increase survivability level.

LEED® Certification considers survivability as a desirable feature, (constructing a building to survive a specific risk), and may contribute to an innovation credit.

5.8 Emerging trends

Technology continually creates better materials suppression, and detection, which further enhances procedures for the protection of lives and property. Compliance with various codes is not always sufficient, nor are minimum standards (particularly when faced with a fire). Designers should always be aware of innovations to improve mitigation. Listed below are a few trends recognized by this guideline:

5.8.1 BIM

Building Information Modeling (BIM) is increasingly used to design and maintain a data base for building management. This method lends itself to effective modeling and analysis of a design to include the context. The possibilities for this tool to 'fine tune' a design to react favorably to a probable wildfire are many, and software programs are evolving for this purpose at a rapid pace. Although all these analyses are approximations, they increase the chances of survival of the building.

Hypothetically, the building could be monitored remotely by trained staff to react to the emergency while the onsite staff is attending to other emergency issues. With strategically placed smoke, radiation, and heat sensors, the sprinkler system, evacuation fans, dampers, etc. could be activated selectively to protect the building and its occupants without activating all systems and wasting precious resources to provide optimum results.

5.8.2 Prometheus© (shareware)

What is Prometheus©?

Prometheus© is a spatially explicit fire growth simulation model that provides operational and strategic assessments of fire behavior potential over time and space. Alberta Sustainable Resource Development led the creation of this new state-of-the-art national tool in collaboration with fire management agencies across Canada. Prometheus© simulates the spread of one or more fires across a landscape with heterogeneous fuels and topography based on daily, hourly or sub-hourly weather data. Spatial wind grids (wind speed and wind direction) produced by WindWizard® or WindNinja®, and multiple weather stations can also be used in Prometheus© to create more spatially accurate fire growth simulations.

The foundation of the Prometheus© model is the Canadian Forest Fire Behavior Prediction (FBP) System and the most recent wave propagation algorithms that were developed with input from various university research teams. The FBP System is a complex, semi-empirical system that mathematically expresses and integrates many of the fuels, weather and topographic features that influence fire behavior. The FBP System is used across Canada and in other parts of the world to predict fire behaviors in a quantitative and structured manner. It produces outputs that describe the physical characteristics of a wildfire such as rate of spread, fuel consumption, head fire intensity and degree of crowning.

How is Prometheus© used?

Fire growth simulation can be a valuable tool in today's wildfire manager's toolbox to provide decision support to suppress fires, plan for the use of prescribed fire, and design future desired FireSmart communities and landscapes. Prometheus© can be used not only by fire management agencies across Canada, but also by other interested stakeholders such as landscape modelers, university fire researchers, forest management planners, municipal planners, and educators. As a result, the program is open and flexible, easy to use, and easy to integrate with other applications.

Prometheus© provides operational decision support by predicting wildfire behavior during escape fire situations. This is important when the fire load exceeds the resource availability to fight all of the fires. Fires are assigned a priority based on values-at-risk and the potential fire behavior. Prometheus© allows users to complete single or multi-day fire spread simulations. The potential threat that a wildfire poses to a community or other important values-at-risk can be evaluated using Prometheus©. This includes the amount of time available to evacuate if a change in weather occurs.

5.8.3 LEED®

LEED® certification may not be possible in conjunction with current defined levels for scoring but both LEED® and withstanding the threat of forest fires are aimed at sustainability and are united by their common goals of longevity and durability. This guideline may assist in future iterations of LEED® certification considering other practical choices when defining survivability.

6 Building Systems and Their Performance in Fire Disaster Conditions

In designing new buildings, it is important to determine the usage and expectations of the building to justify the capital costs to attain an adequate level of protection for sustainability.

It is natural that people expect buildings to provide them with protection and comfort during an event when the natural environment is threatening them. It would be a sound investment to 'go the extra mile' to enhance the building with external sprinklers, self-sufficient localized water storage for suppression, auxiliary sources for power, redundancy for critical equipment, remote temperature probes, reliable communications systems, etc. It is recommended that all critical systems have redundancy measures built into them. Not all building types need the same level of protection (i.e., hospital vs. storage or utility building). Refer to Appendix B, Building Survival Flow Chart.

When discussing the importance of building preparedness three key areas must be considered apart from loss of life or injury to occupants and rescue personnel:

- **Impact of partial or total loss of the building in terms of reconstruction costs and the time needed to rebuild**
- **Impact from loss of the function and loss of services, etc. to the local area**
- **Property and heritage losses that may be more than the value of the building, such as a museum, designated historical or cultural resource**

7 Existing Facilities

This section presents examples of the actual post-wildfire level of survivability for existing infrastructure.

7.1 Example 1 - Slave Lake Government Centre and Library



Figure 1.17 Slave Lake Government Centre and Library *– Building pre-fire, during fire and post fire*

This municipal building in the center of Slave Lake caught fire among other buildings in the vicinity (brick building construction). The fire started on the roof and destroyed the entire facility. The introduction of combustible materials to the façade increased the risk of fire load and the fire started (wooden framing on the exterior and wooden shutters/louvers). Adding fire load for aesthetics is not recommended in forested regions. Please reference Section 5 for additional recommendations with regards to building materials and decreasing the risks by eliminating combustible materials.

7.2 Example 2 - Hillcrest Log Cabin

Figure 1.18 Hillcrest Log Cabin *– illustration showing building sustainability*

Hillcrest Log Cabin is a fully combustible wood cabin that survived the major wildland fire in Lost Creek, near Hillcrest Alberta, in 2003. The cabin survived due to the protection zones (clearance) and the installation of two external sprinkler heads supplied with water from a portable pump and water storage tank installed by ESRD crews. Numerous trailers and recreational vehicles located in the protection zone were destroyed, but the correct installation of sprinklers was able to save the cabin.

Appendix A - Building Design for Forested Areas

ALBERTA INFRASTRUCTURE BUILDING DESIGN FOR FORESTED AREAS

Scenario	**BUILDING CONSTRUCTION** Combustible or noncombustible					**Topography** Slope %	**Passive Exposure Protection**				**Water Supply**	**Active Suppression**	**Risk Score**
	Roof	Walls	Unprotected Openings	Utilities	HVAC Isolation	Slope	Tree Line	Other Building	Barrier	Ground Cover	Reliable	Exterior Sprinkler	max. 100
Scoring	15	10	5	5	5	10	10	5	5	10	10	10	100
A	15	5	5	4	5	8	8	5	2	7	10	10	84
B	10	0	3	2	0	8	5	3	3	3	10	10	57
C	2	0	0	0	0	10	2	5	0	2	5	0	26

This score sheet automatically tallies the values entered when using the attached criteria and indicates the acceptability of the design.

			Usage	Minimum Target
Scenario A scoring	**Consider Mitigation**	USAGE:	**High**	75
Scenario B scoring	**Acceptable**	USAGE:	**Low**	35
Scenario C scoring	**Mitigate**	USAGE:	**Shelter**	85

Multiple scenarios allow comparison of the same building with different options or uses.
Scoring allows an increased risk in one area to be offset by a decrease in other columns
These evaluations must be knowledge based since reducing opening to offset a decrease in wall ratings can be counterproductive.
Building designs that meet the minimum design score are acceptable but should be considered for additional mitigation before final acceptance

ALBERTA INFRASTRUCTURE BUILDING DESIGN FOR FORESTED AREAS

Scoring chart guideline - actual value can vary to meet site conditions or design not specifically covered

Values are relative for comparison only

BUILDING CONSTRUCTION Combustible or noncombustible										**Topography** Slope Incline		**PASSIVE EXPOSURE**								**Water Supply**		**ACTIVE SUPPRESSION**	
Roof	Score	Walls	Score	HVAC Isolation	Score	Utilities	Score	Unprotected Openings	Score	Slope	Score	Tree Line Distance	Score	Other small Buildings	Score	Barriers	Score	Ground Cover	Score	Reliability	Score	Exterior Sprinkler	Score
Combustible unrated	0	Combustible unrated	0	None	0	No back-up	0	50 - 100%	0	30 +	0	Less than tree height	0	Combustible < 3 m	0	None	0	Uncontrolled vegetation	0	No water	0	No protection	0
Rated less than one hour C rated roof	4	Rated less than one hour	2	Manual	1	Battery Pumps	1	25 - 50%	1	20 - 30	2	Tree height	2	Combustible 3 m	2	Cover 25% of perimeter	2	Flower beds with combustible materials	4	Natural supply without pump	4	Portable sprinkler partial coverage	4
Rated one hour B rated roof	8	Rated one hour	5	Automatic with air volume for two hours	3	Available Generator pumps	2	10 – 25 %	3	10 - 20	4	Tree height +10 m	4	Combustible 3 to 5 m	3	Cover 50% of perimeter	3	Lawn with shrubs	6	Natural/tank supply & pump	6	Fixed sprinkler partial coverage	6
Rated two hour A rated roof	12	Rated two hour no combustible projections	7	Automatic with air over 2 hour	4	Protected Generator Pumps, etc.	4	0 – 10%	4	0 -10	7	Tree height +20 m	8	Combustible 6 - 10m	4	Cover 75% of perimeter	4	Lawn	8	Available with sufficient flow	8	Portable sprinkler full coverage	8
Noncombustible	15	Noncombustible	10	Automatic with air scrubber	5	Basic shelter services	5	0%	5	0	10	Tree height +30 m	10	Combustible >10 m	5	Cover 100% of perimeter	5	Irrigation or parking , drives	10	Dedicated with sufficient flow	10	Fixed sprinkler full coverage	10
Differing risks exist for flat versus sloped roofs		*Size, orientation & simplicity of wall can impact risk*		*Volume of air to maintain O_2 over expected time*		*Energy reliability or backup source on standard equipment*		*Protection can increase score Rated shutters=0%*		*Bare rocky slope less risk than tree covered*		*Requires maintenance for growing trees*		*Larger buildings use ABC 3.2.3 to determine distance*				*Well maintained lawn less risk than natural look*		*Size/type of water source & method of pressurizing*		*Quality of water based on source, pressure & flow*	

- The requirement for mitigation varies depending on the classification of the building
- Protection of occupants significantly increases expectation for building survival and maintaining a comfortable environment
- The accompanying worksheet provides the acceptable scoring goals for designs
- This score sheet should be used by knowledgeable designers capable of determining a fair score in each category.
- The above numbers are for comparison and should be reflective of actual expectations (an actual maintained tree height of 15 m with a clearance of 30 m could score as 6)
- Another example is under Slope where a 5% slope may score an 8 or 9 depending on site conditions

Appendix B - Building Survival Flow Chart

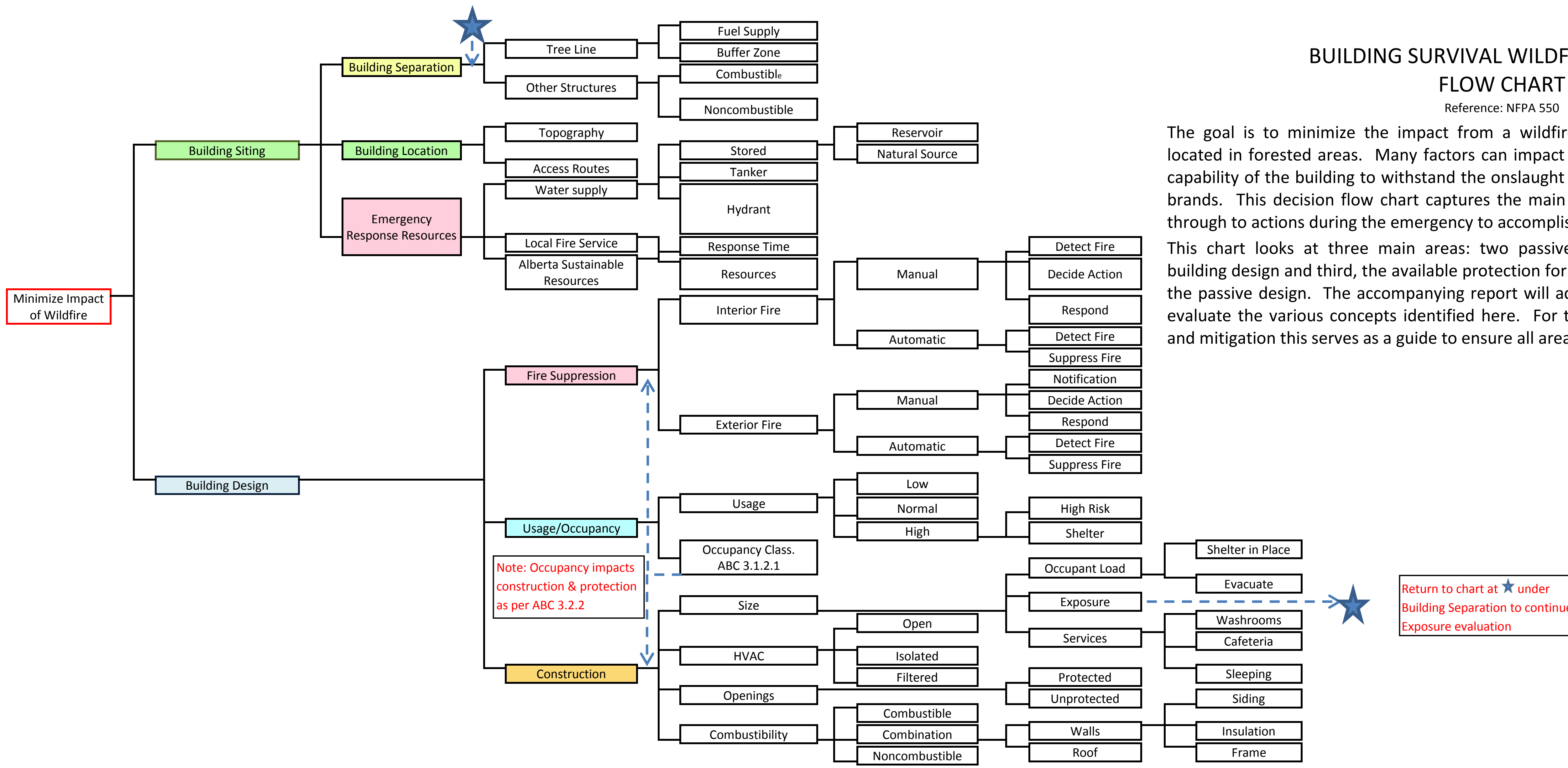
The following flow chart provides various steps in developing this guideline and outlines the options that must be considered globally (versus individually), when designing a building within a specific location where the potential of wildfire is a concern

BUILDING SURVIVAL WILDFIRE CONCEPT FLOW CHART

Reference: NFPA 550

The goal is to minimize the impact from a wildfire on government buildings located in forested areas. Many factors can impact the size of the risk and the capability of the building to withstand the onslaught of heat, smoke and burning brands. This decision flow chart captures the main considerations from design through to actions during the emergency to accomplish that goal.

This chart looks at three main areas: two passive approaches in siting and building design and third, the available protection for the expected risks based on the passive design. The accompanying report will address the methods used to evaluate the various concepts identified here. For those familiar with the risks and mitigation this serves as a guide to ensure all areas have been considered.



Appendix C - Bibliography

ICC (International Code Council)	International Wildland Urban Interface Code
ICC (International Code Council)	International Building Code - Appendix D Fire Districts
Fire Underwriter Survey	Water Supply for Firefighting
Fire Smart	Protecting your Community from Wildfire
Solano Press Books	Managing Fire in the Urban Wild land Interface
Canadian Association of Petroleum Producers (CAPP)	Best Management Practices Wildfire Prevention
NFPA – Fire Wise	Regulations and Plans
	Wildland/Urban Interface Fire Hazards
The Wildland-Urban Interface Fire Problem	http://www.foresthistory.org/publications/FHT/FHTFall2008/Cohen.pdf
Scientific and Social Challenges for the Management of Fire – prone Wildland – urban Interfaces	http://iopscience.iop.org/1748-9326/4/3/034014/pdf/erl9_3_034014.pdf
Alberta Safety Codes Act	Alberta Building Code 2006
	Alberta Fire Code 2006
	STANDATA 06-BCI-020 Post-Disaster Buildings Housing Emergency Response Vehicles and personnel
	STANDATA 06-BCI-025 Fire Department Response Time

Alberta Municipal Affairs, *Building Code Interpretation: Standata, Post-Disaster Building Housing Emergency Response Vehicles and Personnel*, Edmonton, Alberta, 2009

Alberta Sustainable Resource Development, *FireSmart: Protecting your Community from Wildfire, Second Edition*, Partners in Protection, Edmonton, Alberta, July 2003

Alberta Sustainable Resource Development, *Sprinklers in Structural Protection*, Hinton Training Center, Fire Protection Division, Hinton, Alberta, 2004

Australian Bushfire Assessment Consultants, *Bushfire Vegetation & Fire Management Zone Plan: Proposed Redevelopment of the Australian Institute of Police Management:* Collins Beach Road Manly, Australia, July 2008

Building Commission, *Essential Safety Measures, Maintenance Manual: Part 0 - Building Code of Australia*, The Building Commission, Melbourne, Australia, 2007

Cohen, J. P., *A Site Specific Approach for Assessing the Fire Risk to Structure at the Wildland/Urban Interface*, USDA Forest Service SE GTR-69, Ashville, NC, 1991

Cohen, J. P., *Preventing Disasters: Home Ignitability in the Wildland/Urban Interface, Journal of Forestry 2000*, Volume 98(3), pp 15-21

[1]Cohen, J. P., Structure Ignition Assessment Model (SIAM), *Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems*, Walnut Creek, California, February 1994

Cohen, J. P. and Saveland, J., *Structure Ignition Assessment Can Help Reduce Fire damages in the W-UI, Fire Management Notes 1997*, Volume 57 (4), pp 10-23

[7]Cohen, J. P., *Thoughts on the Wildland/Urban Interface Fire Problem*, USDA Forest Service, Missoula, MT, June 2003

[6]Cohen, J. P., *Wildland/Urban Fire – A Different Approach*, USDA Forest Service, Missoula, MT, 2000

Department of Homeland Security, *National Infrastructure Protection Plan – Partnering to Enhance Protection and Resiliency*, Department of Homeland Security, USA, 2009

[4]Flannigan , M. and Wang, X., *Wildfire, Weather and Climate Change in the Canadian Prairie Provinces*, University of Alberta, Edmonton, AB, May 2012

Flat Top Complex - Wildfire Review committee May 2012

[3]Gillett, N. P., Weaver, A. J., Zwiers, F. W., and Flannigan, M. D., *Detecting the Effect of Climate Change of Canadian Forest Fires*, Geophysical Research Letters 2004, Volume 31 (L18211)

Government of Alberta, *Alberta's Oil Sands: Resourceful, Responsible*, Government of Alberta, Edmonton, AB, September 2008

Government of Alberta, *FireSmart: Guide to Landscaping, Second Edition*, Partners in Protection, Edmonton, Alberta, July 2003

Government of British Columbia, *Achieving Global Excellence in Fire Management: Wildfire Management Strategy*, Government of B.C., Vancouver, BC, September 2010

Government of South Australia, *Minister's Specification SA 78– Additional Requirements in Designated Bushfire Prone Areas,* FIS 23243, Building Policy Branch, Department of Planning and Local Government, Australia, May 2011

How We Fight Fire – The Science of Fire (fire behaviour and fire ecology)

Hvenegaard, S., *Health Impact of Smoke Exposure in Wildland/Urban Interface Fires: a Literature Review*, FP Innovations, Hinton, AB, 2012

Institute for Building Home Safety (IBHS), *Mega Fires: The Case for Mitigation*, IHBS, California, USA, July 2008

International Code Council (ICC), *2009 International Building Code (IBC),* ICC, Washington, USA, 2009

International Code Council (ICC), *2009 International Wildland Urban Interface Code (IWUIC),* ICC, Washington, USA, 2009

Kasmauskas, D. G., Green Construction and Fire Protection

[8]Maranghides, A., and Mell, W.*, A Case Study of a Community Affected by the Witch and Guejito Fires*, NIST Technical Note 1635, National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA, April 2009

National Fire Protection Association (NFPA), *NFPA 1141: Fire Protection in Planned Building Groups*, NFPA, Quincy-MA, USA, 2012

National Fire Protection Association (NFPA®), *Firewise® Guide to Landscape and Construction Brochure*, FWC-200-08-PH, NFPA, Quincy, MA, USA, 2008

National Fire Protection Association (NFPA), *NFPA 1142: Water Supplies for Suburban and Rural Fire Fighting*, NFPA, Quincy, MA, USA, 2012

National Fire Protection Association (NFPA), *NFPA 1143: Wildfire Management*, NFPA, Quincy-MA, USA, 2002

National Fire Protection Association (NFPA), *NFPA 1144: Protection of Life and Property from Wildfire*, NFPA, Quincy-MA, USA, 2013

[2]Newman, R., Page, H., and Parminter, J., *Understory Succession following Ecosystem Restoration Treatments in Ingrown Dry Forests*, 16th Int'l Conference, Society for Ecological Restoration, Victoria, BC, Canada, August 2004

Northern Territory Government of Australia, *Framework for the Protection of Northern Territory Critical Infrastructure*, NCCIP, Australia, January 2009

Qualtiere, E., *Impacts of Climate Change on the Western Canadian Southern Boreal Forest Fringe*,

SRC Publication No. 12855-3E11, Saskatchewan Research Council, Saskatoon, SK, 2011

Quarles, S. L., Valachovic, Y., Nader, G. A., and De Lasaux, M. J., *Home Survival in Wildfire – Prone Areas: Building Materials and Design Considerations, ANR Publication 8393*, University of California, Agriculture and Natural Resources, California USA, May 2010

Qunince, A. F., *Performance Measure for Forest Fire Management Organizations: Evaluating and Enhancing Initial Attack Operations in the Province of Alberta's Boreal Natural Region*, M.A.Sc Thesis, University of Toronto, Canada, 2009, 161 pp

[1]Reesor, D.R., *Wildfire and Forest Restoration: A Case Study of the Biscuit Fire and the Healthy Forests Restoration Act of 2003*, Vermont Journal of Environmental Law, Vermont, USA, April 26, 2006

Robertson Focus, *Post-Disaster/Essential Service Buildings – Selecting the Wrong Classification Could be Costly!*, Robertson Focus, Volume 1, November 2008

Smith, R., *Rural Urban Bush Fire Threat Analysis (RUBTA)*, Fire & Emergency Services of Western Australia (FESA), Western Australia, 2003

Stocks, B. J. and Ward, P. C., *Climate Change, Carbon Sequestration, and Forest Fire Protection in the Canadian Boreal Zone*, Climate Change Research Report CCRR-20, Ontario Ministry of Natural Resources, Ottawa, Canada, 2011

Walkinshaw, S., Schroeder, D., and Hvenegoard, S., *Evaluating the Effectiveness of FireSmart Priority Zones for Structure Protection*, FP Innovations, Hinton, AB, 2012

Water Corporation, *Working Together to Protect Communities in Western Australia,* Joint Working Party Information Paper CS01, Fire and Emergency Services Authority of Western Australia (FESA Australia, September 2005

Weber, M. G. and Stocks, B. J., *Forest Fires and Sustainability in the Boreal Forests of Canada,* Ambio 1998, Volume 27, pp 545 – 550

World Economic Forum, *Building Resilience to Natural Disasters: A Framework for Private Sector Engagement*, World Economic Forum, Geneva, USA, January 2008

[5]Zinck, R. D., Pascual, M., and Grimm, V., *Understanding Shifts in Wildfire Regimes and Emergent Threshold Phenomena*, The American Naturalist 2011, Volume 178 (6), pp E49 – E61

Appendix D - Glossary

Asset Protection Zone	The highest level of strategic protection to human life, property and high value assets vulnerable to radiant heat or embers
BIM	Building Information Modeling
Boreal Forest	Forest areas of the northern North Temperate Zone, dominated by coniferous trees such as spruce, fir, and pine
Brise-soleil	A variety of permanent sun-shading structures
Building Envelope	The physical separator between the interior and the exterior environments of a building. It serves as the outer shell to help maintain the indoor environment (together with the mechanical conditioning systems) and facilitate its climate control.
Building Usage Classification	Low Importance buildings represent a low direct or indirect hazard to human life in the event of failure, which include minor storage buildings, and low occupancy buildings. Siting consideration must be given to these structures to ensure they do not contribute to the fire load or fire spread during a wildfire event. Normal Importance, loss of these buildings would impact routine operations, however, the contents can be replaced and temporary arrangements made during replacement if necessary. Most buildings would be considered Normal Importance for design purposes. High Importance is given to buildings where the functions or contents cannot be lost or interrupted. An additional category are those buildings that present an unacceptable threat, such as manufacturing and storage facilities containing toxic substances, explosives or other substances in sufficient quantities to be dangerous to the public if released. Post-disaster buildings are prime examples of High importance for maintaining operations during and after an emergency. Other examples are museums or buildings designated as shelters during an emergency.
Combustion	An act or instance of burning, usually a rapid chemical process (as oxidation) that produces heat and usually light
Conflagration	A large disastrous fire
Defensible Space	An area either natural or man-made, where material capable of allowing a fire to spread unchecked has been treated, cleared or modified to slow the rate and intensity of an advancing wildfire and to create an area for fire suppression operations to occur. (ICC)
ESRD	Environment and Sustainable Resource Development; stewards of air, land, water and biodiversity, will lead the achievement of desired environmental outcomes and sustainable development of natural resources for Albertans.

Exposure	The subjection of a material or construction to a high heat flux from an external source, with or without flame impingement
Façade	Generally one exterior side of a building, usually, but not always, the front
Fenestration	Refers to the design and/or disposition of openings in a building or wall envelope. Fenestration products typically include: windows, doors, louvers, vents, wall panels, skylights, storefronts, curtain walls, and slope glazed systems.
Fire brand	A piece of burning wood
FireSmart	FireSmart uses preventative measures to reduce wildfire threat to Albertans and their communities while balancing the benefits of wildfire on the landscape.
Forest Fire	See Wildfire Ground fires occur on the ground, often below the leaves. Surface Fires occur on the surface of the forest up to 1.3 metres high Crown fires occur in the tops of the trees and can spread the fastest
Forested Region	In Alberta the forested region is primarily in the north and western portions of the province (boreal region) See attached maps
FRR	Fire resistance rating usually expressed in number of hours
FUS	Fire Underwriters Survey
ICC	International Code Council is a US Association that publishes a collection of 14 safety codes that are adopted in whole or part by all US States and a number of other countries
Ignition	The starting of a fire
Institutional Building	All buildings operating government programs
LEED®	Leadership in Energy and Environmental Design (LEED) consists of a suite of rating systems for the design, construction and operation of high performance green buildings, homes and neighborhoods.
NFPA	National Fire Protection Association standards. Several standards are referenced by Canadian Codes for compliance.
Porte-cochere	A roofed structure extending from the entrance of a building over an adjacent driveway and sheltering those getting in or out of vehicles or passageways through a building or screen wall designed to let vehicles pass from the street to an interior courtyard
Post-Disaster	A building that is essential to the provision of services in the event of a disaster
Prevailing Wind	A wind that blows predominantly from a single general direction
Prometheus©	Prometheus© the Canadian Wildland Fire Growth Simulation Model is a computer program that mathematically expresses and integrates many of the fuels, weather and topographic factors influencing forest fire

	behaviour.
Radiant heat flux	The rate of heat energy transfer through a given surface heat as a rate per unit area measured in W/m^2
Scrubber	An air scrubber is a device that is used to remove particles, gases, or chemicals from the air within a given area. While most air filtration systems of this type are designed to handle only one of these types of pollutants, there are a few industrial air cleaners that will handle two and even all three contaminants. Most scrubbers are configured to complete at least six cycles of operation each hour, helping to keep the air in the space free of any type of contamination.
Shelter-in-Place (SIP)	A process for taking immediate shelter in a location readily accessible to the affected individual by sealing a single area (an example being a room) from outside contaminants
Wildfire	An uncontrolled fire in an area of combustible vegetation that occurs in the countryside or a wilderness area. Other names such as brush fire, bushfire, forest fire, desert fire, grass fire, hill fire, peat fire, vegetation fire, and wildfire may be used to describe the same phenomenon.
Wildland-Urban Interface Area	That geographical area where structures and other human developments meet or intermingle with wildland or vegetative fuels

Appendix E - Alberta Government Buildings

The following is a list of municipal and forested areas within the Province that are at a higher risk of wildfire potential.

North-East:

- Boyle
- Fort McMurray
- Fort Chipewyan
- Athabasca

North-West:

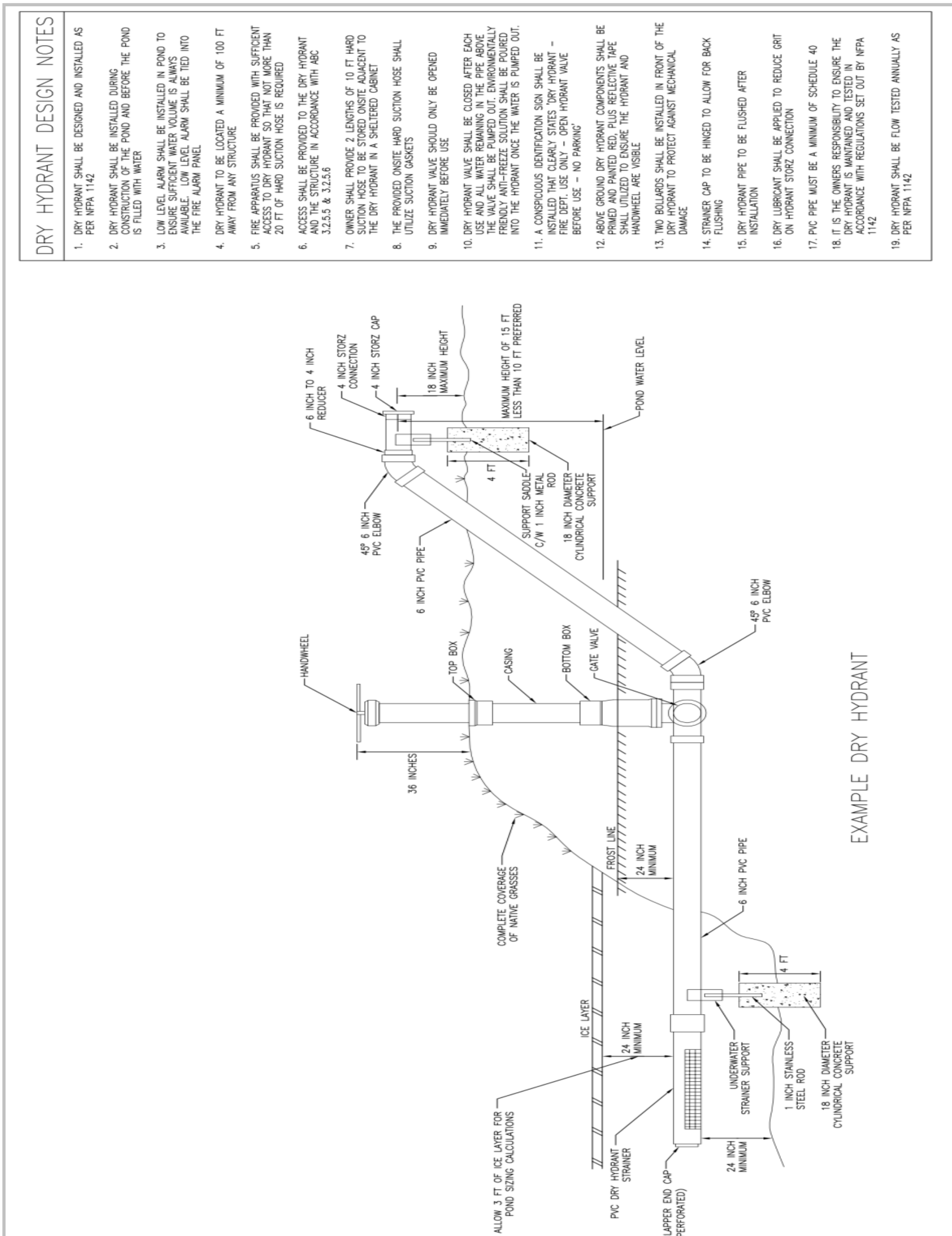
- Whitecourt
- Hinton
- Grande Cache
- Fox Creek
- High Level
- Red Earth
- Wabasca –Desmaris
- Swan Hills

Foothills and Mountain Parks:

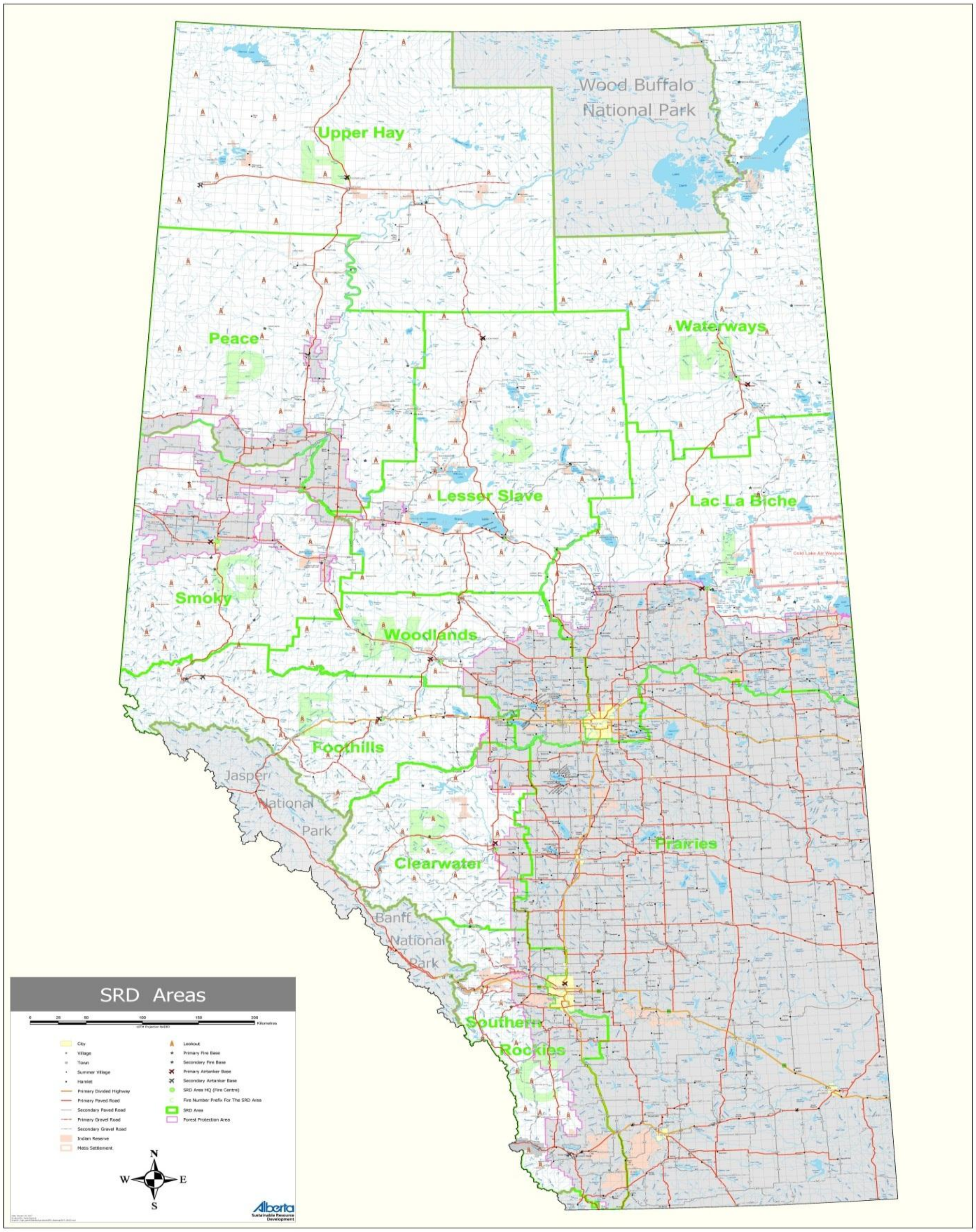
- Crowsnest Pass
- Canmore
- Jasper
- Banff

Appendix F - Dry Hydrant

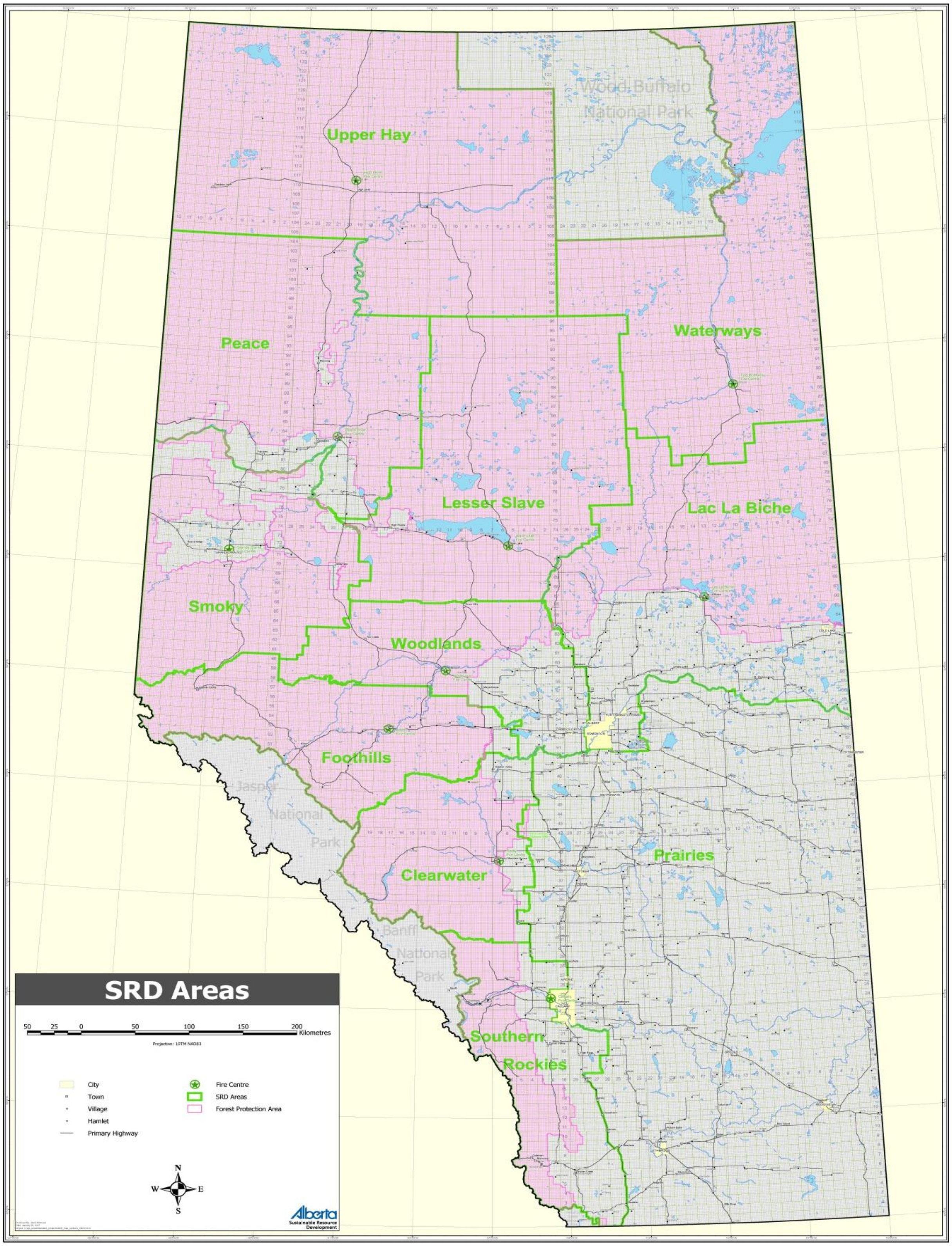
Example Dry Hydrant Design



Appendix G – Sustainable Resource Development Basemap



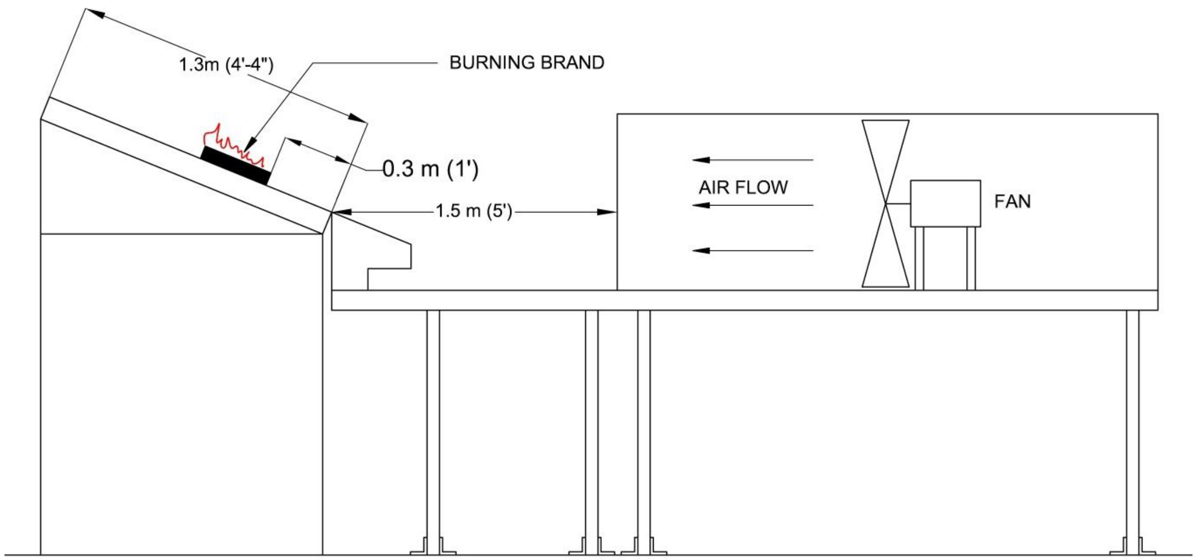
Appendix H - Sustainable Resource Development Sections



Appendix I - Roof Fire Resistance Rate Testing

http://firecenter.berkeley.edu/new_bwmg/roof/code

"Fire ratings for roof coverings are based on test methods developed by standards writing organizations. These include the American Society for Testing and Materials (ASTM) Standard E-108, Underwriters Laboratory (UL) Standard 790 and National Fire Protection Association (NFPA) Standard 276. These standards evaluate three fire-related characteristics of a roof covering, including 1) the ability to resist the spread of fire into the attic (or cathedral ceiling) area, 2) resist flame spreading on the roof covering, and 3) resist generating burning embers.



This is a diagram of the test apparatus used in the ASTM E-108 test. It is a small wind tunnel. The view shown here is for the 'penetration' test, consisting of a 3 ft by 4 ft test deck at the (left) end. The distance between the end of the tunnel and the test deck is specified, as is the location of the burning brand on the test deck and the air flow velocity.

The test deck for the spread of flame test is a different size.

Fire ratings for roof coverings are 'A', 'B', 'C' or 'nonrated'.

- *A - brand: 12"x12" three layer sandwich made from ¾" square Douglas-fir sticks*
- *B - brand: 6"x6" three layer sandwich made from ¾" square Douglas-fir sticks*
- *C - brand: Small piece of Douglas-fir, about the size of an ice cube*

In the brand portion of the ASTM E-108 test one 'A' or one to two 'B' brands will be ignited and placed on the sample roof deck during the test. Multiple 'C' brands are placed on the roof deck during the course of the test. "

Appendix J –
Environment and Sustainable Resource Development Storage Sample Case Study

Environmental and Sustainable Resource Development (ESRD)

Storage Building - Slave Lake, AB

<u>Garage, Warehouse and Workshop (F3) Design Evaluation for Survival in a Forest Fire</u>

The building is classified as a low hazard industrial occupancy with a normal usage. It is not expected to be used as a shelter or post-disaster building.

Located on the NE corner of the tarmac adjacent to the airfield, the building is located on flat terrain bounded by a gravel storage yard (24 m x 60 m) to the west and asphalt parking to the east between warehouses that are approximately 35 m apart. Between the air strip to the south and the storage building is existing bush that is approximately 5 m from the building. The north side has a landscaped lawn with individual trees.

The storage building consists of steel framing with insulated metal panels and translucent panels for light below the eaves. Although constructed of steel with insulation the building does not have any fire resistance rating. A sloped metal roof covers the majority of the building with a flat centre section. The centre section does provide an ideal zone for capturing fire brands and is covered by a bitumen roofing system.

The eaves overhang by almost one metre protecting the walls and windows from burning brands but providing an area for trapping radiated heat.

The building has no internal or external fire suppression systems and the water supply is provided through the Slave Lake municipal system. The new reservoir and pumping system has been activated since the forest fire that impacted much of Slave Lake. The facility must rely on the utilities provided by Slave Lake for operation so any interruption in those services could impact operations.

Based on the above information an evaluation sheet was completed. Using the work sheet under ***Scenario A***, the construction and exposure rating indicates a reasonable expectation that the building would survive a forest fire. The evaluation also indicates that fully protecting the building with portable exterior sprinklers as shown in ***Scenario B*** below would provide an acceptable level for survival.

The building is not designed to provide shelter or be a post-disaster facility. Since this is an ESRD facility, the personnel would most likely be employed in an emergency response role in the event of a forest fire. The area does have the normal evacuation routes along the municipal roads and an alternative along the air strip if necessary.

Recommendations

1. **Ensure a clearing of bush on the south side of the storage building, so that burning trees could not fall onto the building.**
2. **Pre-plan for deployment of portable exterior sprinklers in the event of a forest fire to enhance survivability of the building.**

ALBERTA INFRASTRUCTURE BUILDING DESIGN FOR FORESTED AREAS

Building: ESRD Storage, Slave Lake, AB   Date: 15-Apr-13

Scenario	BUILDING CONSTRUCTION Combustible or noncombustible					Topography Slope %	Passive Exposure Protection				Water Supply	Active Suppression	Risk Score
	Roof	Walls	Unprotected Openings	Utilities	HVAC Isolation	Slope	Tree Line	Other Building	Barrier	Ground Cover	Reliable	Exterior Sprinkler	max. 100
Scoring	15	10	5	5	5	10	10	5	5	10	10	10	100
A	10	8	2	1	1	10	3	4	2	8	8	0	57
B	10	8	2	1	1	10	3	4	2	8	8	8	65
C													0

This score sheet automatically tallies the values entered when using the attached criteria and indicates the acceptability of the design.

			Usage	Minimum Target
Scenario A scoring	**Consider Mitigation**	USAGE:	**Normal**	55
Scenario B scoring	**Acceptable**	USAGE:	**Normal**	55
Scenario C scoring	**Not Applicable**	USAGE:	**Shelter**	85

morrisonhershfield.com

Suite 300, 6807 Railway Street S.E.,
Calgary, AB T2H 2V6

Tel 403 246 4500
Fax 403 246 4220

Suite 300, 1603-91 Street S.W.,
Edmonton, AB T6X 0W8

Tel 780-483-5200
Fax 780-484-3883